BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

APPLICATION FOR LICENSE FOR MAJOR PROJECT

SUSITNA HYDROELECTRIC PROJECT
DRAFT LICENSE APPLICATION

VOLUME 1

EXHIBIT A
PROJECT DESCRIPTION

November 1985

INITIAL STATEMENT

BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION:
APPLICATION FOR LICENSE FOR A
MAJOR UNCONSTRUCTED PROJECT OR MAJOR MODIFIED PROJECT

1. The Alaska Power Authority applies to the Federal Energy Regulatory Commission for a licnese for the Susitna Hydroelectric Water Power Project, as described in the attached exhibits.

2. The location of the proposed project is:

State:	Alaska
Borough:	Matanuska-Susitna
Stream or other Body of Water:	Susitna River

3. The exact name, business address and telephone number of the applicant is:

   Alaska Power Authority
   334 West 5th Avenue
   Anchorage, Alaska 99501
   (907) 276-0001

   The exact names, business addresses and telephone numbers of the persons authorized to act as agents for the applicant in this application are:

   Mr. James B. Dischinger
   Project Manager
   Alaska Power Authority
   334 West 5th Avenue
   Anchorage, Alaska 99501
   (907) 276-0001

   and

   Charles B. Curtis, Esq.
   Van Ness, Feldman, Sutcliffe & Curtis
   1050 Thomas Jefferson Street, NW
   Seventh Floor
   Washington, D.C. 20007
   (202) 331-9400

4. The applicant is a public corporation of the State of Alaska in the Department of Commerce and Economic Development but with separate and independent legal existence.

5. (i) The statutory or regulatory requirements of the state in which the project would be located and that affect the project as

proposed with respect to bed and banks and to the appropriation, diversion, and use of water for power purposes, and with respect to the right to engage in the business of developing, transmitting, and distributing power and in any other business necessary to accomplish the purposes of the license under the Federal Power Act, are:

(A) ALASKA STAT. §§44.83.010-44.83.425 (1984) ("Alaska Power Authority") (including §§44.83.300- 44.83.360, entitled "Susitna River Hydroelectric Project"); ALASKA ADMIN. CODE, tit. 3, §94.010-94.900 (Apr. 1982).

These statutory provisions and regulations establish the Alaska Power Authority as a legal entity, the purpose of which is "to promote, develop and advance the general prosperity and economic welfare of the people of Alaska by providing a means of constructing, acquiring, financing and operating power projects," including hydroelectric facilities. ALASKA STAT. §§44.83.070 (1)(1984). The Alaska Power Authority has a number of specific powers, including (1) the right to perform reconnaissance studies, feasibility studies, and engineering and design with respect to power projects, 2) the right to enter into contracts, (3) the right to issue bonds, (4) the right to exercise the power of eminent domain and (5) the right to construct and operate power projects. See ALASKA STAT. §§44.83.080 (1984).

Sections 44.83.300-44.83.360 deal specifically with the Susitna River Hydroelectric Project, the purpose of which is to generate, transmit and distribute electric power in a manner that will (1) minimize market area electrical power costs, (2) minimize adverse environmental and social impacts while enhancing environmental values to the extent possible and (3) safeguard both life and property. ALASKA STAT. §§44.83.300-44.83.310 (1984). The Alaska Power Authority is permitted to contract for preliminary work on the Susitna Project (including preparation of plans and studies, preparation and submission of license applications, and other types of work necessary before actual construction of the project can begin) without seeking state legislative approval. See ALASKA STAT. §§44.83.325 (1984) (Editor's note). Additionally, the Alaska Power Authority is required to obtain approval by the state legislature of its preliminary report on the Susitna Project, as provided in ALASKA STAT. §§44.83.325 (1984) before contracting for preparation of the site or contracting for actual construction of the project. See Alaska Sess. Laws, Ch. 133,§21. In addition, state legislative approval of the financing of the project is required. See ALASKA STAT. §§44.83.360 (1977)

(B) <u>ALASKA STAT. §§46.15.030-46.15.185 (1982) ("Appropriation and Use of Water"); ALASKA ADMIN. CODE tit. 11, §§93.040-93.140 (Jan. 1980) ("Appropriation of Water").</u>

These statutory provisions and regulations set forth the manner in which a right to appropriate water in Alaska may be acquired. They require that application for a permit to appropriate be made to the Department of Natural Resources. <u>See</u> ALASKA STAT. §46.15.040 (1982); ALASKA ADMIN. CODE tit. 11, §93.040 (Apr. 1985). They also list certain criteria which must be considered when evaluating the application. <u>See</u> ALASKA STAT. §46.15.080 (1982); ALASKA ADMIN. CODE titl. 11, §93.120 (Apr. 1985). In addition, the cited statute and regulations specify under what conditions one who has been granted a permit to appropriate shall be granted a certificate of appropriation.

(C) <u>ALASKA ADMIN. CODE tit. 11, §§93.150-93.200.185 (Jan. 1980) ("Dam Safety and Construction").</u>

These regulations (also promulgated pursuant to ALASKA STAT. §46.15.030-46.15.185 (1982), discussed in (B) above) require a "certificate of approval" to be obtained from the Department of Natural Resources prior to construction of dams as large as those proposed for the Susitna Project. Approval is based on information contained in drawings and design data submitted with the application for the certificate.

(D) <u>ALASKA STAT. §16.05.870 (1983) ("Protection of Fish and Game").</u>

This section required that any person or governmental agency intending to "use, divert... or change the natural flow or bed" of a river, lake or stream, such as the Susitna River, which has been designed as important to the spawning, rearing or migration of anadromous fish (1) notify the Department of that intent and (2) await its approval of the construction.

(E) <u>ALASKA STAT. §§16.10.010-16.10.020 (1983) ("Interference With Salmon Spawning Streams and Waters", "Grounds for Permit or License").</u>

These sections essentially require that any person who will erect a dam which may affect salmon spawning streams or waters first apply for and obtain a permit or license from the Department of Environmental Conservation. One purpose for which a permit or license may be granted is the development of power. As a condition for such a permit adequate fishways may be required.

(F) ALASKA STAT. §16.05.840 (1983) ("Fishway Required").

The Commissioner of the Department of Fish and Game may require that a fishway be provided for a dam built across a stream frequented by salmon or other fish. In the event that a fishway is considered necessary, plans and specifications must be submitted for approval.

(G) ALASKA ADMIN. CODE tit. 18, §§15.130-15.180 (Jan. 1978) ("Certification").

Under Federal law, an applicant for a Federal license to construct or operate a facility must make application to obtain from the State a certification of compliance with the Federal Water Pollution Control Act. 33 U.S.C. §1341 (1977). Issuance of such a certificate is governed by ALASKA ADMIN. CODE tit. 18, §§15.130-15.180. The procedures governing that certification process are set forth in these sections of the Code.

(H) ALASKA STAT. §38.05.020-38.05.330 (1984) ("Alaska Lands Act").

These sections of the Alaska Statutes provide the methods by which the Alaska Power Authority may obtain use of state lands. The Department of Natural Resources may lease, sell or otherwise dispose of state land to a state or political subdivision for less than its appraised value if such action is found by the Department to be fair and proper and in the best interests of the public. ALASKA STAT. §38.05.810 (1984). The Department may issue permits, rights-of-way or easements on state land for roads and electric transmission and distribution lines. ALASKA STAT. §38.05.810 (1984). Prior to disposing of state land which is adjacent to a body of water or a waterway, the Department must determine whether the body of water or waterway is navigable or public water or neither. If it is navigable or public water, the Department may provide for easements or rights-of-way. ALASKA STAT. §38.05.127 (a)(1984).

(I) ALASKA STAT. §§46.40.030-46.40.040; §§46.40.090-46.40.100 (1982) ("Development of Alaska Coastal Management Program"); ALASKA ADMIN. CODE tit. 6, §50.011-50.190 (Apr. 1984) ("Project Consistency with Alaska Coastal Management Program").

These sections require that the Alaska Coastal Policy Council, state agencies, and municipalities administer the resources within a coastal area in a manner consistent with the applicable district coastal management plan. The Susitna Project is located within a designated coastal resource district.

(J) ALASKA ADMIN. CODE tit. 18, §§15, 50 (Jan. 1984)("Air Quality Control").

These regulations provide for permit applications for various facilities as described in ALASKA ADMIN. CODE tit. 18, §50.300(a). Applications for permits from the Department of Environmental Conservation must include information set forth in ALASKA ADMIN. CODE tit. 18, §§50.300(b), (c), (d), and (e).

(K) ALASKA ADMIN. CODE tit. 18, §72 (Jan. 1983) ("Waste Water Disposal").

These regulations provide for permits issued by the Department of Environmental Conservation for the disposal of domestic wastewater into or onto waters or lands in Alaska, as well as general permits for activities producing wastewater. ALASKA ADMIN. CODE tit. 18, §§72.015 and 72.920.

5. (ii) The steps which the applicant has taken, or plans to take, to comply with each of the laws cited above are:

(A) ALASKA STAT. §§44.83.010-44.83.425 (1977), 1982 Supp.).

The Alaska Power Authority has sought legislative approval of its preliminary report on the Susitna Project.

(B) ALASKA STAT. §§46.15.030-46.15.185 (1982); ALASKA ADMIN. CODE tit. 11, §§93.040-93.140 (Apr. 1985).

An investigation of existing water rights has been completed in connection with the permit required by the cited statute and regulations. The results indicate that the project would have a materially adverse impact on existing water rights. In addition, the Alaska Power Authority has applied for a permit to appropriate water for the Susitna Project. In addition, the Alaska Power Authority has applied for a permit to appropriate water for the Susitna Project from the Department of Natural Resources, and has been in cooperation with the Department in providing the necessary information to establish that such appropriation is in the public interest.

(C) ALASKA ADMIN. CODE tit. 11, §§93.150-93.200 (Apr. 1985).

The required drawings and design data are contained in Exhibits B, F, and G of this Initial Statement. The Alaska Power Authority has applied for a certificate of approval.

(D) ALASKA STAT. §16.05.870 (1983).

The Alaska Power Authority has notified the Department of Fish and Game of its intent to construct the project on the Susitna River.

(E) ALASKA STAT. §§16.10.010-16.10.020 (1977).

The Alaska Power Authority has apprised the appropriate Departments of the Susitna Project and requested a ruling of its permitting requirements pursuant to these sections. Authorization pursuant to ALASKA STAT. §16.14.010 has been received from the Department of Environmental Conservation.

(F) ALASKA STAT. §16.05.840 (1977).

The Alaska Power Authority has notified the Department of Fish and Game of the Susitna Project.

(G) ALASKA ADMIN. CODE tit. 18, §§15.130-15.180 (Jan. 1978).

The Alaska Power Authority has notified the Department of Environmental Conservation that it will seek a certificate of compliance with the Federal Water Pollution Control Act. Under Alaska regulations, application for such a certificate is made by serving on the Department a copy of the Federal license application contemporaneously with submission of the application to the Federal agency. ALASKA ADMIN. CODE tit. 18, §15.180(c). The Alaska Power Authority has complied with this requirement.

(H) ALASKA STAT. §38.05.020-38.05.030 (1982 Supp.).

The Alaska Power Authority has requested a right-of-way for transmission lines from the Department of Natural Resources. Rights-of-way may be requested for an access road and a railroad spur. If any state land acquired for the Susitna Project is adjacent to public or navigable waters, the Department of Natural Resources will determine whether easements or rights-of-way shall be provided.

(I) ALASKA STAT. §§46.40.030-46.40.040; §§46.40.040-46.40.100 (1982); ALASKA ADMIN. CODE tit. 6 §§50.010-50.190 (Apr. 1984).

The Susitna Project will be reviewed for consistency with the coastal management plan of the borough of Matanuska. This review process is initiated when federal permit-granting agencies forward copies of the Susitna application to the the Govenor of the State of Alaska (Office of Management and Budget) as part of the federal permit process.

(J) ALASKA ADMIN. CODE tit. 18, §§15, 50 (Jan. 1984).

The Alaska Power Authority has requested a permit from the Department of Environmental Conservation, and has submitted a proposed air quality control program along with supplemental information including a proposed monitoring program.

(K) ALASKA ADMIN. CODE tit. 18, §72 (Jan. 1983).

The Alaska Power Authority has requested a wastewater disposal permit from the Department of Environmental Conservation.

IN WITNESS WHEREOF, the applicant, Alaska Power Authority, has caused its name to be signed below by Robert B. Heath, its Executive Director, and its seal to be affixed hereto by __________________________, its ____________________, this _____ day of ___________, 1985.

ALASKA POWER AUTHORITY

By _______________________
Robert B. Heath
Executive Director

(SEAL)

ALASKA STATUTES

Chapter 83. Alaska Power Authority.

Article 1. Creation and Organization.

Sec. 44.83.010. Legislative finding and policy. (a) The legislature finds, determines and declares that

(1) there exist numerous potential hydroelectric and fossil fuel gathering sites in the state;

(2) the establishment of power projects at these sites is necessary to supply power at the lowest reasonable cost to the state's municipal electric, rural electric, cooperative electric, and private electric utilities, and regional electric authorities, and thereby to the consumers of the state, as well as to supply existing or future industrial needs;

(3) the achievement of the goals of lowest reasonable consumer power costs and beneficial long-term economic growth and of establishing, operating and developing power projects in the state will be accelerated and facilitated by the creation of an instrumentality of the state with powers to construct, acquire, finance, and operate power projects.

(b) It is declared to be the policy of the state, in the interests of promoting the general welfare of all the people of the state, and public purposes, to reduce consumer power costs and otherwise to encourage the long-term economic growth of the state, including the development of its natural resources, through the establishment of power projects by creating the public corporation with powers, duties and functions as provided in this chapter. (§ 1 ch 278 SLA 1976; am § 1 ch 156 SLA 1978)

Revisor's notes. — Formerly AS 44.56.010. Renumbered in 1980.

Sec. 44.83.020. Creation of authority. There is created the Alaska Power Authority. The authority is a public corporation of the state in the Department of Commerce and Economic Development but with separate and independent legal existence. (§ 1 ch 278 SLA 1976)

Revisor's notes. — Formerly AS 44.56.020. Renumbered in 1980.

Sec. 44.83.030. Membership of the authority. The authority shall consist of the following directors:

(1) three public directors to be appointed by the governor and confirmed by the legislature; only one director may be appointed from each judicial district described in AS 22.10.010;

(2) the director of the office of management and budget, or the director's designee within that office, and three commissioners of principal executive departments appointed by the governor. (§ 1 ch 278 SLA 1976; am § 2 ch 156 SLA 1978; am § 2 ch 118 SLA 1981; am § 25 ch 63 SLA 1983)

Revisor's notes. — Formerly AS 44.56.030. Renumbered in 1980.

Cross references. — For transitional provisions related to the authority's 1981 reorganization, see § 15, ch. 118, SLA 1981.

Effect of amendments. — The 1981 amendment deleted the subsection designation (a) and repealed subsection (b) which read "The commissioners of community and regional affairs, natural resources, transportation and public facilities, and revenue shall have the rights and privileges of directors except for the right to vote and may not be considered for purposes of quorum or voting." The amendment also substituted "three public" for "four" preceding "directors," deleted "at large" preceding "to be appointed" and added "only one director may be appointed from each judicial district described in AS 22.10.010" in paragraph (1) and substituted "the director of the division of budget and management and three commissioners of principal executive departments appointed by the governor" for "the commissioner of commerce and economic development" in paragraph (2).

The 1983 amendment, in paragraph (2) substituted "office of management and budget, or the director's designee within that office," for "division of budget and management."

Sec. 44.83.040. Officers; meetings; quorum. (a) The directors shall elect one of their number as chairman and may elect other officers they determine desirable. The powers of the authority are vested in the directors, and four directors of the authority constitute a quorum. Action may be taken and motions and resolutions adopted by the authority at a meeting by the affirmative vote of a majority of the directors. The directors of the authority serve without compensation, but they shall receive the same travel pay and per diem as provided by law for board members.

(b) The board may meet and transact business by an electronic medium if

(1) public notice of the time and locations where the meeting will be held by an electronic medium has been given in the same manner as if the meeting were held in a single location;

(2) participants and members of the public in attendance can hear and have the same right to participate in the meeting as if the meeting were conducted in person; and

(3) copies of pertinent reference materials, statutes, regulations, and audio-visual materials are reasonably available to participants and to the public.

(c) A meeting by an electronic medium as provided in this section has the same legal effect as a meeting in person.

(d) A director of the authority may not vote on a resolution of the authority relating to a lease or contract to be entered into by the authority under this chapter if the director is a party to the lease or contract or has a direct ownership or equity interest in a firm, partnership, corporation, or association that is a party to the contract or lease. When abstaining from voting, the director must disclose the reason for the abstention. A director who is a member of an electric cooperative that is organized under or subject to the Electric and Telephone Cooperative Act (AS 10.25) may vote on a resolution relating to a contract or lease to which that cooperative is a party. The director shall disclose the cooperative membership at the time of voting. A resolution of the authority that is approved by a majority of the directors present who are not barred from voting under this subsection is a valid action of the authority for all purposes. (§ 1 ch 278 SLA 1976; am § 3 ch 156 SLA 1978; am § 3 ch 118 SLA 1981; am §§ 1, 2 ch 89 SLA 1983)

Revisor's notes. — Formerly AS 44.56.040. Renumbered in 1980.

Effect of amendments. — The 1981 amendment substituted "directors" for "director," substituted "their number" for "the directors at large" and added "may elect" preceding "other officers" in the first sentence and substituted "four" for "three" preceding "directors" in the second sentence.

The 1983 amendment substituted "a majority of the directors" for "at least three directors" at the end of the third sentence of subsection (a) and added subsections (b)-(d).

Sec. 44.83.045. Qualifications, powers, and duties of officers and directors. (a) The public directors shall be residents and qualified voters of Alaska and shall comply with the requirements of AS 39.50.010 — 39.50.200 (conflict of interests). The public directors shall serve overlapping four-year terms.

(b) A vacancy in a directorship occurring other than by expiration of a term shall be filled in the same manner as the original appointment, but for the unexpired portion of the term only.

(c) The authority shall employ an executive director who may, with the approval of the authority, employ additional staff as necessary. In addition to its staff of regular employees, the authority may contract for and engage the services of legal and bond counsel, consultants, experts, and financial and technical advisors the authority considers necessary for the purpose of conducting studies, investigations, hearings, or other proceedings. The board of directors shall establish the compensation of the executive director. The executive director of the authority is subject to the provisions of AS 39.25.010 — 39.25.220. (§ 4 ch 156 SLA 1978; am § 4 ch 118 SLA 1981)

Revisor's notes. — Formerly AS 44.56.045. Renumbered in 1980.

Effect of amendments. — The 1981 amendment added "public" preceding "directors" and substituted "shall" for "at large must" preceding "be residents" in the first sentence, added "public" preceding "directors," deleted "at large" following "directors" and added "overlapping" preceding "four-year terms" in the second sentence and deleted the former third sentence which read "The four original directors at large have terms of one, two, three, and four years, respectively."

Sec. 44.83.050. Staff. [Repealed, § 23 ch 156 SLA 1978.]

Article 2. Purpose and Powers.

Sec. 44.83.070. Purpose of the authority. The purpose of the authority is to promote, develop and advance the general prosperity and economic welfare of the people of Alaska by providing a means of constructing, acquiring, financing and operating

(1) power projects; and

(2) facilities that recover and use waste energy. (§ 1 ch 278 SLA 1976; am § 5 ch 156 SLA 1978; am § 1 ch 133 SLA 1982)

Revisor's notes. — Formerly AS 44.56.070. Renumbered in 1980.

Effect of amendments. — The 1982 amendment substituted paragraphs (1) and (2) for "power production facilities limited to fossil fuel, wind power, tidal, geothermal, hydroelectric, or solar energy production and waste energy conservation facilities."

Sec. 44.83.080. Powers of the authority. In furtherance of its corporate purposes, the authority has the following powers in addition to its other powers:

(1) to sue and be sued;

(2) to have a seal and alter it at pleasure;

(3) to make and alter bylaws for its organization and internal management;

(4) to adopt regulations governing the exercise of its corporate powers;

(5) to acquire, whether by construction, purchase, gift or lease, and to improve, equip, operate, and maintain power projects;

(6) to issue bonds to carry out any of its corporate purposes and powers, including the acquisition or construction of a project to be owned or leased, as lessor or lessee, by the authority, or by another person, or the acquisition of any interest in a project or any right to capacity of a project, the establishment or increase of reserves to secure or to pay the bonds or interest on them, and the payment of all other costs or expenses of the authority incident to and necessary or convenient to carry out its corporate purposes and powers;

(7) to sell, lease as lessor or lessee, exchange, donate, convey or encumber in any manner by mortgage or by creation of any other security interest, real or personal property owned by it, or in which it has an interest, when, in the judgment of the authority, the action is in furtherance of its corporate purposes;

(8) to accept gifts, grants or loans from, and enter into contracts or other transactions regarding them, with any person;

(9) to deposit or invest its funds, subject to agreements with bondholders;

(10) to enter into contracts with the United States or any person and, subject to the laws of the United States and subject to concurrence of the legislature, with a foreign country or its agencies, for the financing, construction, acquisition, operation and maintenance of all or any part of a power project, either inside or outside the state, and for the sale or

transmission of power from a project or any right to the capacity of it or for the security of any bonds of the authority issued or to be issued for the project;

(11) to enter into contracts with any person and with the United States, and, subject to the laws of the United States and subject to the concurrence of the legislature, with a foreign country or its agencies for the purchase, sale, exchange, transmission, or use of power from a project, or any right to the capacity of it;

(12) to apply to the appropriate agencies of the state, the United States and to a foreign country and any other proper agency for the permits, licenses, or approvals as may be necessary, and to construct, maintain and operate power projects in accordance with the licenses or permits, and to obtain, hold and use the licenses and permits in the same manner as any other person or operating unit;

(13) to perform reconnaissance studies, feasibility studies, and engineering and design with respect to power projects;

(14) to enter into contracts or agreements with respect to the exercise of any of its powers, and do all things necessary or convenient to carry out its corporate purposes and exercise the powers granted in this chapter;

(15) to exercise the power of eminent domain in accordance with AS 09.55.240 — 09.55.460;

(16) to recommend to the legislature

(A) the issuance of general obligation bonds of the state to finance the construction of a power project if the authority first determines that the project cannot be financed by revenue bonds of the authority at reasonable rates of interest;

(B) the pledge of the credit of the state to guarantee repayment of all or any portion of revenue bonds issued to assist in construction of power projects;

(C) an appropriation from the general fund

(i) for debt service on bonds or other project purposes; or

(ii) to reduce the amount of debt financing for the project;

(D) an appropriation to the power project fund for a power project;

(E) *[Repealed, § 16 ch 161 SLA 1984.]*

(F) development of a project under financing arrangements with other entities using leveraged leases or other financing methods;

(G) an appropriation for a power project acquired or constructed under the energy program for Alaska (AS 44.83.380 — 44.83.425). (§ 1 ch 278 SLA 1976; am §§ 6 — 11 ch 156 SLA 1978; am §§ 16, 17 ch 83 SLA 1980; am § 5 ch 118 SLA 1981; am § 16 ch 161 SLA 1984)

Revisor's notes. — Formerly AS 44.56.080. Renumbered in 1980.

Effect of amendments. — The 1980 amendment inserted in the middle of paragraph (13), "feasibility studies, and engineering and design," and added paragraph (16).

The 1981 amendment added subparagraph (G) of paragraph (16).

The 1984 amendment repealed paragraph (16)(E).

Sec. 44.83.090. Power contracts and the Alaska Public Utilities Commission. (a) The authority shall, in addition to the other methods which it may find advantageous, provide a method by which municipal electric, rural electric, cooperative electric, or private electric utilities and regional electric authorities, or other persons authorized by law to engage in the distribution of electricity may secure a reasonable share of the power generated by a project, or any interest in a project, or for any right to the power and shall sell the power or cause the power to be sold at the lowest reasonable prices which cover the full cost of the electricity or services, including capital and operating costs, debt coverage as considered appropriate by the authority, and other charges that may be authorized by AS 44.83.010 — 44.83.425. Except for a contract or lease entered into under AS 44.83.380 — 44.83.425, a contract or lease for the sale, transmission and distribution of power generated by a project or any right to the capacity of it shall provide:

(1) for payment of all operating and maintenance expenses of a project and costs of renewals, replacements and improvements of it;

(2) for interest on and amortization charges sufficient to retire bonds of the authority issued for the project and reserves for them, plus a debt service coverage factor as may be determined by the authority to be necessary for the marketability of its bonds;

(3) for monitoring of the project by the authority or its agents;

(4) for full and complete disclosure to the authority of all factors of costs in the transmission and distribution of power, so that rates to any persons may be fixed initially in the contract or lease and may be adjusted from time to time on the basis of true cost data;

(5) for periodic revisions of the service and rates to persons on the basis of accurate cost data obtained by the accounting methods and systems approved by the directors and in furtherance and effectuation of the policy declared in AS 44.83.010 — 44.83.425;

(6) for the cancellation and termination of a contract or lease upon violation of its terms by any person;

(7) for security for performance as the authority may consider practicable and advisable, including provisions assuring the continuance of the distribution and transmission of power generated by a project and the use of its facilities for these purposes; and

(8) other terms not inconsistent with the provisions and policy of this chapter as the authority may consider advisable.

(b) The authority is not subject to the jurisdiction of the Alaska Public Utilities Commission. Nothing in AS 44.83.010 — 44.83.425 grants the authority any jurisdiction over the services or rates of any public utility or diminishes or otherwise alters the jurisdiction of the Alaska Public Utilities Commission with respect to any public utility, including any right the commission may have to review and approve or disapprove contracts for the purchase of electricity by a public utility. (§ 1 ch 278 SLA 1976; am § 12 ch 156 SLA 1978; am § 6 ch 118 SLA 1981)

Revisor's notes. — Formerly AS 44.56.090. Renumbered in 1980.

Effect of amendments. — The 1981 amendment substituted "except for a contract or lease entered into under AS 44.83.380 — 44.83.425, a" for "a" preceding "contract" and added "or lease" preceding "for the sale" in the second sentence of subsection (a) and added "or lease" following "contract" in paragraphs (4) and (6) of subsection (a).

Sec. 44.83.092. Authority for municipalities and utilities to enter into power sales contracts. The authority and any municipality or public or private entity operating an electric utility, or a municipality or private entity and another municipality or private entity, may enter into a contract providing for or relating to the sale of electric power by the authority to the municipality or entity, or by the municipality or entity to another municipality or entity. The contract may provide

(1) that the amounts payable under the contract are operating expenses of the utility and are valid and binding obligations of the municipality or other entity payable from the gross revenues of the utility;

(2) for one or more appropriations of the amounts payable under the contract;

(3) for the municipality or other entity to assume the obligations of another contracting party in the event of a default by that party;

(4) that after completion of a project the municipality or other entity is obligated to make payments notwithstanding a suspension or reduction in the amount of the power supplied by the project; or

(5) that payments under the contract are not subject to reduction by offset or otherwise. (§ 3 ch 89 SLA 1983)

Article 3. Financial Provisions.

Sec. 44.83.100. Bonds of the authority. (a) The authority may borrow money and may issue bonds, including but not limited to bonds on which the principal and interest are payable (1) exclusively from the income and receipts or other money derived from the project financed with the proceeds of the bonds; (2) exclusively from the income and receipts or other money derived from designated projects whether or not they are financed in whole or in part with the proceeds of the bonds; (3) from its income and receipts or other assets generally, or a designated part or parts of them; or (4) from one or more revenue-producing contracts including a contract providing for the security of the bonds made by the authority with any person. The authority may issue bonds to pay, fund or refund the principal of, or interest or redemption premiums on, bonds issued by it, whether or not the bonds or interest to be funded or refunded have become due.

(b) Bonds shall be authorized by resolution of the authority, and shall be dated and shall mature as the resolution may provide, except that no bond may mature more than 50 years from the date of its issue. Bonds shall bear interest at the rates, be in the denominations, be in the form, either coupon or registered, carry the registration privileges, be executed in the manner, be payable in the medium of payment, at the places, and be subject to the terms of redemption which the resolution or a subsequent resolution may provide.

(c) All bonds, regardless of form or character, shall be negotiable instruments for all the purposes of the Uniform Commercial Code.

(d) All bonds may be sold at public or private sale in the manner, for the price or prices, and at the time or times which the authority may determine. (§ 1 ch 278 SLA 1976)

Revisor's notes. — Formerly AS 44.56.100. Renumbered in 1980.

Sec. 44.83.105. Bonds for power projects under the energy program for Alaska. The authority may borrow money and issue its bonds for the acquisition or construction of power projects to be acquired or constructed under the energy program for Alaska. The principal of and interest on the bonds are payable from money derived from the sale of wholesale power from power projects financed under AS 44.83.380 — 44.83.425 from the power development fund or from a source referred to in AS 44.83.100 as the authority determines. The bonds may be issued if

(1) appropriations to the power development fund for the power project are insufficient to cover the cost of acquiring or constructing the power project; and

(2) the authority determines that the amount of interest the authority will pay on its bonds is not more than alternative costs of securing money from other sources, except for the general fund, to pay for the acquisition or construction of the power project. (§ 7 ch 118 SLA 1981; am § 4 ch 89 SLA 1983)

Effect of amendments. — The 1983 amendment, divided the section into three sentences; in the first sentence, substituted "may borrow" for "shall borrow," deleted "shall" preceding "issue its bonds," and substituted the language beginning "for the acquisition or construction" for "on which" at the end; in the second sentence, inserted "of" following "principal" and added "on the bonds" following "and interest" and added the language beginning "or from a source" to the end; and in the third sentence, added "The bonds may be issued" at the beginning, added "the authority determines that" at the beginning of paragraph (2), and inserted "from other sources, except for the general fund" in paragraph (2).

Sec. 44.83.110. Trust indentures and trust agreements. (a) In the discretion of the authority, an issue of bonds may be secured by a trust indenture or trust agreement between the authority and a corporate trustee (which may be a trust company, bank, or national banking association, with corporate trust powers, located inside or outside the state) or by a secured loan agreement or other instrument or under a resolution giving powers to a corporate trustee by means of which the authority may

(1) make and enter into any and all the covenants and agreements with the trustee or the holders of the bonds that the authority may determine to be necessary or desirable, including, without limitation, covenants, provisions, limitations and agreements as to

(A) the application, investment, deposit, use and disposition of the proceeds of bonds of the authority or of money or other property of the authority or in which it has an interest;

(B) the fixing and collection of rentals, charges, fees or other consideration for, and the other terms to be incorporated in, contracts with respect to a project or to generated power;

(C) the assignment by the authority of its rights in contracts with respect to a project or to generated power or in a mortgage or other security interest created with respect to a project or generated power to a trustee for the benefit of bondholders;

(D) the terms and conditions upon which additional bonds of the authority may be issued;

(E) the vesting in a trustee of rights, powers, duties, funds or property in trust for the benefit of bondholders, including, without limitation, the right to enforce payment, performance, and all other rights of the authority or of the bondholders, under a lease, power of contract, contract of sale, mortgage, security agreement, or trust agreement with respect to a project by injunction or other proceeding or by taking possession of by agent or otherwise and operating a project and collecting rents or other consideration and applying the same in accordance with the trust agreement;

(2) pledge, mortgage or assign money, leases, agreements, property or other rights or assets of the authority either presently in hand or to be received in the future, or both; and

(3) provide for any other matters of like or different character which in any way affect the security or protection of the bonds.

(b) Notwithstanding any other provisions of this chapter, the trust indenture, trust agreement, secured loan agreement, or other instrument or the resolution constituting a contract with bondholders shall contain a covenant by the authority that it will at all times maintain rates, fees or charges sufficient to pay, and that a contract entered into by the authority for the sale, transmission or distribution of power shall contain rates, fees or charges sufficient to pay the costs of operation and maintenance of the project, the principal of and interest on bonds issued under the trust agreement as the same severally become due and payable, to provide for debt service coverage as considered necessary by the authority for the marketing of its bonds and to provide for renewals, replacements and improvements of the project, and to maintain reserves required by the terms of the trust agreement. This subsection does not require a covenant that varies from a covenant entered into in accordance with the provisions of AS 44.83.380 — 44.83.425.

(c) For the purpose of securing any one or more issues of its bonds, the authority may establish one or more special funds, called "capital reserve funds", and shall pay into those capital reserve funds the proceeds of the sale of its bonds and any other money that may be made available to the authority for the purposes of those funds from any other source. The funds shall be established only if the authority determines that the establishment would enhance the marketability of the bonds. All money held in a capital reserve fund, except as provided in this section, shall be used as required, solely for (1) the payment of the principal of, and interest on, bonds or of the sinking fund payments with respect to those bonds, (2) the purchase or redemption of bonds, or (3) the payment of a redemption premium required to be paid when those bonds are redeemed before maturity; however, money in a fund may not be withdrawn from it at any time in an amount that would reduce the amount of that fund to less than the capital reserve requirement set out in (2) of this subsection, except for the purpose of making, with respect to those bonds, payment, when due, of principal, interest, redemption premiums and the sinking fund payments for the payment of which other money of the authority is not available. Income or interest earned by, or increment to, a capital reserve fund, due to the investment of the fund or any other amounts in it, may be transferred by the authority to other funds or accounts of the authority to the extent that the transfer does not reduce the amount of the capital reserve fund below the capital reserve fund requirement.

(d) If the authority decides to issue bonds secured by such a capital reserve fund, the bonds may not be issued if the amount in the capital reserve fund is less than such an amount as may be established by resolution of the authority (called the "capital reserve fund requirement"), unless the authority, at the time of issuance of the obligations, deposits in the capital reserve fund from the proceeds of the obligations to be issued or from other sources, an amount which, together with the amount then in the fund, will not be less than the capital reserve fund requirement.

(e) In computing the amount of a capital reserve fund for the purpose of this section, securities in which all or a portion of the funds are invested shall be valued by some reasonable method established by the authority by resolution. Valuation on a particular date shall include the amount of any interest earned or accrued to that date.

(f) The chairman of the authority shall annually, no later than January 2, make and deliver to the governor and the legislature a certificate stating the sum, if any, required to restore any capital reserve fund to the capital reserve fund requirement. The legislature may appropriate such a sum, and all sums appropriated during the then current fiscal year by the legislature for such restoration shall be deposited by the authority in the proper capital reserve fund. Nothing in this section creates a debt or liability of the state.

(g) When the authority has created and established a capital reserve fund, the commissioner of revenue may lend surplus money in the general fund to the authority for deposit in a capital reserve fund in an amount equal to the capital reserve fund requirement. The loans shall be made on such terms and conditions as may be agreed upon by the commissioner of revenue and the authority, including without limitation terms and conditions providing that the loans need not be repaid until the obligations of the authority secured and to be secured by the capital reserve fund are no longer outstanding.

(h) If the authority decides to covenant to issue or to issue bonds secured by a capital reserve fund, the bonds may not be issued until 10 days after the authority has mailed notification to the State Bond Committee and the Legislative Budget and Audit Committee by certified mail of its intention to establish a capital reserve fund to secure the bond issue. The notification shall include the amount of the capital reserve fund to be established, the amount of bonds proposed to be issued, and the total cost of the project for which the bonds are to be issued. The notification shall be accompanied by an estimate by the authority of the need to withdraw money from the capital reserve fund during the term of the bond issue, the amount that it may be necessary to withdraw, and the time at which withdrawals are estimated to be needed. The authority shall annually prepare a revised estimate, considering the same factors, and a statement of all withdrawals that have occurred from the date of issuance of the bonds to the end of the calendar year. The revised estimate and statement shall be submitted to the State Bond Committee and the Legislative Budget and Audit Committee by January 30 of the succeeding year. (§ 1 ch 278 SLA 1976; am §§ 13, 14 ch 156 SLA 1978; am § 2 ch 133 SLA 1982; am § 5 ch 89 SLA 1983)

Revisor's notes. — Formerly AS 44.56.110. Renumbered in 1980.

Effect of amendments. — The 1982 amendment added subsection (h).

The 1983 amendment, in subsection (b), substituted the language beginning "the trust indenture, trust agreement" and ending "constituting a contract with bondholders" for "the trust agreement" near the beginning of the first sentence and added the second sentence.

Sec. 44.83.120. Validity of pledge. It is the intention of the legislature that a pledge made in respect of bonds is considered perfected and is valid and binding from the time the pledge is made; that the money or property so pledged and thereafter received by the authority shall immediately be subject to the lien of the pledge without physical delivery or further act; and that the lien of the pledge shall be valid and binding as against all parties having claims of any kind in tort, contract or otherwise against the authority irrespective of whether the parties have notice. Neither the resolution, trust agreement nor any other instrument by which a pledge is created need be recorded or filed under the provisions of the Uniform Commercial Code to be perfected or to be valid, binding or effective against the parties. (§ 1 ch 278 SLA 1976; am § 6 ch 89 SLA 1983)

Revisor's notes. — Formerly AS 44.56.120. Renumbered in 1980.

Effect of amendments. — The 1983 amendment, substituted "is considered perfected and is valid" for "shall be valid" near the beginning of the first sentence and inserted "perfected or to be" in the second sentence.

Sec. 44.83.130. Nonliability on bonds. (a) Neither the members of the authority nor a person executing the bonds is liable personally on the bonds or is subject to personal liability or accountability by reason of the issuance of the bonds.

(b) The bonds issued by the authority do not constitute an indebtedness or other liability of the state or of a political subdivision of the state, except the authority, but shall be payable solely from the income and receipts or other funds or property of the authority. The authority may not pledge the faith or credit of the state or of a political subdivision of the state, except the authority, to the payment of a bond and the issuance of a bond by the authority does not directly or indirectly or contingently obligate the state or a political subdivision of the state to apply money from, or levy or pledge any form of taxation whatever to the payment of the bond. (§ 1 ch 278 SLA 1976)

Revisor's notes. — Formerly AS 44.56.130. Renumbered in 1980.

Sec. 44.83.140. Pledge of the state. The state pledges to and agrees with the holders of bonds issued under this chapter and with the federal agency which loans or contributes funds in respect to a project, that the state will not limit or alter the rights and powers vested in the authority by this chapter to fulfill the terms of a contract made by the authority with the holders or federal agency, or in any way impair the rights and remedies of the holders until the bonds, together with the interest on them with interest on unpaid installments of interest, and all costs and expenses in connection with an action or proceeding by or on behalf of the holders, are fully met and discharged. The authority is authorized to include this pledge and agreement of the state, insofar as it refers to holders of bonds of the authority, in a contract with the holders, and insofar as it relates to a federal agency, in a contract with the federal agency. (§ 1 ch 278 SLA 1976)

Revisor's notes. — Formerly AS 44.56.140. Renumbered in 1980.

Sec. 44.83.150. Tax exemption. All property of the authority is public property devoted to an essential public and governmental function and purpose and is exempt from all taxes of the state or a political subdivision of the state; however, the authority may make payments in place of taxes in amounts equal to the real and personal property taxes which would be assessed on its real and personal property by each political subdivision in which its property is located to the same extent as if that property were private property and the authority were a non-public corporation. All bonds issued under this chapter are issued by a body corporate and public of this state and for an essential public and governmental purpose and the bonds and the interest and income on and from the bonds and all income of the authority are exempt from taxation except for transfer, inheritance and estate taxes. (§ 1 ch 278 SLA 1976; am § 15 ch 156 SLA 1978)

Revisor's notes. — Formerly AS 44.56.150. Renumbered in 1980.

Sec. 44.83.160. Bonds legal investments for fiduciaries. The bonds of the authority are securities in which all public officers and bodies of the state and all municipalities and municipal subdivisions, all insurance companies and associations and other persons carrying on any insurance business, all banks, bankers, trust companies, savings banks, savings associations, including savings and loan associations and building and loan associations, investment companies and other persons carrying on a banking business, all administrators, guardians, executors, trustees and other fiduciaries, and all other persons whatsoever who are now or may hereafter be authorized to invest in bonds or other obligations of the state, may properly and legally invest funds including capital in their control or belonging to them. Notwithstanding any other provisions of law, the bonds of the authority are also securities which may be deposited with and may be received by all public officers and bodies of this state and all municipalities and minicipal subdivisions for any purpose for which the deposit of bonds or other obligations of the state is now or may hereafter be authorized. (§ 1 ch 278 SLA 1976)

Revisor's notes. — Formerly AS 44.56.160. Renumbered in 1980.

Article 4. Power Cost Equalization Program.

Sec. 44.83.162. Power cost equalization. (a) The power cost equalization fund is established as a separate fund for the purpose of equalizing power cost per kilowatt-hour statewide at a cost close or equal to the mean of the cost per kilowatt-hour in Anchorage, Fairbanks, and Juneau by paying money from the fund to eligible electric utilities in the state. The fund shall be administered by the authority as a fund distinct from the other funds of the authority. The fund is composed of money appropriated for the purpose of providing power cost equalization to eligible electric utilities.

(b) The costs used to calculate the amount of power cost equalization for all electric utilities eligible under this section include all allowable costs, except return on equity, used by the commission to determine the revenue requirement for electric utilities subject to rate regulation under AS 42.05. The costs used in determining the power cost equalization per kilowatt-hour shall exclude any other type of assistance that reduces the customer's costs of power on a kilowatt-hour basis and that is provided to the electric utility within 60 days before the commission determines the power cost equalization per kilowatt-hour of the electric utility.

(c) An eligible electric utility is entitled to receive power cost equalization

(1) for sales of power to local community facilities, calculated in the aggregate for each community served by the electric utility, for actual consumption of not more than 70 kilowatt-hours per month for each resident of the community; and

(2) for actual consumption of not more than 750 kilowatt-hours per month sold to each customer in all classes served by the electric utility except to customers of the utility under (1) of this subsection.

(d) The amount of power cost equalization provided per kilowatt-hour under (c) of this section may not exceed 95 percent of the power costs, or the average rate per eligible kilowatt-hour sold, whichever is less, as determined by the commission. However,

(1) during the state fiscal year that begins July 1, 1984 the power costs for which power cost equalization may be paid to an electric utility are limited to minimum power costs of more than 8.5 cents per kilowatt-hour and less than 52.5 cents per kilowatt-hour;

(2) during each following state fiscal year, the power costs for which power cost equalization may be paid to an electric utility shall be adjusted by the commission, considering the rate of change in fuel cost and power demand; and

(3) the power cost equalization per kilowatt-hour may be determined for a utility without historical kilowatt-hour sales data by using kilowatt hours generated.

(e) An electric utility whose customers receive power cost equalization under this section shall set out in its tariff the rates without the power cost equalization and the amount of power cost equalization per kilowatt-hour sold. The rate charged to the customer shall be the difference between the two amounts. Power cost equalization paid under this section shall be used to reduce the cost of all power sold to local community facilities, in the aggregate, to the extent of 70 kilowatt-hours per month per resident of the community, and to reduce the cost of the first 750 kilowatt-hours per customer per month for all other classes served by the electric utility.

(f) The power cost equalization program shall be administered by the authority based on a determination by the commission under (b) and (d) of this section of power cost equalization per kilowatt-hour for each eligible electric utility.

(g) An eligible electric utility may not be denied power cost equalization because complete cost information is not available. An eligible electric utility that is exempt from rate regulation under AS 42.05 shall be assisted by the commission to provide the cost information the commission considers necessary to comply with the requirements of this section. Only power costs that are supportable may be considered in calculating power cost equalization. Each electric utility is responsible for keeping records that provide the information necessary to comply with the requirements of this section including, but not limited to, records of monthly kilowatt-hour sales or generation, monthly fuel balances, fuel purchases, and monthly utility fuel consumption.

(h) For each eligible electric utility, the determination of the cost of fuel by the commission shall be in accordance with the procedure for approving fuel cost rate adjustments of electric utilities subject to rate regulation under AS 42.05.

(i) Each electric utility receiving power cost equalization approved by the commission shall

(1) report monthly to the authority within the time and in the form the authority requires; and

(2) use operational equipment designed to meter individual utility customer power consumption and to determine and record the utility's overall fuel consumption.

(j) The authority shall review the report required under (i)(1) of this section and may submit the report to the commission for additional review before payment. After review and approval of the report by the authority, the authority shall, subject to appropriation, pay to each eligible electric utility an amount equal to the power cost equalization per kilowatt-hour determined by the commission under (b) and (d) of this section, multiplied by the number of kilowatt-hours eligible for power cost equalization that were sold during the preceding month to all customers of the utility in accordance with (c) of this section. Payment shall be made by the authority within 30 days after receipt from the utility of the report required under (i) of this section. However, if there is a dispute between the authority and the utility relating to the payment, the authority shall submit the report to the commission for review within 30 days after its receipt by the authority. When a report is submitted to the commission for review under this section, payment shall be made by the authority within 30 days after submission, based on a commission determination. If appropriations are insufficient for payment in full, the amount paid to each electric utility is reduced on a pro rata basis.

(k) If an electric utility receives power cost equalization under this section, the utility shall either

(1) give the following notice to its electric service customers eligible under this program for each period for which the payment is received:

NOTICE TO CUSTOMER

For the current billing period the utility will be paid under the State of Alaska's power cost equalization program (AS 44.83.162) to assist the utility and its customers in reducing the high cost of generation of electric energy.

Your total electrical service cost	$. . . . . . .
Less state equalization	$. . . . . . .
Your charge	$. . . . . . .; or

(2) give to its electric service customers a notice approved by the authority, which notice provides electric service customers the same information provided by the notice in (1) of this subsection.

(*l*) In order to qualify for power cost equalization, each electric utility must make every reasonable effort to minimize administrative, operating, and overhead costs, including using the best available technology consistent with sound utility management practices. In reviewing applications for power cost equalization, the commission has the authority to require the elimination of duplicative or otherwise unnecessary operating expenses. Each eligible electric utility shall cooperate with appropriate state agencies to implement cost-effective energy conservation measures, and to plan for and implement feasible alternatives to diesel generation.

(m) For purposes of (c) of this section, the number of residents of the community equals the number of residents of the community determined by the Department of Community and Regional Affairs in accordance with AS 29.88.015.

(n) If the authority receives a petition requesting power cost equalization, signed by at least 25 percent of the customers of an electric utility that is subject to rate regulation under AS 42.05 and that has not applied for power cost equalization under this section, the authority shall require the utility to submit a power cost equalization application. Upon a determination of eligibility for power cost equalization, the utility, as a part of its service, shall receive power cost equalization and pass power cost equalization benefits to its customers in accordance with this section.

(o) In this section

(1) "commission" means the Alaska Public Utilities Commission;

(2) "community facility" means a water and sewer facility, public outdoor lighting, charitable educational facility, or community building whose operations are not paid for by the state, the federal government, or private commercial interests;

(3) "eligible electric utility" or "electric utility" means each corporation (whether public, cooperative, or otherwise), company, individual, or association of individuals, their lessees, trustees, or receivers appointed by a court, that

(A) owns, operates, manages, or controls a plant or system for the furnishing, by generation, transmission or distribution, of electric service to the public for compensation;

(B) during calendar year 1983 had a residential consumption level of power eligible for power cost equalization under this chapter of less than 7,500 megawatt hours or had a residential consumption level of power eligible for power cost equalization under this chapter of less than 15,000 megawatt hours if the utility served two or more municipalities or unincorporated communities; and

(C) during calendar year 1984 used diesel-fired generators to produce more than 75 percent of the electrical consumption of the utility; an electric utility that is a subsidiary of another electric utility is an "eligible electric utility" if the operations of the subsidiary, considered separately, meet the eligibility requirements of this section; if an electric utility did not receive power cost assistance in 1983 but is otherwise eligible for power cost equalization under this section, the utility is an "eligible electric utility";

(4) "energy conservation measures" include weatherization and other insulating methods, utilization of waste heat, appropriate sizing of new generating equipment, and other programs of the state or federal government intended and available for the purpose of energy conservation;

(5) "feasible energy projects" include projects that are selected after a field reconnaissance study under AS 44.83.177 and after completion of a feasibility study according to the criteria in AS 44.83.181 to determine cost benefit in comparison to existing power generating methods and other alternatives considered in reconnaissance studies;

(6) "fund" means the power cost equalization fund established under (a) of this section;

(7) "power costs" means costs used in determining power cost equalization in accordance with (b) and (d) of this section. (§ 42 ch 83 SLA 1980; am § 8 ch 118 SLA 1981; am § 3 ch 79 SLA 1983; am § 1 ch 133 SLA 1984)

Revisor's notes. — Formerly AS 44.56.162. Renumbered in 1980.

Cross references. — For transitional provisions relating to the 1981 amendments, see § 16, ch. 118, SLA 1981.

Effect of amendments. — The 1981 amendment rewrote this section.

The 1983 amendment, in subsection (*l*), deleted "including but not limited to the Alaska Public Utilities Commission, the Alaska Power Authority, the Alaska Energy Center, and the division of energy and power development in the Department of Commerce and Economic Development" following "appropriate state agencies" in the last sentence.

The 1984 amendment rewrote this section.

Sec. 44.83.163. Adjustments to power cost equalization. (a) The power cost equalization per kilowatt-hour determined under AS 44.83.162 payable to an electric utility that is subject to rate regulation under AS 42.05 may be adjusted by the commission if

(1) an increase or decrease in the electric utility's cost of fuel has resulted in the approval of a fuel cost rate adjustment by the commission;

(2) a permanent or interim rate increase or decrease has been approved by the commission, thereby establishing a higher or lower power cost;

(3) an adjustment is required after the authority has discovered discrepancies in its review of monthly data submitted by the electric utility; or

(4) the authority determines that appropriations are insufficient to finance full payments to eligible electric utilities.

(b) An electric utility that is eligible to receive power cost equalization under this section and that receives power cost equalization per kilowatt-hour approved by the commission shall report monthly to the authority within the time and in the form the authority requires. An electric utility shall report

(1) the power cost equalization per kilowatt-hour approved by the commission;

(2) the total kilowatt-hours sold to each class of customer during the preceding month;

(3) the total kilowatt-hours eligible for power cost equalization under this section sold to each class of customer during the preceding month;

(4) the total kilowatt-hours generated during the preceding month, if available;

(5) any commission-approved amendments to the schedule of rates in effect during the preceding month; and

(6) an increase or decrease in the current unit price of fuel from the base price used by the commission in the determination of power costs which may be expected to result in a subsequent power cost equalization adjustment.

(c) The provisions of AS 44.83.162 relating to the determination of the amount of power cost equalization and payment of the equalization assistance apply to equalization assistance under this section. (§ 9 ch 118 SLA 1981; am § 2 ch 133 SLA 1984)

Effect of amendments. — The 1984 amendment substituted "power cost equalization" for "power cost assistance" in the introductory language of subsection (a), in two places in the first sentence of subsection (b), in paragraphs (1), (3) and (6) of subsection (b), and in subsection (c); and inserted "equalization" preceding "assistance" in two places in subsection (c).

Sec. 44.83.164. Equalization assistance to utilities not regulated by Public Utilities Commission. (a) An electric utility that is not subject to rate regulation by the commission may receive power cost equalization if the utility is otherwise eligible for equalization assistance under AS 44.83.162 and if the utility

(1) files with the commission financial data necessary to determine the power cost equalization per kilowatt-hour as prescribed by the commission and that is in compliance with AS 44.83.162;

(2) reports monthly to the authority, within the time and in the form the authority requires, the information required in (b) of this section;

(3) sets rates

(A) that consider the power cost equalization provided under AS 44.83.162 by subtracting from its revenue requirements for electric services the power cost equalization per kilowatt-hour that it is eligible to receive; and

(B) under which the power cost equalization provided in AS 44.83.162 is applied as a credit only against the cost of kilowatt-hours eligible for equalization assistance under AS 44.83.162 that are consumed by each customer in any month;

(4) allows audits that the commission determines are necessary to ensure compliance with this section; and

(5) furnishes its electric service customers eligible under this program a notice as specified in AS 44.83.162(k).

(b) An electric utility that is eligible to receive power cost equalization under this section shall report in accordance with (a)(2) of this section

(1) the power cost equalization per kilowatt-hour approved by the commission;

(2) the total kilowatt-hours sold to each class of customer during the preceding month;

(3) the total kilowatt-hours eligible for power cost equalization under this section sold to each class of customer during the preceding month;

(4) the total kilowatt-hours generated during the preceding month, if available;

(5) any amendments to the schedule of rates in effect during the preceding month; and

(6) an increase or decrease in the current unit price of fuel from the base price used by the commission in the determination of power costs that may be expected to result in a subsequent equalization assistance level adjustment.

(c) An electric utility that is eligible to receive power cost equalization under this section may have its power cost equalization per kilowatt-hour determination changed by the commission if

(1) an increase or decrease in the electric utility's cost of fuel has been verified by the commission;

(2) an increase in rates has occurred based on an increase in costs and has been verified by the commission;

(3) an adjustment is required after the authority has discovered discrepancies in its review of monthly data submitted by the electric utility; or

(4) the authority determines that appropriations are insufficient to finance full payments to eligible electric utilities.

(d) The provisions of AS 44.83.162 relating to the determination of the amount of power cost equalization and payment of the equalization assistance apply to equalization assistance under this section.

(e) An application for power cost equalization by an electric utility that is eligible to receive power cost under this section does not extend the jurisdiction of the commission beyond that established by AS 42.05. (§ 42 ch 83 SLA 1980; am § 10 ch 118 SLA 1981; am § 3 ch 133 SLA 1984)

Revisor's notes. — Formerly AS 44.56.164. Renumbered in 1980.

Effect of amendments. — This 1981 amendment rewrote this section.

The 1984 amendment substituted "power cost equalization" for "power cost assistance" in the introductory language of subsection (a), in paragraph (a)(1), throughout paragraph (a)(3), in the introductory language of subsection (b), in paragraphs (b)(1) and (b)(3), in two places in the introductory language of subsection (c), and in subsections (d) and (e); inserted "equalization" preceding "assistance" in the introductory language of subsection (a), in paragraph (a)(3)(B), and in two places in subsection (d); and made a minor word change in paragraphs (a)(1), (a)(4) and paragraph (b)(6).

Sec. 44.83.165. Continuing appropriation for power cost equalization. The sum of $16,300,000 is appropriated on July 1, 1984, and the sum of $21,700,000 is appropriated on July 1 of each subsequent fiscal year from the general fund to the power cost equalization fund (AS 44.83.162). (§ 314 ch 171 SLA 1984)

Editor's notes. — Section 316, ch. 171, SLA 1984, provides that the appropriations made in §§ 313-315 and 319 of ch. 171, SLA 1984, which enacted this section, are not one-year appropriations and do not lapse under AS 37.25.010.

Article 5. Power Project Fund.

Sec. 44.83.170. Power project fund. (a) There is established as a separate fund the power project fund which shall be distinct from any other money or funds of the authority, and which includes only money appropriated by the legislature.

(b) The authority may make loans from the power project fund

(1) to electric utilities, regional electric authorities, municipalities, cities, boroughs, regional and village corporations, village councils, and nonprofit marketing cooperatives to pay the costs of

(A) reconnaissance studies, feasibility studies, license and permit applications, preconstruction engineering, and design of power projects;

(B) constructing, equipping, modifying, improving, and expanding small-scale power production facilities, conservation facilities, bulk fuel storage facilities, and transmission and distribution facilities, including energy production, transmission and distribution, and waste energy conservation facilities which depend on fossil fuel, wind power, tidal, geothermal, biomass, hydroelectric, solar or other non-nuclear energy sources; and

(C) reconnaissance studies, preconstruction engineering, design, construction, equipping, modification, and expansion of potable water supply including surface storage and groundwater sources and transmission of water from surface storage to existing distribution systems;

(2) to a borrower for a power project if

(A) the loan is entered into under a leveraged lease financing arrangement;

(B) the party which will be responsible for the power project is an electric utility, regional electric authority, municipality, city, borough, regional or village corporation, village council, or nonprofit marketing cooperative; and

(C) the borrower seeking the loan demonstrates to the authority that the financing arrangement for the power project will reduce project financing costs below costs of comparable public power projects.

(c) Before making a loan from the power project fund, the authority shall, by regulation, specify

(1) standards for the eligibility of borrowers and the types of projects to be financed with loans;

(2) standards regarding the technical and economic viability and revenue self-sufficiency of eligible projects;

(3) collateral or other security required for loans;

(4) the terms and conditions of loans;

(5) criteria to establish financial feasibility and to measure the amount of state assistance necessary for particular projects to meet the financial feasibility criteria; and

(6) other relevant criteria, standards or procedures.

(d) Any loan made by the authority must be made according to the standards, criteria, and procedures established by regulation under this section.

(e) Repayment of the loans shall be secured in any manner which the authority determines is feasible to assure prompt repayment under a loan agreement entered into with the borrower. The authority may make an unsecured loan from the power project fund to a borrower regulated by the Alaska Public Utilities Commission under AS 42.05 if the borrower has a substantial history of repaying long-term loans and the capacity to repay the loan. Under a loan agreement, repayment may be deferred for 10 years or until the project for which the loan is made has achieved earnings from its operations sufficient to pay the loan, whichever is earlier.

(f) Power projects are subject to the following limitations on interest and specific restrictions:

(1) Power projects for which loans are outstanding from the former water resources revolving loan fund (former AS 45.86) on July 13, 1978, may receive additional financing from the power project fund; the additional financing, if granted,

(A) shall be granted for a term not exceeding 50 years;

(B) shall be granted at an interest rate of not less than three or more than five percent a year on the unpaid balance;

(C) shall be conditioned on the repayment of loan principal and interest to begin on the earlier of

(i) the date of the start of commercial operation of the project; or

(ii) 10 years from the date the loan is granted.

(2) Loans for power projects

(A) shall be granted for a term not to exceed 50 years; and

(B) shall be granted at an interest rate which is not less than five percent and which is the lesser of

(i) a rate equal to the percentage which is the average weekly yield of municipal bonds for the 12 months preceding the date of the loan, as determined by the authority from municipal bond yield rates reported in the 30-year revenue index of the Weekly Bond Buyer; or

(ii) a rate determined by the authority which allows the project to meet criteria of financial feasibility established under AS 44.83.170(c).

(g) Loan repayments and interest earned by loans from the power project fund shall be deposited in the state general fund.

(h) The legislature may forgive the repayment of a loan made from the power project fund for a reconnaissance study or a feasibility study when the authority finds that the power project for which the loan was made is not feasible. (§ 1 ch 278 SLA 1976; am § 16 ch 156 SLA 1978; am §§ 19 — 23 ch 83 SLA 1980)

Revisor's notes. — Formerly AS 44.56.170. Renumbered in 1980.

In 1984, "former" was inserted before "water resources revolving loan fund" and the reference to AS 45.86. That section was repealed by sec. 44, ch. 83, SLA 1980.

Effect of amendments. — The 1980 amendment rewrote subsections (a) through (c), (e), and (f), and added subsections (g) and (h).

Article 6. General Provisions.

Sec. 44.83.177. Reconnaissance study. (a) To identify power project alternatives and energy consumption patterns and needs for a community or region, the authority shall, after consultation with other state agencies and after review of information on alternative sources of energy, complete a reconnaissance study for each proposed new power project or combination of projects.

(b) A reconnaissance study shall

(1) identify the present and anticipated electrical and thermal energy requirements of a community or region;

(2) survey all electrical and thermal energy sources and combinations of sources available to the community or region and evaluate the relative economic merits of alternative sources of power and heat, including energy conservation;

(3) assess the effect of development of alternative sources of power and heat on the environment; and

(4) include public comment from residents of the community and adjacent area.

(c) The authority, in consultation with the office of management and budget, shall adopt regulations defining

(1) the methods which it shall apply to determine that the information required by (b) of this section is obtained; and

(2) standard criteria and measures for comparative analysis of alternative energy sources.

(d) In completing a reconnaissance study, the authority shall consult with the Department of Community and Regional Affairs to determine the information that each may require for energy planning and the development of technology. (§ 24 ch 83 SLA 1980; am § 11 ch 118 SLA 1981; am §§ 3 — 5 ch 133 SLA 1982; am § 4 ch 79 SLA 1983; am § 28 ch 63 SLA 1983)

Revisor's notes. — Formerly AS 44.56.177. Renumbered in 1980.

Cross references. — For transitional provisions related to current and pending projects as of 1980, see § 47, ch. 83, SLA 1980.

Effect of amendments. — The 1981 amendment added subsection (d).

The 1982 amendment, in subsection (a), inserted "and energy consumption patterns and needs" and "or region," substituted "sources of energy" for "sources of power," and added "or combination of projects" to the end. The amendment also rewrote subsection (b), which defines the scope of a reconnaissance study, and substituted "alternative energy sources" for "alternative power sources" in paragraph (2) of subsection (c).

The first 1983 amendment, substituted "office of management and budget" for "division of budget and management" in subsection (c).

The second 1983 amendment, substituted "Department of Community and Regional Affairs" for "division of energy and power development in the Department of Commerce and Economic Development" in subsection (d).

Sec. 44.83.179. Review of reconnaissance study by office of management and budget. (a) The office of management and budget in the Office of the Governor shall review reconnaissance studies for proposed projects of the authority.

(b) The review shall examine each reconnaissance study for compliance with the requirements of AS 44.83.177(b) and (c). The office of management and budget may approve or disapprove a reconnaissance study. If the office of management and budget disapproves of a reconnaissance study, it shall return the reconnaissance study to the authority together with a comprehensive statement of the reasons for its disapproval. The authority may amend the portions of the reconnaissance study which the office of management and budget identifies as deficient and resubmit the reconnaissance study to the office of management and budget for reconsideration.

(c) For purposes of this section, a power project is approved if the reconnaissance study for the project has not been disapproved by the office of management and budget within 30 days of submission of the reconnaissance study for the project to it by the authority. (§ 24 ch 83 SLA 1980; am § 28 ch 63 SLA 1983)

Revisor's notes. — Formerly AS 44.56.179. Renumbered in 1980.

Cross references. — For transitional provisions related to current and pending projects as of 1980, see § 47, ch. 83, SLA 1980.

Effect of amendments. — The 1983 amendment, substituted "office of management and budget" for "division of budget and management" throughout this section.

Sec. 44.83.180. Assessment, proposal, and construction of projects. [Repealed, § 44 ch 83 SLA 1980.]

Sec. 44.83.181. Feasibility study and finance plan. (a) Unless the reconnaissance study has been disapproved by the office of management and budget under AS 44.83.179, the authority shall complete a feasibility study and plan of finance for each proposed project.

(b) A feasibility study shall include

(1) information about the proposed project, including but not limited to estimates of total project construction costs, total project operating costs, the costs of transmission systems and reserve power requirements, the timing and amount of anticipated returns from the completed project, a benefit-to-cost ratio, the potential effect of the project on the environment of the area that will be served by the project when completed, and the availability of alternative government financing;

(2) a statement of all assumptions which affect the economic feasibility of the project, including but not limited to the discount rate and interest rate of amounts of money to be used for the project, anticipated fuel prices, an escalation rate, state and local electric load growth, and estimates of indirect costs and benefits;

(3) a comparative analysis of all reasonable alternatives to construction of the proposed project; and

(4) information based on engineering and design work that meets the requirements for submission of a license application for the project to the Federal Energy Regulatory Commission.

(c) The plan of finance shall include recommendations of the most appropriate means to finance a project, including, but not limited to,

(1) the issuance of revenue bonds of the authority;

(2) the issuance of

(A) general obligation bonds of the state; or

(B) revenue bonds of the authority that are guaranteed or partially guaranteed by the state;

(3) an appropriation from the general fund

(A) to pay debt service on bonds or for other project purposes; or

(B) to reduce the amount of debt financing for the project;

(4) a loan from the general fund;

(5) financing arrangements with other entities using leveraged leases or other financing methods;

(6) assistance from any federal agency, including, but not limited to, the Rural Electrification Administration;

(7) a loan from the power project fund (AS 44.83.170(a)); or

(8) any combination of financing arrangements listed in this subsection.

(d) When financial assistance from the state is necessary for a project to meet financial feasibility criteria, the plan of finance shall include an estimate of the minimum amount of financial assistance required from the state. The plan of finance shall include an estimate of the present value of the financial assistance from the state, computed as the difference between

(1) a market rate of interest, which is

(A) the rate determined under AS 44.83.170(f)(2)(B)(i); or

(B) the estimated interest rate for revenue bonds to be issued by the authority for the project; and

(2) the effective rate of interest because of state financial assistance provided.

(e) The authority, in consultation with the office of management and budget, shall adopt regulations defining

(1) the techniques which it shall apply to determine that the information required by (b) — (d) of this section is obtained; and

(2) standard criteria and measures for comparative analysis of alternative financing arrangements. (§ 24 ch 83 SLA 1980; am § 6 ch 133 SLA 1982; am § 28 ch 63 SLA 1983; am § 14 ch 161 SLA 1984)

Revisor's notes. — Formerly AS 44.56.181. Renumbered in 1980.

Cross references. — For transitional provisions related to current and pending projects as of 1980, see § 47, ch. 83, SLA 1980.

Effect of amendments. — The 1982 amendment inserted "the costs of transmission systems and reserve power requirements" in paragraph (1) of subsection (b).

The 1983 amendment, substituted "office of management and budget" for "division of budget and management" in subsections (a) and (e).

The 1984 amendment substituted "that" for "which" in paragraph (c)(2)(B) and deleted "or from the renewable resources investment fund (AS 37.11.050)" following the reference to the power project fund in paragraph (c)(7).

Sec. 44.83.183. Review of feasibility studies and plans of finance by office of management and budget. (a) The office of management and budget in the Office of the Governor shall review the feasibility study and plan of finance for a project of the authority for compliance with the provisions of AS 44.83.181(b) — (d).

(b) In its review under this section, the office of management and budget may obtain an independent evaluation of a feasibility study and plan of finance to determine compliance with the provisions of AS 44.83.181(b) — (d).

(c) When the office of management and budget has completed a review of the feasibility study and the plan of finance for a project under this section, it shall submit a report to the governor. The report shall examine the feasibility study and plan of finance for compliance with the requirements of AS 44.83.181(b) — (d). The report of the office of management and budget shall include a recommendation to the governor and legislature for approval or disapproval of the project based on the office's review of the feasibility study and plan of finance for compliance with the requirements of AS 44.83.181(b) — (d).

(d) The report required by (c) of this section shall be prepared and submitted not later than 60 days after the feasibility study and plan of finance for a proposed project have been received by the office of management and budget.

(e) The report required by (c) of this section shall include a financial analysis of the proposed project of the authority that evaluates proposed bond resolutions or other financial arrangements or financial plans, security plans and arrangements, cost and demand uncertainties, and debt volume, as they relate to the total direct and indirect indebtedness of the state. In preparing the financial analysis required by this section the office of management and budget may use the services of outside agencies or institutions that are not otherwise involved in the project. (§ 24 ch 83 SLA 1980; am § 7 ch 133 SLA 1982; am § 28 ch 63 SLA 1983)

Revisor's notes. — Formerly AS 44.56.183. Renumbered in 1980.

Cross references. — For transitional provisions related to current and pending projects as of 1980, see § 47, ch. 83, SLA 1980.

Effect of amendments. — The 1982 amendment added subsection (e).

The 1983 amendment, substituted "office of management and budget" for "division of budget and management" throughout this section.

Sec. 44.83.185. Submission to the legislature. (a) The authority shall submit a feasibility study and plan of finance, including a cost estimate from an independent source, for a proposed new project to the legislature. When the report of the office of management and budget examining the feasibility study and plan of finance is completed as required by AS 44.83.183, it shall be submitted to the legislature.

(b) The authority may not proceed with work on the engineering or design phase of a proposed new project for which legislative approval is required until the legislature approves the proposed new project. However, the authority may proceed with the engineering or design work necessary to meet the requirements for submission of a license application for the proposed new project to the Federal Energy Regulatory Commission without obtaining legislative approval of the proposed new project.

(c) The legislature shall consider and must approve all proposed new projects except proposed new projects that are exempt under AS 44.83.187. The legislature may approve a proposed new project only by enacting law that authorizes the project and approves a construction cost for that project. (§ 24 ch 83 SLA 1980; am § 8 ch 133 SLA 1982; am § 28 ch 63 SLA 1983; am § 7 ch 89 SLA 1983)

Revisor's notes. — Formerly AS 44.56.185. Renumbered in 1980.

Effect of amendments. — The 1982 amendment substituted "that authorizes the project and approves a construction cost for" for "authorizing" in the second sentence of subsection (c).

The first 1983 amendment, substituted "office of management and budget" for "division of budget and management" in subsection (a).

The second 1983 amendment, inserted "including a cost estimate from an independent source" in the first sentence of subsection (a).

Sec. 44.83.186. Final cost estimate and reauthorization by the legislature. [Repealed, § 27 ch 89 SLA 1983.]

Sec. 44.83.187. Applicability of sections. (a) The provisions of AS 44.83.177 — 44.83.185 and 44.83.189 apply only to a proposed new project that will generate more than 1.5 megawatts of power and

(1) requires an appropriation more from the state general fund, from the power project fund, or from the renewable resources funds; or

(2) is based on a plan of finance which requires the issuance of general obligation bonds or other pledge of the credit of the state.

(b) The provisions of AS 44.83.177 — 44.83.185 and 44.83.189 apply to a project that generates more than 25 megawatts of power for which the authority will issue its revenue bonds for costs of construction.

(c) The provisions of AS 44.83.177 — 44.83.183 do not apply when a reconnaissance study and a feasibility study for a proposed new project have been prepared by an agency of the federal government, if the authority determines that the reconnaissance study and the feasibility study prepared by the agency of the federal government provide information sufficient to permit the authority to finance and construct the proposed new project in accordance with the requirements of this chapter. When a reconnaissance study and feasibility study are prepared for a proposed new project by an agency of the federal government and the authority proposes to finance and construct the proposed new project, the authority shall provide copies of the studies and a proposed plan of finance to the office of management and budget in the Office of the Governor. The office of management and budget shall review the studies and plan of finance. Within 60 days after its receipt of the studies and plan of finance, the office of management and budget shall submit a report to the governor and legislature. The report shall examine the feasibility study and plan of finance and comment upon compliance of the feasibility study and plan of finance with the requirements of AS 44.83.181. Approval of the legislature under AS 44.83.185 is required for a proposed new project that is exempt from the requirements of AS 44.83.177 — 44.83.183 under this subsection. The authority may not proceed with engineering or design work for a project until legislative approval of the project has been given under AS 44.83.185(c), except that the authority may undertake engineering or design work necessary to submit a license application for the project to the Federal Energy Regulatory Commission without first obtaining legislative approval of the project.

(d) The provisions of AS 44.83.177 — 44.83.185 do not apply to

(1) an addition, modification, repair, reconstruction, design, acquisition or construction for the purpose of completing a project;

(2) the construction of an electrical transmission or distribution facility that is estimated to cost less than $3,000,000. (§ 24 ch 83 SLA 1980; am § 1 ch 169 SLA 1980; am § 28 ch 63 SLA 1983)

Revisor's notes. — Formerly AS 44.56.187. Renumbered in 1980.

Effect of amendments. — The 1980 amendment added "will generate more than 1.5 metawatts of power and" at the end of the introductory paragraph of subsection (a), and substituted "funds" for "investment fund and the appropriation exceeds (A) $3,000,000, for projects for which legislative approval is sought during 1981; (B) $3,000,000 multiplied by a factor equal to a ratio determined by dividing the construction cost index of the engineering news record determined for

January of the year during which a project is submitted for legislative approval, by the construction cost index of the engineering news record for March, 1980, for projects for which legislative approval is sought after December 31, 1981" at the end of paragraph (1) of subsection (a).

The 1983 amendment, substituted "office of management and budget" for "division of budget and management" in subsection (c).

Editor's notes. — Section 3, ch. 169, SLA 1980 provides: "The projects authorized in sec. 48 of House CS for CS for Senate Bill No. 438 (Finance) am H, Eleventh Legislature, Second Session, are exempt from the amendments made in sec. 1 of this Act."

Sec. 44.83.189. Project construction. If a new project is to be designed, acquired and constructed by the authority, it shall be designed, acquired and constructed as a public work of the state. For the purpose of this section and AS 44.83.187 a new project does not include

(1) an addition or modification to an existing project unless the total cost of the addition or modification exceeds $1,000,000;

(2) repair or reconstruction of a project; or

(3) design, acquisition or construction necessary to complete a project for which bonds have been issued. (§ 24 ch 83 SLA 1980)

Revisor's notes. — Formerly AS 44.56.189. Renumbered in 1980.

Sec. 44.83.190. Annual audit. The authority shall have its financial records audited annually by a certified public accountant. The legislative auditor may prescribe the form and content of the financial records of the authority and shall have access to these records at any time. (§ 1 ch 278 SLA 1976)

Revisor's notes. — Formerly AS 44.56.190. Renumbered in 1980.

Sec. 44.83.191. Limitations on issuance of bonds by the authority. The authority may not issue bonds except after 60 days notification of its intent to issue bonds is given to the governor and to the legislature, if the legislature is in session, or to the Legislative Budget and Audit Committee, if the legislature is not in session. (§ 24 ch 83 SLA 1980)

Revisor's notes. — Formerly AS 44.56.191. Renumbered in 1980.

Sec. 44.83.192. Insurance requirements in construction contracts. In requesting bids and awarding construction contracts under this chapter the authority may not require a contractor to obtain workers' compensation, general liability, or other required insurance from a particular insurer, agent, or broker and may not agree to provide insurance to a contractor who is awarded a construction contract. (§ 8 ch 89 SLA 1983)

Sec. 44.83.195. Operation of projects. (a) When a project is operated by the authority, the authority shall enter into one or more contracts for the sale of electrical power, energy, transmission capacity, or service from the project. Unless the contract is entered into under AS 44.83.380 — 44.83.425, a contract entered into under this section shall meet all requirements of AS 44.83.090.

(b) *[Repealed, § 27 ch 89 SLA 1983.]* (§ 24 ch 83 SLA 1980; am §§ 9, 27 ch 89 SLA 1983)

Revisor's notes. — Formerly AS 44.56.195. Renumbered in 1980.

Effect of amendments. — The 1983 amendment, in subsection (a), inserted "energy, transmission capacity, or service" in the first sentence and added "Unless the contract is entered into under AS 44.83.380 — 44.83.425" to the beginning of the second sentence. The amendment also repealed subsection (b).

Sec. 44.83.200. Annual report. Before March 1 of each year, the authority shall submit to the governor and the legislature a comprehensive report describing operations, income and expenditures for the preceding 12-month period. (§ 1 ch 278 SLA 1976)

Revisor's notes. — Formerly AS 44.56.200. Renumbered in 1980.

Sec. 44.83.210. Appropriations and reports. (a) Notwithstanding any other provision in this chapter, the authority is subject to the provisions of the Executive Budget Act (AS 37.07).

(b) The authority shall, by the 15th day of each regular legislative session, present to the legislature a report detailing project status, original costs and projected costs, particularly highlighting any costs in excess of the original cost estimates submitted for each project when that project was originally approved by the legislature. (§ 1 ch 278 SLA 1976; am § 19 ch 156 SLA 1978)

Revisor's notes. — Formerly AS 44.56.210. Renumbered in 1980.

Sec. 44.83.220. Public records; open meetings. The provisions of AS 09.25.110 — 09.25.120 and AS 44.62.310 — 44.62.312 apply to the authority. The authority shall publish a proposed agenda of its meetings and afford the public an opportunity to be heard in accordance with AS 44.62.312. (§ 1 ch 278 SLA 1976)

Revisor's notes. — Formerly AS 44.56.220. Renumbered in 1980.

Sec. 44.83.224. Long-term energy plan. The Department of Commerce and Economic Development, assisted by the authority, shall, after public hearings, prepare and annually revise a long-term energy plan. The plan, and its annual revisions, shall be submitted to the commissioners of the departments of the executive branch of the government for review and to the governor for the governor's approval. After approval, the plan shall be submitted to the legislature not later than Feburary 1 of each year. The plan, and its annual revisions, shall include

(1) an "end-use" study examining and reporting on the nature and amount of energy used and the purpose of its use; and

(2) an energy development component for meeting projected thermal, electrical and transportation energy needs in the state at the lowest reasonable cost, including environmental and social costs, consistent with acceptable standards of reliability, giving an equal consideration as practicable to all types of energy sources (except those based on nuclear fuels) which are technologically feasible, and which promote the efficient use of facilities and fuels consistent with energy conservation goals, and the considerations specified in AS 44.83.180(e);

(3) an energy conservation component, including but not limited to,

(A) conservation goals for reducing consumption of energy, identifying the region for which applicable, and the source or type of energy to which the goals are applicable; and

(B) specific methods and means of achieving the goals of (A) of this paragraph;

(4) a component for emergency energy conservation measures applicable during times of emergency; and

(5) a report on areas or subjects of research and development and demonstration projects involving alternative energy systems, local energy sources, and energy conservation. (§ 20 ch 156 SLA 1978; am § 25 ch 83 SLA 1980)

Revisor's notes. — Formerly AS 44.56.224. Renumbered in 1980.

In 1984, "former" was inserted before the reference to AS 44.83.180 in paragraph (2). That section was repealed by § 44, ch. 83, SLA 1980.

Effect of amendments. — The 1980 amendment rewrote the section.

Sec. 44.83.230. Definitions. In this chapter, unless the context requires otherwise,

(1) "authority" means the Alaska Power Authority established by this chapter;

(2) "bonds" means bonds, notes, or other obligations of the authority issued under this chapter;

(3) "power" includes any and all electrical energy generated, distributed, bought or sold for purposes of lighting, heating, power and every other useful purpose;

(4) "power project" or "project" means a plant, works, system, or facility, together with related or necessary facilities and appurtenances, including a divided or undivided interest in or a right to the capacity of a power project or project, that is used or is useful for the purpose of

(A) electrical or thermal energy production other than nuclear energy production;

(B) waste energy utilization and energy conservation; or

(C) transmission, purchase, sale, exchange, and interchange of electrical or thermal energy, including district heating or interties;

(5) "public agency" means any city or other municipal corporation, political subdivision, governmental unit, or public corporation created by or under the laws of this state or of another state of the United States, and any state or the United States, and any person, board or other body declared by the laws of any state or the United States to be a department, agency, or instrumentality of them;

(6) "person" includes a public agency in addition to the entities set out in AS 01.10.060(7);

(7) "reconnaissance study" means a study conducted for the purpose of assessing the present and future electrical and thermal energy needs of an area under AS 44.83.177;

(8) "feasibility study"

(A) means a study conducted for the purpose of establishing the economic and environmental practicality of completing a proposed power project under AS 44.83.181;

(B) includes engineering and design work to meet the requirements for submission of a license application for a proposed new project to the Federal Energy Regulatory Commission;

(9) "small-scale power production facility" means a facility which, by design, is to produce less than 25 megawatts of power. (§ 1 ch 278 SLA 1976; am §§ 21, 22 ch 156 SLA 1978; am §§ 26, 27 ch 83 SLA 1980; am §§ 10, 11 ch 133 SLA 1982)

Revisor's notes. — Formerly AS 44.56.230. Renumbered in 1980.

Effect of amendments. — The 1980 amendment rewrote paragraph (7), and added paragraphs (8) and (9).

The 1982 amendment rewrote the definition for "power project" or "project" in paragraph (4) and substituted "electrical and thermal energy needs" for "power needs" in paragraph (7).

Sec. 44.83.240. Short title. This chapter may be cited as the Alaska Power Authority Act. (§ 1 ch 278 SLA 1976)

Revisor's notes. — Formerly AS 44.56.240. Renumbered in 1980.

Article 7. Susitna River Hydroelectric Project.

Sec. 44.83.300. Description of project. The Susitna River hydroelectric project consists of dams and related reservoirs, and power plants located in the Upper Susitna River Basin, and related transmission lines, facilities, and load centers, as described in the Alaska Power Authority's report required by AS 44.83.320(b). (§ 2 ch 169 SLA 1980)

Revisor's notes. — Enacted as AS 44.56.300. Renumbered in 1980.

Sec. 44.83.310. Purpose of project. The primary purpose of the Susitna River hydroelectric project is to generate, transmit and distribute electric power in a manner which will

(1) minimize market area electrical power costs;

(2) minimize adverse environmental and social impacts while enhancing environmental values to the extent possible; and

(3) safeguard both life and property. (§ 2 ch 169 SLA 1980)

Revisor's notes. — Enacted as AS 44.56.310. Renumbered in 1980.

Sec. 44.83.320. Preliminary reports. (a) By March 30, 1981, the authority shall prepare and submit to the governor and to the legislature a preliminary report recommending whether work should continue on the Susitna River hydroelectric project, and, if the recommendation is to continue on the project, the report shall explain in detail

(1) economic evaluations and preliminary environmental impact assessments for the Susitna River hydroelectric project and all viable alternatives;

(2) the federal and state permits required to be obtained before construction can begin and the expected construction start date; and

(3) any other information the authority considers appropriate or necessary to adequately inform the governor and the legislature of the status of the Susitna River hydroelectric project.

(b) By April 30, 1982, the authority shall prepare and submit to the governor and to the legislature a preliminary report recommending whether work should continue on the Susitna River hydroelectric project, and other valuable alternatives. If the recommendation is to continue on the Susitna River hydroelectric project, the report shall explain in detail

(1) the proposed conceptual design and phases of construction of the Susitna River hydroelectric project;

(2) the expected completion date of each phase of construction;

(3) the expected cost of each phase of construction;

(4) the costs to the state and consumers of the project under alternative methods of project financing, including revenue bonds, general obligation bonds, and general fund appropriations; and

(5) any other information the authority considers appropriate or necessary to adequately inform the governor and the legislature of the status of the Susitna River hydroelectric project.

(c) The preliminary reports required under (a) and (b) of this section are in addition to any reports required under former AS 44.83.180 — 44.83.224. (§ 2 ch 169 SLA 1980)

Revisor's notes. — Enacted as AS 44.56.320(a)-(c). Renumbered in 1980.

In 1984, "former" was inserted before the reference to AS 44.83.180. That section was repealed by sec. 44, ch. 83, SLA 1980.

Sec. 44.83.325. Restrictions on contracting. The authority may not enter into contracts under AS 44.83.300 — 44.83.360 other than those contracts necessary to complete (1) feasibility studies, (2) the preliminary reports required by AS 44.83.320, or (3) construction of the Anchorage-Fairbanks intertie, until the legislature approves by law the preliminary report required under AS 44.83.320(b). (§ 2 ch 169 SLA 1980)

Revisor's notes. — Enacted as AS 44.56.320(d). Renumbered in 1980.

Editor's note. — Section 21, ch. 133, SLA 1982, provides: "Notwithstanding the provisions of AS 44.83.325, the Alaska Power Authority may enter into contracts under AS 44.83.300 — 44.83.360 for preliminary work without the approval required by AS 44.83.325. In this section, 'preliminary work' means the preparation of plans and studies and the preparation and submission of license applications, as well as other types of work, that must be completed before actual construction of the Susitna River hydroelectric project, described in AS 44.83.300, may begin. This section does not authorize the Alaska Power Authority to enter into contracts for the actual construction of the Susitna River hydroelectric project or for the preparation of the site of the Susitna River hydroelectric project without the approval required by AS 44.83.325."

Sec. 44.83.330. Construction, maintenance and operation of project. Within one year after approval of its preliminary report submitted under AS 44.83.320(b), the authority may enter into a contract for the construction of the Susitna River hydroelectric project in a manner consistent with the purpose of the project as described in AS 44.83.310. (§ 2 ch 169 SLA 1980)

Revisor's notes. — Enacted as AS 44.56.330. Renumbered in 1980.

Sec. 44.83.340. Annual report. (a) If the Susitna River hydroelectric project is approved by the legislature under AS 44.83.325, beginning in 1983 the authority shall prepare an annual report which explains in detail

(1) the status of construction on the Susitna River hydroelectric project;

(2) the completion date of any phase of the Susitna River hydroelectric project which has been completed and the reasons for any

deviation between the completion date and the expected completion date stated in the preliminary report required under AS 44.83.320(b);

(3) the actual cost of any phase of the Susitna River hydroelectric project which has been completed and the reasons for any deviation between the actual cost and the expected cost stated in the preliminary report required under AS 44.83.320(b);

(4) the federal and state permits necessary to begin or continue construction of the Susitna River hydroelectric project, the actual dates on which the federal and state permits necessary to begin or continue construction were obtained, and the reasons for any deviation between the actual dates and the expected dates stated in the preliminary report required under AS 44.83.320(a) or in the earlier annual reports required under this section;

(5) any other information the authority considers appropriate or necessary to adequately inform the governor and the legislature of the status of the Susitna River hydroelectric project.

(b) The annual report required under (a) of this section is in addition to any reports required under AS 44.83.180 — 44.83.224 and shall be submitted by March 30 of each year to the governor and to each member of the legislature. (§ 2 ch 169 SLA 1980)

Revisor's notes. — Enacted as AS 44.56.340. Renumbered in 1980.

Sec. 44.83.350. Legislative and executive oversight. The legislature or the governor may provide for ongoing oversight, review and selected in-depth analysis of the Susitna River hydroelectric project plan of study. The authority shall provide all data, analyses, reports, and other information to whoever conducts the oversight, review, or analysis activities. Selected in-depth analyses shall include assessments of the power alternatives, financing, and power marketing sections of the Susitna River hydroelectric project plan of study. (§ 2 ch 169 SLA 1980)

Revisor's notes. — Enacted as AS 44.56.350. Renumbered in 1980.

Sec. 44.83.360. Project financing. The Susitna River hydroelectric project shall be financed by general fund appropriations, general obligation bonds, revenue bonds, or other plans of finance as approved by the legislature. (§ 2 ch 169 SLA 1980)

Revisor's notes. — Enacted as AS 44.56.360. Renumbered in 1980.

Article 8. Rural Electrification Revolving Loan Fund.

Sec. 44.83.361. Rural electrification revolving loan fund. (a) The rural electrification revolving loan fund is established in the Alaska Power Authority. The fund consists of

(1) appropriations made to the fund; and

(2) principal payments on loans made under this section.

(b) The authority may make loans from the rural electrification revolving loan fund to electric utilities certified by the Alaska Public Utilities Commission. A loan from the fund may be made only for the purpose of extending new electric service into an area of the state that an electric utility may serve under a certificate of public convenience and necessity issued by the Alaska Public Utilities Commission. A loan may be made from the fund to an electric utility if the utility invests the money necessary to provide one pole, one span of line, one transformer, and one service drop for each consumer for whom immediate service would be provided by the extension of electric service. However, a loan may not be made from the fund unless

(1) the loan is recommended by a loan advisory committee appointed under AS 44.83.363; and

(2) the extension of electric service would provide immediate service to at least three consumers.

(c) A loan from the rural electrification revolving loan fund shall bear an annual rate of interest of two percent of the unpaid balance of the loan. Interest received on a loan made under this section must be transferred monthly to the commissioner of revenue for deposit in the general fund.

(d) When a loan is made by the authority under this section, the electric utility receiving the loan

(1) shall, in addition to the rates that it is authorized to charge, charge the consumers served by the electric service extended with the loan proceeds an amount sufficient to pay the interest costs of the loan;

(2) shall pay to the authority annually an amount equal to

(A) interest of two percent on the unpaid balance of the loan; and

(B) payments on the unpaid balance of the principal of the loan for each new consumer served by the electric service extended with the loan proceeds; payments on the unpaid balance of the principal of the loan shall be made at a rate equal to the difference between the actual cost of making the service connection to the consumers and the minimum investment per consumer required of the utility before a loan is made under (b) of this section.

(e) The authority shall

(1) adopt regulations necessary to carry out the provisions of this section;

(2) administer the rural electrification revolving loan fund; and

(3) submit to the legislature within the first 10 days of each regular legislative session a report of actions taken by the authority under this section and an accounting of the rural electrification revolving loan fund.

(f) In this section,

(1) "consumer" means a person, as defined in AS 01.10.060(7), or a governmental agency, if the person or governmental agency requests and offers to pay for electrical service to a facility or part of a facility; the authority shall consider a person who, or a governmental agency that, offers to pay for electrical service to several facilities to be a separate consumer for each facility, if each facility is physically separate from another facility, other than through electric service lines, and if the person or governmental agency requests and offers to pay for electrical service to each facility;

(2) "facility" means a structure capable of receiving and using electrical energy; and

(3) "governmental agency" includes, with respect to the state or federal government or a municipal government, a legislative body, board of regents, administrative body, board, commission, committee, subcommittee, authority, council, agency, public corporation, school board, department, division, bureau, or other subordinate unit, whether advisory or otherwise, of the state, federal, or municipal government. (§ 1 ch 118 SLA 1981; am §§ 10 — 13 ch 89 SLA 1983)

Effect of amendments. — The 1983 amendment, deleted "and interest" following "principal" in paragraph (a)(2), added the second sentence of subsection (c), substituted "extended with the loan proceeds" for "during the preceding year for which the loan was made" in paragraph (d)(2)(B), and added subsection (f).

Sec. 44.83.363. Loan advisory committee. When an application for a rural electrification loan is submitted to the authority under AS 44.83.361, the authority shall appoint a local advisory committee from persons residing in the area that the applicant utility is certified to serve. The loan advisory committee shall consider the loan application, and shall recommend whether the loan application is to be approved or disapproved. A favorable recommendation from the loan advisory committee shall be based on a determination that development in the area of the proposed extension of electric service is likely to provide for full repayment of the loan under AS 44.83.361(d) within 10 years. In making that determination the committee shall consider

(1) permanence of the premises to be served by the extension;

(2) land use patterns in the area;

(3) access for the line that would be installed with loan proceeds;

(4) availability of other utility service in the area; and

(5) the economic feasibility of the extension of electric service with the proceeds of the loan. (§ 1 ch 118 SLA 1981)

Article 9. Energy Program for Alaska.

Sec. 44.83.380. Program established. (a) The energy program for Alaska is established. The program shall be administered by the Alaska Power Authority.

(b) The energy program for Alaska is a program by which the authority may acquire or construct power projects with money appropriated by the legislature to the power development fund established in AS 44.83.382. A power project may be acquired or constructed as part of the energy program for Alaska only if the project is submitted to and approved by the legislature in accordance with procedures set out in AS 44.83.177 — 44.83.187.

(c) The provisions of AS 36.10.010 — 36.10.125 apply to power projects constructed by the authority under AS 44.83.380 — 44.83.425. (§ 1 ch 118 SLA 1981)

Revisor's notes. — Enacted as AS 44.83.400. Renumbered in 1981.

Sec. 44.83.382. Power development fund established. (a) A power development fund is established in the Alaska Power Authority to carry out the purposes of the energy program for Alaska (AS 44.83.380 — 44.83.425).

(b) The fund includes

(1) money appropriated to it by the legislature; and

(2) *[Repealed, § 27 ch 89 SLA 1983.]* (§ 1 ch 118 SLA 1981; am § 27 ch 89 SLA 1983)

Revisor's notes. — Enacted as AS 44.83.410. Renumbered in 1981.

Effect of amendments. — The 1983 amendment, repealed paragraph (2) of subsection (b).

Sec. 44.83.384. Use of fund balance. (a) The fund may be used by the authority to provide money for

(1) reconnaissance and feasibility studies and power project finance plans prepared under AS 44.83.177 — 44.83.181;

(2) the cost of a power project, including but not limited to costs of acquiring necessary licenses, preparing engineering designs, obtaining land, and constructing the power project;

(3) the defeasance of bonds, or the payment of debt service on loans for or on an issue of bonds sold in connection with a power project;

(4) the cost of operating and maintaining power projects; and

(5) debt service on power projects.

(b) Money in the fund may be used under (a) of this section only for a power project that

(1) is economically feasible; and

(2) provides the lowest reasonable power cost to utility customers in the market area for the estimated life of the power project, whether operated by itself or in conjunction with other power projects in the market area, and that operates or will operate on one or more of the following:

(A) renewable energy resources, including but not limited to hydroelectric power, wind, biomass, geothermal, tidal or solar energy, or a method that uses temperature differentials or other physical properties of the ocean;

(B) coal or peat;

(C) energy derived from waste heat; or

(D) fossil fuel, including oil or natural gas.

(c) Notwithstanding (b)(1) of this section and AS 44.83.396 — 44.83.398, the fund may be used by the authority to provide money for the cost of a power project that is or was either constructed or owned by the United States government if the requirements of this subsection are met. The provisions of AS 44.83.177 — 44.83.187 do not apply to a power project financed under this subsection. The authority may use money in the fund for the cost of a power project under this subsection if

(1) the legislature enacts a law approving the project;

(2) the office of management and budget in the Office of the Governor reviews a feasibility study and a plan of finance for the project and determines that the feasibility study complies with the requirements for a feasibility study submitted under AS 44.83.181(b) and that the plan of finance complies with the requirements for a plan of finance submitted under AS 44.83.181(c); and

(3) the project meets the other requirements of this chapter. (§ 1 ch 118 SLA 1981; am § 12 ch 133 SLA 1982; am § 28 ch 63 SLA 1983; am §§ 14, 15 ch 89 SLA 1983)

Revisor's notes. — Enacted as AS 44.83.420. Renumbered in 1981.

Effect of amendments. — The 1982 amendment added subsection (c).

The first 1983 amendment, substituted "office of management and budget" for "division of budget and management" in paragraph (c)(2).

The second 1983 amendment, rewrote paragraph (1) of subsection (b) and substituted "AS 44.83.396 — 44.83.398" for "AS 44.83.394 — 44.83.398" and "or was either constructed or owned" for "constructed and owned" in the first sentence of subsection (c).

Sec. 44.83.386. Investment of fund. The Department of Revenue shall invest the money in the fund in accordance with AS 37.10.070 and 37.10.075. The Department of Revenue shall provide money in the fund to the authority only after costs have been incurred or amounts in the fund have been otherwise obligated under contracts for the acquisition and construction of a project. Amounts that have been obligated, but for which costs have not yet been incurred, may be segregated by the Department of Revenue or transferred to the authority only with the prior approval or agreement of the commissioner of revenue. Interest received on money that is segregated or transferred under this section must be deposited in the general fund. (§ 1 ch 118 SLA 1981; am § 16 ch 89 SLA 1983)

Revisor's notes. — Enacted as AS 44.83.430. Renumbered in 1981.

Effect of amendments. — The 1983 amendment, substituted the language beginning "costs have been incurred" for "a cost for a project is incurred" at the end of the second sentence and added the third and fourth sentences.

Sec. 44.83.388. Allotment to projects. (a) The authority shall maintain records of power project allocations from the fund for each power project

(1) approved in accordance with AS 44.83.185; and

(2) for which an allocation is made from an appropriation made by the legislature without specifying an appropriation to a project.

(b) Income earned from investment of money appropriated to the fund shall be deposited in the general fund and may be appropriated to the fund by the legislature. (§ 1 ch 118 SLA 1981)

Revisor's notes. — Enacted as AS 44.83.440. Renumbered in 1981.

Sec. 44.83.390. Reappropriation of fund balance. (a) If a power project designated by the legislature by law is not constructed, the amount appropriated to it may be reappropriated to other power projects by the legislature.

(b) The legislature may reappropriate money under (a) of this section only for a power project that is economically feasible under AS 44.83.181(b) and only if the project will serve the market area that would have been served by the power project designated by the legislature and not constructed. (§ 1 ch 118 SLA 1981)

Revisor's notes. — Enacted as AS 44.83.450. Renumbered in 1981.

Sec. 44.83.392. Lapse of excess appropriations. If at the end of construction of a power project appropriations for the power project exceed the amount required for construction of it, the excess lapses into the general fund. (§ 1 ch 118 SLA 1981)

Revisor's notes. — Enacted as AS 44.83.460. Renumbered in 1981.

Sec. 44.83.394. Revenue requirements. [Repealed, § 27 ch 89 SLA 1983.]

Sec. 44.83.396. Operation of power project. (a) A power project that is acquired or constructed as part of the energy program for Alaska is owned, and shall be administered, by the authority.

(b) When a power project has been acquired or constructed by the authority, the project may be operated for the authority under a contract or lease entered into by a qualified utility and the authority.

(c) The authority shall enter into a contract or lease under reasonable terms and conditions to permit the applicant utility to operate the power project when the applicant utility is the only wholesale power customer to be served directly by the power project unless the authority determines a utility making application for a contract or lease to operate a power project is not a qualified utility or is not capable of operating that power project efficiently and in a manner that is consistent with national standards for the industry and with agreements with bondholders.

(d) The authority shall adopt regulations to determine the manner of selecting a qualified utility to operate a power project under a contract or lease when there is more than one wholesale power customer to be served directly by the power project.

(e) When the authority permits a power project to be operated by a qualified utility under a contract or lease, the authority shall

(1) review and approve the annual budget for the operation and maintenance of the power project; and

(2) assure that the project is being operated efficiently and in a manner that is consistent with national standards for the industry and agreements with bondholders. (§ 1 ch 118 SLA 1981; am §§ 17 — 19 ch 89 SLA 1983)

Revisor's notes. — Enacted as AS 44.83.480. Renumbered in 1981.

Effect of amendments. — The 1983 amendment, deleted "by the state" following "is owned" in subsection (a), inserted "a qualified utility or is not" near the end of subsection (c), added the language beginning "efficiently and in a manner that is consistent" to the end of subsection (c), added "and" to the end of paragraph (1) of subsection (e), and added "and agreements with bondholders" to the end of paragraph (2) of subsection (e).

Sec. 44.83.398. Sale of power from power project. (a) The authority shall sell power produced from power projects acquired or constructed under the energy program for Alaska. For purposes of this section, Lake Tyee, Swan Lake, Solomon Gulch, and Terror Lake hydroelectric facilities are considered to be one power project. This power project is referred to as the initial project

(b) The authority shall establish a wholesale power rate structure applicable to sales of power to the customers of a power project as follows:

(1) The authority shall establish and maintain a separate wholesale power rate applicable to each power project that it has acquired or constructed under the energy program for Alaska, other than a project described in (f) of this section. The wholesale power rate established by the authority for the initial project shall be a rate calculated under this paragraph except that the portion of the rate applicable to (A) and (C) of this paragraph shall be adjusted for the hydroelectric facilities in the initial project as set out in (3) of this subsection. The wholesale power rate shall be computed by the authority annually, or more frequently as may be necessary, and shall equal the rate that the authority estimates is necessary to produce revenue that is sufficient to pay

(A) operation, maintenance, and equipment replacement costs of the power project;

(B) the power project's proportionate share of the debt service on state loans and bonds for all power projects in the energy program for Alaska, determined in accordance with (g) of this section;

(C) safety inspections and investigations of the power project by the authority.

(2) *[Repealed, § 7 ch 169 SLA 1984.]*

(3) For the purposes of determining amounts to be allocated to each hydroelectric facility in the initial project under (1)(A) and (1)(C) of this subsection, the authority shall determine for each hydroelectric facility its individual operation, maintenance, equipment replacement, safety inspection, and investigation costs.

(c) The authority shall transmit all the money that it receives under (a) of this section to the commissioner of revenue for deposit in the state general fund except for money it has pledged or otherwise covenanted to secure bonds.

(d) *[Repealed, § 8 ch 169 SLA 1984.]*

(e) After determining the wholesale power rate for a power project under the provisions of this section, the authority may adjust the rate or change the rate provisions to insure that the revenue derived from that power project and the aggregate revenues of the authority will be adequate to comply with the rate covenants and other agreements contained in any trust indenture or trust agreement entered into by the authority for the seurity of the holders of bonds issued to finance power projects in the energy program for Alaska. The authority may agree with a purchaser of power to limit rate increases caused by debt service payable by the authority on subsequent projects.

(f) The provisions of (b) of this section do not apply to an intertie that is authorized as a separate project under AS 44.83.380. The authority shall establish and maintain separate power rate schedules applicable to each intertie that it has acquired or constructed as a separate power project under the energy program for Alaska. The power rate schedules shall produce sufficient revenue from utilities connected by the intertie to pay (1) operation, maintenance, and equipment replacement costs of the intertie; (2) debt service of the intertie; and (3) safety inspections and investigations of the intertie by the authority. If the authority determines that an intertie has ceased to function as a separate project and has become a part of one or more other power projects and has become a part of one or more other power projects as a transmission line, the power rate schedules established under this subsection shall be terminated and a wholesale power rate applicable to the former intertie shall be calculated under (b) of this section for the project or projects of which it has become a part.

(g) For the purposes of (b)(1)(B) of this section, a power project's proportionate share of debt service on state loans and bonds for all power projects in the energy program for Alaska is equal to the state's investment in the power project divided by the state's investment in all power projects in the energy program for Alaska and multiplied by the debt service on state loans and bonds for all power projects in the energy program for Alaska. In this subsection

(1) "state's investment in the power project" includes all state money invested in a power project, including loans, grants, and proceeds from bonds, less the principal repayments on the project's proportionate share of debt service on state loans and bonds;

(2) "state's investment in all power projects in the energy program for Alaska" includes all state money invested in the power projects, other than interties, in the energy program for Alaska, including loans, grants, and proceeds from bonds, less the principal repayments on bonds and state loans issued for the power projects.

(h) Notwithstanding (g) of this section, in the 1983 state fiscal year the proportionate share of debt service under (b) of this section, expressed as a rate, for a power project for which a construction contract has been awarded before June 25, 1982 may not exceed the average debt service component of the wholesale power rate for all power projects in the energy program for Alaska. The limit imposed by this subsection shall be increased in the 1984 state fiscal year to four percent above the average debt service component of the wholesale power rate for all power projects in the energy program for Alaska and by an additional four percent above that average in each succeeding state fiscal year. If application of this subsection results in the production of insufficient revenue to pay the total debt service for all projects in the energy program for Alaska, a project that does not have its share of debt service limited under this subsection shall be subject to a rate in addition to the rate established under (b) of this section. The additional rate is the rate that the authority estimates is necessary to produce revenue that is sufficient to pay the difference between the total debt service for all projects in the energy program for Alaska and the revenue actually produced to pay that debt service, multiplied by a fraction whose numerator is the total cost of the project and whose denominator is the total cost of all of the projects that are subject to the additional rate. In this subsection, "projects in the energy program for Alaska" does not include an intertie that is authorized as a separate project as described in (f) of this section.

(i) The authority may place in a separate interest bearing account money appropriated to the authority as a loan for the purpose of meeting the operating expenses of a facility in the initial project. The money may be used to replace amounts which were expected to be paid by a utility potentially served by a facility in the initial project, which has not entered into a power sales agreement with the authority. Repayment of the amount loaned must be made from revenues attributable to power sales from that facility, as limited by the terms of power sales agreements with power purchasers from that facility. A loan made in accordance with this subsection is not a state loan for purposes of calculating the wholesale power rate under (b)(1) of this section. (§ 1 ch 118 SLA 1981; am §§ 13 — 16 ch 133 SLA 1982; am §§ 20 — 23 ch 89 SLA 1983; am § 125 ch 6 SLA 1984; am §§ 2-8 ch 169 SLA 1984)

Revisor's notes. — Enacted as AS 44.83.490. Renumbered in 1981.

Effect of amendments. — The 1982 amendment, in subsection (b), substituted "a power project" for "the power project" in the introductory language, substituted "separate" for "single" and "each power project" for "all power projects" in the first sentence of paragraph (1), added "other than a project described in (f) of this section" to the end of the first sentence of paragraph (1), inserted "or more frequently as may be necessary" in the introductory language of the second sentence of paragraph (1), substituted "power project" for "power projects" in subparagraph (1)(A) and (C), added "the power project's proportionate share of the" to the beginning of subparagraph (1)(B), substituted the language beginning "on state loans and bonds" for "of the power projects" in subparagraph (1)(B), substituted "separate" for "single" and "each power project that is" for "all power projects that it has" in the first sentence of paragraph (2), inserted "or more frequently as may be necessary" in the introductory language of the second sentence of paragraph (2), substituted "power project" for "power projects" in subparagraph (2)(A) and (2)(B)(iii), and substituted the present provisions of subparagraph (2)(B)(ii) for the former provisions, which read: "debt service of power projects by the authority; and." In subsection (c), the amendment substituted "under (a) of this section" for "under (b) of this section" and "money it has pledged to secure bonds in accordance with contracts with bondholders" for "the money it receives under (b)(1)(A) and (B) and (b)(2)(B)(i) and (ii), or the money it would have received under (b)(1)(A) and (B) and (b)(2)(B)(i) and (ii) of this section if those items had been used in part to establish the wholesale power rate in effect at the time the money is received by the authority." In subsection (e), the amendment substituted "a wholesale" for "the wholesale" and "or (f)" in the first sentence and added the second sentence. The amendment also added subsections (f) — (h).

The 1983 amendment, substituted "July 1, 1991" for "July 1, 1986" near the beginning of paragraph (2) of subsection (b), substituted "or otherwise covenanted to secure bonds" for "to secure bonds in accordance with contracts with bondholders" at the end of subsection (c), rewrote subsection (e), and added the last sentence of subsection (h).

The first 1984 amendment made a technical change in the last sentence in subsection (f).

The second 1984 amendment added subsection (i), repealed former paragraph (2) of subsection (b), relating to a separate wholesale power rate beginning July 1, 1991, and repealed former subsection (d), relating to industrial consumer rates. The 1984 amendment also, in subsection (a), deleted former paragraphs (1) and (2) and the former last sentence in the introductory paragraph, relating to a utility that purchases power produced by a power project of the authority, and, in the remaining language, added the last two sentences; in subsection (b), substituted "the customers" for "its customers at the busbar" in the introductory language, inserted the second sentence in the introductory paragraph of paragraph (1), and added paragraph (3); in subsection (e), added the second sentence and substituted "energy program" for "Energy Program" in the first sentence; and changed the internal reference in the first sentence in the introductory paragraph of subsection (g).

Sec. 44.83.400. Energy conservation. The authority shall ensure

(1) that communities that benefit from the energy program for Alaska implement cost-effective energy conservation measures for residences, commercial and public buildings, and industries; and

(2) that communities shall fulfill their responsibilities under (1) of this section by cooperating with state agencies concerned with development and conservation of energy, including but not limited to

(A) the Alaska Public Utilities Commission;

(B) the Department of Community and Regional Affairs; and

(C) the division of business loans, Department of Commerce and Economic Development. (§ 1 ch 118 SLA 1981; am § 5 ch 79 SLA 1983)

Revisor's notes. — Enacted as AS 44.83.500. Renumbered in 1981.

Effect of amendments. — The 1983 amendment, substituted "Department of Community and Regional Affairs" for "division of energy and power development, Department of Commerce and Economic Development" in paragraph (2)(B).

Sec. 44.83.410. Continuing appropriation for Susitna River Hydroelectric project. [Repealed effective June 30, 1991] The sum of $100,000,000 is appropriated on July 1, 1984 and the sum of $200,000,000 is appropriated on July 1 of each subsequent fiscal year from the general fund to the authority for deposit in the power development fund (AS 44.83.382) for the purpose of equity investment in, and rate stabilization for, the Susitna River hydroelectric project. (§ 314 ch 171 SLA 1984; r § 317 ch 171 SLA 1984)

Postponed repeal. — This section is repealed effective June 30, 1991.

Editor's notes. — Section 316, ch. 171, SLA 1984, provides that the appropriations made in §§ 313—315 and 319 of ch. 171, SLA 1984, which enacted this section, are not one-year appropriations and do not lapse under AS 37.25.010.

Sec. 44.83.420. Continuing appropriation for Bradley Lake hydroelectric project. [Repealed effective June 30, 1988.] The sum of $50,000,000 is appropriated on July 1, of each fiscal year from the general fund to the authority for deposit in the power development fund (AS 44.83.382) for the purpose of equity investment in, and rate stabilization for, the Bradley Lake hydroelectric project. (§ 314 ch 171 SLA 1984; r § 318 ch 171 SLA 1984)

Postponed repeal. — This section is repealed effective June 30, 1988.

Editor's notes. — Section 316, ch. 171, SLA 1984, provides that the appropriations made in §§ 313—315 and 319 of ch. 171, SLA 1984, which enacted this section, are not one-year appropriations and do not lapse under AS 37.25.010.

Sec. 44.83.425. Definitions. In AS 44.83.380 — 44.83.425,

(1) "bus bar" means the substation that serves as the delivery point from the generation and transmission system of the authority to the transmission and distribution system of the utility;

(2) "debt service" means the amounts covenanted with respect to, or pledged to pay, bonds under a trust agreement securing bonds;

(3) "fund" means the power development fund established by AS 44.83.382;

(4) "industrial consumer" means a customer of a utility which customer has a peak power demand in excess of 500 kilowatts and uses the power principally for

(A) manufacturing;

(B) pipeline transportation;

(C) the recovery or processing of minerals;

(D) the processing of timber, agricultural, or seafood products or their by-products; or

(E) the operation of facilities owned by the federal government;

(5) "qualified utility" means an electric utility that is certified by the Alaska Public Utilities Commission to serve all or part of a market area that is served or will be served by the power project, and that the authority determines is capable of operating and maintaining the power project. (§ 1 ch 118 SLA 1981; am § 24 ch 89 SLA 1983)

Revisor's notes. — Enacted as AS 44.83.510. Renumbered in 1981.

Effect of amendments. — The 1983 amendment, rewrote the definition of "debt service" in paragraph (2).

NOTICE

A NOTATIONAL SYSTEM HAS BEEN USED
TO DENOTE DIFFERENCES BETWEEN THIS AMENDED LICENSE APPLICATION
AND
THE LICENSE APPLICATION AS ACCEPTED FOR FILING BY FERC
ON JULY 29, 1983

This system consists of placing one of the following notations beside each text heading:

(o) No change was made in this section, it remains the same as was presented in the July 29, 1983 License Application

(*) Only minor changes, largely of an editorial nature, have been made

(**) Major changes have been made in this section

(***) This is an entirely new section which did not appear in the July 29, 1983 License Application

VOLUME COMPARISON

VOLUME NUMBER COMPARISON

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EXHIBIT A
PROJECT DESCRIPTION

The Susitna Hydroelectric Project will be comprised of two major developments on the Susitna River some 120 miles north and east of Anchorage, Alaska (see Figure A.1). The project will be constructed in three distinct phases hereinafter referred to as stages.

The following is a brief description of the three phases of the Project. A further description of Watana Stage I is presented in the following Sections 1 through 5; Devil Canyon Stage II is described in Sections 6 through 10. Watana Stage III is described in sections 11 through 15. Project lands for the entire project are discussed in Section 16. Reference drawings are in Exhibit F.

WATANA STAGE I

The Watana Initial Dam would be built to el. 2,025 with a maximum normal reservoir el. of 2,000 (see Exhibit F Figures). The internal zoning of the earthfill dam will include an inclined upstream impervious core. The inclination of the core will reduce the amount of shell material required for stability of the Stage III dam that will be submerged by the Stage I pool, and therefore placed during Stage I construction. When the dam is being raised, all the additional fill will then be placed in the dry during the seasonal drawdown of the reservoir. The raising of the Watana Dam causes no adverse effects on the safety of either the Stage I or Stage III dam, and no unusual construction operation is required during raising. An additional five feet of freeboard is added in Stage I to facilitate flood control with the small reservoir storage volume.

The spillway and approach channel excavation would be deepened by approximately 185 feet below that shown in the original two stage project in order to accommodate the reservoir during Stage I. The rock excavated from these areas would be used in the construction of the dam and would minimize or eliminate the need for opening a quarry site during Stage I. The deeper excavation would be designed with suitable rock reinforcement and berms. The spillway in Stage I will pass the probable maximum flood.

For Stage I, there would be one outlet facility structure and two power intake structures. The outlet facility, in conjunction with the four powerhouse units in Stage I, will discharge a 50-year flood before flow would be discharged over the spillway.

The power house in Stage I will have four generating units, each with a nominal capability at average operating head of 110 MW for a total of 440 MW. The December - January dependable capability of the Stage I installation will be 360 MW.

The construction schedule for Stage I will be one year shorter than the first stage of the two stage project. The shortening of the schedule is a result of a decrease in the quantities of the fill material necessary for the Stage I construction.

DEVIL CANYON STAGE II

Stage II will be the construction of the Devil Canyon development consisting of a concrete double curvature thin arch dam with crest el. 1,463 (see Exhibit F Figures). The normal maximum reservoir will be at el. 1,455. The powerhouse will have four units each with a nominal capability at average operating head of 170 MW for a total of 680 MW. The December - January dependable capability of the Devil Canyon powerplant will be 600 MW. Outlet facilities will be provided to discharge the routed 1:50 year flood in conjunction with the power facilities. A gated chute spillway with flip bucket will be provided capable of passing the probable maximum flood. A saddle dam will be constructed on the right bank to el. 1,472 and adjacent to the arch dam. The saddle dam will be an embankment of similar construction to the Watana Dam. During construction, diversion of the river will be accomplished by construction of upstream and downstream fill cofferdams and a diversion tunnel with capacity to pass the 1:25 year flood routed through the Watana Stage I reservoir.

WATANA STAGE III

The Watana Initial Dam would be raised to el. 2,205 with a maximum normal reservoir el. of 2,185 (see Exhibit F Figures). During seasonal drawdown when the Stage I reservoir elevation is below el. 1,925 (the elevation of the upstream berm) rockfill would be in the dry on the upstream side of the dam.

The concrete spillway ogee crest would be raised to el. 2,135 and the spillway gates relocated to accommodate the higher ogee elevation.

The outlet facility structure and the two power intakes would be raised to el. 2,201. A third power intake would be built in Stage III with an inlet at el. 2,012.

Two additional units would be added to the powerhouse bringing the total number of units to six. After completion of Stage III, the nominal capacity of the powerhouse at average operating head would increase from 440 MW to 1,110 MW because of the increase in head on the four Stage I units and the addition of two 185 MW nominal capacity units. The December - January dependable capability of Watana in Stage III will be 1020 MW for a total project dependable capability of 1620 MW.

1 - PROJECT STRUCTURES - WATANA STAGE I (**)

1.1 - General Arrangement (**)

The Watana Stage I Dam will create a reservoir approximately 39 miles long, with a surface area of 20,000 acres, and a gross storage capacity of 4,300,000 acre-feet at the normal maximum operating level of el. 2,000.

The maximum water surface elevation during flood conditions will be 2,017. The minimum operating level of the reservoir will be 1,850, providing 2,400,000 acre-feet of live storage during normal operation.

The dam will be an earth and rockfill embankment with an inclined impervious core. The nominal crest elevation of the dam will be 2,025, with a maximum height of approximately 700 feet above the foundation and a crest length of 2,700 feet. The embankment crest will initially be cambered to el. 2,027 in the zone of maximum dam height to allow for potential seismic and static settlement. The total volume of the structure will be approximately 32,110,000 cubic yards. During construction, the river will be diverted through two concrete-lined diversion tunnels on the north side of the river, each 36 feet in diameter and averaging 3,700 feet long.

The power intake will be located on the north bank with an approach channel excavated in rock. The intake will be a concrete structure with multi-level gates capable of operating over the full 150 foot drawdown range. From the intake structure, two 24 foot diameter concrete-lined power conduits and shafts will lead to an underground powerhouse complex, housing four generating units with Francis type turbines and synchronous generators. Near the powerhouse the conduits will branch into four 15-foot diameter steel-lined penstocks.

Access to the powerhouse complex will be by means of an unlined access tunnel and a road which will pass from the crest of the dam, down the south bank of the river valley and across a berm constructed on the downstream toe of the main dam. Turbine discharge will flow through four draft tube tunnels to a surge chamber downstream from the powerhouse. The surge chamber will discharge to the river through a 34 foot modified-horseshoe concrete-lined tailrace tunnel. A separate transformer gallery just upstream of the powerhouse cavern will house seven single-phase 15-345/ 1.73 kV transformers (three transformers per group of two generators, and one spare), and an SF_6 gas insulated substation. Each bank of transformers will be connected through generator circuit breakers by isolated phase bus located in individual bus tunnels. The HV bushings for the transformers will be connected to the 345 kV SF_6 gas insulated substation (GIS) by single-phase SF_6 gas insulated buses (GIB). The substation will provide switching for two transformer banks and two transmission lines. Two sets of single-phase SF_6 GIB will be carried from the GIS to the surface through a single vertical shaft. At the surface the GIB will be terminated at SF_6-to- air entrance bushings where they will be connected to overhead transmission lines.

Outlet facilities will also be located on the north bank with a capacity of approximately 24,000 cfs. A flood storage pool is provided between el. 2,000 and el. 2,014. In combination with the average powerhouse flow of 9,200 cfs, the 50-year flood can be stored and released without raising the pool level above el. 2,014 and without requiring use of the spillway.

The spillway located on the north bank will consist of an upstream ogee control structure with three radial gates and an inclined concrete chute and flip bucket designed to pass a maximum discharge of 278,300 cfs. This spillway, together with the outlet facilities, will be capable of discharging the estimated Probable Maximum Flood (PMF) of 326,000 cfs, while maintaining eight feet of freeboard on the dam. Emergency release facilities will be located in one of the diversion tunnels after closure to allow lowering of the reservoir over a period of time for emergency inspection or repair of impoundment structures.

1.2 - Dam Embankment (**)

The Watana Stage I Dam embankment will be located at mile 184 above the mouth of the Susitna River, in a broad U-shaped valley approximately 2.5 miles upstream of the Tsusena Creek confluence. The dam will be of compacted earth and rockfill construction and will consist of an impervious core protected by fine and coarse filters upstream and downstream. The upstream and downstream outer shells will consist of rockfill. A typical cross section is shown on Plate F7 and is described below.

1.2.1. Typical Cross Section (**)

The thickness of the core at any horizontal section will be slightly more than 0.5 times the head of water at that section. Flaring will be required of the cross section at each end of the embankment.

The upstream and downstream filter zones are sized to provide protection against possible piping through transverse cracks that could occur because of settlement or resulting from internal displacement during a seismic event.

The shells of the dam will consist of rockfill obtained from required surface or underground excavations. The rockfill will minimize pore pressure generation and insure rapid dissipation of pore pressures should seismic shaking occur.

Protection against wave and ice action on the upstream slope will consist of a rock raked layer of large stone comprising quarried rock up to 36 inches in size.

The volume of material required to construct the Watana Dam is presently estimated as follows:

Material	Volume (cy)
Impervious	6,300,000
Fine filter	2,217,000
Coarse filter	2,000,000
Rockfill	21,590,000

1.2.2 - Crest Details and Freeboard (**)

The typical crest detail is shown in Plate F7. Because of the narrowing at the dam crest, the filter zones are reduced in width, but still protect the core material from damage by frost penetration and desiccation.

The nominal crest elevation of Watana Stage I will be 2,025.

Total settlement allowance has been made for post-construction settlement of the dam under its own weight, for the effects of saturation on the upstream rock fill when the reservoir is first filled, and for possible settlement from seismic shaking. Provision will be made during construction for placement of additional fill at the crest should settlements exceed the estimated amounts. At each abutment the crest elevation will be 2,025, while at the maximum section the crest elevation will be 2,027 allowing for two feet of settlement. Under normal operating conditions the minimum freeboard, relative to the maximum operating pool elevation of 2,000, will be approximately 25 feet, not including settlement allowances.

The freeboard allowance is eight feet above the PMF reservoir level and is based on the crest level after all settlement has taken place. Ultimate security against overtopping of the main dam will be provided by the spillway which is designed to pass the PMF without overtopping the dam.

1.2.3 - Grouting and Pressure Relief System (**)

A combination of consolidation grouting, grout curtain and installation of a downstream pressure relief (drainage) system will be undertaken in the bedrock foundation beneath Watana Dam.

The grout curtain and drilling for the pressure relief system will be largely carried out from galleries in the rock foundation in the abutments and beneath the dam. Details of the grouting, pressure relief and galleries are shown on Plate F8.

1.2.4 - Instrumentation (**)

Instrumentation will be installed to provide monitoring of performance of the dam and foundation during construction as well as during operation. Instruments for measuring internal vertical and horizontal displacements, stresses and strains, and total and fluid pressures, as well as surface monuments and markers, will be installed. Conservative quantity estimates for instrumentation have been made on the basis of currently available geotechnical data for the site. This instrumentation includes:

- Piezometers
  - Piezometers will be used to measure hydrostatic pressure in the pore spaces of soil and rockfill, and in the rock foundation.

- Internal Vertical Movement Devices
  - Cross-arm settlement devices,
  - Various versions of the taunt-wire devices which have been developed to measure internal settlement, and
  - Hydraulic-settlement devices of various kinds.

- Internal Horizontal Movement Devices
  - Taunt-wire arrangements,
  - Cross-arm devices,
  - Inclinometers, and
  - Strain meters.

- Other Measuring Devices
  - Stress meters,
  - Surface monuments and alignment markers,
  - Seismographic records and seismoscopes, and
  - Flow meters to record discharge from drainage and pressure relief system.

1.3 - Diversion (**)

1.3.1 - Tunnels (**)

Diversion of the river flow during construction will be accomplished with two 36-foot diameter circular diversion tunnels. The tunnels will be concrete-lined and located on the north bank of the river. The tunnels are 3,305 feet and 4,020 feet in length. The diversion tunnels are shown in plan and profile on Plate F9.

The tunnels are designed to pass a flood with a return frequency of 1:50 years, equivalent to peak inflow of 89,500 cfs. Routing effects are small, and thus at peak flow the tunnels will discharge 77,000 cfs. The estimated maximum water surface elevation upstream from the cofferdam for this discharge will be 1,532.

The upper tunnel (Tunnel No. 1) will be converted to the permanent emergency outlet after construction. A local enlarging of the tunnel diameter to 45 feet will accommodate the low-level outlet gates and expansion chamber.

1.3.2 - Cofferdams (**)

The upstream cofferdam will be a zoned embankment founded on the diversion dike (see Plate F10). The diversion dike will be constructed to el. 1,480, and will consist of finer material on the upstream side grading to coarser material on the downstream side. Provision has been made for a slurry trench cutoff through the river bed alluvium to bedrock to control seepage during dam construction. The slurry wall cutoff is shown on Plate F10.

The upstream cofferdam will receive the usual foundation treatment and will be a zoned embankment consisting of an impervious core, fine and coarse upstream and downstream filters, and rock and/or gravel supporting shell zones with slope protection on the upstream face to resist ice action. This cofferdam will be constructed to el. 1,550 and provide an 18-foot freeboard for wave run-up and ice protection.

The downstream cofferdam will be a zoned earth and rockfill embankment (see Plate F-10). The diversion dike will be constructed to el. 1,460, and will consist of random rock material placed on the downstream side of the cofferdam section. The cofferdam will be raised in the dry to its crest elevation of 1,495. The diversion scheme will allow an unwatering of the river reach between the cofferdams, so the slurry trench cut-off to bedrock may be constructed for control of under seepage.

1.3.3 - Tunnel Portals and Gate Structures (**)

A reinforced concrete gate structure will be located at the upstream end of each tunnel, each housing two closure gates (see Plate F11).

Each gate will be 36 feet high by 14 feet wide separated by a center concrete pier. The gates will be of the fixed-roller vertical lift type operated by a wire rope hoist. The gate hoist will be located in an enclosed, heated housing. Provision will be made for heating the gates and gate guides. The gate in

Tunnel No. 1 will be designed to operate with the reservoir at el. 1,532, a 64-foot operating head. The gate in Tunnel No. 2 will be designed to operate with the reservoir at el. 1,532, an 87-foot operating head. The gate structures for each tunnel will be designed to withstand external (static) heads of 160 feet (No. 2) and 500 feet (No. 1), respectively. The downstream portals will be reinforced concrete structures with guides for stoplogs.

1.3.4 - Final Closure and Reservoir Filling (**)

As discussed above, the upper diversion tunnel (No. 1) will be converted to a low-level outlet or emergency release facility during construction.

It is estimated that one year will be required to construct and install the permanent low-level outlet in the existing tunnel. This will require that the lower tunnel (No. 2) pass all flows during this period. The main dam will, at this time, be at an elevation sufficient to allow a 100-year recurrence interval flood (99,000 cfs) to pass through Tunnel No. 2. This flow will result in a reservoir elevation of approximately 1,618. During the construction of the low level outlet, the intake gates in the upper tunnel (No. 1) will be closed. Prior to commencing operation of the low-level outlet, coarse trashracks will be installed at the entrance to Tunnel No. 1 intake structure.

Upon commencing operation of the low-level outlet, the lower tunnel (No. 2) will be closed with the intake gates, and construction of the permanent plug and filling of the reservoir will commence.

When the lower tunnel (No. 2) is closed the main dam crest will have reached an elevation sufficient to start filling the reservoir and still have adequate storage available to store a 250-year recurrence period flood.

During the filling operation, the low-level outlet will pass summer flows of up to 12,000 cfs and winter flows of up to 800 cfs. In case of a large flood occurring during the filling operation, the low-level outlet would be opened to its maximum capacity of 30,000 cfs to maintain the reservoir pool at a safe level.

Reservoir filling is estimated to take one year to fill to a level required for testing, commissioning, and operating the first two units during the first winter. Completion of filling to el. 2,000 would occur during the second summer.

The filling sequence is based on the main dam elevation at any time during construction and the capability of the reservoir

storage to absorb the inflow volume from a 250-year recurrence period flood without overtopping the main dam.

1.4 - Emergency Release Facilities (**)

The upper diversion Tunnel No. 1 will be converted to a permanent low-level outlet, or emergency release facility. These facilities will be used to pass the required minimum discharge during the reservoir filling period and will also be used for draining the reservoir in an emergency.

During operation, energy will be dissipated by means of two gated concrete plugs separated by a 340-foot length of tunnel (see Plate F19). Each plug will contain three water passages.

Bonnetted type high pressure slide gates will be installed in each of the passages in the tunnel plugs. The gate arrangement will consist of one emergency gate and one operating gate in the upstream plug and one operating gate in the downstream plug. A 340-foot length of tunnel between plugs will act as an energy dissipating expansion chamber.

The 7.5-foot by 11.5-foot gates will be designed to withstand a total static head of about 720 feet; however, they will only be operated with a maximum head of about 420 feet.

During operation, the operating gate opening in the upstream plug will be equal to the opening of the corresponding gate in the downstream plug. This should effectively balance the head across the gates.

Each gate will have a hydraulic cylinder operator designed to raise or lower it against a maximum head of 600 feet. Three hydraulic units will be installed, one for the emergency gates, one for the upstream operating gates and one for the downstream operating gates. Each gate will have an opening/closing time of about 30 minutes. A grease injection system will be installed in each gate to reduce frictional forces when the gates are operated.

The design of the gate will be such that the hydraulic cylinder as well as the cylinder packing may be inspected and repaired without dewatering the area around the gate. All gates may be locally or remotely operated.

To prevent concrete erosion, the conduits in each of the tunnel plugs will be steel-lined. An air vent will be installed at the downstream side of the operating gate in the downstream plug. Energy dissipation at the downstream tunnel exit will be accomplished by means of a concrete flip bucket in the exit channel (Plate F20).

1.5 - Outlet Facilities (**)

The primary function of the outlet facilities will be to discharge floods with recurrence frequencies of up to once in 50 years after they have been routed through the Watana reservoir. The use of fixed-cone discharge valves will ensure that downstream erosion will be minimal and the dissolved nitrogen content in the discharges will be reduced sufficiently to avoid harmful effects on the downstream fish population. A secondary function will be to provide the capability to rapidly draw down the reservoir during an extreme emergency situation.

The facilities will be located on the north bank and will consist of a gate structure, pressure tunnel, and an energy dissipation and control structure housing located beneath the spillway flip bucket. This structure will accommodate six fixed-cone valves which will discharge into the river 105 feet below.

1.5.1 - Approach Channel and Intake (**)

The approach channel to the outlet facilities will be shared with the power intake and spillway. The channel at the maximum normal operating level of el. 2,000 will be 680 feet wide immediately upstream of the outlet facility's gate structure. The gate structure will be founded deep in the rock at the forebay end of the channel. The single intake passage will have an invert elevation of 1,915. It will be divided upstream by a central concrete pier which will support steel trashracks located on the face of the structure, spanning the openings to the water passage. The trashracks will be split into panels mounted one above the other and run in vertical steel guides installed at the upstream face. The trashrack panels can be raised and lowered for cleaning and maintenance by a mobile gantry crane located at deck level.

Two fixed-wheel gates will be located downstream of the trashracks between the pier and each of the sidewalls. These gates will be operated by a hydraulic hoist mounted in the gate shaft. The fixed-wheel gates will not be used for flow control but will function as closure gates to isolate the downstream tunnel and allow dewatering for maintenance of the tunnel or ring gates located in the discharge structure. Stoplog guides will be provided upstream from the two fixed-wheel gates to permit dewatering of the structure and access to the gate guides for maintenance.

1.5.2 - Intake Gates and Trashracks (**)

The gates will be of the fixed-wheel vertical lift type with upstream skinplate and seals. The nominal gate size will be 18

feet wide by 28 feet high. Each gate will be operated by a hydraulic hoist located above the gate in the gate shaft.

The gates will be capable of being lowered either from a remote control room or locally from the intake area. Gate raising will be from the hoist area only.

The trashracks will have a bar spacing of 6 inches and will be designed for a maximum differential head of 40 feet. The maximum net velocity through the racks will be approximately 7.5 ft/sec. Provision will be made for monitoring the head loss across the trashracks.

1.5.3 - Shaft and Tunnel (**)

Discharges will be conveyed from the upstream gate structure by a concrete-lined tunnel terminating in a steel liner and manifold. The manifold will branch into six steel-lined tunnels which will run through the main spillway flip bucket structure to the fixed-cone valves mounted in line with the downstream face.

The water passage will be 28 feet in diameter from the intake to the steel manifold. The upstream concrete-lined portion will run a short distance horizontally from the back of the intake structure before dipping at an angle of 55° to a lower level tunnel of similar cross section. The lower tunnel will run at a 5 percent gradient to a centerline elevation of 1,560 approximately 450 feet upstream of the flip bucket. At this point the depth of overlying rock is insufficient to withstand the large hydrostatic pressure which will occur within the tunnel. Downstream of this point the tunnel will be steel-lined. The steel liner will be 28 feet in diameter and embedded in concrete filling the space between the liner and the surrounding rock. The area between the outside face of the liner and the concrete will be contact grouted.

1.5.4 - Discharge Structure (**)

The concrete discharge structure is shown on Plate F15. It will form a part of the flip bucket for the main spillway and will house the fixed-cone valves and individual upstream ring follower gates. The valves will be set with a centerline elevation of 1,560 and will discharge into the river approximately 105 feet below. Openings for the valves will be formed in the concrete and the valves will be recessed within these openings sufficiently to allow enclosure for ease of maintenance and heating of the movable valve sleeves. An access gallery upstream from the valves will run the length of the discharge structure, and will terminate in the access tunnel and access road on either side of the structure.

Housing for the ring follower gates will be located upstream from the fixed-cone valve chambers. The ring follower gates will serve to isolate the discharge valves. Provision will be made for relatively easy equipment maintenance and removal by means of a 25-ton service crane, transfer trolley and individual 25-ton monorail hoists.

1.5.5 - Fixed-Cone Discharge Valves (**)

Six 78-inch diameter fixed-cone discharge valves will be installed at the downstream end of the outlet manifold, as shown on Plate F15. The valves will be operated by two hydraulic cylinder operators. The valves will be operated either locally or remotely.

1.5.6 - Ring Follower Gates (**)

A ring follower gate will be installed upstream from each valve and will be used:

- o To permit inspection and maintenance of the fixed-cone valves;
- o To relieve the hydrostatic pressure on the fixed-cone valves when they are in the closed position; and
- o To close against flowing water in the event of malfunction or failure of the valves.

The ring follower gates will have a nominal diameter of 90 inches and will be designed to withstand a total static head of 630 feet.

The ring follower gates will be designed to be lowered under flowing water conditions and raised under balanced head conditions. A grease injection system will be installed in each gate to reduce frictional forces when the gates are operated. The gates will be operated by hydraulic cylinders from either a local or remote location.

1.5.7 - Discharge Area (**)

Immediately downstream from the discharge structure, the rock will be excavated at a slope of 2H:3V to a lower elevation of 1,510. This face will be heavily reinforced by rock bolts and protected by a concrete slab anchored to the face. The lower level will consist of unlined rock extending to the river.

1.6 - Spillway (**)

The spillway will provide discharge capability for floods exceeding the capacity of the outlet facilities (50-year flood). The combined total capacity of the spillway and outlet facilities will be sufficient to pass the PMF.

The spillway, shown on Plate F12, will be located on the north bank of the river and will consist of an approach channel, a gated ogee control structure, a concrete-lined chute, and a flip bucket.

The spillway is designed to discharge flows of up to 258,000 cfs with a corresponding reservoir elevation of 2,014. The total head dissipated by the spillway is approximately 545 feet.

1.6.1 - Approach Channel and Control Structure (**)

The approach channel at the spillway will be excavated to a depth of approximately 335 feet into rock. It will be located on the north side of the power and outlet facilities intakes, and will be integrated with the approach channels upstream of these intake structures.

The concrete control structure will be located at the end of the approach channel. Flows will be controlled by three 64-foot high by 44-foot wide radial gates, as shown on Plate F13. The structure will be constructed in individual monoliths separated by contraction joints. The main access route to the dam will pass across the roadway deck and along the dam crest.

Hydraulic model tests will be undertaken during the detailed design stage to confirm the precise geometry of the control structure.

The sides of the approach channel will be excavated to 1H:4V slopes. Only localized rock bolting and shotcrete support are expected. The control structure will be founded deep in sound rock and consolidation grouting is not anticipated. However, minor shear or fracture zones passing through the foundation may require dental excavation, concrete backfill and/or consolidation grouting.

The dam embankment grouting and drainage tunnel will join the control structure gallery. Access to the grouting tunnels will be via a vertical shaft within the control structure side wall and a gallery running through the ogee weir.

1.6.2 - Spillway Gates and Stoplogs (**)

The three spillway gates will be of the radial type operated by hydraulic hoists mounted at the sides of the piers downstream of the gates. The gate size is 44 feet wide by 64 feet high. Provision will also be made for heating the gate guides for winter operation.

An emergency engine will be provided to enable the gates to be raised in the event of loss of power to the spillway's gate hoist motor hydraulic system.

Stoplog guides will be installed upstream of each of the three spillway gates. One set of stoplogs will be provided to permit maintenance of the radial gates.

1.6.3 - Spillway Chute (**)

The control structure will discharge down an inclined chute that tapers uniformly until a width of 120 feet is reached near the flip bucket. Convergence of the chute walls as such will be gradual to minimize any shock wave development.

The chute section will be rectangular in cross section, excavated in rock, and lined with concrete anchored to the rock. An extensive underdrainage system will be provided to ensure stability of the structure. The dam grout curtain and drainage system will also extend under the spillway control structure utilizing a gallery through the mass concrete rollway. A system of box drains will be constructed in the rock under the concrete slab in a herringbone pattern at 20 feet spacing for the entire length of the spillway. A drainage trench will be excavated beneath the entire length of the spillway. Drain pipes will intersect the gallery. Drainage holes drilled into the high rock cuts will also ensure increased stability of excavations.

A series of four aeration galleries will be provided at intervals down the chute to prevent cavitation damage of the concrete. Details of these aeration devices are shown in Plate F14.

1.6.4 - Flip Bucket (**)

The function of the flip bucket will be to direct the spillway flow clear of the concrete structures and well downstream into the river below. A mass concrete block will form the flip bucket for the main spillway. Detailed geometry of the bucket, as well as dynamic pressures on the floor and walls of the structure, will be confirmed by model studies.

1.7 - This section deleted

1.8 - Power Intake (**)

1.8.1 - Intake Structure (**)

The power intake will be a concrete structure located deep in the bedrock on the north bank. Access to the structure will be by road from the south side of the spillway bridge.

In order to draw from the reservoir surface over a drawdown range of 150 feet, two openings at five levels will be provided in the upstream concrete wall of the structure for each of the two independent power intakes serving the four generating units. Openings can be closed off by sliding steel shutters operated in a common guide. All openings will be protected by upstream trashracks. A heated boom will operate in guides upstream from the racks following the water surface, keeping the racks ice free.

Two lower control gates will be provided in each intake unit. A single set of upstream bulkhead gates will be provided for routine maintenance of the two sets of intake gates.

The overall base width of the intake will be 150 feet, providing a minimum spacing of power tunnel excavations of 2.75 times the excavated diameter.

The upper level of the concrete structure will be set at el. 2,020. The level of the lowest intake is governed by the vortex criterion for flow into the penstock from the minimum reservoir level elevation of 1,850. The foundation of the structure will be approximately 400 feet below existing ground level and is expected to be in sound rock.

The wall between intake structures will be perforated with a series of holes (see Plate F24) in the section between the guides for the shutter gates and the bulkhead gate. These perforations will allow for a more uniform withdrawal distribution across the approach channel width when only one power tunnel is conveying water.

Mechanical equipment will be housed in a steel-frame building on the upper level of the concrete structure. The general arrangement of the power intake is shown on Plate F24.

1.8.2 - Approach Channel (**)

The overall width of the approach channel at the upper shutter gate level is governed by the combined width of the power intake outlet facilities gate structure and spillway control structure, and will be approximately 700 feet. The length of the channel will be 1,600 feet.

The maximum velocity in the intake approach channel will occur when four machines are operating with the reservoir drawn down to el. 1,850. The velocity in the approach channel will be 1.4 ft/sec, which will not cause any erosion problems. Velocities of 6.2 ft/sec may occur where the intake approach channel intersects the approach channel to the main spillway.

1.8.3 - Mechanical Arrangement (**)

(a) Ice Boom (**)

A heated boom will be installed in guides immediately upstream from the trashracks for each of the two power intakes. The boom will be operated by a movable hoist and will automatically follow the reservoir level. The boom will serve to minimize ice accumulation in the trashrack and intake shutter area, and prevent thermal ice-loading on the trashracks.

(b) Trashracks (**)

Each of the two power intakes will have five sets of trashracks, one set in front of each pair of intake openings. Each set of trashracks will be in two sections to facilitate handling by the intake service crane. Each set of trashracks will cover two openings each 24 feet wide by 25 feet. The trashracks will have a bar spacing of six inches and will be designed for a maximum differential head of 20 feet.

(c) Intake Shutters (**)

Each of the two power intakes will have four sets of intake shutters which will serve to prevent flow through the openings behind which the shutters will be installed. As the reservoir level drops, the sliding shutters will be removed as necessary using the intake service crane.

Each of the shutters will be designed for a differential head of 15 feet, and will incorporate a flap gate. This will prevent failure of the shutters in the event of accidental blocking of all intake openings.

The shutter guides will be heated to facilitate shutter removal in sub-freezing weather. In addition, a bubbler system will be provided in the intake behind the shutters to keep the intake structure water surface free of ice.

(d) Intake Service Crane (**)

A single overhead traveling-bridge type intake service crane will be provided in the intake service building. The crane will be used for:

- o Servicing the ice boom and ice boom hoist
- o Handling and cleaning the trashracks
- o Handling the intake shutters
- o Handling the intake bulkhead gates and
- o Servicing the intake gate and hoist

The overhead crane will have a double point lift and followers for handling the trashrack, shutters and bulkhead gates. The crane will be radio-controlled with a pendant or cab control for backup.

(e) Intake Bulkhead Gates (**)

One set of intake bulkhead gates will be provided for closing the two intakes upstream of the intake gates. The bulkhead gates will be used to permit inspection and maintenance of the intake gate and intake gate guides. The gates will be designed to withstand full differential pressure.

(f) Intake Gates (**)

The intake gates will close the two openings of 12 feet by 24 feet of each power intake. They will be of the vertical fixed-wheel lift type with upstream seals and skinplate.

Each gate will be operated by a hydraulic cylinder type hoist. The length of a cylinder will allow withdrawal of the gate from the water flow. The intake service crane will be used to raise the gate above deck level for maintenance. The gates will normally be closed under balanced flow conditions to permit dewatering of the power tunnel penstock water passages for inspection and maintenance. The gates will also be designed to close in an emergency with full turbine flow conditions in the event of loss of control of the turbine.

1.9 - Power Tunnels and Penstocks (**)

The general arrangement of the power tunnels and penstocks is shown on Plates F21 and F23.

Two power tunnels, each of which bifurcate to penstocks, are provided to convey water from the power intakes to the powerhouse, one penstock for each generating unit. The power tunnel geometry shall consist of a short horizontal reach, a 90 degree bend, a shaft, another 90 degree bend and a short horizontal reach before the bifurcation. The power tunnel will be concrete lined with internal diameter of 24 feet. Each penstock will be a concrete-lined tunnel 18 feet in internal diameter. The minimum concrete lining thickness will be 18 inches. The lateral spacing between power tunnels will be 75 feet on centers at the intake and the penstocks, and 60 feet on centers at the powerhouse. The difference in lateral spacing will be achieved by staggering the bifurcation point of each power tunnel.

The design static head on each penstock is 763 feet, the Stage III maximum normal reservoir level, at centerline distributor level (el. 1,422). An allowance of 35 percent has been made for pressure rise in the penstock caused by hydraulic transients.

1.9.1 - Steel Liner (**)

The rock immediately adjacent to the powerhouse cavern will be incapable of resisting the internal hydraulic forces within the penstocks. Consequently, the first 50 feet of each penstock upstream of the powerhouse will be reinforced by a steel liner designed to resist the maximum design head, without support from the surrounding rock. Beyond this section the steel liner will be extended a further 150 feet, and support from the surrounding rock will be assumed, up to a maximum of 50 percent of the design pressure.

The steel liner will be surrounded by concrete with a minimum thickness of 18 inches. The internal diameter of the steel lining will be 15 feet. A steel transition will be provided between the liner and the 18-foot diameter concrete-lined penstock.

1.9.2 - Concrete Lining (**)

The power tunnels and penstocks will be fully lined with concrete from the intake to the steel-lined section of the penstocks. The internal diameter of the concrete- lined penstock will be 18 feet. The minimum lining thickness will be 18 inches.

1.9.3 - Grouting and Pressure Relief System (**)

A comprehensive pressure relief system will protect the underground caverns against seepage from the high pressure penstock. The system will comprise small diameter boreholes set out to intercept the jointing in the rock. A grouting and drainage gallery will be located upstream from the transformer gallery.

1.10 - Powerhouse (**)

The underground powerhouse complex will be constructed beneath the north abutment of the dam. This will require the excavation in rock of three major caverns, the powerhouse, transformer gallery, and surge chamber, with interconnecting rock tunnels for the draft tubes and isolated phase bus ducts.

Unlined rock tunnels, with concrete inverts where appropriate, will be provided for vehicular access to the three main rock caverns and the penstock construction adit. Vertical shafts will be provided for personnel access to the underground powerhouse, for SF6 gas-insulated busses from the transformer gallery, for surge chamber venting, and for the heating and ventilation system.

The general layout of the powerhouse complex is shown in plan and section on Plates F25 and F26, and in isometric projection on Plate F24. The transformer gallery will be located on the upstream side of the powerhouse cavern; the surge chamber will be located on the downstream side.

The draft tube gate gallery and crane will be located in the surge chamber cavern, above the maximum anticipated surge level. Provision will also be made in the surge chamber for tailrace tunnel intake stoplogs, which will be handled by the same crane.

1.10.1 - Access Tunnels and Shafts (**)

Vehicular access to the underground facilities at Watana will be provided by a single unlined rock tunnel from the north bank area at el. 1,560, adjacent to the diversion tunnel portals. The access tunnel will descend to the south end of the powerhouse cavern at generator floor level, el. 1,463. Separate branch tunnels from the main tunnel will provide access to the transformer gallery at el. 1,507, and the surge chamber at el. 1,495. A separate penstock construction adit will be driven to el. 1,420 from immediately downstream of the diversion tunnel portals. The gradient will not exceed 0.3 percent at the construction access tunnel, and 9.5 percent at the permanent access tunnels, except for along the short transformer access tunnel where the gradient is 11 percent.

The cross section of the access tunnel has a modified horseshoe shape, 35 feet wide by 28 feet high. The access tunnel branch to the surge chamber and draft tube gallery will have a reduced section consistent with the anticipated size of vehicle and loading required.

The main access shaft will be at the north end of the powerhouse cavern, providing personnel access from the surface control building by elevator. Access tunnels will be provided from this shaft for pedestrian access and ventilation to the transformer gallery and the draft tube gate gallery and ventilation. Elevator access will also be provided to the fire protection head tank, located approximately 250 feet above powerhouse level. The main access shaft will be 20 feet in internal diameter with a concrete lining of 9 to 18 inches.

1.10.2 - Powerhouse Cavern (**)

The main powerhouse cavern will be designed to accommodate four vertical-shaft Francis turbines, in line, with direct coupling to synchronous generators. The length of the cavern will allow for a unit spacing of 60 feet, with a 95-foot long service bay at the south end for routine maintenance and for construction erection. Vehicular access will be by tunnel to the generator floor at the south end of the cavern; pedestrian access will be by elevator from the surface control building to the north end of the cavern. Multiple stairway access points will be available from the main floor to each gallery level. Access to the transformer gallery from the powerhouse will be by tunnel from the main access shaft, or by stairway through each of the isolated phase bus tunnels. A service elevator will be provided for access to the various powerhouse floors.

Hatches will be provided through all main floors for installation and maintenance of heavy equipment using the powerhouse cranes.

In order to minimize interruption to power generation during future Stage III extension, the powerhouse superstructure excavation will be extended by five feet, bringing the total Stage I excavation length to 365 feet above el. 1,441. Similarly, a 76 foot long drainage tunnel will be excavated to allow gravity drainage to occur from the future bays to Unit 4 sumps.

1.10.3 - Transformer Gallery (**)

The transformers will be located underground in a separate gallery, 120 feet upstream from the main powerhouse cavern, with two connecting tunnels for the isolated phase bus. There will be six single-phase transformers installed in groups of

three transformers for two generating units. Generator circuit breakers will be installed in the powerhouse on the generator floor level.

The transformer gallery will be 45 feet wide, 40 feet high, and 308 feet long; the bus tunnels will be 16 feet wide and 16 feet high.

Two sets of 345 kV SF6 gas-insulated busses will be taken to the surface by a single vertical shaft with an internal diameter of 9.0 feet. Provision will be made for installation of an inspection hoist in the shaft. A spare transformer will be located in the transformer gallery. The station service auxiliary transformers (2 MVA) and the surface auxiliary transformer (7.5/10 MVA) will be located in the bus tunnels. Generator excitation transformers will be located in the powerhouse on the main floor.

Vehicle access to the transformer gallery will be the main powerhouse access tunnel at the south end. Pedestrian access will be from the main access shaft or through each of the two isolated phase bus tunnels.

The transformer gallery will also be over-excavated by five feet similar to the powerhouse cavern bringing the total excavated Stage I length to 308 feet.

1.10.4 - Surge Chamber (**)

A surge chamber will be provided 120 feet downstream from the powerhouse cavern to control pressure fluctuations in the turbine draft tubes and tailrace tunnels under transient load conditions, and to provide storage of water for the machine start-up sequence. The chamber will be common to all four draft tubes, and will discharge into a tailrace tunnel. The overall surge chamber size is 290 feet long, 50 feet wide, and 150 feet high (including the draft tube gate gallery).

The draft tube gate gallery and crane will be located in the same cavern, above the maximum anticipated surge level. The crane has also been designed to allow installation of tailrace tunnel intake stoplogs for emergency closure of the tailrace tunnel.

The chamber will generally be an unlined rock excavation, with localized rock support as necessary for stability of the roof arch and walls. The gate guides for the draft tube gates and tailrace stoplogs will be embedded in reinforced concrete, and anchored to the rock by rock bolts.

Access to the draft tube gate gallery will be by an adit from the main access tunnel. This access will be widened locally for storage of tailrace tunnel intake stoplogs.

1.10.5 - Grouting and Pressure Relief System (**)

Control of seepage in the powerhouse area will be achieved by a grout curtain upstream from the transformer gallery and an arrangement of drain holes downstream from this curtain. In addition, drain holes will be drilled from the caverns extending to a depth greater than the rock anchors. Seepage water will be collected by surface drainage channels and directed into the powerhouse drainage system.

1.10.6 - SF6 Gas Insulated Bus Shaft (**)

The SF6 gas-insulated bus shaft will be 9 feet internal diameter. Although not required for rock stability, a 9-inch thick concrete lining has been specified for convenience of installing hoist, stairway and cable supports.

1.10.7 - Draft Tube Tunnels (**)

The draft tube tunnels will be shaped to provide a transition to a uniform horseshoe section with a 19-foot diameter and a concrete lining approximately two feet thick. The initial rock support will be concentrated at the junctions with the powerhouse and surge chamber where the two free faces give greatest potential for block instability.

1.11 - Tailrace (**)

The tailrace pressure tunnel will be provided to carry water from the surge chamber to the river. The tunnel will have a modified horseshoe cross section with a major internal dimension of 34 feet.

The tunnel will be fully concrete-lined throughout, with a minimum concrete thickness of 18 inches and a length of 1,430 feet. The tailrace tunnel will be arranged to discharge into the river between the dam and spillway. The tunnel will start at the downstream wall of the surge chamber and then turn parallel to it until joining the penstock construction adit. The tunnel portal will be used for the tailrace outlet. The tunnel will be concrete-lined for hydraulic considerations. A rock berm will be left in place to the south of the portal to separate the outlet and diversion tunnel channels.

The tailrace portal will be a reinforced concrete structure designed to reduce the outlet flow velocity, and hence the velocity head loss at the exit to the river.

1.12 - Main Access Plan (**)

1.12.1 - Access Objectives (*)

The primary objective of access is to provide a transportation system that will support construction activities and allow for the orderly development and maintenance of site facilities.

1.12.2 - Access Plan Selection (**)

Detailed access studies resulted in the development of eighteen alternative access plans within three distinct corridors. The three corridors were identified as:

- A corridor running west to east from the Parks Highway to the damsites on the north side of the Susitna River;
- A corridor running west to east from the Parks Highway to the damsites on the south side of the Susitna River; and
- A corridor running north to south from the Denali Highway to the Watana damsite.

Criteria were established to evaluate the responsiveness of the plans to project objectives and the desires of the resource agencies and affected communities. The selected access plan (Plan 18, otherwise referred to as Denali-North) represents the most favorable solution to meeting both project related goals and minimizing impacts to the environment and the surrounding communities. Where adverse environmental impacts are unavoidable or project objectives compromised, mitigation and management measures have been formulated to reduce these impacts to a minimum. These mitigation measures are outlined in detail within Exhibit E of the license application.

1.12.3 - Description of Access Plan (**)

Access to the Watana damsite will connect with the existing Alaska Railroad at Cantwell where a railhead and storage facility occupying 40 acres will be constructed. This facility will act as the transfer point from rail to road transport and as a storage area for backup supply of materials and equipment. From the railhead facility the road will follow an existing route to the junction of the George Parks and Denali Highways (a distance of two miles), then proceed in an easterly direction for a distance of 21.3 miles along the Denali Highway. A new road, 41.6 miles in length, will be constructed from this point due south to the Watana camp site. On completion of the dam, access to Native lands on the south side of the Susitna River will be provided from the Watana camp site with the road crossing along

the top of the dam. This will involve the construction of an additional 2.6 miles of road bringing the total length of new road to 44.2 miles.

Plate F2 shows the proposed access plan route. Plate F3 shows details, for both the Watana and Devil Canyon developments, of typical road and railroad cross sections, railhead facilities, and the high-level bridge at Devil Canyon.

Assessment of projected traffic volumes and loadings during construction resulted in the selection of the following design parameters for the access roads.

Surfacing	Unpaved (Treated Gravel Surface)
Width of Running Surface	24 feet
Shoulder Width	4 feet
Design Speed	50 mph
Maximum Grade	5%
Maximum Curvature	$6\ ^3/_4°$
Stopping Site Distance	475 feet
Design Loading	
- during construction	80^k axle, 200^k total
- after construction	HS - 20

These design parameters were chosen for the efficient, economical, and safe movement of supplies and are in accordance with Federal Department of Transportation design standards.

In the community of Cantwell the road will be paved from the marshalling yard to four miles east of the junction of the George Parks and Denali Highways. This will eliminate any problem with dust and flying stones in the residential district. In addition, the following measures will be taken:

- o Speed restrictions will be imposed along the above segment;
- o A bike path will be provided along the same segment to safeguard children in transit to and from a school which is situated close to the road; and
- o Improvements will be made to the intersection of the George Parks and Denali Highways including pavement markings and traffic signals.

1.12.4 - Right-of-Way (**)

The 21.3 miles of existing road along the Denali Highway will be upgraded to approximately the aforementioned standards. The present alignment is such that any realignment required should be possible within the existing easement.

The majority of the new road will follow terrain and soil types which allow construction using side borrow techniques, resulting in a minimum of disturbance to areas away from the alignment. A berm type cross section will be formed, with the crown of the road being approximately two to three feet above the elevation of adjacent ground. To reduce the visual impact, the side slopes will be flattened and covered with excavated peat material. A 200-foot right-of-way will be sufficient for this type of construction. Although sidehill cuts must be minimized to avoid the effects of thawing permafrost and winter icing on the section of road running parallel to Deadman Creek, in isolated spots of extensive sidehill cutting it may be necessary to exceed the 200-foot width.

1.12.5 - Construction Schedule (**)

The overall schedule for the Watana development relies heavily on the ability to move supplies, materials and equipment to the site as soon as possible after the start of project construction. The selected plan involves the least mileage of new road construction and follows relatively level, open terrain in comparison with the alternative routes in the two other corridors. Consequently, construction of this route has the highest probability of meeting schedule and hence affords the least risk of project delay. It has been estimated that it will take approximately 1.5 years to construct the access road. One year will be required for completion and upgrading of the Denali Highway section.

1.13 - Site Facilities (**)

1.13.1 - General (**)

The construction of the Watana development will require various facilities to support the construction activities throughout the entire construction period. Following construction, the operation of the Watana hydroelectric development will require certain permanent staff and facilities to support the permanent operation and maintenance program.

The most significant item among the site facilities will be a construction camp and village that will be constructed and maintained at the project site. The camp/village will be a largely self- sufficient community housing up to 3,300 people during construction of the project. After Stage I construction is complete, it is planned to demobilize most of the camp facility for later use. The buildings and other items from the camp will be used during construction of Stage III. Other site facilities include contractors' work areas, site power, services, and communications. Items such as power and communications will

be required for construction operations independent of camp operations. The same will be true regarding a hospital or first-aid room.

Permanent facilities required will include a permanent town or small community for approximately 130 staff members and their families. Other permanent facilities will include maintenance buildings for use during subsequent operation of the power plant.

A conceptual plan for the permanent town is shown on Plate F37.

1.13.2 - <u>Temporary Camp and Village</u> (**)

The proposed location of the construction camp and village will be on the north bank of the Susitna River near Deadman Creek, approximately six miles northeast of the Watana Dam. The north side of the Susitna River was chosen because the main access will be from the north and south-facing slopes can be used for siting the structures. The location is shown in Plate F34.

The construction camp will consist of woodframe dormitories with mess halls, recreational buildings, bank, post office, fire station, warehouses, hospital, offices, etc. The camp will accommodate approximately 3,000 workers.

The village, accommodating approximately 300 families, will be grouped around a service core containing a school, gymnasium, stores, and recreation area.

The village and construction camp areas will be separated to provide a buffer zone between areas. The hospital will serve both the main camp and village.

The camp location will be separated from the work areas by approximately three miles. Travel time to the work area will generally be less than 15 minutes.

The camp/village will be constructed in stages to accommodate the peak work force. The facilities have been designed for the peak work force plus 10 percent for turnover. The turnover will include allowances for overlap of workers and vacations. The conceptual layouts for the camp and village are presented on Plates F36 and F37.

(a) <u>Site Preparation</u> (**)

Both the camp and the village areas will be cleared and in certain areas filter fabric may be installed and granular material placed over it for building foundations. At the

village site, selected areas will be left with trees and natural vegetation intact. Topsoil stripped from Borrow Site D will be utilized to reclaim camp and village sites.

Both the construction camp and the village site have been selected to provide well-drained land.

(b) Facilities (**)

Construction camp buildings will consist largely of factory-built modules assembled on site to provide the various facilities required. The modules will be fabricated complete with heating, lighting and plumbing services, interior finishes, furnishings, and equipment. Larger structures such as the central utilities building, warehouses and hospital will be pre-engineered, steel-framed structures with metal cladding.

1.13.3 - Permanent Town (**)

The permanent town which will be utilized during construction is designed around a small lake for aesthetic purposes. The permanent town will consist of permanently constructed buildings. The various buildings in the permanent town are as follows:

- Single family dwellings;
- Multi-family dwellings;
- Hospital;
- School;
- Fire station;
- A town center will be constructed and will contain the following: 1) a recreation center; 2) a gymnasium and swimming pool; and, 3) a shopping center.

1.13.4 - Site Power and Utilities (**)

(a) Power (**)

A 34.5 kV transmission line from the Cantwell substation will follow the Denali Highway and the access road to Watana for servicing during the Stage I construction activities. Two transformers will be installed at a Watana substation to reduce the line voltage to the desired voltage levels.

The peak demand during the peak camp population year is estimated at 20 MW for the camp/village and four MW for construction requirements. The distribution system in the camp/village and construction area will be 4.16 kV.

Power for the permanent town and during Stage III construction, will be supplied by station service system after the power plant is in operation.

(b) Water (**)

The water supply system will provide for potable water and fire protection for the camp/village and selected contractors' work areas. The estimated peak population to be served will be 3,338 (2,315 in the camp and 1,023 in the village).

The principal source of water will be Deadman Creek, with a backup system of wells drawing on ground water. The water will be treated in accordance with the U.S. Environmental Protection Agency's (EPA) primary and secondary requirements, and Drinking Water Standards of the State of Alaska, Department of Environmental Conservation (ADEC).

A system of pumps and storage reservoirs will provide the necessary system capacity. The distribution system will be contained within utilidors constructed using plywood box sections integral with the permawalks.

(c) Wastewater (**)

A wastewater collection and treatment system will serve the camp/village. One treatment plant will serve the camp/village. Gravity flow lines with lift stations will be used to collect the wastewater from all of the camp and village facilities. The "in-camp" and "in-village" collection systems will be run through the utilidors so that the collection system will be protected from freezing.

The chemical toilets located around the construction site will be serviced by sewage trucks, which will discharge directly into the sewage treatment plant. The sewage treatment system will be a biological system with lagoons designed to meet Alaska ADEC and Federal EPA standards. The sewage plant will discharge its treated effluent through a force main to Deadman Creek. All treated sludge will be disposed in a solid waste sanitary landfill.

The location of the treatment plant is shown in Plate F37. The location was selected to avoid unnecessary odors in the camp.

1.13.5 - Contractors' Area (**)

The on-site contractors facilities will require office, shop, and general work areas. Partial space required by the contractors for fabrication shops, maintenance shops, storage or warehouses, and work areas will be located between the main camp and the dam site road.

1.14 - Relict Channel (***)

A relict channel exists on the north bank of the Watana reservoir approximately 2,600 feet upstream from the dam. This channel runs from the Susitna River gorge to Tsusena Creek, a distance of about 1.5 miles. The surface elevation of the lowest saddle is approximately 2,210. Depths of up to 454 feet of glacial deposits have been identified. The maximum average hydraulic gradient along any flow path in the buried channel from the edge of the Stage I pool (el. 2,000) to Tsusena Creek is approximately two percent. Tsusena Creek at the relict channel outlet area is at least 120 feet above the natural river level. There are several surface lakes within the channel area, and some artesian water is present in places. Zones of permafrost have also been identified throughout the channel area.

To insure the integrity of the rim of the Watana reservoir and to control losses due to potential seepage, a number of conditions have been evaluated. Study types include settlement of the reservoir rim, subsurface flows, permafrost and liquefaction during earthquakes.

1.14.1 - Surface Flows (**)

Based on information gained from past exploration programs, the relict channel soils are either dense or cohesive and as such are not deemed to be subject to settlement resulting for seismic shaking. Therefore the low ground surface in the relict channel area will more than provide adequate freeboard as it is 185 feet above the Stage I dam crest which is el. 2,025.

1.14.2 - Subsurface Flows (**)

During Stage I, the potential for progressive piping and erosion in the area of discharge into the Tsusena Creek will be controlled by the placement of properly graded granular materials to form a filter blanket over any zones of emergence. Further field investigations will be carried-out to fully define critical areas, and only such areas will be treated. Subsequent to Stage I, the relict channel will receive continuous monitoring of the outlet area for a lengthy period after reservoir filling to ensure that a state of equilibrium is established with respect to permafrost and seepage gradients in the buried channel area.

1.14.3 - Permafrost (**)

Thawing of permafrost will occur in portions of the relict channel area. This thawing will have minimum impact on subsurface flows and ground settlement. Although no specific remedial work is foreseen; flows, groundwater elevation, and ground surface elevation in the buried channel area will be carefully and continuously monitored by means of appropriate instrumentation systems and any necessary maintenance work carried out to maintain freeboard and control seepage discharge.

1.14.4 - Liquefaction (***)

Underground information compiled to date indicates that the buried channel area is filled with outwash, glacial till and lacustrine deposits. Initial evaluations, outlined in the original license application indicated concern in regard to the upper outwash deposits because they did not appear dense enough to resist seismic shaking without experiencing considerable loss in stability.

The most likely prospects for liquefaction are saturated foundations consisting of fine grained, poorly graded, cohesionless deposits (sands and silts), that are not laterally confined and are loose or only moderately dense. Based on the Winter 1983 Exploration Program (HE 1983) and all other assembled data, an assessment of the liquefaction potential of the relict channel area indicates the deposits are either well graded, dense to very dense or cohesive and therefore have very low potential for liquefaction. Consequently no remedial measures are currently considered necessary as a precaution against the effects of liquefaction.

Further geotechnical studies will be carried out during Stage I design to fully define the extent and characteristics of the materials in the relict channel. Should this information indicate a potential problem, provisions will be made for treatment to cover the conditions identified.

1.14.5 - Remedial Work Influence on Construction Schedules (***)

Relict channel remedial treatment construction work, if necessary, will have practically no impact on the Watana Dam construction schedule. Because the relict channel work will be located in proximity to Borrow Site D, some coordination will be required between these two operations. Once this coordination has been accomplished, dam construction and the relict channel work can proceed concurrently.

1.14.6 - Relict Channel Treatment (***)

During future design investigations, additional boreholes and inspection trenches will be employed to further delineate the relict channel foundation. The area will be studied during Borrow Site D excavation. The area will also be thoroughly monitored by observation devices during the Stage I reservoir filling to assess actual hydrological conditions in the relict channel. In response to the unlikely event that construction remedial measures are considered necessary following those observations and data assessment, a positive remedial treatment such as a downstream toe drain will be employed.

2 - RESERVOIR DATA - WATANA STAGE I (**)

The Watana Reservoir, at normal operating level of 2,000 feet (mean sea level), will be approximately 39 miles long with a maximum width of approximately two miles. The total water surface area at normal operating level is 20,000 acres. The minimum reservoir level will be 1,850 feet during normal operation, resulting in a maximum drawdown of 150 feet. The reservoir will have a total capacity of 4.3 million acre-feet, of which 2.4 million acre-feet will be live storage.

3 - TURBINES AND GENERATORS - WATANA STAGE I (**)

3.1 - Unit Capacity (**)

The Watana powerhouse will have four generating units, each with a maximum generator output of 125 MW in Stage I corresponding to the maximum normal reservoir level (elevation 2,000) and a corresponding net head of 537 feet. The Stage I turbines will be designed to operate in Stage III without modification, and the turbines and generating units will therefore be capable of higher outputs when the head is raised in Stage III. Unit characteristics including generator outputs are described in Table F.1.

The net head on the plant will vary from 384 feet to approximately 537 feet in Stage I. This will increase to a maximum of 719 feet in Stage III with a corresponding increase in generating capacity.

The turbine design net head has been established at 590 feet to meet the operating requirements of Stage I and Stage III.

The generator rating has been selected as 223 MVA with a 90 percent power factor to match with the maximum turbine output of 204 MW under a net head of 719 feet at the third stage. The generator output is assumed to be 98% of the turbine output at full load.

3.2 - Turbines (***)

The turbines will be of the vertical-shaft Francis type with steel spiral casing and a steel lined concrete elbow-type draft tube. The draft tube will comprise a single water passage without a center pier.

The output of the turbine will be 150 MW at 590 feet design net head. Maximium and minimum net operating heads on the units will be 537 feet and 384 feet, respectively. The full gate output of each turbine will be approximately 128 MW at 537 feet net head and approximately 66 MW at 384 feet net head. For study purposes, the best efficiency (best-gate) output of the turbines has been assumed as 85 percent of the full gate turbine output.

Each turbine will be provided with a 12.5-foot diameter straight-flow type butterfly valve. These guard valves will be located within the powerhouse, just upstream of the turbines.

3.3 - Generators (**)

3.3.1 - Type and Rating (**)

Each of the four generators in the Watana powerhouse will be of the vertical-shaft, overhung type directly connected to a vertical Francis turbine.

There will be two generators per transformer bank, with each transformer bank comprising three single-phase transformers. The

generators will be connected to the transformers by isolated phase bus through generator circuit breakers.

Each generator will be provided with a high initial response static excitation system. The units will be controlled from the Watana surface control room, with local control facility also provided at the powerhouse floor. The units will be designed for black start operation.

The generators will be rated as follows to accomodate Stage I and Stage III operating conditions:

Rated Capacity	223 MVA, 0.9 power factor
Rated Power	200 MW
Rated Voltage	15 kV, 3 phase, 60 Hertz
Synchronous Speed	257 rpm
Inertia Constant	3.5 MW-sec/MVA
Transient Reactance	32 percent (calculated)
Short Circuit Ratio	1.1 (minimum)
Efficiency at Full Load	98 percent (minimum)

The generators will be of the air-cooled type, with water-to-air heat exchangers located on the stator periphery. The ratings given above are for a temperature rise of the stator and rotor windings not exceeding 75°C with cooling air at 40°C in accordance with ANSI C50.10, General Requirements for Synchronous Machines.

The generators will operate successfully at rated kVA, frequency, and power factor at any voltage not more than five percent above or below rated voltage.

3.3.2 - Unit Dimensions (**)

Approximate dimensions and weights of the principal parts of the generator are given below:

Stator pit diameter	38 feet
Rotor diameter	24 feet
Rotor length (without shaft)	7 feet
Rotor weight	385 tons
Total weight	740 tons

It should be noted that these are approximate figures and they will vary between manufacturers.

3.3.3 - Generator Excitation System (**)

The generator will be provided with a high initial response type static excitation system supplied with rectified excitation

power from transformers connected directly to the generator terminals. The excitation system will be capable of supplying 200 percent of rated excitation field (ceiling voltage) with a generator terminal voltage of 70 percent. The power rectifiers will have a one-third spare capacity to maintain generation even during failure of a complete rectifier module.

The excitation system will be equipped with a fully static voltage regulating system maintaining output from 30 percent to 115 percent, within ± 0.5 percent accuracy of the voltage setting. Manual control will be possible at the excitation board located on the powerhouse floor, although the unit will normally be under remote control.

3.4 - Governor System (o)

The governor system which controls the generating unit will include a governor actuator and a governor pumping unit. A single system will be provided for each unit. The governor actuator will be the electric hydraulic type and will be connected to the computerized station control system.

4 - APPURTENANT MECHANICAL AND ELECTRICAL EQUIPMENT - WATANA STAGE I (**)

4.1 - Miscellaneous Mechanical Equipment (**)

4.1.1 - Powerhouse Cranes (*)

Two overhead traveling-bridge type powerhouse cranes will be installed in the powerhouse. The cranes will be used for:

- o Installation of turbines, generators, and other powerhouse equipment; and
- o Subsequent dismantling and reassembly of equipment during maintenance overhauls.

Each crane will have a main and auxiliary hoist. The combined capacity of the main hoist for both cranes will be sufficient for the heaviest equipment lift, which will be the generator rotor, plus an equalizing beam. A crane capacity of 200 tons has been established. The auxiliary hoist capacity will be about 25 tons.

4.1.2 - Draft Tube Gates (**)

Draft tube gates will be provided to permit dewatering of the turbine water passages for inspection and maintenance of the turbines. The draft tube gate openings (one opening per unit) will be located in the surge chamber. The gates will be of the bulkhead type, installed under balanced head conditions using the surge chamber crane. Four sets of gates have been assumed for the four units. Each gate will be 20 feet wide by 10 feet high.

4.1.3 - Surge Chamber Gate Crane (*)

A crane will be installed in the surge chamber for installation and removal of the draft tube gates as well as the tailrace tunnel intake stoplogs. The crane will have a capacity of approximately 30 tons.

4.1.4 - Miscellaneous Cranes and Hoists (**)

In addition to the powerhouse cranes and surge chamber gate crane, the following cranes and hoists will be provided in the power plant:

- o A five-ton monorail hoist in the transformer gallery for transformer and SF6 gas-insulated equipment maintenance;

- A four-ton monorail hoist in the circuit breaker gallery for handling the generator circuit breakers;
- Small overhead jib or A-frame type hoists in the machine shop for handling material; and
- A-frame or monorail hoists for handling miscellaneous small equipment in the powerhouse.

4.1.5 - Elevators (**)

Access and service elevators will be provided for the power plant as follows:

- An access elevator from the control buildings to the powerhouse;
- A service elevator in the powerhouse service bay; and
- Inspection hoists in the SF6 gas insulated bus shaft.

4.1.6 - Power Plant Mechanical Service Systems (**)

The power plant mechanical service systems installed under Stage I will provide for future expansion under Stage III. The various systems common to all units will be designed to permit the necessary increase in capacity and the extension of piping and duct work to provide service to units added in Stage III.

(a) Station Water Systems (o)

The station water systems will include the water intake, cooling water systems, turbine seal water systems, and domestic water systems. The water intakes will supply water for the various station water systems in addition to fire protection water.

(b) Fire Protection System (**)

The power plant fire protection system will consist of fire hose stations located throughout the powerhouse, transformer gallery, and bus tunnels; sprinkler systems for the transformers and the oil rooms; CO_2 systems for the generators; and portable fire extinguishers located in strategic areas of the powerhouse and transformer gallery. A fire protection head tank has been indicated adjacent to the access shaft, 250 feet above the powerhouse roof level, but a pumping system may be adopted during detailed design.

(c) Compressed Air Systems (**)

Compressed air will be required in the powerhouse for the following:

- o Service air;
- o Instrument air;
- o Generator brakes;
- o Draft tube water level depression;
- o 345 kV SF6 gas insulated circuit breakers;
- o Generator circuit breakers; and
- o Governor accumulator tanks.

For the preliminary design, two compressed air systems have been assumed: a 100-psig air system for service air, brake air, and air for draft tube water level depression; and a 1,000-psig high-pressure air system for governor air. During detailed plant design, separate air systems for 345 kV SF_6 gas insulated circuit breakers and generator circuit breakers will be provided.

(d) Oil Storage and Handling (**)

Facilities will be provided for replacing oil in the transformers and for topping-off or replacing oil in the turbine and generator bearings and the governor pumping system. For preliminary design purposes, two oil rooms have been included, one in the transformer gallery and one in the powerhouse service bay. An oil separation sump has been indicated adjacent to unit/drainage sumps.

(e) Drainage and Dewatering Systems (**)

The drainage and dewatering systems will consist of:

- o A unit dewatering and filling system
- o A clear water discharge system
- o A sanitary drainage system.

The unit dewatering and filling systems will consist of two sumps each with two dewatering pumps and associated piping and valves from each of the units. To prevent station flooding, the sump will be designed to withstand maximum tailwater pressure. A valved draft tube drain line will connect to a dewatering header running below the drainage gallery. The spiral case will be drained by a valved line connecting the spiral case to the draft tube. It will be necessary to insure that the spiral case drain valve is not open when the spiral case is pressurized to headwater level. The dewatering pump discharge line will discharge water into

the surge chamber. The general procedure for dewatering a unit will be to close the butterfly guard valve, drain the penstock to tailwater level through the unit, then open the draft tube and spiral case drains to dewater the unit. Because the drainage dewatering header is below the bottom of the draft tube elbow, it will be possible to completely dewater the draft tube through the dewatering header.

Unit filling to tailwater level will be accomplished from the surge chamber through the dewatering pump discharge line (with a bypass around the pumps) and then through the draft tube and spiral case drain lines. Alternatively, the unit can be filled to tailwater level through the draft tube drain line from an adjacent unit. Filling the unit to headwater pressure will be accomplished by opening the butterfly guard valve.

(f) Heating, Ventilation, and Cooling (**)

The heating, ventilation, and cooling system for the underground power plant will be designed primarily to maintain suitable temperatures for equipment operation and to provide a safe and comfortable atmosphere for operating and maintenance personnel. The access shaft, vent shaft, and the access tunnel will be utilized for air circulation.

The power plant will be located in mass rock which has a constant year-round temperature of about 40°F. Considering heat given off from the generators and other equipment, the primary requirement will be for air cooling. Initially, some heating will be required to offset the heat loss to the rock, but after the first few years of operation an equilibrium will be reached with a powerhouse rock surface temperature of about 60 to 70°F.

4.1.7 - Surface Facilities Mechanical Service Systems (*)

The mechanical services at the control center on the surface will include:

- o A heating, ventilation, and air conditioning system for the control room;
- o Domestic water and washroom facilities; and
- o A halon fire protection system for the control room.

Domestic water will be supplied from the powerhouse domestic water system, with pumps located in the powerhouse and piping up through the access shaft. Sanitary drainage from the control

center will drain to the sewage treatment plant in the powerhouse through piping in the access tunnel.

The standby generator building will have the following services:

- o A heating and ventilation system;
- o A fuel oil system with buried fuel oil storage tanks outside the building, and transfer pumps and a day tank within the building; and
- o A fire protection system of the carbon dioxide or halon type.

4.1.8 - Machine Shop Facilities (o)

A machine shop and tool room will be located in the powerhouse service bay area with sufficient equipment to take care of all normal maintenance work at the plant, as well as machine shop work for the larger components at Devil Canyon.

4.2 - Accessory Electrical Equipment (**)

The accessory electrical equipment described in this section includes the following:

- o Main generator step-up 15/345 / 1.73 kV transformers,
- o Isolated phase bus connecting the generator and transformers,
- o Generator circuit breakers,
- o 345 kV SF6 busses from the transformer terminals to the transmission yard,
- o Control systems of the entire hydro plant complex, and
- o Station service auxiliary ac and dc systems.

Other equipment and systems described include grounding, lighting system, and communications.

The main equipment and connections in the power plant are shown in the single line diagram, Plate F30. The arrangement of equipment in the powerhouse, transformer gallery, and vertical shaft is shown on Plates F25 through F27.

4.2.1 - Transformers and HV Connections (**)

Six single-phase transformers and one spare transformer will be located in the transformer gallery. Each bank of three single-phase transformers will be connected to two generators through generator circuit breakers by an isolated phase bus located in individual bus tunnels. The H.V. bushings of the single-phase transformers will be of the SF6 to oil type. These

bushings will be star-connected by the SF6 compressed gas-insulated (CGI) bus system at 345 kV and to the gas-insulated switchgear (GIS). Two sets of CGI busses will be carried from the GIS to the surface through a single vertical shaft. Each set of busses consists of three single-phase busses sized to have sufficient capacity to carry the entire plant output. The buses will be terminated at the surface SF6-to-air entrance bushings where they will be connected to the two overhead transmission lines. The vertical shaft will be nine feet I.D. and about 530 feet high and will also contain the control and power cables between the powerhouse and the surface to the underground facilities.

The area at the surface, above the cable shaft, will accommodate conventional open-air equipment such as surge arresters, coupling capacitor voltage transformers, line traps and take-off structures for overhead transmission lines.

4.2.2 - Main Transformers (**)

The six single-phase transformers (three transformers per group of two generators) and one spare transformer will be of the two-winding, oil-immersed, forced-oil water-cooled (FOW) type, with ratings and electrical characteristics as follows:

Rated capacity	150 MVA
High voltage winding	345 /1.73 kV, Grounded Y
Basic insulation level (BIL) of H.V. winding	1300 kV
Low voltage winding	15 kV, Delta
Basic insulation level (BIL) of L.V. winding	95 kV
Taps H.V. winding at rated MVA	2-1/2% and 5% above and 2-1/2% and 5% below rated voltage
Transformer impedance	15 percent

The temperature rise above ambient (40°C) will be 55°C for the windings for continuous operation at the rated MVA.

To minimize fire hazard, each single-phase transformer will be separated by fire walls and will be provided with an automatic deluge system.

4.2.3 - Generator Isolated Phase Bus (**)

The isolated phase bus main connections will be located between the generator, generator circuit breaker, and the transformer.

Tap-off connections will be made to the surge protection and potential transformer cubicle, excitation transformers, and station service transformers. Bus duct ratings are as follows:

	Generator Connection	Transformer Connection
Rated current, amps	9,000	18,000
Short circuit current momentary, amps	240,000	240,000
Short circuit current, symmetrical, amps	150,000	150,000
Basic insulation level, kV (BIL)	110	110

The bus conductors will be designed for a temperature rise of 65°C above 40°C ambient. The short circuit ratings are tentative, and will depend on detailed analysis in the design stage.

4.2.4 - Generator Circuit Breakers (**)

The generator circuit breakers will be enclosed air circuit breakers suitable for mounting in line with the generator isolated phase bus ducts. They are rated as follows:

Rated Current	9,000 Amps
Voltage	24 kV class, 3-phase, 60 Hertz
Breaking capacity, symmetrical, amps	150,000

The short circuit rating is tentative and will depend on detailed analysis in the design stage.

4.2.5 - This section deleted.

4.2.6 - Control Systems (**)

(a) General (*)

A Susitna Area Control Center will be located at Watana to control both the Watana and the Devil Canyon power plants. The control center will be linked through the supervisory system to the Central Dispatch Control Center at Willow as described in Exhibit B, Section 3.6.

The supervisory control of the entire Alaska Railbelt system will be at the Central Dispatch Center in Willow. Using digital computers a high level of automation will be sought. However, complete computerized control of the Watana and Devil Canyon power plants will not be used. Independent operator controlled local-manual and local-auto operations

will still be possible at Watana and Devil Canyon power plants for testing/commissioning or during emergencies. The control system will be designed to perform the following functions at both power plants:

- o Start/stop and loading of units by operator;
- o Load-frequency control of units;
- o Reservoir/water flow control;
- o Continuous monitoring and data logging;
- o Alarm annunciation; and
- o Man-machine communication through visual display units (VDU) and console.

In addition, the computer system will be capable of retrieval of technical data, design criteria, equipment characteristics and operating limitations, schematic diagrams, and operating/ maintenance records of the unit.

The Susitna Area Control Center will be capable of completely independent control of the Central Dispatch Center in case of system emergencies. Similarly it will be possible to operate the Susitna units in an emergency from the Central Dispatch Center, although this should be an unlikely operation considering the size, complexity, and impact of the Susitna generating plants on the system.

The Watana and Devil Canyon plants will be capable of "black start" operation in the event of a complete blackout or collapse of the power system. The control systems of the two plants and the Susitna Area Control Center complex will be supplied by a non-interruptible power supply.

(b) Unit Control System (*)

The unit control system will permit the operator to initiate an entire sequence of actions by pushing one button at the control console, provided all preliminary plant conditions have been first checked by the operator, and system security and unit commitment have been cleared through the central dispatch control supervisor. Unit control will be designed to:

- o Start a unit and synchronize it with the system,
- o Load the unit,
- o Stop a unit,
- o Operate a unit as spinning reserve (runner in air with water depressed in turbine and draft tube), and
- o Operate as a synchronous condenser (runner in air as above).

(c) Computer-Aided Control System (o)

The computer-aided control system at the Susitna Area Control Center at Watana will provide for the following:

- o Data acquisition and monitoring of units (MW, MVAR, speed, gate position, temperatures, etc.);
- o Data acquisition and monitoring of reservoir headwater and tailwater levels;
- o Data acquisition and monitoring of electrical system voltage and frequency;
- o Load-frequency control;
- o Unit start/stop control;
- o Unit loading;
- o Plant operation alarm and trip conditions (audible and visual alarm on control board, full alarm details on VDU on demand);
- o General visual plant operation status on VDU and on large wall mimic diagram;
- o Data logging, plant operation records;
- o Plant abnormal operation or disturbance automatic recording; and
- o Water management (reservoir control).

(d) Local Control and Relay Boards (o)

Local boards will be provided at the powerhouse floor equipped with local controls, alarms, and indications for all unit control functions. These boards will be located near each unit and will be utilized mainly during testing, commissioning, and maintenance of the turbines and generators. They will also be utilized as needed during emergencies if there is a total failure of the remote or computer- aided control systems.

(e) Load-Frequency Control (o)

The load-frequency system will provide remote control of the output of the generator at Watana and Devil Canyon from

the central dispatch control center through the supervisory and computer-aided control system at Watana. The basic method of load-frequency control will use the plant error (differential) signals from the load dispatch center and will allocate these errors to the power plant generators automatically through speed-level motors. Provision will be made in the control system for the more advanced scheme of a closed-loop control system with digital control of generator power.

The control system will be designed to take into account the digital nature of the controller-timed pulses as well as the inherent time delays caused by the speed-level motor runup and turbine-generator time constants.

4.2.7 - Station Service Auxiliary AC and DC Systems (**)

(a) Auxiliary AC System (**)

The station service system will be designed to achieve a reliable and economic distribution system for the power plant to satisfy the following requirements:

- Station service power at 480 volts will be obtained from two 2,000 kVA auxiliary transformers connected directly to the generator circuit breaker outgoing leads of Units 1 and 3;

- Surface auxiliary power at 34.5 kV will be supplied by two separate 7.5/10 MVA transformers connected to the generator leads of Units 1 and 3;

- Station service power will be maintained even when all units are shut down and the generator circuit breakers are open;

- 100 percent standby transformer capacity will be available;

- "Black start" capability will be provided for the power plant in the event of total failure of the auxiliary supply system, and 500 kW emergency diesel generators will be automatically started to supply the power plant with auxiliary power to the essential services to enable start-up of the generators.

The main ac auxiliary switchboard will be provided with two bus sections separated by bus-tie circuit breakers. Under normal operating conditions, the station-service load is divided and connected to each of the two-end incoming

transformers. In the event of failure of one end supply, the tie breakers will close automatically. If both end supplies fail, the emergency diesel generator will be automatically connected to the station service bus.

Each unit will be provided with a unit auxiliary board supplied by separate feeders from the two bus section feeder from the two bus section of the main switchboard interlocked to prevent parallel operation. Separate ac switchboards will furnish the auxiliary power to essential and general services in the power plant.

The unit auxiliary board will supply the auxiliaries necessary for starting, running, and stopping the generating unit. These supplies will include those to the governor and oil pressure system, bearing oil pumps, cooling pumps and fans, generator circuit breaker, excitation system, and miscellaneous pumps and devices connected with unit operation.

The 34.5 kV supply to the surface facilities will be distributed from a 34.5 kV switchboard located in the surface control and administration building. Power supplies to the power intake and spillway as well as the lighting systems for the access roads and tunnels will be obtained from the 34.5 kV switchboard.

The two 2000 kVA, 15,000-480 volt stations will have service transformers of the three-phase, dry-type, sealed gas-filled design. The two 7.5/10 MVA, 15-34.5 kV transformers will be of the three-phase oil-immersed OA/FA type.

Emergency diesel generators, each rated 500 kW, will separately supply the 480 volt and 34.5 kV auxiliary switchboards during emergencies. Both diesel generators will be located in the surface control building.

An uninterruptible high security power supply will be provided for the computer control system.

(b) DC Auxiliary Station Service System (*)

The dc auxiliary system will supply the protective relaying, supervisory, alarm, control, tripping and indication circuit in the power plant. The generator excitation system will be started with "flashing" power from the dc battery. The dc auxiliary system will also supply the emergency lighting system at critical plant locations.

4.2.8 - Grounding System (o)

The power plant grounding system will consist of one mat under the power plant, one mat under the transformer gallery, risers, and connecting ground wires. Grounding grids will also be included in each powerhouse floor.

4.2.9 - Lighting System (*)

The lighting system in the powerhouse will be supplied from 480-208/120 volt lighting transformers connected to the general ac auxiliary station service system. An emergency lighting system will be provided at the power plant and at the control room at all critical operating locations.

4.2.10 - Communications (o)

The power plant will be furnished with an internal communications system, including an automatic telephone switchboard system. A communication system will be provided at all powerhouse floors and galleries, transformer gallery, access tunnels and cable shafts, power intake structures, draft tube gate area, main spillway, dam, outlet facilities, and emergency release facilities.

4.3 - SF6 Gas-Insulated 345 kV Substation (GIS) (***)

The substation provides switching for the two transformer banks and two transmission lines. Four circuit breaker positions arranged in a ring bus switching scheme will be provided as shown in the single line diagram, Plate F31. This arrangement provides the desired switching flexibility and reliability of service required by the adopted system reliability criteria. Disconnecting and grounding switches as well as voltage transformers will be provided for each of the four circuits.

Since the conventional surge arresters do not have the reach to protect the GIS and transformers, metal-enclosed surge arresters will be provided at the end of the CGI buses.

The GIS will consist of two sections. One of the two sections contain three circuit breaker positions for two circuits (line/transformer) and one section contains one circuit breaker position for two circuits (line/transformer). Each of the sections will be installed in the area between the main transformer banks and connected to busses located on the downstream wall of the transformer gallery.

Provisions will be made for future extension and changing the ring bus to a breaker-and-a-half switching scheme.

5 - TRANSMISSION FACILITIES FOR WATANA STAGE I (**)

5.1 - Transmission Requirements (o)

The purpose of the project transmission facilities will be to deliver power from the Susitna River basin generating plants to the major load centers at Anchorage and Fairbanks. The transmission system is to deliver power to the load centers in an economical and reliable manner.

The facilities will consist of overhead transmission lines, under-water cables, switchyards, substations, a load dispatch center, and a communications system. Construction of the transmission facilities will be staged to provide reliable operations from each of the three stages of the development. The design will provide for delivery of power to one substation in Fairbanks, one substation at Willow, and two substations in Anchorage. As the power generated by the Watana Stage I hydroelectric station will be used to serve all the substations noted above, the associated transmission facilities will extend over the full length of the corridor. Later when Devil Canyon Stage II and Watana Stage III are developed, the facilities will be supplemented with additional components along some parts of the corridor.

5.2 - Description of Facilities (o)

5.2.1 - Corridor (o)

The corridor that the transmission lines will follow as they leave the generating plants is generally westward, following the Susitna River valley to Gold Creek near the Alaska Railroad route. At Gold Creek, the corridor divides to provide for lines north to Fairbanks and south to Anchorage; in both cases, the corridor generally follows the Railbelt. However, the lines to Anchorage will leave the Railbelt just outside Willow. At this point, the corridor continues in a southerly direction to reach the north shore of Knik Arm. Underwater cables will be installed to cross the Knik Arm. The corridor enters military reserved territory and is constrained to pass near the northern and eastern perimeter of Fort Richardson through the reservation, and finally loops south and west to the site of the existing University substation located some four miles southeast of the center of Anchorage.

The length of the corridor sections and the number of lines contained within them are shown in the following table:

CORRIDOR SECTION	Corridor Length Miles	NUMBER OF 345 kV CIRCUITS Stage I Watana	Stage II Devil Canyon	Stage III Watana	Devel-opment
1. Watana to Gold Creek	36	2	--	--	2
2. Gold Creek to Fairbanks	185	2	--	--	2
3. Gold Creek to Willow	79	2	--	1	3
4. Willow to Knik Arm (West)	43	2	--	1	3
5. Knik Arm Crossing	3	2	--	1	3
6. Knik Arm to Anchorage	19	2	--	--	2
7. D.C. to Gold Creek	8	--	2	--	2

The physical location of the corridor is shown in a regional context, on Plate No. F105, Exhibit F. A schematic diagram of the system is given on Plates No. F96, F97 and F98, of Exhibit F.

5.2.2 - Components (o)

At the Watana site, a SF6 gas-insulated 345kV substation (GIS) will be provided. The substation will be located in the transformer gallery. The switching arrangement will be a ring bus which will provide the necessary switching feasibility and reliability. Two sets of SF6 compressed gas-insulated busses will be carried from the GIS to the surface. Each set of busses consists of three single-phase busses sized to have sufficient capacity to carry the entire plant output. The busses will be terminated at the surface, where they will be connected to the two overhead transmission lines (refer to Plate F96, Exhibit E).

From Watana, two single-circuit 345 kV lines will be built westward to the Gold Creek switching station. From the Watana substation, both lines will continue in a northwest direction, a distance of approximately two miles crossing Tsusena Creek, then will turn west and share the same general corridor as the

proposed access road all the way to the Devil Canyon dam site. From Devil Canyon, the lines will head in a southwest direction, crossing the Susitna River at river mile 149.8, then will turn westward and follow the proposed railroad extension a distance of approximately six miles to the Gold Creek switching station. The Gold Creek switching station will be located in an area on the south bank terraces of the Susitna River at approximately river mile 142.

The Gold Creek switching station layout will be based on the breaker-and-a-half arrangement. At this station, switching will be provided so that the output of the Watana development can be transmitted partly north along the two lines to Fairbanks and partly to Anchorage along the two lines that run south. Power transmitted in either of these directions will be able to be switched to one line of the pair in the event of an outage on the other. Switching also will allow either of the lines from Watana to supply either Fairbanks or Anchorage, providing complete flexibility.

Access to the Gold Creek switching station site will be by an 8-mile long all-weather road from the railroad at Gold Creek (refer to Plate F 100, Exhibit F). The two 345 kV single-circuit lines to Fairbanks from Gold Creek will share the same right-of-way north, generally following the Railbelt past Chulitna, Cantwell, Denali Park and Healy, sited to the east of the railroad. About 1 mile north of Healy the lines will cross to the west side of the Nenana River and the railroad, continuing northwards for about 14 miles between the Parks Road on the west and the railroad on the east. At this point the lines will recross to the east side of the Nenana River and the railroad, continuing north to cross the Tanana River about 8 miles east of the town of Nenana, and then will continue northeastward to a point six miles west of Fairbanks at Ester substation, the northern terminal of the 345 kV system.

At Ester substation provision will be made to step down the voltage to 138 kV for delivery to the Golden Valley Electric Association. A total of four 150 MVA transformer banks can be installed at the substation site. Switching will be provided at 345 kV to enable the load to be supplied from both or either of the incoming lines. A breaker-and-a-half arrangement will be used. The Ester switchyard will also be provided with switchable 75 MVAR shunt reactors on each of the 345 kV lines for use during line energizing; switching will allow the reactor to be removed from the line if necessary during emergency heavy line loading if one line suffers an outage. For purposes of control of the system static VAR compensation will be required on the 138 kV busses at Ester and will consist of units with +200/-100 MVAR continuous, and +300/-100 MVAR short time ratings. The ratings

of the VAR control equipment will be confirmed and, if necessary, refined during final design (refer to Plate F99, Exhibit F). Access to the Ester Substation will be provided by an all-weather gravel road linked to the nearby Fairbanks Highway.

Two single-circuit 345 kV lines will exit from the Gold Creek switching station in a southwesternly direction following the east bank of the Susitna River past the village of Gold Creek. At this point while the river and the Alaska Railroad continue southwest, the line route will head south departing up to 10 miles to the east from the Railbelt. Approximately 50 miles south of Gold Creek the lines will rejoin the Railbelt near the Kashwitna River. From here the lines will run 6 miles parallel to the Railbelt on the east of the road to reach the Willow switching station. The Willow substation will be sited about 2 miles north of Willow.

The Willow switching station will serve a dual function; firstly, it will provide a facility to feed load in the locality at 138 kV. A total of three 75 MVA, three-phase transformers could be installed. Secondly, the station will provide complete line switching through a breaker-and-a-half arrangement. This switching will facilitate line energizing by limiting overvoltages. It will also allow flexibility to isolate a line section that might suffer an outage and to route load through the remaining lines (refer to Plate F101, Exhibit F). The Willow site access will be provided with an all-weather gravel road about 1 mile long across Willow Creek to the Willow Creek Road.

An Energy Management Center will also be located at the Willow substation site. The entire operation of the power generation and transmission system will be controlled from the Center. Remote control will be provided through communications via a microwave system. Existing microwave communications from Anchorage to Willow and from Fairbanks to Healy will be augmented and extended to provide a continuous link between Fairbanks and Anchorage with a spur into the power developments at Devil Canyon and Watana.

Two single-circuit 345 kV lines leaving Willow switching station will run due west for about 4 miles, then turn south and cross Willow Creek. The lines will continue in a generally southward direction to cross the Little Susitna River about 25 miles from Willow Creek. At this point the lines will bear in a south-easterly direction for about 15 miles to arrive at the west side of Knik Arm about five and a half miles north of Pt. MacKenzie, adjacent to the site of an existing 230 kV line.

Knik Arm will be crossed by submarine cables buried in the inlet bed. Two circuits will be provided, each consisting of three individual single-phase 345 kV submarine cables. A third cable will contain a spare phase. On each shore a cable termination station will contain disconnect switches, surge arrestors and ground connection devices required for operation of the cable facility. Another feature of the terminals will be an arrangement of an upper level bus which will allow for temporary connections to bring into contingency service a spare single phase cable. The spare cable can replace any cable which might suffer accidental damage.

In the bed of the inlet, the circuits will be physically separated into three back-filled trenches; two will contain three single-phase cables making up the two main circuits, the third will contain the spare phase. Each trench will be separated from the other by approximately 1/4 mile with a similar distance being maintained from the existing 230 kV crossing. The separation in the navigation area will be achieved by curving the trenches in plan on the foreshore of the inlet. This arrangement of separating the circuits will provide an added measure of protection against multiple circuit damage due to navigation in the inlet. Access to the east and west terminals will be by gravel road built along the transmission line right-of-way to the nearest public access about 3 miles distant on the east side and 12 miles on the west.

On the southeasterly side of Knik Arm the line route will pass through the Fort Richardson military reservation. The route will follow a path parallel to an existing 230 kV line. Beyond the Knik Arm substation it will consist of two 345 kV circuits. Because of the restricted width available for right-of-way there is a requirement to use compact line design techniques. Double-circuit steel pole structures will be designed with extra conservative safety factors to increase reliability against loss of both circuits due to structural failure. Separation of the circuit onto two separate single pole structures using post type insulators to prevent conductor swing will be adopted where right-of-way width permits. From the southeasterly shore of Knik Arm the route will run southeast to the intersection of Glenn and Davis Highways, where it will turn southwesterly following the Glenn Highway on the southeast side, and then pass east of Homesite Park and southwest to the vicinity of the existing University substation on Tudor Road.

The Knik Arm substation will be located in the general vicinity of the Glen and Davis Highway intersection near where the existing 230 kV and 115 kV lines share the same right-of-way. This facility will allow for a breaker-and-a-half layout with complete flexibility in switching at 345 kV between the incoming and outgoing pairs of lines to cope with possible outage situa-

tions. Each of the incoming lines from Willow will have a switchable 30 MVAR shunt reactor to assist with voltage control during energizing of the line. Also the facility will provide one 75 MVA, three-phase transformer to feed into the 115 kV existing system that passes nearby (refer to Plate F102, Exhibit F).

The University substation site will represent the southernmost terminal of the 345 kV transmission facility. The substation will serve as the major distribution point for power from Watana and Devil Canyon into the Anchorage area. Provision will be made for transformation to 230 kV and 115 kV to suit the existing utility systems in the area. At the 230 kV level up to four 250 MVA banks of single-phase transformers will be accommodated, and at 115 kV two 250 MVA bank of single-phase transformers can be installed. For transient stability, static VAR compensation will be provided on outgoing lines to Anchorage consisting of units with ratings on the 230 kV system of +150/-100 MVAR continuous and +200/-75 MVAR short time; on the 115 kV system rated at +200/-75 MVAR continuous, and +300/-75 MVAR short time. The ratings of the VAR control equipment will be confirmed and, if necessary, refined in final design (refer to Plate F103, Exhibit F). Access to the University substation will be by the existing gravel road directly off Tudor Road.

The Applicant has constructed an Anchorage-Fairbanks "Intertie" project (Commonwealth Associates, Inc. 1982). Approximately 170 miles of one of the 345 kV lines between Healy and Willow on the Fairbanks to Anchorage corridor has been constructed. This line is built to operate eventually at 345 kV, but is initially being operated at 138 kV. When it is integrated into the Watana transmission system it will operate at 345 kV.

5.2.3 - <u>Right-of-Way</u> (o)

The right-of-way for the transmission corridor will consist of a linear strip of land. The width will depend on the number of lines. North of the cable crossing of Knik Arm, the right-of-way will include that area necessary for the additions to the facilities planned in conjunction with the Devil Canyon Stage II and Watana III development. In the sections with two lines, the right-of-way width will be 300 feet; for three lines it will be 400 feet. Between Gold Creek and Devil Canyon, where ultimately four lines will be required, the width will be 510 feet.

In the Knik Arm underwater crossing area, the right-of-way will be widened to account for the fact that each circuit of the total development will be separated from the adjacent circuits by a distance of about 1/4 mile. The spare single phase cable will

also be 1/4 mile from the other cables. The width of the bed affected by the crossing will be approximately one mile.

Southeast of Knik Arm the right-of-way width will be restricted in the military reservation. In this section the right-of-way will be 300 feet from the centerline of an existing 230 kV line.

Approximate right-of-way areas to be occupied by the switching and substations are listed below.

	Area of Right-of-Way (acres)
Gold Creek Switchyard	16
Fairbanks (Ester) Substation	25
Willow Substation	25
Knik Arm Substation	15
Anchorage (University) Substation	45

Rights-of-way for permanent access to switchyard and substations will be required linking back to a public road or in some cases rail access. These rights-of-way will be 100 feet wide.

5.2.4 - Transmission Lines (o)

Access to the transmission line corridor will be via trails from existing access routes at intermittent points along the corridor. The exact location of these trails will be established in the final design phase. Within the transmission corridor itself an access strip 25 feet wide will run along the entire length of the corridor, except at areas such as major river crossings and deep ravines where an access strip would not be utilized for the movement of equipment and materials.

The conductor capacity for the lines will be in the range of 1,950 MCM; this can be provided in several ways. Typical of these is a phase bundle consisting of two 954 MCM "Rail" (45/7) Aluminum Conductor Steel Reinforced (ACSR) or a single 2,156 MCM "Bluebird" (84/17) ACSR conductor, both of which provide comparable levels of corona and radio noise within normally accepted limits. The single "Bluebird" conductor attracts less load under wind or ice loadings and avoids the need to provide the space damper devices required for a bundled phase. The single conductor is stiffer and heavier to handle during stringing operations, although this will tend to be balanced out due to the extra work involved in handling the twin bundle. Selection of the optimum conductor arrangement will be made in final design. The conductor will be specified to have a dull finish treatment to reduce its visibility at a distance. The

conductor capacity between Knik Arm and University will be 2,700 MCM per phase to handle the output of Devil Canyon without an additional circuit in this section of the route.

Two overhead ground wires will be provided the full length of the line. These will consist of 3/8-inch diameter galvanized steel stands. The arrangement will be based on a shielding angle of 15 degrees over the outer phases; this will provide protection against lightning strikes to the line. More refined studies of the lightning performance of the line will be made during final design to confirm the arrangement outlined above.

Vibration control devices will be required on both the conductors and the ground wire. Stockbridge-type dampers on single wires and spacer dampers with an elastometer damping element are expected to be most suitable.

Conductor suspension and dead-end assemblies will be detailed according to "corona free" design and prototype tested to check that corona and radio interference are below nuisance levels when operating at elevations of up to 3,500 feet. Insulators will be standard porcelain or glass disc type suspension units. A chain of 18 units is expected to be sufficient to provide acceptable flashover performance of the line. The configuration will be "M" type with vertical strings on the outside phases and a "V" string supporting the center phase.

The transmission structures and foundations that serve to support the conductors and ground wires will be designed for a region where foundation movement due to permafrost and annual freeze-thaw cycling is common. Of the structural solutions that have proved successful in similar conditions, all utilize an arrangement of guy cables to support the structure. All depend upon the basic flexibility inherent in guyed structures to resist effects of foundation movement. For tangent and small angle applications the guyed type of structure such as the guyed "V", guyed "Y", guyed delta and the guyed portal are the most common economical arrangements. The guyed "X" design has been selected for use on the 345 kV Intertie (1) and is therefore a prime candidate for consideration on the Watana lines. Experience gained during the Intertie project will be used in the final structure design (refer to Plate F104, Exhibit F).

Structures for larger angle and dead-end applications will be in the form of individual guyed masts, one for each phase. Individual guyed masts will also be used for lengths of line that are judged to be in unusually hazardous locations due to exposure terrain is extremely rugged. All structures will utilized a "weathering" steel which matures over several years to a dark

brown color which is considered to have a more aesthetically pleasing appearance than galvanized steel or aluminum (refer to Plate F 104, Exhibit F).

Foundations for structures will utilize driven steel piles in unstable soil conditions. In better soils steel grillage foundations will be used and set sufficiently deep to avoid the effects of the freeze-thaw cycle. Rock footings will employ grouted rock anchors with a minimum use of concrete to facilitate winter construction. Foundations for cantilever pole type structures will be large diameter cast-in-place concrete augered piles. Several types of guy anchor will be available for use; they include the screw-in helix type, the grouted bar earth anchor, driven piles and grouted rock anchors. Selection of the most economical solution in any given situation will depend on the site specific constraints including soil type, access problems and expected guy load. Foundation sites will be graded after installation to contour the disturbed surface to suit the existing grades. Tower grounding provisions will depend upon the results of soil electrical resistivity measurements both prior to and during construction. Continuous counterpoise may be required in sections where rock is at or close to the surface; it also may be required in other areas of high soil resistance. The counterpoise will take the form of two galvanized steel wires remaining at a shallow bury parallel to and under the lines. These will be connected to each tower and cross connected between lines in the right-of-way. Elsewhere, grounding will be installed in the form of ground rods driven into the soil adjacent to the towers.

5.2.5 - Switching and Stations (o)

The physical location of the stations and the system single line diagram is shown on Plate F105 and F96, 97, 98 respectively, of Exhibit F. The single line diagram and layout of the individual stations are contained on Plates F99 through F103 of Exhibit F.

The construction access to all sites will be over the route of the permanent access provided for each location. Any grading of the sites will be carried out on a balanced cut-and-fill basis wherever possible. Equipment will be supported on reinforced concrete pad-and-column type footings with sufficient depth-of-bury to avoid the active freeze-thaw layer. Backfill immediately around footing will be granular to avoid frost heave effects.

Light equipment may be placed on spread footings if movements are not a significant factor in operational performance.

The station equipment requirements are determined by the breaker-and-a-half arrangement adopted for reasons of reliability and security of operation. One and one-half breakers will be needed for each line or transformer circuit termination. The transformer capacities are determined by the load requirements at each substation. Control and metering provisions will cater to the plan for remote operation of all the facilities in normal circumstances. Protective relaying schemes for the 345 kV system will be in accordance with conventional practices, using the general philosophy of dual relaying and the local backup principle.

The station layouts are based on conventional outdoor design with a two-level bus which will result in a relatively low profile to the station. This will assist in limiting the visual impact of the stations and make the most of any available neutral buffers. Although they will be remotely controlled, all stations will be provided with a control building; in larger stations an additional relay building will be provided. A storage building will also be provided for maintenance purposes. Each station will have auxiliary power at 480 V; the normal 480 V ac power will be supplied from the tertiaries on the autotransformers or the local utility. The Willow station will include the Energy Management Center and the headquarters of the system maintenance group.

5.2.6 - Cable Crossing (o)

The cable crossing will consist of two 345 kV circuits each comprising three individual 2,000 MCM single-phase submarine cables; in addition a spare phase cable will be provided. Each circuit will be buried in the inlet bottom, the three cables of the circuit sharing the same trench. Beyond the foreshore area it is anticipated that cables can be buried by a combination of dredging and ploughing as the bed materials are reported to be soft. At each shore, gravel deposits are expected to be encountered so that conventional excavate-and-fill methods are more probable with work being performed from barges in the tidal zone.

The centerline of each circuit will be routed on the foreshore to obtain a physical separation of approximately 1/4 mile between circuits and the spare phase; a similar spacing will be maintained from the existing 230 kV circuit which runs adjacent to the crossing site.

On each side of the arm a terminal yard will be provided to contain the disconnect switches, surge arrestors, and grounding for the cables as well as the cable terminals. The yards will have bus arrangements which will permit the spare phase to be brought into service by installation of temporary bus connections.

5.2.7 - Dispatch Centers - Energy Management Centers and Communications (o)

The operation of the transmission facility and the dispatch of power to the load centers will be controlled from a central dispatch and Energy Management System (EMS) center. It has been proposed that the center be located at Willow since a suitable site could be developed at the Willow switching station site. The location of the center could alternatively be at one of the other key points along the line route. University substation could be considered in final design studies if close proximity to an existing major center of population is thought to be a major advantage in siting. The center will operate in conjunction with northern and southern area control systems in Fairbanks and Anchorage which would control generation in those two areas. The generation at the Susitna hydroelectric sites would be controlled at the Watana power facility. The Energy Management Center would orchestrate the overall operation of the system by request to the three local generation control centers for action and direct operation of the Gold Creek switching station and the four 345 kV switching and substations along the transmission system.

The system communications requirements will be provided by means of a microwave system. The system will be an enlargement of the facility being provided for the operation of the Intertie between Healy and Willow. Communications into the hydroelectric plants will be by a microwave extension from the Gold Creek switching station.

5.3 - Construction Staging (o)

Watana will require staged development of transmission facilities to Fairbanks and Anchorage. Stage I includes the following:

Substations	Line Section	Number of Circuits
Watana	Watana to Intertie switchyard near Gold Creek	2
Gold Creek (Southbound)	Switchyard to Willow	2[1/]
Willow	Willow to Knik Arm	2
Knik Arm	Knik Arm Crossing	2
University (Anchorage)	Knik Arm to University	2
Gold Creek (Northbound)	Gold Creek to Healy	2[1/]
Fairbanks	Healy to Fairbanks	2

[1/] Circuit is the existing Anchorage-Fairbanks Intertie

The transmission will consist of two circuits from Watana to the load centers. The conductor for the sections from Watana to Knik Arm and Watana to Fairbanks will consist of bundled 2 x 954 kcmil, ACSR. The section between Knik Arm and University will employ bundled 2 x 1351 kcmil, ACSR. The submarine cable crossing will consist of two circuits. The cable will be single conductor, 345 kV self-contained oil-filled. For project purposes, the cable size will be 500 mm^2. A size of up to 1,500 mm^2 may be installed if duty requirements are increased. For reliability, a spare cable will be included on a standby basis.

The Matanuska Electric Association will be serviced from the Willow and Knik Arm substations via step-down transformers to suit the local voltage. Chugach Electric Association and Anchorage Municipal Light and Power will be serviced through the University substation in Anchorage. Golden Valley Electric Association will be serviced through the Ester substation at Fairbanks.

6 - PROJECT STRUCTURES - DEVIL CANYON STAGE II (**)

This section describes the various components of the Devil Canyon development, including diversion facilities, emergency release facilities, main dam, primary outlet facilities, reservoir, main spillway, saddle dam, power intake, penstocks, and the powerhouse complex, including turbines, generators, mechanical and electrical equipment, switchyard structures, and equipment and project lands. A summary of project parameters is presented in Table A.1.

A description of permanent and temporary access and support facilities is also included.

6.1 - General Arrangement (**)

The Devil Canyon reservoir and surrounding area are shown on Plate F39. the site layout in relation to main access facilities and camp facilities is shown on Plate F70. A more detailed arrangement of the various site structures is presented in Plate F40.

The Devil Canyon Dam will form a reservoir approximately 26 miles long with a surface area of 7,800 acres and a gross storage capacity of 1,100,000 acre-feet at el. 1,455, the normal maximum operating level. The operating level of the Devil Canyon reservoir is controlled by the tailwater level of the upstream Watana development. The maximum water surface elevation during flood conditions will be 1,466. The minimum operating level of the reservoir will be 1,405, providing a live storage during normal operation of 350,000 acre-feet.

The dam will be a thin arch concrete structure with a crest elevation of 1,463 (not including a 3.0-foot parapet) and maximum height of 646 feet. The dam will be supported by mass concrete thrust blocks on each abutment. On the south bank, the lower bedrock surface will require the construction of a substantial thrust block. Adjacent to this thrust block, an earth- and rockfill saddle dam will provide closure to the south bank. The saddle dam will be an earth and rockfill embankment generally similar in cross section to the Watana Dam. The dam will have a nominal crest elevation of 1,470 with an additional two feet of overbuild for potential settlement. The maximum height above foundation level of the dam is approximately 245 feet.

During construction, the river will be diverted by means of a single 35.5-foot diameter concrete-lined diversion tunnel on the south bank of the river.

A power intake on the north bank will consist of an approach channel excavated in rock leading to a reinforced concrete gate structure. From the intake structure four 20-foot diameter concrete-lined penstock tunnels will lead to an underground powerhouse complex housing four units with Francis turbines and synchronous generators.

Access to the powerhouse complex will be by means of an unlined access tunnel approximately 3,200 feet long as well as by a 950-foot deep vertical access shaft. The turbines will discharge to the river by means of a single 38-foot diameter tailrace tunnel leading from a surge chamber downstream from the powerhouse cavern. A separate transformer gallery just upstream from the powerhouse cavern will house twelve singlephase 15/345 kV transformers. The transformers will be connected by 345 kV single-phase, oil-filled cable through a cable shaft to the switchyard at the surface.

Outlet facilities consisting of seven individual outlet conduits will be located in the lower part of the main dam. These will be designed to discharge all flood flows of up to the estimated 50-year flood with Watana in place. Each outlet conduit will have a fixed-cone valve similar to those provided at Watana to dissipate energy and minimize undesirable nitrogen supersaturation in the flows downstream. The spillway will also be located on the north bank. As at Watana, this spillway will consist of an upstream ogee control structure with three vertical fixed-wheel gates and an inclined concrete chute and flip bucket designed to pass a maximum discharge of 309,000 cfs. This spillway, together with the outlet facilities, will be capable of discharging the PMF without overtopping the dam.

6.2 - Arch Dam (**)

The Devil Canyon Dam will be located at the Devil Canyon gorge, rivermile 152, approximately 32 river-miles downstream from Watana. The arch dam will be located at the upstream entrance of the canyon.

The dam will be a thin arch concrete structure 646 feet high, with a crest length-to-height ratio of approximately two, and designed to withstand dynamic loadings from intense seismic shaking. The proposed height of the dam is well within precedent.

6.2.1 - Foundations (**)

Bedrock is well exposed along the canyon walls, and the arch dam will be founded on sound bedrock. In local areas approximately 20 to 40 feet of weathered and/or loose rock will be removed beneath the dam foundation. All bedrock irregularities will be smoothed out beneath the foundation to eliminate high stress concentrations within the concrete. During excavation the rock will also be trimmed as far as is practical to increase the symmetry of the centerline profile and provide a comparatively uniform bearing stress distribution across the dam. Areas of deteriorated dikes and the local areas of poorer quality rock will be excavated and supplemented with dental concrete.

The foundation will be consolidation grouted over its entire area, and a double grout curtain up to 300 feet deep will run

beneath the dam and its adjacent structures as shown in Plate F47. Grouting will be done from a system of galleries which will run through the dam and into the rock. Within the rock these galleries will also serve as collectors for drainage holes which will be drilled just downstream of the grout curtain to intercept any seepage passing through the curtain.

6.2.2 - Arch Dam Geometry (*)

The canyon is V-shaped below el. 1,350. Sound bedrock does not exist above this level on the south abutment and an artificial abutment will be provided up to crest el. 1,463 in the form of a massive concrete thrust block designed to take the thrust from the upper arches of the dam. A corresponding block will be formed on the north abutment to provide as symmetrical a profile as possible bordering the dam and to give a symmetrical stress distribution across the faces of the horizontal arches.

Two slight ridges will be formed by the rock at both abutments. The arch dam will abut the upstream side of these such that the plane of the contact of the horizontal arches is generally normal to the faces of the dam. An exception will be in the lower portion of the dam where the rock in the upstream corners will be retained in order to decrease the amount of excavation.

The dam will bear directly on the rock foundation over the entire length of the contact surface. The bedrock at the foundation will be excavated to remove all weathered material and further trimmed to provide a smooth line to the foundation, thus avoiding abrupt changes in the dam profile and consequent stress concentrations.

The dam will be a double curvature structure with a cupola shape of the crown cantilever defined by vertical curves of approximately 1,352-foot and 893-foot radii. The horizontal arches are based on a two-center configuration with the arches prescribed by varying radii moving along two pairs of centerlines. The shorter radii of the intrados face cause a broadening of the arches at the abutment, thus reducing the contact stresses. The dam reference plane is approximately central to the floor of the canyon and the two-center configuration assigns longer radii to the arches on the wider north side of the valley, thus providing comparable contact areas and central angles on both sides of the arches at the concrete/rock interface. The longer radii will also allow the thrust from the arches to be directed more into the abutment rather than parallel to the river. The net effect of this two-center layout will be to improve the symmetry of the arch stresses across the dam.

The crown cantilever will be 643 feet high. It will be 20 feet thick at the crest and 90 feet at the base, a base width-to-height ratio of 0.140. The radii of the dam axis at crest level will be 699 feet and 777 feet for the south and north sides of the dam, respectively. The central angles vary between 53° at elevation 1,300 and 10° at the base for the south side of the arch, and 57° to 10° for the north side. The dam crest length is 1,260 feet and the ratio of crest length to height for the dam is 1.96 (thrust blocks not included). The volume of concrete in the dam is approximately 1.3 x 10^6 cubic yards.

6.2.3 - Thrust Blocks (*)

The thrust blocks are shown on Plate F46. The massive concrete block on the south abutment is 113 feet high and 200 feet long. It will be formed to take the thrust from the upper part of the dam above the existing sound rock level. It will also serve as a transition between the concrete dam and the adjacent rockfill saddle dam. The inclined end face of the block will abut and seal against the impervious saddle dam core and be enveloped by the supporting rock shell.

The 113-foot high, 125-foot long thrust block formed high on the north abutment at the end of the dam, adjacent to the spillway control structure, will transmit thrust from the dam through the intake control structure and into the rock.

6.3 - Saddle Dam (**)

The saddle dam at Devil Canyon, which is of similar configuration as the Watana Dam, will be of earth and rockfill construction and will consist of a compacted core protected by fine and coarse filters upstream and downstream. The outer shells will consist of rockfill material. A typical cross section is shown on Plate F49 and described below.

6.3.1 - Typical Cross Section (*)

The thickness of the impervious core at any section will be slightly more than 0.5 times the head of water at that section. Minimum core/foundation contact will be 50 feet, requiring flaring of the cross section at the abutments.

The upstream and downstream filter zones are sized to provide protection against possible piping through transverse cracks that could occur because of settlement or resulting from internal displacement during a seismic event.

Protection against wave and ice action on the upstream slope will consist of a layer of larger quarried rock accomplished by rock raking the outer 40 feet of the fill.

The estimated volumes of material needed to construct the saddle dam are:

o core material	140,000 cubic yards
o fine filter material	150,000 cubic yards
o coarse filter material	160,000 cubic yards
o rockfill material	1,500,000 cubic yards

The saturated sections of both shells will be constructed of compacted clean rockfill to minimize pore pressure generation and ensure rapid dissipation during and after a seismic event. The lower section of the downstream shell, due to a unique combination of bedrock and topographic elevations, may become saturated by natural runoff or dam seepage. During design the cost of a major drainage system to prevent this occurrence will be weighed against the added cost of processing the materials for the lower portion of the fill. Since pore pressures cannot develop in the unsaturated upper section of the downstream shell, the material in that zone will be unprocessed rockfill from surface or underground excavations.

6.3.2 - Crest Details and Freeboard (**)

A parapet 3.0 feet high will be constructed on the crest of the arch dam to provide a freeboard of 11.0 feet.

The highest reservoir level will be at el. 1,465.6 under PMF conditions. The normal maximum pool elevation will be at el. 1,455.

The typical crest detail for the saddle dam is shown in Plate F50.

A minimum saddle dam freeboard of four feet will be provided for the PMF; hence, the nominal crest of the saddle dam will be at el. 1,470. In addition, an allowance will be made for potential settlement of the rockfill shells. The constructed crest elevations of the saddle dam will be 1,470 at the abutments, rising in proportion to the total height of the dam to el. 1,472 at the maximum section. Under normal operating conditions, the freeboard will be 15 feet.

6.3.3 - Grouting and Pressure Relief System (**)

The rock foundation will be improved by consolidation grouting over the core contact area and by a grouted cutoff along the

centerline of the core. The cutoff at any location will extend to a depth in the range of 0.7 of the water head at that location, as shown on Plate F47.

A grouting and drainage tunnel will be excavated in bedrock beneath the dam along the centerline of the core and will connect with a similar tunnel beneath the adjacent concrete arch dam and thrust block. Pressure relief and drainage holes will be drilled from this tunnel, and seepage from the drainage system will be discharged through the arch dam drainage system to ultimately exit downstream below tailwater level.

6.3.4 - Instrumentation (*)

Observation devices will be installed within all parts of the dam to provide monitoring during construction as well as during operation. Instruments for measuring internal vertical and horizontal displacements, stresses and strains, and total and fluid pressures, as well as surface monuments and markers similar to those proposed for the Watana Dam, will be installed.

6.4 - Diversion (**)

6.4.1 - General (*)

Diversion of the river flow during construction will be through a single concrete-lined diversion tunnel on the south bank. The tunnel will have a horseshoe-shaped cross section with a major dimension of 35.5 feet. It will be 1,490 feet in length. The diversion tunnel plan and profile are shown on Plate F51.

The tunnel is designed to pass a flood with a return frequency of 1:25 years routed through the Watana reservoir. The peak flow that the tunnel will discharge will be approximately 43,000 cfs. The maximum water surface elevation upstream of the cofferdam will be el. 944.

6.4.2 - Cofferdams (**)

The upstream cofferdam will consist of a zoned earth and rockfill embankment (see Plate F52). The diversion dike will be constructed to elevation 915 based on a low water elevation of 910 and will consist of quarry-run rock fill. When the diversion dike is completed, a slurry wall cutoff will be constructed to minimize seepage into the main dam excavation. Final details of this cut-off will be determined following further investigations to define the type and properties of river alluvium. The abutment areas will be excavated to sound rock prior to placement of any cofferdam material.

The cofferdam, from elevation 915 to 947, will be a zoned embankment consisting of an impervious core, fine and coarse upstream and downstream filters, and rock shells with larger stone on the upstream face. The downstream cofferdam will be constructed from el. 860 to 898, with a slurry wall cutoff to bedrock.

The upstream cofferdam crest elevation will have a three-foot free-board allowance for settlement and wave runup. Under the proposed schedule, the Watana development will be operational when this cofferdam is constructed. In a cold winter, ice may form between RM 176 and the cofferdam. The diversion tunnel is designed to pass this ice without ponding, therefore a freeboard allowance for ice is not included in the cofferdam design.

6.4.3 - Tunnel Portals and Gates (*)

A gated concrete intake structure will be located at the upstream end of the tunnel (see Plate F53). The portal and gate will be designed for an external pressure (static) head of 250 feet.

Two 30-foot high by 15-foot wide water passages will will be formed in the intake structure, separated by a central concrete pier. Gate guides will be provided within the passages for the operation of 30-foot high by 15-foot wide fixed-wheel closure/control gates.

Each gate will be operated by a wire rope hoist in an enclosed housing, and will be designed to operate with a 75-foot operating head (el. 945).

Stoplog guides will be installed in the diversion tunnel to permit dewatering of the diversion tunnel for plugging operations. The stoplogs will be in sections to facilitate relatively easy handling, with a mobile crane using a follower beam.

6.4.4 - Final Closure and Reservoir Filling (*)

Upon completion of the Devil Canyon Dam to a height sufficient to allow ponding to a level above the outlet facilities, the intake gates will be partially closed, allowing for a discharge of minimum environmental flows while raising the upstream water level. Once the level rises above the lower level of discharge valves, the diversion gates will be permanently closed and discharge will be through the 90-inch diameter fixed-cone valves in the dam. The diversion tunnel will be plugged with concrete and curtain grouting performed around the plug. Construction will take approximately 1 year. During this time the reservoir will not be allowed to rise above el. 1,135 unless a flood

exceeding the outlet works capacity occurs. In this case the water level will be allowed to rise as needed to store the flood.

6.5 - Outlet Facilities (**)

The primary function of the outlet facilities is to provide for discharge in conjunction with the power facilities, of routed floods with up to 1:50 years recurrence period at the Devil Canyon Reservoir. This will require a total discharge capacity of 42,000 cfs. The use of fixed-cone valves will ensure that downstream erosion will be minimal and nitrogen supersaturation of the releases will be reduced to acceptable levels, as in the case of the Watana development. A further function of these releases is to provide an emergency drawdown for the reservoir, should maintenance be necessary on the main dam or low level submerged structures, and also to act as a diversion facility during the latter part of the construction period.

The outlet facilities will be located in the main dam, as shown on Plate F48, and will incorporate seven fixed-cone discharge valves set in the lower part of the arch dam.

6.5.1 - Outlet (*)

The fixed-cone type discharge valves will be located at two elevations: the upper group, consisting of four 102-inch diameter valves, will be set at el. 1,050, and the lower group of three 90-inch diameter valves will be set at elevation 930. The valves will be installed nearly radially (normal to the dam centerline) with the points of impact of the issuing jets staggered as shown in Plate F48.

The fixed-cone valves will be installed on individual conduits passing through the dam, set close to the downstream face, and protected by upstream ring follower gates located in separate chambers within the dam. Provisions will be made for maintenance and removal of the valves and gates. The gates and valves will be linked by a 20-foot high gallery running across the dam and into the left abutment, where access will be provided by means of a vertical shaft exiting through the thrust block. Although secondary access will be provided via a similar shaft from the north abutment, primary access and installation are both from the south side.

The valve and gate assemblies will be protected by individual trashracks installed on the upstream face. The racks will be removable along guides running on the upstream dam face. A travelling gantry crane will be used for raising the racks. Guides will be installed for the installation of bulkhead gates, if required, at the upstream face. The bulkhead gates will be handled by the travelling gantry crane.

6.5.2 - Fixed-Cone Valves (*)

The 102-inch diameter valves operating at a gross head of 405 feet and the 90-inch diameter valves operating at a head of 525 feet are within current precedent considering the valve size and the static head on the valve. The valves will be located in individually heated rooms and will be provided with electric jacket heaters installed around the cylindrical sleeve of each valve. The valves will be capable of year-round operation, although winter operation is not contemplated. Normally, when the valves are closed, the upstream ring follower gates will also be closed to minimize leakage and freezing of water through the valve seats.

The valves will be operated remotely by two hydraulic operators. Operation of the valves will be from either Watana or by local operation.

6.5.3 - Ring Follower Gates (*)

Ring follower gates will be installed upstream of each valve. The ring follower gates will have nominal diameters of 102 and 90 inches and will be of welded or cast steel construction. The gates will be designed to withstand the total static head under full reservoir.

The design and arrangement of the ring follower gates will be as for Watana.

6.5.4 - Trashracks (*)

A steel trashrack will be installed at the upstream entrance to each water passage to prevent debris from being drawn into the discharge valves. The bar spacing on the racks will be approximately six inches. Provision will be made for monitoring head loss across the racks.

6.5.5 - Bulkhead Gates (*)

The bulkhead gates will be installed only under balanced head conditions using the gantry crane. The gates will be 13 feet and 11 feet square for the upper and lower valves, respectively.

Each gate will be designed to withstand full differential head under maximum reservoir water level. One gate for each valve size has been assumed. The gates will be stored at the dam crest level.

A temporary cover will be placed in the bulkhead gate check at trashrack level to prevent debris from getting behind the trashracks.

The bulkhead gates and trashracks will be handled by an electric traveling gantry type crane located on the main dam crest at el. 1,463. The crane and lifting arrangement will have provision for lowering a gate around the curved face of the dam.

6.6 - Spillway (**)

The spillway at Devil Canyon will be located on the north side of the canyon (see Plate F54). The upstream control structure will be adjacent to the arch dam thrust block and will discharge down an inclined concrete-lined chute constructed on the steep face of the canyon wall. The chute will terminate in a flip bucket which will direct flows downstream and into the river.

The Devil Canyon spillway in combination with the outlet works is designed to pass the routed PMF from Watana during both Stages II and III. The maximum outflows from the spillway would be 351,000 cfs and 333,000 cfs in Stages II and III, respectively. The maximum water levels would be el. 1,465.6 and el. 1,463.1 in Stages II and III. These levels will be below the top of the parapet wall on the concrete arch section of the the dam (el. 1,466.0). The capacity of the spillway and outlet works is approximately 280,000 cfs at a water level of el. 1,456.0. This exceeds the 95 percent upper one sided confluence level for the 10,000 year flood inflow of 262,000. Thus the project can release the 10,000 year flood without the water level exceeding el. 1,456.0.

6.6.1 - Approach Channel and Control Structure (*)

The approach channel will be excavated to a depth varying between 100 feet and 176 feet in the bedrock with a width of just over 130 feet and an invert elevation of 1,375.

The control structure, as shown in Plate F55, will be a three-bay concrete structure set at the end of the channel. Each bay will incorporate a 61-foot high by 48-foot wide gate on an ogee-crested weir and, in conjunction with the other gates, will control the flows passing through the spillway. The gates will be radial type operated by individual hydraulic hoists.

A gallery will be provided within the mass concrete weir from which grouting can be carried out and drain holes can be drilled as a continuation of the grout curtain and drainage beneath the main dam. The main access route will cross the control structure deck upstream of the gate tower and bridge structure.

6.6.2 - Spillway Chute (**)

The spillway chute will be excavated in the steep north face of the canyon for a distance of approximately 900 feet, terminating at el. 1,000. The chute will taper uniformly over its length from 176 feet at the upstream end to 150 feet downstream. The chute will be concrete-lined with invert and wall slabs anchored to the rock.

The velocity at the lower end of the chute will be approximately 150 ft/sec. In order to prevent cavitation of the chute surfaces, air will be introduced into the discharges. As at Watana, air will be drawn in along the chute via an underlying aeration gallery and offshoot ducts extending to the downstream side of a raised step running transverse to the chute.

An extensive underdrainage system will be provided to ensure adequate underdrainage of the spillway chute and stability of the structure. This system is designed to prevent excessive uplift pressures due to reservoir seepage under the control structure and from groundwater and seepage through construction joints from the high velocity flows within the spillway itself.

The dam grout curtain and drainage system will be extended under the spillway control structure utilizing a gallery through the rollway. A system of box drains will be installed for the entire length of the spillway under the concrete slab. To avoid blockage of the system by freezing of the surface drains, a 30-foot deep drainage gallery will also be constructed along the entire length of the spillway. Drain holes from the surface drains will intersect the gallery. To ensure adequate foundation quality for anchorage, consolidation grouting will be undertaken to a depth of 20 feet. Drainage holes drilled into the base of the high rock cuts will ensure increased stability of the excavation.

6.6.3 - Flip Bucket (**)

The spillway chute will terminate in a mass concrete flip bucket founded on sound rock at el. 970, approximately 100 feet above the river. Detailed geometry of the curve of the flow surface of the bucket will be confirmed by means of hydraulic model tests. A grouting/drainage gallery will be provided within the bucket. The jet issuing from the bucket will be directed downstream and parallel to the river alignment.

6.6.4 - Plunge Pool (o)

The impact area of the issuing spillway discharge will be limited to the area of the river surface downstream to prevent

excessive erosion of the canyon walls. This will be done by appropriate shaping of the flow surface of the flip bucket on the basis of model studies. Over this impact area the alluvial material in the riverbed will be excavated down to sound rock to provide a plunge pool in which most of the inherent energy of the discharges will be dissipated, although some energy will already have been dissipated by friction in the chute and in dispersion and friction through the air.

6.7 - Emergency Spillway

(This section deleted)

6.8 - Power Facilities (*)

6.8.1 - Intake Structure (*)

The intake structure will be located on the north side of the canyon. Four sets of intake openings will be provided. The intake openings and power tunnels will be grouped in pairs so that each turbine may be supplied by water passing through two sets of intake openings. Each set of intake openings will consist of an upper and lower opening. The reservoir level will vary between elevations 1,455 (in the winter) and 1,405 in the summer of low flow years. In most years the reservoir water level is expected to stay above el. 1,435 all year. When the reservoir is at its maximum level the water will normally be withdrawn from the top opening in each set. As the reservoir is drawn down in August and September, the lower opening will be used. Each opening will be provided with a set of trashracks and a provision for placing sliding steel closure shutters downstream from the intake opening. The trash racks and shutters will be removed for maintenance.

The intake will be located at the end of an approximately 200-foot long unlined approach channel. The overburden in this area is estimated to be approximately ten feet deep. The excavation for the intake structure will require four tunnel portals on 60-foot centers. Rock pillars approximately 32 feet wide by 38 feet deep will separate the portals.

6.8.2 - Intake Gates (*)

Each of the four powerhouse intake tunnels will have a single fixed-wheel intake gate 20 feet wide by 24 feet high. The gates will have an upstream skinplate and seal and will be operated by hydraulic or wire rope hoists located in heated enclosures immediately below deck level. The gates, which will normally close under balanced head conditions to permit

dewatering of the penstock and turbine water passages for turbine inspection and maintenance, will also be capable of closing under their own weight with full flow conditions and maximum reservoir water level in the event of runaway of the turbines. A heated air vent will be provided at the intake deck to satisfy air demand requirements when the intake gate is closed with flowing water conditions.

6.8.3 - Intake Bulkhead Gates (*)

A bulkhead gate consisting of two sections will be provided for closing the intake openings. The gate will be used to permit inspection and maintenance of the intake gate and intake gate guides. The gates will be raised and lowered under balanced head conditions only.

6.8.4 - Intake Gantry Crane (*)

A 50-ton capacity electrical traveling gantry crane will be provided on the intake deck at elevation 1,466 for handling the trashracks, and intake bulkhead gates and for servicing the intake gate equipment.

6.9 - Penstocks (**)

The power plant will have four penstocks, one for each unit. The maximum static head on each penstock will be 638 feet, as measured from normal maximum operating level (el. 1,455) to centerline distributor level (el. 817). An allowance of 35 percent has been made for pressure rise in the penstock under transient conditions, giving a maximum head of 861 feet. Maximum extreme head (including transient loadings) corresponding to maximum reservoir flood level will be 876 feet.

The penstock tunnels are fully concrete-lined. In addition a 250-foot section upstream of the powerhouse which will be steel-lined. The inclined sections of the concrete-lined penstocks will be at 55° to the horizontal.

6.9.1 - Steel Liner (*)

The steel-lined penstock will be 15 feet in diameter. The first 50 feet of steel liner immediately upstream of the powerhouse will be designed to resist the full internal pressure. The remainder of the steel liner, extending another 200 feet upstream, will be designed to partially resist the internal pressure together with the rock. Beyond the steel liner, the hydraulic loads will be supported solely by the rock tunnel with a concrete liner.

The steel liner will be surrounded by a concrete infill with a minimum thickness of 24 inches. A tapered steel transition will be

provided at the junction between the steel liner and the concrete liner to increase the internal diameter from 15 feet to 20 feet.

6.9.2 - Concrete Liner (*)

The thickness of the concrete lining will vary with the design head, with the minimum thickness of lining being 12 inches. The internal diameter of the concrete liner will be 20 feet.

6.9.3 - Grouting and Pressure Relief System (**)

A comprehensive drainage system will be installed to protect the underground caverns against seepage from the high pressure penstocks and reservoirs. The system will consist of small diameter boreholes set out in an array to intercept the jointing in the rock. Grouting around the penstocks will also be undertaken.

6.10 - Powerhouse and Related Structures (**)

The underground powerhouse complex will be constructed in the north side of the canyon. This will require the excavation of three major caverns (powerhouse, transformer gallery and surge chamber), with interconnecting rock tunnels for the draft tubes and isolated phase bus ducts.

An unlined rock tunnel will be constructed for vehicular access to the three main rock caverns. A second unlined rock tunnel will provide access from the powerhouse to the foot of the arch dam.

Vertical shafts will be required for personnel access by elevator to the underground powerhouse, for oil-filled cable from the transformer gallery, and for surge chamber venting.

The draft tube gate gallery and cavern will be located in the surge chamber cavern, above maximum design surge level.

The general layout of the powerhouse complex is shown on Plates F63, F64 and F65. The transformer gallery will be located upstream of the powerhouse cavern and the surge chamber will be located downstream of the powerhouse cavern. The spacing between the underground caverns will be fixed so as to be at least 1.5 times the main span of the larger excavation.

6.10.1 - Access Tunnels and Shafts (**)

The 3,000-foot long main access tunnel will connect the powerhouse cavern at el. 858 with the canyon access road on the north bank. A secondary access tunnel will run from the main powerhouse access tunnel to the foot of the arch dam for routine

maintenance of the fixed-cone valves. Branch tunnels from the secondary access tunnel will provide construction access to the lower section of the penstocks at el. 820. Separate branch tunnels from the main access tunnel will give vehicle access to the transformer gallery at el. 896 and the draft tube gate gallery at el. 908. The maximum gradient on the permanent access tunnel will be eight percent; the maximum gradient on the secondary access tunnel will be nine percent.

The cross section of the access tunnels, which will be dictated by requirements for the construction plant, will be a modified horseshoe shape 35 feet wide by 28 feet high.

The main access shaft will be located at the north end of the powerhouse cavern, providing personnel access by elevator from the surface. Horizontal tunnels will be provided from this shaft for pedestrian access to the transformer gallery and the draft tube gate gallery. At a higher level, access will also be available to the fire protection head tank.

6.10.2 - Powerhouse Cavern (*)

The main powerhouse cavern is designed to accommodate four vertical-shaft Francis turbines, in line, with direct coupling to synchronous generators.

The unit spacing will be 60 feet with an additional 110-foot service bay at the south end of the powerhouse for routine maintenance and construction erection. The control room will be located at the north end of the main powerhouse floor. The width of the cavern will be sufficient for the physical size of the generator plus galleries for piping, air-conditioning ducts, electrical cables, and isolated phase bus. The overall size of the powerhouse cavern will be 74 feet wide, 360 feet long, and 126 feet high.

Multiple stairway access points will be available from the powerhouse main floor to each gallery level. Access to the transformer gallery from the powerhouse will be by a tunnel from the access shaft or by a stairway through each of the four bus tunnels. Access will also be available to the draft tube gate gallery by a tunnel from the main access shaft.

A service elevator will be provided for access from the service bay area on the main floor to the machine shop, and the dewatering and drainage galleries on the lower floors. Hatches will be provided through all main floors for installation and routine maintenance of pumps, valves and other heavy equipment using the main powerhouse crane.

6.10.3 - Transformer Gallery (**)

The transformers will be located underground in a separate unlined rock cavern, 120 feet upstream of the powerhouse cavern, with four interconnecting tunnels for the isolated phase bus. There will be 12 single-phase transformers with one group of three transformers for each generating unit. For increased reliability, one spare transformer and one spare HV circuit will be provided. The station service transformers and the surface facilities transformers will be located in the bus tunnels. Generator excitation transformers will be located on the main powerhouse floor. The overall size of the transformer gallery will be 43 feet wide, 40 feet high, and 446 feet long; the bus tunnels will be 14 feet wide and 14 feet high.

High voltage cables will be taken to the surface in two 7.5-foot internal diameter cable shafts, and provision will be made for an inspection hoist in each shaft.

Vehicle access to the transformer gallery will be from the south end via the main powerhouse access tunnel. Personnel access will be from the main access shaft or through each of the four isolated phase bus tunnels.

6.10.4 - Surge Chamber (**)

A simple surge chamber will be constructed 120 feet downstream of the powerhouse to control pressure fluctuations in the turbine draft tubes and tailrace tunnel under transient load conditions, and on machine start-up. The chamber will be common to all four draft tubes. The overall size of the chamber will be 75 feet wide, 240 feet long, and 190 feet high.

The draft tube gate gallery and crane will be located in the same cavern, above the maximum anticipated surge level. Access to the draft tube gate gallery will be by a rock tunnel from the main access tunnel. The tunnel will be widened locally for storage of the draft tube gates.

The chamber will be an unlined rock excavation with localized rock support as necessary for stability of the roof arch and walls. The guide blocks for the draft tube gates will be of reinforced concrete anchored to the rock excavation by rock bolts.

6.10.5 - Draft Tube Tunnels (*)

The orientation of the draft tube tunnels will be 300°. The tunnels will be 19 feet in diameter and steel- and concrete-lined, with the concrete having a thickness of about two feet.

6.11 - Tailrace Tunnel (*)

The tailrace pressure tunnel will convey power plant discharge from the surge chamber to the river. The tunnel will have a modified horseshoe cross section with an internal dimension of 38 feet, and will be concrete-lined throughout with a minimum thickness of 12 inches. The length of the tunnel is 6,800 feet.

The tailrace portal site will be located at a prominent steep rock face on the north bank of the river. The portal outlet is rectangular in section, which reduces both the maximum outlet velocity (eight ft/sec) as well as the velocity head losses. Vertical stoplog guides will be provided for closure of the tunnel for tunnel inspection and/or maintenance.

6.12 - Access Plan (**)

6.12.1 - Description of Access Plan (*)

Access to the Devil Canyon development will consist primarily of a railroad extension from the existing Alaska Railroad at Gold Creek to a railhead and storage facility adjacent to the Devil Canyon camp area. From here materials and supplies will be distributed using a system of site roads.

To provide flexibility of access the railroad extension will be augmented by a road between the Devil Canyon and Watana damsites. The availability of both road and rail access will reduce the schedule and cost risks associated with limited access.

This road connection will also be required for travel between Watana and Devil Canyon by the post-construction operation and maintenance personnel who will be stationed at Watana.

6.12.2 - Rail Extension (*)

Except for a two-mile section where the route traverses steep terrain alongside the Susitna River, the railroad will climb steadily for 12.2 miles from Gold Creek to the railhead facility near the Devil Canyon camp.

Nearly all of the route traverses potentially frozen Basal till on side slopes varying from flat to moderately steep. Several streams are crossed, requiring the construction of large culverts. However, where the railroad crosses Jack Long Creek small bridges will be built to minimize impacts to the aquatic habitat. In view of the construction conditions it is estimated that it will take eighteen months to two years to complete the extension. Therefore construction should start two years prior to commencement of the main works at Devil Canyon.

The railroad extension will be designed in accordance with the parameters set out below:

Maximum grade	2.5%
Maximum curvature	10°
Design loading	E-72

These parameters are consistent with those presently being used by the Alaska Railroad.

6.12.3 - Connecting Road (**)

From the railhead facility at Devil Canyon a connecting road will be built to a high-level suspension bridge approximately one mile downstream of the damsite. The route then proceeds in a north- easterly direction, crosses Devil Creek and swings around past Swimming Bear Lake at an elevation of 3,500 feet before continuing in a southeasterly direction through a wide pass. After crossing Tsusena Creek, the road continues south to the Watana damsite. The overall length of the road is 37.0 miles.

In general the alignment crosses good soil types with bedrock at or near the surface. Erosion and thaw settlement problems should not be a problem since the terrain has gentle to moderate slopes which will allow roadbed construction without deep cuts.

The connecting road will be built to the same standards and in accordance with the design parameters used for the Watana access road.

6.12.4 - Construction Schedule (**)

The 1,790-foot long high-level suspension bridge crossing the Susitna River is the controlling item in the construction schedule, requiring three years for completion. Therefore, access for the start of the main works at the Devil Canyon damsite will utilize the Watana access road.

6.12.5 - Right-of-Way (**)

The road and railroad routes mainly traverse terrain with gentle to moderate side slopes, where a right-of-way width of 200 feet will be sufficient. Only in areas of major sidehill cutting and deep excavation will it be necessary to go beyond 200 feet.

6.13 - Site Facilities (*)

The construction of Devil Canyon will require various facilities to support the construction activities throughout the entire construction period. Following construction, the planned operation and maintenance

of Devil Canyon will be centered at Watana; therefore, a minimum of facilities at the site will be required to maintain the project during operation.

As described for Watana, a camp and construction village will be constructed and maintained at the project site. The camp/village will provide housing and living facilities for 1,900 people during construction. Other site facilities will include contractors' work areas, site power, services, and communications. Items such as power and communications and hospital services will also be required for construction operations independent of camp operations. Electric power will be provided from Watana.

6.13.1 - Temporary Camp and Village (**)

A tentative location for the camp/village is on the south bank of the Susitna River between the damsite and Portage Creek, approximately 2.5 miles southwest of the Devil Canyon Dam (see Plate F70). The south side of the Susitna was chosen because the main access road in this area will be from the south. South-facing slopes will be used for the camp/village location.

The camp will consist of woodframe dormitories with modular mess halls, recreational buildings, bank, post office, fire station, warehouses, hospital, offices, etc. The camp will accommodate approximately 1,400 workers.

The village, designed for approximately 150 families, will be grouped around a service core containing a school, gymnasium, stores, and recreation area.

The two areas will be separated to provide a buffer zone. The hospital will serve both the main camp and the village.

The camp location will be separated from the work areas by approximately one mile. Travel time to the work area will generally be less than 15 minutes.

The camp/village will be constructed in stages to accommodate the peak work force. The facilities will be designed for the peak work force plus ten percent for "turnover". The "turnover" will include provisions for overlap of workers and vacations. The conceptual layouts for the camp/village are presented in Plates F72 and F73.

Construction camp buildings will consist largely of factory-built modules assembled at site to provide the various facilities required. The modules will be fabricated with heating, lighting, and plumbing facilities, interior finishes, furnishings, and

equipment. Modules will be supported on timber cribbing or blocking approximately two feet above grade.

Larger structures such as the central utilities building, gym, and warehouses will be pre-engineered steel-framed structures with metal cladding.

The various buildings in the camp are identified on Plate F72.

6.13.2 - Site Power and Utilities (**)

(a) Power (**)

A 345 kV transmission line from Watana and a substation will be in service during the construction activities. Two transformers will be installed at the substation to reduce the line voltage to the desired voltage levels.

The peak demand during construction is estimated at 20 MW for the camp/village and four MW for construction requirements. The distribution system for the camp/village will be 4.16 kV.

(b) Water (**)

The water supply system will serve the entire camp/village and selected contractors' work areas. The water supply system will provide for potable water and fire protection. The estimated peak population to be served will be 1,940 (1,410 in the camp and 530 in the village).

The principal source of water will be the Susitna River. The water will be treated in accordance with the U.S. Environmental Protection Agency (EPA) primary and secondary requirements and with Drinking Water Standards of the State of Alaska Department of Environmental Conservation (ADEC).

(c) Wastewater (**)

One wastewater collection and treatment system will serve the camp/village. Gravity flow lines with lift stations will be used to collect the wastewater from all of the camp and village facilities. The "in-camp" and "in-village" collection systems will be run through the permawalks and utilidors so that the collection system will always be protected from the elements.

At the village, an aerated collection basin will be installed to collect the sewage. The sewage will be pumped

from this collection basin through a force main to the sewage treatment plant.

Chemical toilets located around the site will be serviced by sewage trucks which will discharge directly into the sewage treatment plant.

The sewage treatment system will be a biological system with lagoons. The system will be designed to meet Alaska ADEC and Federal EPA standards. The lagoons and system will be modular to allow for growth and contraction of the camp/village.

The location of the treatment plant is shown on Plate F70. The location was selected to avoid unnecessary odors in the camp.

The sewage plant will discharge its treated effluent to the Susitna River. All treated sludge will be disposed of in an approved solid waste sanitary landfill.

6.13.3 - Contractors' Area (**)

Contractors on the site will require offices, workshops, ware houses, storage areas, and fabrication shops. These will be located on the south side of the Susitna River near the dam site.

7 - DEVIL CANYON RESERVOIR STAGE II (*)

The Devil Canyon reservoir, at a normal operating level of 1,455 feet, will be approximately 26 miles long with a maximum width of approximately 1/2 mile. The total surface area at normal operating level will be 7,800 acres. Immediately upstream of the dam, the maximum water depth will be approximately 580 feet. The minimum reservoir level will be 1,405 feet during normal operation, resulting in a maximum drawdown of 50 feet. The reservoir will have a total capacity of 1,100,000 acre-feet of which 350,000 acre-feet will be live storage.

8 - TURBINES AND GENERATORS - DEVIL CANYON STAGE II (**)

8.1 - Unit Capacity (**)

The Devil Canyon powerhouse will have four generating units, each with a maximum output of 173 MW based on the full reservoir level at elevation 1,455 and a corresponding net head of 600 feet. The net head on the plant will vary from 545 feet to 600 feet. Unit characteristics including generator outputs are described in Table F.1.

The operating head for rating the unit will be the minimum net head of 545 feet. Rated unit output at this head is 150 MW.

The generator rating has been selected as 192 MVA with a 90 percent power factor to match the maximum in turbine output under maximum head. Generator output is assumed to be 98 percent of the turbine output at full load.

8.2 - Turbines (**)

The turbines will be of the vertical-shaft Francis type with steel spiral casing and a concrete lined elbow-type draft tube. The draft tube will have a single water passage with no piers.

Maximum and minimum net heads on the turbine will be 600 feet and 545 feet, respectively. The full-gate output of the turbines will be about 177 MW at maximum net head and 153 MW at minimum net head. For study purposes, the best efficiency (best-gate) output of the units has been assumed at 85 percent of the full-gate turbine output.

8.3 - Generators (o)

The four generators in the Devil Canyon powerhouse will be of the vertical-shaft, overhung synchronous directly connected to the vertical Francis turbines.

The generators will be similar in construction and design to the Watana generators. The general features described in Section 3.2 for the stator, rotor, excitation system, and other details also will apply for the Devil Canyon generators.

The rating and characteristics of the generators will be as follows:

Rated Capacity:	192 MVA, 0.9 power factor
Rated Power:	170 MW
Rated Voltage:	15 kV, 3 phase, 60 Hertz

Synchronous Speed:	225 rpm
Inertia Constant:	3.5 MW-Sec/MVA
Short Circuit Ratio:	1.1 (minimum)
Efficiency at Full Load:	98 percent (minimum)

8.4 - Governor System (o)

A governor system with electric hydraulic governor actuators will be provided for each of the Devil Canyon units. The system will be the same as for Watana (see Section 3.4).

9 - APPURTENANT EQUIPMENT - DEVIL CANYON - STAGE II

9.1 - Miscellaneous Mechanical Equipment (o)

9.1.1 - Powerhouse Cranes (o)

Two overhead type powerhouse cranes will be provided at Devil Canyon as at Watana. The crane capacity will be approximately 200 tons.

9.1.2 - Draft Tube Gates (o)

Draft tube gates will be provided to permit dewatering of the turbine water passages for inspection and maintenance of the turbines. The arrangement of the draft tube gates will be the same as for Watana, except that only two sets of gates will be provided, each set with two 21-foot wide by 10.5-foot high sections.

9.1.3 - Draft Tube Gate Crane (o)

A crane will be installed in the surge chamber for installation and removal of the draft tube gates. The crane will be either a monorail (or twin monorail) or a gantry crane with an approximate capacity of 30 tons. The crane will be pendant-operated and have a two point lift. A follower will be used with the crane for handling the gates. The crane runway will be located along the upstream side of the surge chamber and will extend over the intake for the compensation flow pumps as well as a gate unloading area at one end of the surge chamber.

9.1.4 - Miscellaneous Cranes and Hoists (o)

In addition to the powerhouse cranes and draft tube gate cranes, the following cranes and hoists will be provided in the power plant:

- A 5-ton monorail hoist in the transformer gallery for transformer maintenance;
- Small overhead, jib, or A-frame type hoists in the machine shop for handling material; and
- A-frame or monorail hoists in other powerhouse areas for handling small equipment.

9.1.5 - Elevators (o)

Access and service elevators will be provided for the power plant as follows:

- o Access elevator from the control building to the powerhouse;
- o Service elevator in the powerhouse service bay; and
- o Inspection hoists in cable shafts.

9.1.6 - Power Plant Mechanical Service Systems (o)

The power plant mechanical service systems for Devil Canyon will be essentially the same as discussed in Section 5.1(f) for Watana, except for the following:

- o There will be no main generator breakers in the power plant; therefore, circuit breaker air will not be required. The high pressure air system will be used only for governor as well as instrument air. The operating pressure will be 600 to 1,000 psig depending on the governor system operating pressure.
- o An air-conditioning system will be installed in the powerhouse control room.
- o Heating and ventilating will be required for the entrance building to the access shaft in the south abutment.
- o For preliminary design purposes, only one drainage and one dewatering sump have been provided in the powerhouse. The dewatering system will also be used to dewater the intake.

9.1.7 - Surface Facilities Mechanical Service Systems (o)

The entrance building above the power plant will have only a heating and ventilation system. The mechanical services in the standby power building will include a heating and ventilation system, a fuel oil system, and a fire protection system, as at Watana.

9.1.8 - Machine Shop Facilities (o)

A machine shop and tool room will be located in the powerhouse service bay area to take care of maintenance work at the plant.

The facilities will not be as extensive as at Watana. Some of the larger components will be transported to Watana for necessary machinery work.

9.2 - Accessory Electrical Equipment (o)

9.2.1 - General (o)

The accessory electrical equipment described below includes the following:

- o Main generator step-up 15/345 kV transformers;
- o Isolated phase bus connecting the generator and transformers;
- o 345 kV oil-filled cables from the transformer terminals to the switchyard;
- o Control systems; and
- o Station service auxiliary ac and dc systems.

Other equipment and systems described include grounding, lighting system and communications.

The main equipment and connections in the power plant are shown in the single line diagram (Plate F68). The arrangement of equipment in the powerhouse, transformer gallery, and cable shafts is shown in Plates F63 to F65.

9.2.2 - Transformers and HV Connections (o)

Twelve single-phase transformers and one spare transformer will be located in the transformer gallery. Each bank of the three single-phase transformers will be connected to one generator by isolated phase bus located in bus tunnels. The HV terminals of the transformer will be connected to the 345 kV switchyard by 345 kV single-phase, oil-filled cables installed in 800-foot long vertical shafts. There will be two sets of three single-phase 345 kV oil-filled cables installed in each cable shaft. One additional set will be maintained as a spare three-phase cable circuit in the second cable shaft. These cable shafts will also contain the control and power cables between the powerhouse and the surface control room, as well as emergency power cables from the diesel generators at the surface to the underground facilities.

9.2.3 - Main Transformers (o)

The transformers will be of the single-phase, two-winding, oil-immersed, forced-oil water-cooled (FOW) type. A total of twelve single-phase transformers and one spare transformer will be provided, with rating and characteristics as follows:

Rated capacity:	70 MVA
High Voltage Winding:	345/1.73 kV, grounded Y
Basic Insulation Level (BIL) of HV Winding:	1300 kV
Low Voltage Winding:	15 kV, Delta
Transformer Impedance:	15 percent

9.2.4 - Generator Isolated Phase Bus (o)

Isolated phase bus connections will be located between the generator and the main transformer. The bus will be of the self-cooled, welded aluminum tubular type with design and construction details generally similar to the bus at the Watana power plant. The rating of the main bus will be as follows:

Rated current:	9000 amps
Short circuit current momentary:	240,000 amps
Short circuit current symmetrical:	150,000 amps
Basic Insulation Level (BIL):	150 kV

9.2.5 - 345 kV Oil-Filled Cable (o)

The cables will be rated for a continuous maximum current of 400 amps at 345 kV ± 5 percent. The cables will be of single-core construction with oil flowing through a central oil duct within the copper conductor. The cables will be installed in the 800-foot cable shafts from the transformer gallery to the surface. No cable jointing will be necessary for this installation length.

9.2.6 - Control Systems (o)

The Devil Canyon power plant will be designed to be operated as an unattended plant. The plant will be normally controlled through supervisory control from the Susitna Area Control Center at Watana. The plant will, however, be provided with a control room with sufficient control, indication, and annunciation equipment to enable the plant to be operated during emergencies by one operator in the control room. In addition, for the purpose of testing and commissioning and maintenance of the plant, local control boards will be mounted on the powerhouse floor near each unit.

Automatic load-frequency control of the four units at Devil Canyon will be accomplished through the central computer-aided control system located at the Watana Area Control Center.

The power plant will be provided with "black start" capability similar to that provided at Watana to enable the start of one unit without any power in the powerhouse or at the switchyard, except that provided by one emergency diesel generator. After the start- up of one unit, auxiliary station service power will be established in the power plant and the switchyard; the remaining generators can then be started one after the other to bring the plant into full output within the hour.

As at the Watana power plant, the control system will be designed to permit local-manual or local-automatic starting, voltage adjusting, synchronizing, and loading of the unit from the powerhouse control room at Devil Canyon.

The protective relaying system is shown in the main single line diagram (Plate F68) and is generally similar to that provided for the Watana power plant.

9.2.7 - <u>Station Service Auxiliary AC and DC Systems</u> (o)

(a) <u>AC Auxiliary System</u> (o)

The auxiliary system will be similar to that in the Watana power plant except that the switchyard and surface facilities power will be obtained from a 4.16 kV system supplied by two 5/7.5 MVA, OA/FA, oil-immersed transformers connected to generators Nos. 1 and 4, respectively. The 4.16 kV double-ended switchgear will be located in the powerhouse. It will have a normally-open tie breaker which will prevent parallel operation of the two sections. The tie breaker will close on failure of one or the other of the incoming supplies. The 1400 hp compensation flow pumps will be supplied with power directly from the 4.16 kV system. Two 4.16 cables installed in the cable shafts will supply power to the surface facilities.

The 480 V station service system will consist of a main 480 V switchgear, separate auxiliary boards for each unit, essential auxiliaries board, and a general auxiliaries board. The main 480 V switchgear will be supplied by two 2,000 kVA, 15,000/480 V grounded wye sealed gas dry-type transformers. A third 2,000 kVA transformer will be maintained as a spare.

Two emergency diesel generators, each rated 500 kW, will be connected to the 480 V powerhouse main switchgear and 4.16

kV surface switchboard, respectively. Both diesel generators will be located at the surface.

An uninterruptible high-security power supply will be provided for the supervisory computer-aided plant control systems.

(b) DC Auxiliary Station Service System (o)

The dc auxiliary system will be similar to that provided at the Watana plant and will consist of two 125 V dc lead-acid batteries. Each battery system will be supplied by a double-rectifier charging system. A 48 V dc battery system will be provided for supplying the supervisory and communications systems.

9.2.8 - Other Accessory Electrical Systems (o)

The other accessory electrical systems including the grounding system, lighting system, and powerhouse communications system will be similar in general design and construction aspects to the system described in Section 5.2 for the Watana power plant.

9.3 - Switchyard Structures and Equipment (o)

9.3.1 - Single Line Diagram (o)

A breaker-and-a-half single line arrangement will be used at the switchyard. This arrangement was selected for reliability and security of the power system. Plate F69 shows the details of the switchyard single line diagram.

9.3.2 - Switchyard Structures and Layout (o)

The switchyard layout will be based on a conventional outdoor type design. The design adopted for this project will provide a two- level bus arrangement. This design is commonly known as a low station profile.

The two-level bus arrangement is desirable because it is less prone to extensive damage in case of an earthquake. Due to the lower heights, it is also easier to maintain.

10 - TRANSMISSION LINES - DEVIL CANYON STAGE II (**)

As part of the Stage II Devil Canyon development, the transmission system will be supplemented. Two single-circuit 345 kV transmission lines will be built between the Devil Canyon switchyard at the power development and the Gold Creek switching station.

From the Devil Canyon substation the lines will head directly west for a distance of approximately one mile where they will intersect the Watana to Gold Creek transmission corridor. From this point to the Gold Creek switching station the lines will share the same corridor as the Watana lines.

At Gold Creek, 345 kV breakers will be added in an new bay within the switching station. The new circuit breakers will provide switching and terminations for the incoming lines and accommodate a new line to Anchorage.

11 - PROJECT STRUCTURES - WATANA STAGE III (***)

This section describes the project features that will be altered or added during third stage construction of the Watana development. Stage III consists of increasing the plant capacity and energy generation by raising Watana Dam and the reservoir maximum normal operating level, and by adding two generating units.

11.1 - General Arrangement (***)

The raising of Watana Dam during Stage III will create a reservoir approximately 48 miles long with a surface area of 38,000 acres, and a gross storage capacity of 9,500,000 acre-feet at the normal maximum operating level of el. 2,185.

The maximum water surface elevation during flood conditions will be 2,199.3 The minimum operating level of the reservoir will be el. 2,065, providing a live storage during normal operation of 3,700,000 acre-feet.

The Stage I internal zoning will be maintained in raising the dam. The nominal crest elevation of the dam will be 2,205, with a maximum height of 885 feet above the foundation and a crest length of 4,100 feet. The embankment crest will initially be cambered to el. 2,210 to allow for potential settlement. The total volume of fill material placed in the dam during this will be 26,363,000 cubic yards, bringing the total volume of the dam to 58,470,000 cubic yards.

A new power intake will be constructed adjacent to the existing two intakes. The existing intake concrete superstructure will be raised to accommodate the higher reservoir level. Simultaneously, the concrete superstructure for the outlet facilities will also be raised. The approach channel constructed during Stage I will be adequate for the efficient flow of water to all intakes.

Additional power capacity will be achieved by the increased head on the Stage I generating units, which were designed for this reservoir raising, and the two additional generating units installed during this stage. This installation will require an extension of the powerhouse chamber to the south of the service bay. Similar extensions will be required to the south of the transformer gallery and surge chamber. The excavated cross sections of these chambers will be the same as the Stage I chambers.

A third power shaft and tunnel bifurcating into penstocks to supply water to the two generating units will be excavated and lined with concrete from the new intake structure. The power conduit will have an internal diameter of 24 feet.

The penstocks will be steel-lined for a distance of 200 feet upstream of the powerhouse. The steel-lined section will have a diameter of 15 feet. The remaining penstock reach to the bifurcation will be 18 feet in diameter.

The normal reservoir fluctuation for power generation will be 120 feet, from the normal maximum pool at el. 2,185 to the minimum normal pool at el. 2,065.

The surge chamber extension will be hydraulically joined to the powerhouse cavern by two draft tube tunnels. The turbine discharges will flow from the south end of the surge chamber by a second 34 foot diameter concrete-lined modified horseshoe tunnel. This tunnel will intersect the Number 2 diversion tunnel, which will be used to complete the tunnel tailrace system, and discharge to the river downstream of the dam. The transformer gallery extension will house a bank of three additional single-phase 15-345/ 1.73 kV transformers serving the two generators. The transformers will be connected by three 345 kV single-phase gas insulated SF_6 busses, and led through an existing shaft to the transmission yard at the surface.

There will be no change to the outlet facilities downstream of the intake structure.

The maximum outlet works discharge required to pass the 50-year flood at Watana without operating the spillway is approximately 24,000 cfs. In combination with a powerhouse flow of 7,000 cfs this will cause the Watana water level to be raised to el. 2,193. The average powerhouse flow during the passing of the 50-year flood may reach 9,900 cfs. This may result in Watana outflows of 33,900 cfs. The resulting inflow to Devil Canyon may reach approximately 43,000 cfs. The Devil Canyon outlet works has the capacity to pass 42,000 cfs without operating the spillway. A 1.0 foot surcharge has been provided at the Devil Canyon Dam to store flow in excess of the outlet works capacity. Therefore the raising of the reservoir will increase the discharge capacity of the outlet works for the maximum valve settings (80% gate stroke) from 24,000 cfs to 30,000 cfs. However, this extra capacity is not needed in Stage III to store and release the 50-year flood without operating the spillways. The project operating policy during floods is to transfer as much energy generation from the Devil Canyon powerhouse to the Watana powerhouse as necessary to pass the flood without raising the water level above el. 2,193 or opening the spillway. The Devil Canyon outlet works has the capacity to pass the outflow from Watana plus intervening flow without raising the Devil Canyon water level above el. 1,456.0 or requiring use of that spillway. Gas concentrations downstream of the dams are expected to be below naturally occurring levels.

The spillway control structure will require a substantial modification. The bridge will be removed, and the piers and abutment wall concrete

will be raised. This will be followed by raising the ogee section to a crest elevation of 2,135. The Stage I radial gates and hydraulic hoists will be re-installed. The ogee section will, in effect, be a gravity dam section with its downstream face forming the upper reach of the spillway chute prior to joining the lower reach which was constructed during Stage I. The spillway will still have the capacity to pass the Probable Maximum Flood (PMF) without overtopping the dam. The emergency release facilities constructed in diversion tunnel No. 1 will still be available for lowering of the reservoir over a period of time to permit emergency inspection or repair to the impoundment structures.

11.2 - Dam Embankment (***)

The Stage I Watana Dam has been designed with the intent of raising it during Watana Stage III development. In general, the outer slopes and internal zoning of the Stage I dam will be raised to the nominal final Stage III crest level of el. 2,205. Some excavation at the top of the Stage I dam will be necessary to ensure continuity of the zones between Stages I and III construction. The dam will be compacted earth and rockfill construction and will consist of an impervious core protected by fine and coarse filters upstream and downstream. The upstream and downstream outer shells will consist of rockfill. A typical cross section is shown on Plate F77 and is described below.

11.2.1 - Typical Cross Section (***)

The basic cross section of the Stage III dam is the same as the Stage I dam. Filter and impervious core thickness criteria are the same as for Stage I; core and filter thicknesses in the Stage I development take into account for the higher reservoir levels which will be present after Stage III.

The upstream and downstream filter zones provide protection against possible piping through transverse cracks that could occur because of settlement or resulting from internal displacement during a seismic event. The shells of the dam will consist of rockfill obtained from Quarry Site A. The rockfill will minimize pore pressure generation and ensure rapid dissipation of pore pressures should seismic shaking occur.

As in Stage I, protection against wave and ice action on the upstream slope will consist of a quarried-rock raked layer of large stone up to 36 inches in size.

The volume of material required to construct the Stage III Watana Dam is presently estimated as follows:

- o Impervious material: 1,552,000 cubic yards
- o Fine filter material: 753,000 cubic yards

- o Coarse filter material: 679,000 cubic yards
- o Rockfill material: 22,936,000 cubic yards

11.2.2 - Crest Details and Freeboard (***)

The typical crest detail is shown in Plate F77. Because of the narrowing at the dam crest, the filter zones are reduced in width but still protect the core material from damage by frost penetration and desiccation.

The nominal crest elevation of Watana Stage III will be 2,205.

The total settlement allowance considered results in a deformation of up to 0.5 percent of the height of the dam. During construction of the dam, additional allowances will be made for post-construction settlement of the dam under its own weight, for the effects of saturation on the upstream rock fill when the reservoir is first filled, and for possible settlement from seismic shaking. Provision will be made during construction for placement of additional fill at the crest should settlements exceed the estimated amounts. At each abutment the crest el. will be 2,205 while the central portion of the embankment would be to el. 2,210. Under normal operating conditions the minimum freeboard relative to the maximum operating pool elevation of 2,185 will be approximately 20 feet.

The PMF freeboard allowance of six feet is based on the crest level after all settlement has taken place. Less PMF level freeboard is necessary at Stage III than at Stage I because of the greater storage capabilities of the reservoir basin.

Ultimate security against overtopping of the dam will be provided by the spillway which is designed to pass the PMF without overtopping the dam.

11.2.3 - Grouting and Pressure Relief System (***)

The majority of the grouting and pressure relief system will have been constructed during Stage I. However, consolidation grouting along the abutments above el. 2,025 will be required in the core foundation during Stage III. In addition, grouting and drainage galleries, the grout curtain, and pressure relief drain holes, will be constructed above the existing Stage I to the final Stage III level.

The grout curtain and drilling for the pressure relief system will be largely carried out from galleries in the rock foundation in the abutments and beneath the dam. Details of the grouting, pressure relief, and galleries are shown on Plate F78.

11.2.4 - Instrumentation (***)

Instrumentation will have been installed during Stage I to provide monitoring of performance of the dam and foundation during construction as well as during operation. Instruments for measuring internal vertical and horizontal displacement, stresses and strains, and total fluid pressures, as well as surface monuments and markers, were installed. This instrumentation will also provide monitoring capabilities during and after Stage III construction. Some additional instrumentation will be required in the Stage III zone between elevations 2,025 and 2,205. Conservative quantity estimates for instrumentation have been made on the basis of currently available geotechnical data for the site.

(a) Piezometers (***)

- o Piezometers will be used to measure static fluid pressure in the pore space of soil, rockfill, and in the rock foundation.

(b) Internal Vertical Movement Devices (***)

- o Cross-arm settlement devices as developed by the USBR
- o Various versions of the taunt-wire devices which have been developed to measure internal settlement
- o Hydraulic-settlement devices of various kinds

(c) Internal Horizontal Movement Devices (***)

- o Taunt-wire arrangements
- o Cross-arm devices
- o Inclinometers
- o Strain meters

(d) Other Measuring Devices (***)

- o Stress meters
- o Surface monuments and alignment markers
- o Seismographic records and seismoscopes
- o Flow meters to record discharge from drainage and pressure relief system

11.3 - Diversion (***)

Passage of river flows during Stage III will be accomplished by in-place Stage I project features. Stage III diversion will involve reconstructing the downstream cofferdam over the in-place slurry trench cutoff, and dewatering the area between the Stage I dam and the cofferdam by pumping. Construction will involve approximately 10,000

cubic yards of impervious fill, and 16,000 cubic yards of rockfill and filter material. The foundation cutoff of this cofferdam will be sufficiently water tight that once the area downstream of the dam is dewatered, minimum pumping to tailwater will be required to maintain adequate drainage so that Stage III Watana foundation preparation and fill placement can occur. This care and handling of water will be required for one construction season.

11.4 - Emergency Release Facilities (***)

The emergency release facilities constructed during Stage I will not be subjected to any change during Stage III. The description of these facilities is presented in 1.4 - Emergency Release Facilities. The gated concrete plugs, and the bonnetted-type high pressure slide gates installed therein will have been designed for the hydraulic head imposed by the Stage III reservoir level. The emergency release facilities will not be operated under head conditions exceeding 600 feet. The upstream and downstream gates will be operated in unison maintaining equal gate openings in order to balance the hydraulic head drop across the gates. Energy dissipation at the diversion tunnel exit will be accomplished by the concrete flip bucket in the exit channel.

11.5 - Outlet Facilities (***)

The primary function of the outlet facilities remains the same as in Stage I, which is to discharge floods with recurrence frequencies of up to once in 50 years with minimum downstream erosion and minimum generation of dissolved nitrogen in the discharges. As before, the secondary function is the capability of drawing the reservoir down during an extreme emergency situation.

The descriptions (for the approach channel only) found in 1.5.1, Approach Channel and Intake, 1.5.2, Intake Gates and Trashracks, 1.5.3, shaft and Tunnel, 1.5.4, Discharge Structure, 1.5.5, Fixed Cone Valves, 1.5.6, Ring Follower Gates, and 1.5.7, Discharge Area, are still valid for the Stage III development. All structures and equipment constructed and installed in Stage I are designed for Stage III loadings.

The Stage III development of the outlet facilities will be limited to the raising of the intake superstructure. This work will entail raising the concrete exterior walls, central pier and placing a new deck at el. 2,207. The stop log and trashrack guides will be extended so that the stop logs and trashracks may be placed and removed from the new deck level. Access to the intake structure will be via an embankment which joins the crest of the dam. The Stage III Intake is shown on Plate F80.

11.6 - Spillway (***)

The function of the Stage III spillway is still to provide discharge capability for floods exceeding the capacity of the outlet facilities (50-year flood). The spillway and outlet facility will have a combined capacity to pass flood inflows to the reservoir with a frequency of occurrence of up to and including the Probable Maximum Flood (PMF).

Plate F79 shows the Stage III spillway, and indicates that the modification to the Stage I spillway is restricted to the control structure. The control structure will take on the appearance of a gravity dam spillway by raising the Stage I control structure between the approach channel and the chute channel. The overflow and chute sections will be hydraulically model tested to determine its configuration during the Stage I detailed design phase.

11.6.1 - Approach Channel and Control Structure (***)

The approach channel, as excavated in Stage I, will require no change for the Stage III development. The concrete control structure overflow section will be raised in phases once the crest of the dam has reached el. 2,050.

(a) Phase I (***)

At this point, concrete stop logs will be placed upstream of the control structure at a spillway end bay, bearing on the pier nose, and in a slot in the abutment wall. The water will be evacuated from the area between the stop logs and the radial gate prior to the removal of the gate for reuse when the concrete in the bay is at its final level. The remaining two bays, with increased reservoir surcharges, will provide sufficicent capacity to pass extreme flood events. Concrete will be placed in the initial bay to el. 2,014.

(b) Phase II (***)

A second bay will be closed when the dam crest is no less than el. 2,080 and the process indicated in (a) will be repeated. Concrete placement in the second bay will terminate upon reaching el. 2,014.

(c) Phase III(***)

The third and last bay will be closed when the dam crest elevation is no less than el. 2,100 and the initial process indicated in (a) will be repeated. Extreme flood events will be passed over the stop logs of the bay under

construction and incomplete crest at el. 2,014. Once concrete placement in the third bay reaches el. 2,014, concrete placement will begin in the other two bays.

(d) Phase IV (***)

During the final phase of concreting, placement will be in all bays allowing a more or less uniform raising of the concrete structure. The radial gates and bridge structure will be places once again in position on the raised structure.

11.6.2 - Spillway Gates and Stop Logs (***)

This equipment and arrangement is the same as that of Stage I which is described in 1.6.2.

11.6.3 - Spillway Chute (***)

The Stage III control structure will transition to the inclined Stage I chute which is described in 1.6.3.

11.6.4 - Flip Bucket (***)

There are no changes to the Stage I flip bucket described in 1.6.4.

11.6.5 - Access (***)

The deep cuts in rock required for access in Stage I will be filled with impervious material on the abutment side of the spillway and topped out with a roadway surface which follows the Stage I horizontal access road alignment. The south spillway abutment will be joined by the Stage III dam embankment.

11.7 - Power Intake (***)

11.7.1 - Intake Structures (***)

The Stage I intake structures Nos. 1 and 2 serving generating Units 1 to 4 will be raised and an intake structure adjacent to Intake No. 2 will be constructed (see Plate F83). The foundation for the new intake structure is at el. 2,002. Both the new intake and the Stage I intakes will be raised simultaneously while maintaining the Stage I generating requirements. The new intake will be provided with four pairs of openings in its upstream wall, all of which can be closed-off with sliding steel shutters. In the Stage I intakes, which are being raised, the

pattern and spacing of pairs of openings will be the same as in the new intake. All openings will be protected by trashracks upstream of the shutter openings . A heated boom will operate in guides upstream from the racks following the water surface, keeping the racks ice free.

The reservoir fluctuation in Stage III will be 120 feet from the reservoir el. 2,185. The upper level of the intake structures will be el. 2,201. Mechanical equipment will be housed at this level in a steel frame building. Part will have been removed from the Stage I deck, and the remainder will be a new extension for Intake No. 3.

11.7.2 - Approach Channel (***)

There are no changes to the Stage I approach channel described in 1.8.2. Due to the substantially increased depth of flow in the approach channel, the velocities of flow during normal and extreme conditions will be less than that of Stage I for the same conditions.

11.7.3 - Mechanical Arrangement (***)

(a) Ice Boom (***)

A heated boom will be installed in the guides immediately upstream of the trashracks of intake No. 3. The heated booms of intakes No. 1 and 2 will rise in the structures guides as the reservoir is filled minimizing ice accumulation on the trashrack and intake shutters.

(b) Trashracks (***)

The intake structure No. 3 will have four sets of trashracks, each set will consist of a pair of trashracks divided in two sections to facilitate handling by the intake service crane. Each set of trashracks will cover two openings 24 feet wide by 25 feet high. The trashracks will have a bar spacing of 6 inches and will be designed for a maximum differential head of 20 feet.

For Intake Structures No. 1 and 2 the trashracks will be transferred from the lower level to the upper four openings of the Stage III addition. These trashracks will be designed in accordance with the criteria indicated above.

(c) Intake Shutters (***)

Three sets of intake shutters will be installed in each of the new intake No. 3 and the raised intakes Nos. 1 and 2

to prevent flow through the openings behind which the shutter will be installed. As the reservoir level changes, the sliding shutters will be removed or replaced as necessary using the intake service crane.

Each of the shutters will be designed for a differential head of 15 feet, and will incorporate a flap gate. This will prevent failure of the shutters in the event of an accidental blockage of all intake openings.

The shutter guides will be heated to facilitate removal in sub-freezing weather. In addition, a bubbler system will be provided in the intake behind the shutters to keep the intake structure water surface free of ice.

(d) Intake Service Crane (***)

The overhead traveling-bridge type intake service crane used in Stage I will be transferred to the Stage III deck where the crane runway will be extended to cover Intake No. 3. The crane will be used for:

- Servicing the ice boom and ice boom hoist,
- Handling and cleaning the trashracks,
- Handling the intake shutters,
- Handling the intake bulkhead gates, and
- Servicing the intake gate and hoist.

The overhead crane will have a double point lift and followers for handling the trashrack shutters and bulkhead gates. The crane will be radio-controlled with a pendant or cab control for backup.

(e) Intake Bulkhead Gates (***)

The set of bulkhead gates provided to close the Stage I intakes will also be used for the Stage III Intake No. 3. The bulkhead gates will be used to permit inspection and maintenance of the intake gate and intake gate guides. The gates will be designed to withstand maximum differential pressure that will occur in No. 1 and 2 intakes.

(f) Intake Gates (***)

Intake gates will be provided to close the two No. 3 intake openings which are 12 feet wide by 24 feet high. The gates and operation thereof will be similar to the Stage I intake gates described in 1.8.3(f), although by virtue of the intakes vertical location the design head will be substantially reduced.

11.8 - Power Tunnel and Penstocks (***)

The general arrangement of the Stage III power tunnel and penstocks is shown on Plate F76. There are no changes to the Stage I arrangement. A single power tunnel from Intake No. 3 which bifurcates to penstocks is provided to convey water to each of the two new generating units. The power tunnel and penstocks will have a minimum concrete lining thickness of 18 inches and the penstock will be steel lined in the 200 foot reach immediately upstream of the powerhouse cavern.

11.8.1 - Steel Liner (***)

The description of criteria and parameters presented in 1.9.1 is also valid for Stage III.

11.8.2 - Concrete Lining (***)

The description presented in 1.9.2 is also valid for Stage III.

11.8.3 - Grouting and Pressure Relief System (***)

The comprehensive pressure relief system, established in Stage I, to protect the underground caverns against seepage from the high pressure penstock will be continued to provide protection for the extended caverns. This system comprised small diameter bore holes set out to intercept the jointing in the rock. A grouting and drainage gallery previously constructed in Stage I will provide the origin for this system.

11.9 - Powerhouse (***)

The existing Stage I powerhouse complex beneath the north abutment of the dam will be extended in Stage III towards the river to accommodate two additional generating units. This will require rock excavation in three caverns - the powerhouse, transformer gallery, and surge chamber - and interconnecting tunnels for the draft tubes, isolated phase bus ducts and tailrace.

The general layout of the powerhouse complex is shown in Plates F86 to F89.

11.9.1 - Access Tunnels and Shafts (***)

Except for a cross adit to be excavated from diversion tunnel No. 2 to the adjacent penstock construction adit, no additional access tunnels or shafts will need to be excavated in Stage III.

11.9.2 - Powerhouse Cavern (***)

The main powerhouse cavern extension will accommodate two additional vertical-shaft Francis turbines, with direct coupling to synchronous generators. Each unit will have a maximum output capability of 200 MW. The maximum output capabilities of the four Stage I turbines will also be increased to 200 MW due to the increased reservoir head.

The cavern extension will allow for the 60-foot long unit 5 and 6 monolith, and a 40-foot long laydown bay at the south end.

The two additional units will be separated form the existing units by a 69-foot long rock pillar, through which a drainage tunnel will have been excavated during Stage I construction. Multiple stairway access points will be available from the main generator floor to each gallery level. Additional access to the transformer gallery will be provided by stairway through a third isolated phase bus tunnel.

11.9.3 - Transformer Gallery (***)

The unit 5 and 6 transformers will be located underground in an extension of the transformer gallery, which is located 120 feet upstream from the powerhouse cavern. A third connecting tunnel will be added for the isolated phase bus. There will be three single-phase transformers rated at 15-345/1.73 kV, 150 MVA for the two generating units. Generator circuit breakers will be installed in the powerhouse on the generator floor level. The transformer gallery extension will be 45 feet wide, 20 feet high and 106 feet long; the bus tunnel will be 16 feet wide and 16 feet high.

A third station service auxiliary transformer (2 MVA) will be located in the isolated-phase bus tunnel.

Vehicle access to the transformers gallery will be by the existing main powerhouse access tunnel at the south end. Pedestrian access will be from the existing main access shaft or through each of the three isolated phase bus tunnels.

11.9.4 - Surge Chamber (***)

The surge chamber located 120 feet downstream form the powerhouse cavern, will be extended by the length of the powerhouse service bay, and by the two additional unit bays, for a total extension of 215 feet. The runway for the existing crane will be extended to allow access for placement of the stoplogs for a second trailrace tunnel.

11.9.5 - Grouting and Pressure Relief System (***)

Additional drain and grout holes will be drilled from the previously constructed adit, and from the cavern extension.

11.9.6 - SF_6 Gas Insulated Bus Shaft (***)

No additional SF_6 GIS will be required.

11.9.7 - Draft Tube Tunnels (***)

A 19-foot diameter tunnel will be constructed for each of the two additional generating units.

11.10 - Trailrace (***)

A second tailrace pressure tunnel will be provided to carry water from the surge chamber to the river. This second tunnel will also be a modified horseshoe cross section with a major internal dimension of 34 feet. It will connect the southern end of the surge chamber extension to the existing Division Tunnel No. 2, and will incorporate the cross adits between the penstock construction adit and the diversion tunnel which has to be provided for Stage III penstock construction. It will connect the surge chamber extension to the existing Diversion Tunnel No. 2.

11.11 - Access Plan (***)

Project access during Stage III will be the same as developed and used for Stage I. The primary objective of access is to provide a transportation system that will support construction activities and allow for the orderly development and maintenance of site facilities. The access plan is discussed in Section 1.12.

11.12 - Site Facilities (***)

Stage I site facilities will be used during Stage III, and are as described in Section 1.13.

11.13 - Relict Channel (***)

A relict channel exists on the north bank of the reservoir approximately 2,600 feet upstream from the dam. This channel runs from the Susitna River gorge to Tsusena Creek, a distance of about 1.5 miles. The surface elevation of the lowest saddle is approximately 2,205, and depths of up to 454 feet of glacial deposits have been identified.

To ensure the integrity of the rim of the Watana Reservoir and to control losses due to potential seepage, a number of conditions have

been evaluated. Study types include settlement of the reservoir rim, subsurface flows, permafrost and liquefaction during earthquakes.

11.13.1 - Surface Flows (***)

Based on information gained from past exploration programs, the relict channel soils are either dense or cohesive and as such are not deemed to be subject to settlement resulting for seismic shaking. Therefore, the low ground surface in the area will more than provide adequate freeboard as it is several feet above the Stage III dam crest which is at el. 2,205.

11.13.2 - Subsurface Flows (***)

The potential for progressive piping and erosion in the area of discharge into the Tsusena Creek will be controlled by continuous monitoring of the outlet area, undertaken for a lengthy period after Stage I reservoir filling, to ensure that a state of equilibrium has been established with respect to permafrost and seepage gradients in the buried channel area.

If seepage through the alluvium is found to be excessive during or following Stage I impoundment, or becomes excessive following Stage III impoundment, a "worst case" provision has been made to construct a slurry trench cutoff through the upstream alluvium at the narrow throat of the relict channel. A sufficient allowance has been made in the Watana construction cost for such cutoff construction and additional seepage pressure reduction measures.

11.13.3 - Permafrost (***)

The permafrost discussion in Section 1.14.3 for Stage I is applicable to Watana Stage III.

11.13.4 - Liquefaction (***)

Liquefaction was discussed in Section 1.14.4 for Stage I. No additional geotechnical investigations of the relict channel are foreseen during Stage III.

11.13.5 - Remedial Work Influence on Construction Schedules (***)

Relict channel remedial treatment construction work, if necessary, will have pratically no impact on the Watana Dam Stage III construction schedule. Because the relict channel work will be located near Borrow Site D, some coordination will be required between these two operations. Once this coordination has been accomplished, dam construction and the relict channel work can be concurrently accomplished.

11.13.6 - Relict Channel Treatment Summary (***)

Early concerns regarding the critical impact of the relict channel on the Watana project appear to be unfounded. Nevertheless, some uncertainties still exist and, therefore, costs ($57.1 million) for responding to the unknown concerns have been included in the Watana cost estimates for Stages I and III.

During design investigations, additional boreholes and inspection trenches will be employed to further delineate the relict channel foundation. The area will be studied during Borrow Site D excavation. The area will also be thoroughly monitored by observation devices during Stage I reservoir filling and operation, and Stage III reservoir filling to assess actual hydrological conditions in the relict channel.

Based on existing knowledge, the only remedial measures that may possibly be needed for the relict channel involve seepage control. To satisfy project feasibility until future exploration indicate that no seepage problems exist within the buried channels ("K" unit), costs ($51.0 million) have been included in Stage III for a positive seepage cutoff similar to an I.C.O.S. wall. The slurry trench would be in combination with a downstream toe drain. Should future design studies and investigations so indicate, a less conservative design will be considered.

12 - Reservoir Data - Watana Stage III (***)

The Watana Reservoir, at a normal operating level at el. 2,185 feet, will be approximately 48 miles long with a maximum width in the order of 5 miles. The total water surface area at normal operating level is 38,000 acres. The minimum reservoir level will be at el. 2,065 feet during normal operation, resulting in a maximum drawdown of 120 feet. The reservoir will have a total capacity of 9.5 million acre-feet, of which 3.7 million acre-feet will be live storage.

13 - Turbines and Generators - Watana - Stage III (***)

13.1 - Unit Capacity (***)

The Watana powerhouse will have six generating units: the four from Stage I and two additional units installed in Stage III. The maximum generator output of all six units will be 200 MW corresponding to the maximum normal reservoir level (el. 2,185), and a corresponding head of 719 feet. The net head on the plant will very from 600 feet to 719 feet. the turbine design net head of the two new units has been established at 680 feet.

The generator rating is the same as for the Stage I units (Section 3.1). Unit characteristics including generator outputs are described in Table F.1.

13.2 - Turbines (***)

The two additional turbines for Stage III will be of the vertical shaft Francis type, with steel spiral casing and a steel lined concrete elbow-type draft tube. The draft tube will comprise a single water passage without a center pier. These two turbines will be identical. These two turbines will also be identical to the Stage I turbines except for the design head selection. The design head is the head selected for optimum efficiency of operation. The narrower range of operating heads in Stage III will permit selection of a design head at the ultimate average operating head.

The rated output of each turbine will be approximately 174 MW at 645 feet rated net head. Maximum and minimum net operating heads on the units will be 719 feet and 600 feet, respectively. The full gate output of each turbine will be about 204 MW at 719 feet net head and 155 MW at 600 feet net head. Each turbine will be provided with a 12.5-foot diameter, straight flow-type butterfly valve. These guard valves will be located within the powerhouse just upstream of the turbines.

13.3 - Generators (***)

The generators for Stage III will be identical to the generators for Stage I. Type, rating, and excitation equipment are described in Section 3.3 - Generators.

13.4 - Governor System (***)

The governing systems for Stage III will be identical to the governing system for Stage I, as described in Seciton 3.4 - Governor System.

14 - Appurtenant Mechanical and Electrical Equipment - Watana Stage III (***)

14.1 - Miscellaneous Mechanical Equipment (***)

The mechanical service systems required for Stage III will be essentially the same as those installed under Stage I, described in Section 4.1.6 - Power Plant Mechanical Service Systems. On a unit basis, water will be provided for generator air coolers, turbine and generator bearing coolers transformers, and turbine shaft seals. The capacities of powerhouse systems common to all units will be increased as required, with piping and duct work extended to provide service to the new units.

14.2 - Accessory Electrical Equipment (***)

The accessory electrical equipment required for Stage III will be identical to those supplied for Stage I, described in Section 4.2 - Accessory Electrical Equipment.

15 - TRANSMISSION FACILITIES - WATANA STAGE III (***)

The raising of the Watana Dam during Stage III and, consequently, the upgrading of Watana generation, will require a third transmission line from the Gold Creek Switchyard to the Willow Substation and from Willow to the Knik Arm Substation.

The additional Stage III transmission line will use the existing corridor (refer to Plate F98, Exhibit F).

15.1 - Transmission Requirements (***)

Between Gold Creek and Knik Arm switching stations, a third 345 kV single-circuit line will be built parallel to the two Watana lines. The crossing of Knik Arm will be by cable with a similar arrangement to the original two circuits. At Willow switching station, four 345 kV breakers will be added, one in an existing bay, the rest in a new bay. These handle the new line and allow the installation of a third 75 MVA transformer for local supply, if required. Similarly, at Knik Arm switching station, a breaker will be installed in an existing bay to receive the incoming Watana line. Between the Knik Arm and University stations, the lines built for Watana were sized to accommodate the Devil Canyon need in order to limit right-of-way requirements. At University an additional transformer bank at each of 230 kV and 115 kV levels will be provided; this will involve the addition of two breakers in existing bays. At the Ester substation in Fairbanks, an additional 150 MVA transformer bank will be installed to serve the local load; this will require one new breaker in an existing bay.

15.2 - Switching and Substations (***)

The following substation additions will be required as part of Watana Stage III:

15.2.1 - Watana Switchyard (***)

The additional generating units at Watana require a determination in the switchyard. Circuit breakers will be added to provide this termination. The additional breakers will convert the ring bus arrangement, installed during Stage I construction, into a breaker-and-a-half substation.

15.2.2 - Gold Creek Switchyard (***)

Termination of the Stage III transmission line will be required. This termination will be achieved with the addition of necessary circuit breakers, and associated facilities.

15.2.3 - Ester Substation (***)

An additional 150 MVA transformer bank will be installed. The transformer will step-down voltage to 138 kV, and will include a circuit breaker for termination of the transformer. The added transformer will provide additional power at 138 kV for distribution by Golden Valley Electric Association. The transformer bank will have 13.8 kV tertiary windings for connection of static var compensation (SVC) equipment. The SVC equipment will allow control of 138 kV bus voltage.

The circuit breakers for connection of the SVC equipment and for the connection to local transmission lines are also included.

15.2.4 - Willow Substation (***)

Terminations at this substation are for the additional Stage III transmission lines from Gold Creek and Knik Arm, and for an additional 345/138 kV 75 MVA three-phase transformer. This transformer will provide power at 138 kV for local transmission and distribution. The circuit breaker arrangement is based on a breaker-and-a-half arrangement.

15.2.5 - Knik Arm Substation (***)

The termination of the third transmission line from Willow will require installation of additional circuit breaker, disconnect switches, and shunt reactor. Addition of the transmission line termination will make the whole substation arrangement a breaker-and-a-half.

15.2.6 - University Substation (***)

The Stage III development will require the addition of two 250 MVA single- phase transformer banks. The circuit breakers for termination of the transformers will be added to the existing substation, and form a complete breaker-and-a-half arrangement. One transformer bank will step-down the voltage to 230 kV and the other to 115 kV. The power factor from the 230 kV line will be for distribution by CEA, and from the 115 kV bus by AMPL. Both transformer banks will have 13.8 kV tertiary windings for SVC equipment connections. Circuit breakers for SVC equipment connections and local transmission lines are included.

16 - LANDS OF THE UNITED STATES (**)

The Susitna Hydroelectric Project will include numerous parcels of federal land within the project boundary as defined in Exhibit G of this application. Ownership was verified using the Bureau of Land Management (BLM) Alaska Automated Land Record System which has an approximate accuracy of 70 percent. Ownership was further verified from BLM individual case files bringing the accuracy to 95 to 98 percent. The following is a tabulation of those lands with ownership and acreage. Included in the list of federal lands are both those lands which have been selected, but not yet conveyed to non-federal owners and those lands which have been selected by and conveyed to non-federal owners.

DAMSITES, QUARRYSITES AND RESERVOIR AREAS
(Federal Ownership)

SEWARD MERIDIAN, ALASKA

TOWNSHIP/Section	OWNER[a/]	PLATE	U.S. ACREAGE*	U.S. ACREAGE SELECTED AND ALREADY CONVEYED*[b/]
T31N,R1W				
Section 1	BLM (1)	G6	640.0	0
Section 2	BLM (1)	G6	640.0	0
T32N,R1W				
Section 35	Knikatnu	G6	0	320.0
Section 36	CIRI	G6	0	28.5
T31N,R1E				
Section 1	CIRI	G7	0	235.5
Section 2	CIRI	G7	0	340.7
Section 3	CIRI	G7	0	376.5
Section 4	CIRI	G6&G7	0	188.2
Section 5	CIRI	G6	0	19.4
Section 6	BLM (1)	G6	607.4	0
Section 7	BLM (1)	G6	152.1	0
Section 8	BLM (1)	G6	160.0	0
Section 9	BLM (1)	G6	60.0	0
Section 10	BLM (1)	G7	00.6	0
Section 11	BLM (1)	G7	00.5	0

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* Areas shown are true areas at elevation.

a/ Land Owner

(1) Selected by Cook Inlet Region Incorporated

(2) Partially selected by Cook Inlet Region Incorporated

(3) Selected by Ninilchik Native Association, Inc; Salamatoff Native Association, Inc.; Seldovia Native Association, Inc.; Tyonek Native Corporation; Knikatnu, Inc.; Alexander Creek, Inc.; and Chickaloon-Moose Creek Native Association, Inc.

(4) Selected by State of Alaska

b/ Lands selected by Cook Inlet Region Inc. are subjected to being conveyed at any time.

DAMSITES, QUARRYSITES AND RESERVOIR AREAS (Cont'd)

TOWNSHIP/Section	OWNER	PLATE	U.S. ACREAGE	U.S. ACREAGE SELECTED AND ALREADY CONVEYED*
T32N,R1E				
Section 31	CIRI	G6	0	264.4
Section 32	Knikatnu	G6	0	370.0
Section 33	CIRI	G6&G7	0	251.8
Section 34	BLM (1)	G7	22.9	0
T31N,R2E				
Section 1	Tyonek	G8	0	189.3
Section 4	BLM (1)	G7&G8	137.4	0
Section 5	CIRI	G7	0	200.2
Section 6	CIRI	G7	0	275.0
Section 7	BLM (1)	G7	57.9	0
Section 8	BLM (1)	G7	00.7	0
Section 12	Tyonek	G8	0	197.1
Section 13	CIRI	G8&G9	0	207.5
Section 24	BLM (1)	G9	07.4	0
T32N,R2E				
Section 22	BLM (1)	G8	00.2	0
Section 27	BLM (1)	G8	51.2	0
Section 31	BLM (3)	G7	01.1	0
Section 32	Knikatnu	G7	0	48.0
Section 33	Knikatnu	G7&G8	0	222.3
Section 34	Tyonek	G8	0	176.6
Section 35	Tyonek	G8	0	161.8
Section 36	Tyonek	G8	0	120.9
T31N,R3E				
Section 13	BLM (1)	G10	43.4	0
Section 14	BLM (1)	G10	97.8	0
Section 15	BLM (1)	G10	108.8	0
Section 16	BLM (1)	G10	17.2	0
Section 17	BLM (1)	G9&G10	59.9	0
Section 18	CIRI	G9	0	148.0
Section 19	CIRI	G9	0	157.9
Section 20	CIRI	G9&G10	0	149.3
Section 21	CIRI	G10	0	226.2

DAMSITES, QUARRYSITES AND RESERVOIR AREAS (Cont'd)

TOWNSHIP/Section	OWNER	PLATE	U.S. ACREAGE	U.S. ACREAGE SELECTED AND ALREADY CONVEYED*
T31N,R3E (Cont.)				
Section 22	Knikatnu	G10	0	148.0
Section 23	CIRI	G10	0	201.0
Section 24	Tyonek	G10	0	323.4
T31N,R4E				
Section 2	CIRI	G12	0	51.7
Section 3	CIRI	G11&G12	0	268.6
Section 9	BLM (1)	G11	38.3	0
Section 10	CIRI	G11	0	0
Section 15	CIRI	G11	0	300.0
Section 16	CIRI	G11	0	95.6
Section 18	BLM (1)	G10	00.2	0
Section 19	CIRI (3)	G10	0	374.4
Section 20	CIRI	G10&G11	0	445.7
Section 21	CIRI	G11	0	391.5
Section 29	BLM (1)	G10&G11	02.7	0
T32N,R4E				
Section 25	CIRI	G12	0	32.6
Section 26	BLM (3)	G12	225.0	0
Section 34	BLM (1)	G12	130.0	0
Section 35	Tyonek	G12	0	388.0
Section 36	Tyonek	G12	0	262.9
T31N,R5E				
Section 3	BLM (1)	G13&G15	420.0	0
Section 4	BLM (1)	G13	480.0	0
Section 5	BLM (1)	G13	360.0	0
T32N,R5E				
Section 13	BLM (3)	G16	60.0	0
Section 14	BLM (3)	G16	260.0	0
Section 15	BLM (3)	G14&G16	400.0	0
Section 16	BLM (3)	G14	330.0	0
Section 17	BLM (3)	G14	30.0	0
Section 19	BLM (3)	G13&G14	160.0	0
Section 20	BLM (3)	G13&G14	560.0	0
Section 21	BLM (3)	G13&G14	640.0	0

DAMSITES, QUARRYSITES AND RESERVOIR AREAS (Cont'd)

TOWNSHIP/Section	OWNER	PLATE	U.S. ACREAGE	U.S. ACREAGE SELECTED AND ALREADY CONVEYED*
T32N,R5E (Cont.)				
Section 22	BLM (3)	G13,14,15	640.0	0
Section 23	BLM (3)	G15&G16	631.1	0
Section 24	BLM (3)	G10&G11	75.2	0
Section 25	BLM (1)	G15	560.3	0
Section 26	Knikatnu	G15	0	372.2
Section 27	Knikatnu	G13&G15	0	238.3
Section 28	CIRI	G13	0	47.3
Section 29	BLM (3)	G13	640.0	0
Section 30	Tyonek	G13	0	38.1
Section 31	Tyonek	G13	0	127.7
Section 32	Tyonek	G13	0	196.5
Section 33	Tyonek	G13	0	204.3
Section 34	BLM (1)	G13&G15	598.4	0
Section 35	BLM (1)	G15	303.5	0
Section 36	BLM (1)	G15	329.3	0
T31N,R6E				
Section 1	BLM (1)	G17	233.8	0
Section 2	BLM (1)	G17	01.9	0
T32N,R6E				
Section 2	BLM (3)	G18	09.3	0
Section 3	BLM (3)	G18	01.0	0
Section 10	BLM (3)	G18	201.0	0
Section 11	BLM (3)	G18	70.6	0
Section 13	BLM (3)	G18	482.3	0
Section 14	BLM (3)	G18	243.2	0
Section 15	BLM (3)	G18	507.2	0
Section 16	BLM (3)	G18	00.7	0
Section 21	BLM (3)	G15,16,18	162.5	0
Section 22	BLM (3)	G17&G18	640.0	0
Section 23	BLM (3)	G17&G18	640.0	0
Section 24	BLM (3)	G17&G18	640.0	0
Section 25	BLM (1)	G17	640.0	0
Section 26	BLM (1)	G17	640.0	0
Section 27	BLM (1)	G17	640.0	0
Section 28	BLM (1)	G15&G17	630.2	0
Section 29	BLM (1)	G15	496.0	0
Section 30	BLM (3)	G15	382.2	0
Section 31	BLM (1)	G15	333.6	0

DAMSITES, QUARRYSITES AND RESERVOIR AREAS (Cont'd)

TOWNSHIP/Section	OWNER	PLATE	U.S. ACREAGE	U.S. ACREAGE SELECTED AND ALREADY CONVEYED*
T32N,R6E (Cont.)				
Section 32	BLM (1)	G15	256.1	0
Section 33	BLM (1)	G15&G16	184.9	0
Section 34	BLM (1)	G17	257.8	0
Section 35	BLM (1)	G17	396.5	0
Section 36	BLM (1)	G17	633.3	0
T31N,R7E				
Section 1	BLM (1)	G19	338.0	0
Section 2	BLM (1)	G19	634.4	0
Section 3	BLM (1)	G19	629.8	0
Section 4	BLM (2)	G17&G19	495.8	0
Section 5	BLM (1)	G17	332.4	0
Section 6	BLM (1)	G17	302.3	0
Section 10	BLM (3)	G19	88.1	0
Section 11	BLM (2)	G19	311.4	0
Section 12	BLM (2)	G19	621.8	0
Section 13	BLM (3)	G19	141.4	0
Section 14	BLM (3)	G19	01.1	0
T32N,R7E				
Section 3	BLM (3)	G20	246.4	0
Section 4	BLM (3)	G18&G20	160.7	0
Section 7	BLM (3)	G18	166.5	0
Section 8	BLM (3)	G18	331.0	0
Section 9	BLM (3)	G18&G20	517.5	0
Section 10	BLM (3)	G20	31.9	0
Section 16	BLM (3)	G18	141.8	0
Section 17	BLM (3)	G18	637.5	0
Section 18	BLM (3)	G18	563.9	0
Section 19	BLM (3)	G18	601.8	0
Section 20	BLM (3)	G17&G18	640.0	0
Section 21	BLM (3)	G17,G18&G20	391.6	0
Section 22	BLM (3)	G19&G20	60.7	0
Section 27	BLM (3)	G19	174.4	0
Section 28	BLM (3)	G17&G19	624.1	0

DAMSITES, QUARRYSITES AND RESERVOIR AREAS (Cont'd)

TOWNSHIP/Section	OWNER	PLATE	U.S. ACREAGE	U.S. ACREAGE SELECTED AND ALREADY CONVEYED*
T32N,R7E (Cont.)				
Section 29	BLM (3)	G17	640.0	0
Section 30	BLM (1)	G17	605.5	0
Section 31	BLM (1)	G17	640.5	0
Section 32	BLM (2)	G17	640.0	0
Section 33	BLM (3)	G17&G19	640.0	0
Section 34	BLM (3)	G19	423.5	0
Section 35	BLM (3)	G19	53.5	0
Section 36	BLM (3)	G19	11.0	0
T33N,R7E				
Section 27	BLM (4)	G21	80.2	0
Section 28	BLM (4)	G21	40.0	0
Section 33	BLM (4)	G20&G21	74.0	0
Section 34	BLM (4)	G20&G21	182.9	0
T30N,R8E				
Section 4	BLM (3)	G23	08.2	0
T31N,R8E				
Section 1	BLM (3)	G24	56.9	0
Section 7	BLM (3)	G19	386.4	0
Section 8	BLM (3)	G19&G24	535.0	0
Section 9	BLM (3)	G24	576.7	0
Section 10	BLM (3)	G24	372.9	0
Section 11	BLM (3)	G24	138.5	0
Section 12	BLM (3)	G24	287.9	0
Section 13	BLM (3)	G23&G24	598.6	0
Section 14	BLM (3)	G23&G24	612.2	0
Section 15	BLM (3)	G23&G24	640.0	0
Section 16	BLM (3)	G24&G23	280.3	0
Section 17	BLM (3)	G19,G22&G24	334.7	0
Section 18	BLM (3)	G19	353.1	0
Section 21	BLM (3)	G23	182.3	0
Section 22	BLM (3)	G23	248.9	0
Section 23	BLM (3)	G23	09.1	0
Section 24	BLM (3)	G23	55.1	0
Section 27	BLM (3)	G23	06.1	0
Section 28	BLM (3)	G23	245.8	0
Section 33	BLM (3)	G23	138.4	0

DAMSITES, QUARRYSITES AND RESERVOIR AREAS (Cont'd)

TOWNSHIP/Section	OWNER	PLATE	U.S. ACREAGE	U.S. ACREAGE SELECTED AND ALREADY CONVEYED*
T30N,R9E				
Section 1	BLM (3)	G26	143.0	0
Section 12	BLM (3)	G26	105.3	0
Section 13	BLM (3)	G26	05.8	0
T31N,R9E				
Section 6	BLM (3)	G24	49.2	0
Section 7	BLM (3)	G24	00.7	0
Section 17	BLM (3)	G24&G25	178.0	0
Section 18	BLM (3)	G23&G24	450.2	0
Section 19	BLM (3)	G23	175.3	0
Section 20	BLM (3)	G23&G24	432.8	0
Section 21	BLM (3)	G25	499.3	0
Section 22	BLM (3)	G25	267.1	0
Section 23	BLM (3)	G25	185.4	0
Section 25	BLM (3)	G25	280.1	0
Section 26	BLM (3)	G25	316.2	0
Section 27	BLM (3)	G25	309.3	0
Section 28	BLM (3)	G25	107.8	0
Section 36	BLM (3)	G25&G26	408.1	0
T30,R10E				
Section 6	BLM (3)	G26	216.0	0
Section 7	BLM (3)	G26&G27	389.3	0
Section 8	BLM (3)	G27	313.7	0
Section 9	BLM (3)	G27	170.8	0
Section 10	BLM (3)	G27	96.4	0
Section 11	BLM (3)	G27	312.9	0
Section 12	BLM (3)	G27	254.6	0
Section 13	BLM (3)	G27	120.2	0
Section 14	BLM (3)	G27	105.1	0
Section 15	BLM (3)	G27	251.1	0
Section 17	BLM (3)	G27	77.9	0
T31N,R10E				
Section 31	BLM (3)	G26&G27	143.2	0

DAMSITES, QUARRYSITES AND RESERVOIR AREAS (Cont'd)

TOWNSHIP/Section	OWNER	PLATE	U.S. ACREAGE	U.S. ACREAGE SELECTED AND ALREADY CONVEYED*
T29N,R11E				
Section 1	BLM (3)	G29	45.2	0
Section 2	BLM (3)	G29	199.2	0
Section 3	BLM (3)	G29	222.6	0
Section 4	BLM (3)	G29	68.2	0
Section 5	BLM (3)	G29	176.6	0
Section 6	BLM (3)	G29	135.3	0
Section 9	BLM (3)	G29	00.4	0
Section 10	BLM (3)	G29	204.5	0
T30N,R11E				
Section 7	BLM (3)	G27&28	293.8	0
Section 8	BLM (3)	G28	01.8	0
Section 17	BLM (3)	G28	241.0	0
Section 18	BLM (3)	G27&G28	280.4	0
Section 20	BLM (3)	G28	445.9	0
Section 21	BLM (3)	G28	00.9	0
Section 25	BLM (3)	G29	21.2	0
Section 28	BLM (3)	G28&G29	177.9	0
Section 29	BLM (3)	G28&29	480.0	0
Section 32	BLM (3)	G29	482.7	0
Section 33	BLM (3)	G29	437.3	0
Section 34	BLM (3)	G29	640.0	0
Section 35	BLM (3)	G29	471.8	0
Section 36	BLM (3)	G29	35.6	0
TOTAL			61,628.0±	7,430±

ELECTRICAL TRANSMISSION LINE CORRIDOR RIGHT-OF-WAY ACREAGES
(Federal Ownership)

SEWARD MERIDIAN, ALASKA

TOWNSHIP/Section	OWNER	PLATE	U.S. ACREAGE*	U.S. ACREAGE SELECTED AND ALREADY CONVEYED
T13N,R2W				
Section 4	U.S. Army	G30	10.21	0
Section 5	U.S. Army	G30	35.51	0
Section 7	U.S. Army	G30	37.20	0
Section 8	U.S. Army	G30	06.36	0
Section 18	U.S. Army	G30	30.68	0
Section 19	U.S. Army	G30	30.66	0
Section 30	U.S. Army	G30	30.31	0
Section 31	U.S. Army	G30	04.46	0
T14N,R2W				
Section 19	U.S. Army	G30	33.66	0
Section 20	U.S. Army	G30	31.36	0
Section 21	U.S. Army	G30	38.29	0
Section 22	U.S. Army	G30	03.06	0
Section 28	U.S. Army	G30	31.12	0
Section 33	U.S. Army	G30	36.52	0
T14N,3W				
Section 9	U.S. Army	G30	19.56	0
Section 10	U.S. Army	G30	33.29	0
Section 11	U.S. Army	G30	05.31	0
Section 13	U.S. Army	G30	14.15	0
Section 14	U.S. Army	G30	44.50	0
Section 24	U.S. Army	G30	24.64	0
T31N,1W				
Section 3	BLM (3)	G39	62.74	0
Section 4	BLM (3)	G39	54.77	0
Section 5	BLM (3)	G39	62.74	0
Section 6	BLM (3)	G39	61.36	0
T32N,R1E				
Section 13	BLM (3)	G39	11.77	0
Section 23	BLM (3)	G39	34.22	0
Section 24	BLM (3)	G39	33.23	0
Section 26	BLM (3)	G39	07.35	0

ELECTRICAL TRANSMISSION LINE CORRIDOR
RIGHT-OF-WAY ACREAGES (Cont'd)

TOWNSHIP/Section	OWNER	PLATE	U.S. ACREAGE*	U.S. ACREAGE SELECTED AND ALREADY CONVEYED
Section 27	BLM (3)	G39	38.03	0
Section 28	BLM (3)	G39	38.03	0
Section 29	BLM (3)	G39	37.95	0
Section 30	BLM (3)	G39	02.70	0
T32N,R2E				
Section 3	BLM (3)	G39	41.90	0
Section 4	BLM (3)	G39	20.02	0
Section 8	BLM (3)	G39	36.99	0
Section 9	BLM (3)	G39	24.88	0
Section 17	BLM (3)	G39	07.91	0
Section 18	BLM (3)	G39	42.13	0
T33N,R2E				
Section 25	BLM (4)	G40	34.20	0
Section 34	BLM (4)	G40	09.28	0
Section 35	BLM (4)	G40	44.90	0
Section 36	BLM (4)	G40	07.81	0
T32N,R3E				
Section 2	BLM (3)	G40	19.69	0
Section 3	BLM (3)	G40	37.52	0
Section 11	BLM (3)	G40	22.42	0
Section 12	BLM (3)	G40	40.01	0
T32N,R4E				
Section 7	BLM (3)	G40	34.69	0
Section 8	BLM (3)	G40	15.67	0
Section 13	BLM (3)	G40	37.10	0
Section 14	BLM (3)	G40	37.10	0
Section 15	BLM (3)	G40	35.22	0
Section 16	BLM (3)	G40	37.10	0
Section 17	BLM (3)	G40	21.43	0
T32N,R5E				
Section 18	BLM (3)	G40	16.45	0
Section 19	BLM (3)	G40	20.47	0
Section 20	BLM (3)	G40	07.68	0
SEWARD MERIDIAN SUB-TOTAL			1,598.31±	

ELECTRICAL TRANSMISSION LINE CORRIDOR
RIGHT-OF-WAY ACREAGES (Cont'd)

FAIRBANKS MERIDIAN, ALASKA

TOWNSHIP/Section	OWNER	PLATE	U.S. ACREAGE*	U.S. ACREAGE SELECTED AND ALREADY CONVEYED
T12S,R7W				
Section 7	AK R.R.	G46	0	43.77
Section 17	AK R.R.	G46	0	15.71
Section 18	AK R.R.	G46	0	14.52
T7S,R8W				
Section 24	USAF	G48	23.27	0
Section 25	USAF	G48	51.86	0
Section 26	USAF	G48	51.86	0
T7S,R7W				
Section 5	USAF	G48	48.93	0
Section 6	USAF	G48	02.76	0
Section 7	USAF	G48	51.36	0
Section 8	USAF	G48	00.50	0
Section 18	USAF	G48	51.86	0
Section 19	USAF	G48	28.59	0
T6S,R7W				
Section 4	BLM (4)	G49	49.43	0
Section 9	BLM (4)	G49	48.70	0
Section 16	BLM (4)	G49	48.25	0
Section 17	BLM (4)	G49	00.45	0
Section 20	BLM (4)	G49	34.86	0
Section 21	BLM (4)	G49	13.81	0
Section 29	BLM (4)	G49	49.63	0
Section 32	BLM (4)	G49	51.78	0
FAIRBANKS MERIDIAN SUB-TOTAL			681.90±	
TOTAL			2,280.21±	

ACCESS CORRIDOR RIGHT-OF-WAY ACREAGES
(Federal Ownership)

FAIRBANKS MERIDIAN, ALASKA

TOWNSHIP/Section	OWNER	PLATE	U.S. ACREAGE*	U.S. ACREAGE SELECTED AND ALREADY CONVEYED
T18S,R4W				
Section 16	BLM	G53	19.80	0
Section 21	BLM	G53	24.74	0
Section 22	BLM	G53	00.23	0
Section 27	BLM	G53	02.09	0
Section 28	BLM	G53	23.43	0
Section 33	BLM	G53	20.00	0
Section 34	BLM	G53	06.41	0
T19S,R4W				
Section 4	BLM	G53	29.59	0
Section 5	BLM	G53	06.41	0
Section 8	BLM	G53	29.94	0
Section 16	BLM	G53	20.70	0
Section 17	BLM	G53	08.41	0
Section 21	BLM	G53	23.57	0
Section 22	BLM	G53	04.95	0
Section 27	BLM	G53	25.35	0
Section 34	BLM	G53	25.61	0
T20S,R4W				
Section 3	BLM	G53	25.35	0
Section 10	BLM	G53	26.73	0
Section 14	BLM	G53	18.93	0
Section 15	BLM	G53	08.25	0
Section 23	BLM	G53	22.64	0
Section 24	BLM	G54	12.48	0
Section 25	BLM	G54	24.86	0
Section 36	BLM	G54	24.97	0
T21S,R4W				
Section 1	BLM	G54	28.28	0
Section 11	BLM	G54	34.94	0
Section 12	BLM	G54	03.36	0
Section 14	BLM	G54	24.63	0
Section 23	BLM	G54	24.38	0
Section 26	BLM	G54	24.38	0

ACCESS CORRIDOR RIGHT-OF-WAY ACREAGES (Cont'd)

TOWNSHIP/Section	OWNER	PLATE	U.S. ACREAGE*	U.S. ACREAGE SELECTED AND ALREADY CONVEYED
Section 27	BLM	G54	00.11	0
Section 34	BLM	G54	25.30	0
Section 35	BLM	G54	01.00	0
T22S,R4W				
Section 3	BLM	G54	24.39	0
Section 10	BLM	G54	24.53	0
Section 15	BLM	G54	26.96	0
Section 16	BLM	G54	08.55	0
FAIRBANKS MERIDIAN SUB-TOTAL			686.25+	
SEWARD MERIDIAN, ALASKA				
T31N,R1W				
Section 3**	BLM (1)	G59	26.20	0
Section 4**	BLM (1)	G59	27.92	0
Section 5**	BLM (1)	G59	12.92	0
Section 6**	BLM (1)	G59	21.80	0
T32N,R1E				
Section 23	BLM (3)	G58	14.19	0
Section 24	BLM (3)	G58	27.63	0
Section 26	BLM (3)	G58	12.91	0
Section 27	BLM (3)	G58	29.85	0
Section 28	BLM (3)	G58	24.33	0
Section 29	BLM (3)	G58	13.52	0
T32N,R2E				
Section 2	BLM (3)	G57	15.01	0
Section 3	BLM (3)	G57	28.29	0
Section 4	BLM (3)	G57	06.29	0
Section 8	BLM (3)	G58	07.92	0
Section 9	BLM (3)	G57&G58	31.71	0
Section 17	BLM (3)	G58	21.70	0
Section 18	BLM (3)	G58	13.94	0
Section 19	BLM (3)	G58	13.94	0

ACCESS CORRIDOR RIGHT-OF-WAY ACREAGES (Cont'd)

TOWNSHIP/Section	OWNER	PLATE	U.S. ACREAGE*	U.S. ACREAGE SELECTED AND ALREADY CONVEYED
T33N,R2E				
Section 35	BLM (4)	G57	19.42	0
Section 36	BLM (4)	G57	26.34	0
T32N,R3E				
Section 2	BLM (3)	G57	01.15	0
Section 3	BLM (3)	G57	37.09	0
Section 11	BLM (3)	G57	28.62	0
Section 12	BLM (3)	G57	20.09	0
Section 13	BLM (3)	G57	07.22	0
T32N,4E				
Section 11	BLM (3)	G56	22.96	0
Section 12	BLM (3)	G56	16.60	0
Section 13	BLM (3)	G56	21.23	0
Section 14	BLM (3)	G56	10.80	0
Section 15	BLM (3)	G56	26.86	0
Section 16	BLM (3)	G57	24.72	0
Section 17	BLM (3)	G57	24.75	0
Section 18	BLM (3)	G57	24.45	0
T32N,R5E				
Section 3	BLM (3)	G56	47.60	0
Section 4	BLM (3)	G56	26.86	0
Section 5	BLM (3)	G56	28.06	0
Section 8	BLM (3)	G56	26.46	0
Section 10	BLM (3)	G56	25.32	0
Section 15	BLM (3)	G56	09.51	0
Section 17	BLM (3)	G56	09.62	0
Section 18	BLM (3)	G56	23.69	0
SEWARD MERIDIAN SUB-TOTAL			863.59+	
TOTAL			1,549.84+	

17 - REFERENCES

Commonwealth Associates Inc. 1982. Anchorage-Fairbanks Transmission Intertie Route Selection Report. Prepared for Alaska Power Authority, Anchorage, Alaska.

Harza-Ebasco Susitna Joint Venture. 1983. Watana Development Winter 1983 Geotechnical Exploration Program. Prepared for Alaska Power Authority, Anchorage, Alaska.

TABLES

TABLE A.1: PERTINENT PROJECT DATA

Item	Stage I Watana	Stage II[1/] Devil Canyon	Stage III[1/] Watana	Stage III[1/] Devil Canyon
Hydrology				
- Average River Flow (cfs)	8,050	9,160	----	----
- Peak Flood Inflows (cfs)				
. PMF	326,000	358,000 with Watana 362,000 without Watana	----	339,000 with Watana 362,000 without Watana
. 10,000-year	174,000	184,000 without Watana	----	----
. 50-year	89,500	46,000 with Watana 94,800 without Watana	----	44,600 with Watana (Yr 2008) 35,300 with Watana (Yr 2020) 94,800 without Watana
. 25-year	79,800	44,600 with Watana 84,500 without Watana	----	43,200 with Watana (Yr 2008) 31,600 with Watana (Yr 2020) 84,500 without Watana
- Peak Flood Flows through the Dam (cfs)				
. PMF	302,300	351,000 with Watana	283,600	333,000 with Watana
. 50-year	34,000	42,000 with Watana	33,900	42,000 with Watana
Reservoir Characteristics				
- Normal Maximum Operating Level [3/]	2,000	1,455	2,185	----
- Maximum Level, PMF [3/]	2,017.1	1465.6	2,199.3	1,463.1
- Minimum Operating Level [3/]	1,850	1,405	2,065	----
- Area at NMOL (acres)	19,900	7,800	38,000	----
- Length at NMOL (miles)	39	26	48	----
- Total Storage (acre-feet)	4.3×10^6	1.1×10^6	9.5×10^6	----
- Live Storage (acre-feet)	2.4×10^6	0.35×10^6	3.7×10^6	----
- Maximum Allowable Surcharge Level for 50-year Flood [3/]	2,014	1,456	2,193	----
- Average Tailwater [3/]	1,455	850	1,455	----
Project Outputs				
- Dependable Plant Capability (December-January) (MW)	360	600	1,020	----
- Nominal Plant Capability (MW) [4/]	440	680	1,110	----
- Annual Generation (GWh)				
. Firm	1,950	4,490[2/]	5,720[2/]	
. Average	2,400	4,750[2/]	6,900[2/]	

N.A. - Not Applicable

1/ Watana Stage I data as shown applies both before and after construction of Devil Canyon, except where indicated for Stage III. Devil Canyon Stage II data, as shown, applies both before and after construction of Watana Stage III except where indicated otherwise for Stage III.

2/ Total generation from Watana and Devil Canyon.

3/ Contour elevation (feet above mean sea level)

4/ At average operating head

TABLE A.1 (Page 2 of 4)

Item	Stage I Watana	Stage II[1/] Devil Canyon	Stage III[1/] Watana	Stage III[1/] Devil Canyon
Dams				
- Type	Earth/Rockfill, Inclined Core	Concrete Arch (Earth/Rockfill Saddle)	Earth/Rockfill Central Core	----
- Crest Elevation [3/]	2,027	1,463 (1472)	2,210	----
- Crest Length (ft)	2,700	1,650 (950)	4,100	----
- Height Above Foundation [3/]	702	646 (245)	885	----
- Crest Width (ft)	35	20 (35)	35	----
- Upstream Slope (H:V)	2.4:1	N.A. (2.4:1)	2.4:1	----
- Downstream Slope (H:V)	2:1	N.A. (2:1)	2:1	----
- Allowance for Settlement (ft)	2	0 (2)	5	----
- Top of Parapet [3/]	N.A.	1,466.0	N.A.	----
Diversion				
- Recurrence Interval of Design Flood (yrs)	50	25	N.A.	N.A.
- Cofferdams				
. Type	Earth & Rockfill	Earth & Rockfill	----	N.A.
. Upstream Crest Elevation [3/]	1,550	947	N.A.	N.A.
. Downstream Crest Elevation [3/]	1,495	898	1,495	N.A.
. Maximum U/S Water Level for Design Flood [3/]	1,532	944	----	----
- Tunnels				
. Number/Type	2 - Circular, Concrete-Lined	1 - Horseshoe, Concrete-Lined	N.A.	N.A.
. Diameter (ft)	36	35.5	N.A.	N.A.
. Capacity for Design Flood (cfs)	77,000	43,300	N.A.	N.A.
Outlet Facilities				
- Control Structures	6-Fixed Cone Valves	7-Fixed Cone Valves	6-Fixed Cone Valves	----
- Diameter (in)	78	4-102, 3-90	78	----
- Water Passage Diameter (ft)	28	8.5/7.5	28	----
- Capacity (cfs)	24,000	42,000	30,000	----

N.A. - Not Applicable

1/ See first page of this Table.
3/ See first page of this Table.

TABLE A.1 (Page 3 of 4)

Item	Stage I Watana	Stage II[1/] Devil Canyon	Stage III[1/] Watana	Devil Canyon
Spillway				
- Capacity at 50-yr flood surcharge (cfs)	258,000	240,000	220,000	----
- Capacity at PMF surcharge (cfs)	278,400	309,000	259,600	291,000
- Control Structure				
. Type	Gated Ogee	Gated Ogee	Gated Ogee	----
. Crest Elevation [3/]	1,950	1,398	2,135	----
. Gates				
Number	3	3	3	----
Dimensions (HxW, ft)	64 x 44	58 x 48	64 x 44	----
Top of Gate Level [3/]	2,014	1,456	2,199	----
- Chute Width (ft)	164 x 120	176 x 150	164 x 120	----
- Energy Dissipation	Flip bucket	Flip bucket	Flip bucket	----
Power Intakes				
- Intake Structures	Multi-level, Gated	Multi-level, Gated	Multi-level, Gated	----
. Number of Levels	5	2	4	----
. Number of Shutters per Level	4	4	6	----
. Dimensions of Shutters (HxW, ft)	25 x 24	20 x 34±	25 x 24	----
- Control Gates				
. Number	4	± 4	6	
. Dimensions (HxW, ft)	24 x 12	24 x 20	24 x 12	
- Invert Elevation [3/]	1,800	1,365	1,800 & 2012	----
Power Tunnels				
- Number	2	See Penstocks	3	----
- Type	Inclined/Horizontal	See Penstocks	Inclined/Horizonal	----
- Concrete-Lined Diameter (ft)	24	See Penstocks	24	----
Penstocks				
- Number	4	4	6	----
- Type	Horizontal	Inclined/Horizontal	Horizontal	
- Diameter (ft)				----
. Concrete-lined	18	20	18	----
. Steel-lined	15	15	15	----

1/ See first page of this Table.
3/ See first page of this Table.

TABLE A.1 (Page 4 of 4)

Item	Stage I Watana	Stage II[1] Devil Canyon	Stage III[1] Watana	Stage III[1] Devil Canyon
Powerhouses				
- Type	Underground	Underground	Underground	----
- Cavern Size (L x W x H, ft)	365 x 78 x 136	360 x 74 x 126	520 x 78 x 136	
- Turbine (No. and Type)	4 Vertical Francis	4 Vertical Francis	6 Vertical Francis	----
- Speed (rpm)	257	225	257	----
- Nominal Unit Capability at Average Operating Head (MW)	110	170	185	----
- Maximum Unit Capability				
. Net Head (ft)	537	600	719	----
. Flow (cfs)	3,080	3,790	3,800	----
. Output (MW)	125	173	200	----
- Minimum Unit Capability				
. Net Head (ft)	384	545	600	----
. Flow (cfs)	2,310	3,615	3,310	----
. Output (MW)	65	150	150	----
- Generators				
. Type	Vertical Synchronous	Vertical Synchronous	Vertical Synchronous	----
. Rated Capacity (MVA)	223 Air Cooled	192 Air Cooled	223 Air Cooled	----
. Power Factor	0.9	0.9	0.9	----
. Voltage (kV)	15	15	15	----
. Frequency (Hz)	60	60	60	----
. Speed, rpm	257	225	257	----
- Transformers				
. Location	Upstream Gallery	Upstream Gallery	Upstream Gallery	----
. Cavern Size (L x W x H, ft)	308 x 45 x 40	446 x 43 x 40	414 x 45 x 40	
. Number	6	12	9	----
. Rating (MVA)	150	70	150	----
. Voltage (kV)	15-345/1.73 Single Phase	15-345/1.73 Single Phase	15-345/1.73 Single Phase	----
Tailrace Tunnels				
- Number/Type	1 - Horseshoe, Concrete-Lined	1 - Horseshoe Concrete-Lined	2 - Horseshoe Concrete-Lined	----
- Diameter (ft)	34	38	34	----
- Surge Chamber Size (L x W x H, ft)	250 x 50 x 150	240 x 75 x 190	445 x 50 x 150	----

N.A. - Not Applicable

[1] See first page of this Table.

TABLE A.1 (Page 4 of 4)

Item	Stage I Watana	Stage II[1/] Devil Canyon	Stage III[1/] Watana	Stage III[1/] Devil Canyon
Powerhouses				
- Type	Underground	Underground	Underground	----
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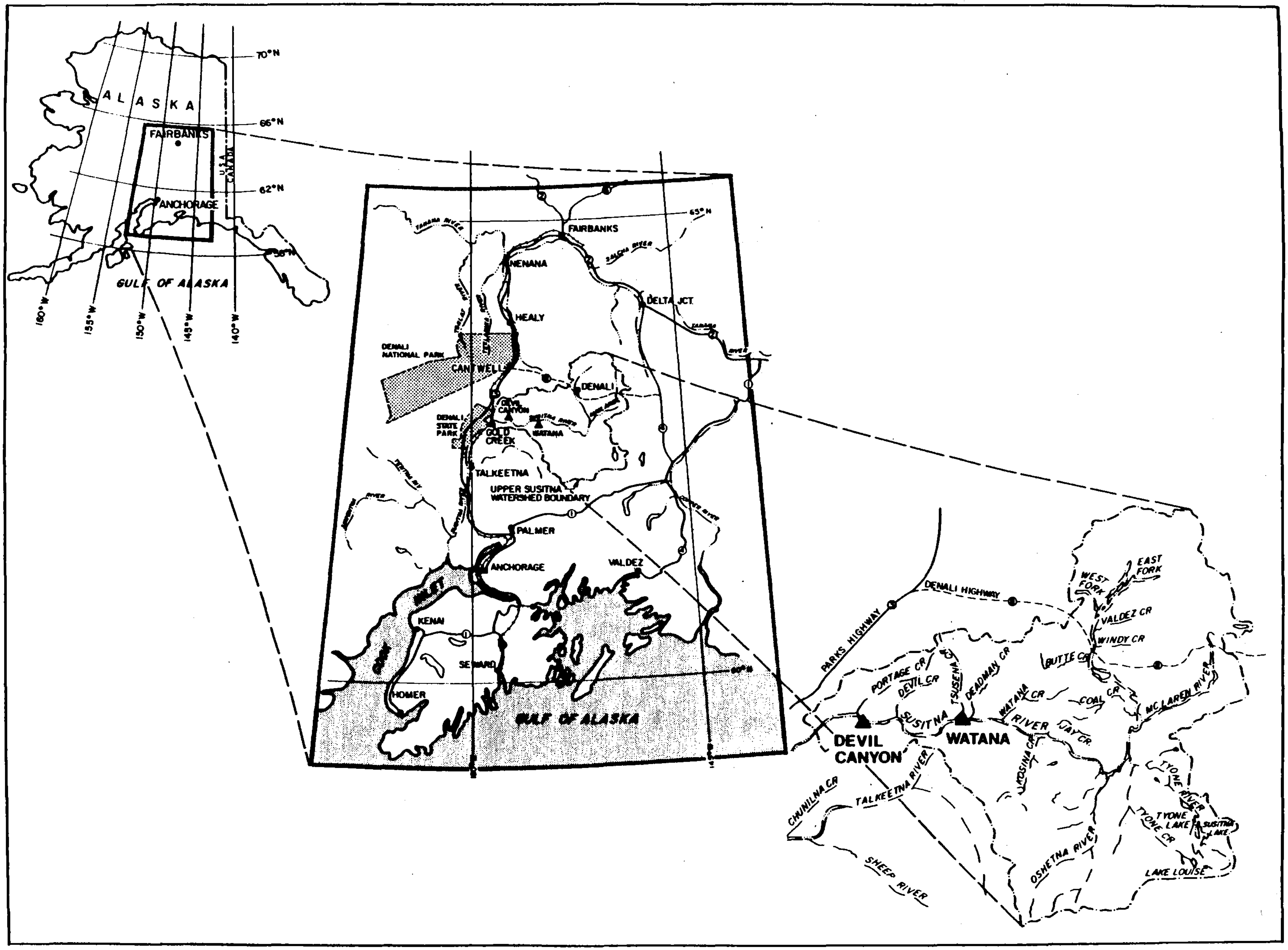
- Turbine (No. and Type)	4 Vertical Francis	4 Vertical Francis	6 Vertical Francis	----
- Speed (rpm)	257	225	257	----
- Nominal Unit Capability at Average Operating Head (MW)	110	170	185	----
- Maximum Unit Capability				
. Net Head (ft)	537	600	719	----
. Flow (cfs)	3,080	3,790	3,800	----
. Output (MW)	125	173	200	----
- Minimum Unit Capability				
. Net Head (ft)	384	545	600	----
. Flow (cfs)	2,310	3,615	3,310	----
. Output (MW)	65	150	150	----
- Generators				
. Type	Vertical Synchronous	Vertical Synchronous	Vertical Synchronous	----
. Rated Capacity (MVA)	223 Air Cooled	192 Air Cooled	223 Air Cooled	----
. Power Factor	0.9	0.9	0.9	----
. Voltage (kV)	15	15	15	----
. Frequency (Hz)	60	60	60	----
. Speed, rpm	257	225	257	----
- Transformers				
. Location	Upstream Gallery	Upstream Gallery	Upstream Gallery	----
. Cavern Size (L x W x H, ft)	308 x 45 x 40	446 x 43 x 40	414 x 45 x 40	
. Number	6	12	9	----
. Rating (MVA)	150	70	150	----
. Voltage (kV)	15-345/1.73 Single Phase	15-345/1.73 Single Phase	15-345/1.73 Single Phase	----
Tailrace Tunnels				
- Number/Type	1 - Horseshoe, Concrete-Lined	1 - Horseshoe Concrete-Lined	2 - Horseshoe Concrete-Lined	----
- Diameter (ft)	34	38	34	----
- Surge Chamber Size (L x W x H, ft)	250 x 50 x 150	240 x 75 x 190	445 x 50 x 150	----

N.A. - Not Applicable

1/ See first page of this Table.

FIGURES



PROPOSED PROJECT LOCATION

FIGURE A.1

SUSITNA HYDROELECTRIC PROJECT

EXHIBIT E

VOLUME 1 CHAPTER 2

WATER USE AND QUALITY

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2 - REPORT ON WATER USE AND QUALITY

1 - INTRODUCTION

The Report on Water Use and Quality is divided into four basic sections: baseline conditions, project impacts, agency concerns and recommendations, and mitigatives, enhancement, and protective measures. Within the sections on baseline conditions and project impacts, emphasis is placed on flows, water quality parameters, ground water conditions and instream flow uses. The importance of flows cannot be overstressed. Flows are important to all instream uses. Mean flows, flood flows, low flows and flow variability are discussed.

The primary focus of the water quality discussion is on those parameters determined most critical for the maintenance of fish populations and other aquatic organisms. Detailed discussions are presented on water temperature both in the mainstem Susitna River and in the sloughs downstream of Devil Canyon, ice, suspended sediment in the reservoirs and downstream, turbidity, dissolved oxygen, nitrogen supersaturation and nutrients. These parameters have previously been identified as areas of greatest concern.

Mainstem-slough groundwater interaction downstream of Devil Canyon is important to salmonid spawning in sloughs and is discussed.

The primary instream flow uses of the Susitna are for fish, wildlife and riparian vegetation. As these are fully discussed in Chapter 3, they are only briefly discussed in this Chapter. However, other instream flow uses including navigation and transportation, waste assimilative capacity and freshwater recruitment to estuaries are discussed. Since minimal out of river use is made of the water, Talkeetna being the only town located near the river and not relying on the river for its water supply, only limited discussions have been presented on out of river uses.

Project impacts have been separated by development. Impacts, associated with each development, are presented in chronological order: construction, impoundment and operation.

The agency concerns and recommendations received to date are summarized.

The mitigation plan incorporates the engineering and construction measures necessary to minimize potential impacts, given the economic and engineering constraints.

2 - BASELINE DESCRIPTION

The entire drainage area of the Susitna River is about 19,400 square miles, of which the upper basin above Gold Creek comprises approximately 6160 square miles (Figure E.2.1). Three glaciers in the Alaska Range feed forks of the Susitna River, flow southward for about 18 miles and then join to form the Susitna River. The river flows an additional 55 miles southward through a broad valley where much of the coarse sediment from the glaciers settles out. The river then flows westward about 96 miles through a narrow valley, with constrictions at the Devil Creek and Devil Canyon areas, creating violent rapids. Numerous small, steep gradient, clear-water tributaries flow to the Susitna in this reach of the river. Several of these tributaries cascade over waterfalls as they enter the gorge. As the Susitna curves south past Gold Creek, 12 miles downstream of the mouth of Devil Canyon, its gradient gradually decreases. The river is joined about 40 miles beyond Gold Creek in the vicinity of Talkeetna by two major tributaries, the Chulitna and Talkeetna Rivers. From this confluence, the Susitna flows south through braided channels about 97 miles until it empties into Cook Inlet near Anchorage, approximately 318 miles from its source.

The Susitna River is typical of unregulated northern glacial rivers with high, turbid summer flow and low, clear winter flow. Runoff from snowmelt and rainfall in the spring causes a rapid increase in flow in May from the low discharges experienced throughout the winter. Peak annual floods usually occur during this period.

Associated with the higher spring flows is a 100 fold increase in sediment transport which persists throughout the summer. The large suspended sediment concentration in the June to September time period causes the river to be highly turbid. Glacial silt contributes most of the turbidity of the river when the glaciers begin to melt in late spring.

Rainfall related floods often occur in August and early September, but generally these floods are not as severe as the spring snow melt floods.

As the weather begins to cool in the fall, the glacial melt rate decreases and the flows in the river gradually decrease correspondingly. Because most of the river suspended sediment is caused by glacial melt, the river also begins to clear. Freeze up normally begins in October and continues to progress up river through early December. The river breakup generally begins in late April or early May near the mouth and progresses upstream with breakup at the damsite occurring in mid-May.

2.1 - Susitna River Water Quality

(a) Mean Monthly and Annual Flows

Continuous historical streamflow records of various record length (8 to 32 years) exist for gaging stations on the Susitna River and its tributaries: Gages are located at Denali, Cantwell (Vee Canyon), Gold Creek and Susitna Station on the Susitna River; on the Maclaren River near Paxson; Chulitna Station on the Chulitna River; Talkeetna on the Talkeetna River; and Skwentna on the Skwentna River. In 1981 a USGS gaging station was constructed at Sunshine on the Susitna River; however, the streamflow record is of such a short duration it has not been used in most of the hydrologic analysis. Statistics on river mile, drainage area and years of record are shown in Table E.2.1. The station locations are illustrated in Figure E.2.1.

A complete 32 year streamflow data set for each gaging station was generated through a correlation analysis, whereby missing mean monthly flows were estimated (Acres 1982a). The resultant monthly and annual maximum, mean and minimum flows for the 32 year record are presented in Table E.2.2.

Mean monthly flows at the Watana and Devil Canyon damsites were estimated using a linear drainage area-flow relationship between the Gold Creek and Cantwell gage sites. The resultant mean, maximum and minimum monthly flows are also provided in Table E.2.2.

Comparison of flows indicates that 40 percent of the streamflow at Gold Creek originates above the Denali and Maclaren gages. It is in this catchment that the glaciers which contribute to the flow at Gold Creek are located.

The Susitna River above Gold Creek contributes 19 percent of the mean annual flow measured at Susitna Station near Cook Inlet. The Chulitna, and Talkeetna Rivers contribute 20 and 10 percent of the Susitna Station flow respectively. The Yentna provides 40 percent of the flow, with the remaining 11 percent originating in miscellaneous tributaries.

The variation between summer and winter flows is greater than a 10 to 1 ratio at all stations. This large seasonal difference is due to the characteristics of the basin. Glacial melt, snowmelt, and rainfall provide the majority of the annual river flow during the summer. At Gold Creek, for example, 88 percent of the annual streamflow occurs during the summer months of May through September.

The maximum and minimum monthly flows for the months of May through September indicate a high flow variability at all stations on a year to year basis.

(b) Floods

The most commong causes of floods in the Susitna River Basin are snowmelt or a combination of snowmelt and rainfall over a large area. This type of flood occurs between May and July with the majority occurring in June. Floods attributable to heavy rains have also occurred in August, September or October. These floods are augmented by snowmelt from higher elevations and glacial run-off. Table E.2.3 presents selected flood peaks at four gaging stations. Figures E.2.2 to E.2.8 illustrate annual instantaneous flood frequency curves for individual stations.

A regional flood frequency analysis was conducted using the recorded floods in the Susitna River and its principal tributaries (R&M, 1981a). The resulting dimensionless regional frequency curve is depicted in Figure E.2.9. A stepwise multiple linear regression computer program was used to relate the mean annual instantaneous peak flow to the physiographic and climatic characteristics of the drainage basins. The mean annual instantaneous peak flows for the Watana and Devil Canyon damsites were computed to be 40,800 cubic feet per second (cfs) and 45,900 cfs respectively. The regional flood frequency curve was compared to the station frequency curve at Gold Creek (Table E.2.4). As the Gold Creek station frequency curve yielded more conservative flood peaks (i.e. larger), it was used to estimate flood peaks at the Watana and Devil Canyon damsites for floods other than the mean annual flood. The flood frequency curves for Watana and Devil Canyon are presented in Figures E.2.10 and E.2.11.

Dimensionless flood hydrographs for the Susitna River at Gold Creek were developed for the May - July snowmelt floods and the August - October rainfall floods using the five largest Gold Creek floods occurring in each period (R&M, 1981a). Flood hydrographs for the 100, 500, and 10,000 year flood events were constructed using the appropriate flood peak and the dimensionless hydrograph. Hydrographs for the May - July and August - October flood periods are illustrated in Figures E.2.12 and E.2.13 respectively.

Probable maximum flood (PMF) studies were conducted for both the Watana and Devil Canyon damsites for use in the design of project spillways and related facilities. These studies which are based on Susitna Basin climatic data and hydrology, indicate that the PMF peak at the Watana damsite is 326,000 cfs.

(c) Flow Variability

The variability of flow in a river system is important to all instream flow uses. To illustrate the variability of flow in the Susitna River, monthly and annual flow duration curves showing the proportion of time that the discharge equals or exceeds a given value were developed for the four mainstem Susitna River gaging stations (Denali, Cantwell, Gold Creek and Susitna Station) and three major tributaries (Maclaren, Chulitna, and Talkeetna Rivers) (R&M, 1982a). These curves which are based on mean daily flows are illustrated on Figures E.2.14 through E.2.17.

The shape of the monthly and annual flow duration curves is similar for each of the stations and is indicative of flow from northern glacial rivers. Streamflow is low in the winter months, with little variation in flow and no unusual peaks. Groundwater contributions are the preliminary source of the small but relatively constant winter flows. Flow begins to increase slightly in April as breakup approaches. Peak flows in May are an order of magnitude greater than in April. Flow in May also shows the greatest variation for any month, as low flows may continue into May before the high snowmelt/breakup flows occur. June has the highest peaks and the highest median flow. The months of July and August have relatively flat flow duration curves. This situation is indicative of rivers with strong base flow characteristics, as is the case on the Susitna with its contributions from snowmelt and glacial melt during the summer. More variability of flow is evident in September and October as cooler weather becomes more prevalent.

The 1-day, 3-day, 7-day and 15-day high and low flow values were determined for each month from May through October for the periods of record at Gold Creek, Chulitna River near Talkeetna, Talkeetna River near Talkeetna and Susitna River at Susitna Station (R&M, 1982a). The high and low flow values are presented for Gold Creek in the form of frequency curves in Figures E.2.18 through E.2.21. May showed the most variability. It is the month when either low winter flows or high breakup flows may occur and thus significant changes occur from year to year. June and July generally exhibited less variability than the late summer months. Flow variability increased in the August through October period. Heavy rainstorms often occur in August, with 28 percent of the annual floods occurring in this month.

2.2 - Susitna River Morphology

(a) Mainstem

The Susitna River originates in the glaciers of the southern slopes of the central Alaskan Range, flowing 318 miles to its mouth at Cook Inlet.

The headwaters of the Susitna River and its major upper tributaries are characterized by broad braided gravel floodplains below the glaciers, with several meltstreams exiting from beneath the glaciers before they combine further downstream. The West Fork Susitna River joins the main river about 18 miles below Susitna Glacier. Below the West Fork confluence, the Susitna River becomes a split-channel configuration with numerous islands. The river is generally constrained by low bluffs for about 55 miles. The Maclaren River, a significant glacial tributary, and the Tyone River, which drains Lake Louise and the swampy lowlands of the southeastern upper basin, both enter the Susitna River from the east. Below the confluence with the Tyone River, the Susitna

River flows west for 96 miles through steep-walled canyons before reaching the mouth of Devil Canyon. The river has a high gradient through this reach and includes the Watana and Devil Canyon Damsites. It is primarily a single channel with intermittent islands. Bed material primarily consists of large grravel cobbles. The mouth of Devil Canyon, at River Mile (RM) 149 forms the lower limit of this reach.

Between Devil Canyon and the mouth at Cook Inlet, the river has been subdivided into nine separate reaches. These reaches are identified in Table E.2.5, together with the average slope and predominent channel pattern. These reaches are discussed in more detail below.

RM 149 to RM 144

Through this reach, the Susitna flows predominately in a single channel confined by valley walls. At locations where the valley bottom widens, depostion of gravel and cobble has formed mid-channel or side-channel bars. Occasionally, a vegetated island or fragmentary floodplain has formed with elevations above normal flood levels, and has become vegetated. Presence of cobbles and boulders in the bed material aids in stabilization of the channel geometry.

RM 144 to RM 139

A broadening of the valley bottom through this reach has allowed the river to develop a split channel with intermittent, well-vegetated islands. A correlation exists between bankfull stage and mean-annual flood. Where the main channel impinges on valley walls or terraces, a cobble armor layer has developed with a top elevation at roughly bankfull flood stage. At RM 144, a periglacial alluvial fan of coarse sediments confines the river to a single channel.

RM 139 to RM 129.5

This river reach is characterized by a well defined split channel configuration. Vegetated islands separate the main channel from side channels. Side channels occur frequently in the alluvial floodplain and receive Susitna water only at flows above 15,000 to 20,000 cfs. Often, valley bottom springs flow into sloughs. There is a good correlation between bankfull stage and the mean annual flood.

Where the main channel impinges valley walls or terraces, a cobble armor layer has developed with a top elevation at roughly bankfull flood stage. The main channel bed has been frequently observed to be well armoured.

Primary tributaries include Indian River, Gold Creek and Fourth of July Creek. Each has formed an alluvial fan extending into the valley bottom and constricting the Susitna to a single channel. Each constriction has established a hydraulic control point that regulates water surface profiles and associated hydraulic parameters at varying discharges.

RM 129.5 to RM 119

River patterns through this reach are similar to those in the previous reach. The most prominent characteristic between Sherman and Curry is that the main channel prefers to flow against the west valley wall and the east floodplain has several side channels and sloughs. The alluvial fan at Curry constricts the Susitna to a single channel and terminates the above described patterns. A fair correlation exists between bankfull stage and mean annual flood through this reach. Comparison of 1950 and 1980 airphotos reveals occasional local changes in banklines and island morphology.

The west valley wall is generally nonerodible and has occasional bedrock outcrops. The resistant boundary on one side of the main channel has generally forced a uniform channel configuration with a well armored perimeter. The west valley wall is relatively straight and uniform except at RM 128 and 125.5. At these locations, bedrock outcrops deflect the main channel to the east side of the floodplain.

RM 119 to RM 104

Through this reach the river is predominantly a very stable, single incised channel with a few islands. The channel banks are well armored with cobbles and boulders, as is the bed. Several large boulders occur intermittently along the main channel and are believed to have been transported down the valley during glacial ice movement. They provide local obstruction to flow and navigation, but do not have a significant impact on channel morphology.

RM 104 to RM 95

At the confluence of the Susitna, Chulitna and Talkeetna Rivers, there is a dramatic change in the Susitna from a split channel to a braided channel. Emergence from confined mountainous basins into the unconfined lowland basin has enabled the river systems to develop laterally. Ample bedload transport and a gradient decrease also assist in establishing the braided pattern.

The Chulitna River has a mean annual flow similar to the Susitna at Gold Creek, yet its drainage basin is about 40 percent smaller. Its glacial tributaries are much closer to the confluence than the Susitna. As it emerges from the incised canyon 20 miles upstream of the confluence, the river transforms into a braided pattern with moderate vegetation growth on the intermediate gravel bars. At about a midpoint between the canyon and confluence, the Chulitna exhibits a highly braided pattern with no vegetation on intermediate gravel bars, evidence of recent lateral instability. This pattern continues beyond the confluence and giving the impression that the Susitna is tributary to the dominant Chulitna River. The split channel Talkeetna River is tributary to the dominant braided pattern.

Terraces generally bound the broad floodplain, but provide little control over channel morphology. General floodplain instability results from the three river system striving to balance out the combined flow and sediment regime.

RM 95 to 61

Downstream of the three-river confluence, the Susitna continues its braided pattern, with multiple channels interlaced through a sparsely vegetated floodplain.

The channel network consits of the main channel, usually one or two subchannels and a number of minor channels. The main channel meanders irregularly through the wide gravel floodplain and intermittently flows against the vegetated floodplain. It has the ability to easily migrate laterally within the active gravel floodplain, as the main channel is simply reworking the gravel that the system previously deposited. When the main channel flows against vegetated bank lines, erosion is retarded due to the vegetation and/or bank materials that are more resistant to erosion. Flow in the main channel usually persists throughout the entire year.

Subchannels are usually positioned near or against the vegetated floodplain and are generally on the opposite side of the floodplain from the main channel. The subchannels normally bifurcate (split) from the main channel when it crosses over to the opposite side of the floodplain and terminate where the main channel meanders back across the floodplain and intercepts them. The subchannels have smaller geometric dimensions than the main channel, and their thalweg is generally about five feet higher. Their flow regime is dependent on the main channel stage and hydraulic flow controls point of bifurcation. Flow may or may not persist throughout the year.

Minor channels are relatively shallow, wide channels that traverse the gravel floodplains and complete the interlaced braided pattern. These channels are very unstable and generally short-lived.

The main channel is intermittently controlled laterally where it flows against terraces. Since the active floodplain is very wide, the presence of terraces has little significance except for determining the general orientation of the river system. An exception is where the terraces constrict the river to a single channel at the Parks Highway bridge. Subchannels are directly dependent on main channel flow and sediment regime, and generally react the same. Minor channels react to both of the larger channels' behaviors.

RM 61 to RM 42

Downstream of the Kashwitna River confluence, the Susitna River branches into multiple channels separated by islands with established vegetation. This reach of the river has been named Delta Islands because it resembles the distributary channel network common with large river deltas. The multiple channels are forced together by terraces just upstream of Kroto Creek (Deshka River).

Through this reach, the very broad floodplain and channel network can be divided into three categories:

- Western braided channels;
- Eastern split channels; and
- Intermediate meandering channels.

The western braided channel network is considered to be the main portion of this very complex river system. Although not substantiated by river surveys, it appears to constitute the largest flow area and lowest thalweg elevation. The reason for this is that the western braided channels constitute the shortest distance between the point of bifurcation to the confluence of the Delta Island channels. Therefore it has the steepest gradient and highest potential energy for conveyance of water and sediment.

RM 42 to RM 0

Downstream of the Delta Islands, the Susitna River gradient decreases as it approaches Cook Inlet. The river tends toward a split channel configuration as it adjusts to the lower energy slope. There are short reaches where a tendency to braid emerges. Downstream of RM 20, the river branches out into delta distributary channels.

Terraces constrict the floodplain near the Kroto Creek confluence and at Susitna Station. Further downstream, the terraces have little or no influence on the river.

The Yentna River joins the Susitna at RM 28 and is a major contributor of flow and sediment.

Tides in the Cook Inlet rise above 30 feet and therefore control the water surface profile and to some degree the sediment regime of the lower river. River elevation of 30 feet exists at about RM 20 and corresponds to where the Susitna begins to branch out into its delta channels.

(b) Sloughs

Sloughs are spring-fed, perched overflow channels that only convey glacial meltwater from the mainstem during median and high flow periods. At intermediate and low flows, the sloughs convey clear water from small tributaries and/or upwelling groundwater. Differences between mainstem water surface elevations and the streambed elevation of the side sloughs are notably greater at the upstream entrance to the slough than at the mouth of the slough. The graidents within the slough are typically greater than the adjacent mainstem. An alluvial berm separates the head of the slough from the river, whereas the water surface elevation of the mainstem generally causes a backwater effect at the mouth of the slough. The sloughs function like small stream systems. Several hundred feed of channel exist in each slough conveying water independent of mainstem backwater effects.

The sloughs vary in length from 2,000 - 6,000 feet. Cross-sections of sloughs are typically rectangular with flat bottoms. At the head of the sloughs, substrates are dominated by boulders and cobbles (8-14 inch diameter). Progressing towards the slough mouth, substrate particles reduce in size with gravels and sands predominating. Beavers frequently inhabit the sloughs. Active and abandoned dams are visible. Vegetation commonly covers the banks to the waters edge with bank cutting and slumping occurring during spring break-up flows. The importance of the sloughs as salmon spawning habitat is discussed in detail in Chapter 3.

2.3 - Susitna River Water Quality

As previously described in Section 2.2, the Susitna River is characterized by large seasonal fluctuations in discharge. These flow variations along with the glacial origins of the river essentially control the water quality of the river.

Existing water quality data have been compiled for the mainstem Susitna River from stations located at Denali, Vee Canyon, Gold Creek, Sunshine, and Susitna Station. In addition, data from two Susitna River tributaries, the Chulitna and Talkeetna Rivers, have also been compiled (R&M, 1982b). The station locations are presented in Figure E2.1.

Data were compiled corresponding to three seasons: breakup, summer, and winter. Breakup is usually short and extends from the time ice begins to move down river until recession of spring runoff. Summer extends from the end of breakup until the water temperature drops to essentially 0°C in the fall, and winter is the period from the end of summer to breakup. The water quality parameters measured and their respectively detection limits appear in Table E.2.6.

The water quality was evaluated (R&M 1982b) using guidelines and criteria established from the following references:

- ADEC, Water Quality Standards. Alaska Department of Environmental Conservation, Juneau, Alaska, 1979.

- EPA, Quality Criteria For Water. U.S. Environmental Protection Agency, Washington, D.C., 1976.

- McNeely, R.N., V.P. Neimanism abd K, Dwyer. Water Quality Sourcebook-- A Guide to Water Quality Parameters. Environment Canada, Inland Waters Directorate, Water Quality Branch, Ottawa, Canada, 1979.

- Sitting, Marshall. Handbook of Toxic and Hazardous Chemicals. Noyes Publications, Park Ridge, New Jersey, 1981.

- EPA, Water Quality Criteria Documents; Availability. Environmental Protection Agency, Federal Register, 45, 79318-79379 (November 28, 1980).

The guidelines or criteria used for the parameters were chosen based on a priority system. Alaska Water Quality Standards were the first choice, followed by criteria presented in EPA's Quality Criteria for Water. If a criterion expressed as a specific concentration was not presented in the above two references, the other cited references were used as the source.

A second priority system was used for selecting the guidelines or criteria presented for each parameter. This was required because the various references presented above cite levels of parameters that provide for the protection of identified water uses, such as (1) the propagation of fish and other aquatic organisms, (2) water supply for drinking, food preparation, industrial processes, and agriculture, and (3) water recreation. The first priority, therefore, was to present the guidelines or criteria that apply to the protection of freshwater aquatic organisms. The second priority was to present levels of parameters that are acceptable for water supply, and the third priority was to present other guidelines or criteria if available. It should be noted that water quality standards set criteria which limit man-induced pollution to protect identified water uses. Although the Susitna River basin is a pristine area, some parameters naturally exceeded their respective criterion. These parameters are presented in Table E.2.7. As noted in Table E.2.7, criteria for three parameters have been set at a level which natural waters usually do not exceed. The suggested criteria for aluminum and bismuth are based on human health effects. The criterion for total organic carbon (TOC) was established at 3 mg/l. Water containing less than this concentration has been observed to be relatively clean. However, streams in Alaska receiving tundra runoff commonly exceed this level. The maximum TOC concentration reported herein, 20 mg/l, is likely the result of natural conditions. The criterion for manganese was established to protect water supplies for human consumption. The criteria presented for the remaining parameters appearing in Table E.2.7 are established by law for protection of freshwater aquatic organisms. The water quality standards apply to man-induced alterations and constitute the degree of degradation which may not be exceeded. Because there are no industries, no significant agricultural areas, and no major cities adjacent to the Susitna, Talkeetna, and Chulitna Rivers, the measured levels of these parameters are considered to be natural conditions. Since criteria exceedance is attributed to natural conditions, little additional discussion will be given to these phenomenon. Also, these rivers support diverse populations of fish and other aquatic life. Consequently, it is concluded that the parameters exceeding their criteria probably do not have significant adverse effects on aquatic organisms.

In the following discussion, parameters measured during breakup will generally not be discussed since data normally indicate a transition period between the winter and summer extremes and the data itself is usually limited. Levels of water quality parameters discussed in the following section are reported by R&M (1982b), unless otherwise noted.

(a) Physical Parameters

(i) Water Temperature

- Mainstem

In general, during winter, the entire mainstem Susitna River is at or near 0°C. However, there are a number of small discontinuous areas with groundwater inflow of near 2°C. As spring breakup occurs the water temperature begins to rise, generally warming with distance downstream.

In summer, glacial melt is near 0°C as it leaves the glacier, but as it flows across the wide gravel floodplain below the glaciers the water begins to warm. As the water winds its way downstream to the proposed Watana damsite it can reach temperatures as high as 14°C. Further downstream there is generally some additional warming but, temperatures may be cooler at some locations due to the effect of tributary inflow. In August, temperatures begin to drop, reaching 0°C in late September or October.

The seasonal temperature variation for the Susitna River at Denali and Vee Canyon during 1980 and for Denali and Watana during 1981 are displayed in Figures E.2.26 and E.2.27. Weekly averages for Watana in 1981 are shown in Figure E.2.28. The shaded area indicates the range of temperatures measured on a mean daily basis. The temperature variations for eight summer days at Denali, Vee Canyon and Susitna Station are presented in Figure E.2.29. The recorded variation in water temperatures at the seven USGS gaging stations is displayed in Figure E.2.30.

Additional data on water temperature are available in the annual reports of U.S.G.S. Water Resources Data for Alaska, the Alaska Department of Fish and Game (ADF&G) Susitna Hydroelectric Project data reports (Aquatic Habitat and Instream Flow Project - 1981, and Aquatic Studies Program - 1982), and in Water Quality Data - 1981b, 1981c, R&M Consultants.

- Sloughs

The sloughs downstream of Devil Canyon have a temperature regime that differs form the mainstem. During the winter of 1982 intergravel and surface water temperatures were measured in sloughs 8A, 9, 11, 19, 20 and 21, the locations of which are illustrated in Figure E.2.31. These measurements indicated that intergravel temperatures were relatively constant through February and March at each location but exhibited some variability from one location to another. At most stations intergravel temperatures were within the 2-3°C range. Slough surface temperatures showed more variability at each location and were generally lower than intergravel temperatures during February and March (Trihey, 1982a).

During spring and summer, when flow at the head of the slough is cut off, slough temperatures tend to differ from mainstem temperatures. During periods of high flows, when the head end is overtopped, slough water temperatures correspond more closely to mainstem temperatures. Figure E.2.32 compares weekly diel surface water temperature variations during September, 1981 in Slough 21 with the mainstem Susitna River at Portage Creek (ADF&G, 1982). The slough temperatures show a marked diurnal variation caused by increased solar warming of the shallow water during the day and subsequent long wave back radiation at night. Mainstem water temperatures are more constant because of the buffering and mixing capability of the river.

- Tributaries

The tributaries to the Susitna River generally exhibit cooler water temperatures than does the mainstem. Continuous water temperatures have been monitored by the USGS in the Chulitna and Talkeetna Rivers near Talkeetna, and also by ADF&G in those two rivers as well as in Portage, Tsusena, Watana, Kosina, and Goose Creeks, and in Indian and the Oshetna River.

The 1982 mean daily temperature records for Indian River and Portage Creek are compared in Figure E.2.33. Portage Creek was consistently cooler than Indian River by 0.1 to 1.9°C. The flatter terrain in the lower reaches of the Indian River valley is apparently more conducive to solar and connective heating than the steep-walled canyon of Portage Creek. Figure E.2.33 also presents water temperature data from the mainstem Susitna for the same period, showing the consistently warmer temperatures in the mainstem.

There are noticeable diurnal flucutations in the open-water tributary temperatures, though not as extreme as in the sloughs. Daily variation of up to 6.5°C (from 3.0 to 9.5°C) was observed at Portage Creek in 1982 (June 14).

The major tributaries joining the Susitna at Talkeetna show uniform variation in temperatures from the mainstem. Compared to the Talkeetna fishwheel site on the Susitna, the Talkeetna River temperature is 1-3°C cooler on a daily average basis. The Chulitna River, being closer to its glacial headwaters, is from 0 to 2°C cooler than the Talkeetna river, and has less during fluctuations.

Winter stream temperatures are expected to be very close to 0°C, as all the tributaries do freeze up. Groundwater inflow at some locations may create local conditions above freezing, but the overall temperature regime would be affected by the extreme cold in the environment.

(ii) Ice

- Freeze-up

Air temperatures in the Susitna basin increase from the headwaters to the lower reaches. While the temperature gradient is partially due to the two - degree latitudinal span of the river, it is, for the most part due to the 3,300-foot difference in elevation between the lower and upper basins, and the climate-moderating effect of Cook Inlet on the lower river reaches. The gradient results in a period (late October - early November) in which the air temperatures in the lower basin are above freezing while subfreezing in the upper basin. The location of freezing air temperatures moves in a downstream direction as winter progresses (R&M, 1982c).

Frazil ice forms in the upper segment of the river first, due to the initial cold temperatures of glacial melt and the earlier cold air temperatures. Additional frazil ice is generated in the fast-flowing rapids between Vee Canyon and Devil Canyon. The frazil ice generation normally continues for a period of 3-5 weeks before a solid ice cover forms in the lower river, often a result of frazil-ice pans and floes jamming in suitable reaches.

Once frazil ice jams form, the ice cover progresses upstream, often raising water levels by 2 to 4 feet. Border ice formation along the river banks also serves to restrict the channel.

The upper Susitna River is the primary contributor of ice to the river system below Talkeetna, contributing 75-85 percent of the ice load in the Susitna-Chulitna-Talkeetna Rivers. Ice formation on the Chulitna and Talkeetna Rivers normally commences several weeks after freeze-up on the middle and upper Susitna River.

- <u>Winter Ice Conditions</u>

Once the solid ice cover forms, open leads still occur in areas of high-velocity water or groundwater upwelling. These leads shrink during cold weather and are the last areas in the main channel to be completely covered by ice. Ice thickness increases throughout the winter. The ice cover averages over 4 feet thick by breakup, but thicknesses of over 10 feet have been recorded near Vee Canyon.

Some of the side-channels and sloughs above Talkeetna do not form an ice cover during winter due to groundwater exfiltration. Winter groundwater temperatures generally varying between 2°C to 4°C contribute enough heat to prevent the ice cover from forming (Trihey 1982a). These areas are often salmonid egg incubation areas.

- <u>Breakup</u>

The onset of warmer air temperatures occurs in the lower basin several weeks earlier than in the upper basin, due to the temperature gradient previously noted. The low-elevation snowpack melts first, causing river discharge to increase. The rising water level puts pressure on the ice, causing fractures to develop in the ice cover. The severity of breakup is dependent on the snowmelt rate, on the depth of the snowpack and the amount of rainfall, if it occurs. A light snowpack and warm spring temperatures result in a gradual increase in river discharge. Strong forces on the ice cover do not occur to initiate ice movement resulting in a mild breakup, as occurred in 1981 (R&M, 1981d). Conversely, a heavy snowpack and cool air temperatures into late spring, followed by a sudden increase in air temperatures may result in a rapid rise in water level. The rapid water level increase initiates ice movement and this movement coupled with ice left in a strong condition from the cooler temperatures leads to numerous and possibly severe ice jams which may result in flooding and erosion, as occurred in 1982 (R&M, 1982f).

The flooding results in high flows through numerous side-channels in the reach above Talkeetna. The flooding and erosion during breakup are believed to be the primary factors influencing river morphology in the reach between Devil Canyon and Talkeetna (R&M, 1982a).

(iii) Suspended Sediments

The Susitna River and many of its major tributaries are glacial rivers which experience extreme fluctuations in suspended sediment concentrations as the result of both glacial melt and runoff from rainfall or snowmelt. Beginning with spring breakup, suspended sediment concentrations begin to rise from their near zero winter levels. During summer, values as high as 5700 mg/l have been recorded at Denali, the gaging station nearest the glacially-fed headwaters. Before entering the areas of the proposed reservoirs, concentrations decrease due to the inflow from several clear water tributaries. Maximum summer concentrations of 2600 mg/l have been observed at Gold Creek. Below Talkeetna, concentrations increase due to the contribution of the sediment-laden Chulitna River which has 28 percent of its drainage area covered by year round ice. Maximum values of 3000 mg/l have been recorded at the Susitna Station gage. A more extensive summary of suspended sediment concentrations is presented in Figure E.2.34.

Suspended sediment discharge has been shown to increase with discharge (R&M, 1982d). This relationship for various upper Susitna River stations is illustrated in Figure E.2.35.

Estimates of the average annual suspended sediment load for three locations on the upper Susitna River are provided in the following table (R&M, 1982d).

Gaging Station	Average Annual Suspended Sediment Load (tons/year)
Susitna River at Denali	2,965,000
Susitna River near Cantwell	6,898,000
Susitna River at Gold Creek	7,731,000

The suspended sediment load entering the proposed Watana Reservoir from the Susitna River is assumed to be that at the gaging site for the Susitna River near Cantwell, or 6,898,000 tons/year (R&M, 1982d).

A suspended sediment size analysis for upper Susitna River stations is presented in Figure E.2.36. The analysis indicates that between 20 and 25 percent of the suspended sediment is less than 4 microns (.004 millimeters) in diameter.

(iv) Turbidity

- Mainstem

The Susitna River is typically clear during the winter months with values at or very near zero. Turbidity increases as snowmelt and breakup commence. The peak turbidity values occur during summer when glacial input is greatest.

Limited turbidity data are available for the headwaters of the Susitna River. However, measurements up to 350 Nepholometer Turbidity units (NTU) have been recorded at Denali. Turbidity tends to decrease in the vicinity of the project areas due to clearwater inflow, although high values still exist. At the mouth of the Chulitna River near Talkeetna, values of over 1900 NTU have been observed. In contrast, maximum observed values on the Talkeetna River, with its minimal glacial input, were 270 NTU. Results of data collection are summarized in Figure E.2.37 (R&M, 1982e). Data collected at various sites in 1982 are tabulated in Table E.2.8.

Figure E.2.38 shows the direct relationship between suspended sediment concentation and turbidity as measured on the Susitna River at Cantwell, Gold Creek, and Chase (Peratrovich, Nottingham and Drage, 1982a). However, suspended sediment concentrations can vary significantly at similar flow ranges, as the glaciers contribute highly variable amounts of sediment (R&M, 1982d).

- Sloughs

Turbidity values for selected sloughs were collected by ADF&G during the summer of 1981. The turbidity in the sloughs was less than the turbidity in the mainstem except when upstream ends were overtopped at which time the turbidities usually mirrored mainstem levels (ADF&G, 1982). Even with overtopping, some sloughs maintained lower turbidity due to groundwater or tributary inflow.

(v) Vertical Illumination

Vertical illumination through the water column varies directly with turbidity and suspended sediment concentration and hence follows the same temporal and spatial patterns. Although no quantitive assessment was conducted, summer vertical illumination is generally a few inches. During winter months, the river bottom can be seen in areas without-ice cover, as the river is exceptionally clear. Vertical illumination under an ice cover is inhibited, especially if the ice is not clear and if a snow cover exists over the ice.

(vi) Total Dissolved Solids (TDS)

Dissolved solids concentratons are higher, and exhibit a wider range during the winter low-flow periods than during the summer period. Data at Denali range from 110-270 mg/l in the winter and from 40-170 mg/l in the summer. Progressing downstream on the Susitna River basin, TDS concentrations are generally lower.

Gold Creek TDS winter values are 100-190 mg/l, while summer concentrations are 50-140 mg/l. Measurements at Susitna Station, range from 100-140 mg/l during winter and between 55 and 80 mg/l in the summer. Figure E.2.39 provides a graphic representation of the data collected.

(vii) Specific Conductance (Conductivity)

Susitna River conductivity values are high during winter low-flow periods and low during the summer. In the upstream reaches where glacial input is most significant, conductivity is generally higher. At Denali, values range from 190-510 umhos/cm in the winter and from 120-205 umhos/cm in the summer.

Below Devil Canyon, conductivity values range from 160-300 umhos in the winter and from 60-230 umhos/cm in the summer. The Chulitna and Talkeetna Rivers have slighly lower conductivity values, but are in the same range as in the Susitna River.

Figure E.2.40 graphically provides the maximum, minimum and the mean values as well as the number of conductivity observations for the seven gaging stations.

(viii) Significant ions

Concentrations of the significant ions are generally low to moderate, with summer concentrations lower than winter concentrations. The ranges of concentrations recorded upstream of the project at Denali and Vee Canyon and downstream of the project at Gold Creek, Sunshine and Susitna Station are listed in Table E.2.9. The ranges of ion concentrations at each monitoring station are presented in Figures E.2.41 to E.2.46.

(ix) pH

Average pH values tend to be slightly alkaline with values typically ranging between 7 and 8. A wider range is generally exhibited during the spring breakup and summer months with values occasionally dropping below 7. This phenomenon is common in Alaskan streams and is attributable to the acidic tundra runoff.

Winter pH ranges at the Gold Creek station are between 7.0 and 8.1 while the range of summer values is 6.6 to 8.1. Figure E.2.47 displays the pH information for the seven stations of record.

(x) Total Hardness

Waters of the Susitna River are moderately hard to hard in the winter, and soft to moderately hard during breakup and summer. In addition, there is a general trend toward softer water in the downstream direction.

Total hardness, measured as calcium magnesium hardness and reported in terms of $CaCO_3$, ranges between 60-120 mg/l at Gold Creek during winter, and betwen 30-105 mg/l in the summer. At Susitna Station, winter values are 70-95 mg/l while summer values range from 45 to 60 mg/l.

Figure E.2.48 presents more detailed total hardness information.

(xi) Total Alkalinity

Total Alkalinity concentrations with bicarbonate typically being the only form of alkalinity present, exhibit moderate to high levels and display a much larger range during winter than the low to moderate summer values. In addition, upstream concentrations are generally larger than downstream values.

Winter values at Gold Creek range between 45 and 145 mg/l, while summer values are in the range of 25 to 85 mg/l. In the lower river at Susitna Station, winter concentrations are between 60-75 mg/l and summer levels are in the range of 40-60 mg/l.

Figure E.2.49 displays a more detailed description of total alkalinity concentrations.

(xii) True Color

True color, measured in platinum cobalt units, displays a wider range during summer than winter. This phenomenon is attributable to organic acids (especially tannin) characteristically present in the summer tundra runoff.

Color levels at Gold Creek vary between 0 and 10 color units during winter and 0 to 40 units in the summer. It is not uncommon for color levels in Alaska to be as high as 100 units for streams receiving tundra runoff, i.e., the maximum recorded value at the Sunshine gauge.

Figure E.2.50 displays the data collected.

(xiii) Metals

The concentrations of many metals monitored in the river were low or within the range characteristic of natural waters. Eight parameters antimony (sb), boron (B), gold (Au), dissolved molybdenum (M), platinum (Pt), tin (Sn), vanadium (V) and zirconium (Zr) were below detectable limits. However, the concentrations of some trace elements exceeded water quality guidelines for the protection of freshwater organisms. (Table E.2.4). These concentrations are the result of natural processes, since with the exception of some placer mining activities, there are no man-induced sources of these elements in the Susitna River basin. Metals which have exceeded these limites include aluminum (Al), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni) and zinc (Zn).

Figures E.2.51 through E.2.68 summarize the heavy metal data that were collected.

(b) Dissolved Gases

(i) Dissolved Oxygen

Dissolved oxygen (D.O.) concentrations generally remain quite high throughout the drainage basin. Winter values average near 13 mg/l while summer concentrations average between 11 and 12 mg/l. These concentrations equate to dissolved oxygen saturation levels generally exceeding 80 percent, although summer values average near 100 percent. Winter saturation levels decline slightly from summer levels, averaging near 97 percent at Gold Creek and 80 percent at Susitna Station.

Figures E.2.69 and E.2.70 contain additional dissolved oxygen data.

(ii) Nitrogen Supersaturation

Limited sampling for dissolved gas concentrations, namely nitrogen and oxygen, was performed during the 1981 field season. However, continuous monitoring equipment was installed in the vicinity of Devil Canyon for approximately two months (8 August - 10 October) during 1982. This data is not available at this time but will be included when it is available. The 1981 data indicated that supersaturation existed above Devil Canyon as well as below ranging from 105.3 percent to 116.7 percent, respectively.

Alaska water quality statutes call for a maximum dissolved gas concentration of no higher than 110 percent.

(c) Nutrients

Nutrient concentrations, specifically nitrate nitrogen and orthophosphate, exist in low to moderate concentration throughout the Susitna River. Nitrate concentrations are less than 1.0 mg/l along the Susitna, although Talkeetna River values have reached 2.5 mg/l. Gold Creek nitrate concentrations vary from below detectable limits to 0.4 mg/l.

Biologically available orthophosphates are generally less than 0.2 mg/l throughout the drainage basin. Gold Creek orthophosphate values vary from below detectable limits to 0.1 mg/l. most values at Vee Canyon are also in this range. This data is depicted in Figures E.2.71 and E.2.72.

Studies of glacially influenced lakes in Alaska (Koenings and Kyle, 1982) and Canada (St. John et al., 1976) indicate that over 50 percent of the total phosphorus concentration in the lakes studied was biologically inactive. This was attributed to the fact that the greatest percentage of the lakes' total phosphorus occurred in the particulate form. Consequently, phosphorus available in the dissolved form is much less than recorded values. This is discussed in more detail by Peterson and Nichols, (1982).

Of the major nutrients--carbon, silica, nitrogen and phosphorus, the limiting nuturient in the Susitna River is phosphorus (Peterson and Nichols 1982).

(d) Other Parameters

(i) Chlorophyll-a

Chlorophyll-a as a measure of algal biomass is quite low due to the poor light transmissivity of the glacial waters. The only chlorophyll-a data available for the Susitna River were collected at the Susitna Station gage. Values up to 1.2 mg/m^3 for chlorophyll-a (periphyton uncorrected) have been recorded. However, using the chromospectropic technique, values ranged from 0.004 to 0.029 mg/m^3 for three samples in 1976 and 1977. All recorded values from 1978 through 1980 were less than detectable limits when analyzed using the chromographic fluorometer technique.

No data on chlorophyll-a are available for the upper basin. However, with the very high suspended sediment concentrations and turbidity values, it is expected that chlorophyll-a values are very low.

(ii) Bacteria

No data are available for bacteria in the upper river basin. However, because of the glacial origins of the river and the absence of domestic, agricultural, and industrial development in the watershed, bacteria levels are expected to be quite low.

Only limited data on bacterial indicators are available from the lower river basin, namely for the Talkeetna River since 1972, and from the Susitna River at Susitna Station since 1975. Indicator organisms monitored include total coliforms, fecal coliforms, and fecal streptococci.

Total coliform counts were generally quite low, with all three samples at Susitna Station and 70 percent of the samples on the Talkeetna River registering less than 20 colonies per 100 ml. Occasional high values have been recorded during summer months, with a maximum value of 130 colonies per 100 ml.

Fecal coliforms were also low, usually registering less than 20 colonies per 100 ml. The maximum recorded summer values were 92 and 91 colonies per 100 ml in the Talkeetna and Susitna Rivers, respectively.

Fecal streptococci data also display the same pattern; low values in winter months, with occasional high counts during the summer months.

All recorded values are believed to reflect natural variation within the river, as there are no significant human influences throughout the Susitna River Basin that would affect bacterial counts.

(iii) Others

Concentrations of organic pesticides and herbicides, uranium, and gross alpha radioactivity were either less than their respective detection limits or were below levels considered to be potentially harmful. Since no significant sources of these parameters are known to exist in the drainage basin, no further discussions will be pursued.

(e) Water Quality Summary

The Susitna River is a fast flowing, cold-water glacial stream of the calcium bicarbonate type containing soft to moderately hard water during breakup and summer, and moderately hard water in the winter. Nutrient concentrations, namely nitrate and orthophosphate, exist in low-to-moderate concentrations. Dissolved oxygen concentrations typically remain high, averaging about 12 mg/l during the summer and 13 mg/l during winter. Percentage saturation of dissolved oxygen generally exceeds 80 percent and averages near 100 percent in the summer. Winter saturation levels decline slightly from the summer levels. Typically, pH values range between 7 and 8 and exhibit a wider range in the summer compared to the winter. During summer, pH occasionally drops below 7, which is attributed to organic acids in the tundra runoff. True color, also resulting from tundra runoff, displays a wider range during summer than winter. Values have been measured as high as 40 color units in the vicinity of the damsites. Temperature remains at or near 0°C during winter, and the summer maximum is 14°C. Alkalinity concentrations, with bicarbonate as the dominant anion, are low to moderate during summer and moderate to high during winter. The buffering capacity of the river is relatively low on occasion.

The concentrations of many trace elements monitored in the river were low or within the range characteristics of natural waters. However, the concentrations of some trace elements exceeded water quality guidelines for the protection of freshwater aquatic organisms. These concentrations are the result of natural processes because with the exception of some placer mining activities there are no man-induced sources of these elements in the Susitna River Basin.

Concentrations of organic pesticides and herbicides, uranium, and gross alpha radioactivity were either less than their respective detection limits or were below levels considered to be potentially harmful to acquatic organisms.

2.4 - Baseline Ground Water Conditions

(a) Description of Water Table and Artesian Conditions

The landscape of the upper basin consists of relatively barren bedrock mountains with exposed bedrock cliffs in canyons and along streams, and areas of unconsolidated sediments (outwash, till, alluvium) with low relief particularly in the valleys. The arctic climate has retarded development of topsoil. Unconfined aquifers exist in the unconsolidated sediments, although there is no water table data in these areas except in the relict channel at Watana and the south abutment at Devil Canyon. Winter low flows in the Susitna River and its major tributaries are fed primarily from ground water storage in unconfined aquifers. The bedrock within the basin comprises crystalline and metamorphic rocks. No significant bedrock aquifers have been identified or are anticipated.

Below Talkeetna, the broad plain between the Talkeetna Mountains and the Alaska Range generally has higher ground water yields, with the unconfined aquifers immediately adjacent to the Susitna River having the highest yields (Freethey and Scully, 1980).

(b) Hydraulic Connection of Ground Water and Surface Water

Much of the ground water in the system is stored in unconfined aquifers in the valley bottoms and in alluvial fans along the slopes. Consequently, there is a direct connection between the ground water and surface water. Confined aquifers may exist within some of the unconsolidated sediments, but no data are available as to their extent.

(c) Locations of Springs, Wells, and Artesian Flows

Due to the wilderness character of the basin, there is no data on the location of springs, wells, and artesian flows. However, winter aufeis buildups have been observed between Vee Canyon and Fog Creek, indicating the presence of ground water discharges. Ground water is the main source of flow during winter months, when precipitation falls as snow and there is no glacial melt. It is believed that much of this water comes from unconfined aquifers (Freethey and Scully, 1980).

(d) Hydraulic Connection of Mainstem and Sloughs

Ground water studies in respresentative sloughs downstream of Devil Canyon indicate that there is a hydraulic connection between the mainstem Susitna River and the sloughs. These sloughs are used by salmonid species for spawning and hence are important to the fisheries. Ground water observation wells indicate that the upwelling in the sloughs, which is necessary for egg incubation, is caused by ground water flow from the uplands and from the mainstem Susitna. The higher permeability of the valley bottom sediments (sand-gravel-cobble-alluvium) compared with the till mantle and bedrock of the valley sides indicates that the mainstem Susitna River is the major source of ground water inflow in the sloughs. Preliminary estimates of the travel time of the ground water from the mainstem to the sloughs indicate a time on the order of six months.

2.5 - Existing Lakes, Reservoirs, and Streams

(a) Lakes and Reservoirs

There are no existing reservoirs on the Susitna River or on any of the tributaries flowing into either Watana or Devil Canyon Reservoirs. No lakes downstream of the reservoirs are expected to realize any impact from project construction, impoundment, or operation. A few lakes at and upstream of the damsites, however, will be affected by the project.

The annual maximum pool elevation of 2190 feet in the Watana Reservoir will inundate several lakes, none of which are named on USGS topographic quadrangle maps. Most of these are small tundra lakes and are located along the Susitna between RM 191 and RM 197 near the mouth of Watana Creek. There are 27 lakes less than 5 acres in surface area, one between 5 and 10 acres, and one relatively large one of 63 acres, all on the north side of the river. In addition, a small lake (less than 5 acres) lies on the south shore of the Susitna at RM 195.5 and another of about 10 acres in area lies on the north side of the river at RM 204. Most of these lakes appear to be simply perched, but five of them are connected by small streams to Watana Creek or to the Susitna River itself.

A small lake (2.5 acres) lies on the south abutment near the Devil Canyon damsite, at RM 151.3, and at about elevation 1400 feet. No other lakes exist within the proposed Devil Canyon Reservoir.

(b) Streams

Several streams in each reservoir will be completely or partially inundated by the raised water levels during project filling and operation. The streams appearing on the 1:63,360 sclae USGS quadrangle maps are listed by reservoir in Tables E.2.10 and E.2.11. Listed in the tables are map name of each stream, river mile locations of the mouth, existing elevation of the stream mouths, the average stream gradient, the number of miles of stream to be inundated. Annual maximum reservoir elevations of 2190 feet and 1455 feet were used for these determinations for the Watana and Devil Canyon pools, respectively.

There is a small slough with two small ponds on it at RM 212, four miles upstream from the mouth of Jay Creek. This slough, which is at approximately elevation 1750, will be completely inundated by the Watana Reservoir. Similarly, there are five sloughs (at RM 180.1, 174.0, 173.4, 172.1, and 169.5) which will be totally inundated by the Devil Canyon Reservoir.

Aside from the streams to be inundated by the two project impoundments, there are several tributaries downstream of the project which may be affected by changes in the Susitna River flow regime. Since post-project summer stages in the Susitna will be several feet lower than pre-project levels, some of the creeks may either degrade to the lower elevation or remain perched above the river. Analysis was done on 19 streams between Devil Canyon and Talkeenta which were determined to be important for fishery reasons or for maintenance of existing crossings by the Alaska Railroad (R&M 1982). These streams are listed in Table E.2.12, with their river mile locations and reason for concern.

2.6 - Existing Instream Flow Uses

Instream flow uses are uses made of water in the stream channel as opposed to withdrawing water from the stream for use. Instream flow used include hydroelectric power generation; commercial or recreational navigation; waste load assimilation; downstream water rights; water requirements for riparian vegetation, fish and wildlife habitat; and recreation; freshwater recruitment to estuaries; and water required to maintain desirable characteristics of the river itself. Existing instream flow uses on the Susitna River include all these uses except hydroelectric power operation.

(a) Downstream Water Rights

The 18 different areas in the Susitna River Basin investigated for water rights are shown in Figure E.2.73 (Dwight, 1981). Table E.2.13 indicates the total amount of surface water and ground water appropriated within each area. The only significant uses of surface water in the Susitna River Basin occur in the headwaters of the Kahiltna and Willow Creek township grids where placer mining operations take place on a seasonal basis. No surface water withdrawals from the Susitna River are on file with the Alaska Department of Natural Resources (DNR). Ground water appropriations on file with DNR for the mainstem Susitna River corridor are minimal, both in terms of number of users and the amount of water being withdrawn.

An analysis of topographic maps and overlays showing the specific location of each recorded appropriation within the mainstem Susitna River corridor indicated that neither the surface water diversions from small tributaries nor the groundwater withdrawals from shallow wells will be adversely affected by the proposed Susitna Hydroelectric project (Dwight 1981). Hence, no further discussion on water rights is presented.

(b) Fishery Resources

The Susitna River supports populations of both anadromous and resident fish. Important commercial, recreational, and subsistence species include pink, chum, coho, sockeye and chinook salmon, eulachon, rainbow trout, and Arctic grayling. Instream flows presently provide for fish passage, spawning, incubation, rearing, overwintering, and outmigration. These activities are correlated to the natural hydrograph. Salmon spawn on the receeding limb of the hydrograph, the eggs incubate through the low-flow period and fry emergence occurs on the ascending limb of the hydrograph. Rainbow trout and grayling spawn during the high flows of the breakup period with embryo development occurring during the early summer. Alteration of the natural flow regime during reservoir filling and project operation will likely result in both detrimental and beneficial effects on the fishery resources of the Susitna River (see Chapter 3).

(c) Navigation and Transportation

Navigation and transportation use of the Susitna River presently consists of boating for recreation sport fishing, hunting, and some transportation of goods. The reach from the headwaters of the Susitna River to the Devil Canyon damsite has experienced limited use, primarily related to hunters and fishers' access to the Tyone River area after launching at the Denali Highway. Some recreational kayaking, canoeing, and rafting has also taken place downstream from the Denali Highway Bridge, generally stopping near Stephan Lake or some other points above the rapids at Devil Creek. Steep rapids near Devil Creek and at the Devil Canyon damsite are barriers to most navigation, though a very small number of kayakers have successfully traveled through the Devil Canyon rapids in recent years. There have been several unsuccessful attempts to penetrate the canyon, both going upstream and downstream, in a powerboat and in kayaks.

Below Devil Canyon, the river is used for access to salmon fishing at several sites as far upstream as Portage Creek. This is undertaken by private boat-owners and by anglers using commercial boat operators. In either case, most of the boat-launching is done at Talkeetna. Commercial operators from Talkeetna also cater to sightseeing tourists, who travel upriver to view the diversified terrain and wildlife. There is recreational boating in this reach, frequently by kayakers or canoeists floating downriver to Talkeetna from the railroad access point at Gold Creek.

Access to the Susitna downstream of Talkeetna is obtained at Talkeetna, from a boat-launching site at Susitna Landing near Kashwitna, at several of the minor tributaries between Talkeetna and Cook Inlet, and from Cook Inlet. Other primary tributaries accessible by road are Willow Creek, Sheep Creek, and Montana Creek. Virtually this entire reach of the Susitna is navigable under most flow conditions although abundant floating debris during extreme high water and occasional shallow areas during low water make navigation treacherous at times.

Identified restrictions of open-water navigation over the full length of the river are tabulated in Table E.2.14.

Under the existing flow regime, the ice on the river breaks up and the river becomes ice-free for navigation in mid to late May. Flows typically remain high from that time through the summer until later September or early October, when freezing begins. The onset of river freezing causes discharge of significant frazil ice for several days in an initial surge, which hinders boat operation, but this is often followed by a frazil-free period of 1 to 2 weeks when navigation is again feasible. The next sequence of frazil generation generally leads into continuous freezing of the river, prohibiting open-water navigation until after the next spring breakup.

The Susitna is used by several modes of non-boat transportation at various times of the year. Fixed-wing aircraft on floats make use of the river for landings and take-offs during the open water season. These are primarily at locations in the lower 50 miles above the mouth. Floatplane access also occurs on occasion within the middle and upper Susitna reaches.

After the river ice cover has solidly formed in the fall, the river is used extensively for transportation access by ground methods in several areas. Snow machines and dogsleds are commonly used below Talkeetna; the Iditarod Trail crosses the river near the Yentna River confluence and is used for an annual dogsled race in February. Occasional crossings are also made by automobiles and ski, primarily near Talkeetna and near the mouth.

(d) Recreation

Information on the recreation uses on the Susitna River are presented in Chapter 7.

(e) Riparian Vegetation and Wildlife Habitat

Wetlands cover large portions of the Susitna River Basin, including riparian zones along the mainstem Susitna, sloughs, and tributary streams. Wetlands are biologically important because they generally support a greater diversity of wildlife species per unit area than most other habitat types in Alaska. In addition, riparian wetlands provide winter browse for moose and, during severe winters, can be a critical survival factor for this species. They also help to maintain water quality throughout regional watersheds. Further information on riparian wetlands and wildlife habitat can be found in Chapter 3.

(f) Waste Assimilative Capacity

Review of the Alaska Department of Environmental Conservation document entitled "Inventory of Water Pollution Sources and Management Actions, Maps and Tables" (1978) indicates that the primary sources of pollution to the Susitna River watershed are placer mining operations. Approximately 350 sites were identified although many of these claims are inactive. As the result of these operations, large amounts of suspended sediments are introduced into the watershed. However, no biochemical oxygen demand (BOD) is placed on the system and therefore, the waste assimilative capacity remains unaffected by these mining activities.

As for BOD discharges in the watershed, the inventory did identify one municipal discharge in Talkeetna, two industrial wastewater discharges at Curry and Talkeetna, and three solid waste dumps at Talkeetna, Sunshine, and Peters Creek. No volumes are available for these pollution sources.

During personal communication (1982) with Joe LeBeau of the Alaska Department of Environmental Conservation (DEC) it was noted that no new wastewater discharges of any significance have developed since the 1978 report. Further, he noted that the sources that do exist are believed to be insignificant.

Mr. Robert Flint of the DEC indicated that, in the absence of regulated flows and significant wastewater discharges, the DEC has not established minimum flow requirements necessary for the maintenance of the waste assimilative capacity of the river (personal communication, 1982).

(g) Freshwater Recruitment to Estuaries

The Susitna River is the chief contributor of freshwater to Cook Inlet and as such has a major influence on the salinity of Cook Inlet. The high summer freshwater flows cause a reduction in Cook Inlet salinities. During winter flows the reduced flows permit the more saline water to move up Cook Inlet from the ocean. Using a computer model for the Cook Inlet, Resource Management

Associates (RMA, 1982) predicted a seasonal salinity variation near the mouth of the Susitna River of 15 parts per thousand (ppt). In the central part of the inlet, salinity varies seasonally by about 5 ppt.

Salinity measurements were taken at the mouth of the Susitna River in August 1982 to determine if and to what extent saltwater intruded upstream. No saltwater intrusion was detected. Flow was approximately 100,000 cfs at Susitna Station at the time the measurements were made. Additional salinity measurements will be made during the 1982-83 winter season to determine if salt water penetration occurs upstream of the mouth of the river during low flow periods.

2.7 - Access Plan

(a) Flows

The streams crossed by the access road are typical of the subarctic, snow-dominated flow regime, in which a snowmelt flood in spring is followed by generally low flow through the summer, punctuated by periodic rainstorm floods. During October- April, precipitation falls as snow and remains on the ground. The annual low flow occurs during this period, and is almost completely base flow.

Streamflow records for these small streams are sparse. Consequently, regression equations developed by the U.S. Geological Survey (Freethey and Scully, 1980) have been utilized to estimate the 30-day low flows for recurrence intervals of 2, 10, and 20 years, and the peak flows for recurrence intervals of 2, 10, 25, and 50 years. These flows are tabulated in Table E.2.15 for three segments of the access route: (1) Denali Highway to Watana Camp; (2) Watana Camp to Devil Canyon Camp; and (3) Devil Canyon to Gold Creek. Only named streams are presented.

(b) Water Quality

At present very little water quality data is available for the water resources in the vicinity of the proposed access routes.

2.8 - Transmission Corridor

The transmission corridor consists of four segments: the Anchorage-Willow line, the Fairbanks-Healy line, the Willow-Healy Intertie, and the Gold Creek-Watana line. The first two (from Anchorage and Fairbanks) have existing facilities, but they will be upgraded before Watana comes on line. The intertie is currently being constructed under another contract. The line between the dam and the intertie has yet to be designed, sited, or constructed.

(a) Flows

Numerous waterbodies in each of the four sections will be crossed by the transmission line. Most of these are small creeks in remote areas of the region, but each segment has some major crossings. Data are very limited on the small streams, both with respect to water quantity and water quality. Most of the major crossings, however, have been gaged at some point along their length by the USGS. Major stream crossings are identified below. Pertinent gage records are summarized in Table E.2.16.

The Anchorage-Willow segment will cross Knik Arm of Cook Inlet with a submarine cable. Further north, major stream crossings include the Little Susitna River and Willow Creek, both of which have been gaged.

The Fairbanks-Healy line will make two crossings of the Nenana River and one of the Tanana River, both large rivers and gaged.

The intertie route between Willow and Healy will cross several dozen small creeks, many of which are unnamed. Major streams, include the Talkeetna, Susitna, and Indian Rivers; the East Fork and Middle Fork of the Chulitna River; the Nenana River; Yanert Fork of the Nenana; and Healy Creek.

The final leg of the transmission corridor, from Gold Creek to Watana Dam, will cross only one major river; the Susitna. Two smaller but sizeable tributaries are Devil Creek and Tsusena Creek, neither of which have been gaged.

(b) Water Quality

At present, essentially no data is available for those sections of streams, rivers, and lakes that exist in close proximity to the proposed transmission corridors.

3 - PROJECT IMPACT ON WATER QUALITY AND QUANTITY

3.1 - Proposed Project Reservoirs

(a) Watana Reservoir Characteristics

The Watana Reservoir will be operated at a normal maximum water level of 2185 feet above mean sea level, but will be allowed to surcharge to 2190 feet in late August during wet years. Average annual drawdown will be 105 feet with the maximum drawdown equalling 120 feet. During extreme flood events the reservoir will rise to 2193.3 for the 1 in 10,000 year flood and 2200.5 feet for the probable maximum flood respectively.

At elevation 2185, the reservoir will have a surface area of 38,000 acres and a total volume of 9.47 million acre-feet. Maximum depth will be 735 feet and the corresponding mean depth will be 250 feet. The reservoir will have a retention time of 1.65 years. The shoreline length will be 183 miles. Within the Watana reservoir area the substrate classification varies greatly. It consists predominantly of glacial, colluvial, and fluvial unconsolidated sediments and several bedrock lithologies. Many of these deposits are frozen.

(b) Devil Canyon Reservoir Characteristics

Devil Canyon reservoir will be operated at a normal maximum operating level of 1455 feet above mean sea level. Average annual drawdown will be 28 feet with the maximum drawdown equalling 50 feet. At elevation 1455 the reservoir has a surface area of 7800 acres and a volume of 1.09 million acre-feet. The maximum depth will be 565 feet and the mean depth 140 feet. The reservoir will have a retention time of 2.0 months. Shoreline length will total 76 miles. Materials forming the walls and floors of the reservoir area are composed predominantly of bedrock and glacial, colluvial, and fluvial materials.

3.2 - Watana Development

For details of the physical features of the Watana development, refer to Section 1 of Exhibit A.

(a) Watana Construction

(i) Flows

During construction of the diversions tunnel, the flow of the mainstem Susitna will be unaffected except during spring flood runoff. Upon completion of thé diversion facilities in the autumn of 1986, closure of the upstream cofferdam will be completed and flow will be diverted through the lower diversion tunnel without any interruption in flow. Although flow will not be interrupted, a one mile section of the Susitna River will be dewatered. No significant impacts should result from this action.

Flows, velocities, and associated water levels upstream of the proposed Watana damsite will be unaffected during construction except for approximately one half mile upstream of the upstream cofferdam during winter and two miles upstream during summer flood flows. During winter, ponding to elevation 1470 feet will be required to form a stable ice cover. However, the volume of water contained in this pond is insignificant relative to the total river flow.

During the summer, the diversion intake gates will be fully opened to pass the natural flows resulting in a run-of-river operation. All flows up to approximately the mean annual flood will be passed through the lower diversion tunnel. Average velocities through the diversion tunnel will be 18, and 35 feet per second (f/s) at discharges of 20,000, and 40,000 cfs respectively. The mean annual flood of 40,800 cfs will cause higher than natural water levels for about several miles upstream of the cofferdam. The water level will rise at the upstream cofferdam from a natural water level of 1,468 feet to 1,520 feet. Two miles upstream, the water level will be about 4 feet higher than the natural water level during the mean annual flood.

The two diversion tunnels are designed to pass the 1 in 50 year return period flood of 87,000 cfs with a maximum headpond elevation of 1,536 feet. For flows up to the 1 in 50 year flood event, water levels and velocities downstream of the diversion tunnels will be the same as preproject levels.

(ii) Effects on Water Quality

- Water Temperature

Since the operation of the diversion structure will essentially be run-of-river, no impact on the temperature regime will occur downstream of the tunnel exit. A small amount of ponding will occur early in the freeze-up stage to enhance the formation of a stable ice cover upstream of the tunnel intake. This will not have a noticeable effect downstream.

- Ice

During freeze-up, the formation of an upstream stable ice cover by use of an ice-boom and some ponding to reduce approach velocities, will serve to protect the diversion works and maintain its flow capacity. The early formation of the cover at this point will cause a more rapid ice front progression upstream of the damsite. The ice formed in the upper reach, which normally feeds the downstream ice growth, will no longer be available. However the major contributer of frazil ice will be the rapids through Devil Canyon as it now is. Hence, no appreciable impact on ice formation downstream of Watana will occur due to the diversion scheme.

The ice cover upstream of the damsite will thermally decay in place, since its movement downstream would be restricted by the diversion structure. Downstream of Devil Canyon the volume of ice in the cover will be essentially the same as the baseline conditions and breakup would likely be similar to natural occurrences.

- Suspended Sediments/Turbidity/Vertical Illumination

During construction, suspended sediment concentrations and turbidity levels are expected to increase within the impoundment area, and for some distance downstream. This will result from the necessary construction activities within and immediately adjacent to the river, including: dredging and excavation of gravel from borrow areas, excavation of diversion tunnels, placement of cofferdams, vegetative clearing, blasting, gravel processing and dewatering.

The location and subsequent excavation of the material from proposed borrow sites will create the greatest potential for suspended sediment and turbidity problems. The proposed borrow sites, identified in Figure E2.74, are tentatively located in the river floodplain both upstream and downstream of the dam site. However, except for the material for the upstream cofferdam, the lower borrow material will be obtained from sites D and E. Material for the core of the main dam will be obtained from site D (10,000,000 yards). Material for the filters and shell of the main dam will be obtained from site E (52,000,000 yards). Borrow excavation will take place during the summer months when suspended sediment and turbidity values in the mainstem of the river are already quite high. As a result, incremental impacts during the summer should not be significant. Stockpiling of gravel is expected to alleviate the need for excavation during the winter, when the impact on overwintering fish due to changes in suspended load would be greatest. As a result of the proposed scheduling of activities, impacts will be minimized. However, it is inevitable that there will be some increases in suspended sediments and turbidity during winter, but these should be short-term and localized. Downstream, turbidity and suspended sediment levels should remain essentially the same as baseline conditions.

Decreases in summer and winter vertical illumination are expected to be commensurate with any increased suspended sediment concentrations.

Since summer flows will be passed through the diversion tunnel with no impoundment, no settling of suspended sediments is expected to occur. The insignificant headpond that will be maintained during winter is not expected to affect the very low suspended sediment and turbidity levels present during the winter season.

- Metals

Slight increases in the concentration of trace metals could occur during construction when disturbances to soils and rock occur on the shoreline and in the riverbed. Such increases are expected to be below detection limits and thus would not indicate a change from baseline conditions described in Section 2.3 (a) (xiii).

- Contamination by Petroleum Products

Accidental spillage and leakage of petroleum products can contaminate water during construction. Lack of maintenance and service to vehicles could increase the leakage of fuel, lubricating oils, hydraulic fluid, antifreeze, etc. In addition, poor storage and handling techniques could lead to accidental spills. Given the dynamic nature of the river, the contaminated water would be quickly diluted; however the potential for such situations will be minimized. All state and federal regulations governing the prevention and reclamation of accidental spills will be adhered to.

- Concrete Contamination

Construction of the Watana project will create a potential for concrete contamination of the Susitna River. The wastewater associated with the batching of concrete, if directly discharged to the river, could seriously degrade downstream water quality and result in substantial mortality of fish. However, this potential problem should not occur since the wastewater will be neutralized and settling ponds will be employed to allow the concrete contaminants to settle prior to the discharge of the wastewater to the river.

- Other

No additional water quality impacts are anticipated.

(iii) Effects on Groundwater Conditions

No impacts on groundwater will occur because of construction, either in the impoundment area or downstream other than in the localized area of the project.

(iv) Impact on Lakes and Streams in Impoundment Area

There will be minor impacts on lakes and streams in the impoundment area due to excavation of borrow material. Also, facilities will be constructed to house and support construction personnel and their families. The construction, operation and maintenance of these facilities is expected to impact the Tsusena and Deadman Creek drainage basins and some of the small lakes located between the two creeks near the dam site. For a complete discussion of these impacts refer to the discussion on Facilities in paragraph (vi) below.

(v) Instream Flow Uses

For all reaches of the Susitna River except for the immediate vicinity of the Watana damsite, there will be virtually no impact on navigation, transportation, recreation, fisheries, riparian vegetation, wildlife habitat, waste load assimilation or the freshwater recruitment to Cook Inlet for flows less than the 1 in 50 year flood event.

- Navigation and Transportation

Since all flow will be diverted, there will only be an impact on navigation and transportation in the immediate vicinity of Watana dam and the diversion tunnel. The cofferdams will form an obstacle to navigation which will be difficult to circumvent. However, since this stretch of river has very limited use due to the heavy rapids upstream and downstream of the site, impact will be minimal.

- Fisheries

During winter, the diversion gate will be partially closed to maintain a headpond with a water surface elevation of 1,470 feet. This will cause velocities greater than 20 feet per second at the gate intake. This coupled with the 50 foot depth at the intake will impact fisheries. The impacts associated with the winter diversion are discussed in Chapter 3.2.3.

During summer, the diversion gates will be fully opened. This will permit downstream fish movement during low flows of about 10,000 cfs (equivalent velocity 9 feet per second (fps)). Higher tunnel velocities will lead to fish mortality. The impacts associated with summer tunnel velocities are discussed in Chapter 3.2.3.

- Riparian Vegetation

Existing shoreline vegetation upstream of the cofferdam will be inundated approximately 50 feet to elevation 1,520 during flood events. However, the flooding will be confined to a two mile river section upstream of the cofferdam, with the depth of flooding lessening with distance upstream. Since the flooding will be infrequent and temporary in nature, and the flooded lands are within the proposed reservoir, the impact is not considered significant. Further information on the impacts to riparian vegetation can be found in Chapter 3.

(vi) Facilities

The construction of the Watana power project will require the construction, operation and maintenance of support facilties capable of providing the basic needs for a maximum population of 4,720 people (3,600 in the construction camp and 1,120 in the village) (Acres, 1982). The facilities, including roads, buildings, utilities, stores, recreation facilities, airports, etc., will be constructed in stages during the first three years (1985-1987) of the proposed ten-year construction period. The camp and village will be located approximately 2.5 miles northeast of the Watana damsite, between Deadman and Tsusena Creeks. The location and layout of the camp and village facilities are presented in Plates 34, 35, and 36 of Exhibit F.

- Water Supply

Nearby Tsusena Creek will be utilized as the major source of water for the community (Plate 34). In addition, wells will be drilled in the Tsusena Creek alluvium as a backup water supply.

During construction, the required capacity of the water treatment plant has been estimated at 1,000,000 gallons per day, or 700 gallons per minute (1.5 cfs) (Acres, 1982). Using the USGS regression equation described in Table E2.15, 30-day minimum flows (cfs), with recurrence intervals of 20 years were estimated for Tsusena Creek near the water supply intake. The low flow was estimated to be 17 cfs for the approximate 126 square miles of drainage basin. As a result, no significant adverse impacts are anticipated from the maximum water supply withdrawal of 1.5 cfs. Further, a withdrawal of this magnitude should not occur during the low flow winter months since construction personnel will be significantly less than during summer.

The water supply will be treated by chemical addition, flocculation, filtration and disinfection prior to its use. Disenfection should probably be with ozone to avoid having to dechlorinate. In addition, the water will be demineralized and aerated, if necessary.

- Wastewater Treatment

A secondary waste water treatment facility will treat all waste water prior to its discharge into Deadman Creek (Plate 34).

Treatment will reduce the BOD and total suspended solids (TSS) concentrations to levels acceptable to the Alaska Department of Environmental Conservation. The levels are likely to be 30 mg/l BOD and 30 mg/l TSS. The maximum volume of effluent, 1 million gallons per day or 1.5 cfs, will be discharged to Deadman Creek which has a low flow of 27 cfs (see below). This will provide a dilution factor of about 17, thereby reducing BOD and TSS concentrations to about 2 mg/l after complete mixing under the worst case flow conditions (maximum effluent and low flow in Deadman Creek). Mixing will occur rapidly in the creek because of turbulent conditions.

The effluent is not expected to cause any degradations of water quality in the 1 1/2 mile section of Deadman Creek between the waste water discharge point and the creek's confluence with the Susitna River. Furthermore, no water quality problems are anticipated within the impoundment area or downstream on the Susitna River as a result of the input of this treated effluent. Using the USGS regression analysis, the one in 20 year, 30-day low flow for Deadman Creek at the confluence with the Susitna, was estimated at 27 cfs. Flow at the point of discharge which is less than two miles upstream, are not expected to differ significantly.

Construction of the waste water treatment facility is expected to be completed in the first 12 months of the Watana construction schedule. Prior to its operation, all waste will be stored in a lagoon system for treatment at a later date. No raw sewage will be discharged to any water body.

The applicant will obtain all the necessary DEC, EPA, DNR, and PHS permits for the water supply and wastewater discharge facilities.

- Construction, Maintenance and Operation

Construction of the Watana camp, village, airstrips, etc. will cause impacts to water quality similar to many of those occuring from dam construction. Increases in sedimentation and turbidity levels are anticipated in the local drainage basns. (i.e., Tsusena and Deadman Creeks). Even with extensive safety controls, accidental spillage and leakage of petroleum products could occur creating localized contamination within the watershed.

(b) Impoundment of Watana Reservoir

(i) Reservoir Filling Criteria

The filling of the Watana reservoir is scheduled to commence in May 1991.

- Minimum downstream target flows

In the selection of minimum target flows, fishery concerns and economics were the two controlling factors. Although not unimportant in the overall impact assessment, other instream flow uses, were determined not to have a significant influence on the selection of minimum downstream target flows. However, instream uses such as navigation and transportation, recreation, and waste load assimilation are closely related to the instream flow requirements of the fishery resources.

Minimum downstream target flows will be provided at Gold Creek since Gold Creek flows are judged to be representative of the Talkeetna to Devil Canyon reach where downstream impacts will be greatest. The minimum target flows at Gold Creek will be attained by releasing that flow necessary from the Watana impoundment, which when added to the flow contribution from the intervening drainage area between Watana and Gold Creek, will equal the minimum Gold Creek target flow. The absolute minimum flow release at Watana will be 1,000 cfs or natural flows, whichever is less. During filling, flows at Gold Creek will be monitored and the flow at Watana adjusted as necessary to provide the required Gold Creek flow.

Table E.2.17 illustrates the targeted minimum Gold Creek flows. The minimum downstream flow of 1000 cfs from November through April is somewhat lower than the average winter flow at Gold Creek.

From May to the last week of July, the target flow will be increased to 6,000 cfs to allow for mainstem fishery movement. During June, it may be desirable to spike the flows to trigger the outmigration of salmon fry from the sloughs. (Schmidt, 1982 personal communication). It is believed that the outmigration is triggered by a combination of stage, discharge and temperature. Trihey (1982) has observed that the fry outmigrate during the falling limb of the spring flood hydrograph.

The 6,000 cfs Gold Creek flow will provide a minimum of 2 feet of river stage for mainstem fishery movement at all 65 surveyed cross sections between Talkeetna and Devil Canyon. Figure E2.75 illustrates computed water surface elevations for various discharges at cross section 32 located near Sherman (RM 130). (Accuracy is $\pm$ 1 foot). This cross section is believed to be the shallowest in the Talkeetna to Devil Canyon reach. The estimated water surface elevation for a discharge of 6000 cfs indicates that the depth is greater than 2 feet.

During the last 5 days of July, flows will be increased from 6,000 cfs to 12,000 cfs in increments of approximately 1,500 cfs per day. Flows will be maintained at 12,000 cfs from August 1 through mid-September to coincide approximately with the sockeye and chum spawning season in the sloughs upstream of Talkeetna. Adverse impacts to fish resulting from this flow regime are discussed in Chapter 3.2.3.

After 15 September, flows will be reduced to 6,000 cfs in daily increments of 1,500 cfs and then held constant until October when they will be further reduced to 2,000 cfs. In November, the flow will be lowered to 1,000 cfs.

- Flood Flows

Taking into account the 30,000 cfs discharge capability of the low level outlet, sufficient storage will be made available during the filling sequence such that flood volumes for all floods up to the 250 year recurrence interval flood can be temporarily stored in the reservoir without endangering the main dam. Whenever this storage criteria is violated, discharge from the Watana reservoir will be increased up to the maximum capacity of the outlet to lower the reservoir level behind the dam.

(ii) Reservoir Filling Schedule and Impact on Flows

Using the reservoir filling criteria, three simulated reservoir filling sequences were examined to determine the likely filling sequence and probable deviations. As approximately three years will be required to bring the reservoir to its normal operating level, three year running averages of the total annual flow volume at Gold Creek were computed. The probability of occurrence for each of the three year average values was then determined. Using the 10, 50, and 90 percent exceedence probability volumes and the long term average monthly Gold Creek flow distribution, Gold Creek flow hydrographs were synthesized for each probability. An identical process was used to synthesize the 10, 50, and 90 percent probability volumes and flow distributions at Watana. The intermediate flow contribution was taken as the difference between the Watana and Gold Creek monthly flows. Then using the downstream flow criteria and the flow values at Watana and Gold Creek, the filling sequence for the three probabilities was determined by repeating the annual flow sequence until the reservoir was filled.

The reservoir water levels and the Gold Creek flows for the three filling cases considered are illustrated in Figure E2.76. Under average conditions the reservoir would fill sufficiently by autumn 1992 to allow testing and commissioning of the units to commence. However, the reservoir would not be filled to its normal operating level until the following summer. There is a 10 percent chance that the reservoir would not be sufficently full to permit the start of testing and commissioning until late spring 1993. Only about one month is saved over the average filling time if a wet sequence occurs. This is because the flood protection criteria is violated and flow must be bypassed rather than stored.

The Watana discharges for the high (10 percent), mean (50 percent) and low (90 percent) flow cases considered are compared to the Watana inflow in Table E2.18. For the average hydrologic case, pre-project discharge for the May-October period is reduced by approximately 60 percent during the filling period. However, from November through April there is little difference.

For the Devil Canyon to Talkeetna reach, Gold Creek flows are considered representative. Monthly pre-project and filling flows at Gold Creek for the wet, (10 percent), mean (50 percent), and dry (90 percent) sequences are illustrated in Table E2.19. Percentage summer and winter flow changes are similar to those at Watana but are somewhat reduced because of additional tributary inflow. For the mean case, August monthly flow at Gold Creek is reduced by 45 percent (21,900 cfs to 12,000 cfs) when the reservoir is capable of storing all flow less the downstream flow requirement.

Flows will be altered in the Talkeetna to Cook Inlet reach, but because of significant tributary contributions the impact on summer flows will be greatly reduced with distance downstream. Table E2.20 is a comparison of mean pre-project monthly flows and monthly flows during reservoir filling at Sunshine and Susitna Station. Pre-project flows are based on the long-term average ratio between the respective stations and Gold Creek. Filling flows are pre-project flows reduced by the flow stored in the reservoir.

- Floods

The reservoir filling criteria, dictates that available storage volume in the reservoir must provide, protection for all floods up to the 250 year recurrence interval flood. Thus, the reservoir must be capable of storing all flood inflow except for the flow which can be discharged through the outlet facilities during the flood event. The maximum Watana discharge of the outlet facilities is 30,000 cfs. A maximum flow at Watana at 30,000 cfs represents a substantial flood peak reduction which will reduce downstream flood peaks substantially as far downstream as Talkeetna. For example, the once in fifty year flood at Gold Creek would be reduced from 106,000 cfs to 49,000 cfs.

After the flood event, the outlet facility will continue to discharge at its maximum capacity until the storage volume criteria is reestablished. This will cause the flood duration to be extended beyond its normal duration although at a reduced flow as noted above.

The flood frequency curve for Watana during reservoir filling is illustrated in Figure E.2.77.

- Flow Variability

The variability of flow in the Watana to Talkeetna reach will be altered. Under natural conditions substantial change in flows can occur daily. This flow variability will be reduced during filling. Using August, 1958 as a example, Figure E.2. 78 shows the daily flow variation that would occur. The average monthly flow of 22,540 cfs during August, 1958 yields a value close to the long term average monthly discharge of 22,000 cfs. Superimposed on Figure E.2.78 are the flow variations that could occur under filling conditions with the August 1958 inflow, first, assuming that the reservoir was capable of accommodating the inflow and second, assuming that the reservoir storage criteria was violated (i.e., 30,000 cfs discharge at Watana). Both Gold Creek hydrographs have reduced flood peaks. In filling sequence 1, outflow is greater than inflow at Watana on the receeding limb of the hydrograph in order to meet the reservoir storage volume criteria. Hence during this time period, Gold Creek flows are greater than natural. In this example it was assumed that ongoing construction did not permit additional storage. In reality, the dam height will be increasing and additional storage would be permitted, thus reducing the required outflow from Watana. This would correspondingly reduce the Gold Creek discharge.

In filling sequence 2, Gold Creek flow is constant at 12,000 cfs. However, at Watana, flow would be 4,350 cfs at the peak and about 10,000 cfs when the natural Gold Creek flow drops to 12,000 cfs.

Further downsteam, the variability of flow for both sequences will increase as a result of tributary inflow, but will be less than under natural conditions.

(iii) River Morphology

During the filling of Watana reservoir, the trapping of bedload and suspended sediment by the reservoir will greatly reduce the sediment transport by the Susitna River in the Watana-Talkeetna reach. Except for isolated areas, bedload movement will remain limited over this reach because of the armor layer and the low flows. The lack of suspended sediments will significantly reduce siltation in calmer areas. The Susitna River main channel will tend to become more defined with a narrower channel in this reach. The main channel river pattern will strive for a tighter, better defined meander pattern within the existing banks. A trend of channel width reduction by encroachment of vegetation will begin, and will continue during reservoir operation. Tributary streams, including Portage Creek, Indian River, Gold Creek, and Fourth of July Creek, will extend their alluvial fans into the river. Figure E.2.79 illustrates the influence of the mainstem Susitna River on the sedimentation process occurring at the mouth of the tributaries. Overflow into most of the side-channels will not occur, as high flows will be greatly reduced. The backwater effects at the mouths of side-channels and sloughs will be significantly reduced.

At the Chulitna confluence, the Chulitna River is expected to expand and extend its alluvial deposits. Reduced summer flows in the Susitna River may allow the Chulitna River to extend its alluvial deposits to the east and south. However, high flows in the Chulitna River may cause rapid channel changes, inducing the main channel to migrate to the west. This would tend to relocate the deposition to the west.

Downstream of the Susitna-Chulitna confluence, the pre-project mean annual bankfull flood will now have a recurrence interval of five to ten years. This will tend to decrease the frequency of occurrence of both bed material movement and, consequently, of changes in braided channel shape, form and network. A trend toward relative stabilization of the floodplain features will begin, but this would occur over a long period of time (R&M, 1982a).

(iv) Effects on Water Quality

Beginning with the filling of the reservoir, many of the physical, chemical and biological processes common to a lentic environment should begin to appear. Some of the more important processes include sedimentation, leaching, nutrient enrichment, stratification, evaporation and ice cover. These processes are expected to interact to alter the water quality conditions associated with the natural riverine conditions that presently exist. A summary discussion of the processes and their interactions is provided in Peterson and Nichols (1982).

- Water Temperature

During the first summer of filling, the temperature in the Watana reservoir will be essentially a composite of the inflow temperature, increased somewhat by the effects of solar heating. The reservoir will fill very rapidly (to about a 400 foot depth by the end of summer) and the effects of solar heating will not penetrate to the depth at which the outlet is located. Therefore, outlet temperatures during the first summer of filling should be an average of the existing river water temperatures with some lagging with the inflow water temperatures.

During fall, the reservoir will gradually cool to 4°C. Once at this temperature the low level outlet will continue to discharge water at just above 4°C until the reservoir water level has increased to where the fixed cone valves can be used.

Downstream of the Watana development the water temperature will be modified by heat exchange with the atmosphere. The filling sequence will cover two winter periods and the temperature at the downstream end of Devil Canyon will reach 0°C at or about the beginning of November in the first year and toward the end of October in the second. This will have the effect of lagging the downstream temperatures by about 5 weeks from the baseliner. Further downstream, the lagging in temperatures will be reduced as climatic conditions continue to influence the water temperature.

During the second summer of filling, outlet temperatures will be 4°C. Downstream of Watana, the water temperature will increase but, will be well below normal water temperatures.

- Ice

With the delay of freezing water temperatures, the entire ice formation process will occur 3-4 weeks later than for natural conditions. However, due to the lower flows the severity of jams will be diminshed and the staging due to ice will be less than presently experienced. At breakup, the reduced flows in combination with the diminished jamming in the river, will tend to produce a less severe breakup than currently occurs.

- Suspended Sediments/Turbidity/Vertical Illumination

  . Watana Reservoir

  As the reservoir beings to fill, velocities will be reduced and deposition of the larger suspended sediment particles will occur. Initially, all but the larger particles will pass through the reservoir, but with more and more water impounded, smaller diameter particles will settle. As the reservoir approaches normal operating levels, the percentage of particles settling will be similar to that occurring during reservoir operation. However, since during filling, water will be passed through the low level outlet which is at invert elevation 1490 feet, whereas during operation it will be drawn from above elevation 2065 feet, larger particles would be expected to pass through the reservoir during filling than during operation (The deposition process during reservoir operation is discussed in detail in Section 3.2 (c)(iii).).

  During the filling process, reservoir turbidity will decrease in conjunction with the settling of suspended sediments. Turbidity will be highest at the upper end of the reservoir where the Susitna River enters. Turbid interflows and underflows may occur during summer months, depending on the relative densities of the reservoir and river waters. Turbidity levels in the winter are expected to decrease significantly from summer levels, however, turbidity is likely to be greater than pre-project winter levels.

  Vertical illumination in the reservoir will decrease during breakup as flow begins to bring glacial silts into the reservoir. Vertical illumination during the summer will vary, depending on where the river water finds its equilibrium depth (overflow, interflow, or underflow). Data from glacially fed Eklutna Lake indicates that vertical illumination will not exceed 4 meters during the mid-summer months (Figure E.2.80). Vertical illumination will gradually increase during the autumn as glacial input decreases.

  During the filling process additional suspended sediments will be introduced to the reservoir by the slumping of the valley walls and continued construction activities. The slumping of valley walls will provide intermittent quantities of suspended sediments. Although no quantitative estimates of this impact are available, it is anticipated that these impacts will be localized, of short duration, and thus not very significant. However, slumping is expected to continue after operation of the project begins until equilibrium is attained. Construction activities, such as the removal of timber from within the proposed impoundment area are also expected to contribute to increased suspended sediment concentrations and turbidity levels and decreased vertical illumination. Once removed, the lack of soil-stabilizing vegetative cover will likely accelerate wall slumping. However, the increase in suspended sediments due to valley wall slumping will be significantly less the reduction due to the sedimentation process and thus the river will be clearer than under natural conditions.

- Watana to Talkeetna

Maximum particle sizes passing through the project area downstream, will decrease from about 500 microns during pre-project conditions to about 5 microns as filling progresses. As can be observed from the particle size distribution (Figure E.2.36) this results in a retention of about 80 percent of the pre-project suspended sediment at Watana. Because of the clear water tributary inflow in the Watana to Talkeetna reach, further reduction of the suspended sediment concentration will occur as the flow moves downstream. During high tributary flow periods, additional suspended sediment will be added to the river by the tributaries. Talus slides may also contribute to the downstream suspended sediment concentrations. In general, the suspended sediment concentration in the Watana to Talkeetna reach will be reduced by approximately 80 percent during the summer months and slightly increased during the winter months.

Downstream summer turbidity levels will be reduced to an estimated 30-50 NTU. Winter turbidity levels, although not presently quantifiable, will be increased above natural levels of near zero. Because of the reduced turbidity in summer, the vertical illumination will be enhanced. Winter vertical illumination will be reduced.

- Talkeetna to Cook Inlet

In the Talkeetna to Cook Inlet reach, the suspended sediment and turbidity levels during summer will decrease slightly from pre-project levels. The Chulitna River is a major sediment contributor to the Susitna with 28 percent of its drainage area covered by glacier. As such, it will tend to keep the suspended sediment concentrations high during summer. Therefore, the summer character of this reach will not change significantly.

- Dissolved Oxygen

Initially, during the 3-year filling process, the reservoir D.O. levels should approximate riverine conditions. As filling progresses, some weak stratification may begin to develop, but no substantial decreases in dissolved oxygen levels are anticipated. The volume of freshwater inflow, the effects of wind and waves, and the location of the outlet structure at the bottom of the reservoir are expected to keep the reservoir fairly well mixed, thereby replenishing oxygen levels in the hypolimnion.

No significant biochemical oxygen demand is anticipated. The timber in the reservoir area will be cleared, thereby eliminating the associated oxygen demand that would be created by the inundation and decomposition of this vegetation. Further, the chemical oxygen demand (COD) in the Susitna River is quite low. COD levels measured upstream at Vee Canyon during 1980 and 1981, averaged 16 mg/l.

No significant BOD loading is expected from the construction camp and village.

As previously noted, a low level outlet will be utilized for discharging water. Therefore, the levels of oxygen immediately downstream of the outlet could be slightly reduced. However, pre-project values will be established within a short distance downstream of the outlet due to reaeration enhanced by the turbulent nature of the river.

- Nitrogen Supersaturation

Nitrogen supersaturation of water below a dam is possible in certain seasons, extending a considerable distance downstream. The detrimental impact of nitrogen supersaturation is its lethal effect on fish. If dissolved gases reach lethal levels of supersaturation, a fish kill due to gas embolisms may result for miles downstream of an impoundment (Turkheim, 1975).

Nitrogen supersaturation can be caused by passing water over a high spillway into a deep plunge pool. The factors influencing this phenomenon include the depth of the plunge pool, the height of the spillway and the amount of water being spilled. Since all flow will be passed through the low level diversion tunnel and no spilling of water will occur at the Watana damsite, this problem will not exist during filling.

- Nutrients

Two opposing factors will affect nutrient concentrations during the filling process. First, initial inundation will likely cause an increase in nutrient concentrations.

Second, sedimentation will strip some nutrients from the water column. The magnitude of net change in nutrient concentrations is unknown, but it is likely that nutrient concentrations will increase for at least a short-term during filling.

- Other

No significant changes in any other water quality parameters are anticipated.

(v) Effects on Groundwater Conditions

- Mainstem

Alluvial gravels in the river and tributary bottoms will be inundated. No significant aquifers are known to be in the reservoir area, other than the unconfined aquifers at the relic channel and in valley bottoms.

Summer releases from the reservoir during filling are discussed in Section 3.2(b)(i). As a result of the decreased summer flows, water levels will be reduced, especially above Talkeetna. This will in turn cause a reduction in groundwater levels downstream but the groundwater level changes will be confined to the river floodplain area. The groundwater table will be reduced by about 2 feet in summer near the shoreline with less change occurring with distance away from the river.

A similar process will occur downstream of Talkeetna, but the changes in groundwater levels will be of less magnitude due to the decreased effect on river stages.

- Impacts on Sloughs

The reduced mainstem flows and subsequently lower Susitna River water levels will reduce the water level gradient between the mainstem and the sloughs. At locations where slough upwelling is unaffected by mainstem backwater effects, the reduced gradient will result in reduced slough upwelling rates. However, an analysis of mainstem water elevations at the decreased flow rate and the slough upwelling elevations, indicates a continued positive flow toward these upwelling areas with the exception that the intersection of the slough and the groundwater table will move downstream. Data to confirm the areal extent of upwelling at low flows is unavailable at this time.

The thalweg profile in slough 9 and computed mainstem water surface profiles in the vicinity of Slough 9 are illustrated in Figure E.2.81. The thalweg profile taken at right angles to the mainstem flow together with the mainstem water levels show that upwelling will continue at lower mainstem flows. (The water surface profiles which were computed using HEC-2 are sufficiently accurate to illustrate the relationship). It should also be noted that the groundwater driving head is more in an upstream-downstream direction than in a direction perpendicular to the mainstem. This can in general be attributed to the location of most sloughs at natural bends in the river. The distance from the mainstem at the head end of the sloughs to the mainstem at the mouth of the sloughs is usually shorter through the sloughs than along the mainstem.

At the slough upwelling locations which are affected by the mainstem backwater, the groundwater gradient between mainstem and slough is relatively unaffected by discharge until backwater effects are no longer present at the upwelling location. (As the mainstem water level decreases at the head end of the slough, there is a corresponding decrease in mainstem water level at the mouth of the slough where the backwater is controlled. Therefore, the gradient between the mainstem water level upstream and the backwater elevation in the slough is essentially unchanged.) Hence upwelling rates in backwater areas would remain virtually unchanged until the area is no longer affected by backwater. At that time the upwelling would behave as discussed above.

Under ice conditions the mainstem water levels increase, resulting in an increased head differential between mainstem and slough, and increased upwelling in the sloughs. Under reservoir filling conditions during winter, discharge will be reduced to about 1000 cfs at Gold Creek during the freeze-up period. This will result in reduced staging from pre-project ice staging levels. Hence, during winter, the mainstem- slough water level differential will be reduced with a corresponding reduction in upwelling area.

In summary, based on available information to date, upwelling in sloughs will continue but at an equal or slightly reduced rate from the natural rate. Additionally, the upper ends of some sloughs may be dewatered because of the lower groundwater table associated with the decrease in mainstem water levels.

(vi) Impacts on Lakes and Streams

Several tundra lakes will be inundated as the reservoir approaches full pool. The mouths of tributary streams entering the reservoir will be inundated for several miles (Sec. 2.4 (b)). Bedload and suspended sediment carried by these streams will be deposited at or near the new mouths of the streams as the river mouths move upstream during the filling process. No significant impacts to Tsusena or Deadman Creeks are anticipated from their use as water supply and waste recipient, respectively.

(vii) Effects on Instream Flow Uses

- Fishery Resources, Riparian Vegetation, and Wildlife Habitat

Impacts on fishery resources, riparian vegetation and wildlife habitat during the filling process are discussed more fully in Chapter 3. As summer flows are reduced, fish access to slough habitats will be decreased. Since temperatures of upwelling groundwater in sloughs are expected to be unchanged and upwelling should continue at most locations, though possibly at a reduced rate, impacts on the incubation of salmonid eggs are not expected to be severe.

- Navigation and Transportation

Once impoundment of the reservoir commences, the character of the river immediately upstream of the dam will change from a fast-flowing river with numerous rapids to a still-water reservoir. The reservoir will ultimately extend 54 miles upstream, just downstream of the confluence with the Tyone River, and will inundate the major rapids at Vee Canyon when the reservoir reaches full pool. The reservoir will allow increased boat traffic to this reach of river by decreasing the navigational difficulties.

The reduced summer flows released from the reservoir during filling could reduce the navigation difficulties between Watana and Devil Canyon during the summer months. However, the lower segment of this reach from Devil Creek to Devil Canyon will still consist of heavy white-water rapids suitable only for expert kayakers.

Navigational difficulties between Devil Canyon and the confluence with the Chulitna River will be increased due to shallower water and a somewhat constricted channel. Although there will be sufficient depth in the river to navigate it, greater care will be required to avoid grounding. There will be less floating debris in this reach of the river, which will reduce the navigational danger somewhat.

There will be little impact on navigation below the confluence of the Chulitna River. The Susitna River is highly braided from Talkeetna to Cook Inlet with numerous channels which can change rapidly due to the high bedload movement and readily erodible bed material. Navigation can be difficult at present and knowledge of the river is beneficial at low flows. The reduced summer flows from the Susitna River will be somewhat compensated for by the high flows from other tributaries. No impacts near the existing boat access points of Susitna Landing, Kaskwitna River or Willow Creek have been identified. Minor restrictions on navigation may occur at the upstream access to Alexander Slough, but this would occur only in low streamflow years when the other tributaries also have low flow.

- Recreation

Information on recreation can be found in Chapter 7.

- Waste Assimilative Capacity

The previously noted, reductions to downstream summer flows could result in a slight reduction in the waste assimilative capacity of the river. However, no significant impact is anticipated given the limited sources of waste loading on the river (see Section 3.2(a)(ii)).

- Freshwater Recruitment to Estuaries

During filling, under average flow conditions, the mean annual freshwater inflow to Cook Inlet will be reduced by about 12 percent. This will cause a few parts per thousand increase in the natural salinity conditions. However, the salinity change would still be within the range of normal variation. If filling were to take place during an average hydrologic sequence, then the annual freshwater input to Cook Inlet would still be greater than the existing annual flows into Cook Inlet 15 percent of the time.

During a dry flow sequence, the downstream flow requirements at Gold Creek would be maintained. Thus, a smaller percentage of the Gold Creek flow is available for storage. Consequently the percent reduction in fresh water inflow into Cook Inlet is less for a sequence of dry years than for average conditions.

The higher Cook Inlet salinities will last only until project operation, at which time a new equilibrium wil be established as described in Section 3.2(c)(v).

(c) Watana Operation

(i) Flows

- Project Operation

Watana will be operated in a storage-and-release mode, such that summer flows will be captured for release in winter. Generally, the Watana reservoir will be at or near its normal maximum operating level of 2185 feet each year at the end of September. Gradually the reservoir will be drawn down to meet winter energy demand. In early May, the reservoir will reach its minimum annual level and then begin to refill from the spring melt. Flow in excess of both the downstream flow requirements and power needs will be stored during the summer until the reservoir reaches the normal maximum operating level of 2185 feet. Once the reservoir is at this elevation, flow above that required for power will be wasted. After the threat of significant flooding has passed in late August, the reservoir will be allowed to surcharge to 2190 feet to minimize wasting of water in late august and September. Then, at the end of September, the annual cycle will be repeated.

. Minimum Downstream Target Flows

During project operation, minimum Gold Creek target flows from May through September will be unchanged from those during reservoir impoundment except that flows from October to April will be maintained at or above 5,000 cfs. It should be noted that these flows are minimum target flows. In reality, project operation flows will normally be greater than the targeted minimum flows during winter. During May, June, July and October, operational flows will also normally be greater than the minimums. The late July, August, and September flows will probably coincide very closely with the minimum requirements. The minimum target flows during operation are shown in Table E.2.17.

If during summer, the natural flows fall below the Gold Creek minimum target, then these flows will be augmented to maintain the downstream flow requirement.

. Monthly Energy Simulations

A monthly energy simulation program was run using the 32 years of Watana synthesized flow data given in Table E2.2 except that the extreme drought (recurrence interval greater than one in 500 years) which occurred in water year 1969, dominated the analysis and was therefore modified to reflect a drought with recurrence interval of one in 32 years for energy planning and drawdown optimization. Energy production was optimized, taking into account the reservoir operating criteria and the downstream flow requirements. The energy simulation program is discussed in Volume 4, Appendix A of the Feasibility Study (Acres, 1982).

Monthly maximum ,minimum,and median Watana reservoir levels for the 32 year simulation are illustrated in Figure E.2.82.

- Daily Operation

In an effort to stabilize downstream flows, Watana will be operated as a base loaded plant until Devil Canyon is completed. This will produce daily flows that are virtually constant most of the year. During summer it may be economically desirable to vary flow on a daily basis to take advantage of the flow contribution downstream of Watana to meet the flow requirements at Gold Creek. This would yield stable flows at Gold Creek, but somewhat variable river flows between Watana and Portage Creek.

- Mean M~~onthly~~ and Annual Flows

Monthly discharges at Watana for the 32 year period were computed using the monthly energy simulation program and are presented in Table E.2.21. The maximum, mean, and minimum flows for each month are summarized in Table E.2.22. Pre-project flows are also presented for comparison. In general, powerhouse flows from October through April will be much greater than natural flows. For example, in March the operational flows will be eight times greater than natural river flow. Average post project flow for May will be about 30 percent less than the natural flow. Mean daily post project flows during May will be similar for each day of the month. In contrast, existing baseline flows vary considerably from the start of the month to the end of the month due to the timing of the snowmelt. Flows during June, July, August and September will be substantially reduced, to effect reservoir filling.

Pre and post project montly flows at Gold Creek are listed in Tables E2.23 and E2.24. A summary is presented in Table E2.25. The comparison is similar to that for Watana although the pre-project/post-project percentage change is less.

Further downstream at the Sunshine and Susitna Station, gaging station pre-and-post project flow differences will become less significant. During July, average monthly flows will be reduced by eleven percent at Susitna

Station. However, during the winter, flows will be 100 percent greater than existing conditions. Monthly pre- and post-project flows at the Sunshine and Susitna Stations are tabulated in Tables E.2.26 through E.2.29 and summarized in E2.30 and E2.31.

Mean annual flow will remain the same at all stations. However, flow will be redistributed from the summer months to the winter months.

- Floods

  - Spring Floods

    For the 32 years simulated, Watana reservoir had sufficient storage capacity to absorb all floods. The largest flood of record, June 7, 1964, had a peak discharge of 90,700 cfs at Gold Creek, corresponding to an annual flood recurrence interval of better than 20 years. This flood provided the largest mean monthly inflow on record at Gold Creek, 50,580 cfs and contained the largest flood volume on record. However, even with this large a flood, the simulated reservoir level increased only 49 feet from elevation 2089 to elevation 2138. A further 47 feet of storage were available before reservoir spillage would have occurred.

    The flood volume for a May-July once in fifty year flood was determined to be 2.3 million acre feet (R&M, 1981a). This is equivalent to the storage volume contained between elevation 2117 and 2185, neglecting discharge. Since the maximum elevation at the beginning of June was always less than 2117 during the simulation, the 50 year flood volume can be stored without spillage if it occurs in June. Assuming the maximum June 30th water level in the simulation, if the flood event occurs in July, the once in fifty year flood volume can also be accommodated without exceeding Elevation 2185 if the powerhouse discharge averages 10,000 cfs. Thus, for flows up to the once in fifty year spring flood event, Watana reservoir capacity is capable of totally absorbing the flood without spillage.

    Only for flood events greater than the once in fifty year event and after the reservoir elevation reaches 2185.5 feet, will the powerhouse and outlet facilities will be operated to match inflow up to the full operating capacity of the outlet facilities and powerhouse. If inflow continues to be greater than outflow, the reservoir will gradually rise to Elevation 2193. At that time, the main spillway gates will be opened and operated so that the outflow matches the inflow. The main spillway will be able to handle floods up to the once in 10,000-year event. Peak inflow for a once in 10,000-year flood will exceed outflow capacity resulting in a slight increase in water level above 2193 feet. The discharges and water levels associated with a once in 10,000-year flood are shown in Figure E.2.83.

If the probable maximum flood were to occur, the main spillway will be operated to match inflow until the capacity of the spillway is exceeded. The reservoir elevation would rise until it reached Elevation 2200. At this elevation, the erodable dike in the emergency spillway would be eroded and the emergency spillway would operate. The resulting total outflow through all the discharge structures would be 15,000 cfs less than the probable maximum flood (PMF) of 326,000 cfs. The inflow and outflow hydrographs for the PMF are illustrated in Figure E.2.83.

- Summer Floods

For floods occurring in August and September, it is probable that the Watana reservoir could reach Elevation 2185. Design considerations were therefore established to ensure that the powerhouse and outlet facilities will have sufficient capacity to pass the once in fifty year summer flood without operating the main spillway as the resultant nitrogen supersaturation could be detrimental to downstream fisheries. During the flood, the reservoir will be allowed to surcharge to Elevation 2193.

An analysis of the once in fifty year summer flood was carried out assuming that the reservoir was at 2185 feet when the flood commenced. The inflow flood hydrograph at Watana was derived by multiplying the mean annual flood peak at Watana by the ratio of the once in two year summer flood peak at Gold Creek to mean annual flood peak at Gold Creek to obtain the once in two year summer flood peak at Watana. This value was then multiplied by the ratio of the once in fifty year summer flood to the once in two year summer flood at Gold Creek, to obtain the Watana once in fifty year summer flood peak of 64,500 cfs. The August to October dimensionless hydrograph (R&M, 1981a) was next multiplied by the Watana peak flood flow to obtain the inflow hydrograph. The inflow was then routed through the reservoir to obtain the outflow hydrograph. Maximum outflow is the sum of the outlet facility discharge and the powerhouse flows. Flows and associated water levels are illustrated in Figure E.2.83.

If summer floods of lesser magnitude than the fifty year event occur with the reservoir full, inflow will match outflow up to the discharge capability of the outlet facilities and powerhouse.

August floods occurring in the 32 year energy simulation period did not cause the reservoir to exceed elevation 2190 feet. Hence, no spills occurred. The simulation included the August 15, 1967 flood. This flood had an instantaneous peak of 80,200 cfs at Gold Creek and an equivalent return of once in 65 years; thus demonstrating the conservative nature of the above analysis.

Downstream of Watana, flood flows at Gold Creek, will be reduced corresponding to the reduction in flood flow at Watana. Flood peaks at Sunshine and Susitna Station will also be attenuated, but to a lesser extent.

The annual and summer flood frequency curves for Watana are illustrated in Figure E.2.84.

- Flow Variability

Under normal hydrologic conditions, flow from the Watana development will be totally regulated. The downstream flow will be controlled by one of the following criteria: downstream flow requirements, minimum power demand, or reservoir level operating rule curve. There will generally not be significant changes in mean daily flow from one day to the next. However, there can be significant variations in discharge from one season to the next and for the same month from one year to the next.

Monthly and annual flow duration curves based on the monthly average flows for pre-project and post-project operating conditions for the simulation period are illustrated in Figures E.2.85 through E.2.88 for Watana, Gold Creek, Sunshine, and Susitna Station. The flow duration curves show a diminished pre-and-post-project difference with distance downstream of Watana.

(ii) River Morphology

Impacts on river morphology during Watana operation will be similar to those occurring during reservor impoundment (Section 3.2(b)(ii), although flow levels will generally be increased for power operations. The reduction in streamflow peaks, and the trapping of bedload and suspended sediments will continue to significantly reduce morphological changes in the river above the Susitna-Chulitna confluence.

The mainstem river will tend to become tighter and better defined. Channel width reduction by vegetation encroachment will continue.

The effects of ice forces during breakup on the river morphology above the Chulitna River will be effectively eliminated. Although an ice cover could form up to Devil Canyon, the rapid rise in streamflows which causes the initial ice movement at breakup will be eliminated due to the reservoir regulation. Instead of moving downriver and forming ice jams, the ice will thermally degrade. When it does move, it will be in a weakened state and will not cause a significant amount of damage.

Occurrences of the overtopping of the gravel berms at the upstream end of sloughs will be virtually eliminated. Movement of sand and gravel bars will be minimized. Debris jams and beaver dams, which previously were washed out by high flows, will remain in place, with resultant ponding. Vegetation encroachment in the sloughs and side-channels will also be evident as the high flows are reduced.

Impacts at the Chulitna confluence and downstream will be similar to those occurring during reservoir impoundment.

(iii) Water Quality

- Water Temperature

. Reservoir and Outlet Water Temperature

After impoundment, Watana reservoir will exhibit the thermal characteristics of a deep glacial lake. Deep glacial lakes commonly show temperature stratification both during winter and summer (Mathews, 1956; Gilbert, 1973; Pharo and Carmack, 1979, Gustavson, 1975), although stratification is often relatively weak. Bradley Lake, Alaska, (Figure E.2.89) demonstrated a weak thermocline in late July, 1980, but was virtually isothermal by late September, and demonstrated a reverse thermocline during winter months (Corps of Engineers, unpublished data).

The range and seasonal variation in temperature within the Watana reservoir and for a distance downstream will change after impoundment. Bolke and Waddell (1975) noted in an impoundment study that the reservoir not only reduced the range in temperature but also changed the timing of the high and low temperature. This will also be the case for the Susitna River where pre-project temperatures generally range from 0°C to 14°C with the lows occurring from October through April and the highs in July or August. However, to minimize the preproject to post-project temperature differences downstream, Watana will be operated to take advantage of the temperature stratification within the reservoir.

During summer, warmer reservoir water will be withdrawn from the surface through a multiport intake structure (Figure E.2.90). The intake nearest the surface generally will be used. In this way warmer waters will be passed downstream.

When water is released from the epilimnion of a deep reservoir, there is likely to be a warming effect on the stream below the dam (Turkheim, 1975; Baxter and Glaude, 1980). However, given the hydrological and meteorological conditions at Watana, this may not occur.

To provide quantitative predictions of the reservoir temperature behavior and outlet temperatures, reservoir thermal studies were undertaken in 1981 and 1982. To date, detailed studies have been completed for only the open water period. A one dimensional computer model, DYRESM, was used to determine the thermal regime of the Watana reservoir and the outlet temperatures.

Temperature profiles were simulated for the June through October time period using 1981 field data. Monthly reservoir temperature profiles and the mean daily inflow and outlet water temperatures are illustrated in Figures E.2.91 and E.2.92. The maximum reservoir temperature simulated was 10.4°C and occurred in early August. This is less than the maximum recorded inflow temperature of 13°C. Although there is an initial lag in outflow temperatures in early June, it is possible to reasonably match inflow temperatures from late June to mid-September. Thus, the summer outlet temperatures from Watana will have no impact on the downstream fishery resource.

In late September the natural water temperature falls to near zero degrees. Because of the large quantity of heat stored in the reservoir, it is not possible to match these natural temperatures. The lowest outlet temperature that could be obtained is 4°C with the use of a lower level outlet.

From September through November, reservoir water temperatures will gradually decrease until an ice cover is developed in late November or December. During the ice cover formation process and throughout the winter, outflow temperatures will be between 0°C and 4°C but, most likely the low temperature will be 1°C or greater. This range of outflow temperature (1°C to 4°C) can be obtained by selectively withdrawing water of the desired temperature from the appropriate port within the intake structure. Thus, when the optimum temperature, between approximately 1°C and 4°C, has been determined, the reservoir will be operated to match that temperature as closely as possible.

- Downstream Mainstem Water Temperatures

In winter, the outflow temperature will initially decrease as reservoir heat is exchanged with the cold atmosphere. The downstream temperatures were investigated with a constant 4°C outflow and also with a temperature of 4°C up to October 15 and decreasing linearly to 1°C by January 1. This sort of analysis brackets the expected temperature regime during Watana operation.

At the downstream end of Devil Canyon, the temperatures would be in the range of 1.5° to 0°C by about the first week in January. This would place the upstream edge of 0°C water somewhere between Sherman and Portage Creek by about the middle of January. This regime would continue through the remainder of the winter until about April when the net heat exchange again becomes positive.

During summer, outlet water temperatures will approximate existing baseline water temperatures. Downstream water temperatures will essentially be unchanged from existing water temperature. For example, at Gold Creek maximum June water temperatures will approximate 13°C. Through July, temperatures will vary from 10°C to 12°C and through mid-August temperatures will remain at about 10°C. About mid-August, temperatures will begin to decrease.

- Slough Water Temperatures

Preliminary investigations show that ground water upwelling temperatures in sloughs reflect the long term water temperature of the Susitna River. Downstream of Devil Canyon, the long term average is not expected to change significantly.

Post-project summer Susitna River water temperatures downstream of Portage Creek will be similar to existing temperatures. Fall temperatures will be slightly warmer but should fall to 0°C by January and will remain at 0°C until temperatures begin to warm. In spring, however, water temperatures should remain cooler longer. This will counteract the warmer fall temperatures and result in the average annual water temperature remaining close to existing conditions in the Talkeetna to Devil Canyon reach.

- Ice

The delayed occurrence of 0°C water in the reach below Devil Canyon will tend to delay the formation of an ice cover significantly. Since 75-80% of the ice supply below Talkeetna is currently from the Susitna River, the formation of the cover will be delayed until about December and ice front progression above the confluence starting in late December or early January. Depending on the water temperatures upstream, the ice cover will progress to a point between Sherman and Portage Creek. Staging will range from about 4 ft at Talkeetna to about 3 ft at Sherman. The more likely occurrence is an ice cover to Portage Creek.

During breakup, the cover will tend to thermally erode from both downstream and upstream. The downstream erosion will be similar to existing conditions while the upstream will be due to the warm water supplied by the reservoir as well as the positive net atmospheric heat exchange. Due to the lower flows, the breakup of the ice cover will be less severe than the baseline case.

- Suspended Sediments

As the sediment laden Susitna River enters the Watana reservoir, the river velocity will decrease and the larger diameter suspended sediments will settle out to form a delta at the upstream end of the reservoir. The delta formation will be constantly adjusting to the changing reservoir water level. Sediment will pass through channels in the delta to be deposited over the lip of the delta. Depending on the relative densities of the reservoir water and the river water, the river water containing the finer unsettled suspended sediments will either enter the lake as overflow (surface current), interflow, or underflow (turbidity current).

Trap efficiency estimates using generalized trap efficiency envelope curves developed by Brune (1953) indicate 90-100 percent of the incoming sediment would be trapped in a reservoir the size of Watana Reservoir. However, sedimentation studies at glacial lakes indicate that the Brune curve may not be appropriate for Watana. These studies have shown that the fine glacial sediment may pass through the reservoir. Indeed, glacial lakes immediately below glaciers have been reported to have trap efficiencies of 70-75 percent. Kamloops Lake, British Columbia, a deep glacial lake on the Thompson River, retains an estimated 66 percent of the incoming sediment (Pharo and Carmack, 1979).

Particle diameters of 3-4 microns have been estimated to be the approximate maximum size of the sediment particles that will pass through the Watana reservoir (Peratrovich, Nottingham & Drage, 1982). By examining the particle size distribution curve (Figure E2.36), it is estimated that about 80 percent of the incoming sediment will be trapped.

For an engineering estimate of the time it would take to fill the reservoir with sediment, a conservative assumption of a 100 percent trap efficiency can be made. This results in 472,500 ac-ft. of sediment being deposited after 100 years (R&M, 1982d) and is equivalent to 5 percent of total reservoir volume and 12.6 percent of the live storage. Thus, sediment deposition will not affect the operation of Watana reservoir.

In the Watana reservoir, it is expected that wind mixing will be significant in retaining particles less than 12 microns in suspension in the upper 50-foot water layer (Peratrovich, Nottingham & Drage, 1982). Re-entrainment of sediment from the shallow depths along the reservoir boundary during high winds will result in short-term high turbidity levels. This will be particularly important during the summer refilling process when water levels will rise, resubmerging sediment deposited along the shoreline during the previous winter drawdown period.

Slumping will occur for a number of years until the valley walls attain stability. This process will cause locally increased suspended sediment and turbidity levels. Sediment suspended during this process are expected to be silts and clays. Because of their small size these particles may stay in suspension for a long period of time. Nonetheless, during summer, the levels of suspended sediments and turbidity should remain on the order of five times less than during pre-project riverine conditions. If slumping occurs during winter, increases in suspended sediment concentrations over natural conditions will occur. Since cold ambient air temperatures during the winter will freeze the valley walls, the number of slides will be reduced and impacts should be minor.

Suspended sediment concentrations downstream will be similar to that discussed in Section 3.2(b), (iv) except that maximum particle sizes leaving the reservoir will be 3-4 microns.

- Turbidity

Turbidity patterns may have an impact on fisheries, both in the reservoir and downstream. Turbidity in the top 100 feet of the reservoir is of primary interest. The turbidity pattern is a function of the thermal structure, wind mixing and reentrainment along the reservoir boundaries. Turbidity patterns observed within Eklutna Lake, a lake 30 miles north of Anchorage, may provide the best available physical model of turbidity within Watana Reservoir. Although it is only one tenth the size of the Watana Reservoir, its morphometric characteristics are similar to Watana. It is 7 miles long, 200 feet deep, has a surface area of 3,420 acres, and has a total storage of about 414,000 ac-ft. Bulk annual residence time is 1.77 years, compared to Watana's 1.65 years. It also has 5.2 percent of its basin covered by glaciers, compared to 5.9 percent of Watana's drainage area. Consequently, it is believed that turbidity patterns in the two bodies of water will be somewhat similar.

Data collected at Eklutna from March through October 1982 demonstrates the expected pattern at Watana. In March, turbidity beneath the ice cover was uniformly less than 10 NTU in the lower end of the lake near the intake to the Eklutna hydroelectric plant. Shortly after the ice melted in late May, but before significant glacial melt had commenced, turbidity remained at 7-10 NTU throughout the water column. By mid-June, the turbidity had risen to 14-21 NTU, but no distinct turbidity plume was evident. It is believed the lake had recently completed its spring overturn, as a warming trend was evident only in the upper 3 meters. By early July a slight increase in turbidity was noted at the lake bottom near the river inlet. Distinct turbidity plumes were evident as interflows in the upstream end of the lake from late July through mid-September. Turbidity levels had significantly decreased by the time the plume had traveled 5 miles down the lake, as sediment was deposited in the lake. In late September, a turbid layer was noted on the bottom of the lake as river water entered as underflow. By mid-October, the lake was in its fall overturn period, with near-uniform temperatures and turbidity at about 7°C and 30-35 NTU, respectively.

In Kamloops Lake, B.C., thermal stratification of the lake tended to "short-circuit" the river plumes especially during periods of high flow (St. John et at., 1976). The turbid plume was confined to the surface layers, resulting in a relatively short residence time of the river water during summer. St. John et al. (1976) noted that high turbidity values extended almost the entire length of Kamloops Lake during the summer, suggesting that the effects of dilution and particle settling were minimal due to the thermocline at 10°-6°C effectively separating the high turbidity waters in the upper layers of the lake from highly transparent hypolimmion waters. This was not apparent in the Eklutna Lake data. Plumes were evident up to 5 miles down the lake, but they were below the thermocline. In addition, particle settling and dilution were evident, as turbidity continually decreased down the length of the lake.

The relatively cool, cloudy climate in southcentral Alaska would tend to prevent a sharp thermocline from developing, so that the processes evident in Kamloops Lake would not be expected in Eklutna Lake, nor will they be expected in the Watana reservoir.

- <u>Total Dissolved Solids, Conductivity, Alkalinity, Significant Ions and Metals</u>

The leaching process, as previously identified in Section 3.2.(a)(ii), is expected to result in increased levels of the above parameters within the reservoir immediately after impoundment. The magnitude of these changes cannot be quantified, but should not be significant (Peterson, 1982). Furthermore, Baxter and Glaude (1980) have found such effects are temporary and diminish with time.

The effects will diminish for two reasons: First, the most soluable elements will dissolve into the water rather quickly and the rate of leachate production will decrease with time. Second, much of the inorganic sediment carried by the Susitna River will settle in the Watana Reservoir. The formation of an inorganic sediment blanket on the reservoir bed will retard leaching (Peterson and Nichols, 1982).

The effects of the leaching process should not be reflected in the river below the dam since the leachate is expected to be confined to a small layer of water immediately adjacent to the reservoir floor and the intake structures will be near the surface.

Due to the large surface area of the proposed impoundment, evaporation will be substantially increased over existing conditions. The annual average evaporation rate for May through September at Watana is estimated at 10.0 inches or 0.3 percent of the reservoir volume (Peterson and Nichols, 1982). During evaporation, slightly higher concentrations of dissolved substances have been found at the surface of impoundments (Love, 1961; Symons, 1969). Neglecting precipitation which would negate the effects of evaporation, the potential increase of less than one percent is not considered significant (Peterson and Nichols, 1982).

Dissolved solid concentrations are expected to increase near the surface of the impoundment during winter. Mortimer (1941,1942) noted that the formation of ice at the reservoir surface forces dissolved solids out of the freezing water, thereby increasing concentrations of these solids at the top of the reservoir. No significant impacts should result either in the reservoir or downstream of the dam.

Precipitation of metals such as iron, manganese and other trace elements have been noticed in reservoirs resulting in reduced concentrations of these elements (Neal, 1967). Oligotrophic reservoirs with high pH and high dissolved salt concentrations generally precipitate more metal than reservoirs with low pH and low dissolved salt concentrations. This is attributed to the dissolved salts reacting with the metal ions and subsequently settling out (Peterson and Nichols, 1982). Average Susitna River conductivity values for Vee Canyon and Gold Creek during winter are 70 and 125 umhos/cm at 25°C, respectively. For summer they are somewhat lower, 45 umhos/cm at 25°C for both stations. Values for pH range between 7.3 and 7.6 for the two stations. Although neither of the parameters were high, some precipitation of metals is expected to reduce the quantities suspended in the reservoir.

- Dissolved Oxygen

Susitna River inflow will continue to have both high dissolved oxygen concentrations and high percentage saturations. The oxygen demand entering the reservoir should continue to remain low. No man-made sources of oxygen demanding effluent exist upstream of the impoundment. Chemical oxygen demand (COD) measurements at Vee Canyon during 1980 and 1981 were quite low, averaging 16 mg/l. No biochemical oxygen demand values were recorded.

Wastewater from the permanent town will not contribute an oxygen demand of any significance to the reservoir. All wastewater will be treated to avoid effluent related problems.

The trees within the inundated area will have been cleared, removing the potential BOD they would have created. The layer of organic matter at the reservoir bottom will still remain and could create some short term localized oxygen depletion. However, the process of decomposition should be very slow due to the cold temperatures.

The weak stratification of the reservoir may cause the oxygen levels in the hypolimnion to diminish due to lack of oxygen replenishment. The spring turnover, with its large inflow of water, will cause mixing; however, the depth to which this mixing will occur is unknown. As a result, the hypolimnion could experience reduced oxygen levels. The upper 200 feet of the impoundment should maintain high D.O. due to river inflow and continual mixing.

Downstream of the dam, no dissolved oxygen changes are anticipated since water will be drawn from the upper layer of the reservoir.

- Nitrogen Supersaturation

As previously noted, nitrogen supersaturation can occur below high-head dams due to spillage. During project operation, specially designed fixed cone valves will be used to discharge spills up to the once in fifty year flood.

- Trophic Effects (Nutrients)

Reservoir trophic status is determined in part by the relative amounts of carbon, silicon, nitrogen and phosphorus present in a system, as well as the quality and quantity of light penetration. The C:Si:N:P ratio indicates which nutrient levels will limit algae productivity. The nutrient which is least abundant will be limiting. On this basis, it was concluded that phosphorus will be the limiting nutrient in the Susitna impoundments. Vollenweider's (1976) model was considered to be the most reliable in determining phosphorus concentrations at the Watana impoundment. However, because the validity of this model is based on phosphorus data from temperate, clear water lakes, predicting trophic status of silt-laden water bodies with reduced light conditions and high inorganic phosphorus levels may overestimate the actual trophic status.

The spring phosphorus concentration in phosphorus limited lakes is considered the best estimate of a lake's trophic status. Bio-available phosphorus is the fraction of the total phosphorus pool which controls algae growth in a particular lake. The measured dissolved orthophosphate concentration at Vee Canyon was considered to be the bio-available fraction in the Susitna River. Accordingly, the average dissolved orthophosphate concentration in June was multiplied by the average annual flow to calculate spring phosphorus supplies. These values were in turn combined with phosphorus values from precipitation and divided by the surface area of the impoundment. The resultant spring phosphorus loading values at Watana were far below the minimum loading levels that would result in anything other than oligotrophic conditions. Likewise, upon incorporating spring loading values into Vollenweider's (1976) phosphorus model, the volumetric spring phosphorus concentration fell into the same range as oligotrophic lakes with similar mean depths, flushing rates, and phosphorus loading values (Peterson and Nichols, 1982).

The aforementioned trophic status predictions depend upon several assumptions that cannot be quantified on the basis of existing information. These assumptions include:

- The C:Si:N:P ratio does not fluctuate to the extent that a nutrient other than phosphorus becomes limiting;

- No appreciable amount of bio-available phosphorus is released from the soil upon filling of the reservoirs;

- Phosphorus loading levels are constant throughout the peak algal growth period;

- June phosphorus concentrations measured at Vee Canyon correspond to the time of peak algal productivity;

- Phosphorus species other than dissolved orthophosphate are not converted to a bio-available form;

- Flushing rates and phosphorus sedimentation rates are constant;

- Phosphorus losses occur only through sedimentation and the outlet; and

- The net loss of phosphorus to sediments is proportional to the amount of phosphorus in each reservoir.

(iv) <u>Effects on Groundwater Conditions</u>

- <u>Mainstem</u>

As a result of the annual water level fluctuation in the reservoir, there will be localized changes in groundwater in the immediate vicinity of the reservoir. Groundwater impacts downstream will be confined to the river area.

- Impacts on Sloughs

During winter, in the Talkeetna to Devil Canyon reach, some sloughs (i.e. those nearer Talkeetna) will be adjacent to an ice covered section of the Susitna River and others will be adjacent to an ice free section. In ice covered sections, the Susitna River will have staged to form the ice cover at project operation flows of about 10,000 cfs. The associated water level will be a few feet above normal winter water levels and will cause increased upwelling in the sloughs because of the increased gradient. The berms at the head end of the sloughs may be overtopped.

A number of sloughs may be adjacent to open water sections of the Susitna River. Since flows will average approximately 10,000 cfs in winter, the associated water level will be less than the existing baseline Susitna River water levels in winter because ice staging under present conditions yields a water level equivalent to an open water discharge that is greater than 20,000 cfs. Hence, it is expected that the winter gradient will be reduced and will result in a decreased upwelling rate in the sloughs.

Duirng summer, the mainstem - slough ground water interaction will be similar to that discussed in Section 3.2 (b)(v), with the exception that operational flows will be greater than the downstream flows during filling and thus upwelling rates will be closer to the natural condition than were the upwelling rates during filling.

(v) Instream Flow Uses

- Fishing Resources, Riparian Vegetation and Wildlife Habitat

Impacts of project operation on the fishery resources, riparian vegetation and wildlife habitat are discussed in Chapter 3.

- Navigation and Transportation

Within the reservoir area, water craft navigation will extend to November because of the delay in ice cover formation. During winter, the reservoir will be available for use by dogsled and snow machine.

Although summer flows will be reduced from natural conditions during project operation, navigation and transportation in the Watana to Talkeetna reach will not be significantly impacted. Flows will be stabilized due to a base-loaded operation. However, because of the reduced water levels, caution will be required in navigating various reaches. There will be less floating debris in this reach of the river, which will reduce the navigational hazards.

During the fall and winter a significant reach of the river downstream of Watana will contain open water. This will allow for a longer boating season but will impede use of the river as a transportation corridor by snow machine or dog sled.

Downstream of Talkeetna, ice formation may be delayed and river stage during freezeup will be increased. This may impede winter transportation across the ice.

- Estuarine Salinity

Salinity changes in Cook Inlet due to project operations were projected through the use of a computer model (Resource Management Associates, 1982). A comparison of the salinity impacts of average project flows with average natural inflow showed that under project operation, the salinity range decreased a maximum of two parts per thousand (ppt) near the mouth of the Susitna River. The change was most notable at the end of winter when post project salinities were 1.5 ppt lower than existing conditions. At the end of September post project salinities were about 0.5 ppt higher than natural salinities because of the reduced summer freshwater inflow. Although there will be seasonal differences in salinity, the post project salinity changes should not have a significant impact.

3.3 - Devil Canyon Development

(a) Watana Operation/Devil Canyon Construction

Construction of the Devil Canyon site is scheduled to begin in 1995. When completed, the Devil Canyon development will consist of a 646 foot high, concrete arch dam, outlet facilities capable of passing 38,500 cfs, a flipbucket spillway with a capacity of 125,000 cfs, an emergency spillway with a capacity of 160,000 cfs, and a 600 MW capacity powerhouse. Further information on the physical features of the Devil Canyon development can be found in Section 7 of Exhibit A.

The Devil Canyon diversion is designed for the 25 year recurrence interval flood. This is because of the degree of regulation provided by Watana.

Any differences in the quantity and quality of the water from existing baseline conditons during the Devil Canyon construction will be primarily due to the presence and operation of the Watana facility. Therefore, the impacts described in Section 3.2(c) will, in most cases, be referred to when discussing the impacts of Devil Canyon construction.

(i) Flows

Operation of Watana will be unchanged during the construction of Devil Canyon. Hence, flows will be as discussed in Section 3.2(c). Mean monthly flows for Watana, Gold Creek, Sunshine, and Susitna Station are illustrated in Tables E.2.21, E.2.24, E.2.27, and E.2.29. Monthly flow duration curves are shown in Figures E.2.85 through E.2.88.

During construction of the diversion tunnel, the flow in the mainstem will be unaffected. Upon completion of the diversion tunnels in 1996, the upstream cofferdam will be closed and flow diverted through the diversion tunnel without any interruption in flow. This action will dewater approximately 1,100 feet of the Susitna River between the upstream and downstream cofferdams.

Because little ice will be generated through the Watana Devil Canyon reach, ponding during winter will be unnecessary at Devil Canyon.

Velocites through the 30 foot diameter tunnel at flows of 10,000 cfs will be 14 feet per second.

The diversion tunnel is designed to pass flood flows up to the once in 25 year summer flood, routed through Watana. The flood frequency curve for Devil Canyon is illustrated in Figure E.2.93. Initially, there is little change in discharge with frequency. This is due to the fact that the

Watana Reservoir can absorb the one in fifty year flood, discharging a maximum of 31,000 cfs (24,000 cfs through the outlet facilities and 7,000 cfs through the powerhouse [assuming minimum energy demand]).

(ii) Water Quality

- Water Temperatures

There will be no detectable difference in water temperatures at Devil Canyon or points downstream from those discussed in Section 3.2(c)(iii) Watana Operation.

- Ice

Ice processes will be unchanged from those discussed in Section 3.2(c)(iii) Watana Operation except that in the event water temperatures are lowered to 0°C upstream of Devil Canyon, any frazil ice produced will be passed through the diversion tunnel.

- Suspended Sediment/Turbidity/Vertical Illumination

Construction of the Devil Canyon facility will have impacts similar to those expected during the Watana construction. Increases in suspended sediments and turbidity are expected during tunnel excavation, placement of the cofferdams, blasting, excavation of gravel from borrow areas, gravel washing, and clearing of vegetation from the reservoir. Any impacts that occur during summer will be minimal compared to pre-Watana baseline conditions. However, stringent construction practices will have to be imposed during the construction of Devil Canyon to prohibit suspended sediments from entering the river and negating the improved water quality, relative to suspended sediments, that will result when Watana becomes operational. During winter, slightly increased suspended sediment concentrations can be expected since particles less than 3-4 microns in diameter will probably pass through the reservoir.

No impoundment of water will occur during the placement and existence of the cofferdam. As a result, no settling of sediments will occur.

Slightly decreased vertical illumination will occur with any increase in turbidity.

- Metals

Similar to Watana construction, disturbances to soils and rock or shorelines and riverbeds will increase dissolved and suspended materials to the river. Although this may result in elevated metal levels within the construction area and downstream, the water quality should not be significantly impaired since substantial concentrations of many metals already exist in the river (Section 2.3(a)).

- Petroleum Contamination

Construction activities at Devil Canyon will increase the potential for contamination of the Susitna River by petroleum products. However, as per the Watana construction, precautions will be taken to ensure this does not happen (Section 3.2(a)ii).

- Concrete Contamination

The potential for concrete contamination of the Susitna River during the construction of the Devil Canyon Dam will be greater than during Watana construction because of the large volume of concrete required. It is estimated that 1.3 million cubic yards of concrete will be used in the construction of the dam. The wastewater associated with the batching of the concrete could, if directly discharged into the river, seriously degrade downstream water quality with subsequent fish mortality. To prevent this, the wastewater will be neutralized and settling ponds will be employed to allow settlement of concrete contaminants prior to the discharge of wastewater to the river.

- Other Parameters

No additional ground water quality impacts are expected from those discussed for the proposed operation of the Watana facility.

(iii) Ground Water

There will be no ground water impacts from Devil Canyon construction other than in the immediate vicinity of the construction site.

(iv) Impact on Lakes and Streams in Impoundment

The perched lake adjacent to the Devil Canyon damsite will be impacted by construction of the saddle dam across the low area on the south bank between the emergency spillway and the main dam. The lake is just west of the downstream toe of the saddle dam and will be drained and partially filled during construcion of the saddle dam.

(v) Instream Flow Uses

The diversion tunnel and cofferdams will block upstream fish movement at the Devil Canyon construction site.

However, the Devil Canyon and Devil Creek rapids, themselves act as natural barriers to most upstream fish movement.

Navigational impacts will be the same as during Watana operation, except that the whitewater rapids at Devil Canyon will be inaccessible because of construction activities.

(vi) Facilities

The construction of the Devil Canyon power project will require the construction, operation and maintenance of support facilities capable of providing the basic needs for a maximum population of 1,900 people (Acres 1982). The facilities, including roads, buildings, utilities, stores, recreation facilities, etc., will be essentially completed during the first three years (1993-1995) of the proposed nine-year construction period. The Devil Canyon construction camp and village will be built using components from the Watana camp. The camp and village will be located approximately 2.5 miles southwest of the Devil Canyon damsite. The location and layout of the camp and village facilities are presented in Plates 70, 71, and 72 of Exhibit F.

- Water Supply and Wastewater Treaatment

The Watana water treatment and wastewater treatment plants will be reduced in size and reutilized at Devil Canyon. As a result, processes identical to those employed at Watana will be used to process the domestic water supply and treat the wastewater.

The water intake has been designed to withdraw a maximum of 775,000 gallons/day to provide for the needs of the support communities, or less than 1 cfs (Acres 1982). Since the source of this supply is the Suistna River no impacts on flows will occur throughout the duration of the camps existence.

The wastewater treatment facility will be sized to handle 500,000 gallons daily. The effluent from this secondary treatment facility will not affect the waste assimilative capacity of the river. The effluent will be discharged approximately 1,000 feet downstream of the intake.

Prior to the completion of the wastewater treatment facility, all wastewater will be chemically treated and stored for future processing by the facility.

The applicant will obtain all the necessary permits for the water supply and waste discharge facilities.

- Construction, Operation and Maintenance

Similar to Watana, the construction, operation and maintenance of the camp and village could cause slight increases in turbidity and suspended sediments in the local drainage basins (i.e., Cheechacko Creek and Jack Long Creek). In addition, there will be a potential for accidental spillage and leakage of petroleum contaminating groundwater and local streams and lakes. Through appropriate preventative techniques, these potential impacts will be minimized.

(b) Watana Operation/Devil Canyon Impoundment

(i) Reservoir Filling

Upon completion of the main dam to a height sufficient to allow ponding above the primary outlet facilities (elevations 930 feet and 1,050 feet), the intake gates will be partially closed to raise the upstream water level from its natural level of about 850 feet. Flow will be maintained at a minimum of 5,000 cfs at Gold Creek if this process occurs between October and April. From May through September, the minimum environmental flows described in Section 3.2(b) will be released (See Table E.2.17).

Once the level rises above the lower level discharge valves, the diversion gates will be permanently closed and flow passed through the fixed cone valves.

Since the storage volume required before operation of the cone valves can commence is less than 76,000 acre feet, the filling process will require about one to four weeks. The reservoir will not be allowed to rise above 1135 feet for approximately one year, while the diversion tunnel is being plugged with concrete.

When the dam is completed, an additional storage volume of one million acre feet will be required to fill the reservoir to its normal operating elevation of 1455 feet. Filling will be accomplished as quickly as possible (currently estimated to be between 5 and 8 weeks) utilizing maximum powerhouse flows at Watana. During filling of Devil Canyon Reservoir, Gold Creek flows will be maintained at or above the minimum target flows depicted in Table E.2.17.

(ii) Flows

Because of the two distinct filling periods, the two-stage impoundment sequence will be several years long, even though the actual time for filling will only be about two months long. Flows during the first stage of filling will be impacted for a short duration.

Between the first stage and second stage of filling, the reservoir will not be allowed to exceed 1135 feet. Thus, the Devil Canyon reservoir will be more or less held at a constant level. Flows along the Susitna will be unchanged from those during Devil Canyon construction (See Section 3.3(a)).

During the second stage of filling, wherein 1,014,000 acre-feet are added to the Devil Canyon reservoir, the Watana reservoir will be lowered about 25 feet if filling occurs during either fall or winter. Although the flow into Devil Canyon will be approximately twice normal power flow from Watana, the impact of increased flow will be minimal in the Devil Canyon-Watana reach because the two sites are close to one another.

Flow downstream of Devil Canyon will be slightly reduced during this filling process. However, the time period will be short and flows will be maintained at or above the minimum target flow at Gold Creek.

Since actual filling times are short and since filling will likely occur in fall or winter, floods are likely to be important only during the time the reservoir is not allowed to increase above 1135 feet. If a flood should occur during this time, the cone valves are designed to pass the once in fifty year design flood of 38,500 cfs.

(iii) Effects on Water Quality

- Water Temperature

The outlet water temperatures from Watana will be unchanged from those of the Watana alone scenario. Because of the rapid filling of the Devil Canyon reservoir, there will be minimal impact on the outlet temperatures at Devil Canyon during both stages of filling.

Between the filling stages, the larger surface area of the reservoir will offer more opportunity for atmospheric heat exchange. However, since the retention time will only be in the order of 4 days, it is expected that little change in water temperature will occur from that experienced under Watana along at the Devil Canyon outlet or downstream.

- Ice

An extensive ice cover is not expected to form on the Devil Canyon reservoir during the period wherein a pool at approximate elevation 1135 is maintained. Additionally, since winter temperatures downstream will not be significantly affected by the pool, ice processes downstream of Devil Canyon will remain the same as during Devil Canyon construction.

- Suspended Sediments/Turbidity/Vertical Illumination

As previously discussed, the Watana reservoir will act as a sediment trap, greatly reducing the quantity of suspended sediment entering the Devil Canyon reservoir. During the filling of Devil Canyon from approximately elevation 1135 feet to full pool, the flow will be increased to the maximum power flow from Watana.

Because of the reduced residence time, this could cause a slight increase in suspended sediment concentrations leaving Watana reservoir. However, Devil Canyon will provide additional settling capability and thus, the net result in suspended sediment concentration downstream of Devil Canyon will not be different from that during operation of Watana alone. Turbidity levels and vertical illumination will remain unchanged from Watana only operation.

Some short-term increases in suspended sediment concentration and turbidity may occur within the Devil Canyon impoundment from slumping of valley walls. However, since the Devil Canyon impoundment area is characterized by a very shallow overburden layer with numerous outcroppings of bedrock, slope instability should not significantly affect turbidity and suspended sediment concentration. A further discussion of slope stability can be found in Appendix K of the Susitna Hydroelectric Project Geotechnical Report (Acres 1981).

- Total Dissolved Solids, Conductivity, Alkalinity, Significant Ions and Metals

Similar to the process occurring during Watana filling, increases in dissolved soilds, conductivity and most of the major ions will likely result from leaching of the impoundment soils and rocks during Devil Canyon filling. However, for initial filling, from elevation 850 to 1135, no significant downstream impacts are foreseen, since it will take only about two weeks to accumulate the 76,000 acre-feet of storage. In such a short time, insignificant leaching would occur which could be detrimental to downstream water quality.

Subsequent to initial filling and for the remainder of the filling process, fixed-cone valves will be utilized for reservoir discharge. Since they will be drawing water from well above the bottom of the impoundment and since the leaching process will be confined to a layer of water near the bottom (Peterson and Nichols, 1982) downstream water quality should not be adversely impacted.

Evaporation at the Devil Canyon reservoir surface will be increased above existing riverine evaporation, but this will be negated by precipitation falling directly on the reservoir. Hence, there will be no impact on total dissolved solid concentration from evaporation.

- Dissolved Oxygen

As previously discussed in Section 3.2(c), (iii) Watana Operation, water entering Devil Canyon will have a high dissolved oxygen concentration and low BOD.

Because of the extremely short residence times, no hypolimentic oxygen depletion is expected to develop during either the one year that the reservoir is held near elevation 1135 feet or the final six weeks of reservoir filling.

Treated wastewater will continue to be discharged downstream of the dam, but the river flow will be more than ample to assimilate any wastes.

- Nitrogen Supersaturation

Nitrogen supersaturation will not be a concern during the filling of Devil Canyon reservoir. During the initial filling to an elevation of no greater than 1135, low level outlets will be employed. No superstauration within the lower level of the reservoir will occur during this two week time frame. Further, there will be no plunging discharge to entrain nitrogen.

During the remainder of the filling sequence, discharge will be via the fixed cone valves. Therefore, no nitrogen superstauration conditions are expected downstream of the dam.

- Support Facilities

No impacts are anticipated during the filling process as the result of the withdrawal of water and the subsequent discharge of the treated wastewater from either the camp or village.

Some localized increases in suspended sediments and turbidity are expected to occur during the dismantling of the camp which may begin at this time. Using the appropriate preventive procedures, any impacts should be minimized.

(iv) Groundwater

No major groundwater impacts are anticipated during the impoundment of Devil Canyon. The increased water level within the reservoir will be confined between bedrock walls. Downstream there may be a slight decrease in water level from reduced flows if fill~~ing~~ oc~~cu~~rs other than in August or the first 3 weeks of September. The associated change in groundwater level will be confined to the immediate area of the riverbank.

(v) Impacts on Lakes and Streams in Impoundment

As the Devil Canyon pool level rises, the mouths of the tributaries entering the reservoir will be inundated for up to 1.6 miles (See Table E.2.11). Sediment transporated by these streams will be deposited at the new stream mouth established when the reservoir is filled.

(vi) Instream Flow Uses

- Fisheries

As Devil Canyon reservoir is filled, additional fishery habitat will become available within the reservoir. However, impacts to fish habitat will occur as tributary mouths become inundated. Further information on reservoir and downstream impacts in Chapter 3.

- Navigation and Transportation

During filling, the rapids upstream of Devil Canyon will be inundated and white water kayaking opportunities will be lost. Since the reservoir will be rising about as much as 8 feet per day during filling, the reservoir will be unsafe for boating. Downstream water levels may be slightly lowered, but this is not expected to affect navigation because of the slight change most likely confined to the winter season.

- Waste Assimilative Capacity

Although flows in the river will be reduced during the two segments of reservoir filling, the waste assimilative capacity of the river will not be affected.

(c) Watana/Devil Canyon Operation

(i) Flows

- Project Operation

When Devil Canyon comes on line, Watana will be operated as a peaking plant and Devil Canyon will be baseloaded. Advantage will be taken of the reservoir storage at Devil Canyon to optimize energy production while at the same time providing the downstream flow requirements.

Each September, the Watana reservoir will be filled to as near the maximum water level of 2190 feet as possible, while still meeting the downstream flow requirements. From October to May the reservoir will be drawn down to approximately elevation 2080 feet, although the reservoir will be allowed to fall to a minimum reservoir level of 2065 feet during dry years. In May, the spring runoff will begin to fill the reservoir.

However, the reservoir will not be allowed to fill above elevation 2185 until late August when the threat of a summer flood will have passed. If September is a wet month, the reservoir will be allowed to fill an additional 5 feet to elevation 2190 because the probability of significant flooding will have passed until the next spring.

From November through the end of July, Devil Canyon will be operated at the normal maximum headpond elevation of 1455 feet to optimize power production. In August, the Devil Canyon reservoir will be allowed to fall to a minimum level of 1405 feet. In this way, much of the August downstream flow requirement at Gold Creek can be met from water coming out of storage at Devil Canyon. This will allow most of the water entering the Watana reservoir to be stored rather than pass through the turbines and produce unsalable energy. In September, the Devil Canyon reservoir will be further lowered if it is not already at its minimum elevation of 1405 feet and if the Watana reservoir is not full. When the downstream flow requirements diminish in October, the Devil Canyon reservoir will be filled to 1455 feet.

- Minimum Downstream Target Flows

The minimum downstream target flows at Gold Creek which controlled the summer operation of Watana alone will be unchanged when Devil Canyon comes on line. Table E.2.17 illustrates these flows (A further explanation is provided in Section 3.2(c)(i)).

. Monthly Energy Simulations

The monthly energy simulation program was run using the 32 years of Watana and Devil Canyon synthesized flow data. Pre-project flow data is presented in Tables E.2.32 and E.2.33. (The development of the Watana and Devil Canyon flow sequences used in the simulation was discussed in Sections 2.1(a) and 3.2(c), (i).)

Monthly maximum, minimum, and median Watana and Devil Canyon reservoir levels for the 32 year simulation are illustrated in Figures E.2.94 and E.2.95.

. Daily Operation

With both Devil Canyon and Watana operating, Watana will operate as a peaking plant since it will discharge directly into the Devil Canyon reservoir where the flow can be regulated. Water levels in Devil Canyon will fluctuate less than one foot on a daily basis due to the peaking operation of Watana. Devil Canyon will operate as a baseloaded plant for the life of the project.

- Mean Monthly and Annual Flows

Monthly Watana, Devil Canyon and Gold Creek flows for the 32 year monthly energy simulation are presented in Tables E.2.34, E.2.35, and E.2.36. The maximum, mean, and minimum flows for each month are summarized and compared to pre-project flows and Watana only post-project flows (where appropriate) in Tables E.2.22, E.2.37, and E.2.25. From October through April, the post-project flows are many times greater than the natural, unregulated flows. Post-project flows during the months of June, July, August, and September are 36, 34, 56, and 79 percent of the average mean monthly pre-project flow at Gold Creek respectively. The reductions represent the flow volume used to fill the Watana reservoir. Variations in mean monthly post-project flows occur but the range is substantially reduced from pre-project flows.

Further downstream, percentage differences between pre- and post-project flows are reduced by tributary inflows. The pre- and post-project monthly flow summaries for Sunshine and Susitna Station are compared in Tables E.2.30 and E.2.31. Monthly post-project flows are presented in Tables E.2.38 and E.2.39. Although summer flows from May through October average about 8 percent less at Susitna station, winter flows are about 100 percent greater than existing conditions.

A comparison of post-project mean monthly flows with Watana operating alone, and with Watana and Devil Canyon both operating shows that although there are some differences, the differences are minor.

- Floods

. Spring Floods

For the 32 years simulated, no flow releases occurred between May and July at either Watana or Devil Canyon. All flow was either absorbed in the Watana reservoir or passed through the respective powerhouses. The June 7, 1964 flood of record with an annual flood recurrence interval of better than 20 years, resulted in a Watana reservoir elevation of 2151 feet at the end of June, an elevation well below the elevation at which flow is released.

The maximum mean monthly discharge at Devil Canyon during the spring flood period was approximately 10,500 cfs. If peak inflow into Devil Canyon reservoir contributed from the drainage area downstream of Watana approached this discharge, flow at Watana would be virtually shut off to maintain a Devil Canyon reservoir level of 1455 feet . Lateral inflow would supply most of the power needs. However, it is unlikely the peak contribution downstream of Watana would be as large as 10,500 cfs. For example, the Gold Creek maximum historical one day peak flow to mean monthly flow ratio for the month of June is 2.05. If it is assumed this is valid for the drainage area between Watana and Devil Canyon, the peak 1 day June inflow during the simulation period would approximate 9300 cfs.

For the once in fifty year flood, the downstream flow with both Watana and Devil Canyon in operation will be similar to the flow with Watana operating alone. The Watana reservoir will be drawn down sufficiently such that the once-in-fifty-year flood volume can be stored within the reservoir if the flood occurs in June. The flow contribution at Devil Canyon for the drainage area between Watana and Devil Canyon would approximate 11,000 cfs. Hence, power needs would be met by running Devil Canyon to near capacity and reducing outflow from Watana as much as possible to prevent flow wastage.

For flood events greater than the once in fifty year event and after Watana reservoir elevation reaches 2185.5, the powerhouse and outlet facilities at both Watana and Devil Canyon will be operated to match inflow up to the full operating capacity of the powerhouse and outlet facilities. If inflow to the Watana reservoir continues to be greater than outflow, the reservoir will gradually rise to elevation 2193. When the reservoir level reaches 2193, the main spillway gates will be opened and operated so that outflow matches inflow. Concurrent with opening the Watana main spillway gates, the main spillway gates at Devil Canyon will be opened such that inflow matches outflow. The main spillways at both Watana and Devil Canyon will have sufficient capacity to pass the one in 10,000 year event. Peak inflow for the one in 10,000 year flood will exceed outflow capacity at Watana resulting in a slight increase above 2193 feet. At Devil Canyon there will be no increase in water level. The discharges and water levels associated with a once in 10,000 year flood for both Watana and Devil Canyon are illustrated in Figures E.2.83 and E.2.96.

If the probable maximum flood (PMF) were to occur, the operation at Watana would be unchanged whether Watana is operating alone or in series with Devil Canyon. The main spillway will be operated to match inflow until the capacity of the spillway is exceeded. At this point, the reservoir elevation would rise until it reached elevation 2200. If the water level exceeds elevation 2200, the erodible dike in the emergency spillway would be washed out and flow would be passed through the emergency spillway. The resulting total outflow through all discharge structures would be 311,000 cfs, 15,000 cfs less than the PMF.

At Devil Canyon a similar scenario would occur. The main spillway would continue to operate, passing the main spillway discharge from Watana. Once the emergency spillway at Watana started operating, the Devil Canyon reservoir would surcharge to 1465 and its emergency spillway would begin to operate. Peak outflow would occur immediately after the fuse plug eroded away. However, the peak is slightly less than the peak inflow. The inflow and outflow hydrographs for both the Watana and Devil Canyon PMF are shown in Figures E.2.83 and E.2.96, respectively.

. Summer Floods

Although there were no flow releases at the Watana site during August or September in the 32 year simulation, in wet years Watana and Devil Canyon may produce more energy than can be used. If this occurs, flow will have to be released through the outlet facilities. However, on a mean monthly basis, the total discharge at Watana will be less than the Watana powerhouse flow capacity of 19,400 cfs. Flow will only be released when the reservoir exceeds elevation 2185.5 feet.

Since Watana was designed to pass the once in fifty year summer flood without requiring operation of the main spillway and since the capacity of the powerhouse and outlet facilities is 31,000 cfs, Watana summer flood flows will vary from a low value equal to the powerhouse flows up to 31,000 cfs for floods with a recurrence interval less than fifty years.

For the once-in-fifty-year summer flood, the Watana discharge will be maintained at 31,000 cfs but the reservoir will surcharge to 2193 feet (refer to Section 3.2(c)(i) for the derivation of the once-in-fifty-year summer flood hydrograph).

At Devil Canyon, design consideration were also established to ensure that the Devil Canyon powerhouse and outlet facilities will have sufficient capacity to pass the once in fifty year summer flood of 39,000 cfs without operating the main spillway as the resultant nitrogen supersaturation could be detrimented to downstream fisheries. This flood is passed through the Devil Canyon reservoir without any change in water level. It includes the 31,000 cfs inflow from the once in fifty year summer flood routed through Watana plus a lateral inflow of 8000 cfs. The lateral inflow of 8000 cfs was obtained by subtracting the once-in-fifty-year Watana natural flood peak from the once-in-fifty-year Devil Canyon natural flood peak.

In the 32 year simulation period there were four years in which flow releases occurred during high summer flow periods. Although the maximum monthly release was only 4100 cfs, the peak flow may vary well have been higher depending on the variability of the tributary inflow downstream of Watana and on the Watana reservoir level. However, the peak Devil Canyon outflow would not have exceeded the capacity of the powerhouse and outlet facilities.

- Flow Variability

As discussed above, at both Watana and Devil Canyon, peak monthly flows may differ from mean monthly flows if the reservoir exceeds elevation 2185.5 at Watana and flow is released. For Devil Canyon, as reservoir inflow from sources other than the Watana Reservoir varies, the peak outflow may also differ from the mean monthly flow.

For the 32 years of simulation, the maximum Devil Canyon discharge in August was 17,900 cfs which included 14,100 cfs from Watana and 3800 cfs from tributary inflow into the Devil Canyon reservoir. In examining flow ratios of one day peaks to mean monthly flow at Gold Creek for the month of August it can be seen that these ratios vary from 1.10 to 2.40. If these ratios can be applied to the tributary inflow, then the peak inflow could have been as high as 9100 cfs. Also, if the Watana powerhouse flow was not constant for the month, then some flow variability could also be attributed to Watana. The net result is a Devil Canyon outflow that could be a constant value for the entire month or a variable outflow that has the same mean value but a peak on the order of 30,000 cfs. The actual variability would depend on the daily inflow hydrograph for Devil Canyon.

The monthly and annual flow duration curves for pre-project and post-project conditions for the 32 year simulation period are illustrated in Figures E.2.97 through E.2.100 for Watana, Gold Creek, Sunshine, and Susitna Station. The flow duration curves show less variability during post-project operations and a diminished pre- and post-project difference with distance downstream of Devil Canyon.

(ii) <u>Effects on Water Quality</u>

- <u>Water Temperatures</u>

The winter time temperatures discharged from Devil Canyon will range from about 4°C to 1°C. The temperature will slowly decrease in the downstream direction because of heat exchange with the colder atmosphere. In January by the time the flow reaches Sherman, a drop in temperature of about 1.3°C will be expected while a drop of about 4°C will occur to Talkeetna. Depending on the outflow temperature, the threshhold of 0°C water will vary from Talkeetna to Sherman. Throughout the winter water temperatures upstream of Sherman will always be above freezing, approaching the outflow temperature as it moves upstream. The minimum temperature expected at Gold Creek will be between 0.5°C and 3°C.

The summer time temperatures will be slightly higher than those for the Watana because of the larger surface area for heat exchange. A peak temperature of about 13°C will be reached at Gold Creek about the middle of June. Through July and the first half of August, the temperatures will ab about 10 to 12°C, slowly decreasing through the latter part of August to the end of September.

- <u>Ice</u>

The initiation of ice formation at Talkeetna will be delayed by several months. The large volume of warm water from upstream will delay and reduce the quantity of ice supplied from the Upper Susitna River. Depending on the reservoir outflow temperatures, the ice cover will start to form by the end of January and progress a short distance upstream through February. The location of the ice front is expected to be between Talkeetna and Sherman. Staging due to the ice cover will be about 3-4 feet.

The breakup in the spring will occur downstream due to warmer climatic conditions and also from the upstream front because of the warmer water from the project. The cover will tend to thermally decay in place. Therefore, the intensity of the breakup should be less severe with fewer ice jams than the preproject occurances.

- <u>Suspended Sediments/Turbidity/Vertical Illumination</u>

Of the suspended sediments passing through the Watana reservoir, only a small percentage is expected to settle in the Devil Canyon reservoir. This is attributable to the small sizes of the particles (less than 3-4 microns in diameter) entering the reservoir and the relatively short retention time. The suspended sediment, turbidity, and vertical illumination levels that occur within the impoundment and downstream wil be only slightly reduced from that which exists at the outflow from Watana.

Some minor slumping of the reservoir walls and resuspension of shoreline sediment will probably continue to occur, especially during August and September when the reservoir may be drawn down as much as 50 feet. These processes will produce short term, localized increases in suspended sediments. However, as previously noted, the overburden layer is shallow so no significant problems will arise. Additionally, since most of this sediment will settle out, downstream increases will be minor.

- Total Dissolved Solids, Conductivity, Alkalinity, Significant Ions and Metals

As previously identified in Section 3.3(b)(iii) the leaching process is expected to result in increased levels of the aforementioned water quality properties. These effects are not expected to diminish as rapidly as was indicated for Watana. Although leaching of the more soluable chemicals will diminish, others will continue to be leached because large quantities of inorganic sediment will not be covering the reservoir bottom. It is, however, anticipated that the leachate will be confined to a layer of water near the impoundment floor and should not degrade the remainder of the reservoir or downstream water quality.

As was the case at Watana, the increased surface area will lead to an increase in the amount of evaporation. However, because of the 2.0 month retention time and the mixing actions of the winds and waves, the concentrations of dissolved substances should virtually be unchanged and no adverse affect on water quality within the reservoir or downstream should occur.

Since no ice cover is anticipated, no increased concentrations of dissolved solids will result at the ice-water interface.

- Dissolved Oxygen

As was previously discussed in Section 3.2 (c)(iii), reduction of dissolved oxygen concentrations can occur in the hypolimnion of deep reservoirs.

Stratification and the slow biochemical decomposition of organic matter will promote low oxygen levels near the reservoir bottom over time. No estimates of the extent of oxygen depletion are available.

Within the upper layers (epilimnion) of the reservoir, dissolved oxygen concentrations will remain high. Inflow water to the impoundment will continue to have a high dissolved oxygen content and low BOD. Since water for energy generation is drawn from the upper layers of the reservoir, no adverse effects to downstream oxygen levels will occur.

- Nitrogen Supersaturation

No supersaturated conditions will occur downstream of the Devil Canyon Dam. Fixed-cone valves will be employed to minimize potential nitrogen supersaturation problems for all floods with a recurrence interval less than one in fifty years.

For flood flows greater than once in fifty year flood when spillage will unavoidably occur, nitrogen supersaturation will be minimized through the installation of spillage deflectors which will prevent the creation of a plunging action that could entrain air.

- Facilities

The construction camp and village will be decommissioned upon completion of construction and filling. Localized increases in turbidity and suspended sediments will occur in the local drainage basins due to these activities, but these effects will not be significant as erosion control measures will be employed.

(iii) Effects on Groundwater Conditions

Effects on ground water conditions will be confined to the Devil Canyon reservoir itself. Downstream flows and hence impacts will be similar to those occurring with Watana operating alone.

(iv) Impact on Lakes and Streams

All the effects identified in Section 3.2(c)(ii) for the streams in the Watana reservoir will be experienced by the streams flowing into the Devil Canyon reservoir listed in Table E.2.11. No lakes in the Devil Canyon impoundment will be impacted other than the previously described small lake at the Devil Canyon damsite. The tributaries downstream of Devil Canyon will not change from the conditions established when Watana was operating alone as discussed earlier.

(v) Instream Flow Uses

The effects on the fishery, wildlife habitat, and riparian vegetation are described in Chapter 3.

- Navigation and Transporation

The Devil Canyon reservoir will transform the heavy whitewater upstream of the dam into flat water. This will afford recreational opportunities for less experienced boaters but totally eliminate the whitewater kayaking opportunities.

Since the Devil Canyon facility will be operated as a base loaded plant, downstream impacts should remain similar to the Watana only operation. The reach of river that remains free of ice may be extended somewhat further downstream.

- Estuarine Salinity

Salinity variations in Cook Inlet were computed using a numerical model of Cook Inlet (Resource Management Associates, 1982). As expected, the salinity changes from baseline conditions were almost identical with those determined for Watana operation alone. The post- project salinity range is reduced, there being lower salinities in winter and higher salinity in summer. Figure E.3.101 illustrates the comparison of annual salinity variation off the mouth of the Susitna River using mean monthly pre- and post-project Susitna Station flows.

3.4 Access Plan Impacts

The Watana access route will begin with the construction of a 2-mile road from the Alaska Railroad at Cantwell, to the junction of the George Parks and Denali Highways. Access will then follow the existing Denali Highway for twenty-one miles. Portions of this road segment will be upgraded to meet standards necessary for the anticipated construction traffic. From the Denali Highway, a 42 mile road will be constructed in a southerly direction to the Watana site.

Access to the Devil Canyon site will be via a 37 mile road from Watana, north of the Susitna River, and a 12 mile railroad extension from Gold Creek, on the south side of the Susitna River. For a more detailed description of the access routes refer to Exhibit A, Section 1.12 and 7.12.

(a) Flows

Flow rates on streams crossed by the access road will not be impacted. However, localized impacts on water levels and flow velocities could occur if crossings are poorly designed. Because they do not restrict streamflow, bridge crossings are preferred to culverts or low-water crossings. Bridge supports should be located outside active channels, if possible.

Where not properly designed, culverts can restrict fish movement due to high velocities or perching of the culvert above the streambed. Culverts are also more susceptible to icing problems, causing restricted drainage, especially during winter snowmelt periods.

Low-water crossings may be used in areas of infrequent, light traffic. They should conform to the local streambed slope and are to be constructed of materials so that water will flow over them instead of percolating through them, which would also restrict fish passage.

(b) Water Quality

Most water quality impacts associated with the proposed access routes will occur during construction. The principal anticipated water quality impacts associated with construction will be increased suspended sediment and turbidity levels and accidental leakage and spillage of petroleum products. Given proper design and construction techniques, few water quality impacts are anticipated from the subsequent use and maintenance of these facilities.

(i) Turbidity and Sedimentation

Some of the more apparent potential sources of turbidity and sedimentation problems include:

- Instream operation of heavy equipment;
- Placement and types of permanent stream crossings (culverts vs. bridges);
- Location of borrow areas;
- Lateral stream transits;
- Vegetative clearing;
- Side hill cuts;
- Disturbances to permafrost; and
- Timing and schedules for construction.

These potential sources of turbidity and sedimentation are discussed more fully in Chapter 3.

(ii) Contamination by Petroleum Products

Contamination of water courses from accidental spills of hazardous materials, namely fuels and oils, is a major concern. During construction of the trans-Alaska oil pipeline, it became apparent that oil spills of various sorts were a greater problem than anticipated. Most spills occurred as a result of equipment repair, refueling and vehicle accidents. When equipment with leaky hydraulic hoses are operated in streams petroleum products are very likely to reach the water. To avoid this, vehicles and equipment will be properly maintained.

Water pumping for dust control, gravel processing, dewatering, and other purposes can also lead to petroleum spills if proper care is not taken. Since water pumps are usually placed on river or lake banks very near the water, poor refueling practices could result in frequent oil spills into the water.

3.5 Transmission Corridor Impacts

The transmission line can be divided into 4 segments: central (Watana to Gold Creek), intertie (Wilow to Healy), northern (Healy to Ester), and southern (Willow to Anchorage).

The central segment is composed of two sections: Watana to Cheechako Creek and Cheechako Creek to Gold Creek. Construction of the portion from the Watana damsite to Cheechako Creek will be undertaken during winter with minimal disturbance to vegetation. Hence, impact on stream flow and water quality should be minimal. From Cheechako Creek to the intertie, the transmission corridor will follow the existing trail. This should also result in minimal impacts.

The Willow-Healy intertie is being built as a separate project and will be completed in 1984 (Commonwealth Associates, 1982). The Susitna project will add another line of towers within the same right-of-way. The impacts, then, will be similar to those experienced during intertie construction. The existing access points and construction trails will be utilized. The Environmental Assessment Report for the intertie (Commonwealth Associates, 1982) discusses the expected environmental impacts of transmission line construction in this segment.

For construction of the north and south stubs, stream crossings will be required. The potential effects will be of the same type as those discussed in Section 3.4, although generally much less severe because of the limited access needed to construct a transmission line. Erosion related problems can be caused by stream crossings vegetative clearing, siting of transmission towers, locations and methods of access, and disturbances to the permafrost. However, given proper design and construction practices, few erosion related problems are anticipated.

Contamination of local waters from accidental spills of fuels and oils is another potential water quality impact. To minimize this potential, vehicles will be properly maintained and appropriate refueling practices will be required.

Once the transmission line has been built, there should be very few impacts associated with routine inspection and maintenance of towers and lines.

Some localized temporary sedimentation and turbidity problems could occur when maintenance vehicles are required to cross wetlands and streams to repair damaged lines or towers. Permanent roads will not be built in conjunction with transmission lines. Rather, grasses and shrubs will be allowed to grow along the transmission corridor but will be kept trimmed so that vehicles are able to follow the right-of-way associated with the lines. Streams may need to be forded, sometimes repeatedly, in order to effect repairs. Depending on the season, crossing location, type and frequency of vehicle traffic, this could cause erosion downstream reaches.

4 - AGENCY CONCERNS AND RECOMMENDATIONS

Throughout the past three years, state and federal resource agencies have been consulted. Numerous water quantity and quality concerns were raised. The issues identified have been emphasized in this report. Some of the major topics include:

- Flow regimes during filling and operation;
- Reservoir and downstream thermal regime;
- Sedimentation process in the reservoir and downstream suspended sediment levels and turbidity;
- Nitrogen supersaturation downstream of the dams;
- Winter ice regime;
- Trophic status of the reservoirs;
- Dissolved oxygen levels in the reservoir and downstream;
- Downstream ground water and water table impacts;
- Effects on instream flow uses;
- Sediment and turbidity increases during construction;
- Potential contamination from accidental petroleum spills and leakage; and
- Wastewater discharge from the temporary community.

A thorough and complete compliment of agency concerns and recommendations will be presented pursuant to the review of this draft license application.

5 - MITIGATION, ENHANCEMENT, AND PROTECTIVE MEASURES

5.1 - Introduction

Mitigation measures were developed to protect, maintain, or enhance the the water quality and quantity of the Susitna River. These measures were developed primarily to avoid or minimize impacts to aquatic habitats, but they will also have a beneficial effect on other instream flow uses.

The first phase of the mitigation process identified water quality and quantity impacts from construction, filling and operation, and incorporated mitigative measures in the preconstruction planning, design, and scheduling. Three key mitigation measures were incorporated into the engineering design: (1) Minimum flow requirements were selected during the salmon spawning season that were greater than what would be discharged if flow was selected solely from an optimum economic point of view. (2) A multilevel intake was added to improve temperature control and minimize project effects. (3) Fixed-cone valves were incorporated to prevent nitrogen supersaturation from occurring more frequently than once in fifty years. Other mitigation measures incorporated in the project design and construction procedures are discussed below.

The second phase of the mitigation process will be the implementation of environmentally sound construction practices during the construction planning process. This will involve the education of project personnel to the proper techniques needed to minimize impacts to aquatic habitats. Monitoring of construction practices will be required to identify and correct construction related problems. Upon completion of construction, the third phase of mitigation consists of operational monitoring and surveillance to identify problems and employ corrective measures.

5.2 - Construction

The mitigation, enhancement, and protective measures included in Chapter 3.2.4(a) are appropriate for construction of the Watana and Devil Canyon facilities; the access road construction; and the transmission line construction.

5.3 - Mitigation of Watana Impoundment Impacts

The primary concerns during filling of the reservoir discussed in Section 3 of this chapter include:

- Maintenance of minimum downstream flows;
- Maintenance of an acceptable downstream thermal regime throughout the year;
- Changes in downstream sediment loads, deposition and flushing;

- Downstream gas supersaturation;
- Eutrophication processes and trophic status; and
- Effects on ground water levels and ground water upwelling rates.

Minimum downstream flows, will be provided to mitigate the impact the filling of the reservoir could have on downstream fish and other instream flow uses. Although access may be difficult, the 12,000 cfs flow at Gold Creek in August will provide spawning salmon access to most of the sloughs between Devil Canyon and Talkeetna. Additionally, the selected downstream flow of 12,000 cfs will assist in maintaining adequate ground water levels and upwelling rates in the sloughs.

Eutrophication was determined not be a problem and therefore no mitigation is required.

Downstream gas supersaturation will be prevented by the design of the energy disipating valves and chambers incorporated in the emergency release outlet.

Changes in the downstream river morphology will occur but are not expected to be significant enough to warrant mitigation except for the mouth of some tributaries between Devil Canyon and Talkeetna where selective reshaping of the mouth may be required to insure salmon access.

From the first winter of filling to the commencement of project operation, the water temperature at the Watana low level outlet will approximate 4°C to 5°C. Although these temperatures will be moderated somewhat downstream, downstream impacts are likely to occur. No mitigation measures have been incorporated in the design to offset these low downstream temperatures during the second and third year of the filling process. If during the final design phase of the project a technically acceptable cost-effective method can be developed to mitigate this potential temperature impact, it will be incorporated into the final designs.

5.4 - Mitigation of Watana Operation Impacts

The primary concerns during Watana operation are identified in Section 5.3.

(a) Flows

The minimum downstream flows at Gold Creek will be unchanged from those provided during impoundment from May through September. However, for October through April, the minimum flow at Gold Creek will be increased to 5000 cfs.

These mininum flows are not the most attractive from a project economic point of view. However, they do provide a base flow of sufficient magnitude that permits the development of mitigation measures to substantially reduce the project's impact on the downstream fishery. Hence, the minimum downstream flows will provide a balance between power generation and downstream flow requirements.

To provide stable flows downstream and minimize the potential for downstream ice jams, Watana when it is operating alone will be operated primarily as a base loaded plant, even though it would be desirable to operate Watana as a peaking plant.

(b) Temperature and D.O.

As noted in Section 3, the impoundment of the Watana reservoir will change the downstream temperature regime of the Susitna River. Multilevel intakes have been incorporated in the power plant intake structures so that water can be drawn from various depths (usually the surface). By selectively withdrawing water, the desired temperature can be maintained at the powerhouse tailrace and downstream. Using a reservoir temperature model, it was possible to closely match existing Susitna River water temperatures except for periods in spring and fall.

(c) Nitrogen Supersaturation

Nitrogen supersaturation is avoided by the inclusion of fixed-cone valves in the outlet facilities. Fixed-cone valves have been proven effective in preventing nitrogen supersaturation (Ecological Analysts Inc. 1982). Instead of passing water over the spillway into a plunge pool, excess water is released through the valves. These facilities are designed to pass a once in fifty year flood event without creating supersaturated water conditions downstream.

The Watana facilities incorporate six fixed-cone valves that are capable of passing a total design flow of 24,000 cfs.

5.5 - Mitigation of Devil Canyon Impoundment Impacts

Other than the continuance of the downstream flows at Gold Creek established during the operation of Watana no additional mitigation measures are planned during the Devil Canyon impoundment period.

5.6 - Mitigation of Devil Canyon/Watana Operation

(a) Flows

The downstream flow requirement at Gold Creek will be the same as for Watana operation alone. After Devil Canyon is on line, Watana will be operated as a peaking plant since the discharge feeds directly into the Devil Canyon reservoir. The Devil Canyon reservoir will provide the flow regulation required to stabilize the downstream flows.

(b) Temperature

As with Watana, multilevel intakes will be incorporated into the Devil Canyon design. Two intake ports will be needed because of the limited drawdown at Devil Canyon.

(c) Nitrogen Supersaturation

The Devil Canyon Dam is designed with seven fixed-cone valves, three with a diameter of 90 inches and four more with a diameter of 102 inches. Total design capacity of the seven valves will be 38,500 cfs.

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TABLE E.2.1: GAGING STATION DATA

Station	USGS Gage Number	Drainage Area (mi^2)	Years of Record	River Mile
Denali	15291000	950	25	291
Maclaren	15291200	280	24	260 (1)
Cantwell	15291500	4140	20	225
Gold Creek	15292000	6160	32	137
Chulitna	15292400	2570	23	98
Talkeetna	15291500	2006	18	97 (1)
Skwenta	15294300	2250	20	28 (1)
Susitna	15294350	19400	9	26

(1) Confluence of tributary with Susitna River.

TABLE E.2.2: BASELINE MONTHLY FLOWS (cfs)

		Denali[1] (20)	Vee Canyon[2] (30)	Devil Watana[2] (32)	Gold Canyon[2] (32)	Susitna Creek (32)	Maclaren Station (5)	Chulitna (Paxson) (21)	Station (14)	Talkeetna (15)	Skwenta (20)
OCT	Max	2135	4626	6458	7518	8212	52636	687	9314	4438	6196
	Mean	1132	3033	4523	5324	5654	31250	409	4859	2505	4297
	Min	528	1638	2403	2867	3124	15940	249	2898	1450	1929
NOV	Max	680	2200	3525	3955	3954	21548	265	3014	1786	3094
	Mean	500	1449	2050	2391	2476	13247	177	1994	1146	1780
	Min	192	780	1021	1146	1215	6606	95	1236	770	678
DEC	Max	575	1535	2259	2905	3264	15081	190	2143	1239	2871
	Mean	317	998	1415	1665	1788	9070	118	1457	842	1267
	Min	146	543	709	810	866	4279	49	891	515	628
JAN	Max	651	1300	1780	2212	2452	12269	162	1673	1001	2829
	Mean	246	824	1166	1362	1466	8205	96	1276	675	1078
	Min	85	437	636	757	824	6072	44	974	504	600
FEB	Max	321	1200	1560	1836	2028	11532	140	1400	805	1821
	Mean	206	722	983	1153	1242	7409	84	1099	565	903
	Min	64	426	602	709	768	4993	42	820	401	490
MARCH	Max	287	1273	1560	1779	1900	9193	121	1300	743	1200
	Mean	188	692	898	1042	1115	6562	76	978	496	809
	Min	42	408	569	664	713	4910	36	738	379	522
APRIL	Max	415	1702	1965	2405	2650	9803	145	1600	710	1700
	Mean	230	853	1099	1267	1351	7214	87	1154	569	1016
	Min	43	465	609	697	745	5531	50	700	371	607
MAY	Max	4259	13751	15973	19777	21890	94143	2084	20025	7790	13460
	Mean	2056	7520	10355	12190	13277	60822	802	8371	4195	7920
	Min	629	2643	2857	3428	3745	29809	208	3971	1694	1635
JUNE	Max	12210	34630	42842	47816	50580	176219	4297	40330	19040	40356
	Mean	7306	19655	23024	26078	28095	122510	2891	22495	11610	18583
	Min	4647	9909	13233	14710	15530	67838	1751	15587	7429	10650
JULY	Max	12110	22890	28767	32388	34400	168815	4649	35570	14440	25270
	Mean	9399	17079	20810	23152	23919	130980	3165	26424	10560	17089
	Min	6756	12220	15871	17291	18093	102121	2441	22761	7080	11670
AUGUST	Max	10400	22710	31435	35270	32620	138334	3741	33670	18033	20590
	Mean	8124	14474	18629	20928	21727	109360	2566	22292	9331	13374
	Min	3919	6597	13412	15257	16220	62368	974	11300	3787	7471
SEPT	Max	5452	12910	17206	19799	21240	104218	2439	23260	10610	13371
	Mean	3356	7897	792	12414	13327	68060	1166	12003	5546	8156
	Min	1822	3376	5712	6463	6881	34085	470	6424	2070	3783
ANNUAL	Max	3651	7962	9833	10947	11565	59395	1276	12114	5276	10024
	Mean	2723	6295	8023	9130	9670	48148	975	8748	4029	6386
	Min	2127	4159	6100	7200	7200	31228	693	6078	2233	4939

NOTES:

1 Years of Record
2 Computed

TABLE E.2.5: SUSITNA RIVER REACH DEFINITIONS

River Mile	Average Slope	Predominent Channel Pattern
RM 149 to 144	0.00195	Single channel confined by valley walls. Frequent bedrock control points.
RM 144 to 139	0.00260	Split channel confined by valley wall and terraces.
RM 139 to 129.5	0.00210	Split channel confined occasionally by terraces and valley walls. Main channels, side channels sloughs occupy valley bottom.
RM 129.5 to 119	0.00173	Split channel with occasional tendency to braid. Main channel frequently flows against west valley wall. Subchannels and sloughs occupy east floodplain.
RM 119 to 104	0.00153	Single channel frequently incised and occasional islands.
RM 104 to 95	0.00147	Transition from split channel to braided. Occasionally bounded by terraces. Braided through the confluence with Chulitna and Talkeetna Rivers.
RM 95 to 61	0.00105	Braided with occasional confinement by terraces.
RM 61 to 42	0.00073	Combined patterns; western floodplain braided, eastern floodplain split channel.
RM 42 to 0	0.00030	Split channel with occasional tendency to braid. Deltaic distributary channels begin forming at about RM 20.

TABLE E.2.6: DETECTION LIMITS FOR WATER QUALITY PARAMETERS (Cont'd)

	R&M Detection Limit(1)	USGS Detection Limit(5)	Criteria Levels
Laboratory Parameters (Cont'd)			
- Cu, Copper	0.05	.001	0.01
- Fe, Iron	0.05	.01	1.0
- Hg, Mercury	0.1	.0001	0.00005
- K, Potassium	0.05	.1	--
- Mg, Magnesium	0.05	.1	--
- Mn, Manganese	0.05	.001	0.05
- Mo, Molybdenum	0.05	.001	0.07
- Na, Sodium	0.05	.1	--
- Ni, Nickel	0.05	.001	0.025
- Pb, Lead	0.05	.001	0.03
- Pt, Platinum	0.05	--	--
- Sb, Antimony	0.10	.001	9
- Se, Selenium	0.10	.001	0.01
- Si, Silicon	0.05	--	--
- Sn, Tin	0.10	.1	--
- Sr, Strontium	0.05	.01	--
- Ti, Titanium	0.05	--	--
- W, Tungsten	1.0	--	--
- V, Vanadium	0.05	--	0.007 (S)
- Zn, Zinc	0.05	.01	0.03
- Zr, Zirconium	0.05	--	--

(1) All values are expressed in mg/l unless otherwise noted.

(2) TDS - (filterable) material that passes through a standard glass fiber filter and remains after evaporation (SM p 93).

(3) TSS - (nonfilterable) material required on a standard fiber filter after filtration of a well-mixed sample.

(4) ICAP SCAN - thirty-two (32) element computerized scan in parts/million (Ag, Al, As, Au, B, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, Pb, Pt, Sb, Se, Si, Sn, Sr, Ti, V, W, Zn, Zr).

(5) USGS detection limits are taken from "1982 Water Quality Laboratory Services Catalog" USGS Open-File Report 81-1016. The limits used are the limits for the most precise test available.

(S) - Suggested Criteria

(M) - Migration Routes

(Sp) - Spawning Areas

TABLE E.2.7: PARAMETERS EXCEEDING CRITERIA BY STATION AND SEASON

Parameter	Station	Season	Criteria
D.O. % Saturation	G	S	L
pH	T	S, W, B	L
	G	B	
Color	T, S	S	L
Phosphorus, Total (d)	V, G, T, S, SS	S, W, B	L
Total Organic Carbon	G, SS	S	S
	V, G, SS	W	
	SS	B	
Aluminum (d)	V, G	S, W	S
Aluminum (t)	G, S, SS	S	
Bismuth (d)	V, G	S	S
	G	W	
Cadmium (d)	T, SS	S, W	L
	SS	B	
Cadmium (t)	G, T, S, SS	S	
	T, SS	W, B	
Copper (d)	T, SS	S	A
	T	W	
	SS	B	
Copper (t)	G, T, S, SS	S	
	T, S, SS	W	
	T, SS		
Iron (d)	D, V, C	S	L
Iron (t)	G, T, S, SS	S	
	T	B	
Lead (t)	G, T, S, SS	S	A
	T, SS	W, B	
Manganese (d)	D, V, G, C	S	L
Manganese (t)	G, T, S	S	
	T, SS	B	
Mercury (d)	G, S	S	L
	S	W	
Mercury (t)	G, T, S, SS	S	
	T, S, SS	W	
	T, SS	B	
Nickel (t)	G, S, SS	S	A
Zinc (d)	V	S	A
Zinc (t)	G, S, SS	S	
	T, S, SS	W	
	SS	B	

Stations

D - Denali
V - Vee Canyon
G - Gold Creek
C - Chulitna
T - Talkeetna
S - Sunshine
SS - Susitna Station

Seasons

S - Summer
W - Winter
B - Breakup

Criteria

L - Established by law as per Alaska Water Quality Standards

S - Criteria that have been suggested but are now law, or levels which natural waters usually do not exceed

A - Alternate level to 0.02 of the 96-hour LC50 determined through bioassay

TABLE E.2.8: 1982 TURBIDITY ANALYSIS OF THE SUSITNA, CHULITNA AND TALKEETNA RIVERS CONFLUENCE AREA

Location	Date Sampled[1]	Date Analyzed	Turbidity[2] (NTU)	Suspended[3] Sediment Concentration (mg/l)	Discharge[4] (cfs)
Susitna at Sunshine (Parks Highway Bridge)	6/3/82	6/11/82	164	--	71,800
	6/10/82	6/24/82	200	403	62,100
	6/17/82	6/24/82	136	322	48,700
	6/21/82	8/3/82	360	755	76,600
	6/28/82	8/18/82	1,056	--	71,600
	7/6/82	8/3/82	352	--	44,800
	7/12/82	8/3/82	912	--	58,000
	7/19/82	8/18/82	552	--	59,400
	7/26/82	8/18/82	696	--	97,100
	8/2/82	8/18/82	544	--	61,000
	8/9/82	8/26/82	720	--	50,200
	8/16/82	8/26/82	784	--	45,600
	8/23/82	9/14/82	552	--	--
	8/30/82	9/14/82	292	--	--
	9/17/82	10/12/82	784	--	--
Susitna Below Talkeetna	5/26/82*	5/29/82	98	--	--
	5/28/82*	6/2/82	256	--	43,600
	5/29/82*	6/2/82	140	--	42,900
	5/30/82*	6/2/82	65	--	38,400
	5/31/82*	6/2/82	130	--	39,200
	6/1/82*	6/2/82	130	--	47,000
Susitna at LRX-4[5]	5/26/82*	5/29/82	81	--	--
Susitna near Chase[5] (R.R. Mile 232)	6/3/82	6/11/82	140		
	6/8/82	6/24/82	130	547	--
	6/15/82	6/24/82	94	170	20,700
	6/22/82	8/3/82	74	426	--
	6/30/82	8/18/82	376	--	--
	7/8/82	8/18/82	132	--	18,100
	7/14/82	8/3/82	728	--	27,300
	7/21/82	8/18/82	316	--	21,900
	7/28/82	8/18/82	300	--	25,600
	8/4/82	8/18/82	352	--	18,500
	8/10/82	8/26/82	364	--	16,700
	8/18/82	8/26/82	304	--	--
	8/25/82	9/14/82	244	--	--
	8/31/82	9/14/82	188	--	--
	9/19/82	10/12/82	328	--	--
Susitna at Vee Canyon	6/4/82	6/11/82	82	--	--
	6/30/82	8/3/82	384	--	--
	7/27/82	8/18/82	720	--	--
	8/26/82	9/14/82	320	--	--
Chulitna (Canyon)[6]	6/4/82	6/11/82	272	--	--
	6/22/82	8/3/82	680	--	--
	6/29/82	8/18/82	1,424	--	--
	7/7/82	8/3/82	976	--	--
	7/13/82	8/18/82	1,136	--	--
	7/20/82	8/18/82	1,392	--	--
	7/27/82	8/18/82	664	--	--
	8/3/82	8/18/82	704	--	--
	8/11/82	8/26/82	592	--	--
	8/17/82	8/26/82	1,296	--	--
	8/24/82	9/14/82	632	--	--
	9/1/82	9/14/82	316	--	--
	9/18/82	10/12/82	1,920	--	--

TABLE E.2.8 - (Cont'd)

Location	Date Sampled[1]	Date Analyzed	Turbidity[2] (NTU)	Suspended Sediment Concentration[3] (mg/l)	Discharge[4] (cfs)
Chulitna near Confluence[6]	5/26/82*	5/29/82	194	--	--
	5/28/82*	6/2/82	272	--	--
	5/29/82*	6/2/82	308	--	--
	5/30/82*	6/2/82	120	--	--
	5/31/82*	6/2/82	360	--	--
	6/1/82*	6/2/82	324	--	--
Talkeetna at USGS Cable[7]	6/2/82	6/11/82	146	311	16,000
	6/9/82	6/24/82	49	311	13,400
	6/17/82	6/24/82	28	--	10,300
	6/23/82	8/3/82	26	164	11,700
	6/29/82	8/18/82	41	--	11,800
	7/7/82	8/3/82	20	--	6,830
	7/13/82	8/3/82	132	--	9,390
	7/20/82	8/18/82	148	--	8,880
	7/28/82	8/18/82	272	--	16,000
	8/3/82	8/18/82	49	--	9,730
	8/10/82	8/26/82	53	--	7,400
	8/17/82	8/26/82	82	--	6,490
	8/24/82	9/14/82	68	--	--
	8/31/82	9/14/82	37	--	--
	9/20/82	10/12/82	34	--	--
Talkeetna at R.R. Bridge[7]	5/26/82*	5/29/82	17	--	5,680
	5/28/82*	6/2/82	39	--	6,250
	5/29/82*	6/2/82	21	--	5,860
	5/30/82*	6/2/82	20	--	5,660
	5/31/82*	6/2/82	44	--	7,400
	6/1/82*	6/2/82	55	--	9,560

Notes: [1] *Refers to samples collected by R&M Consultants, all other samples were collected by USGS.

[2] R&M Consultants conducted all turbidity measurements.

[3] Suspended sediment concentrations are preliminary, unpublished data provided by the U.S. Geological Survey.

[4] Discharges for "Susitna at Sunshine" and "Susitna Below Talkeetna" are from the U.S. Geological Survey stream gage at the Parks Highway Bridge at Sunshine.

[5] Discharges for "Susitna at LRX-4" and "Susitna near Chase" are from the USGS stream gage at the Alaska Railroad Bridge at Gold Creek.

[6] Discharges for "Chulitna" and "Chulitna near Confluence" are from the USGS stream gage at the Parks Highway Bridge at Chulitna.

[7] Discharges for "Talkeetna at USGS Cable" and "Talkeetna at R.R. Bridge" are from the USGS stream gage near Talkeetna.

TABLE E.2.9: SIGNIFICANT ION CONCENTRATIONS

	Ranges of Concentrations (mg/l)			
	Upstream of Project		Downstream of Project	
	Summer	Winter	Summer	Winter
Bicarbonate (alkalinity)	39 - 81	57 - 187	25 - 86	45 - 145
Chloride	0 - 11	4 - 30	1 - 15	6 - 35
Sulfate	2 - 23	11 - 39	1 - 28	10 - 38
Calcium (dissolved)	13 - 29	23 - 51	10 - 37	22 - 32
Magnesium (dissolved)	1 - 4	0 - 16	1 - 6	1 - 10
Sodium (dissolved)	2 - 10	4 - 23	2 - 8	5 - 17
Potassium (dissolved)	1 - 7	0 - 9	1 - 4	1 - 5

TABLE E.2.10: STREAMS TO BE PARTIALLY OR COMPLETELY INUNDATED BY WATANA RESERVOIR (El. 2,185)

Stream Name	Susitna River Mile at Mouth	Approximate Existing Elevation at Mouth (ft. msl)	Approximate Stream Gradient at Mouth (ft/mile)	Length of Stream to be Inundated (miles)
1. unnamed	240.8	2,185	380	mouth only
2. unnamed	240.0	2,175	1,000	mouth only
3. unnamed	239.4	2,170	500	mouth only
4. unnamed	238.5	2,165	600	mouth only
5. unnamed	236.0	2,140	500	0.1
6. unnamed	233.8	2,055	400	0.3
7. Oshetna River	233.5	2,050	65	2.0
8. unnamed	232.7	2,040	1,500	0.2
9. Goose Creek	231.2	2,030	125	1.2
10. unnamed	230.8	2,025	1,400	0.2
11. unnamed	229.8	2,015	550	0.3
12. unnamed	229.7	2,015	1,500	0.2
13. unnamed	229.1	2,010	2,000	0.1
14. unnamed	228.5	2,000	1,300	0.1
15. unnamed	228.4	2,000	2,000	0.2
16. unnamed	227.4	1,980	1,700	0.1
17. unnamed	226.8	1,970	250	0.6
18. unnamed	225.0	1,930	400	0.4
19. unnamed	224.4	1,920	1,250	0.2
20. unnamed	221.5	1,875	230	1.0
21. unnamed	220.9	1,865	1,000	0.2
22. unnamed	219.2	1,845	350	1.0
23. unnamed	217.6	1,830	700	0.5
24. unnamed	215.1	1,785	900	0.3
25. unnamed	213.2	1,760	1,000	0.4
26. unnamed	213.0	1,755	600	0.6
27. unnamed	212.1	1,750	1,200	0.3
28. unnamed slough	212.0	1,750	13	0.5 (full length)
29. unnamed slough	211.7	1,745	1,000	0.3
30. unnamed	210.2	1,720	400	0.7
31. Jay Creek	208.6	1,700	120	3.2
32. unnamed	207.3	1,690	300	0.9 (full length)
33. unnamed	207.0	1,685	160	1.0
34. Kosina Creek	206.9	1,685	120	4.2
35. unnamed	205.0	1,665	1,100	0.5 (full length)
36. unnamed	204.9	1,665	750	0.4 (full length)
37. unnamed	203.9	1,655	800	0.7
38. unnamed	203.4	1,650	350	0.5 (full length)
39. unnamed	201.8	1,635	400	0.8
40. unnamed	200.7	1,625	1,000	1.0
41. unnamed	198.7	1,610	400	0.7
42. unnamed	198.6	1,605	700	0.6
43. unnamed	197.9	1,600	500	0.6
44. unnamed	197.1	1,595	650	0.7
45. unnamed	196.7	1,590	1,000	0.7
46. unnamed	196.2	1,585	550	1.0
47. unnamed	195.8	1,580	350	1.1
48. unnamed	195.2	1,575	200	1.3 (full length)
49. unnamed	194.9	1,570	200	1.7
50. Watana Creek	194.1	1,560	50	10.0 (longest fork)

TABLE E.2.10 - (Cont'd)

Stream Name	Susitna River Mile at Mouth	Approximate Existing Elevation at Mouth (ft. msl)	Approximate Stream Gradient at Mouth (ft/mile)	Length of Stream to be Inundated (miles)
50A. Delusion Creek (tributary to Watana Creek)	--	1,700	200	1.9
51. unnamed	192.7	1,550	400	1.5 (full length)
52. unnamed	192.0	1,545	200	3.9 (longest fork)
53. unnamed	190.0	1,530	1,300	0.5
54. unnamed	187.0	1,505	1,250	0.7
55. unnamed	186.9	1,505	2,000	1.7
56. Deadman Creek	186.7	1,500	450	2.3

TABLE E.2.11: STREAMS TO BE PARTIALLY OR COMPLETELY INUNDATED BY DEVIL CANYON RESERVOIR (EL. 1,455)

Stream Name	Susitna River Mile at Mouth	Approximate Existing Elevation at Mouth (ft. msl)	Approximate Stream Gradient at Mouth (ft/mile)	Length of Stream to be Inundated (miles)
1. Tsusena Creek	181.9	1,450	250	0.2
2. unnamed	181.2	1,440	250	0.2
3. unnamed slough	180.1	1,430	10	0.6 (full length)
4. unnamed slough	179.3	1,420	250	0.1
5. unnamed slough	179.1	1,420	500	0.2
6. unnamed slough	177.0	1,385	600	0.1
7. Fog Creek	176.7	1,380	125	1.0
8. unnamed	175.3	1,370	75	0.6
9. unnamed	175.1	1,365	1,100	0.1
10. unnamed	174.9	1,360	650	0.1
11. unnamed	174.3	1,350	350	0.3
12. unnamed slough	174.0	1,350	15	2.0 (full length)
12A. unnamed (tributary to slough)	--	1,350	550	0.2
12B. unnamed (tributary to slough)	--	1,350	550	0.2
12C. unnamed (tributary to slough)	--	1,350	1,600	0.1
13. unnamed slough	173.4	1,340	20	0.5 (full length)
14. unnamed	173.0	1,335	600	0.1
15. unnamed	173.0	1,335	1,000	0.2
16. unnamed	172.9	1,330	1,300	0.2
17. unnamed slough	172.1	1,320	15	0.8 (full length)
17A. unnamed (tributary to slough)	--	1,320	2,000	0.1
17B. unnamed (tributary to slough)	--	1,320	2,000	0.1
18. unnamed	171.4	1,315	2,000	0.1
19. unnamed	171.0	1,310	250	0.6
20. unnamed slough	169.5	1,290	15	0.7 (full length)
21. unnamed	168.8	1,280	1,400	0.2
22. unnamed	166.5	1,235	350	0.6
23. unnamed	166.0	1,230	1,250	0.2
24. unnamed	164.0	1,200	2,000	0.2
25. unnamed	163.7	1,180	1,350	0.2
26. Devil Creek	161.4	1,120	180	1.4
27. unnamed	157.0	1,030	400	1.3
28. unnamed	154.5	985	3,000	0.4
29. unnamed (Cheechako Creek)	152.4	950	500	1.6

TABLE E.2.12: DOWNSTREAM TRIBUTARIES POTENTIALLY IMPACTED BY PROJECT OPERATION

No.	Name	River Mile	Bank of Susitna[1]	Reason for Concern
1	Portage Creek	148.9	RB	fish
2	Jack Long Creek	144.8	LB	fish
3	Indian River	138.5	RB	fish
4	Gold Creek	136.7	LB	fish
5	Trib. @ 132.0	132.0	LB	RR
6	Fourth of July Creek	131.1	RB	fish
7	Sherman Creek	130.9	LB	RR, fish
8	Trib. @ 128.5	128.5	LB	RR
9	Trib. @ 127.3	127.3	LB	RR
10	Skull Creek	124.7	LB	RR
11	Trib. @ 123.9	123.9	RB	fish
12	Deadhorse Creek	121.0	LB	fish, RR
13	Trib. @ 121.0	121.0	RB	fish
14	Little Portage Creek	117.8	LB	RR
15	McKenzie Creek	116.7	LB	fish
16	Lane Creek	113.6	LB	fish
17	Gash Creek	111.7	LB	fish
18	Trib. @ 110.1	110.1	LB	RR
19	Whiskers Creek	101.2	RB	fish

[1] Referenced by facing downstream (LB = left bank, RB = right bank).

TABLE E.2.13: SUMMARY OF SURFACE WATER AND GROUND WATER APPROPRIATIONS IN EQUIVALENT FLOW RATES

Township Grid	Surface Water Equivalent		Ground Water Equivalent	
	cfs	ac-ft/yr	cfs	ac-ft/yr
Susitna	.153	50.0	.0498	16.3
Fish Creek	.000116	.02100	.00300	2.24
Willow Creek	18.3	5,660	.153	128
Little Willow Creek	.00613	1.42	.001907	1.37
Montana Creek	.0196	7.85	.366	264
Chulina	.00322	.797	.000831	.601
Susitna Reservoir	.00465	3.36		
Chulitna			.00329	2.38
Kroto-Trapper Creek	.0564	10.7		
Kahiltna	125	37,000		
Yentna	.00155	.565		
Skwentna	.00551	1.90	.000775	.560

TABLE E.2.14: SUSITNA RIVER - LIMITATIONS TO NAVIGATION

River Mile Location*	Description	Severity
19	Alexander Slough Head	Access to slough limited at low water due to shallow channel
52	Mouth of Willow Creek	Access from creek limited at low water
61	Sutitna/Landing Mouth of Kashwitna River	Access from launching site limited at low water
127-128	River Cross-Over near Sherman and Cross-Section 32	Shallow in riffle at low water
151	Devil Canyon	Severe rapids at all flow levels
160-161	Devil Creek Rapids	Severe rapids at all flow levels
225	Vee Canyon	Hazardous ~~but~~ accessible rapids at most flows
291	Denali Highway Bridge	Shallow water and frequent sand bars at low water

*Reference: River Mile Index (R&M Consultants, 1981)

TABLE E.2.15: ESTIMATED LOW AND HIGH FLOWS AT ACCESS ROAD STREAM CROSSINGS

Drainage[1] Basin	A Area (mi²)	30-Day Minimum Flow (cfs) Recurrence Interval (yrs)			Peak Flows (cfs) Recurrence Interval (yrs)			
		2	10	20	2	10	25	50
Denali Highway to Watana Camp								
Lily Creek	3.70	0.8	0.6	0.5	25	54	78	96
Seattle Creek	11.13	2.4	1.8	1.5	74	147	205	248
Seattle Creek Tributary	1.49	0.3	0.2	0.2	10	24	35	44
Seattle Creek Tributary	2.70	0.8	0.5	0.4	13	29	42	51
Brushkana Creek	22.00	5.5	3.8	3.4	115	217	299	354
Brushkana Creek Site	21.01	4.9	3.5	3.1	121	228	315	374
Upper Deadman Creek	12.08	3.0	2.1	1.9	64	127	177	211
Deadman Creek Tributary	21.28	4.6	3.3	2.9	138	263	363	432
Deadman Creek Tributary	14.71	3.2	2.3	2.0	97	189	262	315
Watana to Devil Canyon								
Tsusena Creek	126.61	26	19	17	780	1309	1744	2000
Devil Creek	31.0	6.7	4.8	4.2	199	369	506	597
Devil Canyon to Gold Creek								
Gold Creek	25.00	5.4	3.9	3.4	162	304	418	497

[1]Minimum flows estimated from the following equation (Freethey and Scully, 1980, Water Resources of the Cook Inlet Basin, U.S. Geological Survey, Atlas HA-620)

$$M_{d,rt} = aA^{b} (LP + 1)^{c} (J + 10)^{d}$$

where: M = minimum flow (cfs)
d = number of days
rt = recurrence interval (yrs)
A = drainage area (mi²)
LP = area of lakes and ponds (percent)
J = mean minimum January air temperature (°F)

TABLE E2.16: AVAILABLE STREAMFLOW RECORDS FOR MAJOR STREAMS CROSSED BY TRANSMISSION CORRIDOR

Stream Name	USGS Gage Description	USGS Number	Period of Continuous Record	Drainage Area[1] (mi^2)	Transmission Line Crossing from Gage[2] (approx.)	Mean Annual Streamflow[3] (cfs)
Anchorage-Willow Segment						
Little Susitna River	Near Palmer	15290000	1948-	61.9	35 mi. d/s	206
Willow Creek	Near Willow	15294005	1978-	166	7 mi. d/s	472
Fairbanks-Healy Segment						
Nenana River #1	Near Healy	15518000	1950-1979	1,910	2 mi. d/s	3,506
Nenana River #2	Near Healy	15518000	1950-1979	1,910	20 mi. d/s	3,506
Tanana River	At Nenana	15515500	1962-	15,600	5 mi. u/s	23,460
Willow-Healy Intertie						
Talkeetna River	Near Talkeetna	15292700	1964-	2,006	5 mi. d/s	4,050
Susitna River	At Gold Creek	15292000	1949-	6,160	5 mi. u/s	9,647
Indian River	--	--	--	82	15 mi. u/s	--
E.F. Chulitna River	Chulitna River near Talkeetna	15292400	1958-72, 1980-	2,570	40 mi. u/s	8,748
M.F. Chulitna River	Chulitna River near Talkeetna	15292400	1958-72, 1980-	2,570	50 mi. u/s	8,748
Nenana River	Near Windy	15516000	1950-56, 1958-73	710	5 mi. u/s	--
Yanent Fork	--	--	--	N/A	1 mi. u/s	--
Healy Creek	--	--	--	N/A	1 mi. u/s	--
Watana-Gold Creek Segment						
Tsusena Creek	--	--	--	149	3 mi. u/s	--
Devil Creek	--	--	--	N/A	3 mi. u/s	--
Susitna River	At Gold Creek	15292000	1949-	6,160	15 mi. u/s	9,647

[1] Areas for ungaged streams are at the mouth.
[2] d/s = downstream, u/s = upstream. Distances for ungaged stream are from the mouth.
[3] Averages determined through the 1980 water year at gage sites.

TABLE E2.17: DOWNSTREAM FLOW REQUIREMENTS AT GOLD CREEK

Month	Flow (cfs) During Filling	Flow (cfs) Operation
Jan	1,000	5,000
Feb	1,000	5,000
Mar	1,000	5,000
Apr	1,000	5,000
May	6,000	6,000
Jun	6,000	6,000
Jul	6,480 (1)	6,480
Aug	12,000	12,000
Sep	9,300 (2)	9,300
Oct	2,000	5,000
Nov	1,000	5,000
Dec	1,000	5,000

(1)

July	1-26	6,000
	27	6,000
	28	7,500
	29	9,000
	30	10,500
	31	12,000

(2)

September	1-14	12,000
	15	12,000
	16	10,500
	17	9,000
	18	7,500
	19	6,000
	20	6,000

TABLE E2.18: WATANA INFLOW AND OUTFLOW FOR FILLING CASES

	10%				50%				90%			
	Inflow (cfs)	Outflow (cfs) 1991	1992	1993	Inflow (cfs)	Outflow (cfs) 1991[1]	1992	1993	Inflow (cfs)	Outflow (cfs) 1991[1]	1992	1993
Jan	1,340	1,340	1,340	1,340	1,190	1,198	1,198	1,000	1,071	1,071	1,071	1,000
Feb	1,138	1,138	1,138	1,138	1,018	1,018	1,018	1,000	910	910	910	910
Mar	1,028	1,028	1,028	1,028	919	919	919	919	822	822	822	822
Apr	1,261	1,261	1,000	1,000	1,127	1,127	1,000	1,000	1,008	1,008	1,000	1,000
May	12,158	8,690	3,276	3,276	10,870	7,402	3,649	3,649	9,715	6,247	4,016	4,016
Jun	25,326	20,005	1,000	10,527	22,644	17,323	1,103	1,939	20,238	14,917	1,867	1,867
Jul	22,327	5,309	9,031	1,000	19,963	2,945	2,181	2,163	17,842	2,836	2,836	2,836
Aug	20,142	14,993	8,649	15,859	18,008	12,859	8,105	10,198	16,095	8,934	8,713	8,713
Sep	12,064	6,743	6,597	12,064	10,787	6,967	6,967	10,787	9,641	7,331	7,331	7,331
Oct	5,272	5,272	1,000	5,272	4,713	3,261	1,000	4,713	4,213	1,230	1,000	1,000
Nov	2,352	2,352	1,000	2,352	2,102	2,102	1,000	2,102	1,879	1,879	1,000	1,000
Dec	1,642	1,642	1,020	1,642	1,468	1,468	1,000	1,468	1,312	1,312	1,000	1,000

Note: [1] Prior to 1991, no water is stored in Watana reservoir.

TABLE E2.19: FLOWS AT GOLD CREEK DURING WATANA FILLING

	10%				50%				90%			
		During Filling				During Filling				During Filling		
	Pre-Project	1991	1992	1993	Pre-Project	1991	1992	1993	Pre-Project	1991	1992	1993
Jan	1,640	1,640	1,640	1,640	1,457	1,457	1,457	1,259	1,290	1,290	1,290	1,219
Feb	1,393	1,393	1,393	1,393	1,238	1,238	1,238	1,220	1,096	1,096	1,096	1,096
Mar	1,258	1,258	1,258	1,258	1,118	1,118	1,118	1,118	990	990	990	990
Apr	1,544	1,544	1,283	1,283	1,371	1,371	1,244	1,244	1,214	1,214	1,206	1,206
May	14,882	11,414	6,000	6,000	13,221	9,753	6,000	6,000	11,699	8,231	6,000	6,000
Jun	31,002	25,680	6,675	16,202	27,541	22,220	6,000	6,836	24,371	19,050	6,000	6,000
Jul	27,331	10,312	4,034	6,003	24,280	7,262	6,498	6,480	21,486	6,480	6,480	6,480
Aug	24,655	19,506	3,162	20,371	21,903	16,754	2,000	14,093	19,382	12,221	12,000	12,000
Sep	14,767	9,446	9,300	14,767	13,119	9,300	9,300	3,120	11,609	9,300	9,300	9,300
Oct	6,453	6,453	2,181	6,453	5,732	4,280	2,019	5,732	5,073	2,159	1,860	1,860
Nov	2,879	2,879	1,527	2,879	2,557	2,557	1,455	2,557	2,263	2,263	1,384	1,384
Dec	2,010	2,010	1,388	2,010	1,785	1,785	1,317	1,785	1,580	1,580	1,268	1,268

TABLE 2.21 POST-PROJECT FLOW AT WATANA (cfs)
WATANA ALONE : CASE C

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1	5664.6	9716.3	11285.3	9705.6	8958.2	8080.8	7383.7	5632.5	4853.9	4617.4	9033.6	8301.0	7761.9
2	5840.9	6640.7	7716.0	7189.9	6290.0	6468.3	5674.3	7874.1	4835.5	4778.1	8808.0	5265.5	6459.0
3	7082.9	10164.1	11617.4	10165.0	9157.5	8246.7	7507.5	5326.8	5002.3	4797.2	8436.3	6391.0	7819.7
4	8269.3	10750.7	11397.6	9709.4	8928.2	8182.4	8085.6	11375.6	4959.6	4560.9	8071.6	5543.5	8325.3
5	5691.2	6591.6	11300.2	9978.3	9119.6	8149.9	7646.2	8369.3	4962.2	4590.8	6320.6	5545.5	7353.8
6	5684.0	7246.1	11665.9	10278.8	9367.0	8397.8	7644.4	5258.9	5174.6	6849.6	14063.1	8457.8	8345.5
7	7620.0	9582.1	11155.0	9707.4	9071.3	8206.1	7421.9	9500.1	9088.6	8818.7	10055.4	8275.0	9046.5
8	7778.5	10270.5	11823.4	10263.5	9505.5	8446.7	7648.7	7000.7	7123.4	4748.4	8777.7	7254.1	8381.0
9	9605.4	10929.9	12374.9	10371.1	9358.2	8485.2	7969.0	6804.2	4963.6	4755.7	8303.4	7550.0	8455.1
10	5731.9	6512.7	7772.5	9971.5	9265.5	8205.7	7589.3	6968.7	4838.2	4780.9	8969.2	7390.3	7325.4
11	8736.0	10207.4	11788.7	10290.9	9455.4	8472.8	7773.5	9581.9	4870.4	4812.9	7733.1	4875.6	8220.4
12	6482.7	10321.7	12089.6	10670.4	9621.3	8842.7	8668.6	10116.3	5203.3	4747.4	9380.2	6076.2	8519.7
13	6050.3	10257.3	11876.8	10499.4	9573.9	8688.5	8161.0	8042.3	16898.9	7579.4	11004.0	7286.0	9649.7
14	9130.6	10502.9	11825.3	10199.4	9501.2	8395.3	7480.2	11611.4	4959.4	9515.9	12488.0	7780.0	9468.1
15	6516.0	9783.1	11311.1	9742.5	9098.1	8086.9	7312.8	5333.1	18353.5	5020.1	9608.2	7253.2	8931.5
16	5759.3	6535.8	7538.2	9560.5	9089.2	8319.0	7936.0	7711.6	4962.8	5167.4	8274.1	10381.7	7592.4
17	8791.7	9559.3	11320.0	9950.9	9301.2	8496.4	8042.0	5258.9	6476.3	4555.1	7560.9	6764.1	7999.0
18	5722.3	6504.8	7606.3	9992.7	9347.8	8401.2	7553.3	9142.1	6837.7	5550.2	16188.9	8753.5	8471.0
19	7589.5	9928.2	11820.6	10508.1	9876.9	9072.1	8280.3	9386.2	7755.8	5705.5	8977.5	7647.6	8876.0
20	5756.8	6543.1	7573.0	7636.5	9064.5	8197.7	7553.6	5258.9	4851.7	4629.7	9756.0	7674.0	7028.9
21	5907.9	6809.4	7856.2	7330.4	6420.2	6619.0	5826.2	5428.1	4902.6	4747.2	8283.8	7403.1	6470.6
22	5971.4	6790.2	7879.0	7336.3	6419.1	6614.8	5823.1	5501.8	5166.8	4938.7	8685.6	7048.9	6518.8
23	7860.2	10580.9	12073.8	10561.4	9807.9	8877.7	8009.0	12218.0	9601.0	4742.3	10219.5	7855.7	9367.6
24	5697.0	6589.5	11362.9	9922.0	9316.7	8385.6	7617.7	5258.9	4973.6	4585.1	9726.7	8325.7	7641.5
25	5780.5	6573.2	7622.2	7091.7	6638.2	8139.0	7575.5	9442.3	4859.5	4654.8	9303.7	6836.2	7052.8
26	5901.1	6782.7	7811.4	7274.2	6358.6	6537.0	5739.0	5346.7	7869.7	6791.1	9036.6	6065.3	6798.3
27	7756.1	9595.1	10992.6	9648.3	9059.7	8202.4	7763.4	5887.1	4964.3	4587.9	10593.5	6881.0	7993.1
28	5827.7	6628.1	7677.0	7135.9	6231.4	7593.1	7907.0	5554.6	12444.1	4745.4	9567.3	7273.1	7378.6
29	5692.1	9188.0	12096.1	10468.4	9584.2	8768.4	8112.0	7950.5	4844.1	4608.4	9022.1	7825.6	8176.0
30	5881.8	6683.9	7750.7	7215.6	6306.8	6477.9	5679.0	8309.9	5122.8	7742.0	8210.7	7626.7	6929.3
31	5681.2	11305.1	12148.4	10360.5	9549.5	8688.7	8107.6	6968.2	5432.6	9231.9	9070.3	7020.0	8630.1
32	9053.3	11290.9	11501.4	10037.5	9287.5	8400.7	7806.6	7207.6	4874.0	5632.0	19391.0	9316.0	9497.5
MAX	9605.4	11305.1	12374.9	10670.4	9876.9	9072.1	8668.6	12218.0	18353.5	9515.9	19391.0	10381.7	9649.7
MIN	5664.6	6504.8	7538.2	7091.7	6231.4	6468.3	5674.3	5258.9	4835.5	4555.1	6320.6	4875.6	6459.0
MEAN	6766.1	8667.7	10300.9	9399.2	8685.3	8098.3	7478.1	7519.6	6628.3	5549.6	9778.8	7310.7	8015.1

TABLE 2.22 MONTHLY MAXIMUM, MINIMUM, AND MEAN FLOWS AT WATANA

MONTH				POST-PROJECT					
	PRE-PROJECT			WATANA ALONE			WATANA/DEVIL CANYON		
	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
OCT	6458.0	2403.1	4522.8	9605.4	5664.6	6766.1	11900.7	5564.1	9764.4
NOV	3525.0	1020.9	2059.1	11305.1	6504.8	8667.7	11048.4	6683.3	9112.6
DEC	2258.5	709.3	1414.8	12374.9	7538.2	10300.9	12386.3	7775.9	10881.2
JAN	1779.9	636.2	1165.5	10670.4	7091.7	9399.2	11497.6	7227.3	10287.5
FEB	1560.4	602.1	983.3	9876.9	6231.4	8685.3	11021.6	6272.0	9924.6
MAR	1560.4	569.1	898.3	9072.1	6468.3	8098.3	10315.6	6459.8	9059.2
APR	1965.0	609.2	1099.7	8668.6	5674.3	7478.1	9199.9	5100.4	7793.9
MAY	15973.1	2857.2	10354.7	12218.0	5258.9	7519.6	7501.6	4072.9	5826.6
JUN	42841.9	13233.4	23023.7	18353.5	4835.5	6628.3	6626.9	3198.6	5123.6
JUL	28767.4	15871.0	20810.1	9515.9	4555.1	5549.6	6625.6	3442.5	4736.1
AUG	31435.0	13412.1	18628.5	19391.0	6320.6	9778.8	14043.2	3263.4	5947.5
SEP	17205.5	5711.5	10792.0	10381.7	4875.6	7310.7	13672.9	4009.2	7838.4
ANNUAL	9832.9	6100.4	8023.0	9649.7	6459.0	8015.1	9832.9	6343.8	8015.1

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TABLE 2.23 PRE-PROJECT FLOW AT GOLD CREEK (cfs)
MODIFIED HYDROLOGY

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1	6335.0	2583.0	1439.0	1027.0	788.0	726.0	870.0	11510.0	19600.0	22600.0	19880.0	8301.0	8032.1
2	3848.0	1300.0	1100.0	960.0	820.0	740.0	1617.0	14090.0	20790.0	22570.0	19670.0	21240.0	9106.0
3	5571.0	2744.0	1900.0	1600.0	1000.0	880.0	920.0	5419.0	32370.1	26390.0	20920.0	14480.0	9552.1
4	8202.0	3497.0	1700.0	1100.0	820.0	820.0	1615.0	19270.0	27320.1	20200.0	20610.0	15270.0	10090.4
5	5604.0	2100.0	1500.0	1300.0	1000.0	780.0	1235.0	17280.0	25250.0	20360.0	26100.0	12920.0	9681.6
6	5370.0	2760.0	2045.0	1794.0	1400.0	1100.0	1200.0	9319.0	29860.0	27560.0	25750.0	14290.0	10256.4
7	4951.0	1900.0	1300.0	980.0	970.0	940.0	950.0	17660.0	33340.0	31090.1	24530.0	18330.0	11473.3
8	5806.0	3050.0	2142.0	1700.0	1500.0	1200.0	1200.0	13750.0	30160.0	23310.0	20540.0	19800.0	10384.1
9	8212.0	3954.0	3264.0	1965.0	1307.0	1148.0	1533.0	12900.0	25700.0	22880.0	22540.0	7550.0	9476.4
10	4811.0	2150.0	1513.0	1448.0	1307.0	980.0	1250.0	15990.0	23320.0	25000.0	31180.0	16920.0	10559.9
11	6558.0	2850.0	2200.0	1845.0	1452.0	1197.0	1300.0	15780.0	15530.0	22980.0	23590.0	20510.0	9712.3
12	7794.0	3000.0	2694.0	2452.0	1754.0	1810.0	2650.0	17360.0	29450.0	24570.0	22100.0	13370.0	10809.3
13	5916.0	2700.0	2100.0	1900.0	1500.0	1400.0	1700.0	12590.0	43270.0	25850.0	23550.0	15890.0	11565.2
14	6723.0	2800.0	2000.0	1600.0	1500.0	1000.0	830.0	19030.0	26000.0	34400.0	23670.0	12320.0	11072.9
15	6449.0	2250.0	1494.0	1048.0	966.0	713.0	745.0	4307.0	50580.0	22950.0	16440.0	9571.0	9799.6
16	6291.0	2799.0	1211.0	960.0	860.0	900.0	1360.0	12990.0	25720.0	27840.0	21120.0	19350.0	10168.8
17	7205.0	2098.0	1631.0	1400.0	1300.0	1300.0	1775.0	9645.0	32950.0	19860.0	21830.0	11750.0	9431.8
18	4163.0	1600.0	1500.0	1500.0	1400.0	1200.0	1167.0	15480.0	29510.0	26800.0	32620.0	16870.0	11218.5
19	4900.0	2353.0	2055.0	1981.0	1900.0	1900.0	1910.0	16180.0	31550.0	26420.0	17170.0	8816.0	9810.6
20	4272.0	1906.0	1330.0	1086.0	922.0	833.0	1022.0	9852.0	20523.0	18093.0	16322.0	9776.0	7200.1
21	3124.0	1215.0	866.0	824.0	768.0	776.0	1080.0	11380.0	18630.0	22660.0	19980.0	9121.0	7591.2
22	5288.0	3407.0	2290.0	1442.0	1036.0	950.0	1082.0	3745.0	32930.0	23950.0	31910.0	14440.0	10251.0
23	5847.0	3093.0	2510.0	2239.0	2028.0	1823.0	1710.0	21890.0	34430.0	22770.0	19290.0	12400.0	10885.5
24	4826.0	2253.0	1465.0	1200.0	1200.0	1000.0	1027.0	8235.0	27800.0	18250.0	20290.0	9074.0	8086.2
25	3733.0	1523.0	1034.0	874.0	777.0	724.0	992.0	16180.0	17870.0	18800.0	16220.0	12250.0	7631.0
26	3739.0	1700.0	1603.0	1516.0	1471.0	1400.0	1593.0	15350.0	32310.0	27720.0	18090.0	16310.0	10275.4
27	7739.0	1993.0	1081.0	974.0	950.0	900.0	1373.0	12620.0	24380.0	18940.0	19800.0	6881.0	8189.3
28	3874.0	2650.0	2403.0	1829.0	1618.0	1500.0	1680.0	12680.0	37970.0	22870.0	19240.0	12640.0	10109.0
29	7571.0	3525.0	2589.0	2029.0	1668.0	1605.0	1702.0	11950.0	19050.0	21020.0	16390.0	8607.0	8194.5
30	4907.0	2535.0	1681.0	1397.0	1286.0	1200.0	1450.0	13870.0	24690.0	28880.1	20460.0	10770.0	9489.3
MAX	8212.0	3954.0	3264.0	2452.0	2028.0	1900.0	2650.0	21890.0	50580.0	34400.0	32620.0	21240.0	11565.2
MIN	3124.0	1215.0	866.0	824.0	768.0	713.0	745.0	3745.0	15530.0	18093.0	16220.0	6881.0	7200.1
MEAN	5654.3	2476.3	1788.0	1465.7	1242.3	1114.8	1351.3	13276.7	28095.1	23919.4	21726.7	13327.2	9670.1

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TABLE 2.24 POST-PROJECT FLOWS AT GOLD CREEK (cfs)
WATANA : CASE C

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1	7279.7	10215.7	11555.4	9917.5	9104.5	8237.7	7573.6	8486.6	8021.8	8024.0	12000.0	9281.6	9145.8
2	6389.8	6833.4	7909.8	7341.9	6437.0	6588.5	5989.1	10314.3	7107.6	7561.5	12000.0	9300.0	7831.3
3	8061.0	10738.0	12016.4	10490.5	9316.5	8391.7	7623.6	6529.3	11599.0	9076.3	12000.0	9300.0	9595.1
4	10185.6	11490.9	11816.4	9990.5	9136.5	8331.7	8318.6	15608.4	10809.9	7405.6	12000.0	9300.0	10380.5
5	7076.3	7092.0	11616.4	10190.5	9316.5	8291.7	7938.6	13952.5	10735.5	7967.2	12000.0	9300.0	9635.0
6	7194.8	7955.0	12161.4	10684.5	9716.5	8611.7	7903.6	7859.8	10153.2	10621.7	16276.1	9300.0	9882.5
7	8468.7	9894.0	11416.4	9870.5	9286.5	8451.7	7653.6	14206.8	15256.8	14077.5	15432.0	13410.6	11468.8
8	9376.5	11044.0	12258.4	10590.5	9816.5	8711.7	7903.6	10574.5	12008.4	8109.5	12000.0	12213.0	10384.1
9	11782.5	11948.0	13380.4	10855.5	9623.5	8659.7	8236.6	9746.4	8565.8	7883.0	12000.0	9121.3	10162.0
10	6874.9	6933.2	8170.4	10338.5	9623.5	8491.7	7953.6	12818.1	9828.6	9287.8	16208.8	11843.4	9874.3
11	10128.5	10843.9	12316.4	10735.5	9768.5	8708.7	8003.6	12317.7	7167.0	8286.8	12000.0	9300.0	9978.8
12	8227.4	10993.9	12810.4	11342.5	10070.5	9321.7	9353.6	13838.4	11869.2	9477.6	12000.0	9300.0	10726.1
13	7328.7	10694.0	12216.4	10790.5	9816.5	8911.7	8403.6	9298.8	24151.8	9985.7	14666.9	10429.8	11381.9
14	10293.5	10794.0	12116.4	10490.5	9816.5	8511.7	7533.6	15342.2	10296.0	15148.5	15146.6	9300.0	11263.3
15	7777.9	10244.0	11610.4	9938.5	9282.5	8224.7	7448.6	6061.3	26091.6	7887.3	12000.0	9300.0	10468.3
16	7290.9	6966.6	7678.9	9657.5	9176.5	8411.7	8063.6	9735.6	9469.8	9771.5	12000.0	13506.1	9309.7
17	10775.5	10092.0	11747.4	10290.5	9616.5	8811.7	8478.6	7809.8	13486.7	8261.6	12000.0	9300.0	10056.4
18	6615.5	6902.6	7984.7	10390.5	9716.5	8711.7	7870.6	12066.6	11635.8	10362.9	22704.4	11950.6	10593.9
19	8470.5	10346.9	12171.4	10871.5	10216.5	9411.7	8613.6	12739.5	13601.8	10042.6	12000.0	9300.0	10654.4
20	6581.8	6882.1	7830.0	7838.5	9238.5	8344.7	7725.6	7168.9	7865.7	6851.7	12000.0	9300.0	8128.7
21	6628.8	7003.5	8012.9	7518.2	6586.1	6770.9	5919.8	7271.7	9213.6	8997.1	12000.0	9300.0	7947.1
22	7491.4	7700.8	8481.6	7681.2	6677.7	6847.7	6091.4	6389.6	10484.0	7762.3	13149.0	9300.0	8181.2
23	8728.1	11086.9	12626.4	11129.5	10344.5	9334.7	8413.6	18134.9	16601.7	7692.0	12000.0	9300.0	11289.7
24	6221.8	6864.6	11581.4	10090.5	9516.5	8511.7	7730.6	6206.9	8914.3	6484.0	12000.0	9300.0	8615.7
25	6457.0	6741.5	7724.6	7179.3	6725.3	8235.7	7695.6	12733.3	7948.9	7482.9	12000.0	9300.0	8370.1
26	6551.3	7008.3	8137.7	7574.4	6719.3	6895.6	6120.8	9024.5	13490.5	11080.7	12000.0	9300.0	8671.0
27	9816.0	9987.0	11197.4	9864.5	9266.5	8411.7	8076.6	9568.3	9350.3	6512.6	12000.0	8050.5	9347.6
28	6728.2	7351.4	8392.5	7616.2	6646.5	7982.3	8383.6	9665.2	19061.3	7908.1	12000.0	9300.0	9255.0
29	7469.2	10067.7	12705.4	10919.5	9984.5	9116.7	8405.6	8669.0	6616.9	7243.2	12000.0	9300.0	9378.3
30	7014.9	7274.0	8119.1	7475.8	6537.4	6576.7	5811.1	9810.6	6908.0	11710.4	12000.0	9300.0	8235.0
31	6842.2	11972.1	12532.4	10638.5	9782.5	8911.7	8373.6	8888.2	11112.6	15151.9	12030.3	9300.0	10469.9
32	10320.3	11979.9	11889.5	10344.1	9552.1	8626.0	8071.1	10118.3	6000.0	9792.0	26494.0	10461.1	11172.4
MAX	11782.5	11979.9	13380.4	11342.5	10344.5	9411.7	9353.6	18134.9	26091.6	15151.9	26494.0	13506.1	11468.8
MIN	6221.8	6741.5	7678.9	7179.3	6437.0	6576.7	5811.1	6061.3	6000.0	6484.0	12000.0	8050.5	7831.3
MEAN	8014.0	9185.7	10693.3	9707.8	8951.1	8323.7	7740.1	10404.9	11419.5	9184.6	13378.4	9839.6	9745.4

TABLE 2.25 MONTHLY MAXIMUM, MINIMUM, AND MEAN FLOWS AT GOLD CREEK

MONTH	PRE-PROJECT			POST-PROJECT WATANA ALONE			POST-PROJECT WATANA/DEVIL CANYON		
	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
OCT	8212.0	3124.0	5654.3	11782.5	6221.8	8014.0	10983.0	6453.2	7764.9
NOV	3954.0	1215.0	2476.3	11979.9	6741.5	9185.7	11848.8	7103.9	9630.8
DEC	3264.0	866.0	1788.0	13380.4	7678.9	10693.3	13134.1	8040.5	11270.9
JAN	2452.0	824.0	1465.7	11342.5	7179.3	9707.8	12045.8	7423.9	10596.7
FEB	2028.0	768.0	1242.3	10344.5	6437.0	8951.1	11452.8	6457.3	10190.9
MAR	1900.0	713.0	1114.8	9411.7	6576.7	8323.7	10604.2	6618.1	9285.6
APR	2650.0	745.0	1351.3	9353.6	5811.1	7740.1	9759.4	5950.4	8100.4
MAY	21890.0	3745.0	13276.7	18134.9	6061.3	10404.9	12380.0	6000.0	8706.3
JUN	50580.0	15530.0	28095.1	26091.6	6000.0	11419.5	13305.2	6000.0	9882.9
JUL	34400.0	18093.0	23919.4	15151.9	6484.0	9184.6	11846.2	6484.0	8387.3
AUG	32620.0	16220.0	21726.7	26494.0	12000.0	13378.4	21146.2	12000.0	12633.5
SEP	21240.0	6881.0	13327.2	13506.1	8050.5	9839.6	18330.0	9300.0	10510.3
ANNUAL	11565.2	7200.1	9670.1	11468.8	7831.3	9745.4	11473.3	7776.4	9745.4

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TABLE 2.26 PRE-PROJECT FLOW AT SUNSHINE (cfs)
MODIFIED HYDROLOGY

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1	14003.0	5639.0	3611.0	2748.0	2276.0	2033.0	2311.0	22418.0	45613.0	59179.0	54849.0	27734.0	20347.1
2	12226.0	4712.0	3804.0	2930.0	2435.0	2144.0	3563.0	42196.0	58872.0	69474.0	58356.0	51069.0	26136.1
3	13713.0	5702.0	3782.0	3470.0	2511.0	2282.0	2357.0	11258.0	68738.0	64937.0	53363.0	32057.0	22117.5
4	17394.0	7199.0	4080.0	2818.0	2343.0	2317.0	4292.0	50302.0	64075.0	54231.0	49954.0	33737.0	24544.3
5	13227.0	5092.0	3977.0	3667.0	2889.0	2423.0	3204.0	32595.0	54805.0	53386.0	57701.0	28376.0	21921.8
6	12188.0	6340.0	4313.0	3927.0	3189.0	2577.0	2658.0	21758.0	69686.0	70894.0	77692.0	35385.0	26041.6
7	11011.0	4367.0	3161.0	2612.0	2286.0	2209.0	2244.0	33157.0	73941.0	80569.0	69034.0	44495.0	27588.4
8	15252.0	7029.0	4907.0	4006.0	3471.0	2844.0	2907.0	34140.0	79153.0	62302.0	53243.0	48121.0	26550.7
9	18399.0	9032.0	6139.0	4067.0	2996.0	2643.0	3399.0	27759.0	60752.0	59850.0	56902.0	20098.0	22824.2
10	11578.0	5331.0	3592.0	3387.0	3059.0	2280.0	2895.0	29460.0	64286.0	67521.0	71948.0	36915.0	25345.8
11	15131.0	6415.0	4823.0	4059.0	3201.0	2675.0	2928.0	34802.0	39311.0	58224.0	55315.0	43086.0	22651.3
12	16996.0	6109.0	5504.0	4739.0	3478.0	3480.0	5109.0	32438.0	60886.0	63640.0	60616.0	36071.0	25075.2
13	14579.0	6657.0	4820.0	4222.0	3342.0	2975.0	3581.0	24520.0	87537.0	67756.0	61181.0	38711.0	26766.6
14	13956.0	6052.0	4690.0	4074.0	3621.0	2399.0	2025.0	35245.0	56629.0	78219.0	52938.0	29182.0	24260.8
15	18555.0	5907.0	3533.0	2797.0	2447.0	2013.0	2381.0	8645.0	111073.0	58836.0	46374.0	23267.0	23864.9
16	15473.0	7472.0	4536.0	3373.0	2962.0	2818.0	3435.0	24597.0	58488.0	65042.0	56375.0	53703.0	24971.3
17	18208.0	5321.0	3965.0	3404.0	3009.0	2875.0	3598.0	16479.0	69569.0	55243.0	62007.0	30156.0	22934.7
18	11551.0	4295.0	3856.0	3698.0	3294.0	2793.0	2639.0	32912.0	66162.0	77125.0	82747.0	37379.0	27566.1
19	10706.0	5413.0	4563.0	4181.0	3986.0	3898.0	4359.0	36961.0	76770.0	69735.0	46730.0	20885.0	24149.1
20	10524.0	4481.0	3228.0	2689.0	1731.0	2022.0	2442.0	21306.0	49349.0	48565.0	42970.0	24832.0	17950.7
21	9416.0	3978.0	2848.0	2600.0	2448.0	2382.0	3150.0	35687.0	47602.0	60771.0	54926.0	27191.0	20393.7
22	12264.0	7467.0	4930.0	3325.0	2514.0	2351.0	2640.0	10652.0	76208.0	64787.0	74519.0	32402.0	24629.0
23	14313.0	6745.0	4922.0	4257.0	3801.0	3335.0	3210.0	36180.0	66856.0	62292.0	51254.0	34156.0	24407.1
24	13588.0	6018.0	4030.0	3312.0	2984.0	2646.0	2821.0	18215.0	59933.0	51711.0	51085.0	25238.0	20235.8
25	11284.0	4699.0	3524.0	2882.0	2519.0	2220.0	2916.0	31486.0	43713.0	51267.0	43222.0	29114.0	19195.1
26	12302.0	4938.0	3777.0	3546.0	2990.0	2810.0	3160.0	29380.0	72836.0	75692.0	51678.0	35567.0	25023.2
27	15565.0	4238.0	2734.0	2507.0	2355.0	2281.0	3294.0	22875.0	56366.0	55506.0	52155.0	18502.0	20000.7
28	10620.0	5888.0	5285.0	4231.0	3640.0	3171.0	3537.0	27292.0	87773.0	62194.0	55157.0	32719.0	25221.6
29	17399.0	7130.0	5313.0	4213.0	3227.0	3002.0	3542.0	22707.0	48044.0	57930.0	42118.0	22742.0	19910.2
30	11223.0	5646.0	4308.0	3674.0	3206.0	2963.0	3704.0	33876.0	59849.0	71774.0	48897.0	26790.0	23144.3
MAX	18555.0	9032.0	6139.0	4739.0	3986.0	3898.0	5109.0	50302.0	111073.0	80569.0	82747.0	53703.0	27588.4
MIN	9416.0	3978.0	2734.0	2507.0	1731.0	2013.0	2025.0	8645.0	39311.0	48565.0	42118.0	18502.0	17950.7
MEAN	13754.8	5843.8	4218.5	3513.8	2940.3	2628.7	3143.4	27709.9	64495.8	63288.4	56510.2	32656.0	23525.6

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TABLE 2.27 POST-PROJECT FLOW AT SUNSHINE (cfs)
WATANA ALONE ; CASE C

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1	14947.7	13271.7	13727.4	11638.5	10592.5	9544.7	9014.6	19394.6	34034.8	44603.0	46969.0	28714.6	21460.9
2	14767.8	10245.4	10613.8	9311.9	8052.0	7992.5	7935.1	38420.3	45189.6	54465.5	50686.0	39129.0	24861.4
3	16203.0	13696.0	13898.4	12360.5	10827.5	9793.7	9060.6	12368.3	47966.9	47623.3	44483.0	26877.0	22160.5
4	19377.6	15192.9	14196.4	11708.5	10659.5	9828.7	10995.6	46640.4	47564.8	41436.6	41344.0	27767.0	24834.4
5	14699.3	10084.0	14093.4	12557.5	11205.5	9934.7	9907.6	29267.5	40290.5	40993.2	43601.0	24756.0	21875.2
6	14012.8	11535.0	14429.4	12817.5	11505.5	10088.7	9361.6	20298.8	49979.2	53955.7	68218.1	30395.0	25667.8
7	14528.7	12361.0	13277.4	11502.5	10602.5	9720.7	8947.6	29703.8	55857.8	63556.4	59936.0	39575.6	27583.9
8	18822.5	15023.0	15023.4	12896.5	11787.5	10355.7	9610.6	30964.5	61001.4	47101.5	44703.0	40534.0	26550.7
9	21969.5	17026.0	16255.4	12957.5	11312.5	10154.7	10102.6	24605.4	43617.8	44853.0	46362.0	21669.3	23509.9
10	13641.9	10114.2	10249.4	12277.5	11375.5	9791.7	9598.6	26288.1	50794.6	51808.8	56976.8	31838.4	24660.1
11	18701.5	14408.9	14939.4	12949.5	11517.5	10186.7	9631.6	31339.7	30948.0	43530.8	43725.0	31876.0	22917.7
12	17429.4	14102.9	15620.4	13629.5	11794.5	10991.7	11812.6	28916.4	43305.2	48547.6	50516.0	32001.0	24992.0
13	15991.7	14651.0	14936.4	13112.5	11658.5	10486.7	10284.6	21228.8	68418.8	51891.7	52297.9	33250.8	26583.3
14	17526.5	14046.0	14806.4	12964.5	11937.5	9910.7	8728.6	31557.2	40925.0	58967.5	44414.6	26162.0	24451.1
15	19883.9	13901.0	13649.4	11687.5	10763.5	9524.7	9084.6	10399.3	86584.6	43773.3	41934.0	22996.0	24533.6
16	16472.9	11639.6	11003.9	12070.5	11278.5	10329.7	10138.6	21342.6	42237.8	46973.5	47255.0	47859.1	24112.2
17	21778.5	13315.0	14081.4	12294.5	11325.5	10386.7	10301.6	14643.8	50105.7	43644.6	52177.0	27706.0	23559.4
18	14003.5	9597.6	10340.7	12588.5	11610.5	10304.7	9342.6	29498.6	48287.8	60687.9	72831.4	32459.6	26941.5
19	14276.5	13406.9	14679.4	13071.5	12302.5	11409.7	11062.6	33520.5	58821.8	53357.6	41560.0	21369.0	24992.9
20	12833.8	9457.1	9728.0	9441.5	10047.5	9533.7	9145.6	18622.9	36691.7	37323.7	38648.0	24356.0	18879.2
21	12920.8	9766.5	9994.9	9294.2	8266.1	8376.9	7989.8	21578.7	38185.6	47108.1	46946.0	27370.0	20749.6
22	14467.4	11760.8	11121.6	9564.2	8155.7	8248.7	7649.4	13296.6	53762.0	48599.3	55758.0	27262.0	22559.2
23	17194.1	14738.9	15038.4	13147.5	12117.5	10846.7	9913.6	32424.9	49027.7	47214.0	43964.0	31056.0	24811.2
24	14983.8	10629.6	14146.4	12202.5	11300.5	10157.7	9524.6	16186.9	41047.3	39945.0	42795.0	25464.0	20765.2
25	14008.0	9917.5	10214.6	9187.3	8467.3	9731.7	9619.6	28039.3	33791.9	39949.9	39002.0	26164.0	19934.2
26	15114.3	10246.3	10311.7	9604.4	8238.3	8305.6	7687.8	23054.5	54016.5	59052.7	45588.0	28557.0	23418.8
27	17642.0	12232.0	12850.4	11397.5	10671.5	9792.7	9997.6	19823.3	41336.3	43078.6	44355.0	19671.5	21159.0
28	13474.2	10589.4	11274.5	10018.2	8668.5	9653.3	10240.6	24277.2	68864.3	47232.1	47917.0	27379.0	24367.6
29	17297.2	13672.7	15429.4	13103.5	11543.5	10513.7	10245.6	19426.0	35610.9	44153.2	37728.0	23435.0	21094.0
30	13330.9	10387.0	10746.1	9752.8	8457.4	8339.7	8065.1	29816.6	42067.0	54604.3	40437.0	25320.0	21889.9
MAX	21969.5	17026.0	16255.4	13629.5	12302.5	11409.7	11812.6	46640.4	86584.6	63556.4	72831.4	47859.1	27583.9
MIN	12833.8	9457.1	9728.0	9187.3	8052.0	7992.5	7649.4	10399.3	30948.0	37323.7	37728.0	19671.5	18879.2
MEAN	16076.7	12367.2	13022.6	11703.7	10601.4	9807.9	9500.0	24898.2	48011.1	48334.4	47769.6	29165.7	23529.2

TABLE 2.28 PRE-PROJECT FLOW AT SUSITNA (cfs)
MODIFIED HYDROLOGY

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1	26869.4	11367.1	6197.0	6071.9	5255.5	5376.7	5656.9	66293.5	101615.7	124889.8	106431.8	39331.2	42444.7
2	18026.1	6932.8	5980.9	7073.6	7294.9	6381.5	7354.2	59272.5	82254.6	123164.1	100946.9	73471.0	41783.1
3	31052.6	16363.8	6988.5	8274.3	7036.4	5853.0	5985.1	45294.3	132547.3	137321.8	116186.1	82076.3	49825.4
4	44952.4	16289.1	9746.0	8068.7	6774.5	6349.8	7992.6	88840.0	130561.3	125949.2	97610.0	44167.7	49279.5
5	20168.5	11829.1	5271.6	7202.0	4993.1	4979.7	6305.5	58516.4	108881.0	116731.6	128586.7	66275.3	45270.4
6	23895.7	9167.8	6183.0	7254.6	5845.1	5315.6	6412.4	58164.0	169044.8	148876.5	120120.0	53504.2	51429.1
7	19923.4	10521.9	7294.7	6179.2	6830.8	6324.4	7182.2	82485.8	161346.1	168814.6	131619.5	104218.4	59701.9
8	41821.6	21547.5	14146.3	10600.1	8356.1	7353.1	7705.3	63204.4	176218.8	140318.3	124812.9	87825.0	58911.9
9	52636.0	19886.6	10635.3	7552.9	6386.9	6678.8	8098.6	70320.5	112896.8	122280.2	99608.5	53053.3	47830.1
10	30543.1	9528.4	4763.4	7795.1	6564.3	5665.5	6467.8	56601.4	110602.3	146216.8	138334.3	67903.5	49606.5
11	25754.1	10164.5	7004.6	6716.3	6310.0	5651.4	5829.6	50061.6	84134.4	129403.4	113971.6	81565.4	44172.5
12	33782.3	12914.2	13768.2	12669.1	10034.0	9192.6	9802.6	85456.7	151715.1	138968.5	116696.5	62504.3	55111.2
13	29028.7	13043.3	8976.6	9050.1	6182.5	5950.6	6635.2	54553.8	163049.0	143441.3	121220.5	74806.4	53254.8
14	27716.2	10754.5	8864.6	8670.7	7853.6	6058.1	5564.7	53903.2	85647.9	146420.1	106706.8	70782.4	45235.4
15	37846.3	11701.6	5626.0	6351.1	5761.6	4910.4	5530.8	35536.2	153126.4	124805.8	92379.5	46109.8	44338.1
16	28746.9	10458.0	6126.6	6951.9	6195.8	6169.9	7120.1	49485.4	110074.6	138406.5	111845.9	89944.3	47893.5
17	36553.2	12312.5	9159.3	8030.8	7489.4	7090.5	8048.3	52311.4	125182.8	117607.4	118729.3	63887.3	47470.1
18	26396.2	12962.6	8321.9	8028.5	7726.1	6683.2	7280.6	58106.6	134880.9	136306.3	137318.0	89527.0	53073.6
19	37724.5	15872.8	15081.0	11604.2	11532.2	8772.0	8762.6	94143.2	137867.2	130513.6	86874.5	42384.8	50399.0
20	26322.5	11086.4	7194.5	6924.0	6163.5	5535.3	6112.0	52954.0	108336.2	115547.9	97076.0	57771.6	41999.8
21	22683.4	6799.3	5016.4	6074.2	5581.3	5731.6	5769.1	53036.2	94612.1	132984.7	117728.0	80584.8	45014.0
22	32817.3	16607.2	8633.2	6508.7	6253.8	5882.6	5787.5	29809.3	122258.2	139183.4	133310.1	69021.2	48289.9
23	32763.2	14921.9	8790.8	9379.7	8458.3	6645.8	6894.9	74062.0	176023.9	142786.8	107596.6	60220.4	54303.3
24	26781.9	14852.9	8147.1	7609.2	7476.7	6312.6	7688.2	64534.0	122797.1	123362.2	107260.8	45226.8	45453.5
25	20975.7	10113.3	6081.0	7401.6	6747.3	6293.7	6962.8	61457.8	67838.0	102184.3	80251.5	56123.5	36285.1
26	19520.0	10400.0	9419.0	8597.0	7804.0	7048.0	6867.0	47540.0	128800.2	135700.0	91360.1	77740.1	46102.6
27	31550.0	9933.0	6000.0	6529.0	5614.0	5368.0	7253.0	70460.1	107000.0	115200.1	99650.1	48910.0	43089.2
28	30140.0	18270.0	13100.0	10100.0	8911.0	6774.0	6233.0	56180.0	165900.3	143900.0	125500.1	83810.1	55979.3
29	38230.0	12630.0	7529.0	6974.0	6771.0	6590.0	7033.0	48670.0	90930.0	117600.1	102100.2	55500.0	42002.4
30	36810.0	15000.0	9306.0	8823.0	7946.0	7032.0	8683.0	81260.1	119900.0	142500.0	128200.0	74340.0	53676.8
MAX	52636.0	21547.5	15081.0	12669.1	11532.2	9192.6	9802.6	94143.2	176218.8	168814.6	138334.3	104218.4	59701.9
MIN	18026.1	6799.3	4763.4	6071.9	4993.1	4910.4	5530.8	29809.3	67838.0	102184.3	80251.5	39331.2	36285.1
MEAN	30401.0	12807.7	8311.8	7968.9	7071.7	6332.3	6967.3	60750.5	124534.8	132379.5	111997.7	66752.9	48307.6

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TABLE 2.29 POST-PROJECT FLOW AT SUSITNA (cfs)
WATANA ALONE ; CASE C

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1	27814.1	18999.8	16313.4	14962.4	13572.0	12888.4	12360.5	63270.1	90037.5	110313.8	98551.8	40311.8	43558.5
2	20567.9	12466.2	12790.7	13455.5	12911.9	12230.0	11726.3	55496.8	68572.2	108155.6	93276.9	61531.0	40508.4
3	33542.6	24357.8	17104.9	17164.8	15352.9	13364.7	12688.7	46404.6	111776.2	120008.1	107266.1	76896.3	49868.4
4	46936.0	24283.0	19862.4	16959.2	15091.0	13861.5	14696.2	85178.4	114051.1	113154.8	89000.0	38197.7	49569.6
5	21640.8	16821.1	15388.0	16092.5	13309.6	12491.4	13009.1	55188.9	94366.5	104338.8	114486.7	62655.3	45223.8
6	25720.5	14362.8	16299.4	16145.1	14161.6	12827.3	13116.0	56704.8	149338.0	131938.2	110646.1	48514.2	51055.3
7	23441.1	18515.9	17411.1	15069.7	15147.3	13836.1	13885.8	79032.6	143262.9	151802.0	122521.5	99299.0	59697.5
8	45392.1	29541.5	24262.7	19490.6	16672.6	14864.8	14408.9	60028.9	158067.2	125117.8	116272.9	80238.0	58911.8
9	56206.5	27880.6	20751.7	16443.4	14703.4	14190.5	14802.2	67166.9	95762.6	107283.2	89068.5	54624.6	48515.7
10	32607.0	14311.6	11420.8	16685.6	14880.8	13177.2	13171.4	53429.5	97110.9	130504.6	123363.1	62826.9	48920.8
11	29324.6	18158.4	17121.0	15606.8	14626.5	13163.1	12533.2	46599.3	75771.4	114710.2	102381.6	70355.4	44438.9
12	34215.7	20908.1	23884.6	21559.6	18350.5	16704.3	16506.2	81935.1	134134.3	123876.1	106596.5	58434.3	55028.0
13	30441.4	21037.3	19093.0	17940.6	14499.0	13462.3	13338.8	51262.6	143930.8	127577.0	112337.4	69346.2	53071.5
14	31286.7	18748.5	18981.0	17561.2	16170.1	13569.8	12268.3	50215.4	69943.9	127168.6	98183.4	67762.4	45425.8
15	39175.2	19695.6	15742.4	15241.6	14078.1	12422.1	12234.4	37290.5	128638.0	109743.1	87839.5	45838.8	45006.8
16	29746.8	14625.6	12594.5	15649.4	14512.3	13681.6	13823.7	46231.0	93824.4	120338.0	102725.9	84100.4	47034.4
17	40123.7	20306.5	19275.7	16921.3	15805.9	14602.2	14751.9	50476.2	105719.5	106009.0	108899.3	61437.3	48094.7
18	28848.7	18265.2	14806.6	16919.0	16042.6	14194.9	13984.2	54693.2	117006.7	119869.2	127402.4	84607.6	52448.9
19	41295.0	23866.7	25197.4	20494.7	19848.7	16283.7	15466.2	90702.7	119919.0	114136.2	81704.5	42868.8	51242.8
20	28632.3	16062.5	13694.5	13676.5	14480.0	13047.0	12815.6	50270.9	95678.9	104306.6	92754.0	57295.6	42928.4
21	26188.2	12587.8	12163.3	12768.4	11399.4	11726.5	10608.9	48927.9	85195.7	119321.8	109748.0	80763.8	45370.0
22	35020.7	20901.0	14824.8	12747.9	11895.5	11780.3	10796.9	32453.9	99812.2	122995.7	114549.1	[illegible]3881.2	46220.2
23	35644.3	22915.8	18907.2	18270.2	16774.8	14157.5	13598.5	70306.9	158195.6	127708.8	100306.6	57120.4	54709.5
24	28177.7	19464.5	18263.5	16499.7	15793.2	13824.3	14391.8	62505.9	103911.4	111596.2	98970.8	45452.8	45983.0
25	23699.7	15331.8	12771.6	13706.9	12695.6	13805.4	13656.4	58011.1	57916.9	90867.2	76031.5	53173.5	37024.2
26	22332.3	15708.3	15953.7	14655.4	13052.3	12543.6	11394.8	41214.5	109980.7	119060.7	85270.1	70730.1	44498.1
27	33627.0	17927.0	16116.4	15419.5	13930.5	12879.7	13956.6	67408.4	91970.3	102772.7	91850.1	50079.5	44247.5
28	32994.2	22971.4	19089.5	15887.2	13939.5	13256.3	12936.6	53165.2	146991.6	128938.1	118260.1	80470.1	55125.2
29	38128.2	19172.7	17645.4	15864.5	15087.5	14101.7	13736.6	45389.0	78496.9	103823.3	97710.2	56193.0	43186.2
30	38917.9	19739.0	15744.1	14901.8	13197.4	12408.7	13044.1	77200.7	102118.0	125330.3	119740.0	72870.0	52422.5
MAX	56206.5	29541.5	25197.4	21559.6	19848.7	16704.3	16506.2	90702.7	158195.6	151802.0	127402.4	99299.0	59697.5
MIN	20567.9	12466.2	11420.8	12747.9	11399.4	11726.5	10608.9	32453.9	57916.9	90867.2	76031.5	38197.7	37024.2
MEAN	32723.0	19331.1	17115.8	16158.7	14732.8	13511.6	13324.0	57938.7	108050.0	117425.5	103257.1	63262.5	48311.2

TABLE 2.30 MONTHLY MAXIMUM, MINIMUM, AND MEAN FLOWS AT SUNSHINE

MONTH	PRE-PROJECT			POST-PROJECT WATANA ALONE			POST-PROJECT WATANA/DEVIL CANYON		
	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
OCT	18555.0	9416.0	13754.8	21969.5	12833.8	16076.7	21536.9	13141.6	15868.7
NOV	9032.0	3978.0	5843.8	17026.0	9457.1	12367.2	16926.8	9753.6	12948.4
DEC	6139.0	2734.0	4218.5	16255.4	9728.0	13022.6	16009.1	9989.0	13608.6
JAN	4739.0	2507.0	3513.8	13629.5	9187.3	11703.7	14332.8	9383.1	12569.7
FEB	3986.0	1731.0	2940.3	12302.5	8052.0	10601.4	13402.5	8133.9	11818.5
MAR	3898.0	2013.0	2628.7	11409.7	7992.5	9807.9	12508.0	8035.9	10722.5
APR	5109.0	2025.0	3143.4	11812.6	7649.4	9500.0	12218.4	7508.4	9820.8
MAY	50302.0	8645.0	27709.9	46640.4	10399.3	24898.2	42287.3	10338.0	23217.5
JUN	111073.0	39311.0	64495.8	86584.6	30948.0	48011.1	73798.2	30357.5	46332.3
JUL	80569.0	48565.0	63288.4	63556.4	37323.7	48334.4	60567.5	36956.0	47622.6
AUG	82747.0	42118.0	56510.2	72831.4	37728.0	47769.6	65318.8	37728.0	47154.4
SEP	53703.0	18502.0	32656.0	47859.1	19671.5	29165.7	44997.5	20921.0	29790.7
ANNUAL	27588.4	17950.7	23525.6	27583.9	18879.2	23529.2	27588.4	19068.6	23538.0

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TABLE 2.31 MONTHLY MAXIMUM, MINIMUM, AND MEAN FLOWS AT SUSITNA

MONTH				POST-PROJECT					
	PRE-PROJECT			WATANA ALONE			WATANA/DEVIL CANYON		
	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
OCT	52636.0	18026.1	30401.0	56206.5	20567.9	32723.0	55407.0	20926.6	32514.9
NOV	21547.5	6799.3	12807.7	29541.5	12466.2	19331.1	30171.3	12773.9	19912.3
DEC	15081.0	4763.4	8311.8	25197.4	11420.8	17115.8	25763.1	11432.2	17701.8
JAN	12669.1	6071.9	7968.9	21559.6	12747.9	16158.7	22262.9	12763.8	17024.7
FEB	11532.2	4993.1	7071.7	19848.7	11399.4	14732.8	20933.1	11427.2	15949.8
MAR	9192.6	4910.4	6332.3	16701.3	11726.5	13511.6	17986.8	11699.0	14426.2
APR	9802.6	5530.8	6967.3	16506.2	10608.9	13324.0	16912.0	10655.9	13644.7
MAY	94143.2	29809.3	60750.5	90702.7	32453.9	57938.7	88615.3	32626.2	56258.1
JUN	176218.8	67838.0	124534.8	158195.6	57916.9	108050.0	157474.1	57089.1	106371.2
JUL	168814.6	102184.3	132379.5	151802.0	90867.2	117425.5	148813.1	90191.2	116713.7
AUG	138334.3	80251.5	111997.7	127402.4	76031.5	103257.1	120709.4	76031.5	102641.9
SEP	104218.4	39331.2	66752.9	99299.0	38197.7	63262.5	104218.4	38197.7	63887.6
ANNUAL	59701.9	36285.1	48307.6	59697.5	37024.2	48311.2	59701.9	36786.6	48320.0

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TABLE 2.32 PRE-PROJECT FLOW AT WATANA (cfs)
MODIFIED HYDROLOGY

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1	4719.9	2083.6	1168.9	815.1	641.7	569.1	680.1	8655.9	16432.1	19193.4	16913.6	7320.4	6648.1
2	3299.1	1107.3	906.2	808.0	673.0	619.8	1302.2	11649.8	18517.9	19786.6	16478.0	17205.5	7733.7
3	4592.9	2170.1	1501.0	1274.5	841.0	735.9	803.9	4216.5	25773.4	22110.9	17356.3	11571.0	7776.7
4	6285.7	2756.8	1281.2	818.9	611.7	670.7	1382.0	15037.2	21469.8	17355.3	16681.6	11513.5	8035.2
5	4218.9	1599.6	1183.8	1087.8	303.1	638.2	942.6	11696.8	19476.7	16983.6	20420.6	9165.5	7400.4
6	3859.2	2051.1	1549.5	1388.3	1050.5	886.1	940.8	6718.1	24881.4	23787.9	23537.0	13447.8	8719.3
7	4102.3	1588.1	1038.6	816.9	754.8	694.4	718.3	12953.3	27171.8	25831.3	19153.4	13194.4	9051.0
8	4208.0	2276.6	1707.0	1373.0	1189.0	935.0	945.1	10176.2	25275.0	19948.9	17317.7	14841.1	8381.0
9	6034.9	2935.9	2258.5	1480.6	1041.7	973.5	1265.4	9957.8	22097.8	19752.7	18843.4	5978.7	7769.4
10	3668.0	1729.5	1115.1	1081.0	949.0	694.0	885.7	10140.6	18329.6	20493.1	23940.4	12466.9	8011.0
11	5165.5	2213.5	1672.3	1400.4	1138.9	961.1	1069.9	13044.2	13233.4	19506.1	19323.1	16085.6	7954.0
12	6049.3	2327.8	1973.2	1779.9	1304.8	1331.0	1965.0	13637.9	22784.1	19839.8	19480.2	10146.2	8602.9
13	4637.6	2263.4	1760.4	1608.9	1257.4	1176.8	1457.4	11333.5	36017.1	23443.7	19887.1	12746.2	9832.9
14	5560.1	2508.9	1708.9	1308.9	1184.7	883.6	776.6	15299.2	20663.4	28767.4	21011.4	10800.0	9277.7
15	5187.1	1789.1	1194.7	852.0	781.6	575.2	609.2	3578.8	42841.9	20082.8	14048.2	7524.2	8262.7
16	4759.4	2368.2	1070.3	863.0	772.7	807.3	1232.4	10966.0	21213.0	23235.9	17394.1	16225.6	8451.5
17	5221.2	1565.3	1203.6	1060.4	984.7	984.7	1338.4	7094.1	25939.6	16153.5	17390.9	9214.1	7374.4
18	3269.8	1202.2	1121.6	1102.2	1031.3	889.5	849.7	12555.5	24711.9	21987.3	26104.5	13672.9	9095.7
19	4019.0	1934.3	1704.2	1617.6	1560.4	1560.4	1576.7	12826.7	25704.0	22082.8	14147.5	7163.6	8032.2
20	3447.0	1567.0	1073.0	884.0	748.0	686.0	850.0	7942.0	17509.0	15871.0	14078.0	8150.0	6100.4
21	2403.1	1020.9	709.3	636.2	602.1	624.1	986.4	9536.4	14399.0	18410.1	16263.8	7224.1	6114.6
22	3768.0	2496.4	1687.4	1097.1	777.4	717.1	813.7	2857.2	27612.8	21126.4	27446.6	12188.9	8588.5
23	4979.1	2587.0	1957.4	1670.9	1491.4	1366.0	1305.4	15973.1	27429.3	19820.3	17509.5	10955.7	8963.4
24	4301.2	1977.9	1246.5	1031.5	1000.2	873.9	914.1	7287.0	23859.3	16351.1	18016.7	8099.7	7112.0
25	3056.5	1354.7	931.6	786.4	689.9	627.3	871.9	12889.0	14780.6	15971.9	13523.7	9786.2	6313.7
26	3088.8	1474.4	1276.7	1215.8	1110.3	1041.4	1211.2	11672.2	26689.2	23430.4	15126.6	13075.3	8402.7
27	5679.1	1601.1	876.2	757.8	743.2	690.7	1059.8	8938.8	19994.0	17015.3	18393.5	5711.5	6834.8
28	2973.5	1926.7	1687.5	1348.7	1202.9	1110.8	1203.4	8569.4	31352.8	19707.3	16807.3	10613.1	8232.6
29	5793.9	2645.3	1979.7	1577.9	1267.7	1256.7	1408.4	11231.5	17277.2	18385.2	13412.1	7132.6	6992.2
30	3773.9	1944.9	1312.6	1136.8	1055.4	1101.2	1317.9	12369.3	22904.8	24911.7	16670.7	9096.7	8183.7
31	6150.0	3525.0	2032.0	1470.0	1233.0	1177.0	1404.0	10140.0	23400.0	26740.0	18000.0	11000.0	8907.9
32	6458.0	3297.0	1385.0	1147.0	971.0	889.0	1103.0	10406.0	17017.0	27840.0	31435.0	12026.0	9580.4
MAX	6458.0	3525.0	2258.5	1779.9	1560.4	1560.4	1965.0	15973.1	42841.9	28767.4	31435.0	17205.5	9832.9
MIN	2403.1	1020.9	709.3	636.2	602.1	569.1	609.2	2857.2	13233.4	15871.0	13412.1	5711.5	6100.4
MEAN	4522.8	2059.1	1414.8	1165.5	983.3	898.3	1099.7	10354.7	23023.7	20810.1	18628.5	10792.0	8023.0

TABLE 2.35 POST-PROJECT FLOW AT DEVIL CANYON (cfs)
WATANA /DEVIL CANYON : CASE C

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1	6602.4	10756.1	12488.2	11574.6	10879.8	8809.3	7405.0	6305.0	6047.5	5989.5	5987.9	8177.1	8401.8
2	12252.9	7072.3	8065.7	7443.3	6471.5	6589.0	7026.2	7913.0	5743.6	5714.3	6046.0	9532.7	7499.2
3	9690.7	10219.4	12532.8	11610.6	11123.8	9801.3	7481.3	5765.5	7439.4	6379.7	7461.0	7630.4	8918.0
4	10493.0	11392.6	12518.4	11589.2	11137.2	9923.2	8134.6	9750.1	9980.3	5760.1	6293.2	6607.4	9456.0
5	12368.3	7062.3	11783.4	11239.8	10909.5	8868.7	7733.4	9876.4	7023.5	5950.4	6914.4	6537.5	8858.1
6	11179.8	7139.0	12568.9	11637.5	11186.2	10453.1	7710.2	6222.3	8382.9	7553.6	8438.2	13007.4	9616.6
7	7623.3	11012.4	12485.2	11560.4	10872.9	8991.6	7470.1	9907.0	10079.3	9210.5	11699.7	16495.8	10608.2
8	8210.7	11404.3	12527.7	11605.1	11167.2	10364.0	8736.0	7279.6	9677.4	5931.7	7193.3	12179.6	9668.7
9	10205.5	11485.2	12775.0	11624.3	11113.1	10320.3	9369.8	7950.9	7940.7	5865.2	6794.4	6863.3	9349.4
10	12408.6	7079.9	8039.7	9862.0	11158.9	9017.2	7722.7	8638.5	6640.4	6339.8	10204.2	13012.6	9166.9
11	9036.1	11356.4	12561.2	11646.1	11168.3	10355.1	8767.2	9260.3	5749.6	6024.0	6443.2	6853.5	9094.8
12	11458.3	10500.5	12635.8	11805.8	11292.4	10433.1	9514.8	9570.9	10254.5	7147.3	8582.9	6967.0	10010.8
13	10242.2	9900.3	12566.1	11597.4	11147.6	10353.0	9101.7	6904.7	10414.4	8172.5	16223.3	14767.2	10946.5
14	9283.1	11235.5	12476.8	11592.5	11168.9	10314.7	8306.9	9585.2	9808.2	9378.0	10306.2	11777.2	10431.8
15	8973.7	11309.2	12498.3	11568.9	11118.3	8803.1	7299.3	5610.6	10681.9	8342.2	8465.0	6479.3	9250.7
16	11462.0	9034.9	12443.5	11559.9	10808.6	9006.2	7917.2	7043.1	7634.2	7546.9	7797.5	12496.3	9555.5
17	9471.9	11131.6	12542.6	11617.6	11180.8	9828.6	8221.9	6206.0	10402.5	6056.7	6477.6	6565.4	9125.9
18	12312.6	7070.6	8036.4	9555.7	11248.1	9228.4	7656.5	9024.1	9647.2	8122.5	12864.8	15728.2	10031.5
19	7560.7	11280.2	12611.8	11621.8	11179.6	10388.7	9399.6	9454.5	9988.1	8922.8	5956.0	7942.7	9680.4
20	12294.1	7055.6	7998.0	8703.6	10838.8	8919.3	7561.8	5988.5	5991.7	5588.0	5757.2	8520.2	7918.0
21	12364.1	7143.0	8140.1	7540.0	6554.6	6689.2	5160.6	7426.7	6448.9	6324.6	6302.5	7248.0	7293.0
22	12672.8	7399.5	8285.0	7573.9	6563.5	6686.7	5854.6	5194.9	7881.1	5742.0	9253.2	10446.7	7805.2
23	8512.4	11310.7	12564.7	11665.0	11214.5	10417.7	9414.3	10266.8	10319.6	8408.5	8263.0	10142.1	10199.0
24	8052.8	10925.2	12470.4	11559.3	11142.7	9477.8	7589.5	5682.3	6871.3	5451.0	5842.5	8952.0	8648.6
25	12279.3	7043.8	8003.9	7392.6	6426.2	8067.3	7551.9	9442.6	6011.0	5796.9	5918.7	7818.5	7662.0
26	12318.1	7119.5	8152.2	7527.7	6568.9	6690.3	5853.2	8173.9	9921.7	8905.6	7518.0	9416.0	8194.8
27	9978.7	11076.8	12465.6	11356.3	10856.0	8964.5	7864.0	6575.2	6444.8	5463.2	6130.6	8802.3	8824.6
28	12380.2	7257.3	8235.9	7536.0	6538.8	9075.6	8112.6	6715.4	10235.4	8499.0	8549.6	6491.5	8319.8
29	11321.0	10978.4	12597.1	11649.5	11197.4	10391.1	9388.6	6723.3	5579.5	5721.3	5989.2	7995.1	9117.7
30	12486.4	7228.4	8140.7	7489.2	6504.2	6582.8	7318.3	7986.2	7605.9	8592.4	7508.9	6047.6	7809.6
31	12392.2	8885.1	12519.0	11590.6	11142.6	10351.8	9255.8	6238.7	9481.9	9194.7	8848.7	8376.9	9855.3
32	10221.4	11352.5	12458.0	11592.9	11121.6	10331.1	8858.2	6509.5	5366.9	8407.1	17878.2	12762.0	10577.9
MAX	12672.8	11485.2	12775.0	11805.8	11292.4	10453.1	9514.8	10266.8	10681.9	9378.0	17878.2	16495.8	10946.5
MIN	6602.4	7043.8	7998.0	7392.6	6426.2	6582.8	5160.6	5194.9	5366.9	5451.0	5757.2	6047.6	7293.0
MEAN	10565.9	9444.3	11130.9	10484.0	10093.8	9202.9	7961.2	7662.2	8178.0	7078.2	8247.2	9469.0	9121.8

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TABLE 2.37 MONTHLY MAXIMUM, MINIMUM, AND MEAN FLOWS AT DEVIL CANYON

MONTH				POST-PROJECT					
	PRE-PROJECT			WATANA ALONE			WATANA/DEVIL CANYON		
	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
OCT	7517.6	2866.5	5324.3	11005.0	6034.4	7567.6	12672.8	6602.4	10565.9
NOV	3955.0	1145.7	2390.8	11735.1	6681.4	8999.4	11485.2	7043.8	9444.3
DEC	2904.9	810.0	1664.5	13021.3	7628.7	10550.6	12775.0	7998.0	11130.9
JAN	2212.0	756.9	1362.1	11102.5	7148.0	9595.7	11805.8	7392.6	10484.0
FEB	1836.4	708.7	1152.5	10152.9	6384.5	8854.5	11292.4	6426.2	10093.8
MAR	1778.7	663.8	1042.1	9290.4	6541.4	8242.1	10453.1	6582.8	9202.9
APR	2405.4	696.5	1267.0	9109.0	5763.9	7645.4	9514.8	5160.6	7961.2
MAY	19776.8	3427.9	12190.3	16021.7	5801.2	9355.2	10266.8	5194.9	7662.2
JUN	47816.4	14709.8	26078.1	23328.0	5598.0	9682.7	10681.9	5366.9	8178.0
JUL	32388.4	17291.0	23152.2	13136.9	5805.8	7891.7	9378.0	5451.0	7078.2
AUG	35270.0	15257.0	20928.2	23226.0	9971.6	12078.5	17878.2	5757.2	8247.2
SEP	19799.1	6463.3	12413.6	12390.3	7632.8	8932.3	16495.8	6047.6	9460.0
ANNUAL	10946.5	6800.1	9129.7	10763.2	7341.2	9121.8	10946.5	7293.0	9121.8

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TABLE 2.38 POST-PROJECT FLOW AT SUNSHINE (cfs)
WATANA/DEVIL CANYON ; CASE C

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1	14847.2	13990.4	14750.2	13371.3	12427.3	10172.3	8913.8	18232.3	33191.9	43785.1	46969.0	28733.0	21695.3
2	15126.5	10553.1	10838.9	9467.6	8139.0	8035.9	9084.6	36890.5	44637.1	53612.4	50686.0	39129.0	24806.6
3	14981.1	13389.1	14550.8	13596.9	12691.6	11261.6	8959.8	12034.0	46163.2	46448.5	44443.0	26877.0	22174.9
4	16499.4	15352.3	15048.0	13407.6	12734.6	11480.0	10894.8	42287.3	48824.6	40807.1	41344.0	27767.0	24791.3
5	14874.7	10239.7	14373.3	13682.6	12868.8	10562.3	9806.8	27185.4	38640.4	40182.4	43601.0	24756.0	21813.5
6	14104.5	10972.2	15007.4	13915.4	13100.0	12013.0	9260.8	19590.2	49987.0	52228.3	63942.0	31539.4	25573.7
7	13992.9	13590.8	14433.1	13257.2	12265.8	10348.3	8846.8	27078.5	52883.2	60567.5	58123.9	44495.0	27588.4
8	18233.9	15652.8	15448.1	14027.9	13249.3	12102.6	10540.8	28946.0	60408.3	46124.1	44703.0	38493.8	26550.7
9	21170.0	16926.8	16009.1	13899.3	12896.9	11877.6	11331.4	23867.2	44279.2	43952.1	46362.0	21848.0	23791.6
10	13883.3	10411.1	10260.8	11932.1	13038.8	10419.3	9497.8	24197.6	49388.7	50470.4	53551.3	34598.0	24378.4
11	18112.9	15142.0	15372.7	14018.9	13029.1	11917.3	10484.2	29252.9	30357.5	42508.7	43725.0	31876.0	23076.1
12	16405.6	13856.3	15696.7	14332.8	13176.8	12274.2	12218.4	25978.2	44071.2	47906.7	50516.0	32001.0	24958.3
13	15736.8	14019.9	15400.9	14023.4	13076.2	12007.7	11076.0	19283.5	57265.0	50937.9	55162.5	38711.0	26458.7
14	16937.9	14584.8	15270.8	14170.5	13402.5	11755.3	9527.7	27126.1	42343.1	55208.6	41268.0	28412.9	24260.8
15	21536.9	15130.8	14637.7	13387.9	12672.3	10152.3	8983.8	10338.0	73798.2	45252.2	41934.0	22976.0	24264.4
16	16487.8	13868.6	15812.2	14014.1	12941.8	10957.3	10037.8	19373.0	42011.9	46386.7	47255.0	44997.5	24571.8
17	21189.9	14544.8	15022.7	13742.9	13002.4	11522.7	10200.8	13951.0	49518.5	42763.5	52177.0	27706.0	23848.3
18	14319.1	9907.7	10527.5	11895.8	13273.8	10932.3	9241.8	27500.6	48006.1	60166.3	65318.8	37379.0	26652.5
19	13687.9	14483.0	15245.1	13951.6	13386.9	12508.0	11967.6	31433.1	57296.0	53786.8	41560.0	21369.0	25138.8
20	13141.6	9753.6	9989.0	10380.6	11710.8	10161.3	9044.8	18140.5	35919.7	36956.0	38648.0	24356.0	19068.6
21	13213.1	9975.3	10178.1	9383.1	8293.9	8349.4	8647.8	21053.0	36932.0	45953.4	46946.0	27370.0	20622.9
22	14491.1	11784.7	11140.2	9580.1	8133.9	8170.9	7508.4	13468.9	51973.2	47587.4	54609.0	28014.8	22292.2
23	17294.9	15136.7	15174.1	13885.9	13179.1	12092.9	11058.8	26670.0	45245.8	48984.0	43964.0	31056.0	24558.8
24	15215.2	14795.1	15106.9	13731.5	12998.1	11175.3	9423.8	16000.9	40411.7	39945.0	42795.0	25464.0	21479.0
25	14371.4	10279.9	10530.5	9431.9	8199.3	9597.8	9518.8	25917.5	32964.1	39273.9	39002.0	26164.0	19696.6
26	15412.9	10438.1	10442.7	9664.9	8216.7	8228.4	7556.5	23517.4	52448.4	58409.6	45508.0	28557.0	23313.0
27	16353.6	13461.8	14185.2	12973.0	12334.8	10420.3	9896.8	18144.9	39997.2	43050.0	44355.0	20921.0	21418.1
28	13747.4	10753.6	11373.4	10109.6	8709.1	10885.6	10139.8	22795.5	62395.0	48952.5	47917.0	29379.0	24008.5
29	17184.7	14904.3	15532.2	13994.6	12899.4	11912.5	11333.5	17743.4	35206.7	43572.3	37728.0	23435.0	21356.9
30	13506.6	10552.1	10899.3	9859.1	8506.6	8381.1	9619.5	28528.2	43402.5	52897.1	40437.0	25320.0	21930.9
MAX	21536.9	16926.8	16009.1	14332.8	13402.5	12508.0	12218.4	42287.3	73798.2	60567.5	65318.8	44997.5	27588.4
MIN	13141.6	9753.6	9989.0	9383.1	8133.9	8035.9	7508.4	10338.0	30357.5	36956.0	37728.0	20921.0	19068.6
MEAN	15868.7	12948.4	13608.6	12569.7	11818.5	10722.5	9820.8	23217.5	46332.3	47622.6	47151.4	29790.7	23548.0

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TABLE 2.39 POST-PROJECT FLOW AT SUSITNA (cfs)
WATANA/DEVIL CANYON : CASE C

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1	27713.6	19718.5	17336.2	16695.2	15406.8	13516.0	12259.7	62107.8	89194.6	109495.9	98551.8	40330.2	43792.9
2	20926.6	12773.9	13015.8	13611.2	12998.9	12273.4	12875.8	53967.0	68019.7	107302.5	93276.9	61531.0	40453.6
3	32320.7	24050.9	17757.3	18401.2	17217.0	14832.6	12587.9	46070.3	109972.5	118833.3	107266.1	76896.3	49082.8
4	44057.8	24442.4	20714.0	18658.3	17166.1	15512.8	14595.4	80825.3	115310.9	112525.3	89000.0	38197.7	49526.4
5	21816.2	16976.8	15667.9	17217.6	14972.9	13119.0	12908.3	53106.8	92716.4	103528.0	114486.7	62655.3	45162.1
6	25812.2	13800.0	16877.4	17243.0	15756.1	14751.6	13015.2	55996.2	149345.8	130210.8	106370.0	49658.6	50961.3
7	22905.3	19745.7	18566.8	16824.4	16810.6	14463.7	13785.0	76407.3	140288.3	148813.1	120709.4	104218.4	59701.9
8	44803.5	30171.3	24687.4	20622.0	18134.4	16611.7	15339.1	58010.4	157474.1	124140.4	116272.9	78197.8	58911.9
9	55407.0	27781.4	20505.4	17385.2	16287.8	15913.4	16031.0	66428.7	96424.0	106382.3	89068.5	54803.3	48797.4
10	32848.4	14608.5	11432.2	16340.2	16544.1	13804.8	13070.6	51339.0	95705.0	129166.2	119937.6	65586.5	48639.1
11	28736.0	18891.5	17554.3	16676.2	16138.1	14893.7	13385.8	44512.5	75180.9	113688.1	102381.6	70355.4	44597.2
12	33191.9	20661.5	23960.9	22262.9	19732.8	17986.8	16912.0	78996.9	134900.3	123235.2	106596.5	58434.3	54994.3
13	30186.5	20406.2	19557.5	18851.5	15916.7	14983.3	14130.2	49317.3	132777.0	126623.2	115202.0	74806.4	52946.9
14	30698.1	19287.3	19445.4	18767.2	17635.1	15414.4	13067.4	45784.3	71362.0	123409.7	95036.8	70013.3	45235.4
15	40828.2	20925.4	16730.7	16942.0	15986.9	13049.7	12133.6	37229.2	115851.6	111222.0	87839.5	45838.8	44737.5
16	29761.7	16854.6	17402.8	17593.0	16175.6	14309.2	13722.9	44261.4	93598.5	119751.2	102725.9	81238.8	47494.0
17	39535.1	21536.3	20217.0	18369.7	17482.8	15738.2	14651.1	49783.4	105132.3	105127.9	108899.3	61437.3	48383.6
18	29164.3	18575.3	14993.4	16226.3	17705.9	14822.5	13883.4	52695.2	116725.0	119347.6	119889.8	89527.0	52160.0
19	40706.4	24942.8	25763.1	21374.8	20933.1	17382.0	16371.2	88615.3	118393.2	114565.4	81704.5	42868.8	51388.7
20	28940.1	16359.0	13955.5	14615.6	16143.3	13674.6	12714.8	49788.5	94906.9	103938.9	92754.0	57295.6	43117.8
21	26480.5	12796.6	12346.5	12857.3	11427.2	11699.0	11266.9	48402.2	83942.1	118167.1	109748.0	80763.8	45243.2
22	35044.4	20924.9	14843.4	12763.8	11873.7	11702.5	10655.9	32626.2	98023.4	121983.8	113400.1	64634.0	45953.2
23	35745.1	23313.6	19042.9	19008.6	17836.4	15403.7	14743.7	64552.0	154413.7	129478.8	100306.6	57120.4	54457.1
24	28409.1	23630.0	19224.0	18028.7	17490.8	14841.9	14291.0	62319.9	103275.8	111596.2	98970.8	45452.8	46696.8
25	24063.1	15694.2	13087.5	13951.5	12427.6	13671.5	13565.6	55889.3	57089.1	90191.2	76031.5	53173.5	36786.6
26	22630.9	15900.1	16084.7	14715.9	13030.7	12466.4	11263.5	41677.4	108412.6	118417.6	85270.1	70730.1	44392.3
27	32338.6	19156.8	17451.2	16995.0	15593.8	13507.3	13855.8	65730.0	90631.2	102744.1	91850.1	51329.0	44506.6
28	33267.4	23135.6	19188.4	15978.6	13980.1	14488.6	12835.8	51683.5	140522.3	130658.5	118260.1	80470.1	54766.1
29	38015.7	20404.3	17748.2	16755.6	16443.4	15500.5	14824.5	43706.4	78092.7	103242.4	97710.2	56193.0	43449.0
30	39093.6	19904.1	15897.3	15008.1	13246.6	12450.1	14598.5	75912.3	103453.5	123623.1	119740.0	72870.0	52463.4
MAX	55407.0	30171.3	25763.1	22262.9	20933.1	17986.8	16912.0	88615.3	157474.1	148813.1	120709.4	104218.4	59701.9
MIN	20926.6	12773.9	11432.2	12763.8	11427.2	11699.0	10655.9	32626.2	57089.1	90191.2	76031.5	38197.7	36786.6
MEAN	32514.9	19912.3	17701.8	17024.7	15949.8	14426.2	13644.7	56258.1	106371.2	116713.7	102641.9	63887.6	48320.0

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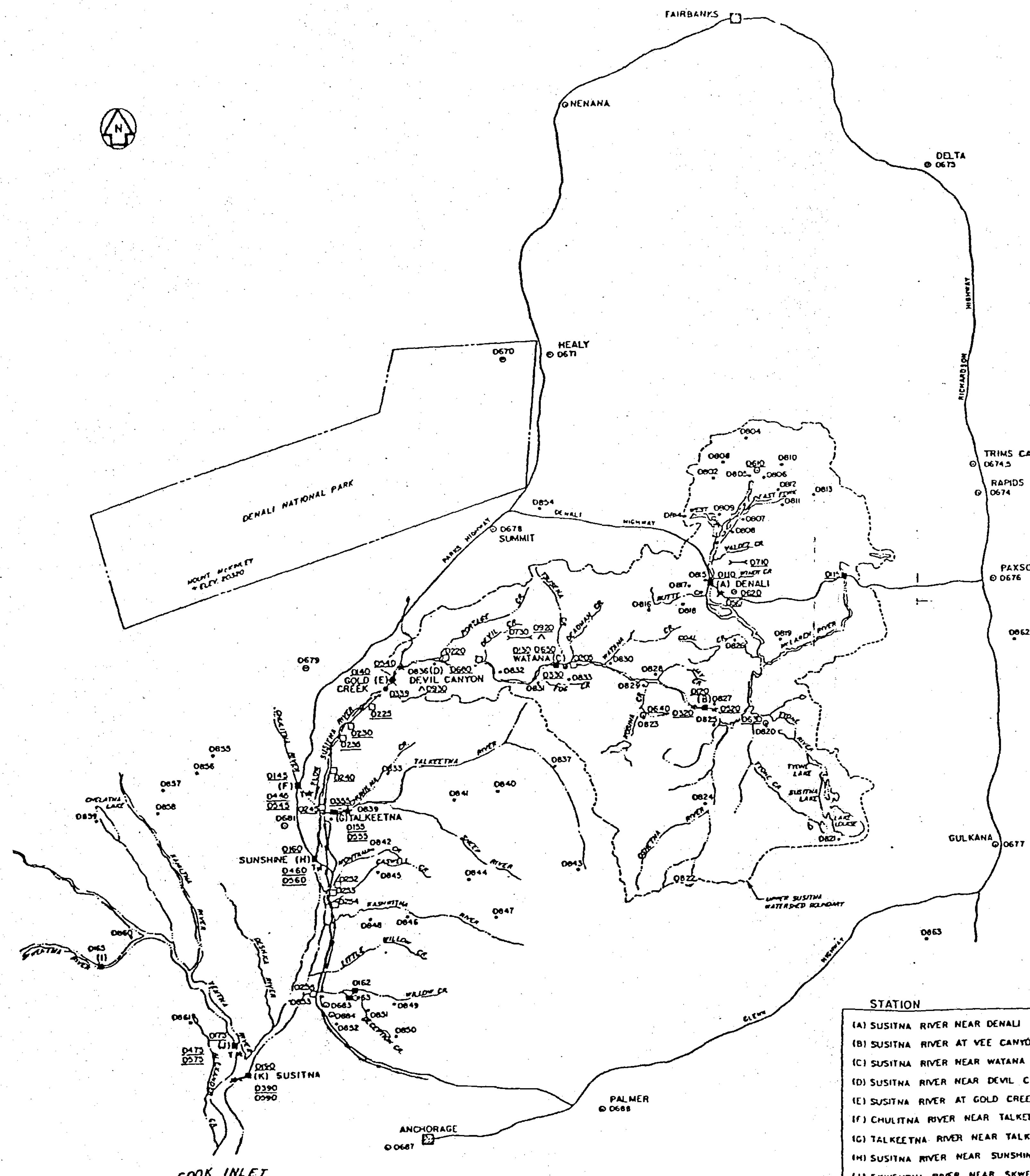


DATA COLLECTION STATIONS

SCALE 0 10 20 MILES (APPROX.)

DATA COLLECTED

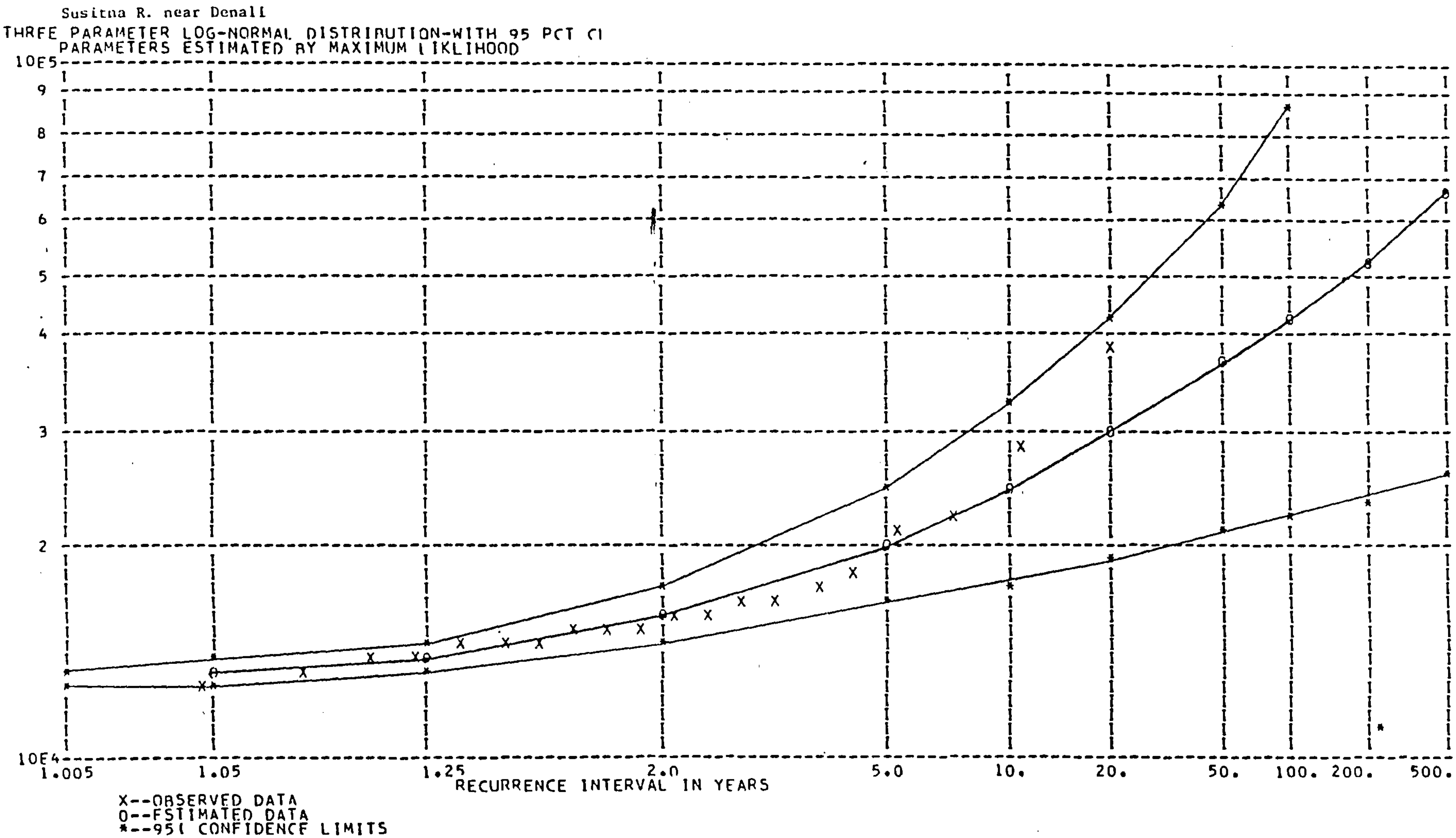
	INDEX NUMBERING
■ STREAMFLOW - CONTINUOUS RECORD	0100
□ STREAMFLOW - PARTIAL RECORD	0200
● WATER QUALITY	0300
T WATER TEMPERATURE	0400
SEDIMENT DISCHARGE	0500
○ CLIMATE	0600
FREEZING RAIN AND INCLOUD ICING	0700
• SNOW COURSE	0800
^ SNOW CREEP	0900

NOTES

2. CONTINUOUS WATER QUALITY MONITOR INSTALLED
3. DATA COLLECTION 1981 SEASON
4. THE LETTER BEFORE EACH STATION NAME IN THE TABLE IS USED ON THE MAP TO MARK THE APPROXIMATE LOCATION OF THE STATIONS.
5. STATION NUMBERS UNDERLINED INDICATES DATA COLLECTED BY STUDY TEAM IN 1980-82. SNOW COURSES MEASURED ARE NOT UNDERLINED FOR CLARITY.

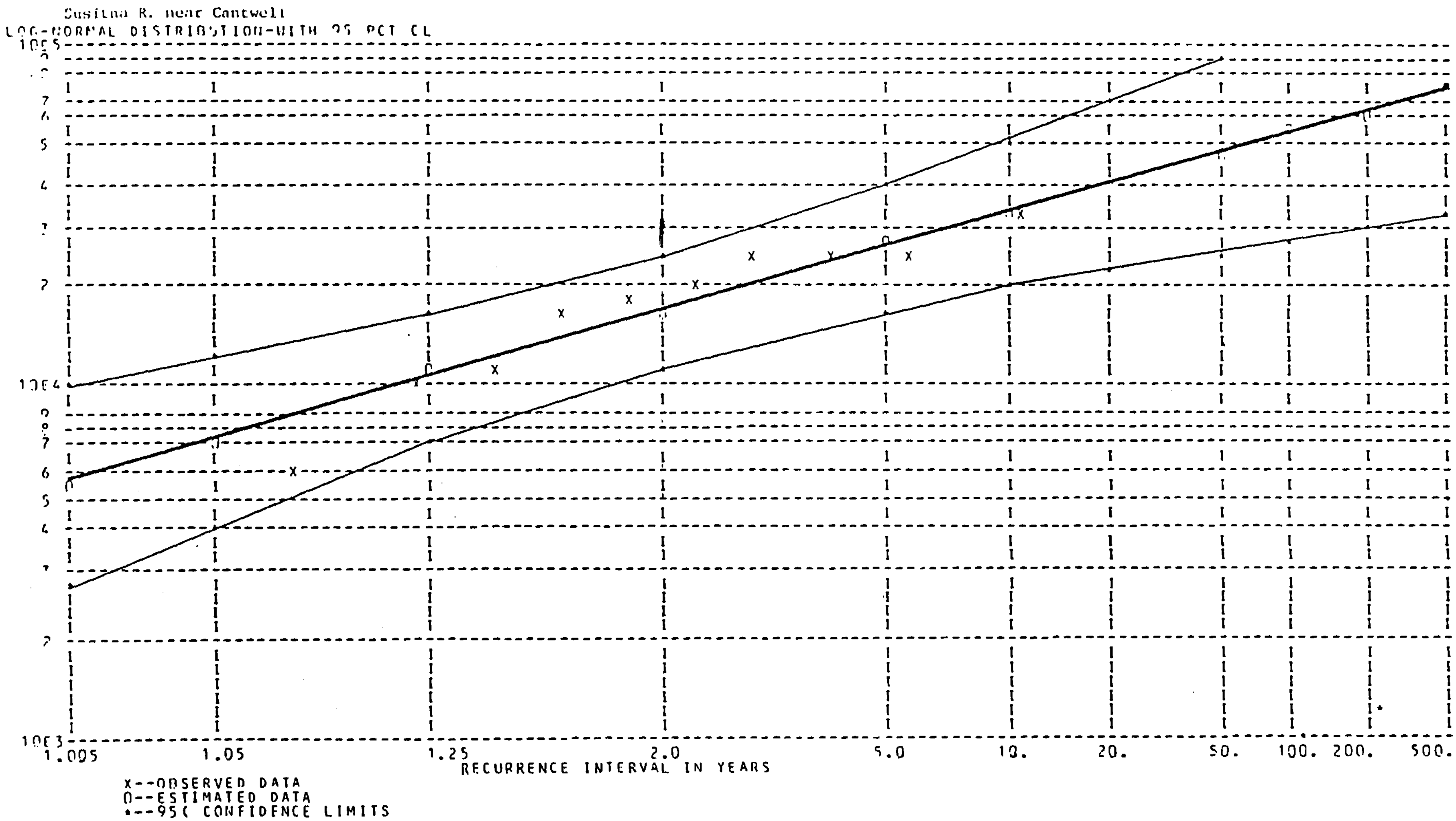
STATION	STREAMFLOW GAGING	CREST STAGE GAGE	STAFF GAGE	WATER QUALITY (1)	WATER TEMPERATURE	SEDIMENT DISCHARGE	BEDLOAD SAMPLING (3)	CLIMATE	IN-CLOUD ICING	FREEZING RAIN	SNOW CREEP	PERIOD OF RECORD OF STREAMFLOW
(A) SUSITNA RIVER NEAR DENALI	X		X		X	X		X	X	X		1957 - PRESENT
(B) SUSITNA RIVER AT VEE CANYON	X		X	X	X	X						1961 - 1972 & 1980 - PRESENT
(C) SUSITNA RIVER NEAR WATANA DAMSITE	X	X		X^2	X			X	X	X	X	1980 - PRESENT
(D) SUSITNA RIVER NEAR DEVIL CANYON		X	X					X			X	
(E) SUSITNA RIVER AT GOLD CREEK	X			X	X	X	X					1949 - PRESENT
(F) CHULITNA RIVER NEAR TALKEETNA	X				X	X	X					195[illegible] - 1972 & 198[illegible] - PRESENT
(G) TALKEETNA RIVER NEAR TALKEETNA	X			X	X	X	X					1964 - PRESENT
(H) SUSITNA RIVER NEAR SUNSHINE	X				X	X	X					198[illegible] - PRESENT
(I) SKWENTNA RIVER NEAR SKWENTNA	X			X	X	X		X				1959 - 1980
(J) YENTNA RIVER NEAR SUSITNA STATION	X				X	X						1980 - PRESENT
(K) SUSITNA RIVER AT SUSITNA STATION	X			X	X	X						1974 - PRESENT
(L) MCLAREN RIVER AT PAXSON	X											

FIGURE E.2.1



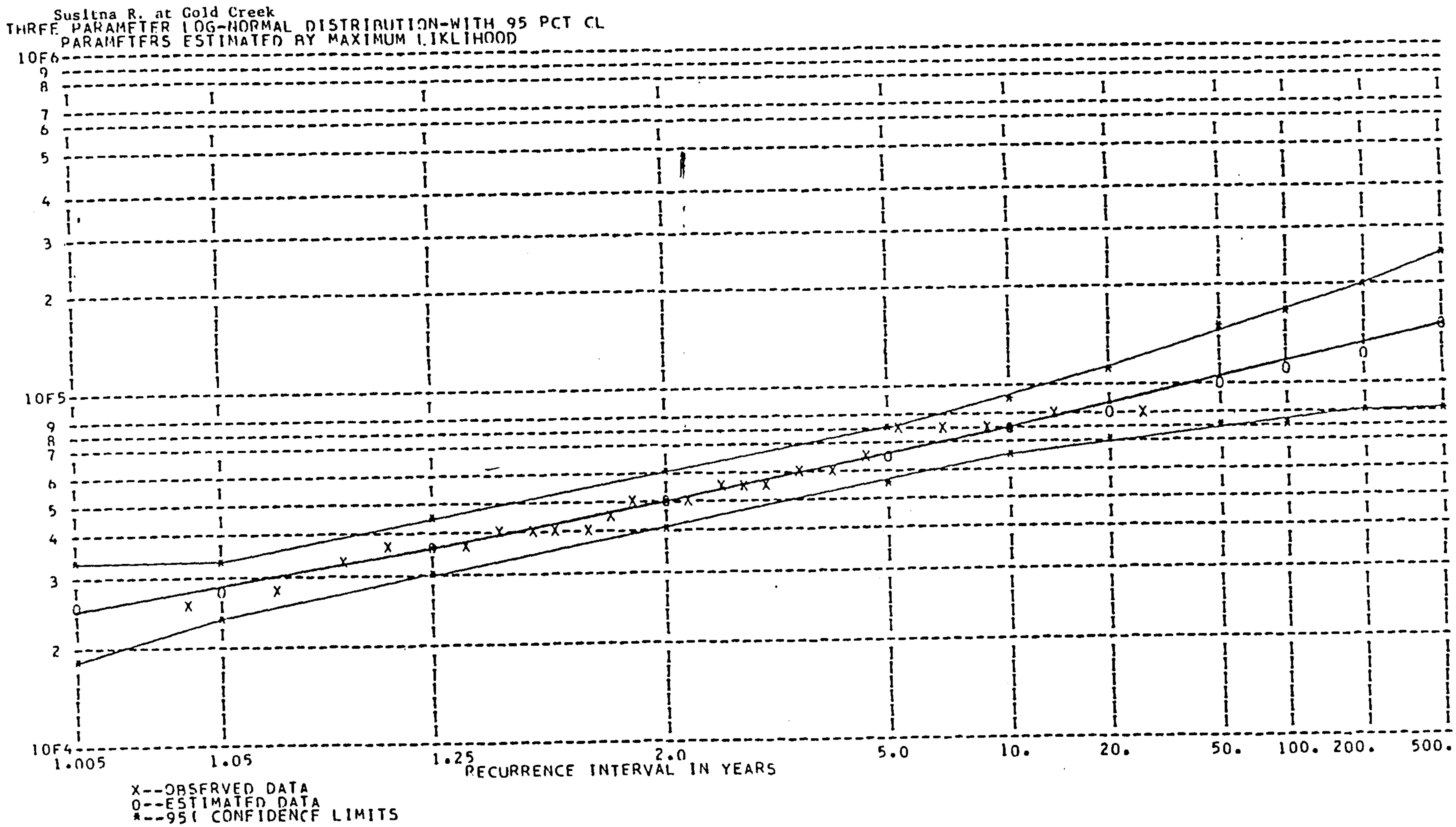
ANNUAL FLOOD FREQUENCY CURVE
SUSITNA RIVER NEAR DENALI

FIGURE E.2.2



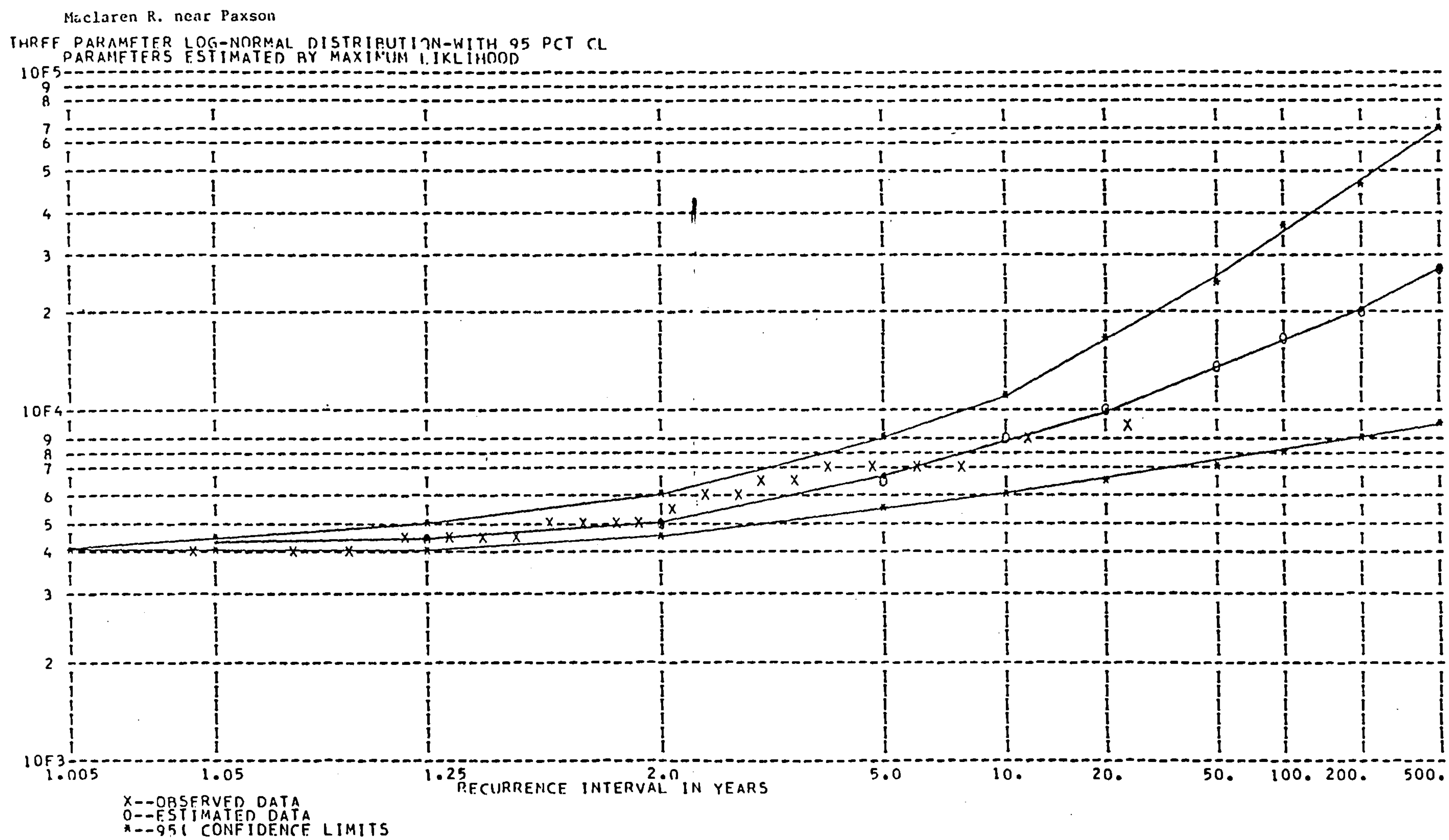
ANNUAL FLOOD FREQUENCY CURVE
SUSITNA RIVER NEAR CANTWELL

FIGURE E.2.3



ANNUAL FLOOD FREQUENCY CURVE
SUSITNA RIVER AT GOLD CREEK

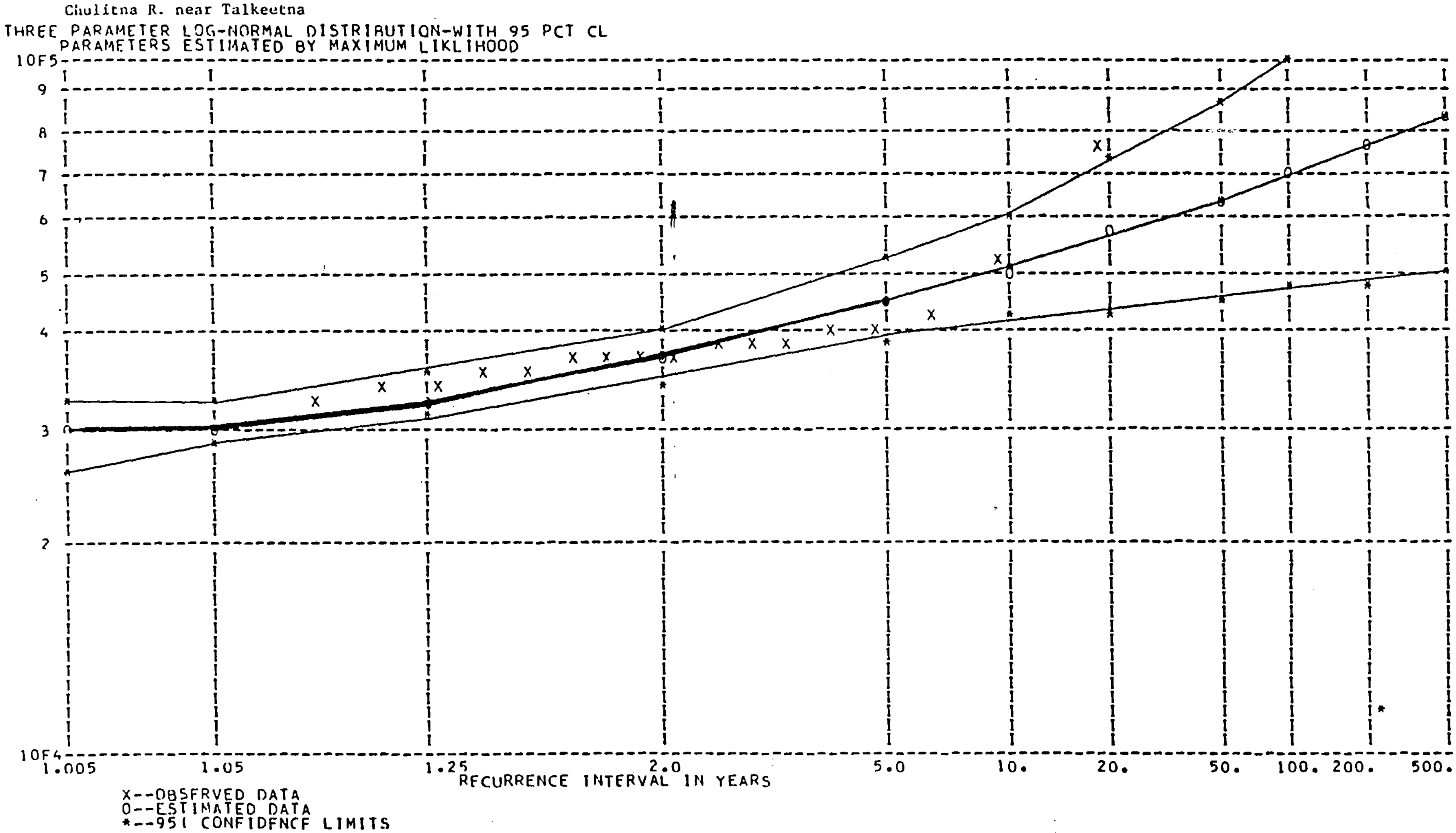
FIGURE E.2.4



ANNUAL FLOOD FREQUENCY CURVE

MACLAREN RIVER NEAR PAXSON

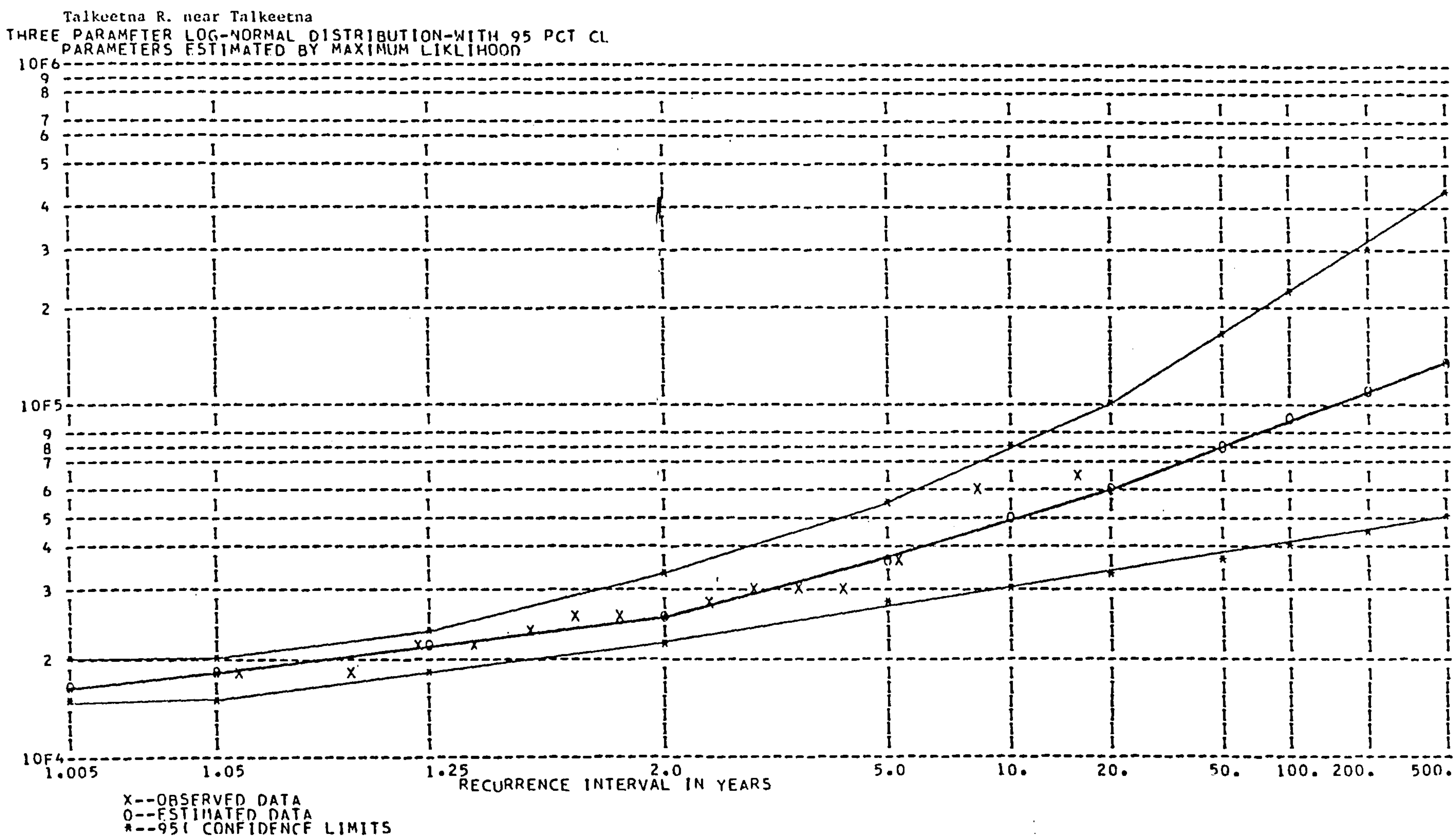
FIGURE E.2.5



ANNUAL FLOOD FREQUENCY CURVE

CHULITNA RIVER NEAR TALKEETNA

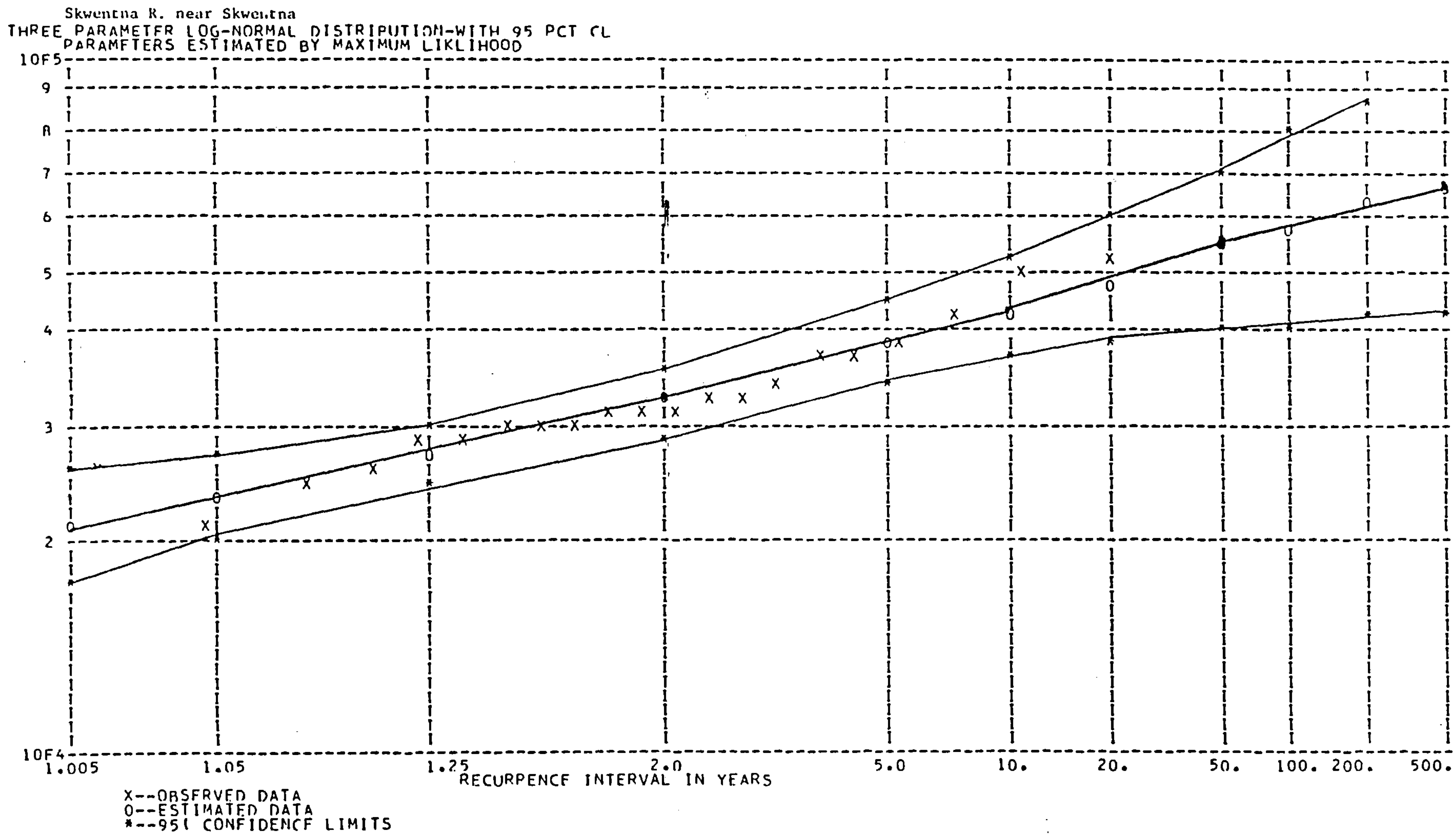
FIGURE E.2.6



ANNUAL FLOOD FREQUENCY CURVE

TALKEETNA RIVER NEAR TALKEETNA

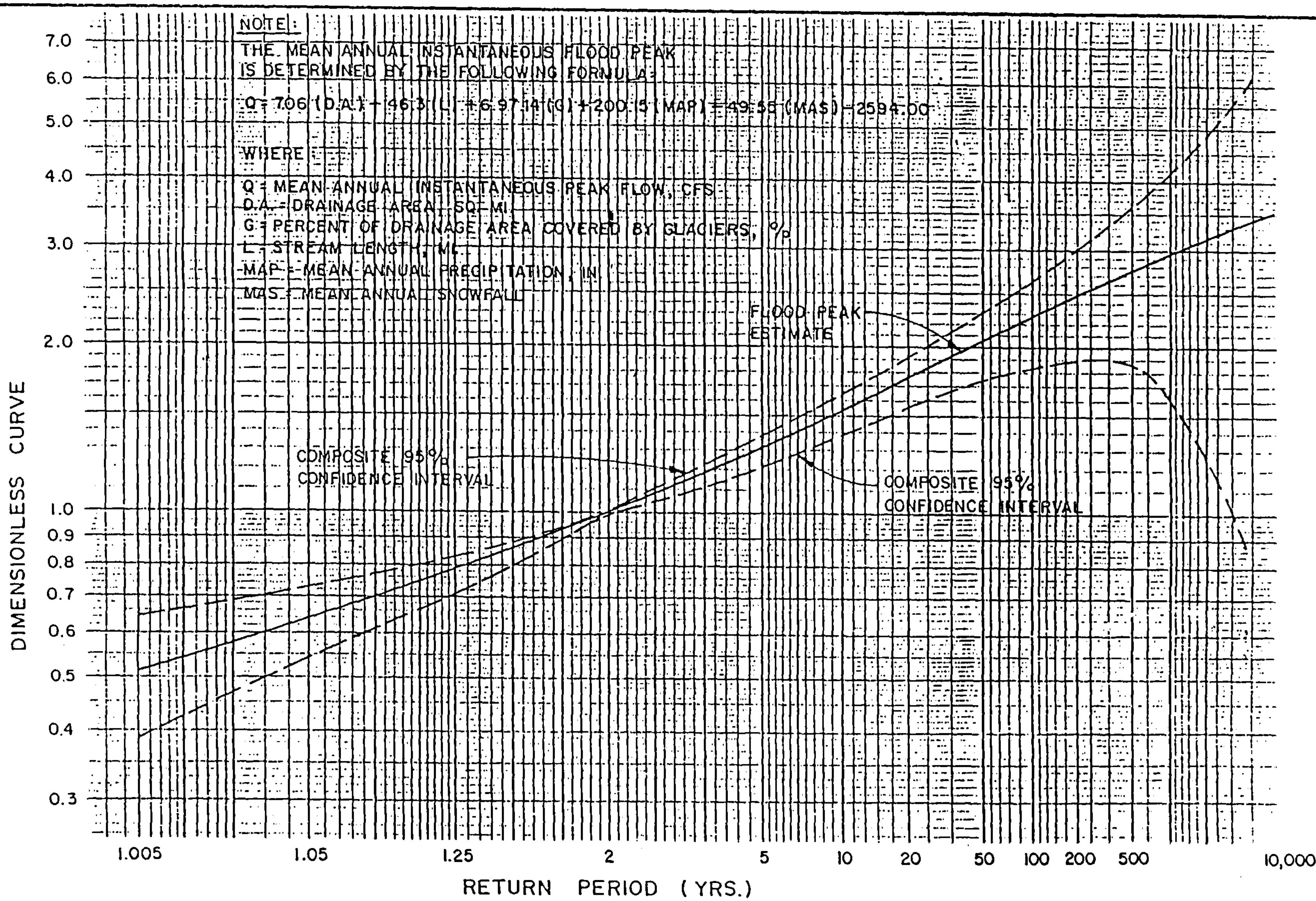
FIGURE E.2.7



ANNUAL FLOOD FREQUENCY CURVE

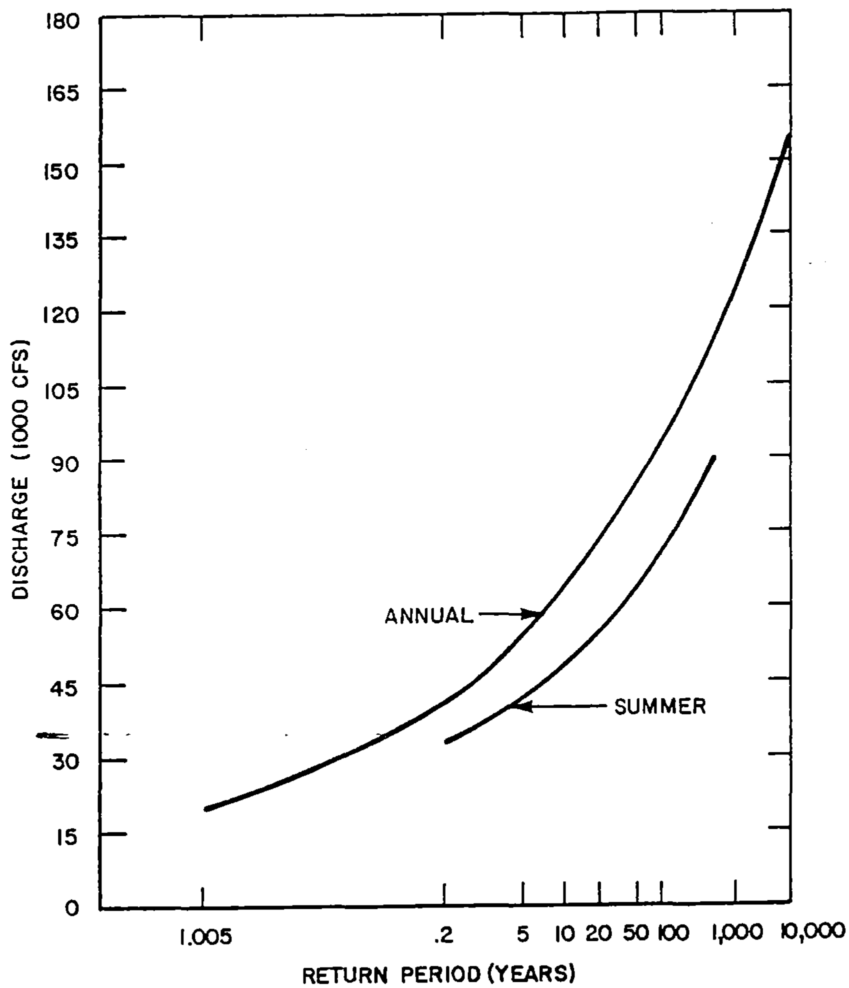
SKWENTNA RIVER NEAR SKWENTNA

FIGURE E.2.8



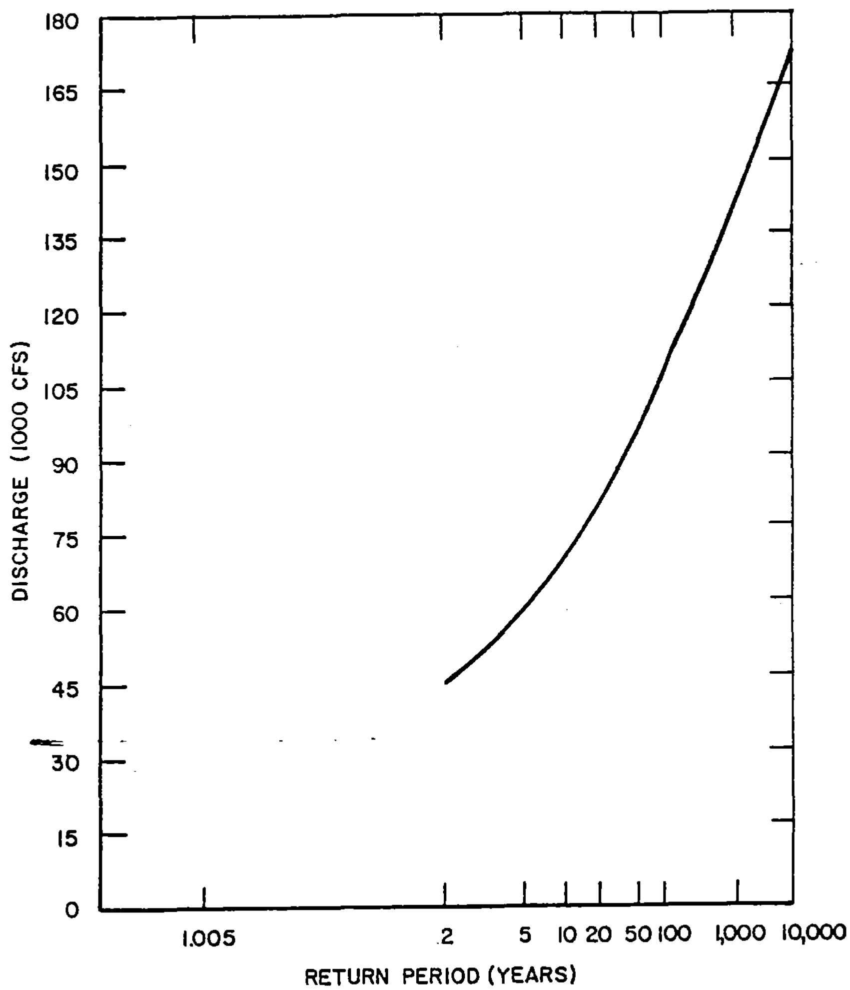
DESIGN DIMENSIONLESS REGIONAL FREQUENCY CURVE
ANNUAL INSTANTANEOUS FLOOD PEAKS

FIGURE E.2.9



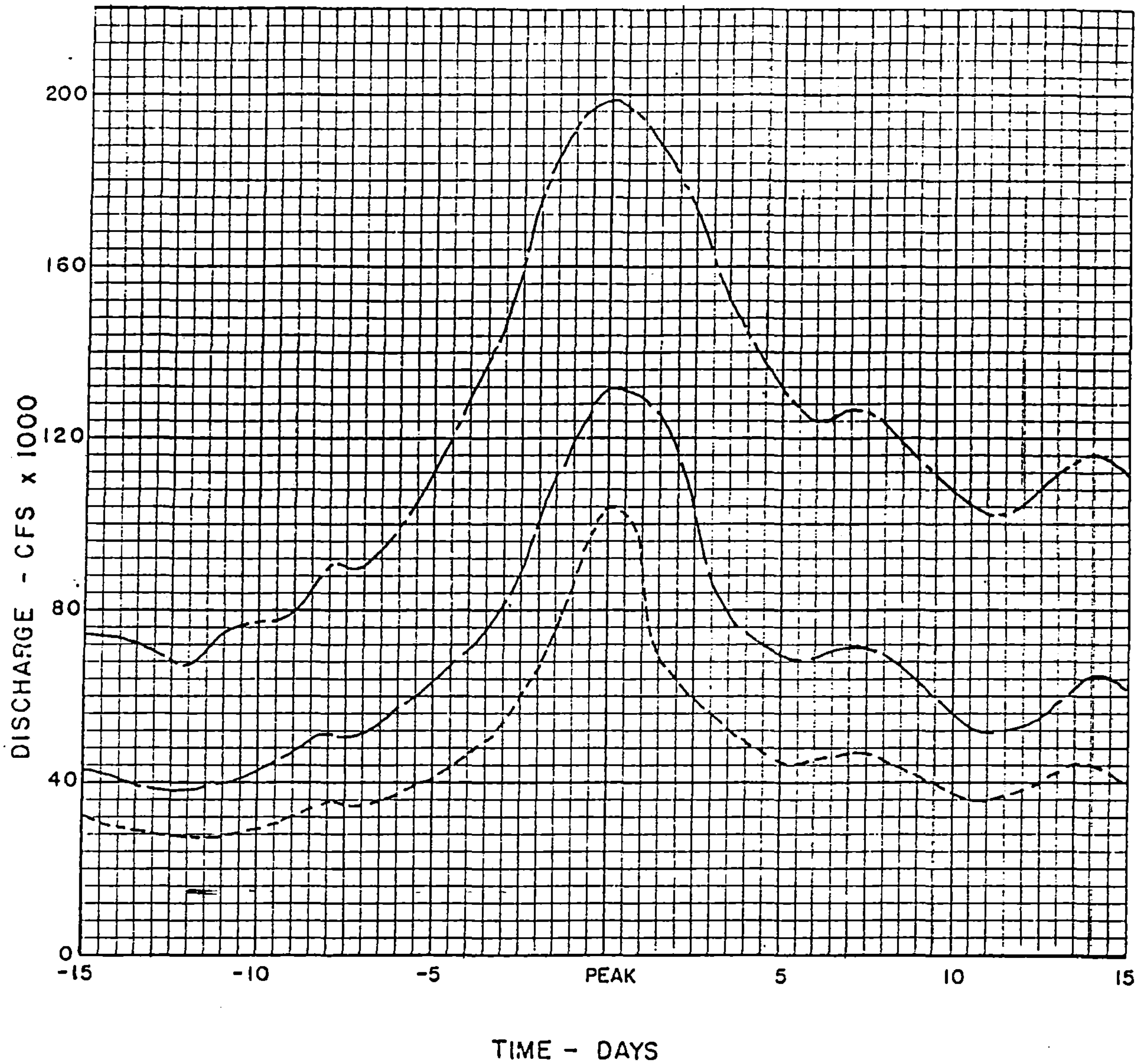
WATANA
NATURAL FLOOD FREQUENCY CURVE

FIGURE E.2.10



DEVIL CANYON
NATURAL FLOOD FREQUENCY CURVE

FIGURE E.2.11



SUSITNA RIVER AT GOLD CREEK

100, 500, 10000 yr. FLOOD VOLUMES

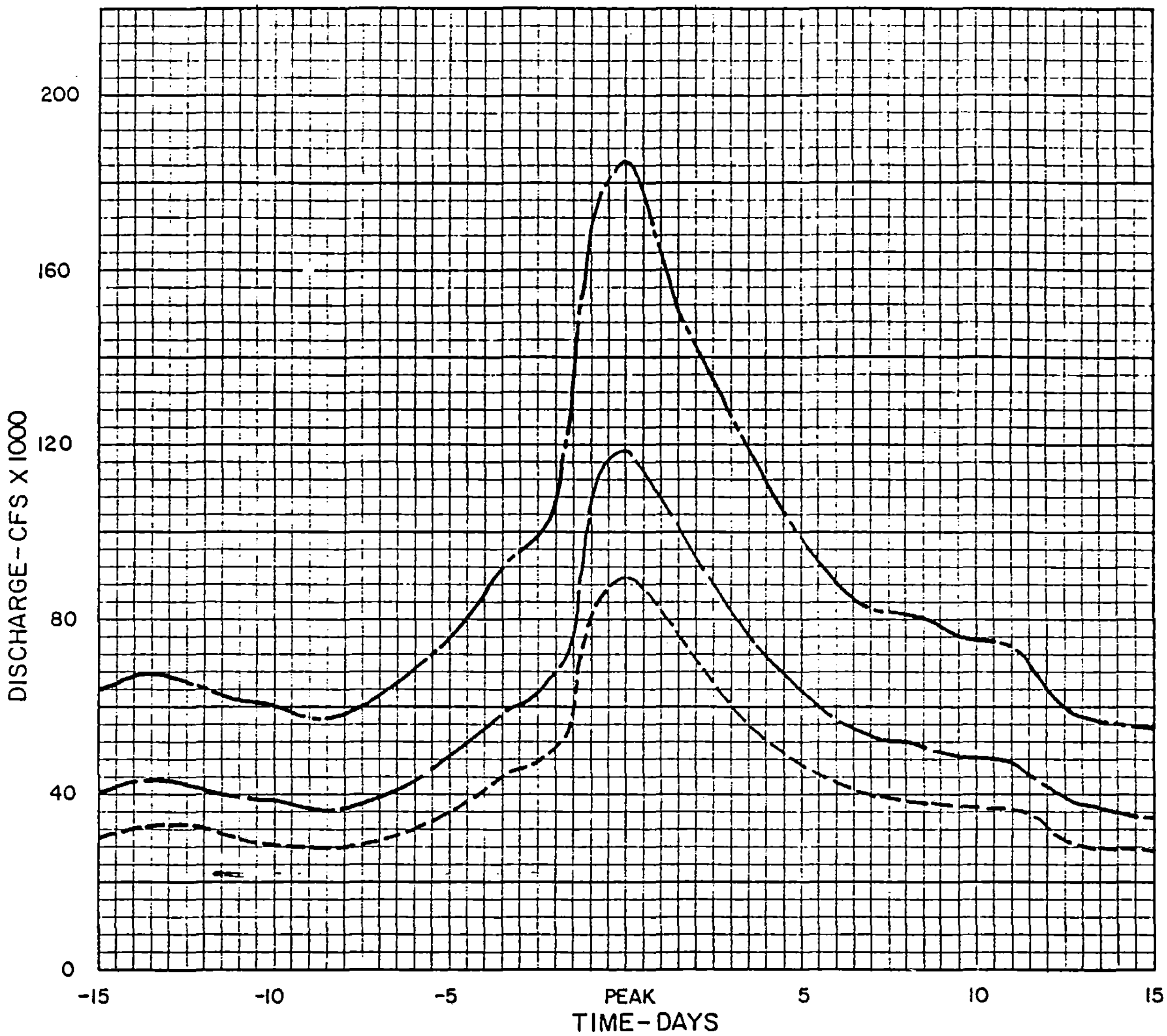
LEGEND

	Flood Volume ft^3	Peak Discharge (cfs)
-----100 yr	122.3×10^9	104,550
— — 500 yr	178.2×10^9	131,870
-·—10,000 y	310.0×10^9	198,000

FLOOD HYDROGRAPHS

MAY - JULY

FIGURE E.2.12



SUSITNA RIVER AT GOLD CREEK

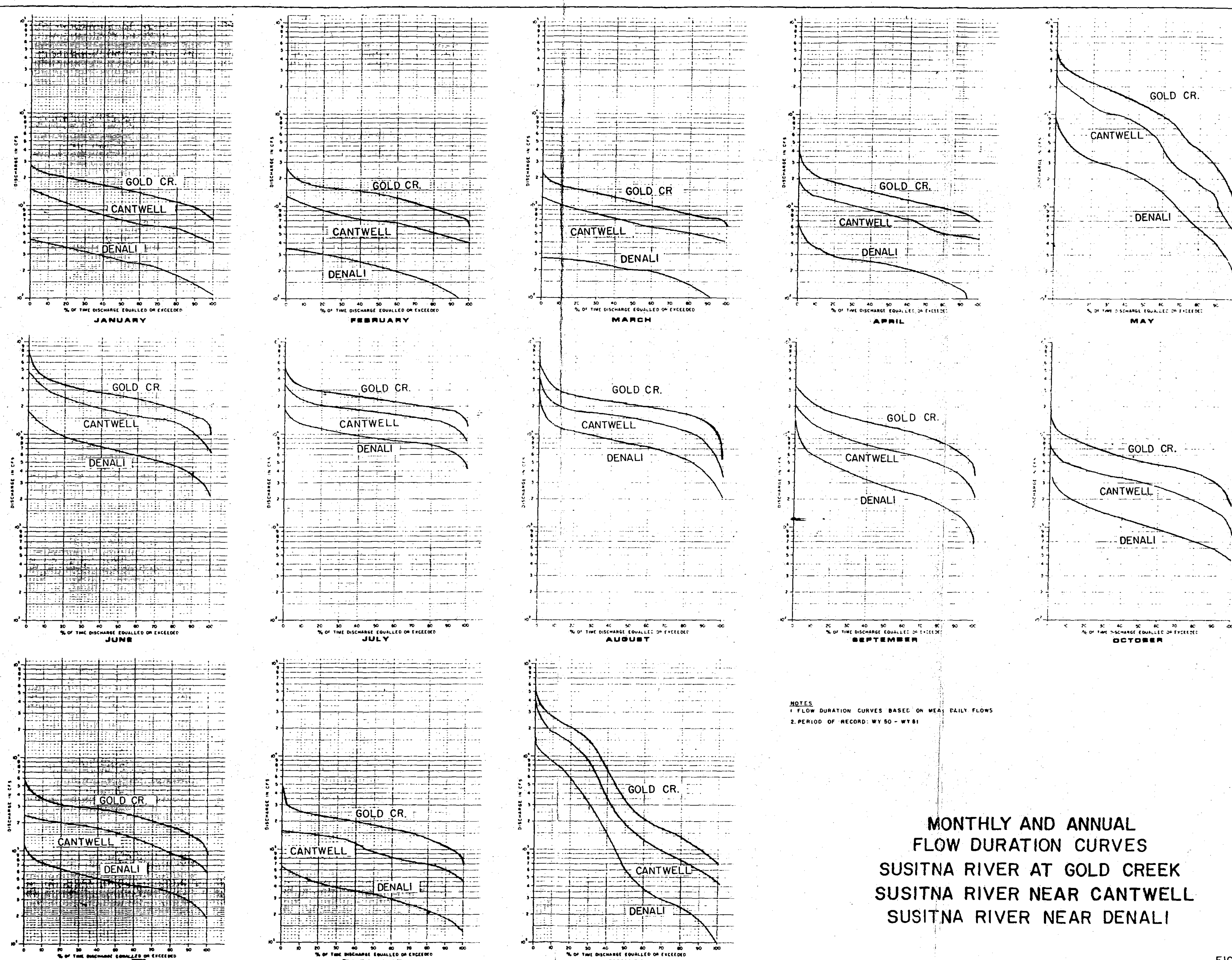
LEGEND

	Flood Volume ft^3	Peak Discharge (cfs)
---- 100 yr	53.8×10^9	90,140
—— 500 yr	78.8×10^9	119,430
–·–·– 10,000 yr	140.0×10^9	185,000

FLOOD HYDROGRAPHS

AUG - OCT

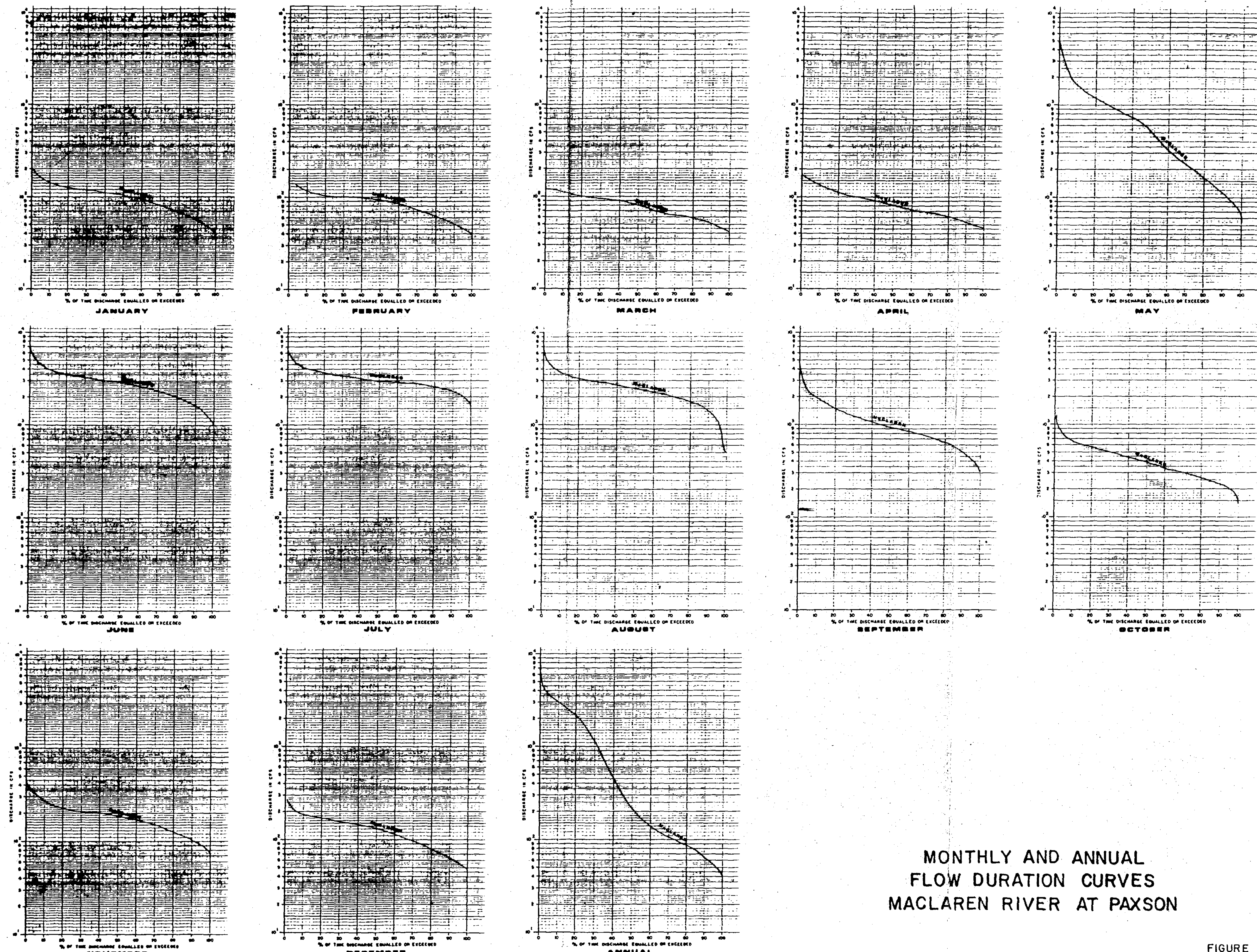
FIGURE E.2.13



NOTES
1. FLOW DURATION CURVES BASED ON MEAN DAILY FLOWS
2. PERIOD OF RECORD: WY 50 - WY 81

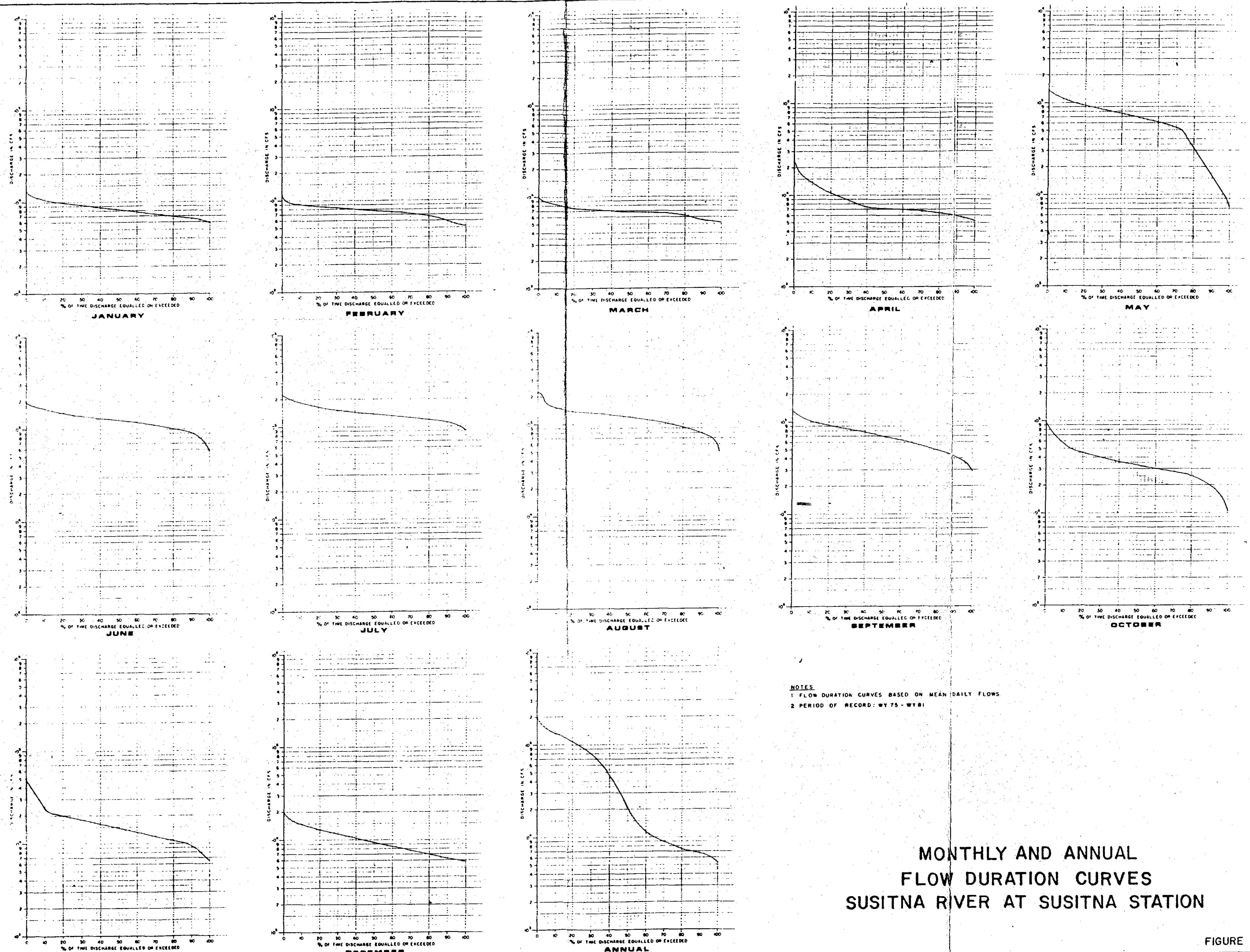
MONTHLY AND ANNUAL
FLOW DURATION CURVES
SUSITNA RIVER AT GOLD CREEK
SUSITNA RIVER NEAR CANTWELL
SUSITNA RIVER NEAR DENALI

FIGURE E.2.14



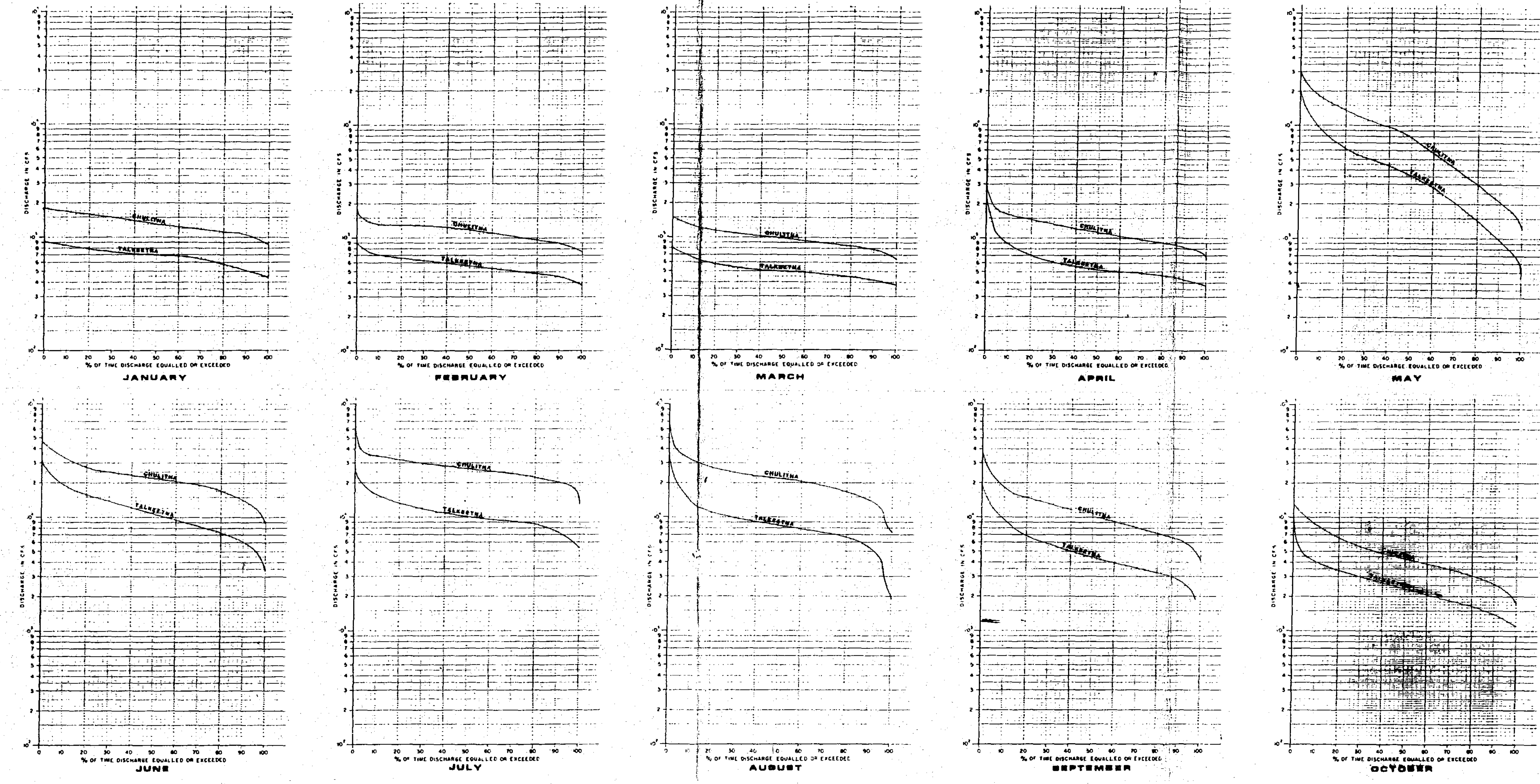
MONTHLY AND ANNUAL
FLOW DURATION CURVES
MACLAREN RIVER AT PAXSON

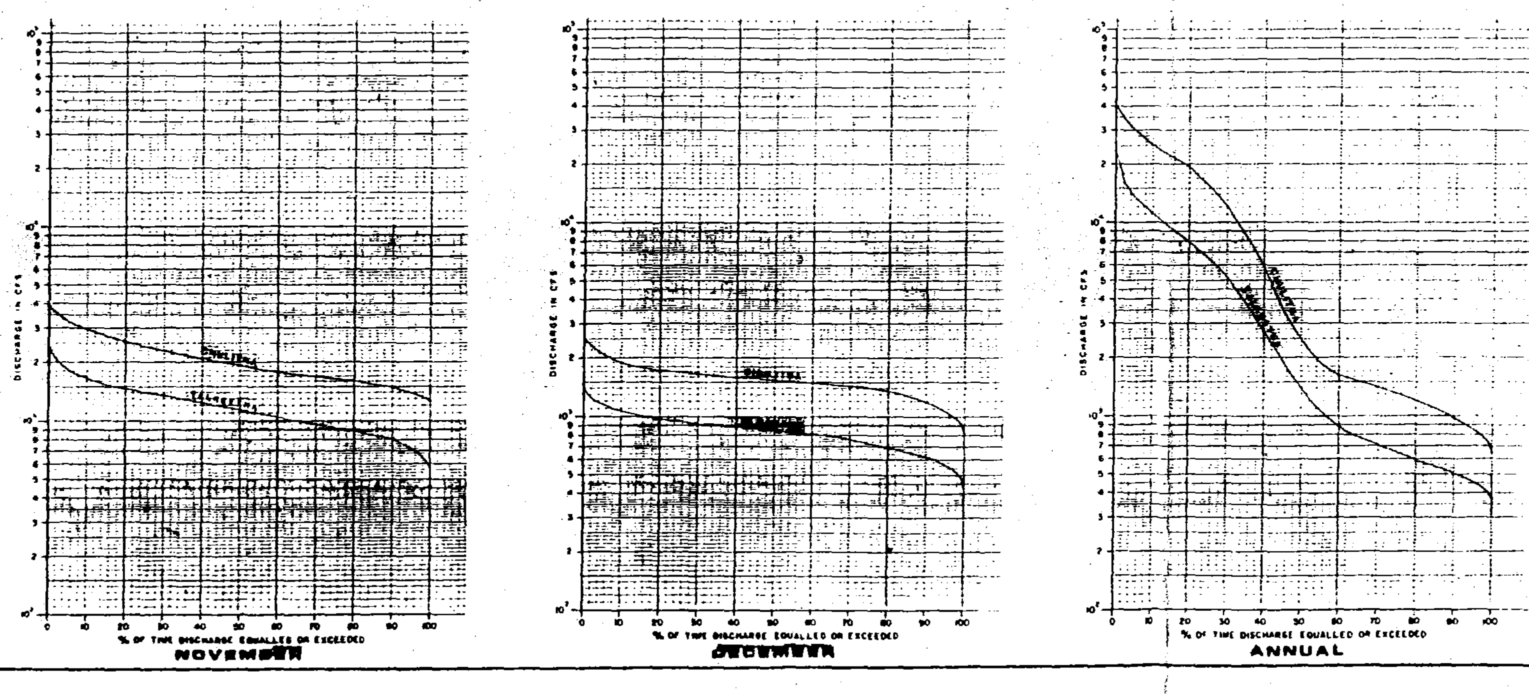
FIGURE E.2.15



MONTHLY AND ANNUAL
FLOW DURATION CURVES
SUSITNA RIVER AT SUSITNA STATION

FIGURE E.2.16





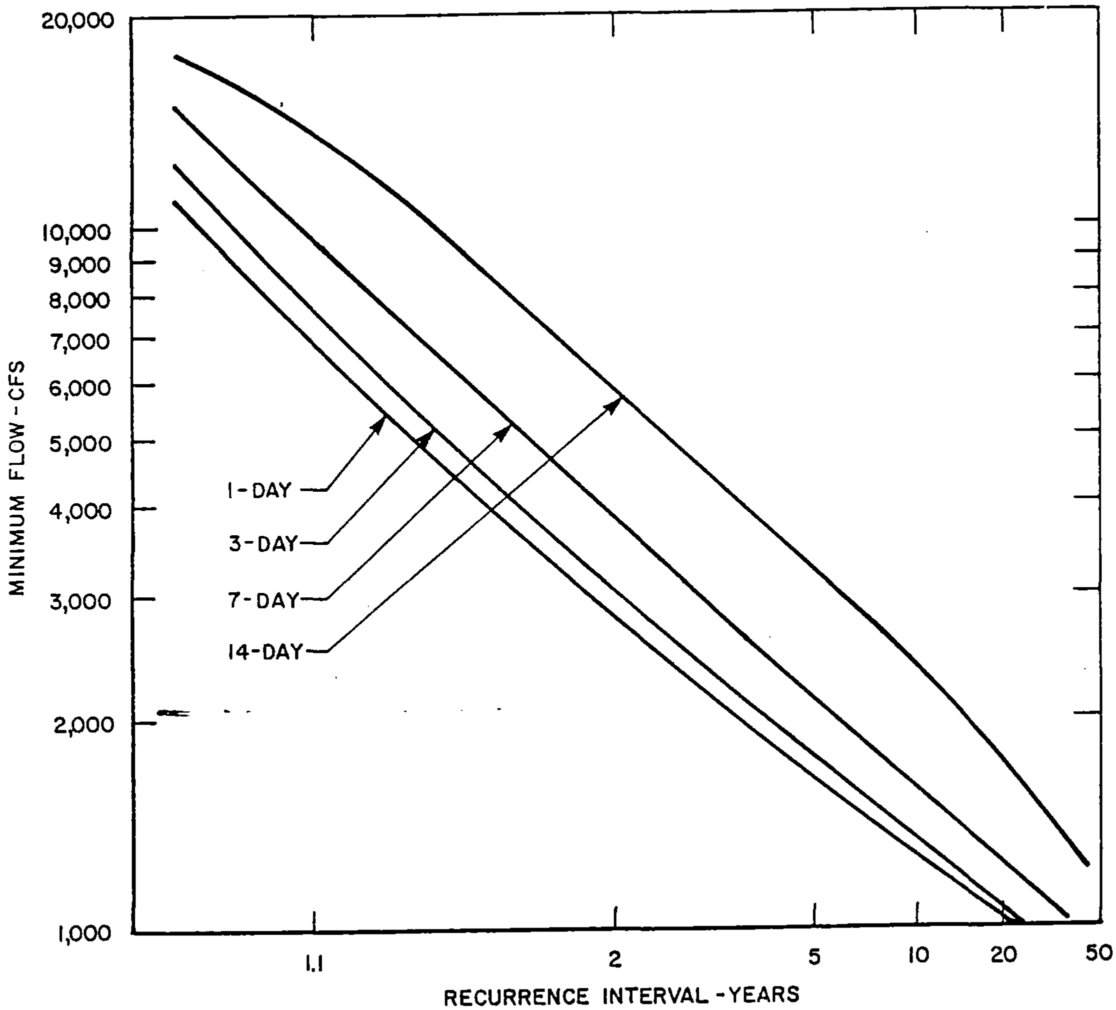
NOTES

1 FLOW DURATION CURVES BASED ON MEAN DAILY FLOWS

2 PERIOD OF RECORD: CHULITNA RIVER WY59-WY72; WY81
TALKEETNA RIVER WY65-WY81

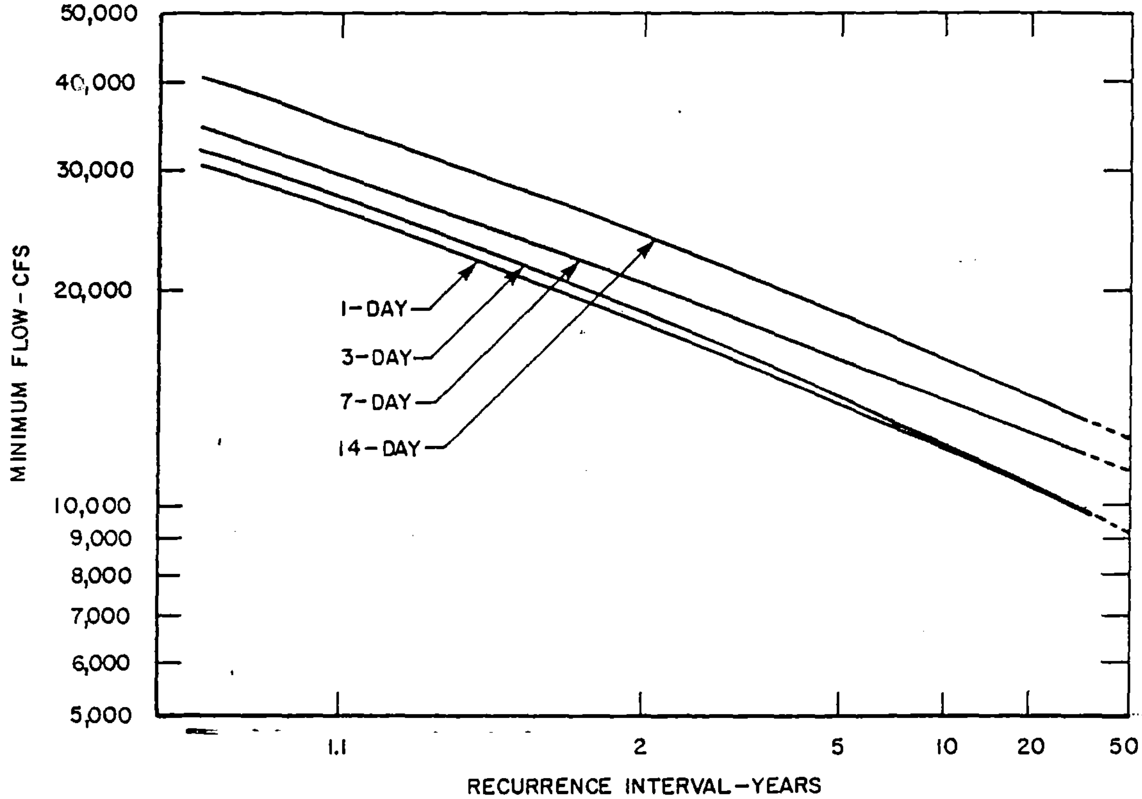
MONTHLY AND ANNUAL
FLOW DURATION CURVES
TALKEETNA RIVER NEAR TALKEETNA

FIGURE E.2.17



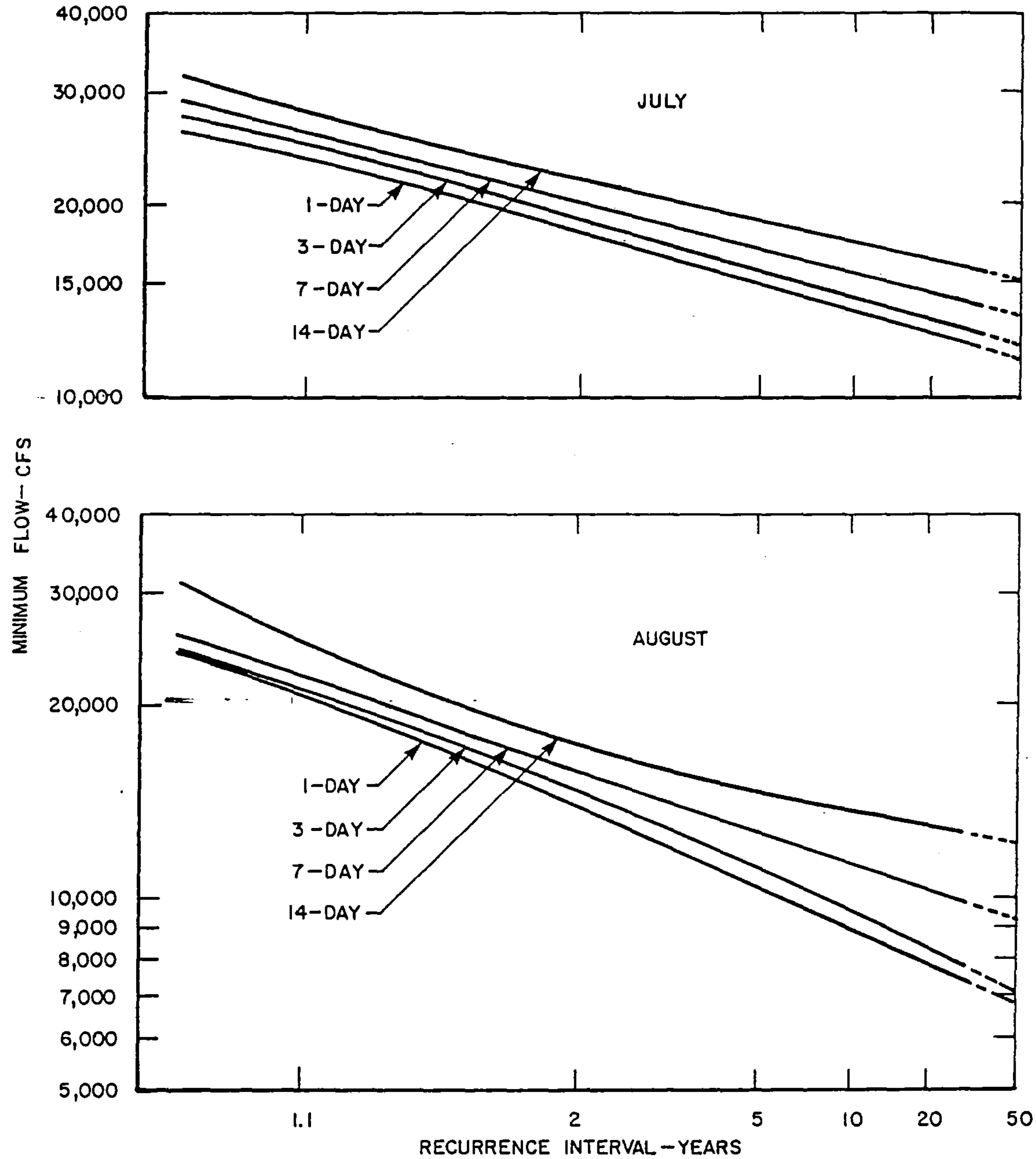
SUSITNA RIVER AT GOLD CREEK
LOW-FLOW FREQUENCY CURVES
MAY

FIGURE E.2.18



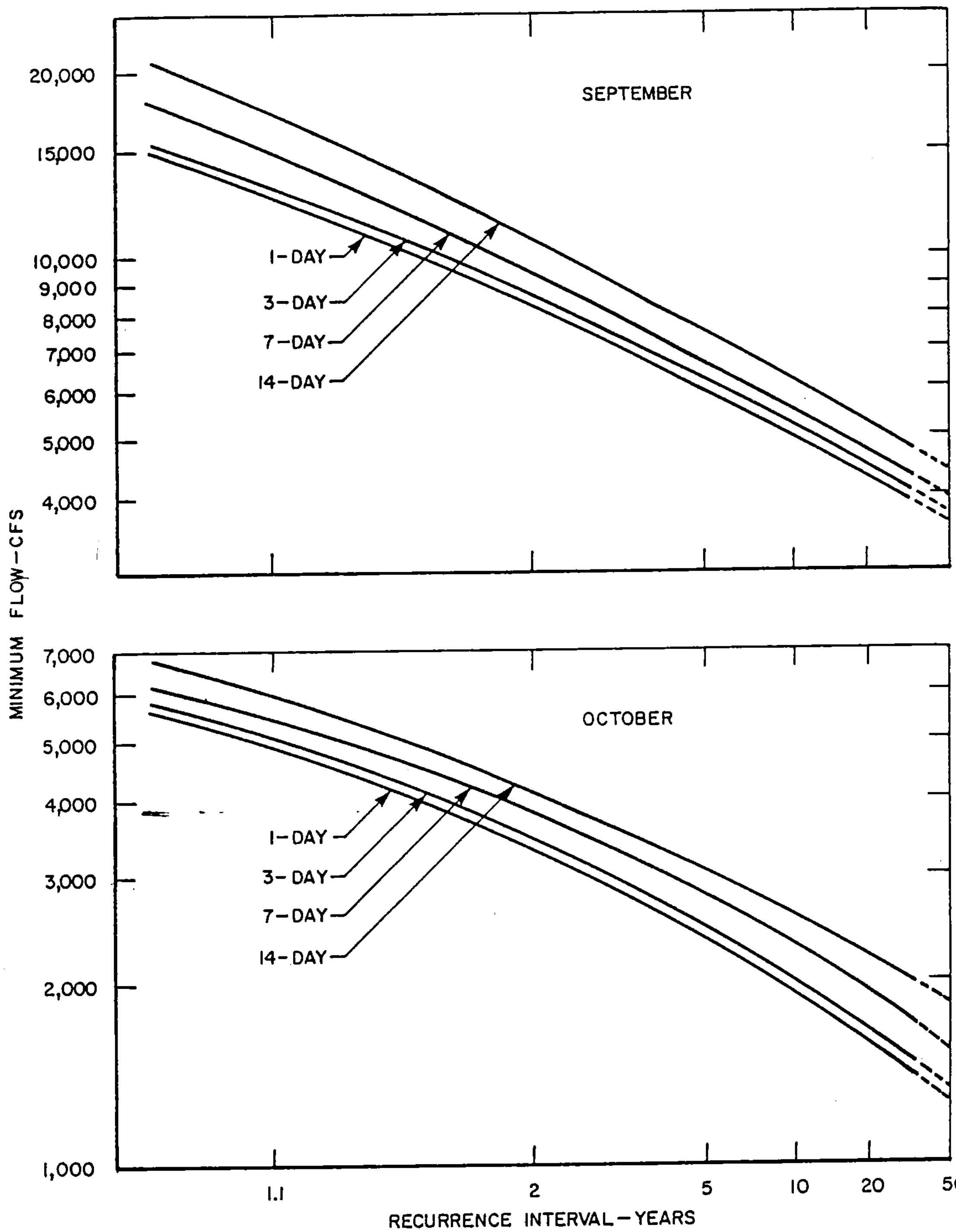
SUSITNA RIVER AT GOLD CREEK
LOW-FLOW FREQUENCY CURVES
JUNE

FIGURE E.2.19



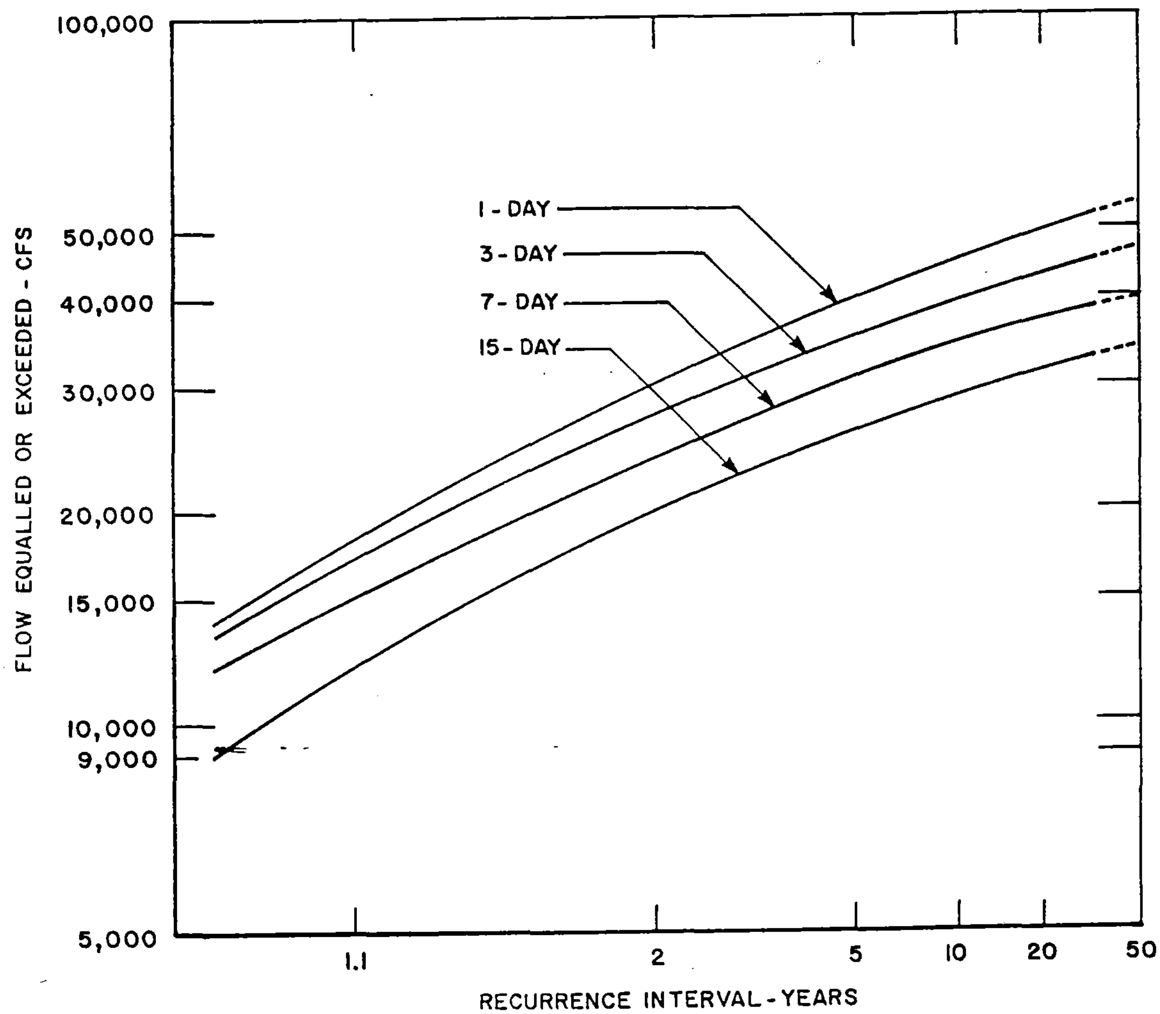
SUSITNA RIVER AT GOLD CREEK
LOW-FLOW FREQUENCY CURVES
JULY AND AUGUST

FIGURE E.2.20



SUSITNA RIVER AT GOLD CREEK
LOW-FLOW FREQUENCY CURVES
SEPTEMBER AND OCTOBER

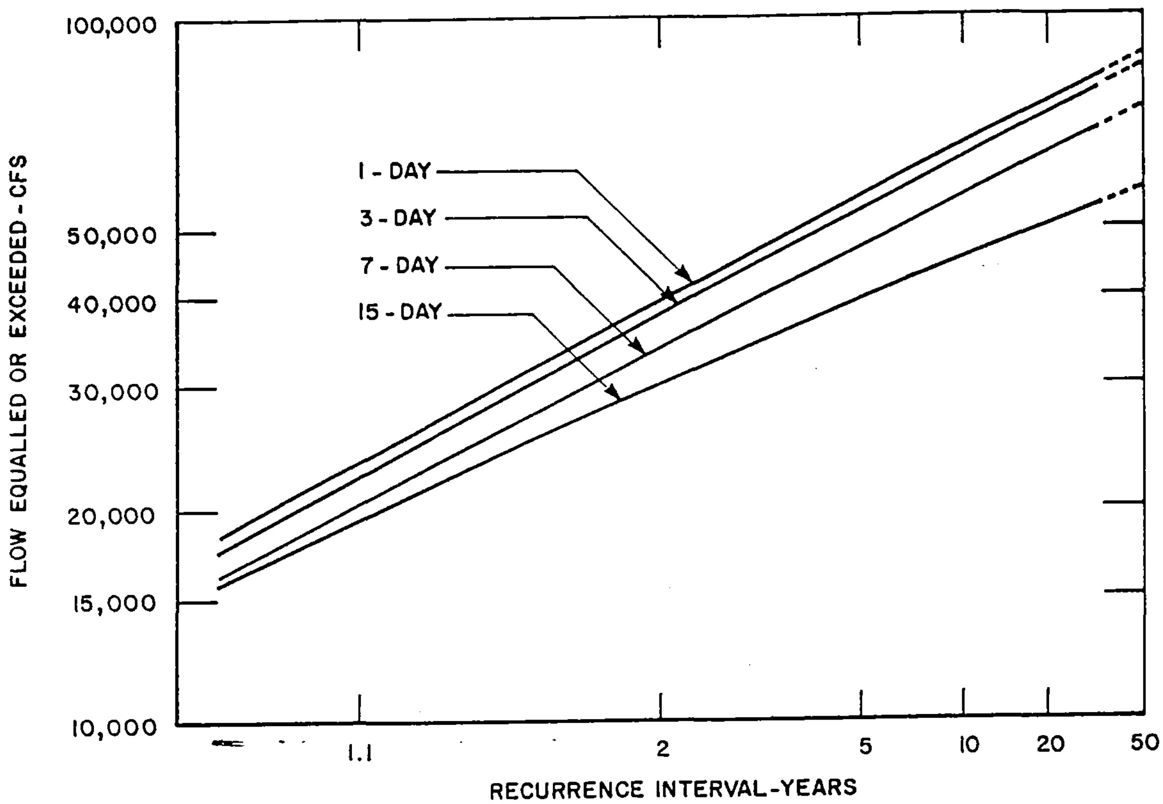
FIGURE E.2.21



NOTE: PERIOD OF RECORD IS 1950-1981.

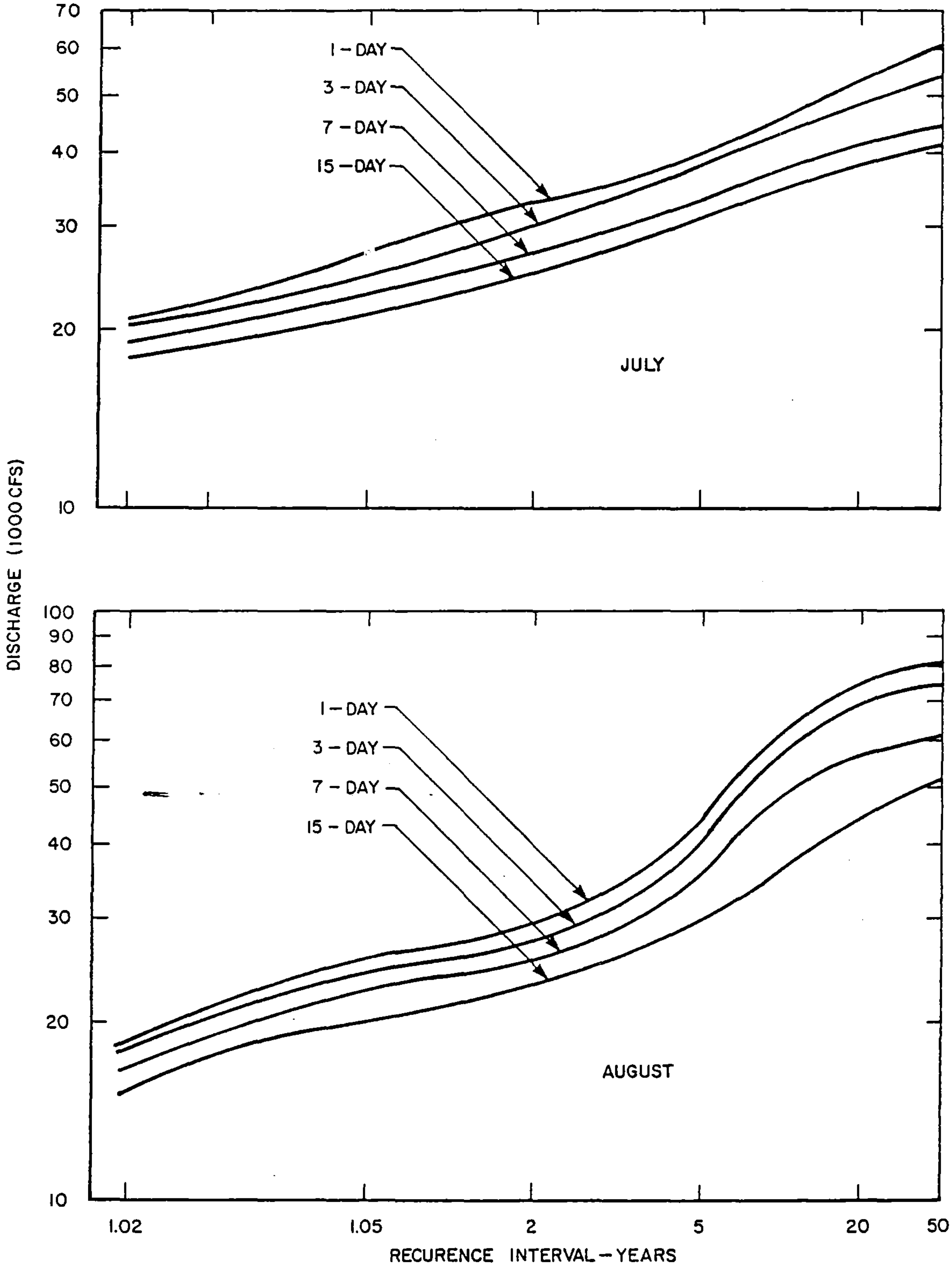
SUSITNA RIVER AT GOLD CREEK
HIGH-FLOW FREQUENCY CURVES
MAY

FIGURE E.2.22



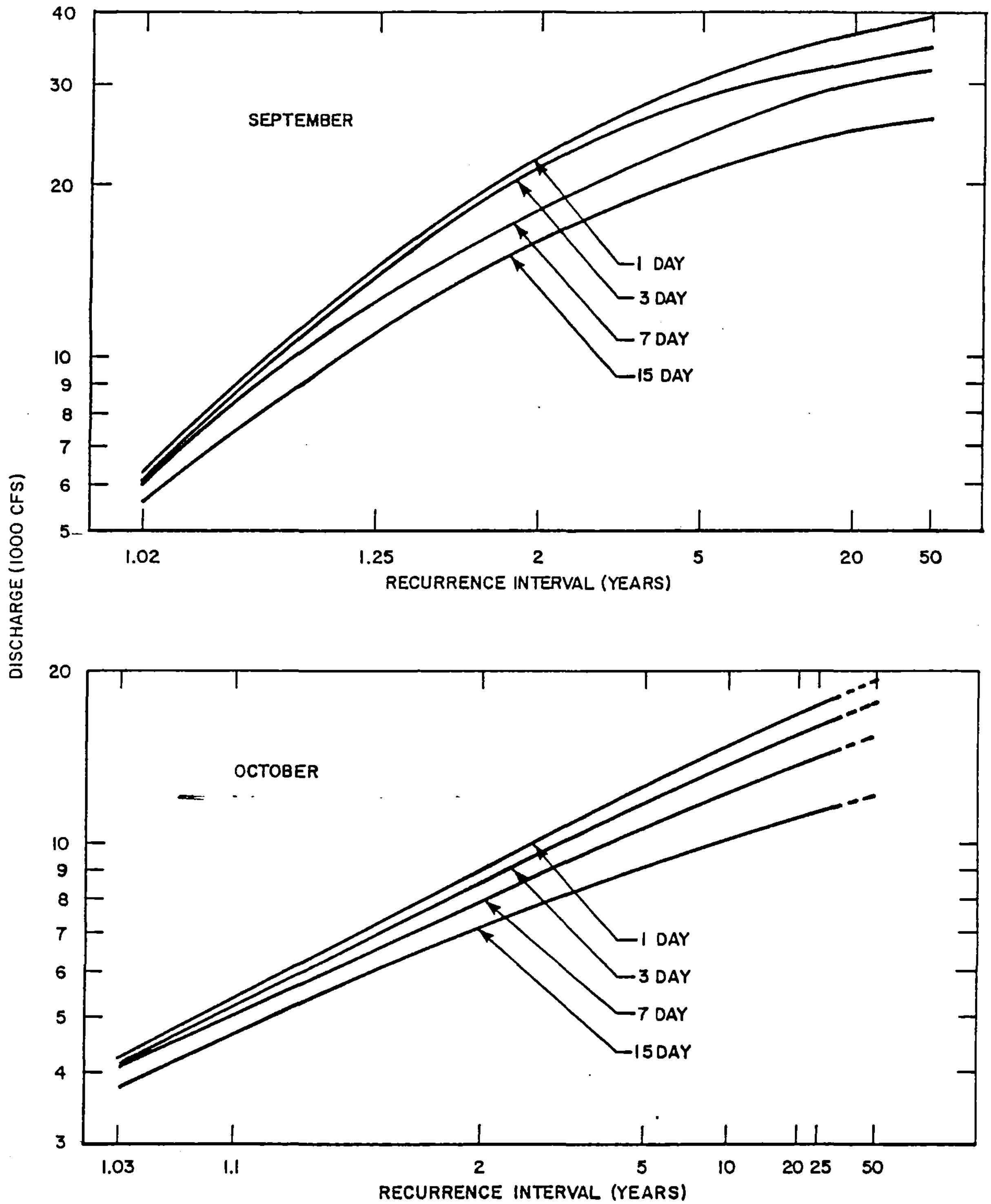
SUSITNA RIVER AT GOLD CREEK
HIGH-FLOW FREQUENCY CURVES
JUNE

FIGURE E.2.23



SUSITNA RIVER AT GOLD CREEK
HIGH-FLOW FREQUENCY CURVES
JULY AND AUGUST

FIGURE E.2.24



SUSITNA RIVER AT GOLD CREEK
HIGH-FLOW FREQUENCY CURVES
SEPTEMBER AND OCTOBER

FIGURE E.2.25

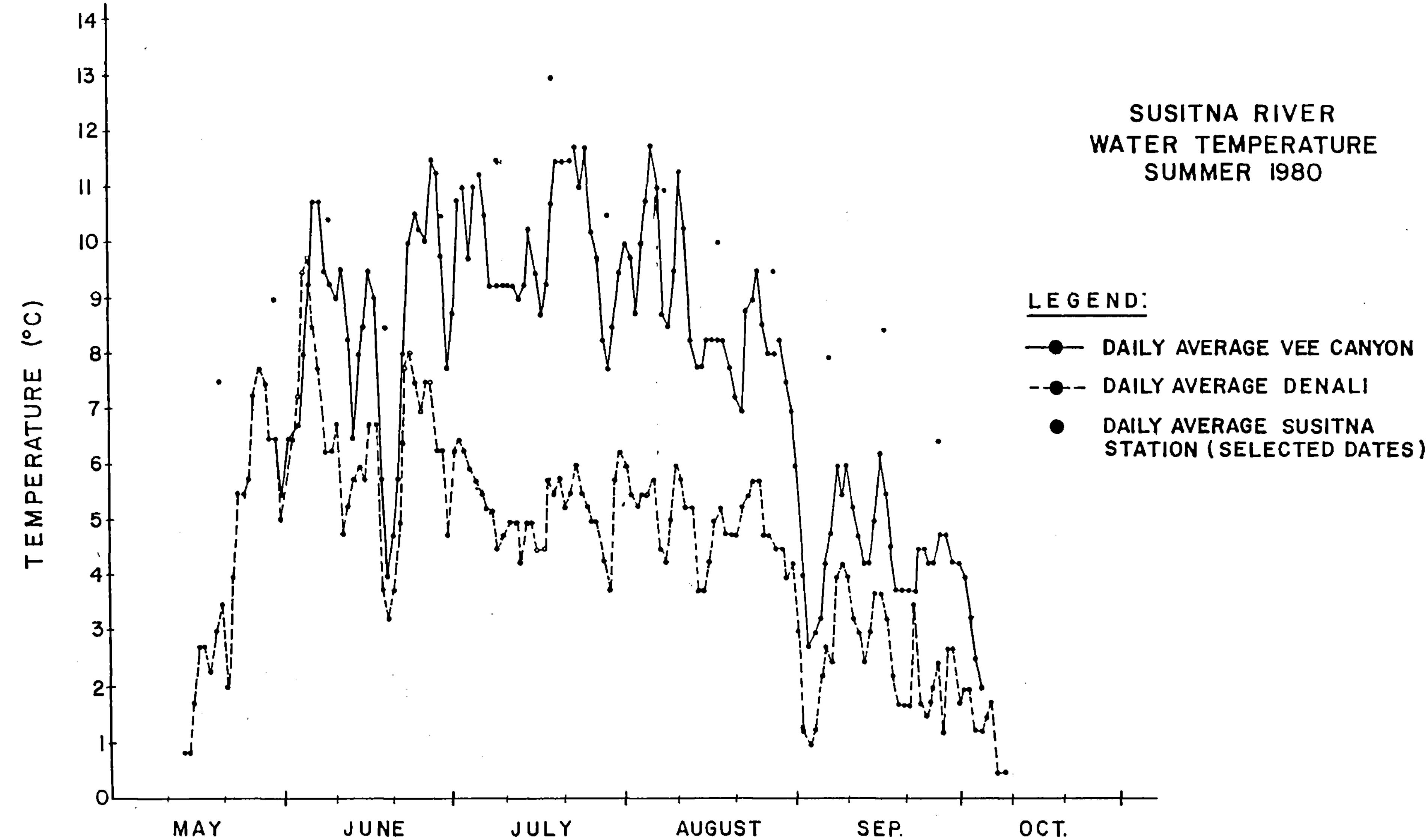

SUSITNA RIVER
WATER TEMPERATURE
SUMMER 1980
LEGEND:
DAILY AVERAGE VEE CANYON
DAILY AVERAGE DENALI
DAILY AVERAGE SUSITNA STATION (SELECTED DATES)
TEMPERATURE (°C)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
MAY
JUNE
JULY
AUGUST
SEP.
OCT.

FIGURE E.2.26

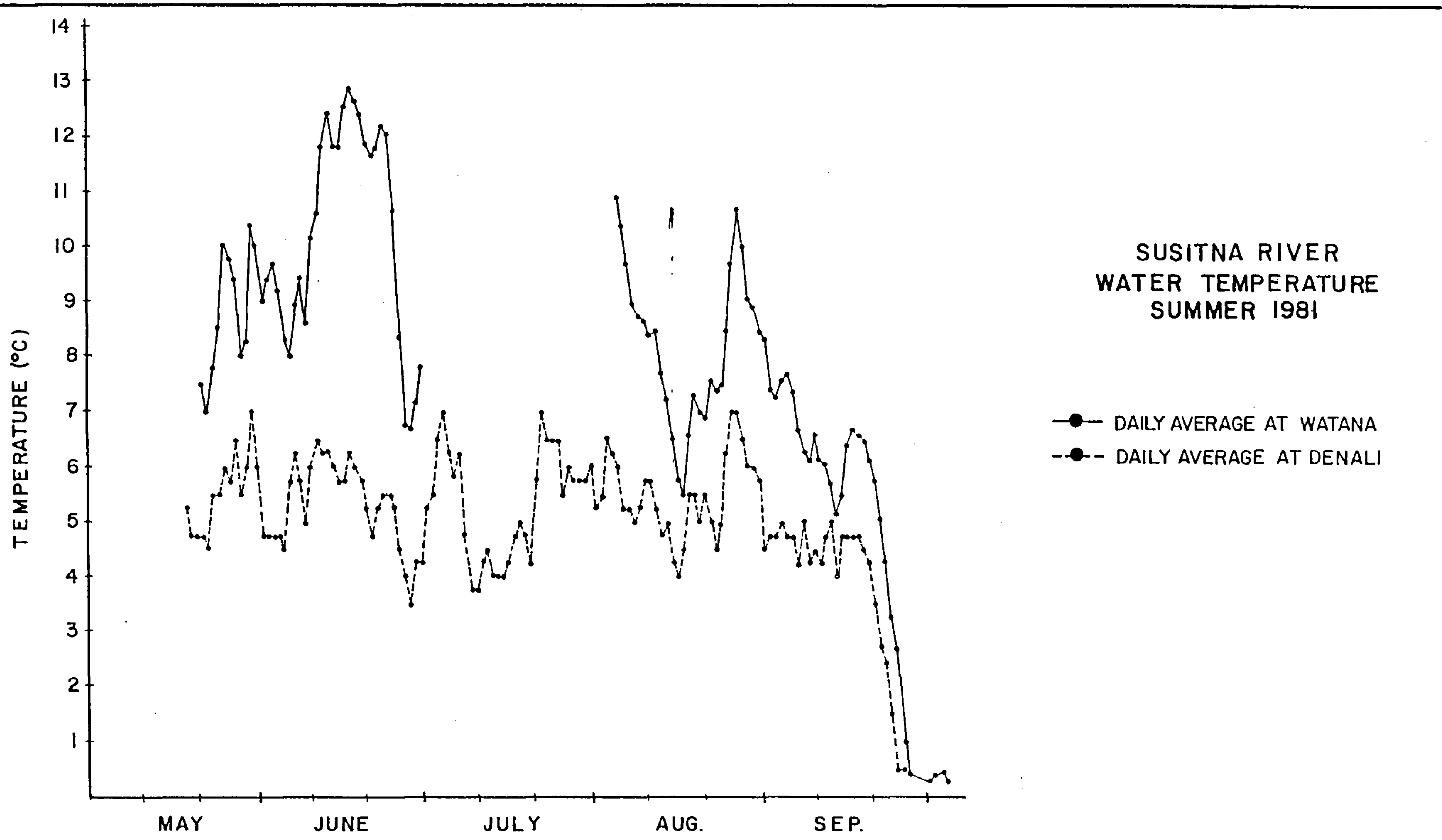
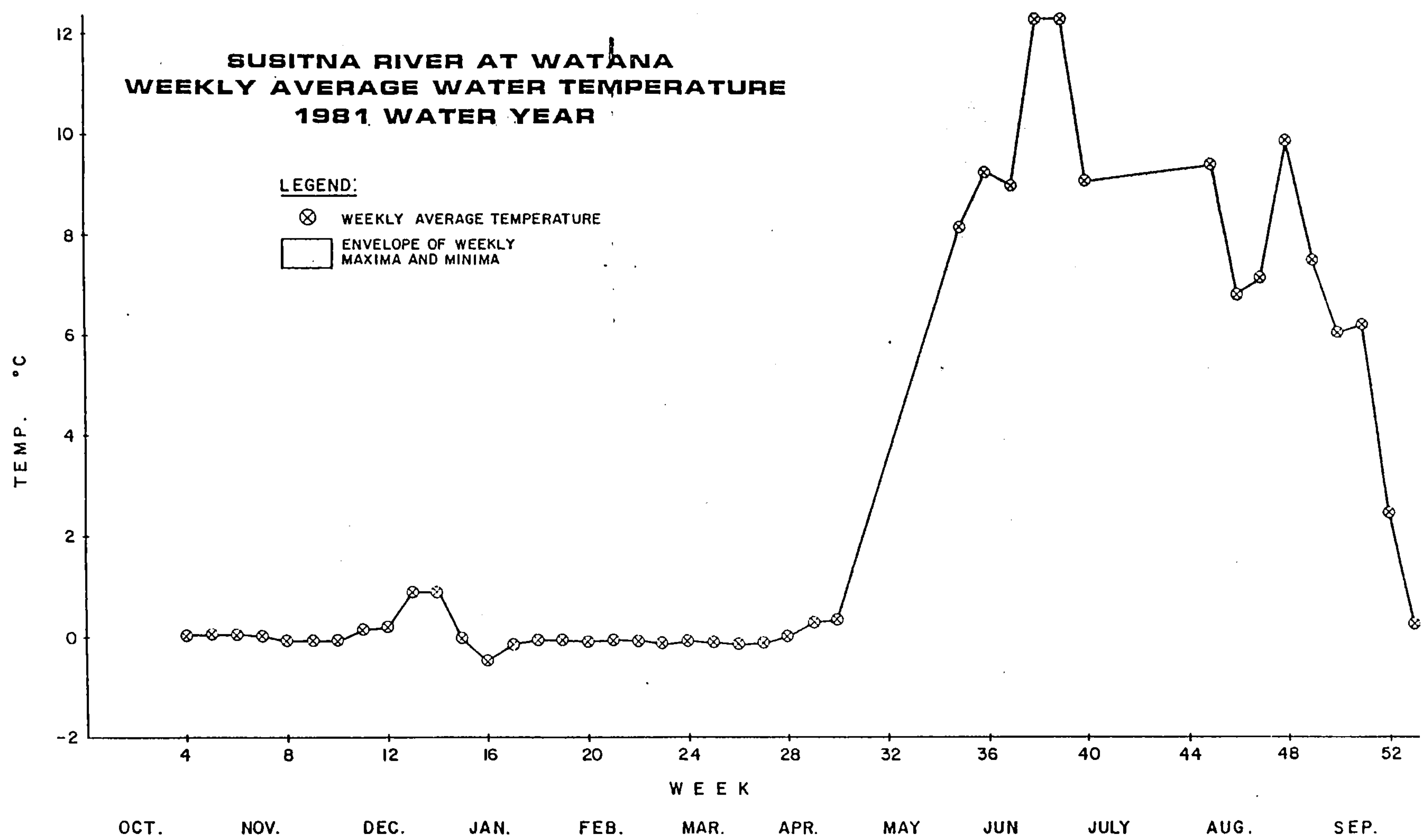
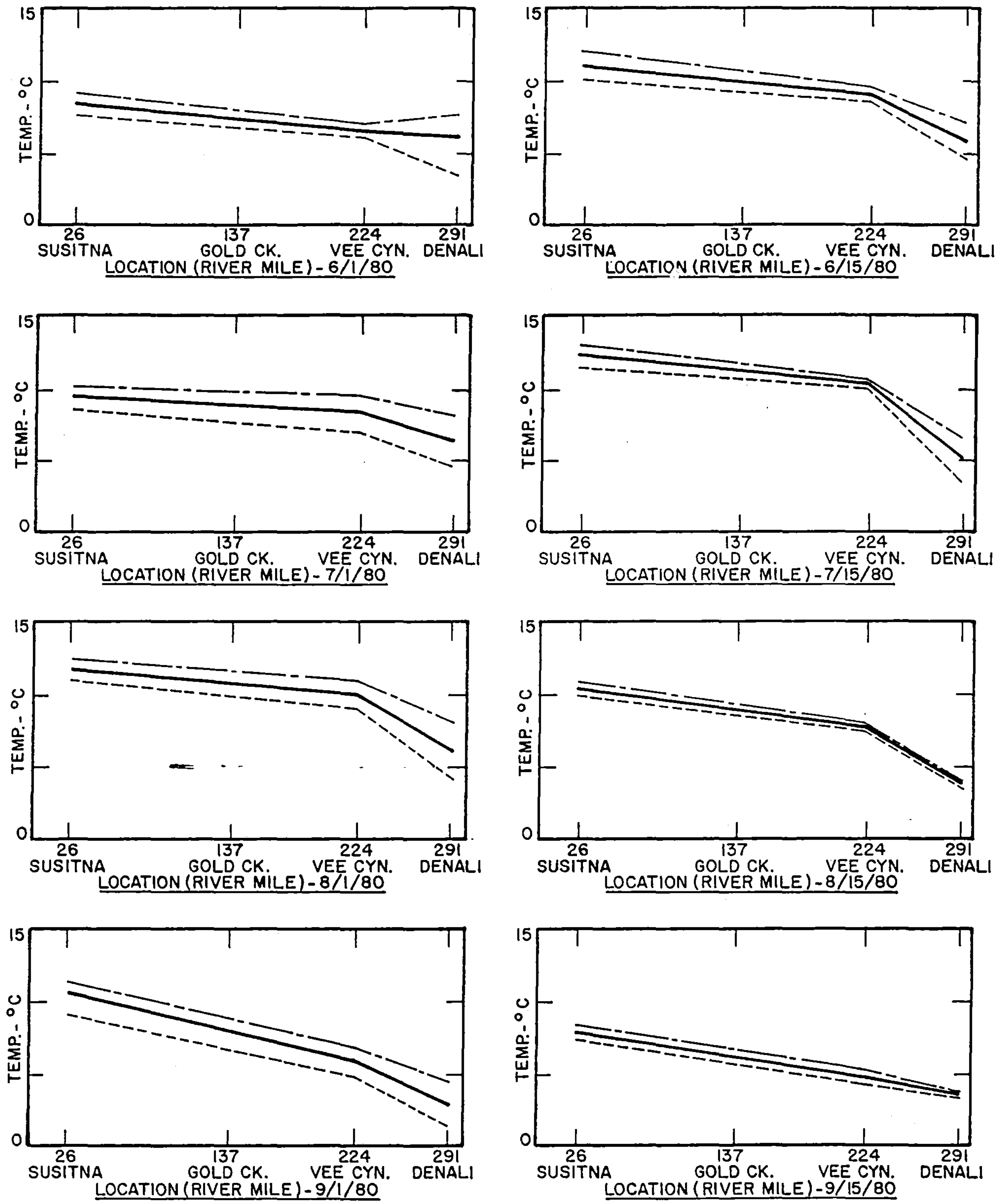

SUSITNA RIVER
WATER TEMPERATURE
SUMMER 1981
DAILY AVERAGE AT WATANA
DAILY AVERAGE AT DENALI
TEMPERATURE (°C)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
MAY
JUNE
JULY
AUG.
SEP.

FIGURE E.2.27



SUSITNA RIVER AT WATANA
WEEKLY AVERAGE WATER TEMPERATURE
1981 WATER YEAR
LEGEND:
WEEKLY AVERAGE TEMPERATURE
ENVELOPE OF WEEKLY MAXIMA AND MINIMA
TEMP. °C
12
10
8
6
4
2
0
-2
4
8
12
16
20
24
28
32
36
40
44
48
52
WEEK
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUN
JULY
AUG.
SEP.

FIGURE E.2.28



LEGEND

- MAXIMUM
- MEAN
- MINIMUM

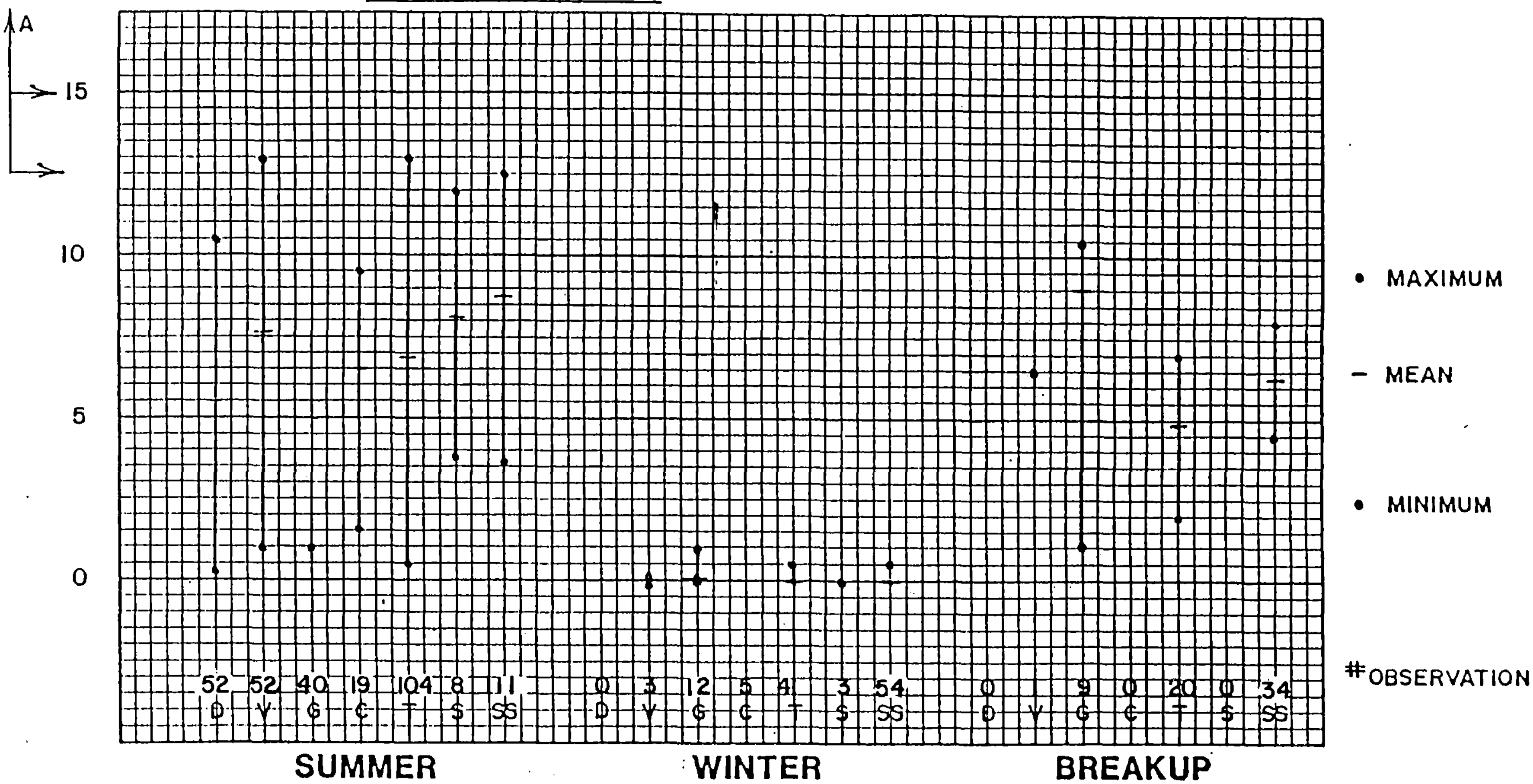
NOTES

1.) ALL TEMPERATURES WERE RECORDED BY THE USGS WITH SINGLE THERMOGRAPHS AT EACH SITE.
2.) GOLD CREEK'S TEMPERATURES MAY BE INFLUENCED BY TRIBUTARY INFLOW AT THE SITE.
3.) DAILY MEAN TEMPERATURES COMPUTED AS AVERAGE OF MINIMUM AND MAXIMUM FOR THE DAY.

SUSITNA RIVER - WATER TEMPERATURE GRADIENT

FIGURE E.2.29

PARAMETER: TEMPERATURE, °C



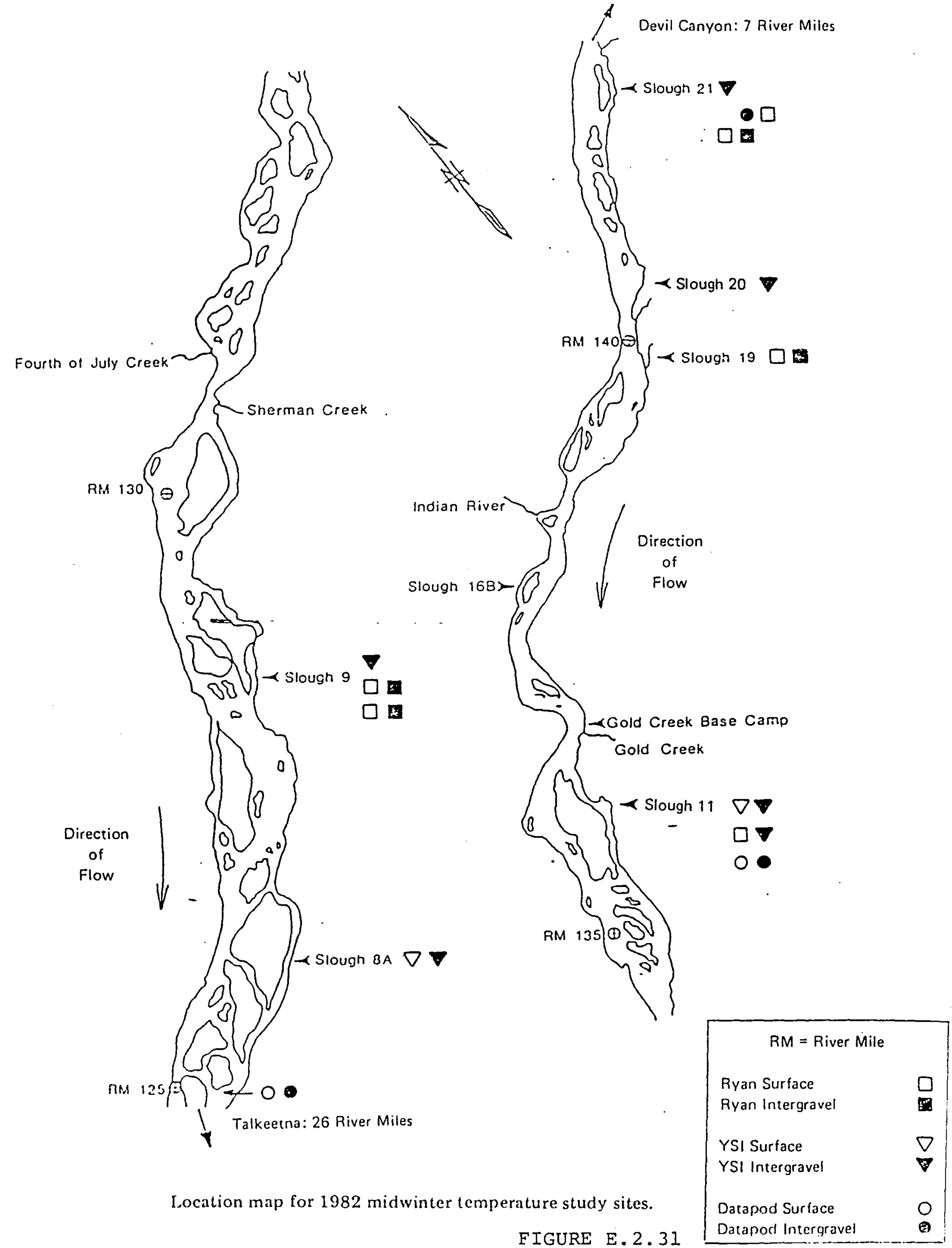
D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S- SUNSHINE SS- SUSITNA STATION

A. Shall not exceed 20°C at any time. The following maximum temperature shall not be exceeded where applicable: migration routes and rearing areas--15°C, spawning areas and egg and fry incubation--13°C (ADEC, 1979)

Established to protect sensitive important fish species, and for the successful migration, spawning, egg-incubation, fry-rearing, and other reproductive functions of important species.

DATA SUMMARY -TEMPERATURE

FIGURE E.2.30



Location map for 1982 midwinter temperature study sites.

FIGURE E.2.31

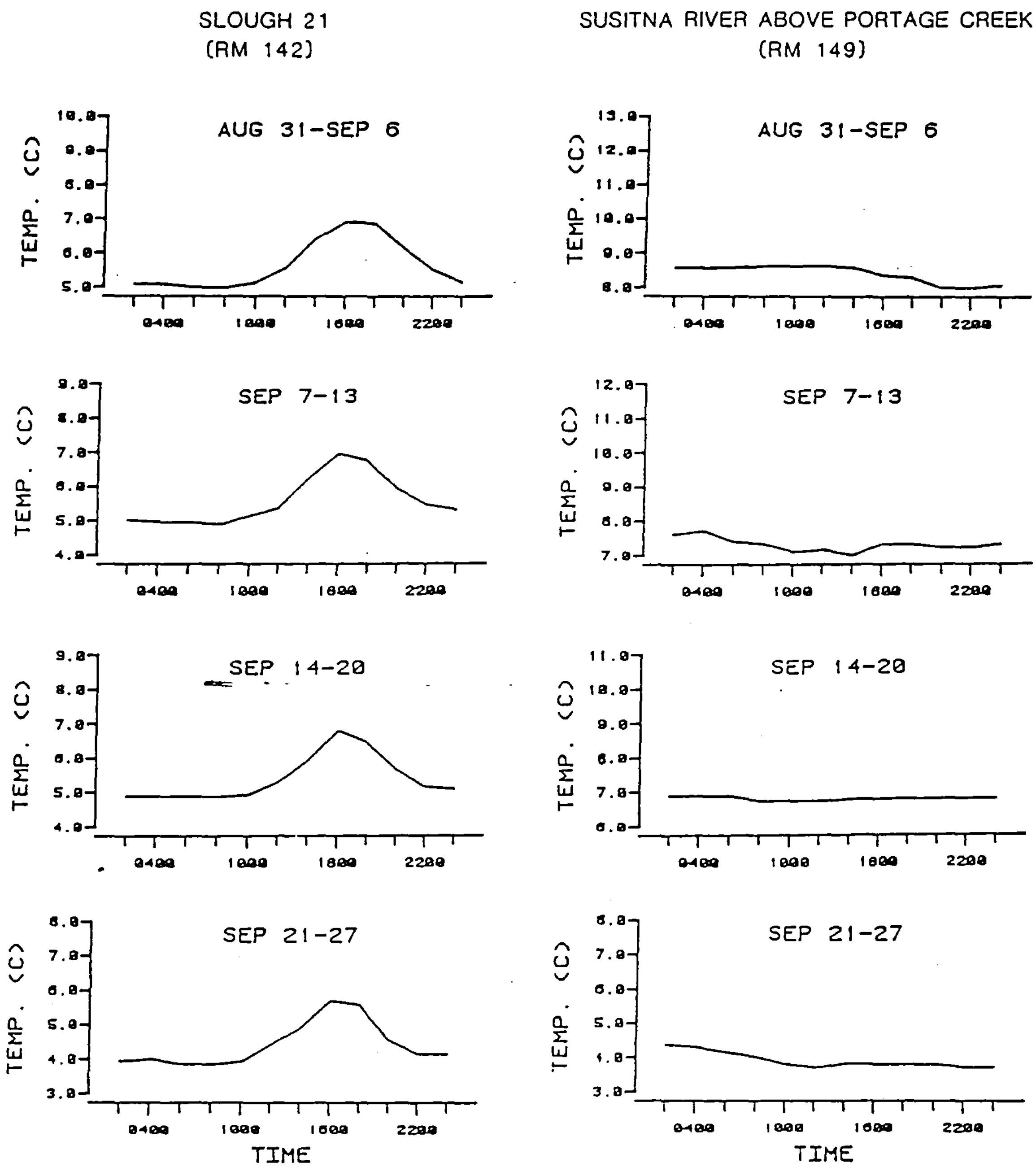
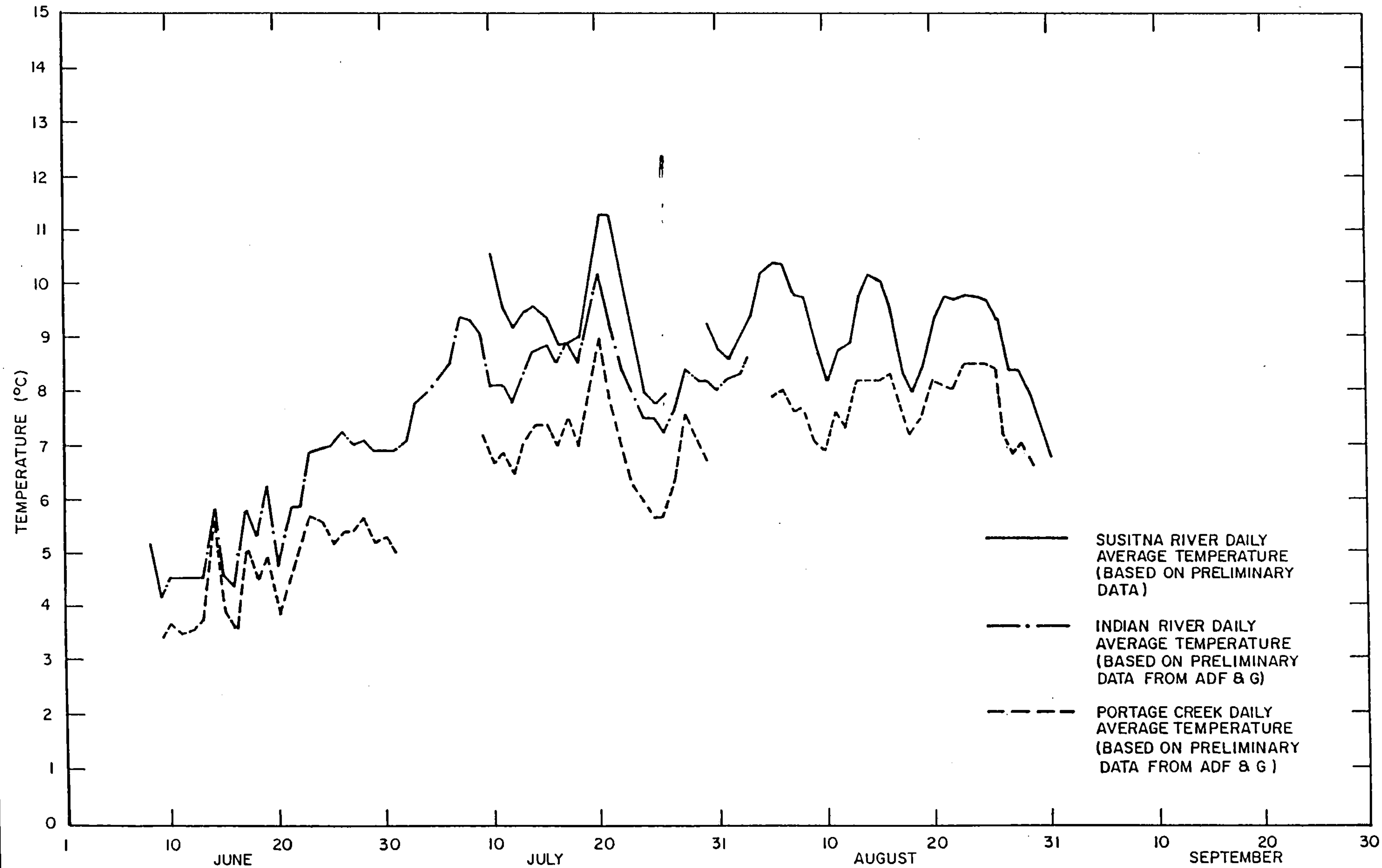


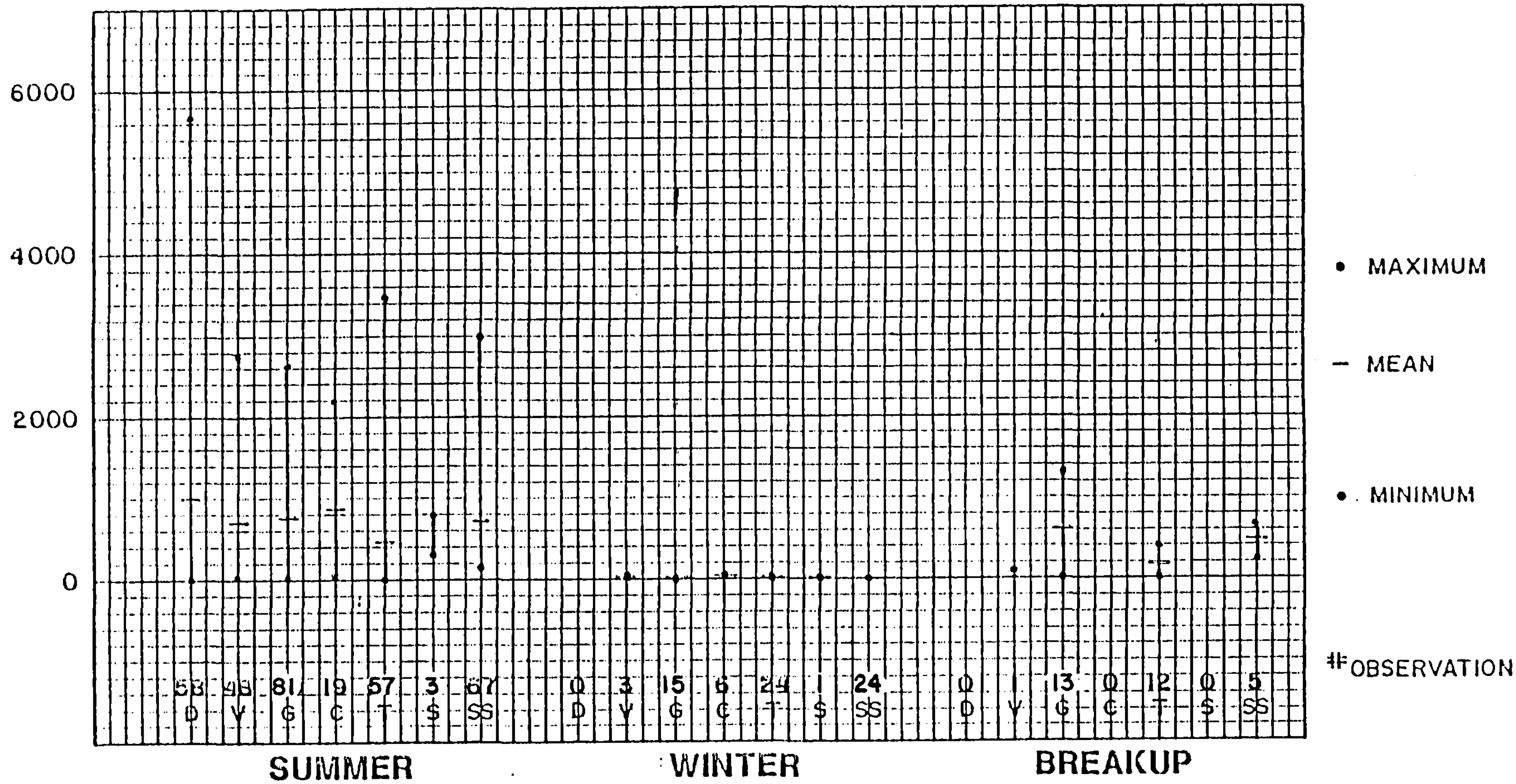
FIGURE E.2.32 Comparison of weekly diel surface water temperature variations in Slough 21 and the mainstem Susitna River at Portage Creek (adapted from ADF&G 1981).



SUSITNA RIVER, PORTAGE CREEK AND INDIAN RIVER WATER TEMPERATURES SUMMER 1982

FIGURE E.2.33

PARAMETER: TOTAL SUSPENDED SOLIDS, (mg./l.)



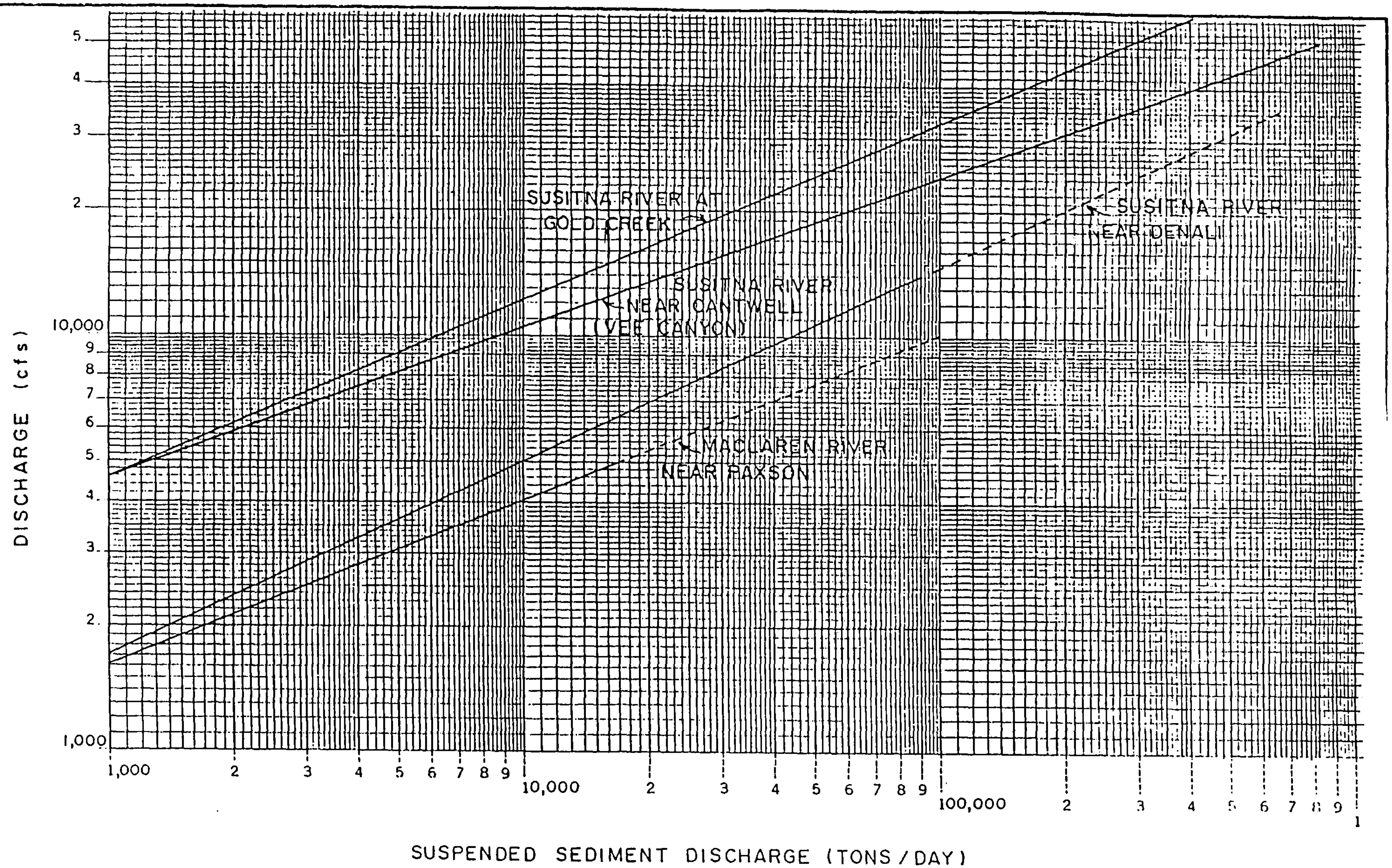
D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No measurable increase above natural conditions (ADEC,1979).

Established to prevent deleterious effects on aquatic animal and plant life, their reproduction and habitat.

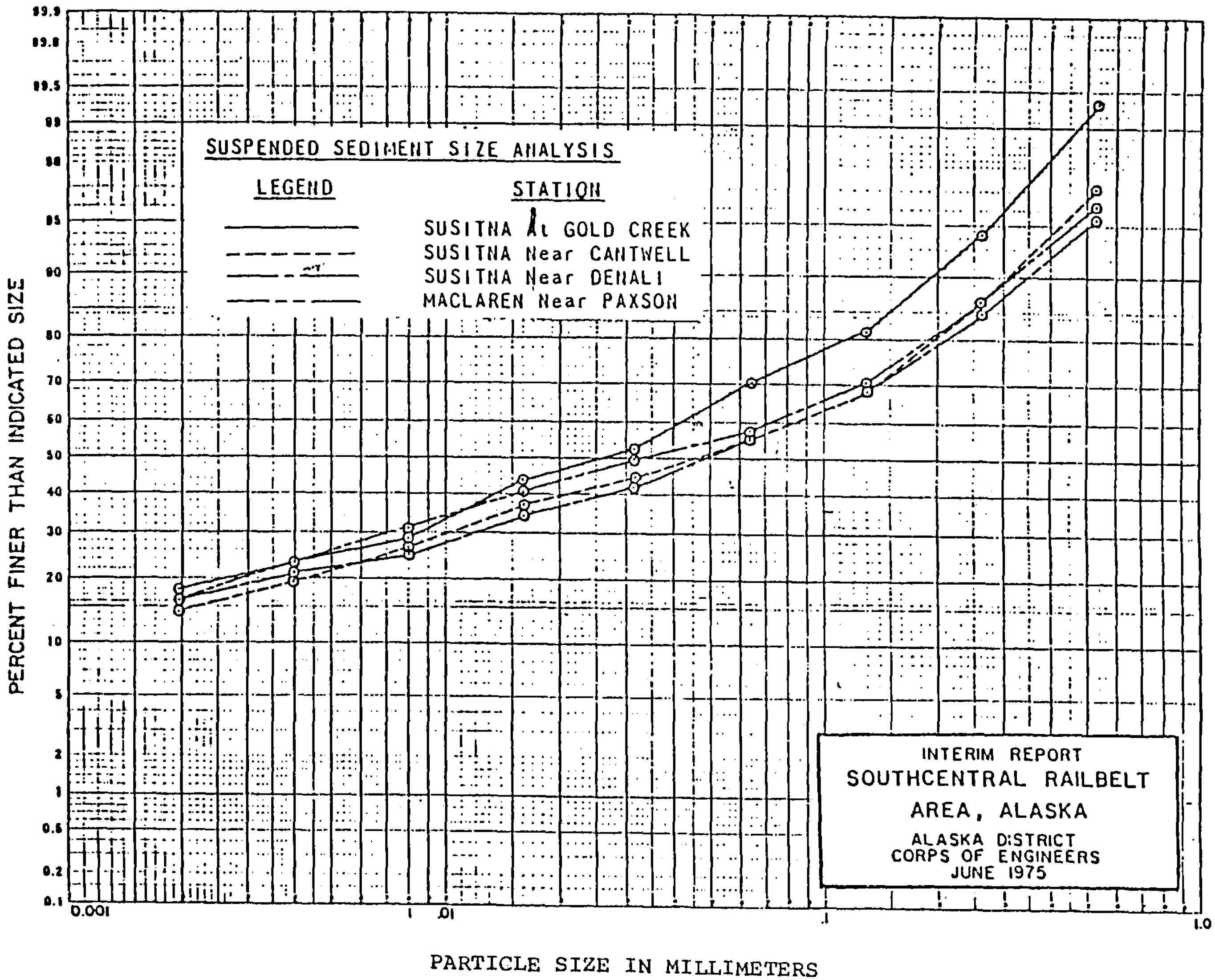
DATA SUMMARY - TOTAL SUSPENDED SEDIMENTS

FIGURE E.2.34



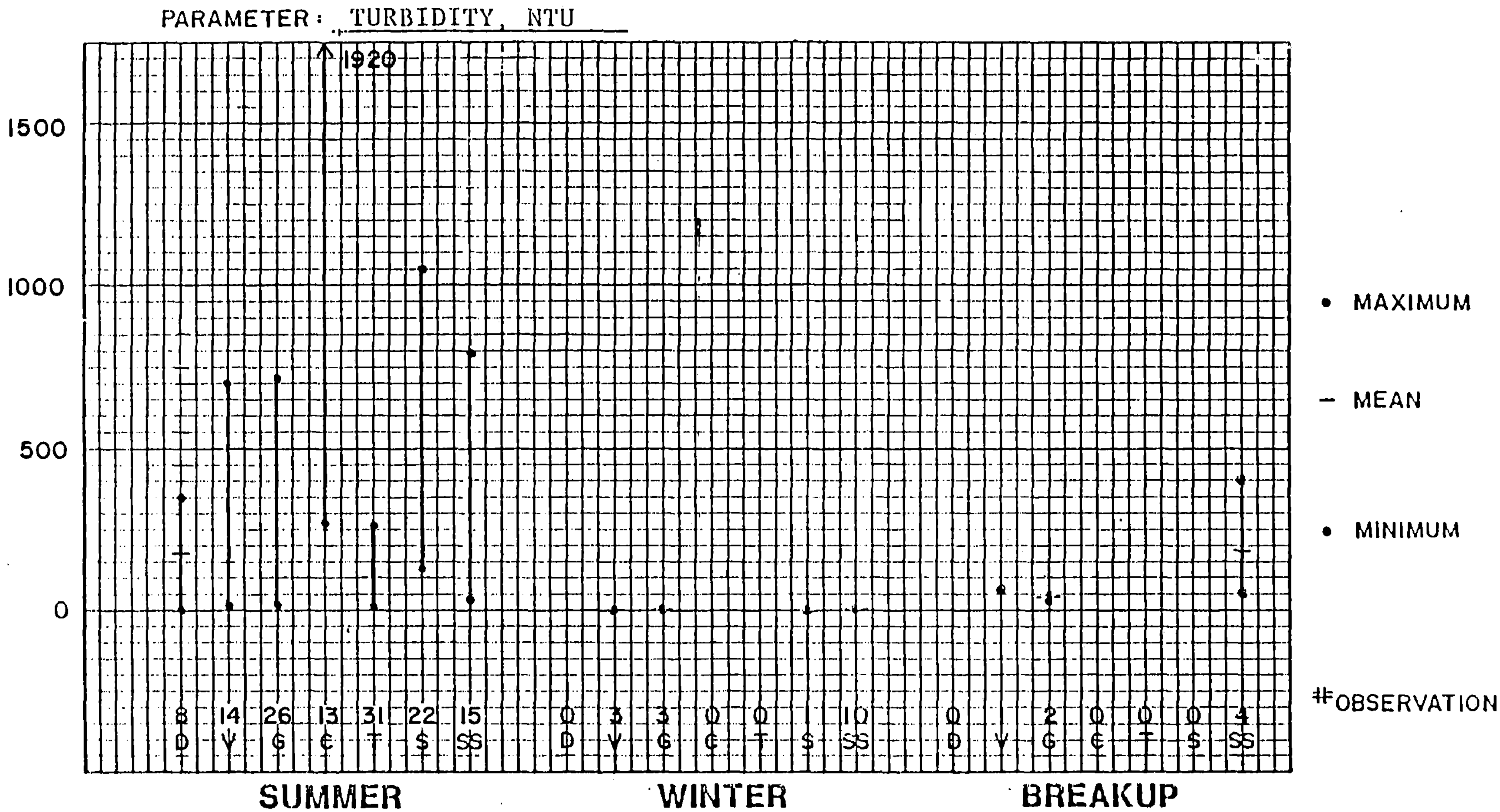
SUSPENDED SEDIMENT RATING CURVES
UPPER SUSITNA RIVER BASIN

FIGURE E.2.35



SUSPENDED SEDIMENT SIZE ANALYSIS
SUSITNA RIVER

FIGURE E.2.36



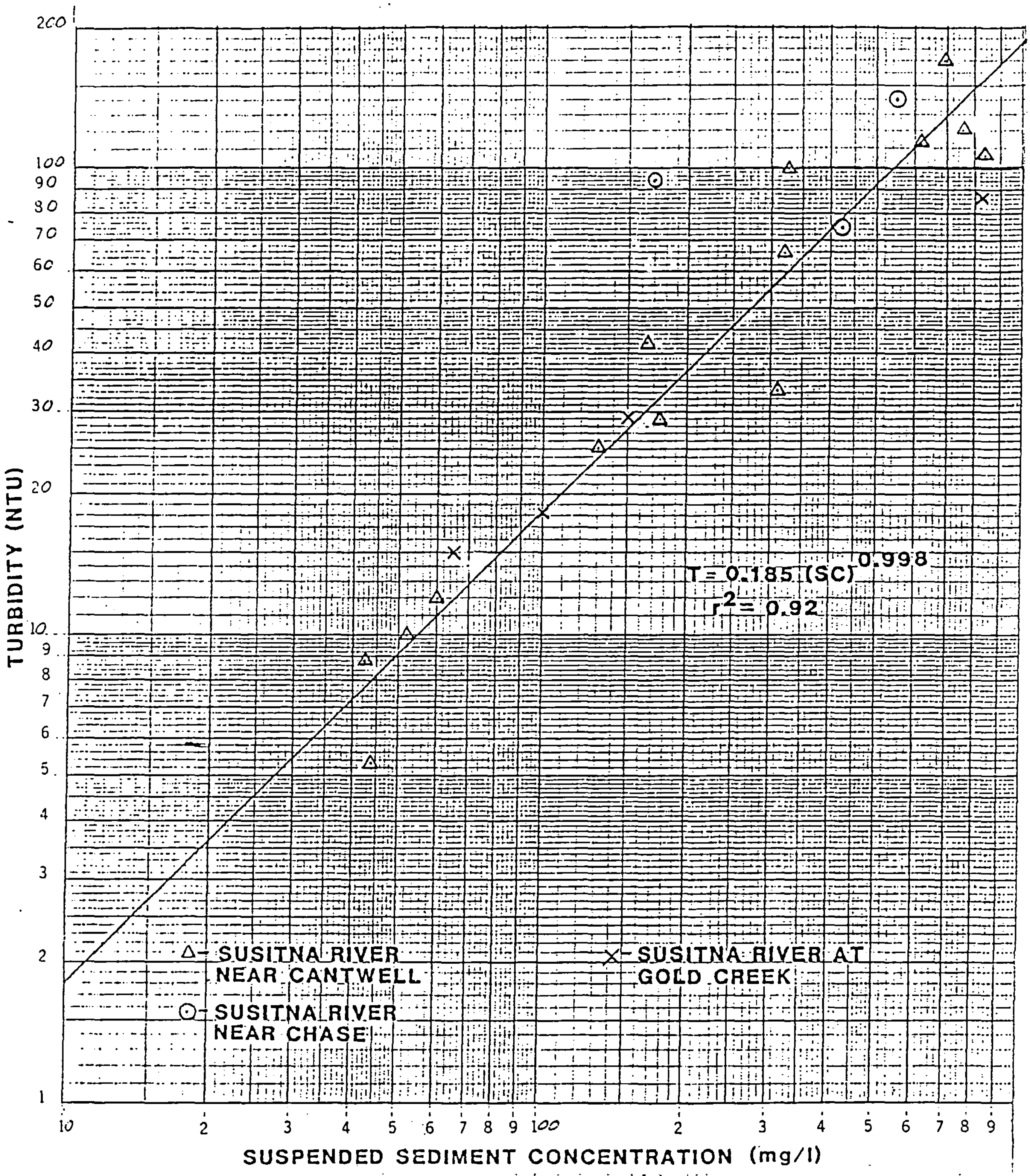
D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

Shall not exceed 25 NTU above natural conditions (ADEC, 1979)

Established to prevent the reduction of the compensation point for photosynthetic activity, which may have adverse effects on aquatic life.

DATA SUMMARY - TURBIDITY

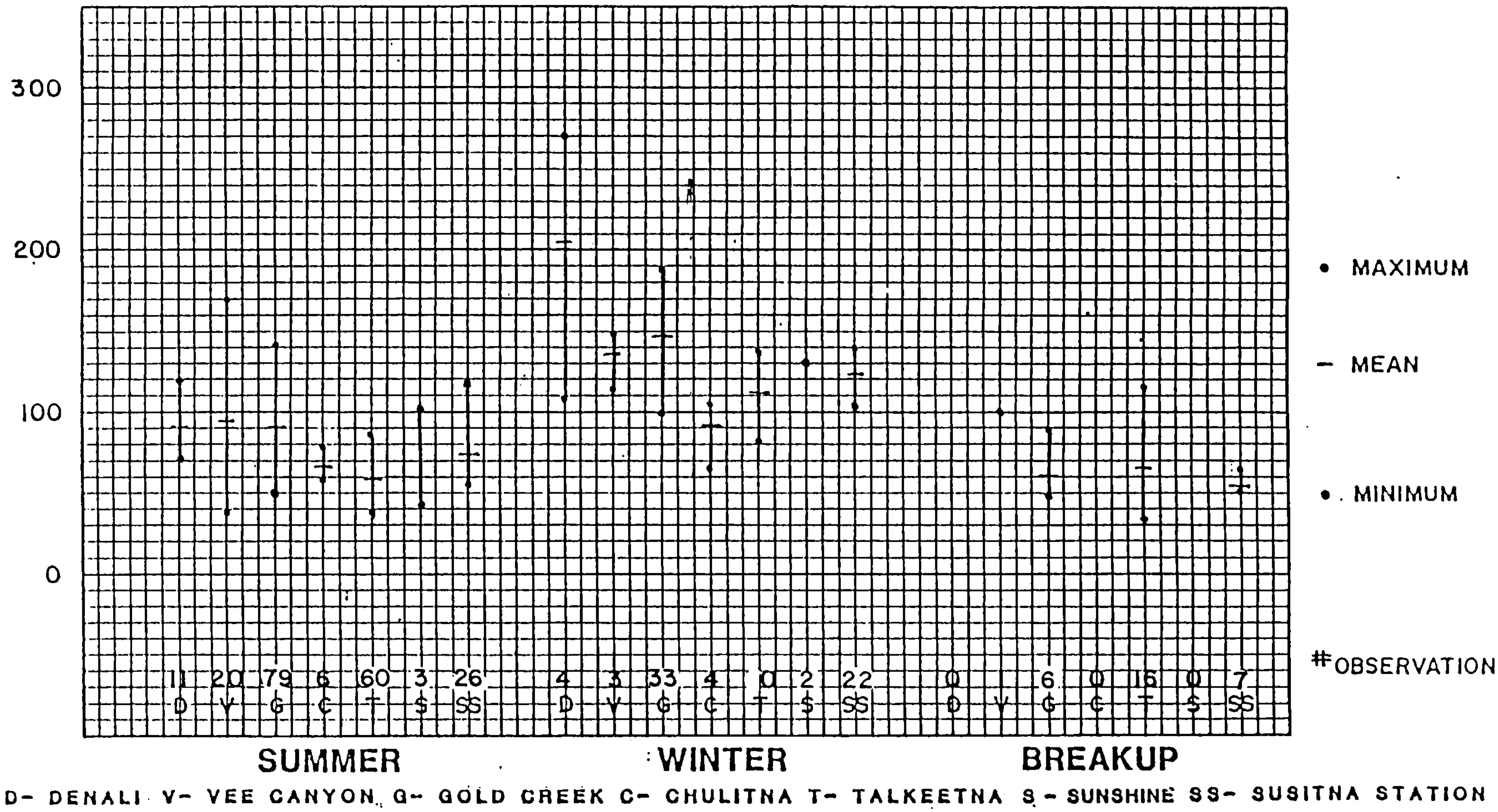
FIGURE E.2.37



TURBIDITY vs SUSPENDED SEDIMENT CONCENTRATION

FIGURE E.2.38

PARAMETER: TOTAL DISSOLVED SOLIDS, (mg./1.)



A. 1,500 mg/1 (ADEC, 1979).

Established to protect natural condition of freshwater ecosystems (500 mg/1 is the criterion for water supplies).

DATA SUMMARY - TOTAL DISSOLVED SOLIDS

FIGURE E.2.39

PARAMETER: CONDUCTIVITY, µmhos/cm @ 25°C

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

No criterion established

DATA SUMMARY - CONDUCTIVITY

FIGURE E.2.40

PARAMETER: CHLORIDE, (mg./1.)

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

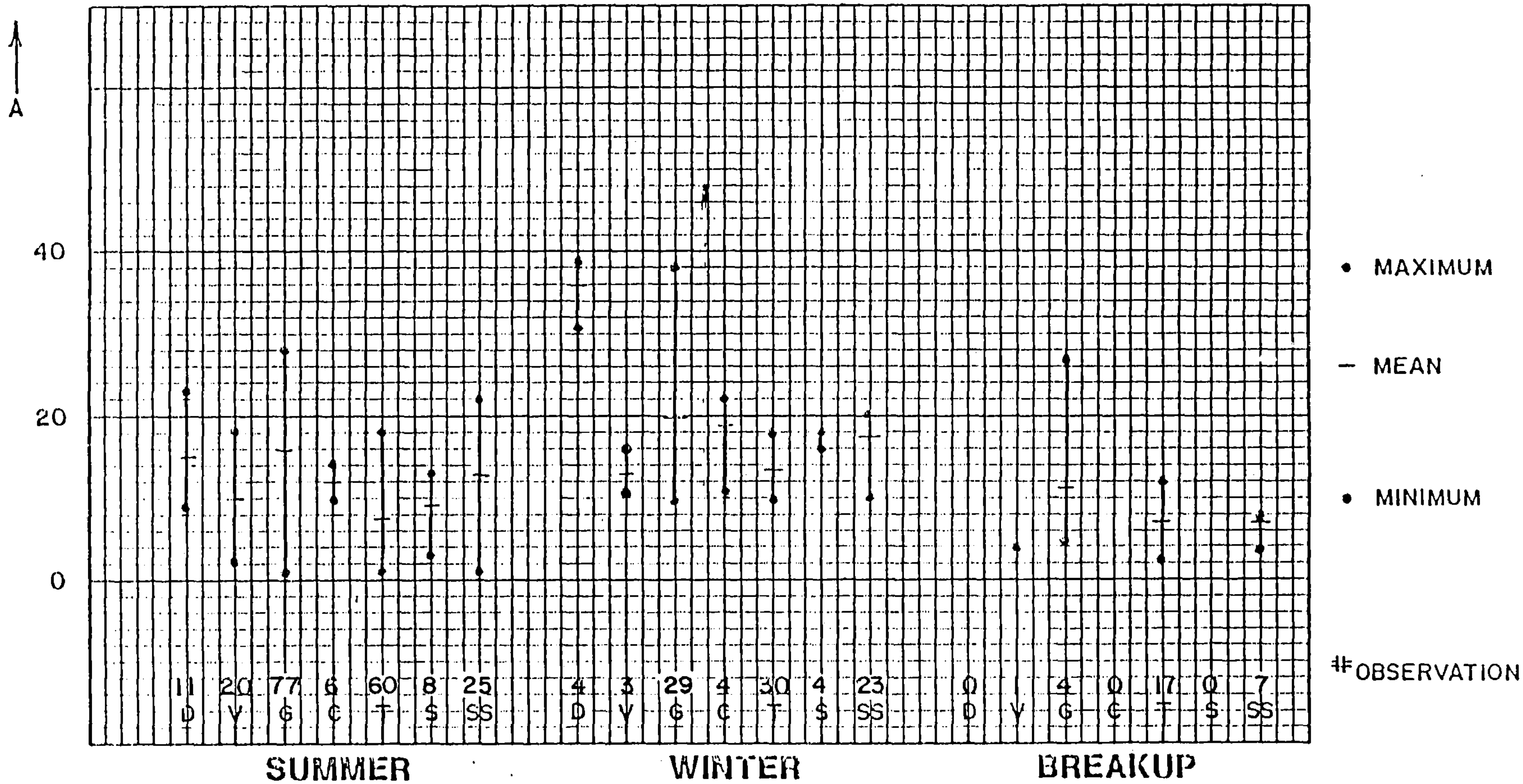
Less than 200 mg/l$_x$ (ADEC, 1979)

Established to protect water supplies.

DATA SUMMARY - CHLORIDE

FIGURE E.2.41

PARAMETER: SULFATE, (mg./1.)



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

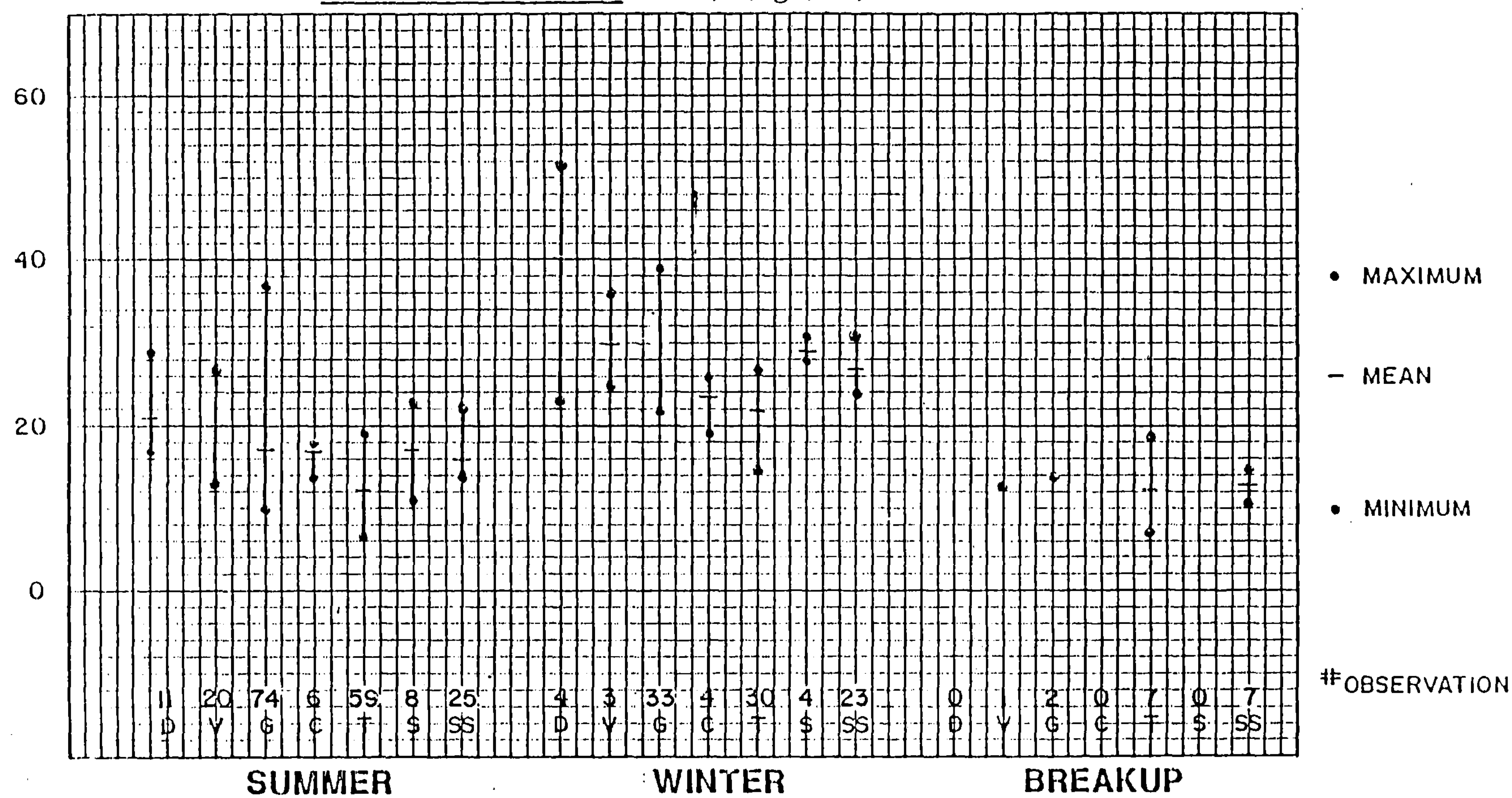
A. Shall not exceed 200 mg/1. (ADEC, 1979).

Established to protect water supplies.

DATA SUMMARY - SULFATE

FIGURE E.2.42

PARAMETER: CALCIUM (Ca) DISSOLVED, (mg./1.)

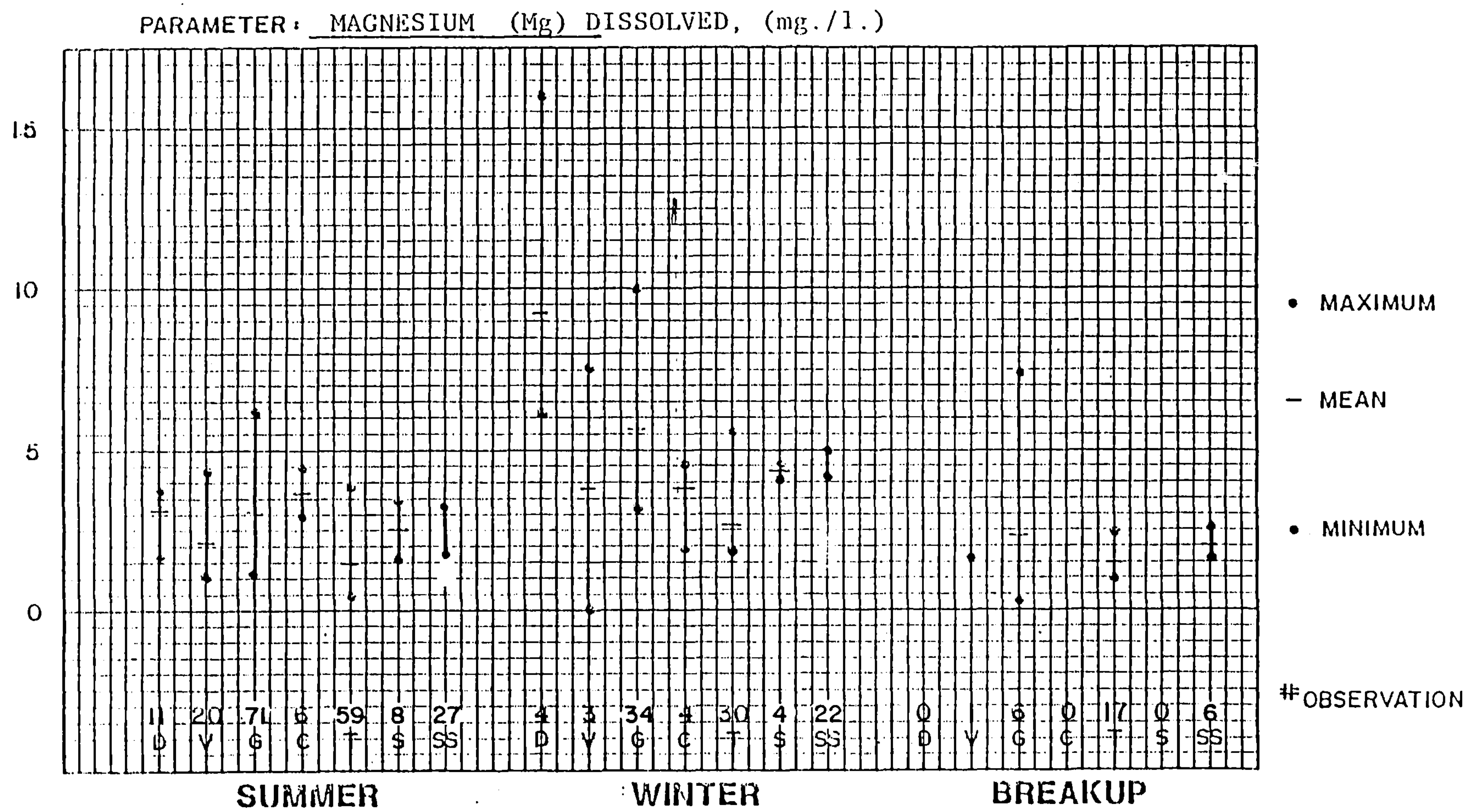


D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established

DATA SUMMARY - CALCIUM (d)

FIGURE E.2.43



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

No criterion established.

DATA SUMMARY - MAGNESIUM (d)

FIGURE E.2.44

PARAMETER: SODIUM (Na) DISSOLVED, (mg./l.)

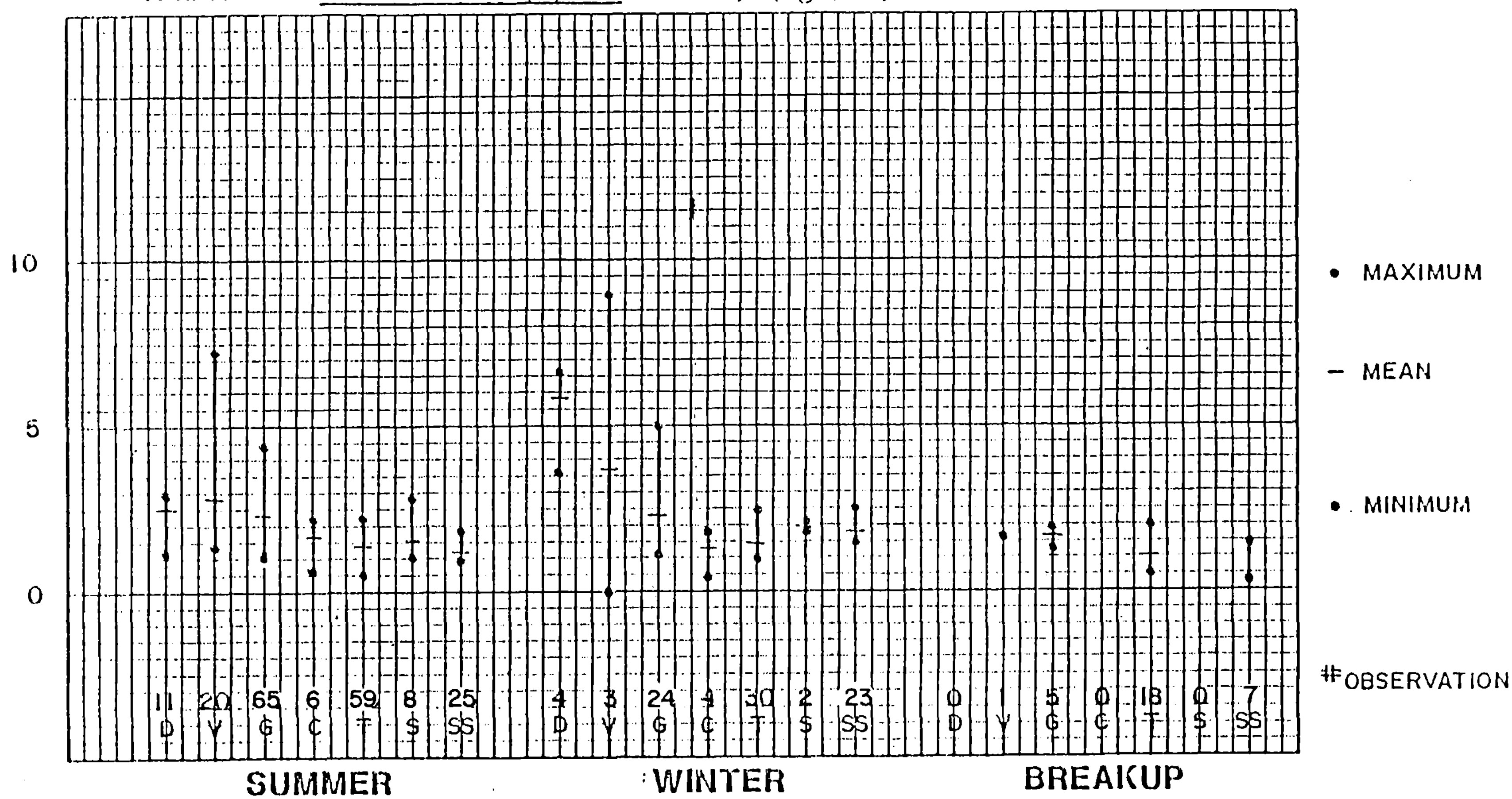
D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established.

DATA SUMMARY - SODIUM (d)

FIGURE E.2.45

PARAMETER: POTASSIUM (K) DISSOLVED, (mg./l.)

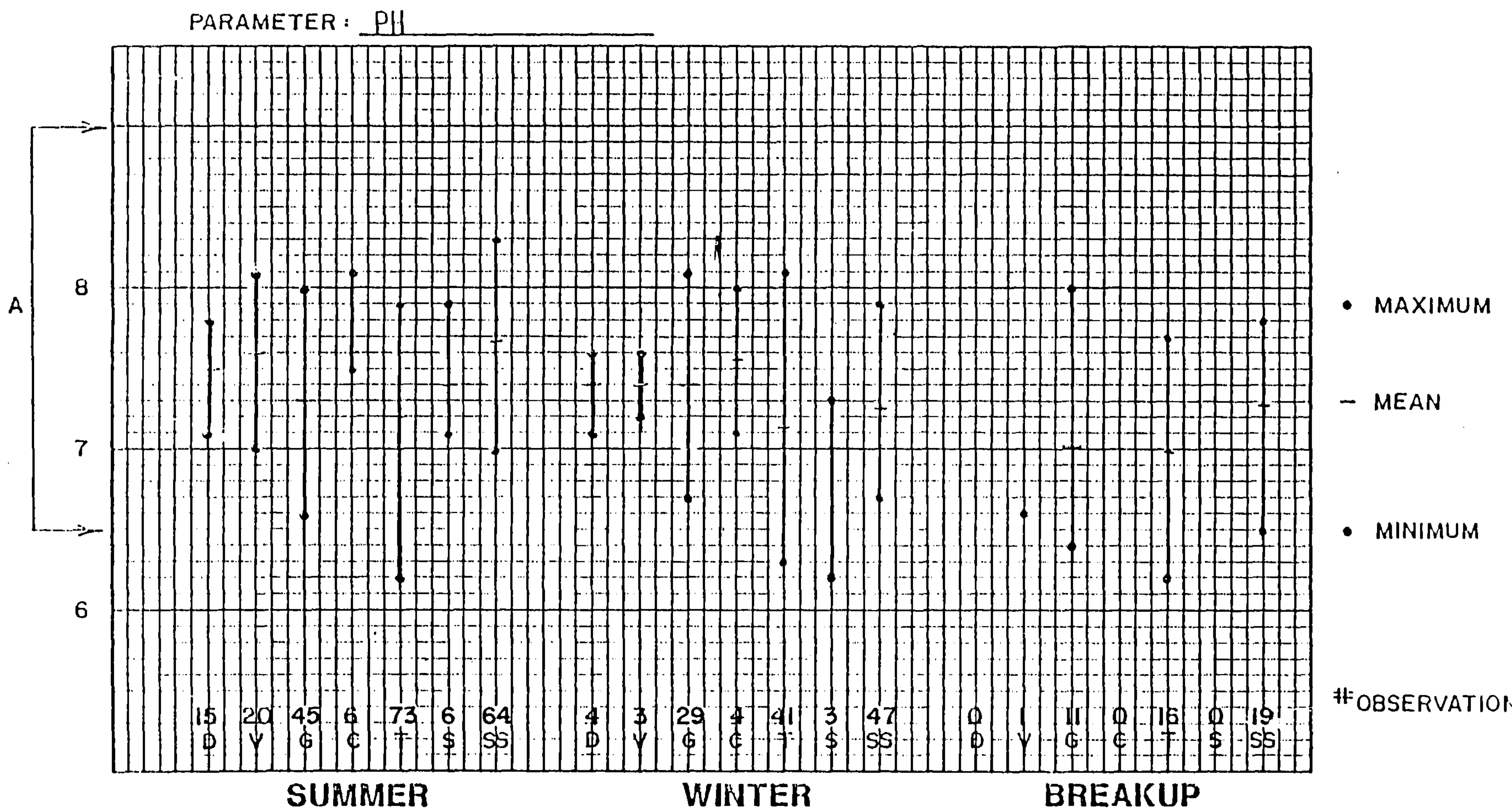


D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established.

DATA SUMMARY POTASSIUM (d)

FIGURE E.2.46



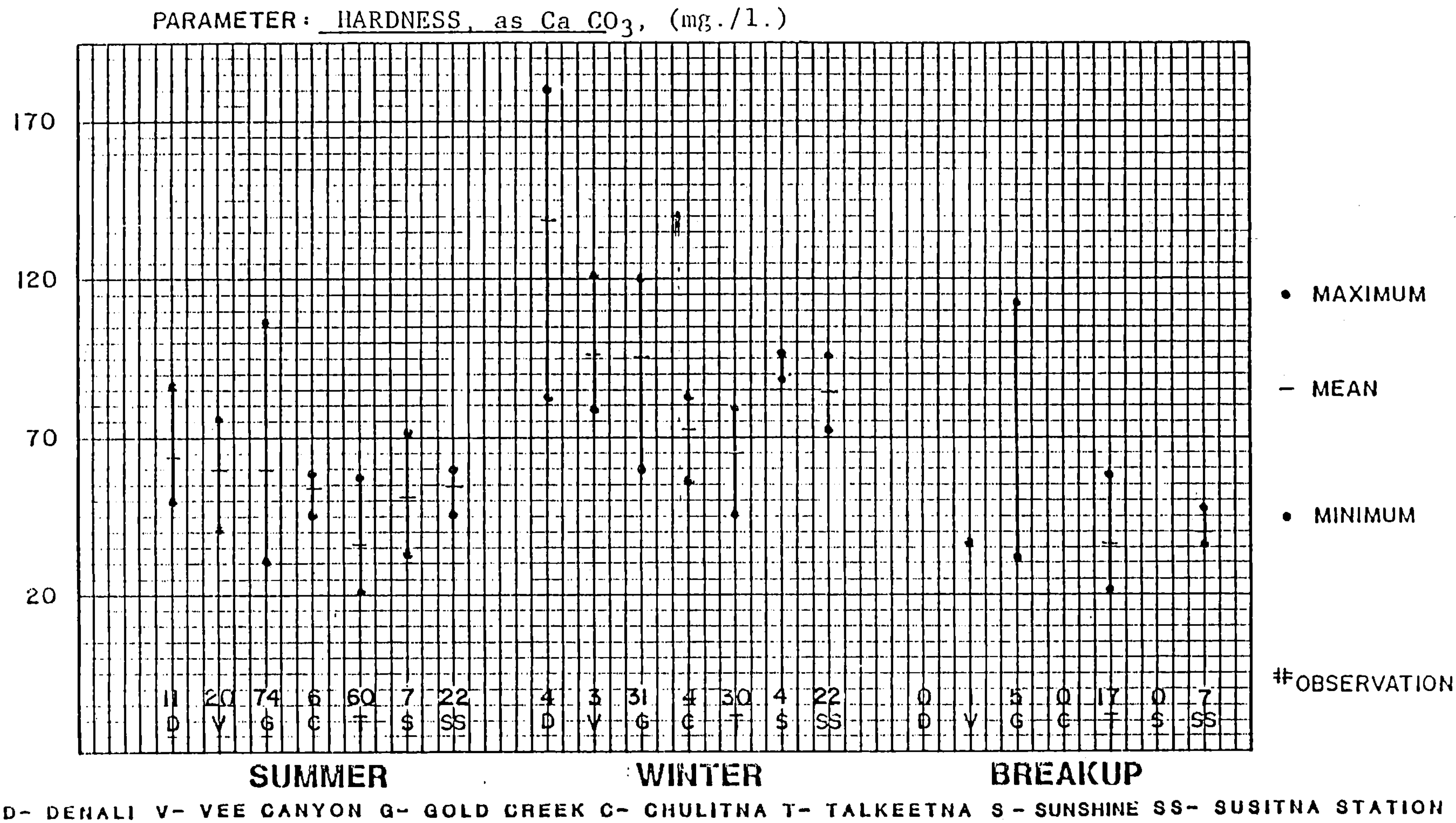
D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Not less than 6.5 or greater than 9.0. Shall not vary more than 0.5 pH unit from natural condition (ADEC, 1979).

Established to protect freshwater aquatic organisms.

DATA SUMMARY - PH

FIGURE E.2.47



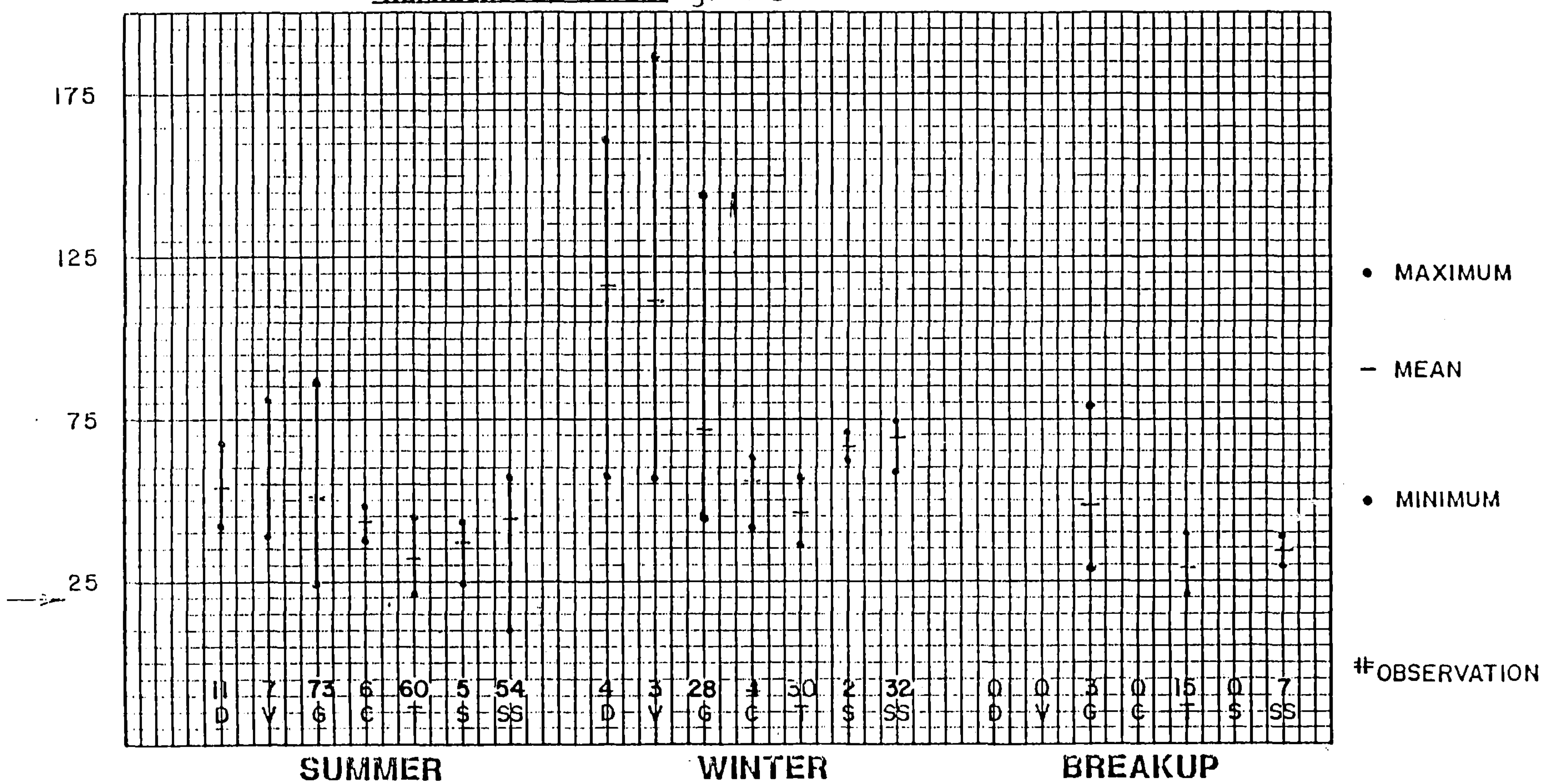
No criterion established

Some metals have variable synergistic effects with hardness, dependent on the prevailing hardness in the water. The criteria for cadium, for example, is 0.0012 mg/l in hard water and 0.0004 mg/l in soft water.

DATA SUMMARY - HARDNESS

FIGURE E.2.48

PARAMETER: ALKALINITY, as $CACO_3$, (mg./1.)



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

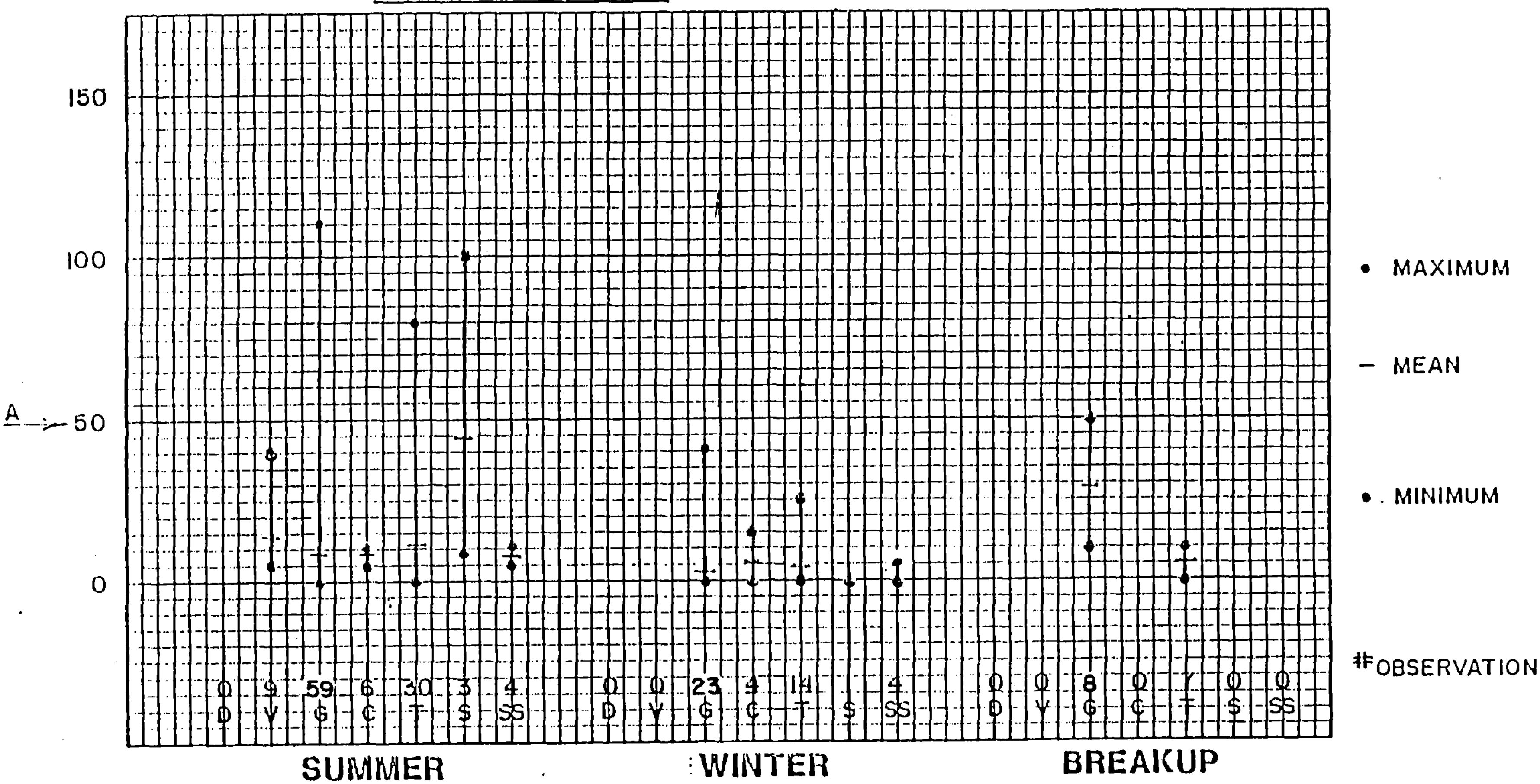
20mg/1 or more except where natural conditions are less. (EPA, 1976).

Established to protect freshwater aquatic organisms.

DATA SUMMARY - ALKALINITY

FIGURE E.2.49

PARAMETER: TRUE COLOR, PLATINUM COBALT UNIT



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

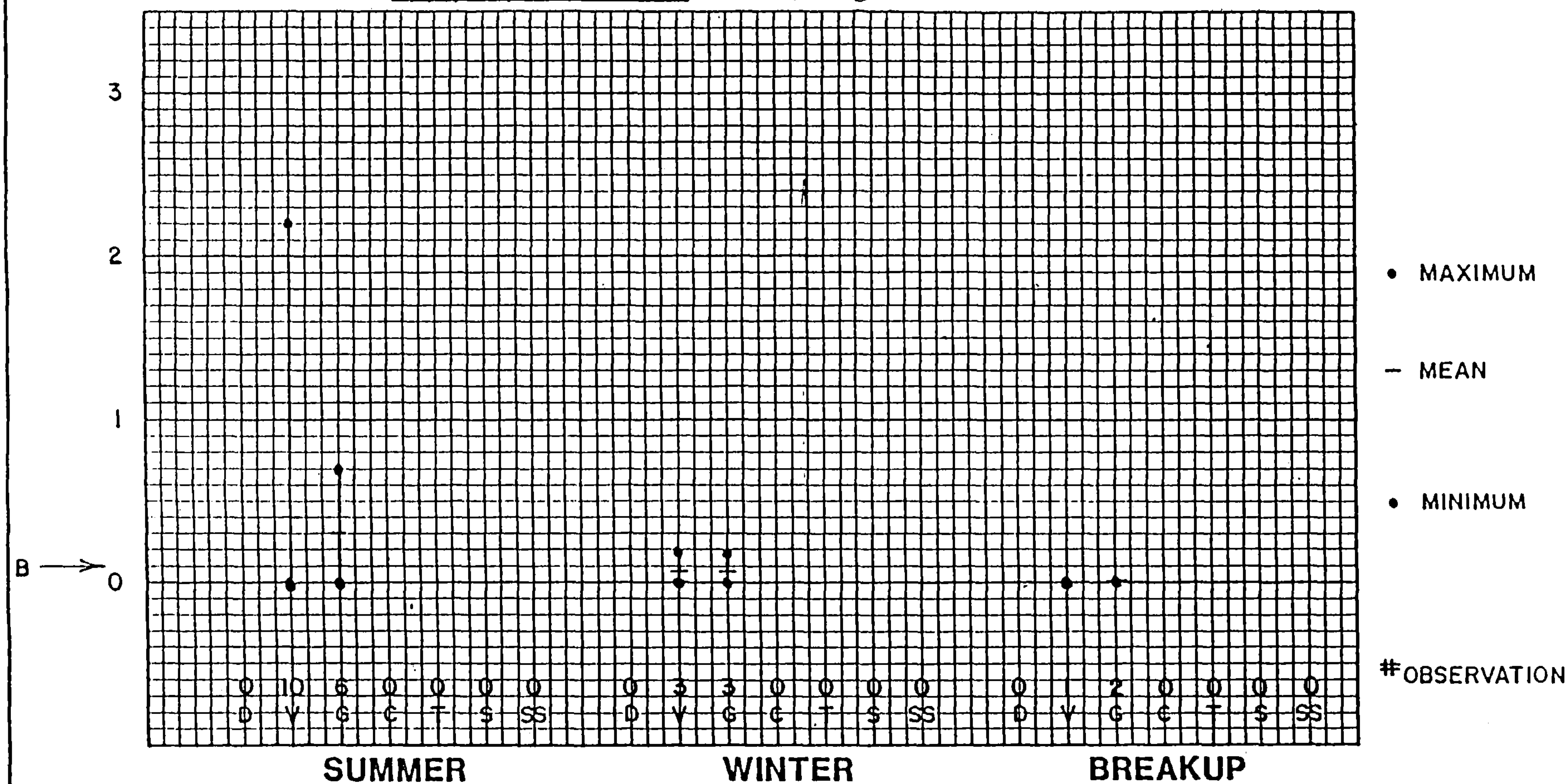
A Shall not exceed 50 units (ADEC, 1979)

Established to prevent the reduction of photosynthetic activity which may have deleterious effects on aquatic life.

DATA SUMMARY - TRUE COLOR

FIGURE E.2.50

PARAMETER: ALUMINUM (Al) DISSOLVED, (mg./l.)



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

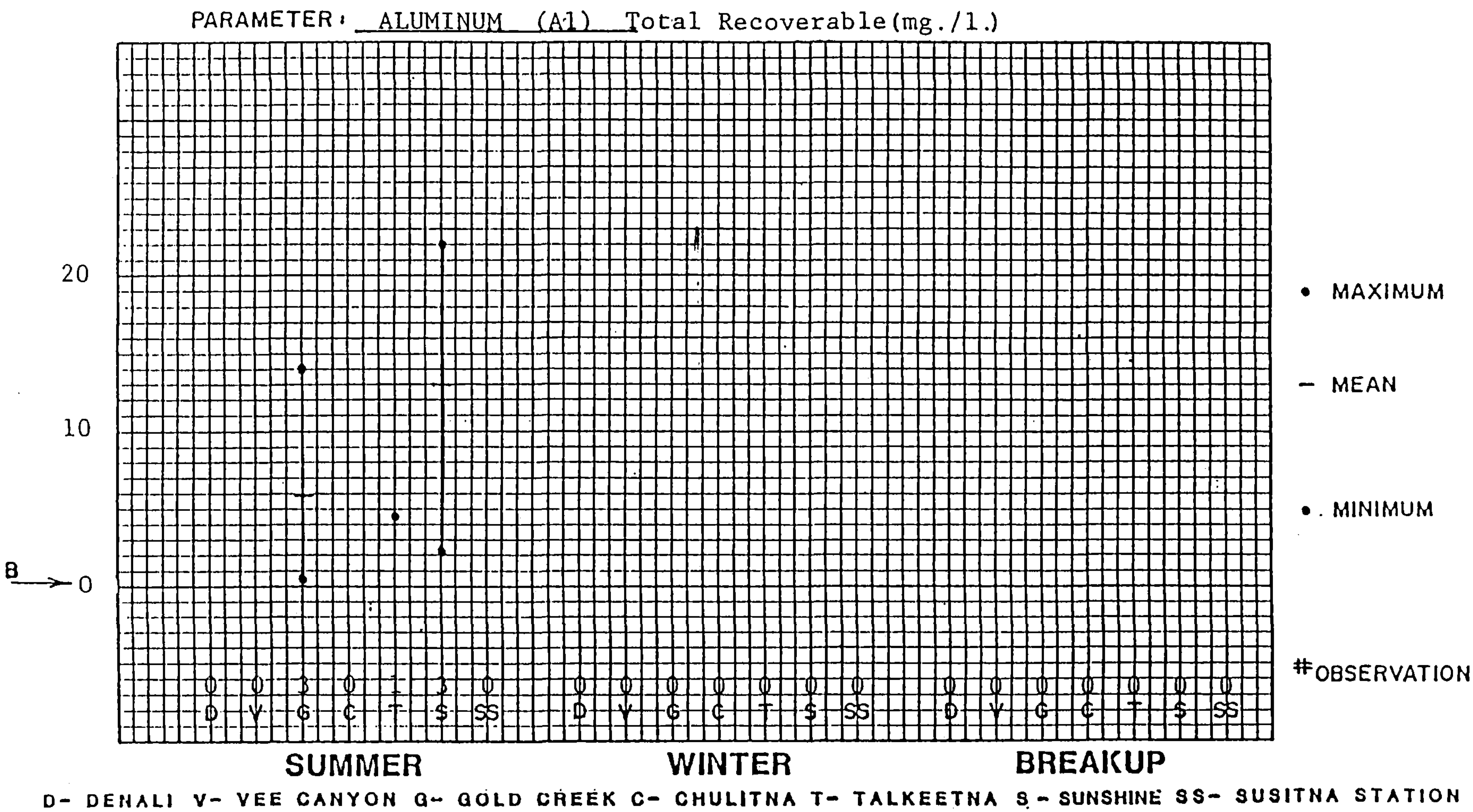
A. No criterion established

B. A limit of 0.073 mg/l has been suggested by EPA (Sittig, 1981).

This suggested limit is based on the effects of aluminum on human health.

DATA SUMMARY - ALUMINUM (d)

FIGURE E.2.51



A. No criterion established

B. A limit of 0.073 mg/l has been suggested by EPA (Sittig, 1981)

This suggested limit is based on the effects of aluminum on human health.

DATA SUMMARY - ALUMINUM (t)

FIGURE E.2.52

PARAMETER: CADMIUM (Cd) DISSOLVED, (mg./1.)

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

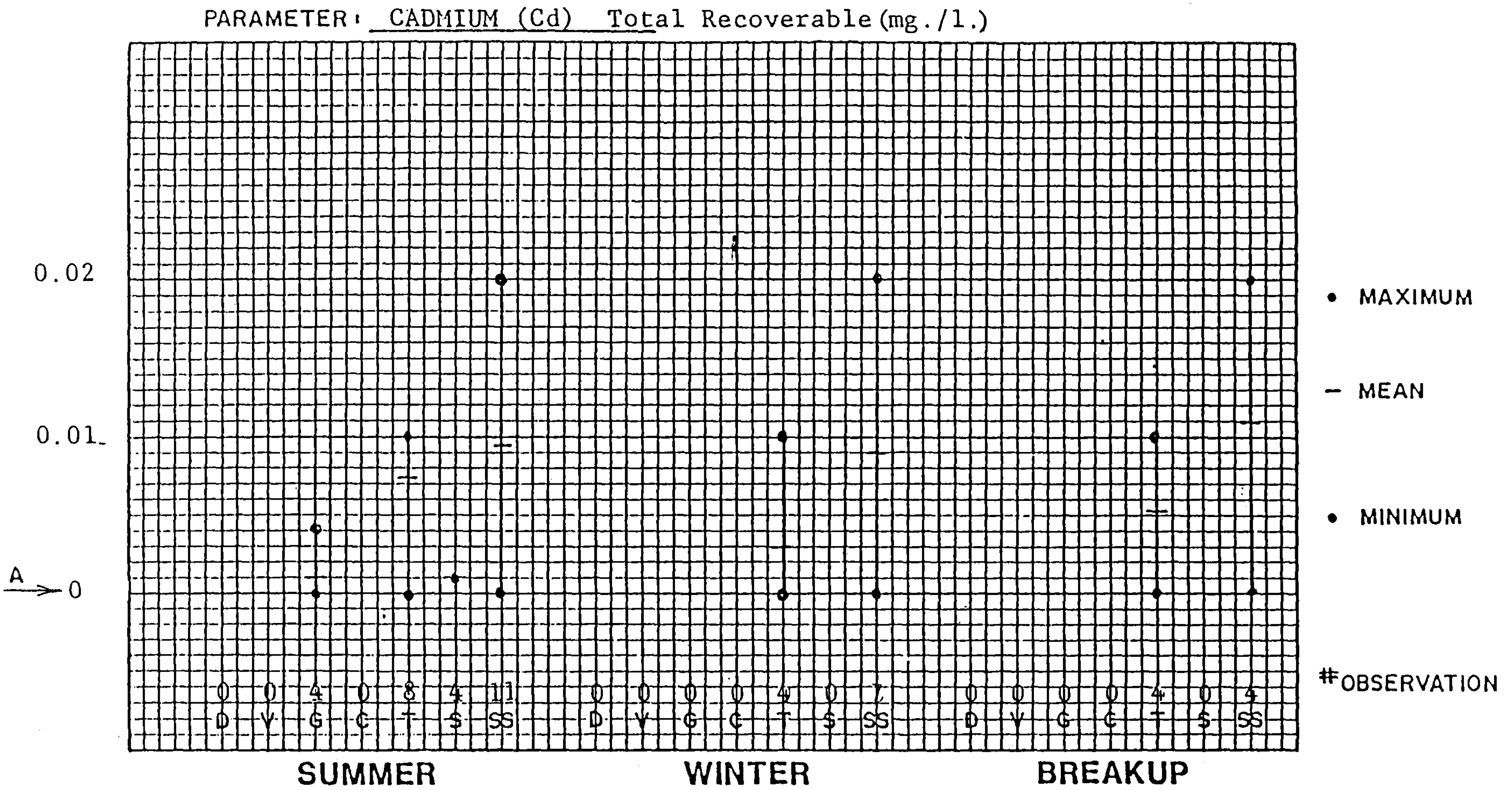
A. 0.0012 mg/1 in hard water and 0.0004 in soft water. (EPA, 1976)

B. Less than 0.0002 mg/1. (McNeely, 1979)

Established to protect freshwater aquatic organisms.

DATA SUMMARY - CADMIUM (d)

FIGURE E.2.53



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

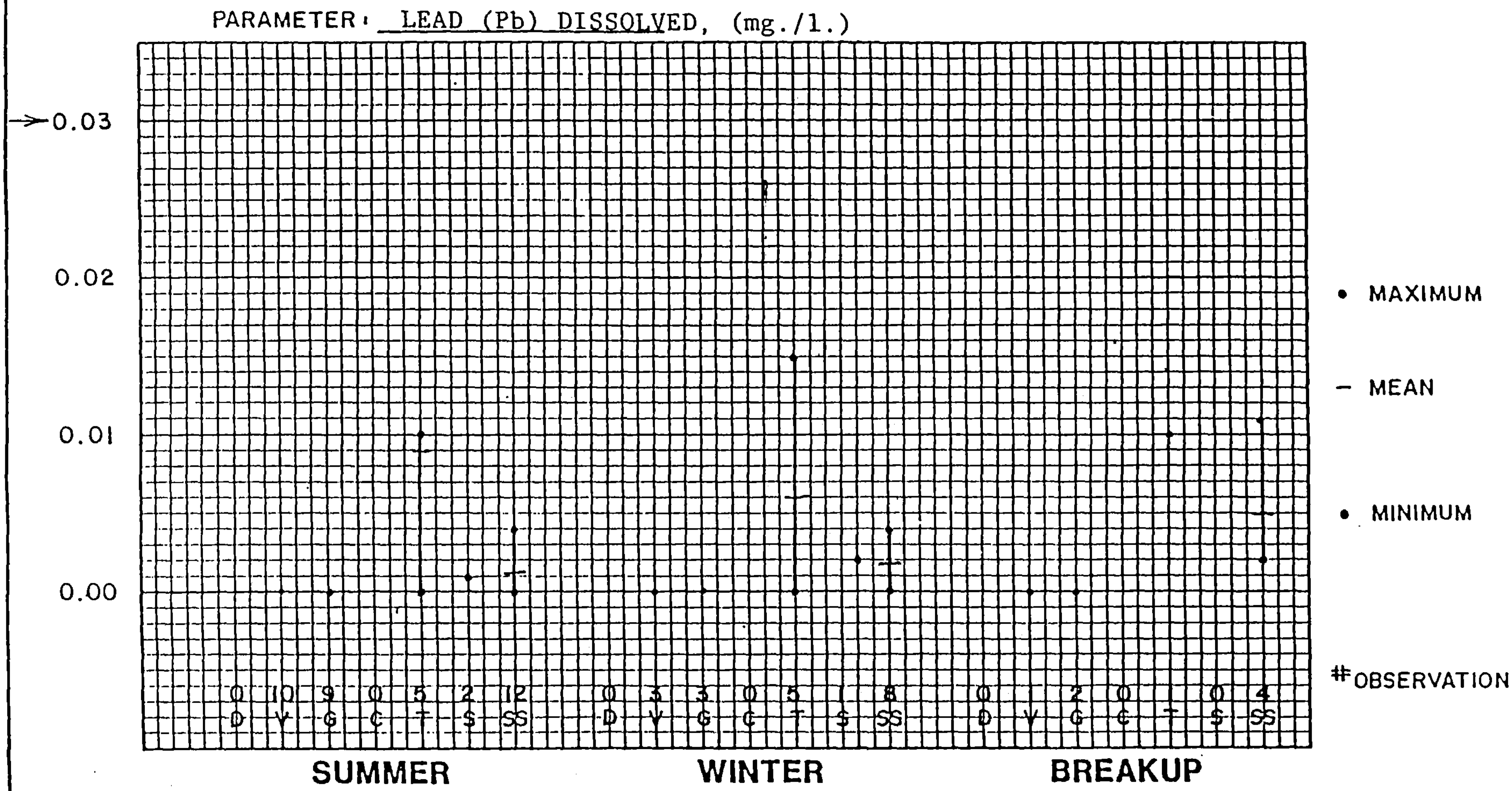
A. 0.0012 in hard water and 0.0004 mg/l in soft water (EPA, 1976).

B. Less than 0.0002 mg/l (McNeely et al, 1979).

Established to protect freshwater aquatic organisms.

DATA SUMMARY - CADMIUM (t)

FIGURE E.2.54



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

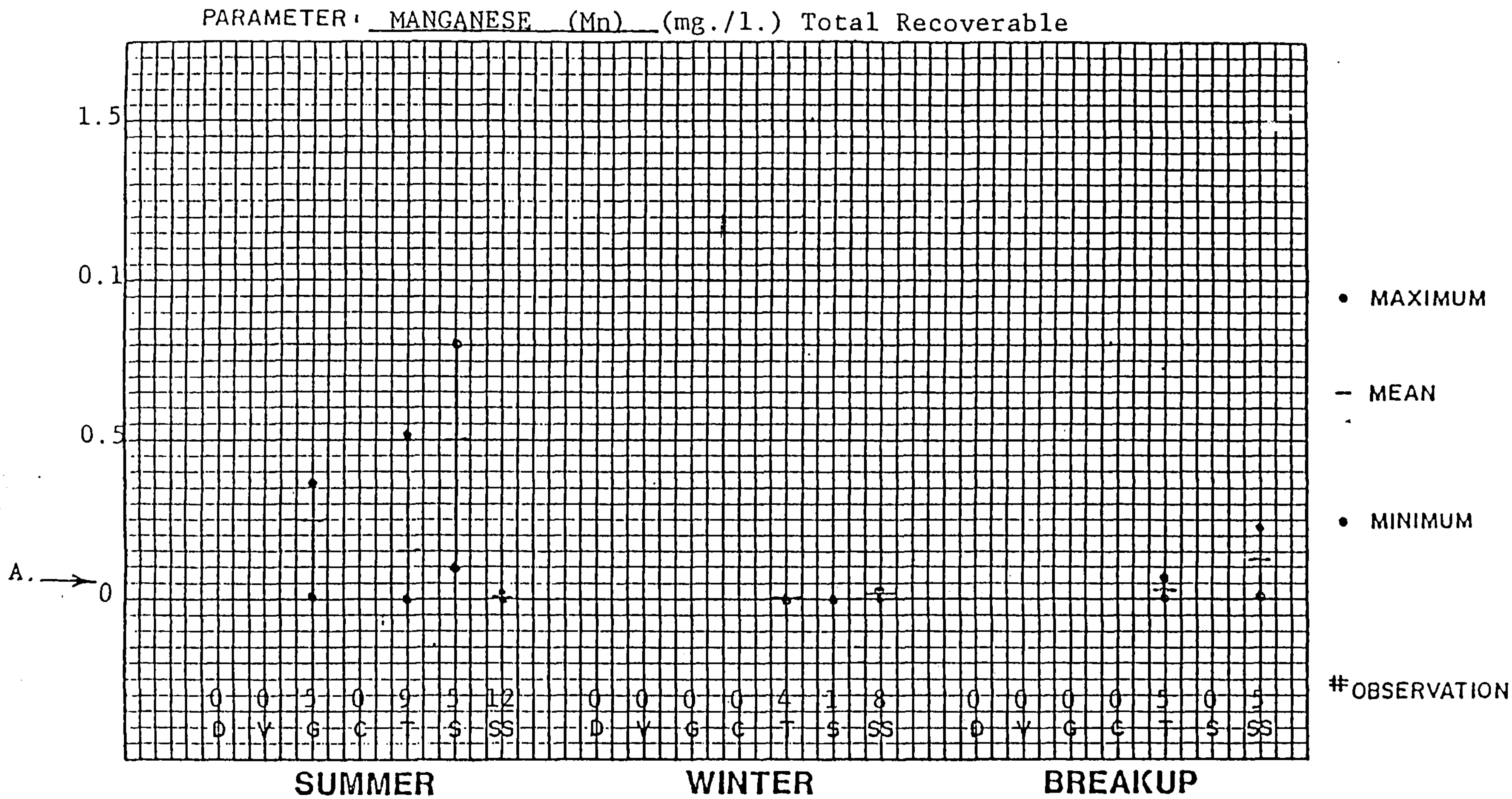
A. Less than 0.03 mg/1, (McNeely et al, 1979).

B. 0.01 of the 96-hour LC_{50} determined through bioassay. (EPA, 1976).

Established to protect freshwater aquatic orgqnisms.

DATA SUMMARY - LEAD (d)

FIGURE E.2.59



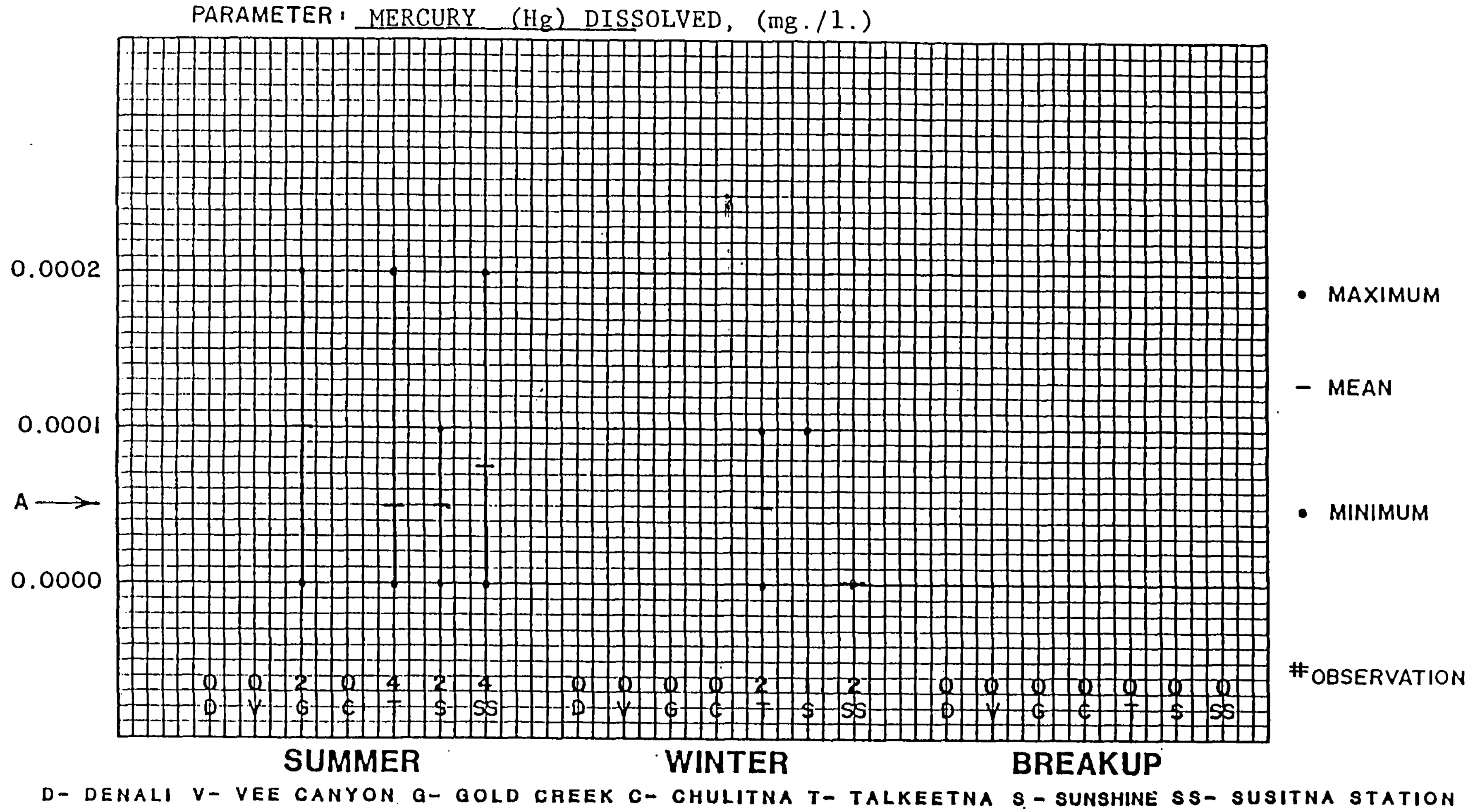
D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Less than 0.05 mg/1 for water supply (EPA, 1976)

Established to protect water supplies.

DATA SUMMARY - MANGANESE (t)

FIGURE E.2.62



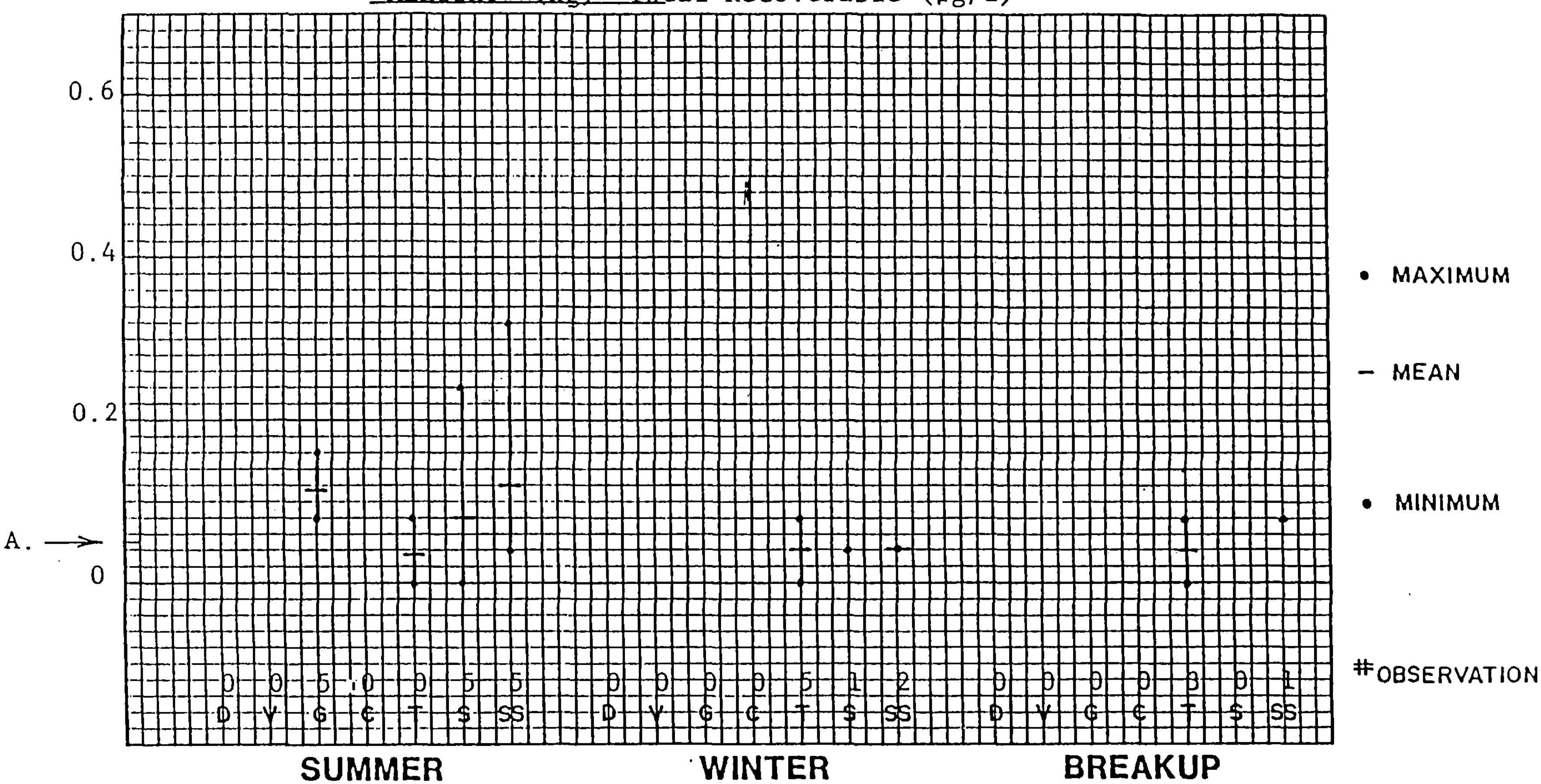
A. Less than 0.00005 mg/l. (EPA, 1976).

Established to protect freshwater aquatic organisms.

DATA SUMMARY - MERCURY (d)

FIGURE E.2.63

PARAMETER: MERCURY (Hg) Total Recoverable (µg/l)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHUL'TNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

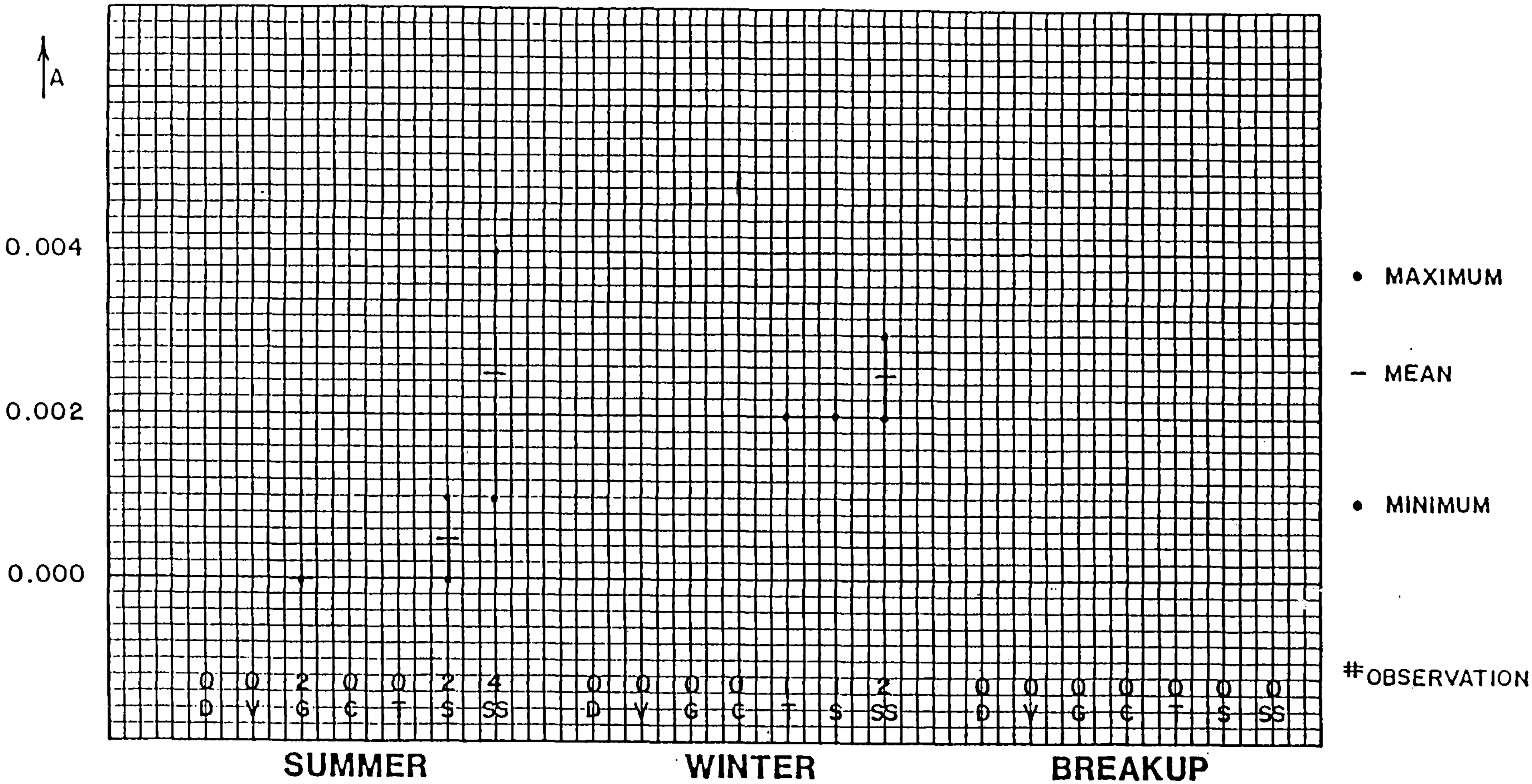
A. Less than 0.05 µg/l (EPA, 1976)

Established to protect freshwater aquatic organisms.

DATA SUMMARY - MERCURY (t)

FIGURE E.2.64

PARAMETER: NICKEL (Ni) DISSOLVED, (mg./1.)



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

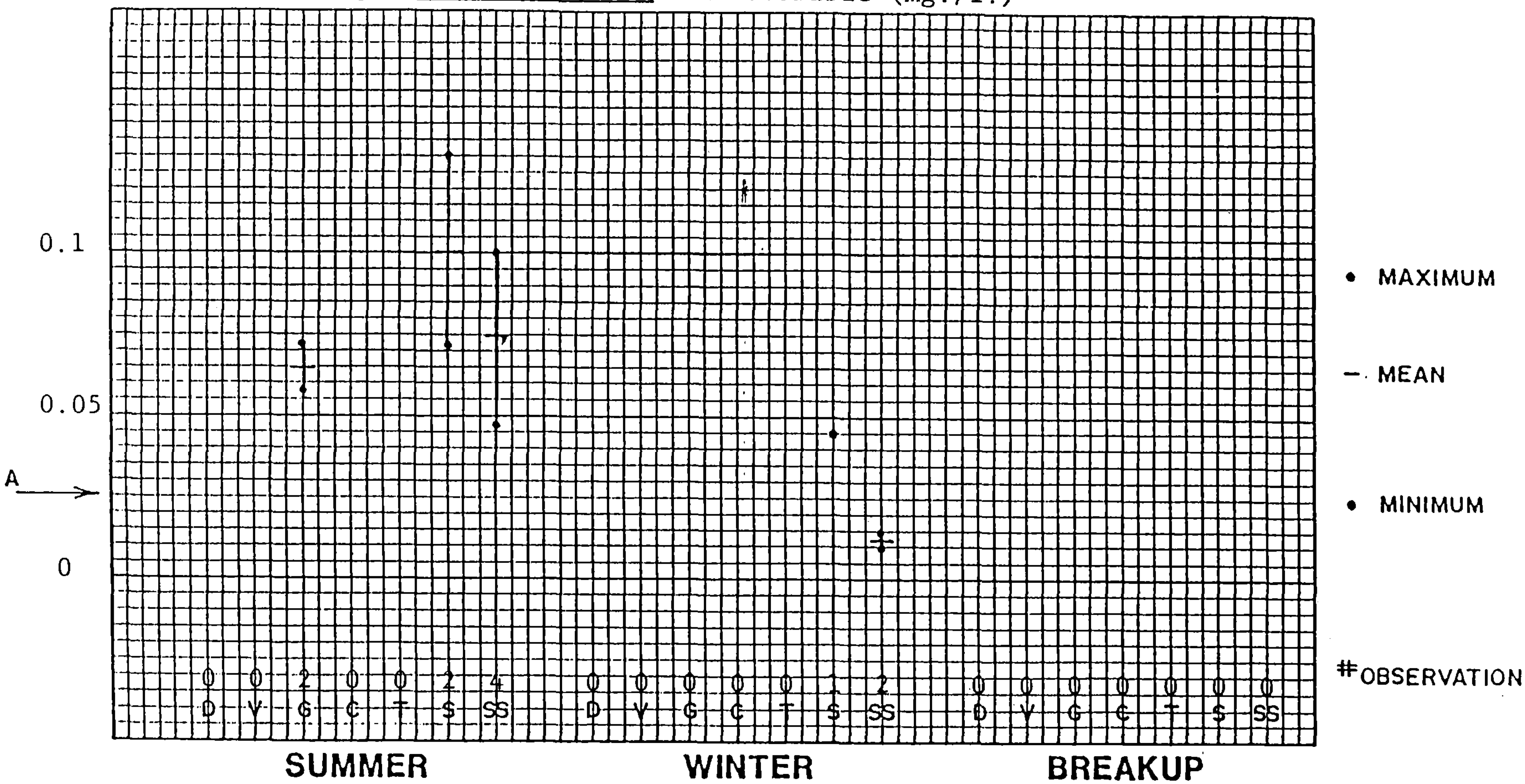
A. Less than 0.025 mg/1. (McNeely et al, 1979).

B. 0.01 of the 96-hour LC_{50} determined through bioassay. (EPA, 1976). Established to protect freshwater aquatic organisms.

DATA SUMMARY - NICKEL (d)

FIGURE E.2.65

PARAMETER: NICKEL (Ni) Total Recoverable (mg./l.)



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

A. Less than 0.025 mg/l (McNeely et al, 1979).

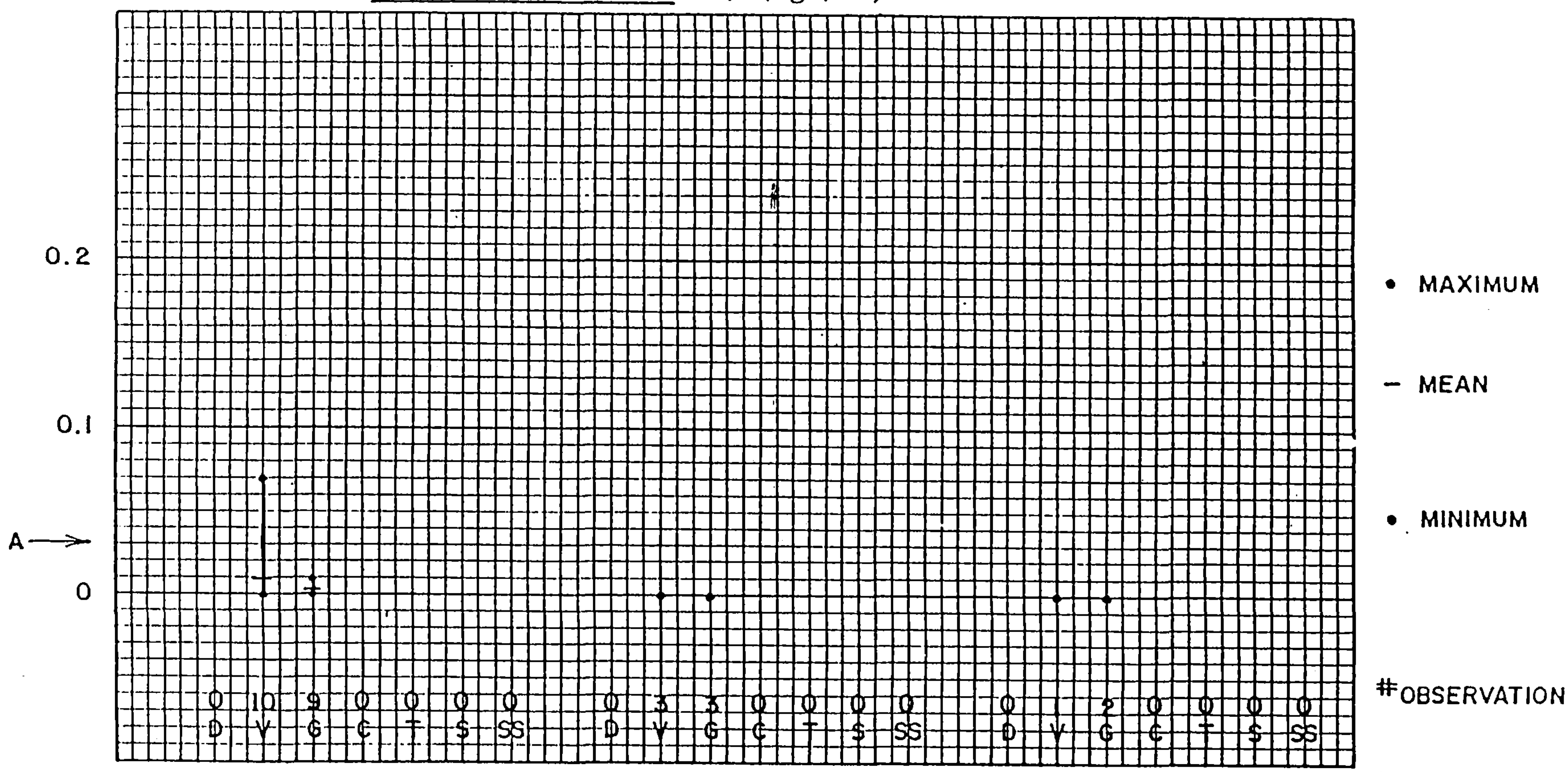
B. 0.01 of the 96 - hour LC_{50} determined through bioassay (EPA, 1976)

Established to protect freshwater aquatic organisms.

DATA SUMMARY - NICKEL (t)

FIGURE E.2.66

PARAMETER: ZINC (Zn) DISSOLVED, (mg./l.)



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

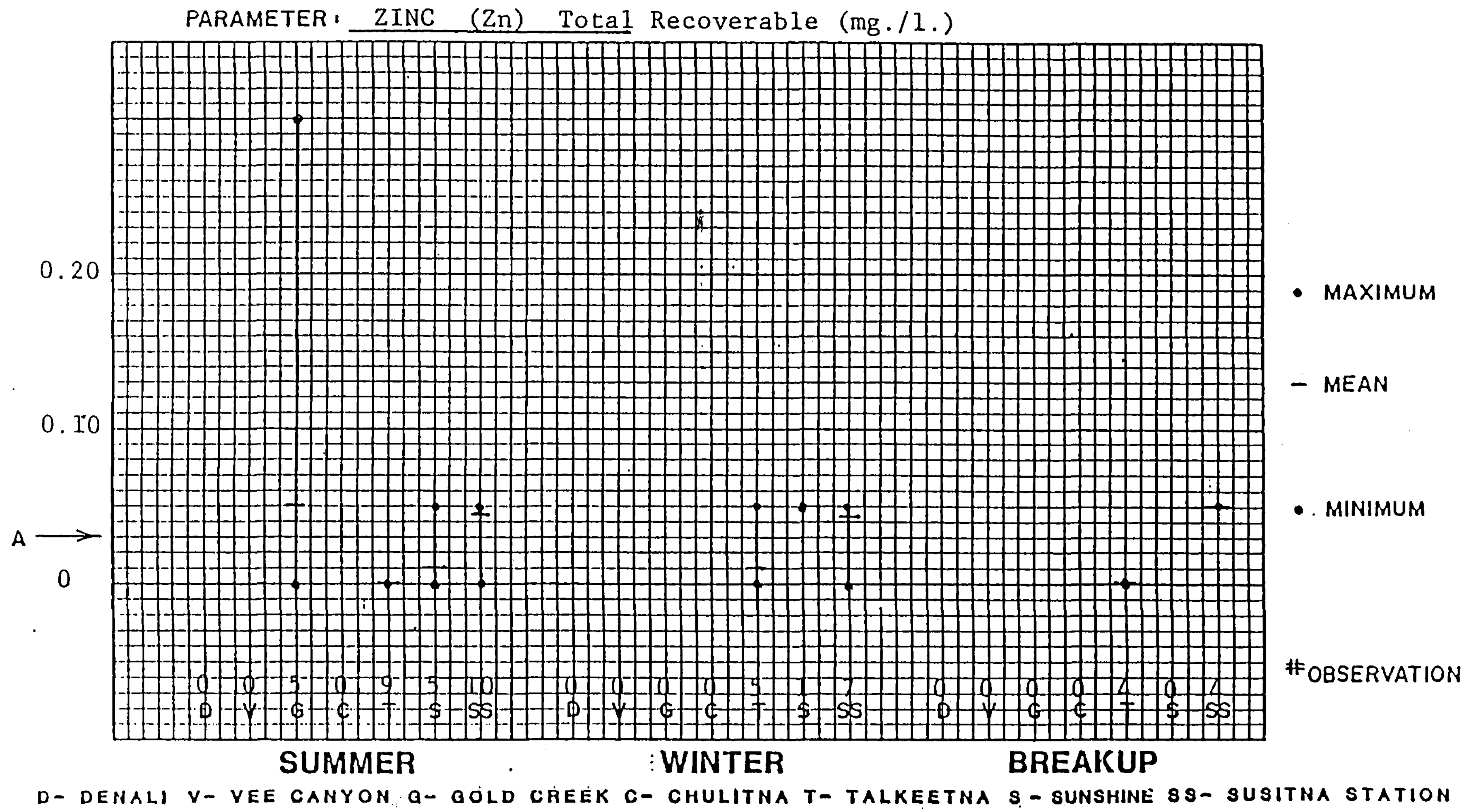
A. Less than 0.03 mg/l (McNeely, 1979)

B. 0.01 of the 96-hour LC_{50} determined through bioassay (EPA, 1976).

The suggested limit is based on human health effects.

DATA SUMMARY - ZINC (d)

FIGURE E.2.67

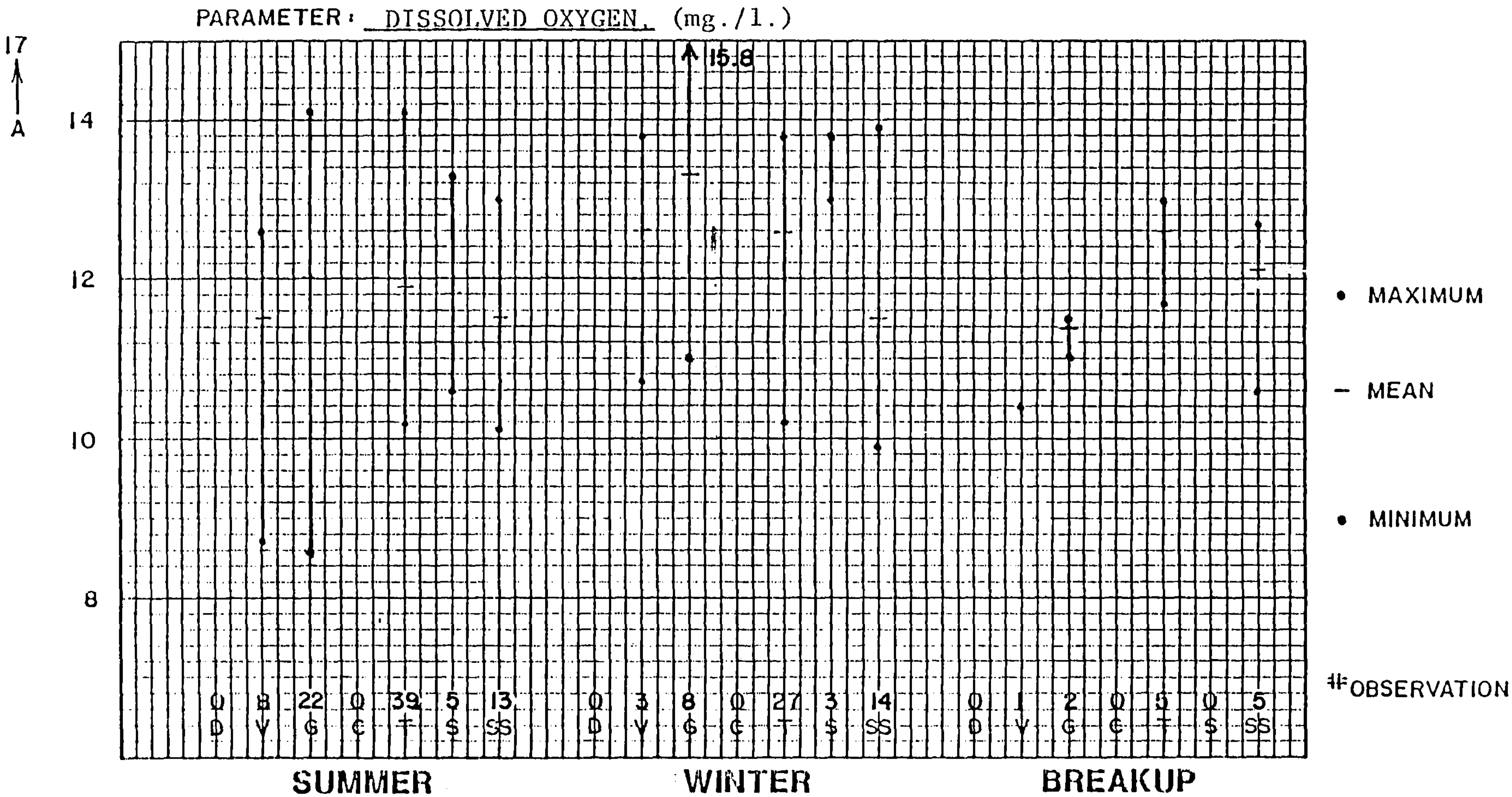


A. Less than 0.03 mg/l (McNeely, 1979).

B. 0.01 of the 96 - hour LC_{50} determined through bioassay (EPA, 1976). Established to protect freshwater aquatic organisms.

DATA SUMMARY - ZINC (t)

FIGURE E.2.68



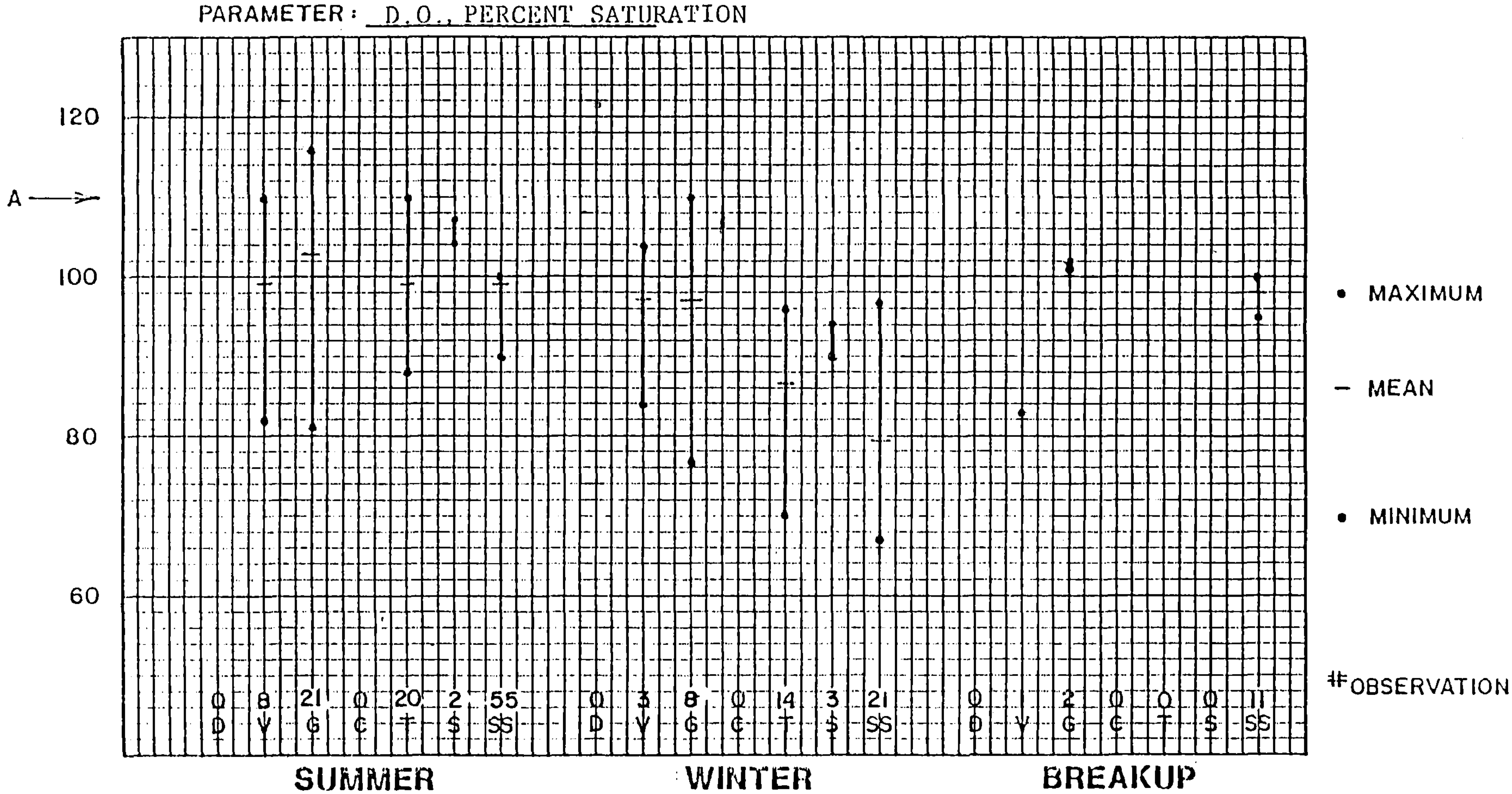
D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Greater than 7mg/l, but in no case shall D.O. exceed 17mg/l (ADEC, 1979).

Established for the protection of anadromous and resident fish.

DATA SUMMARY - OXYGEN, DISSOLVED

FIGURE E.2.69



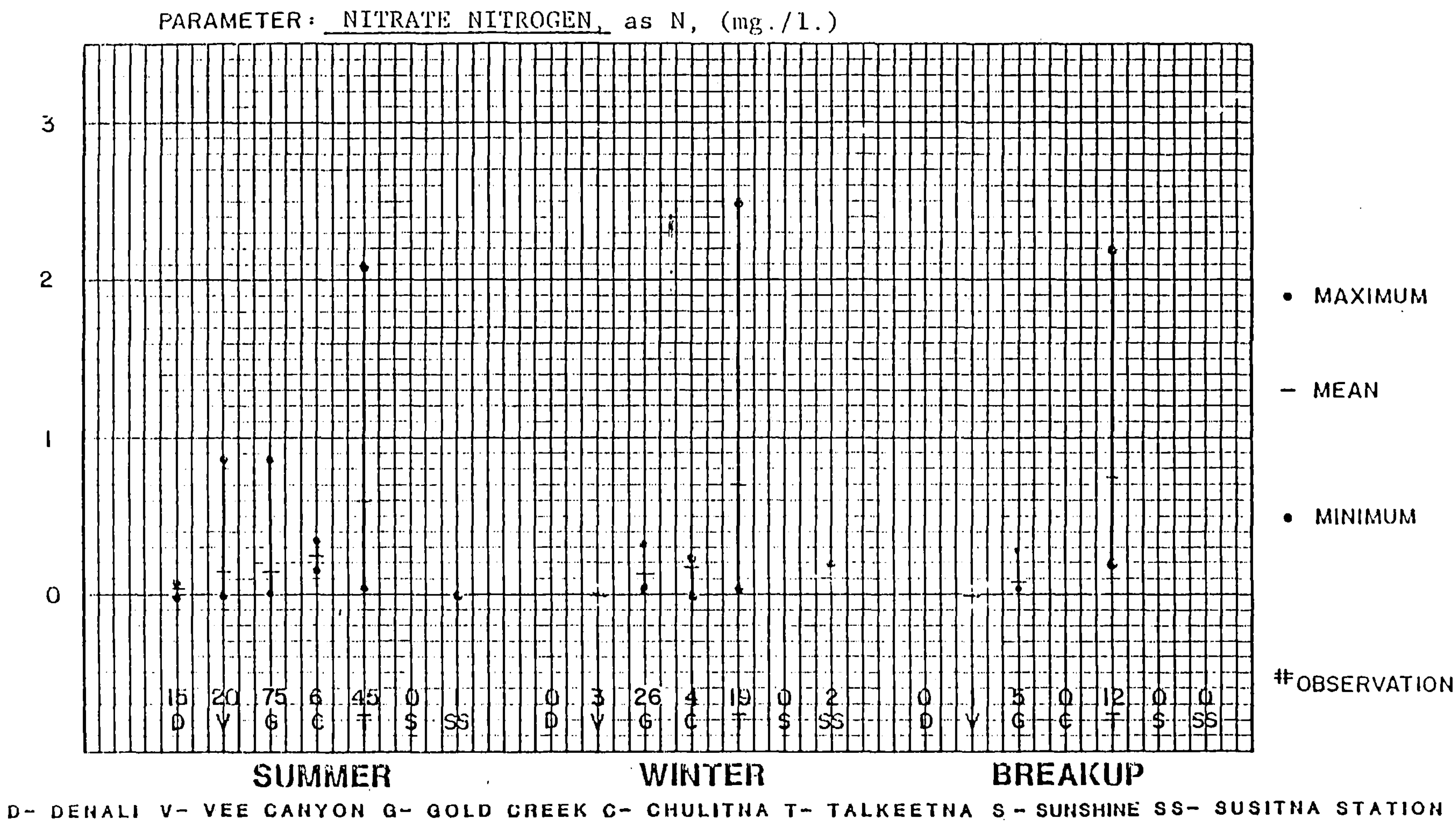
D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. The concentration of total disolved gas shall not exceed 110% saturation at any point. (ADEC, 1979).

Established for the protection of anadromous and resident fish.

DATA SUMMARY - D.O., % SATURATION

FIGURE E.2.70



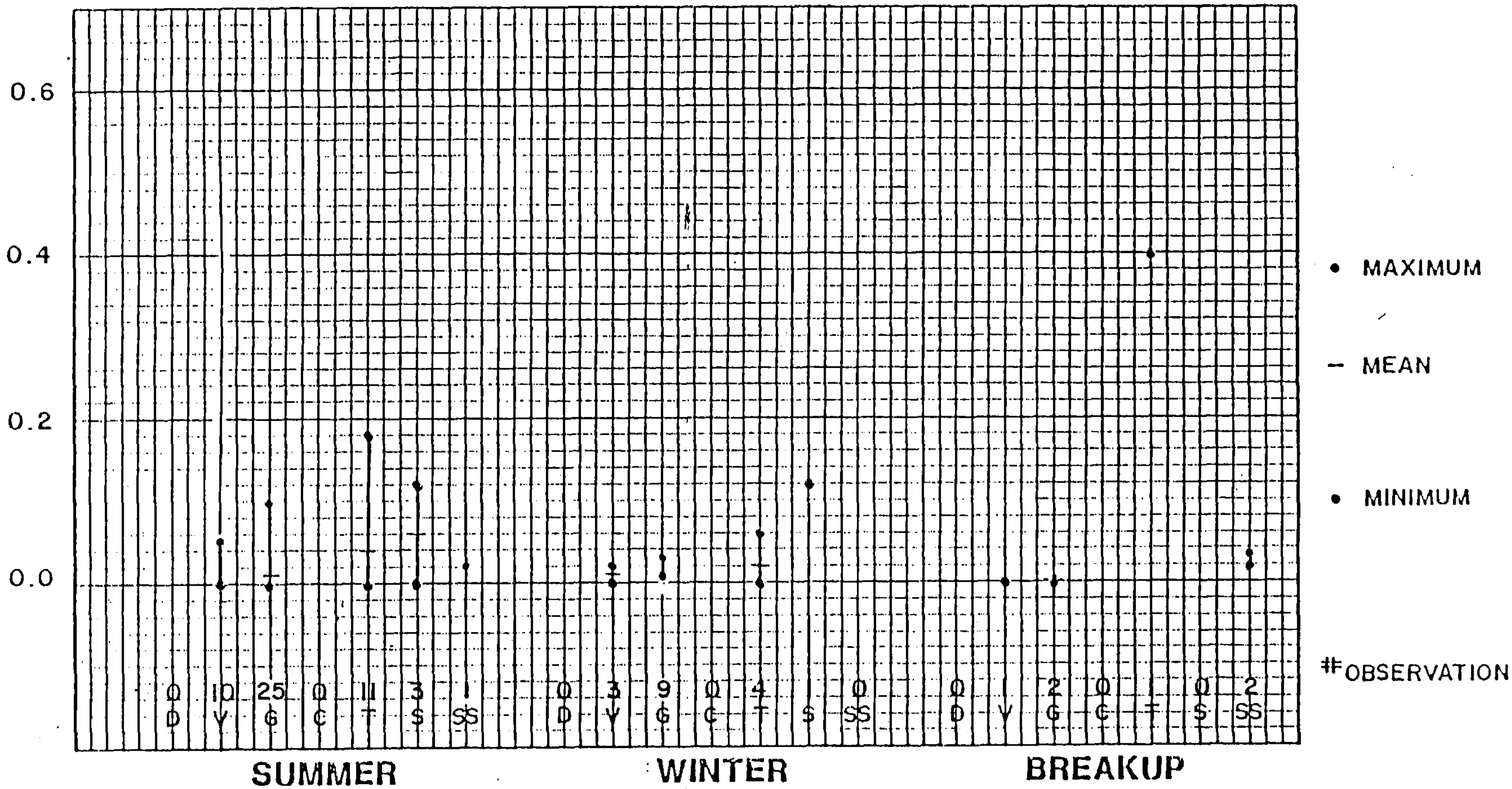
Less than 10 mg/l (water supply). (EPA, 1976).

Established to protect water supplies.

DATA SUMMARY - NITRATE NITROGEN

FIGURE E.2.71

PARAMETER: ORTHO PHOSPHATE, as P, (mg./l.)



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

No criterion established

DATA SUMMARY - ORTHO PHOSPHATE

FIGURE E.2.72

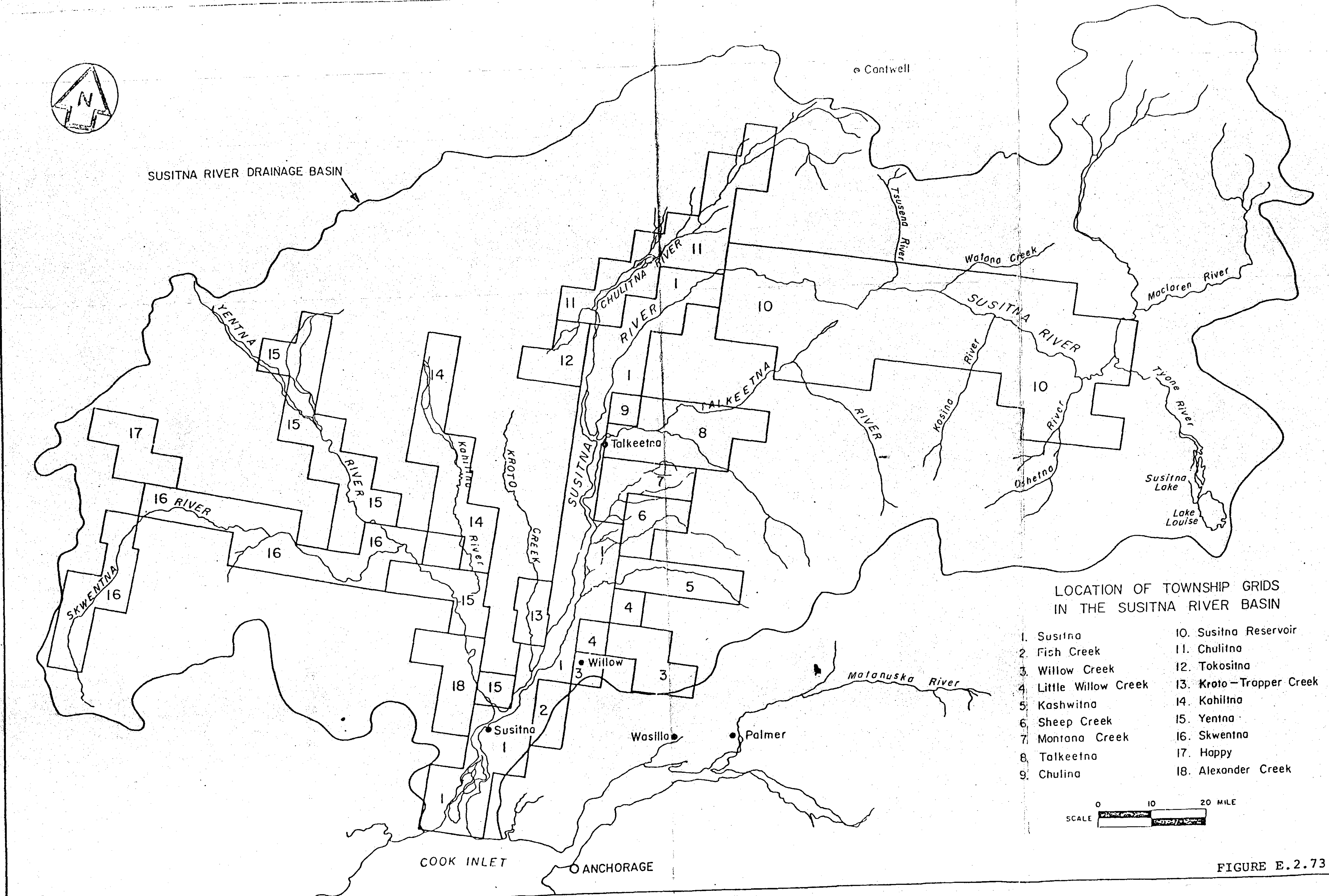
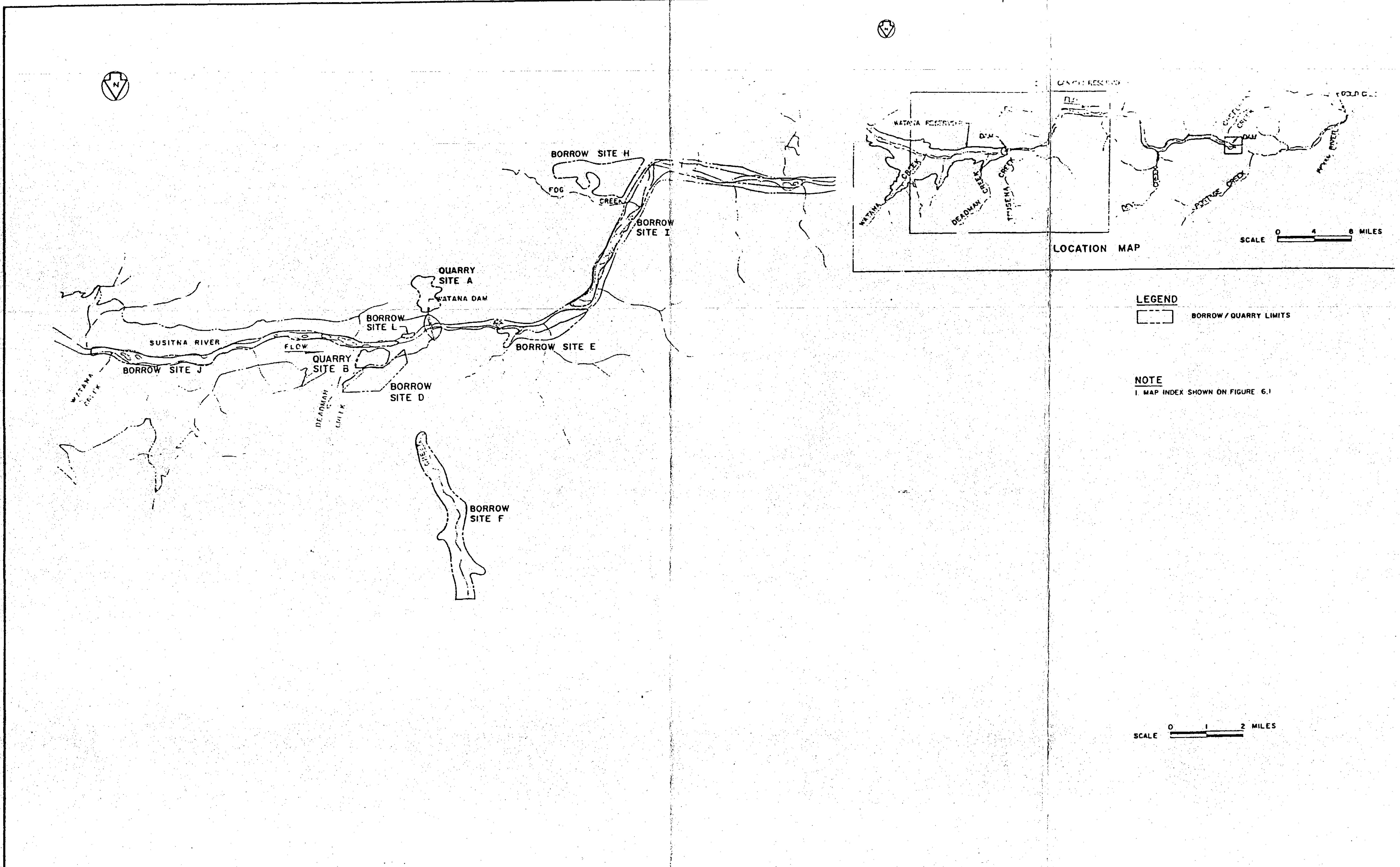
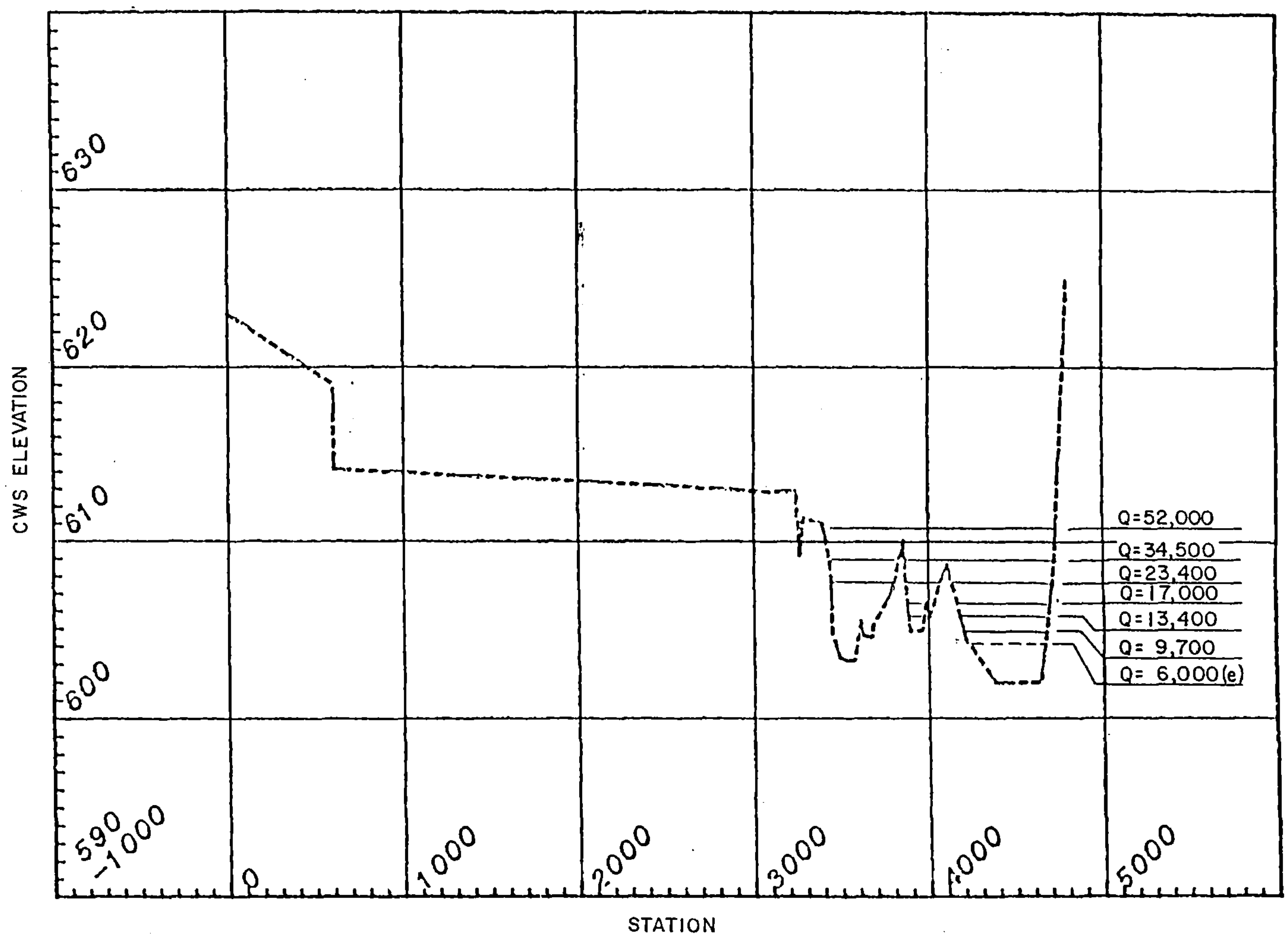

N
SUSITNA RIVER DRAINAGE BASIN
Cantwell
Tsusena River
Watana Creek
Maclaren River
SUSITNA RIVER
CHULITNA RIVER
YENTNA
RIVER
TALKEETNA RIVER
Kosina River
Oshetna River
Tyone River
Susitna Lake
Lake Louise
Kahiltna River
KROTO CREEK
SUSITNA
SKWENTNA
16 RIVER
Talkeetna
Willow
Susitna
Wasilla
Palmer
Matanuska River
COOK INLET
ANCHORAGE
LOCATION OF TOWNSHIP GRIDS
IN THE SUSITNA RIVER BASIN
1. Susitna
2. Fish Creek
3. Willow Creek
4. Little Willow Creek
5. Kashwitna
6. Sheep Creek
7. Montana Creek
8. Talkeetna
9. Chulina
10. Susitna Reservoir
11. Chulitna
12. Tokositna
13. Kroto – Trapper Creek
14. Kahiltna
15. Yentna
16. Skwentna
17. Happy
18. Alexander Creek
0 10 20 MILE
SCALE

FIGURE E.2.73



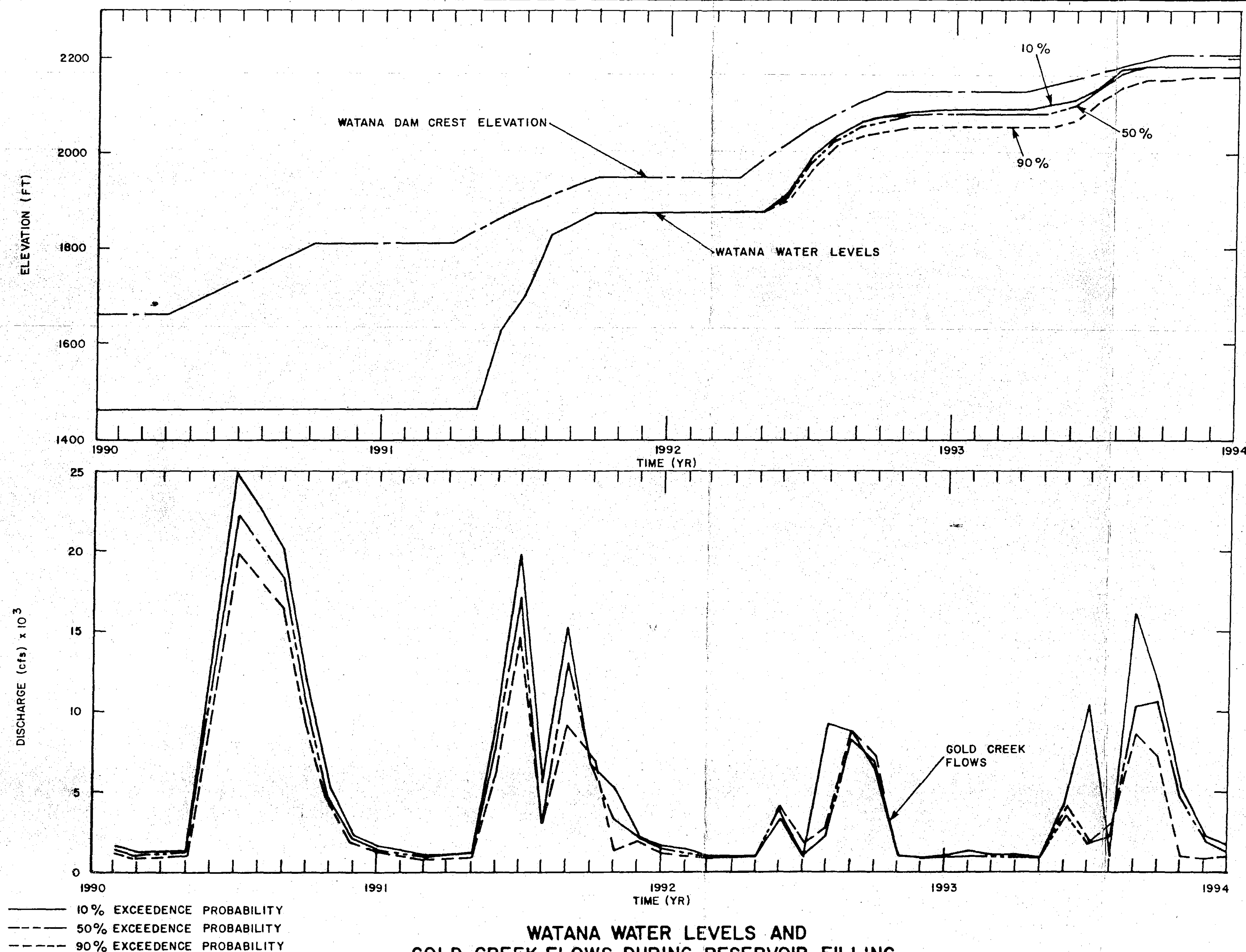
WATANA
BORROW SITE MAP

FIGURE E.2.74



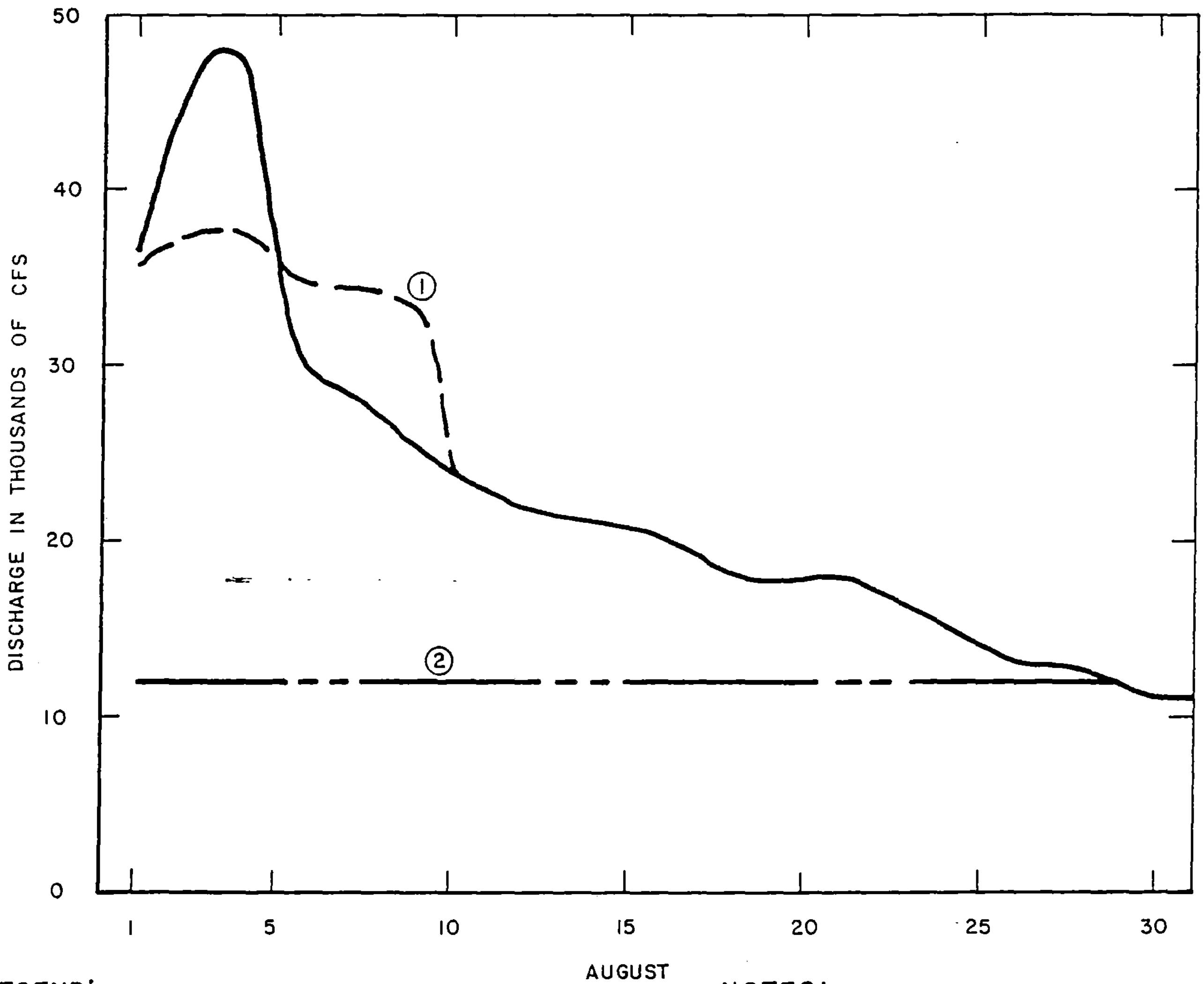
CROSS-SECTION NUMBER 32
RM 130

FIGURE E.2.75



WATANA WATER LEVELS AND
GOLD CREEK FLOWS DURING RESERVOIR FILLING

FIGURE E.2.76



LEGEND:

AUGUST 1958 FLOWS

① FILLING SEQUENCE 1, AUGUST 1958 FLOWS – WATANA MINIMUM STORAGE CRITERIA VIOLATED

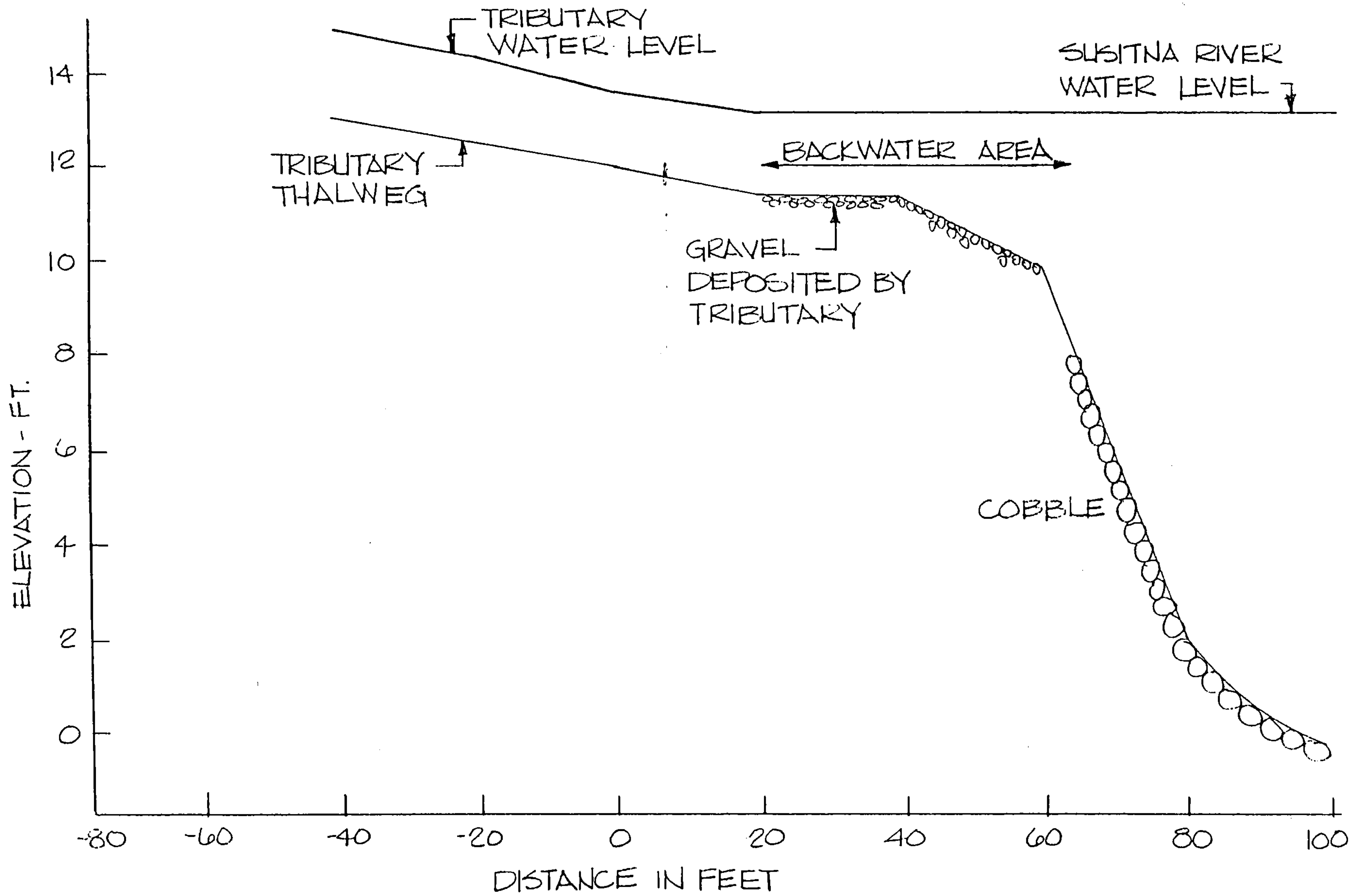
② FILLING SEQUENCE 2, AUGUST 1958 FLOWS – WATANA CAPABLE OF ABSORBING HYDROGRAPH

NOTES:

1. WATANA FLOW 84% OF GOLD CREEK FLOW
2. RESERVOIR FILLING CRITERIA EXCEEDED AUGUST WITH SEQUENCE ②
3. NEGLIGIBLE CHANGE IN DAM HEIGHT DURING FLOOD EVENT
4. MAXIMUM RELEASE AT WATANA 30,000 CFS

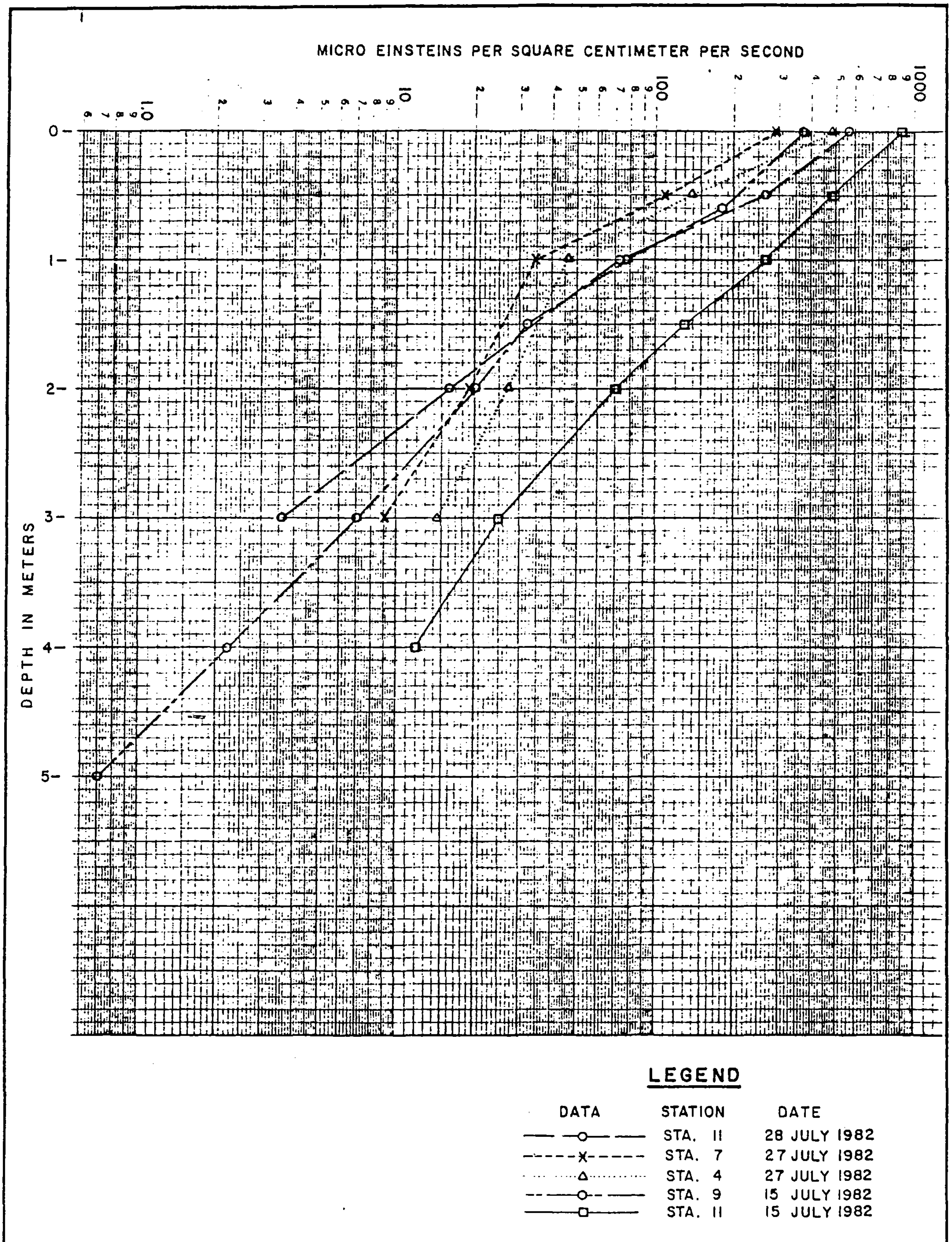
FLOW VARIABILITY
NATURAL AND FILLING CONDITIONS
DISCHARGE AT GOLD CREEK

FIGURE E.2.78



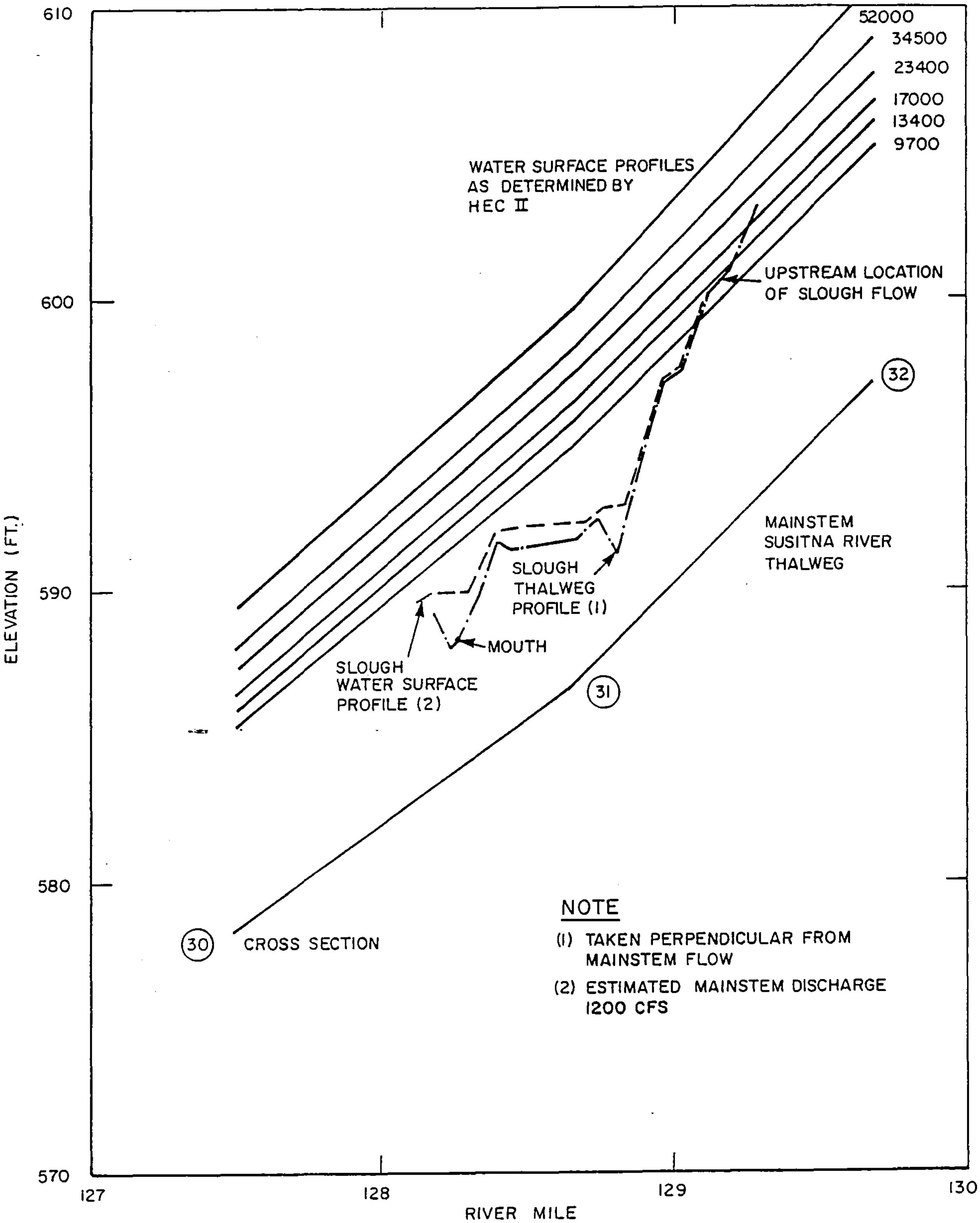
SCHEMATIC OF THE EFFECT OF THE SUSITNA RIVER ON A TYPICAL TRIBUTARY MOUTH

FIGURE E.2.79



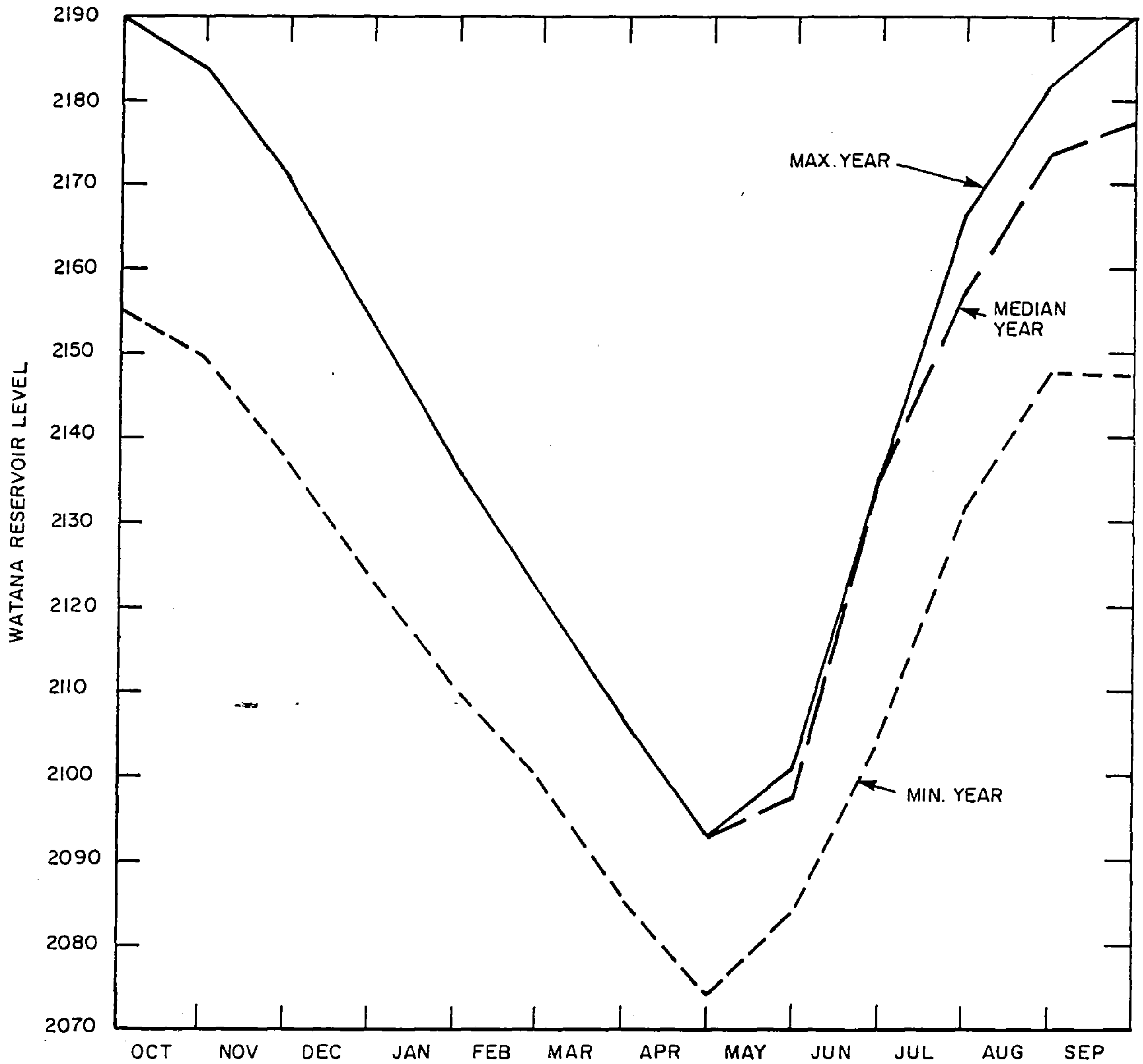
EKLUTNA LAKE
LIGHT EXTINCTION
IN SITU MEASUREMENTS

FIGURE E.2.80



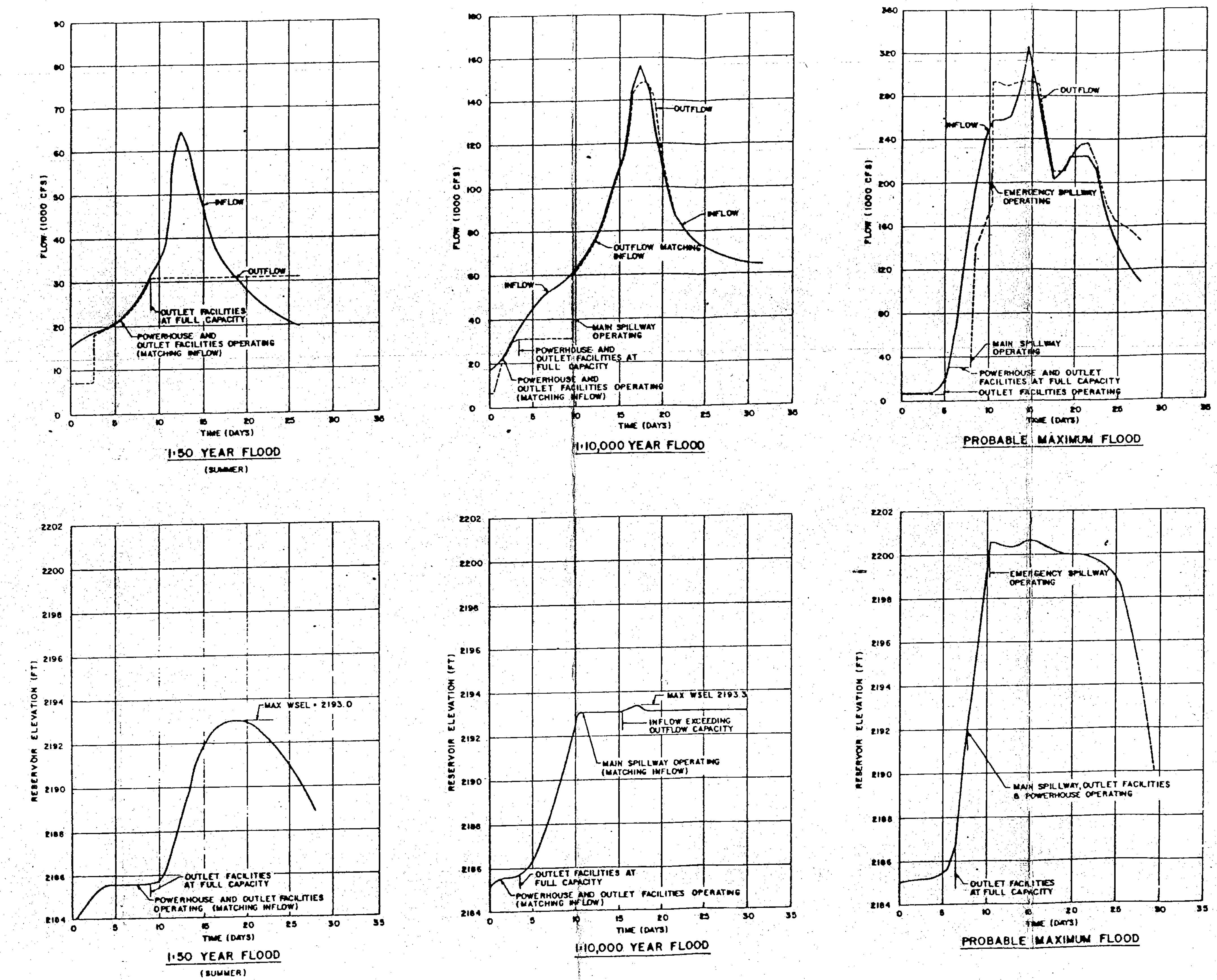
SLOUGH 9 THALWEG PROFILE AND SUSITNA RIVER MAINSTEM WATER SURFACE PROFILES

FIGURE E.2.81



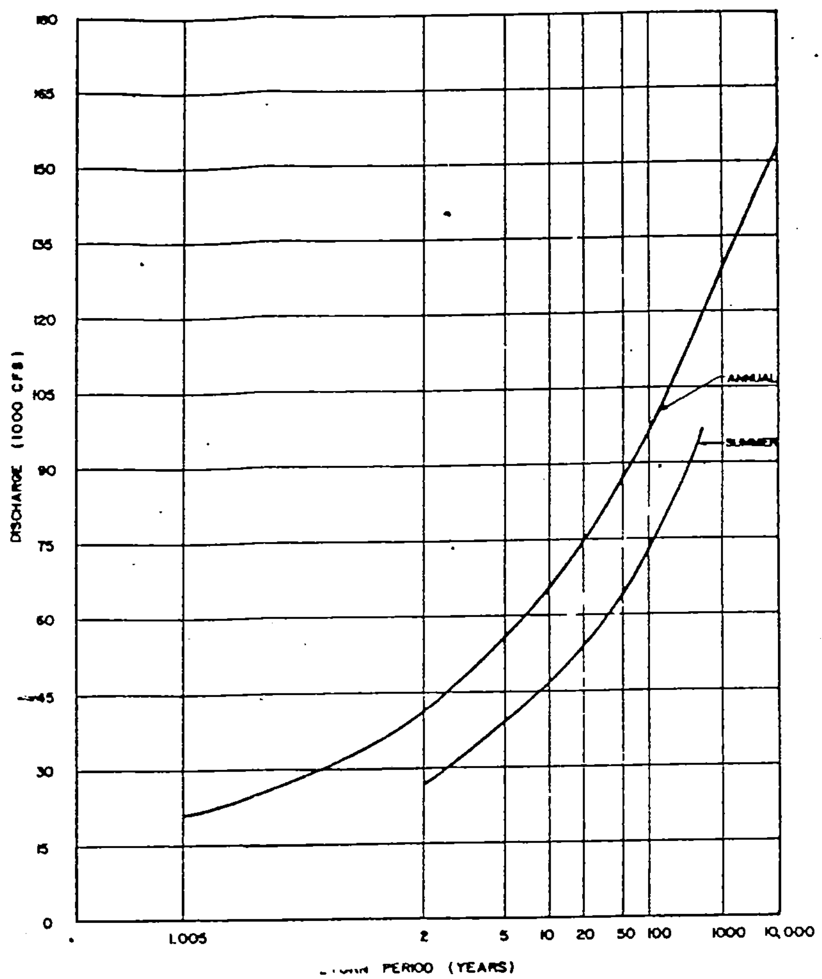
WATANA RESERVOIR WATER LEVELS
(WATANA ALONE)

FIGURE E.2.82



WATANA
HYDROLOGICAL DATA
SHEET 2

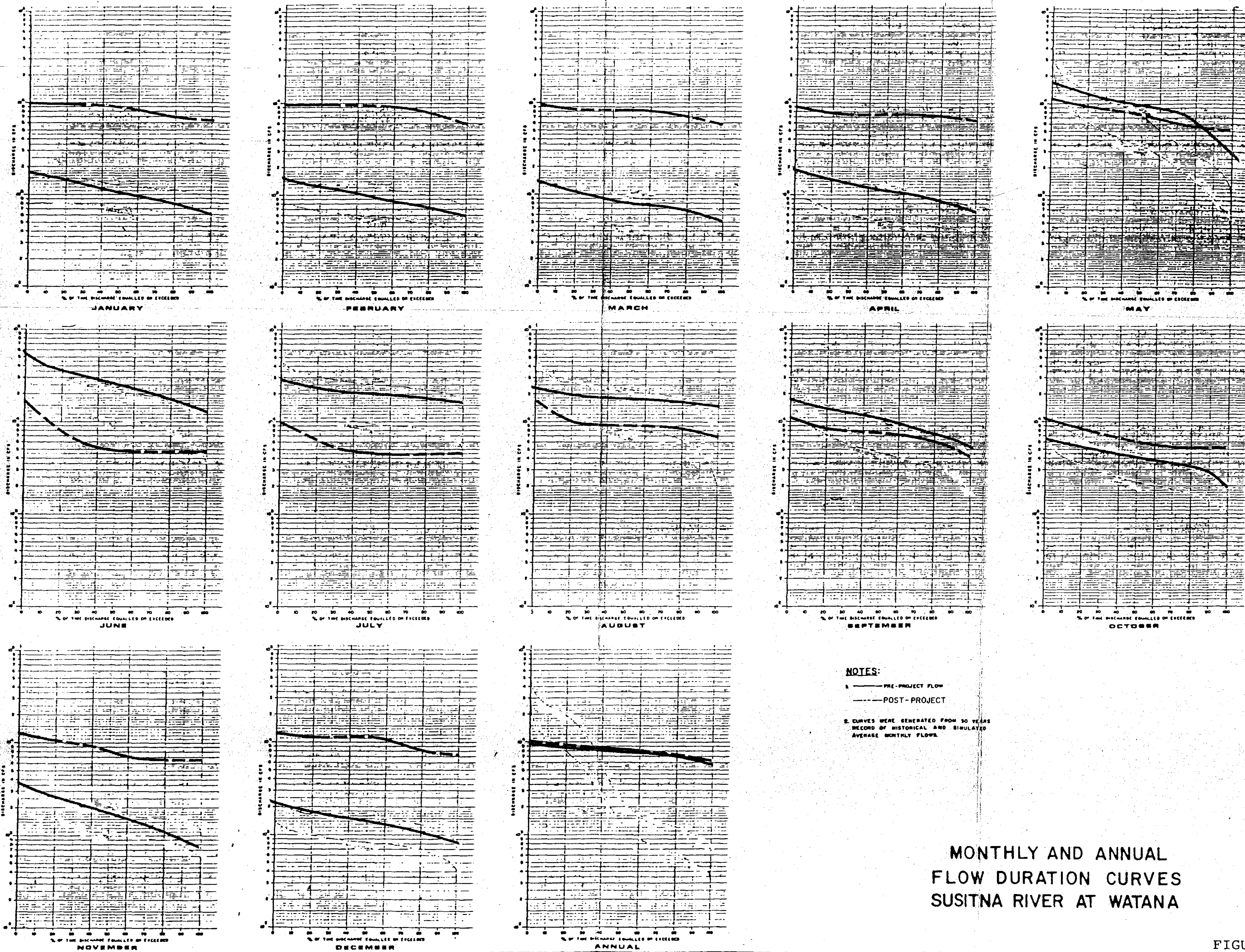
FIGURE E.2.83



INFLOW FLOOD FREQUENCY

WATANA
INFLOW FLOOD FREQUENCY

FIGURE E.2.84

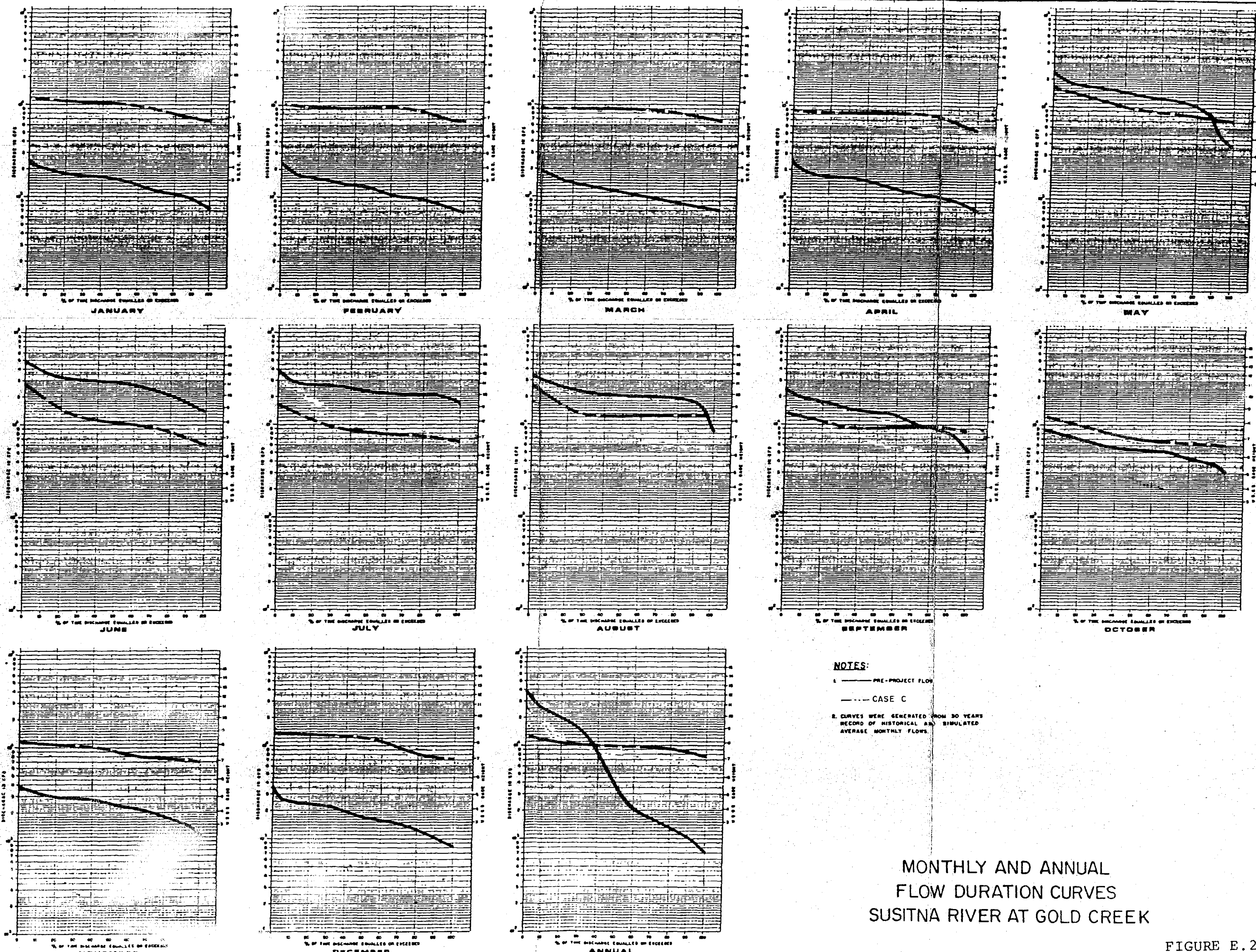


NOTES:

1. ——— PRE-PROJECT FLOW
   - - - POST-PROJECT
2. CURVES WERE GENERATED FROM 30 YEARS RECORD OF HISTORICAL AND SIMULATED AVERAGE MONTHLY FLOWS.

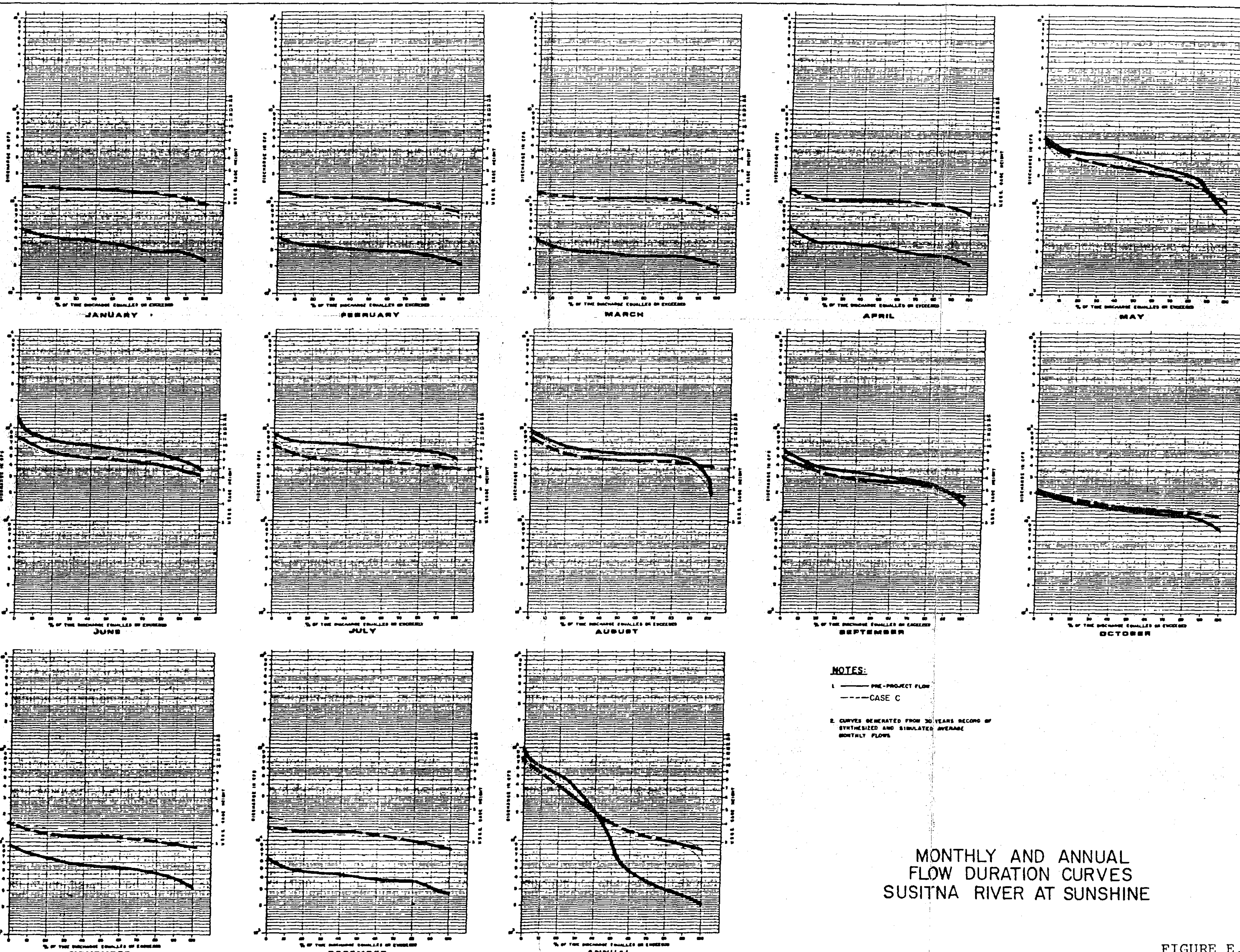
MONTHLY AND ANNUAL
FLOW DURATION CURVES
SUSITNA RIVER AT WATANA

FIGURE E.2.85



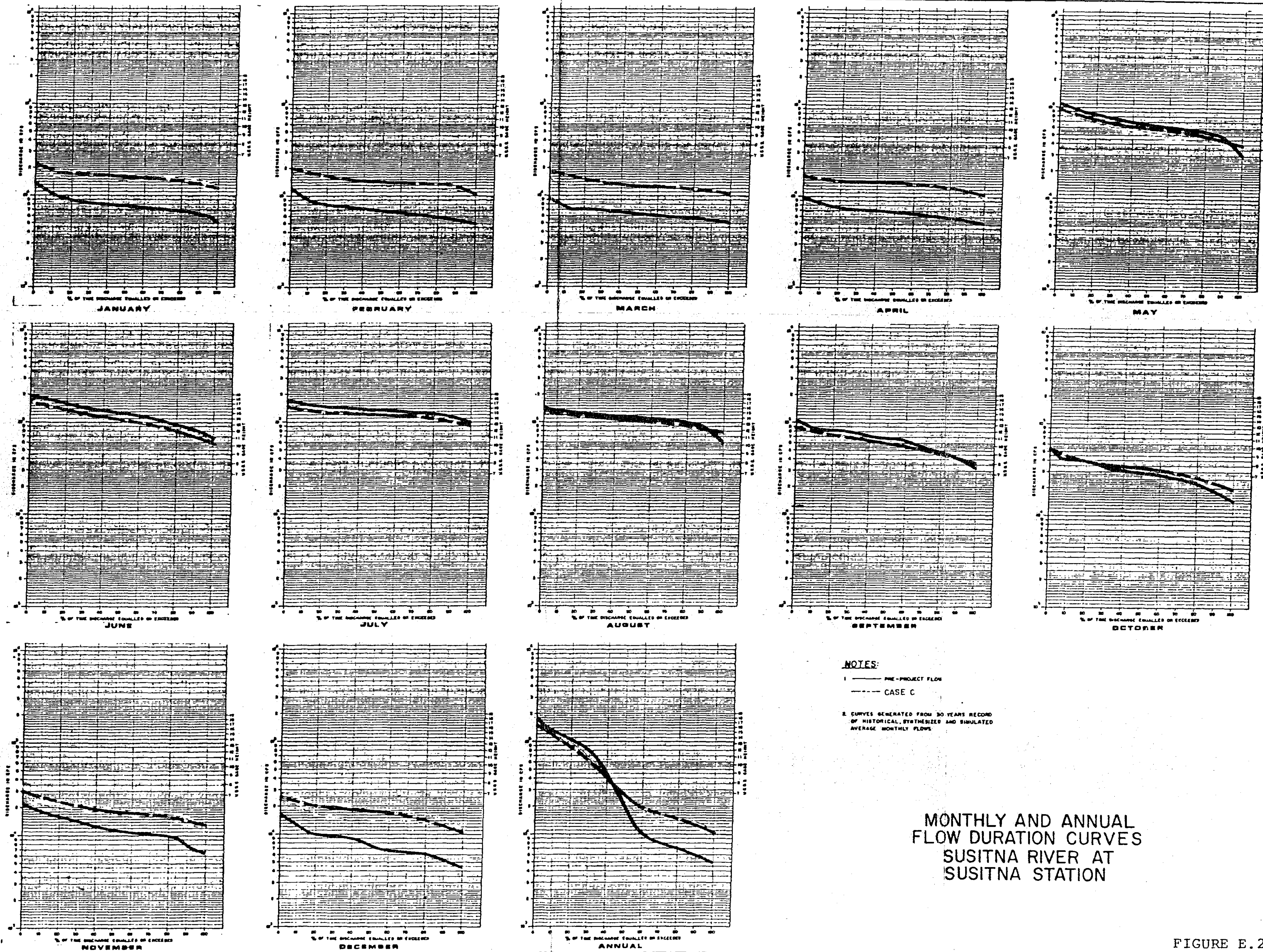
MONTHLY AND ANNUAL
FLOW DURATION CURVES
SUSITNA RIVER AT GOLD CREEK

FIGURE E.2.86



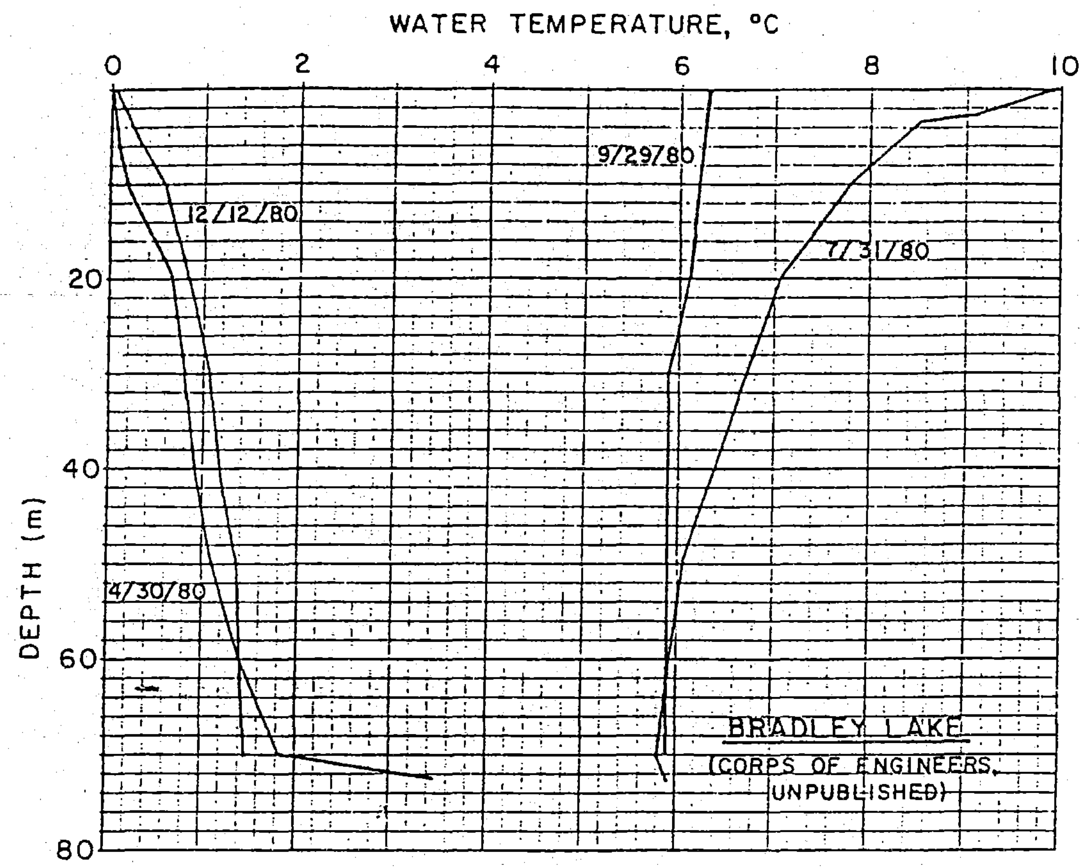
MONTHLY AND ANNUAL
FLOW DURATION CURVES
SUSITNA RIVER AT SUNSHINE

FIGURE E.2.87



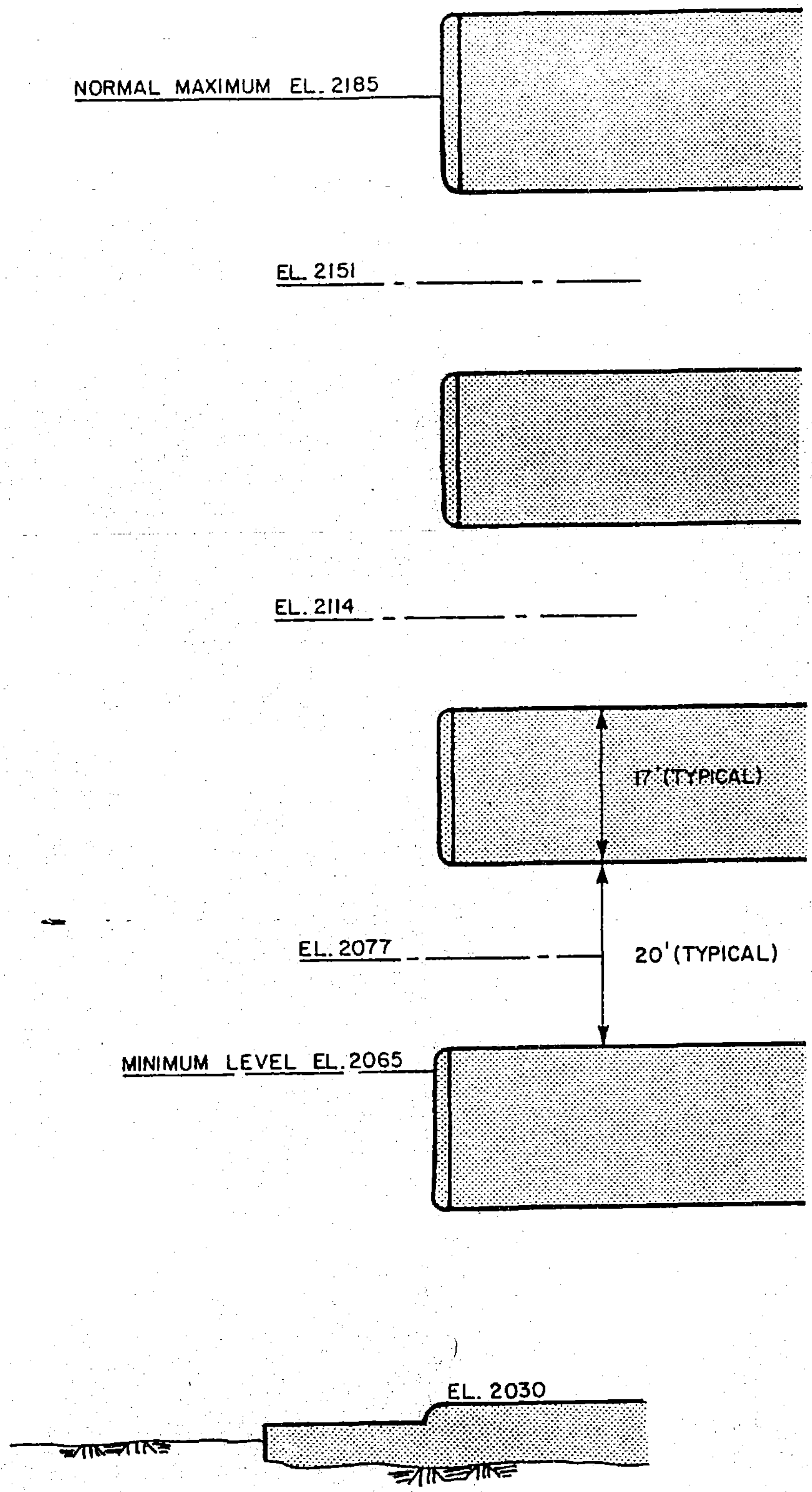
MONTHLY AND ANNUAL
FLOW DURATION CURVES
SUSITNA RIVER AT
SUSITNA STATION

FIGURE E.2.88



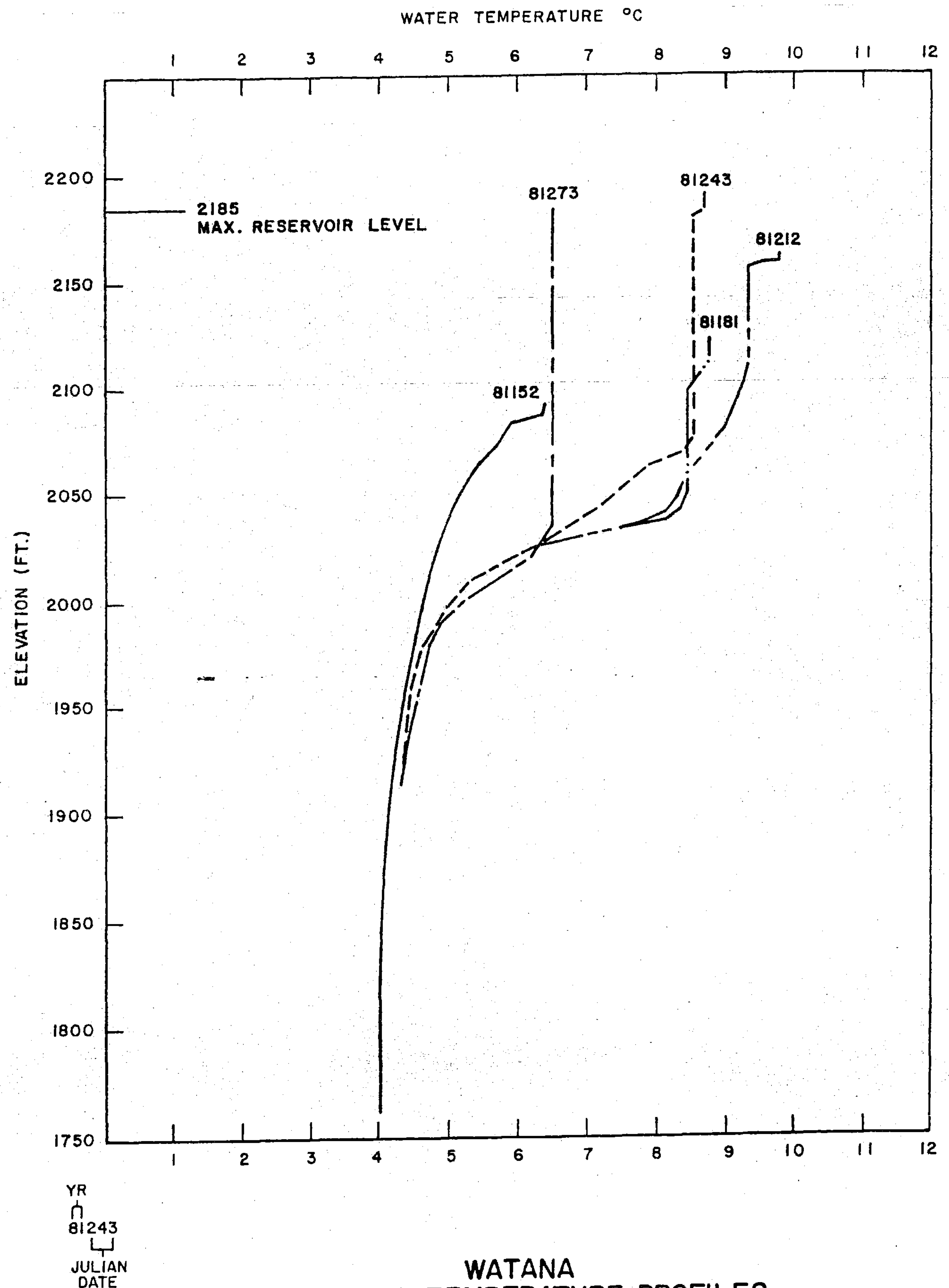
WATER TEMPERATURE PROFILES
BRADLEY LAKE, ALASKA

FIGURE E.2.89



MULTIPORT INTAKE LEVELS

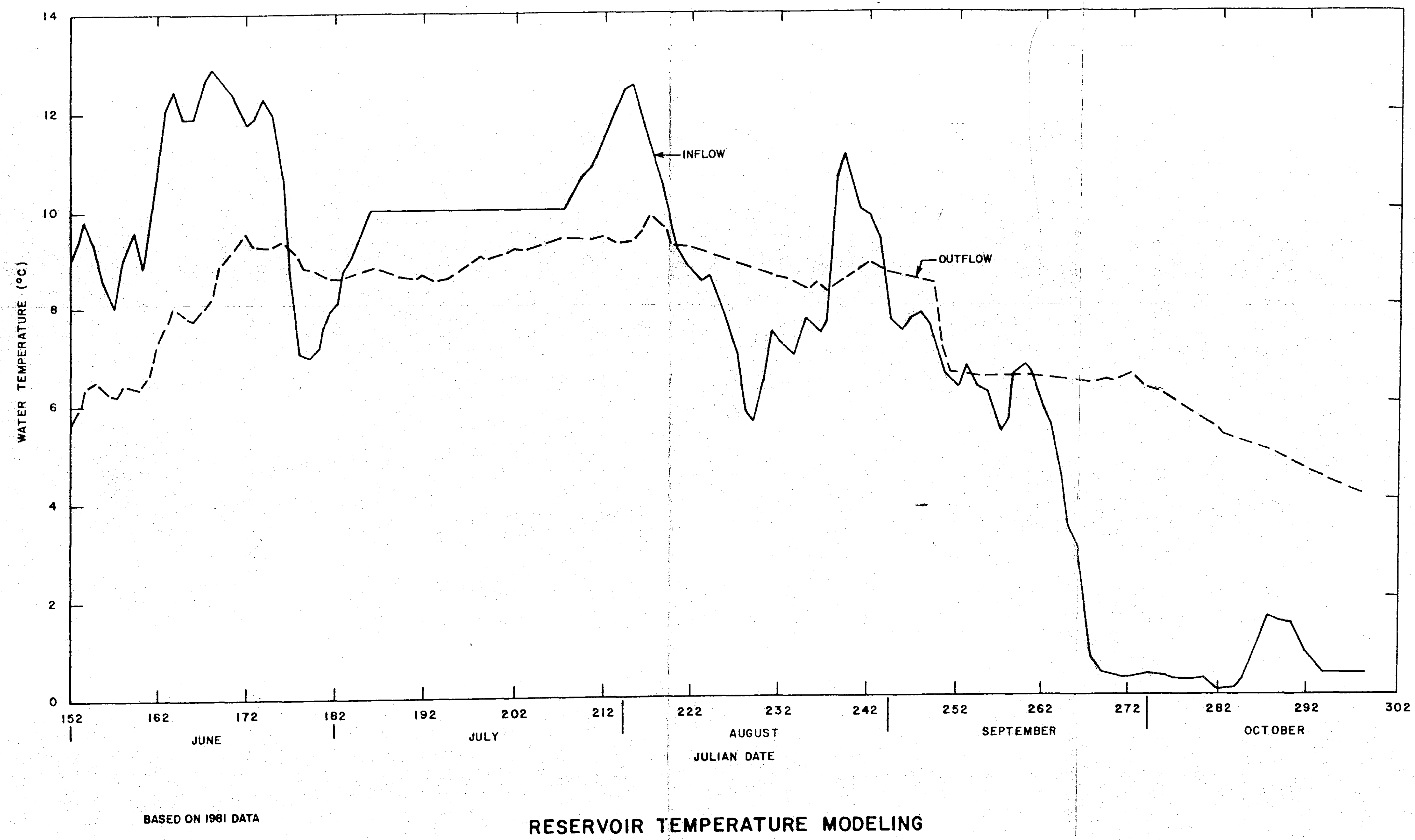
FIGURE E.2.90



WATANA
RESERVOIR TEMPERATURE PROFILES

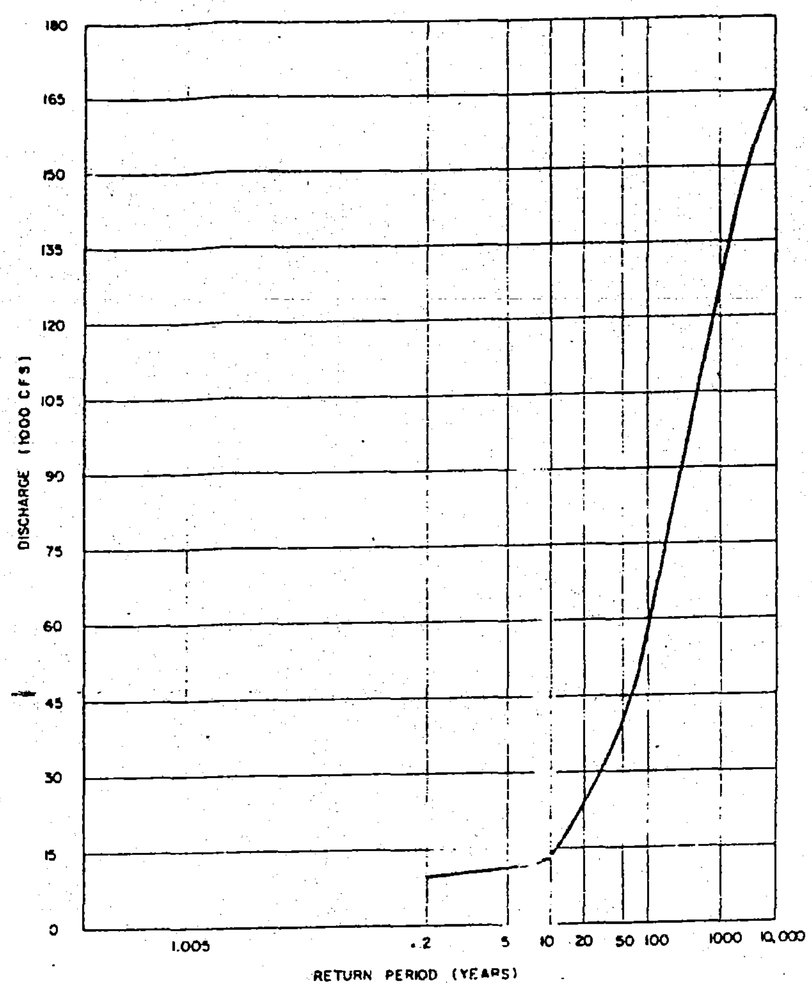
BASED ON 1981 DATA

FIGURE E.2.91



RESERVOIR TEMPERATURE MODELING
OUTFLOW TEMPERATURE

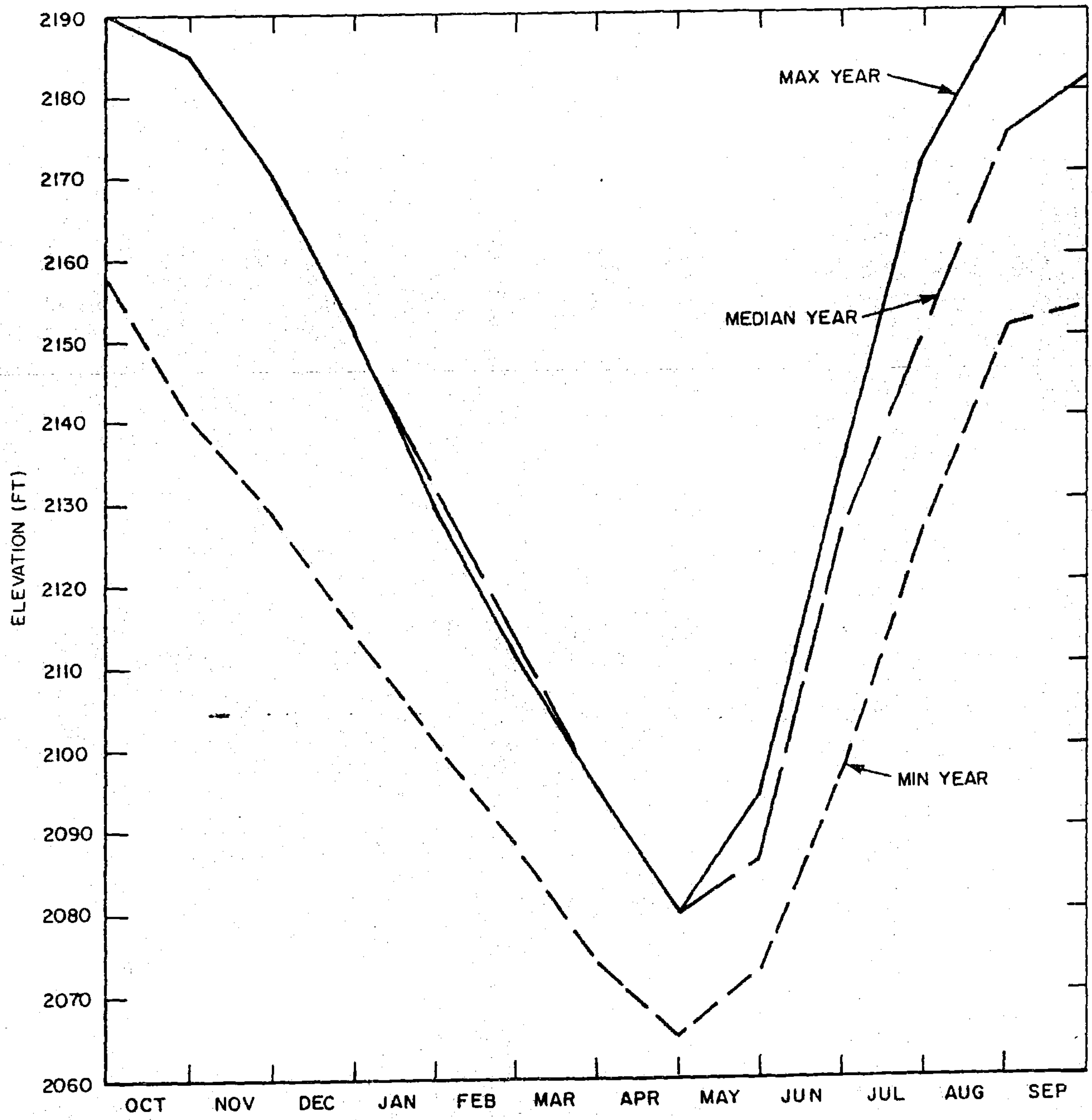
FIGURE E.2.92



FLOOD FREQUENCY CURVE
(INFLOW AFTER ROUTING THROUGH WATANA)

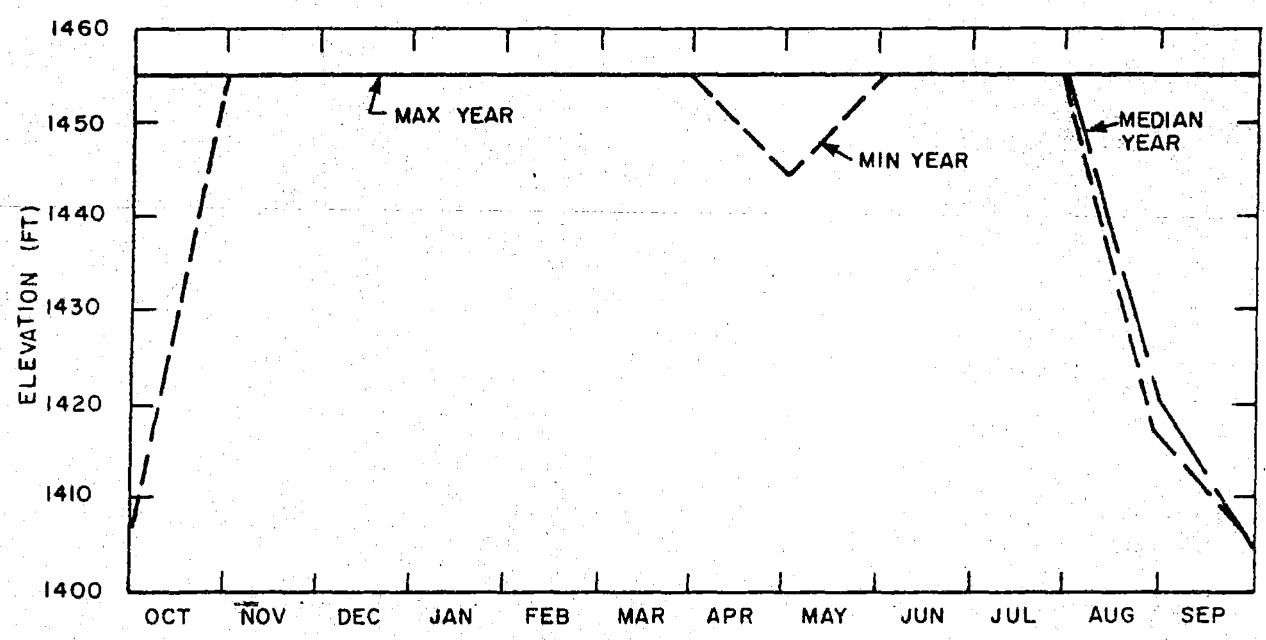
DEVIL CANYON
FLOOD FREQUENCY CURVE

FIGURE E.2.93



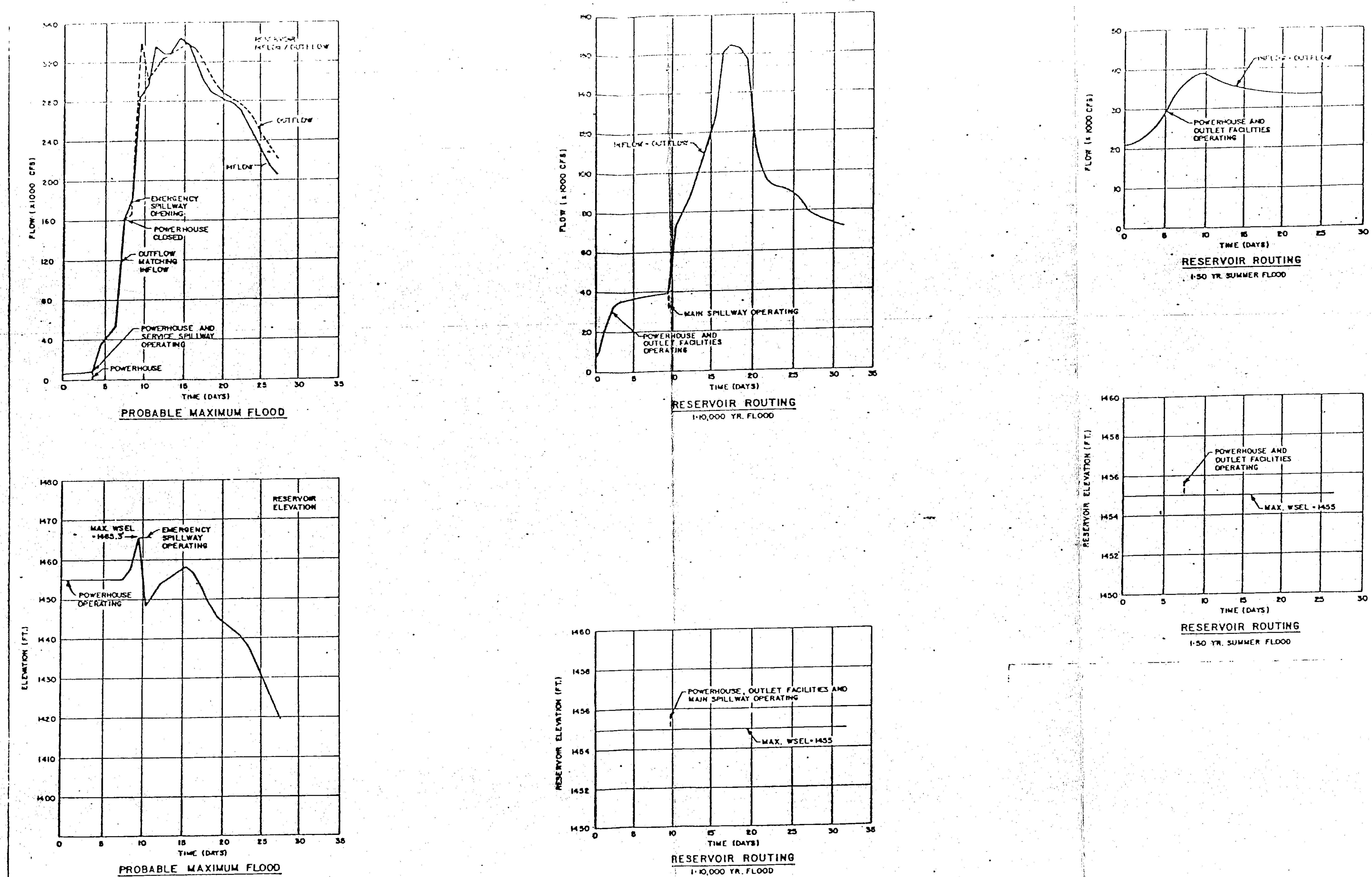
WATANA RESERVOIR WATER LEVELS
(WATANA AND DEVIL CANYON IN OPERATION)

FIGURE E.2.94



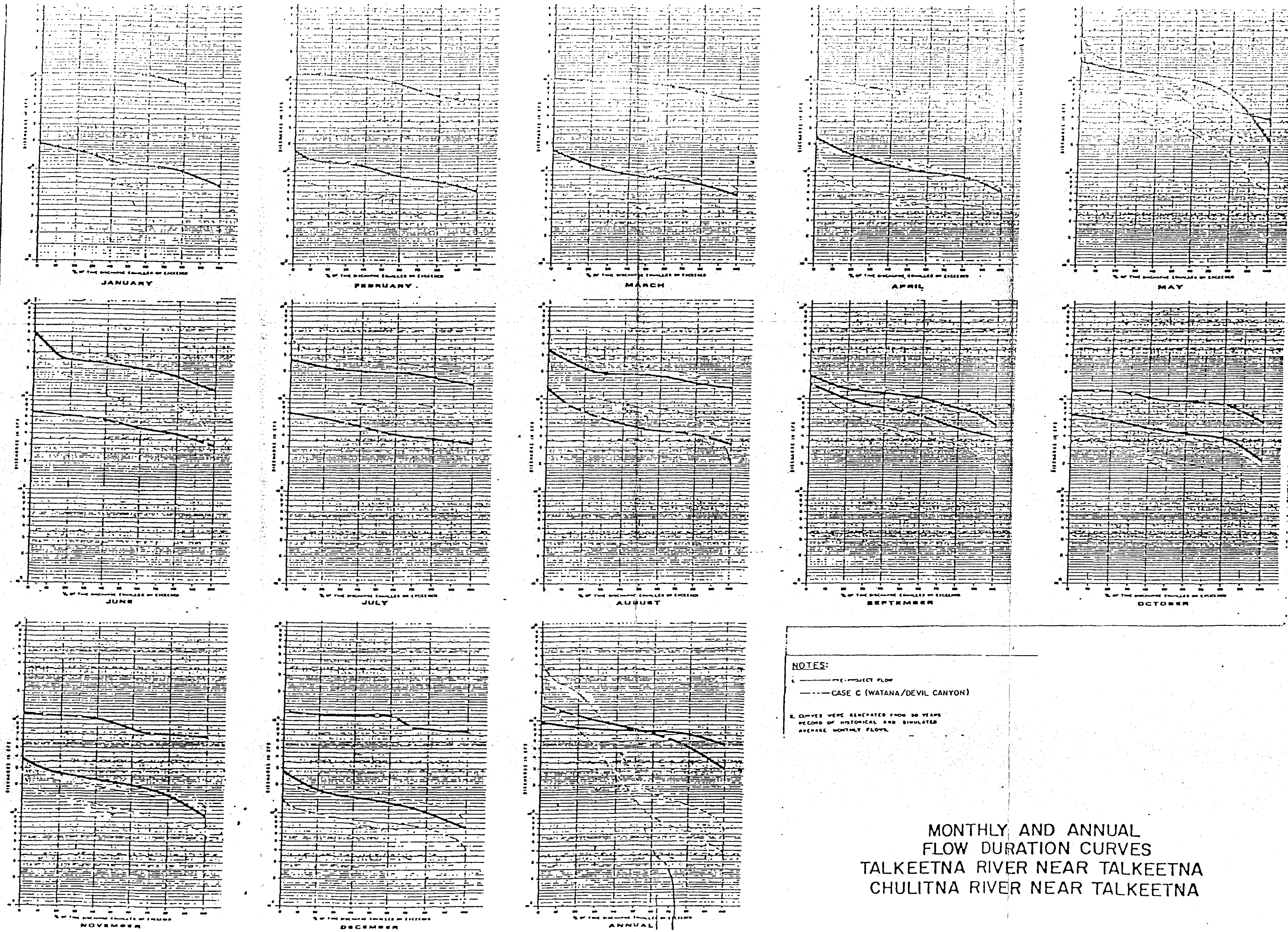
DEVIL CANYON RESERVOIR WATER LEVELS

FIGURE E.2.95



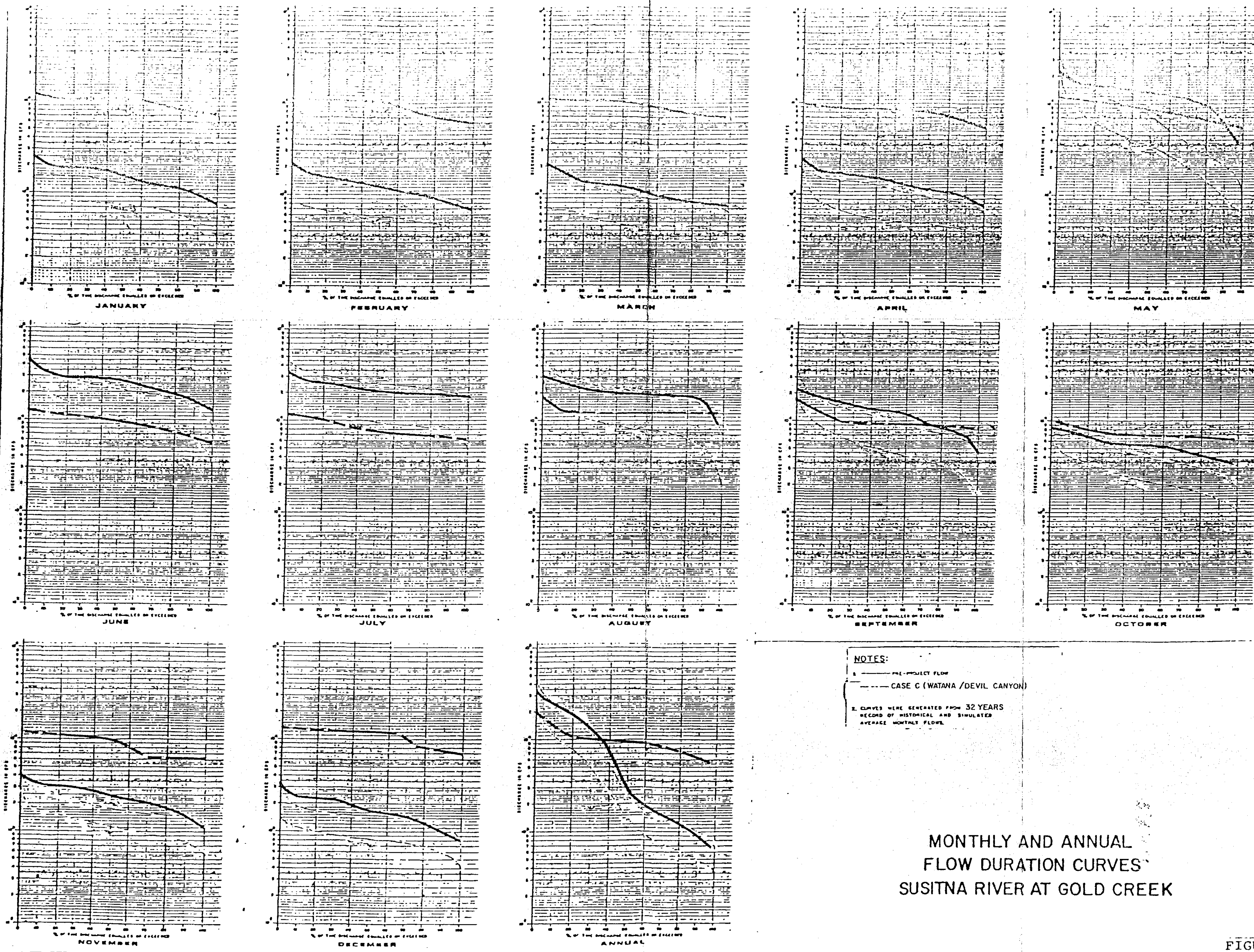
DEVIL CANYON
HYDROLOGICAL DATA

FIGURE E.2.96



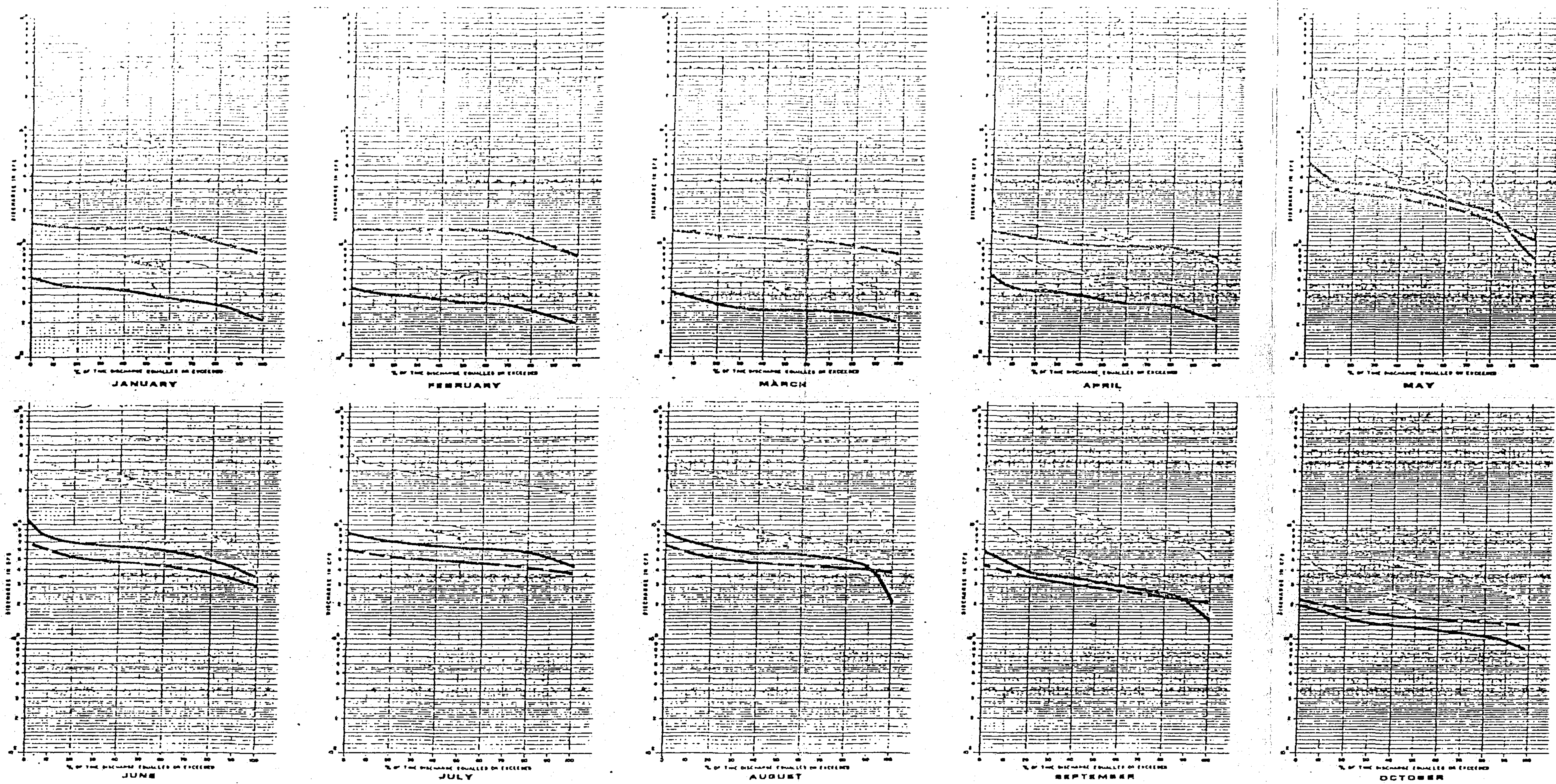
MONTHLY AND ANNUAL
FLOW DURATION CURVES
TALKEETNA RIVER NEAR TALKEETNA
CHULITNA RIVER NEAR TALKEETNA

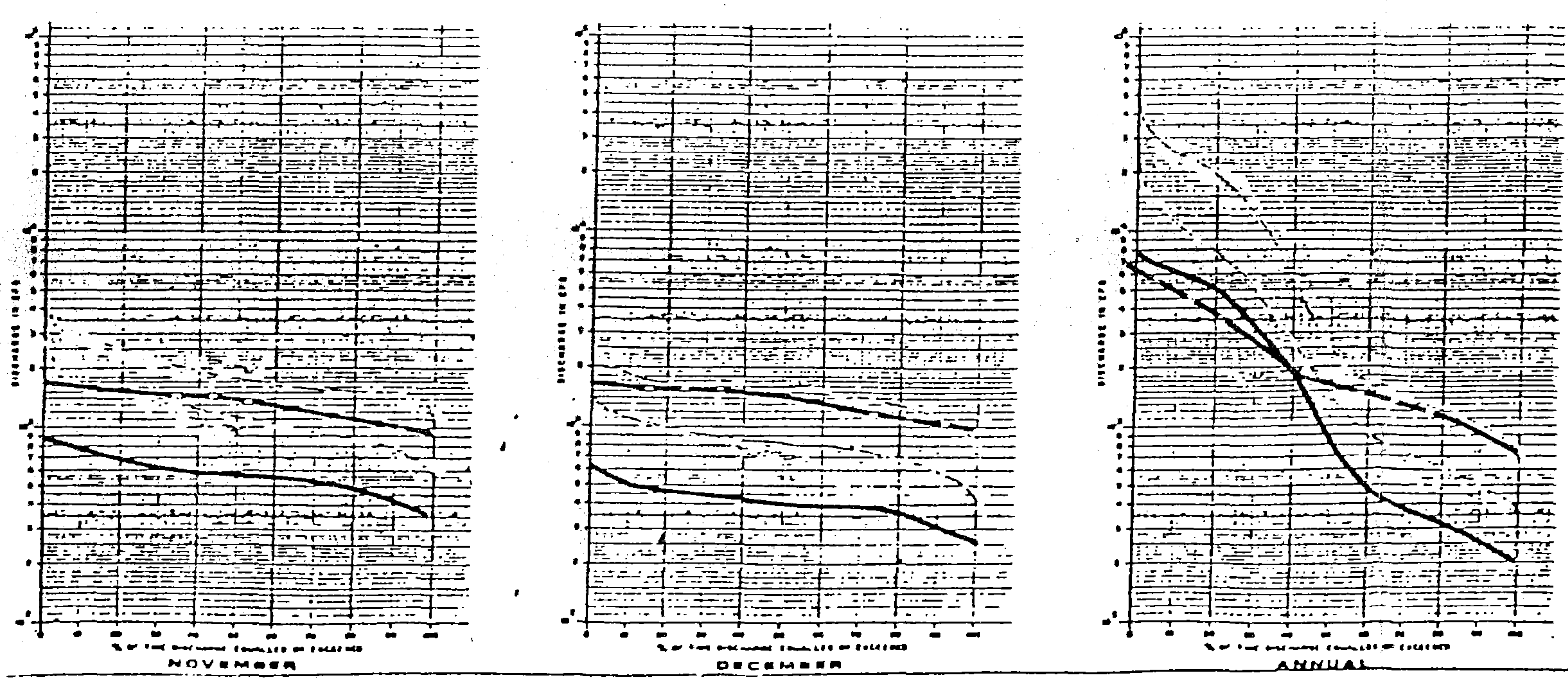
FIGURE E.2.97



MONTHLY AND ANNUAL
FLOW DURATION CURVES
SUSITNA RIVER AT GOLD CREEK

FIGURE E.2.98



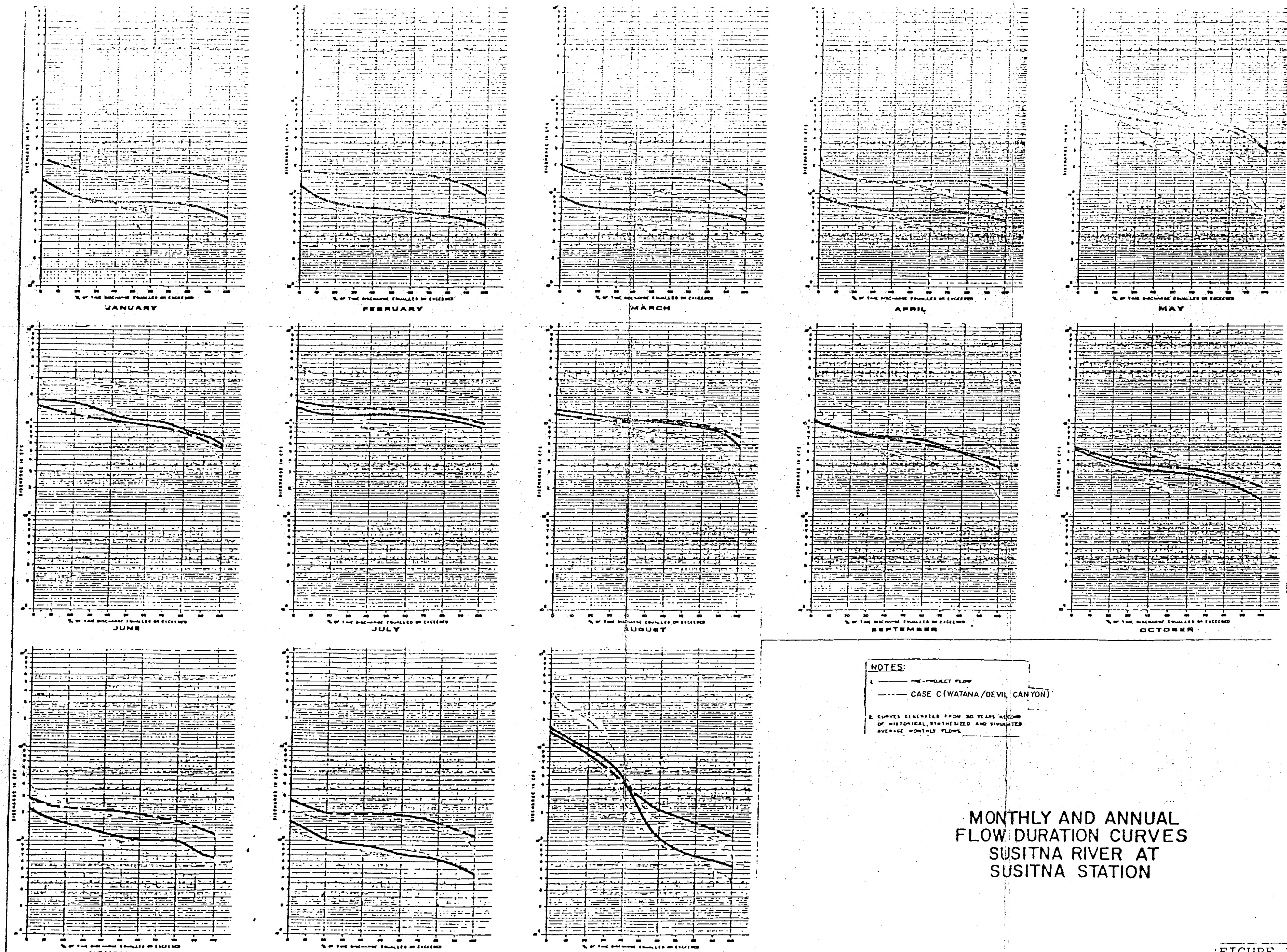


NOTES:

1. ——— PRE-PROJECT FLOW
   - - - - CASE C (WATANA/DEVIL CANYON)
2. CURVES GENERATED FROM 30 YEARS RECORD OF SYNTHESIZED AND SIMULATED AVERAGE MONTHLY FLOWS

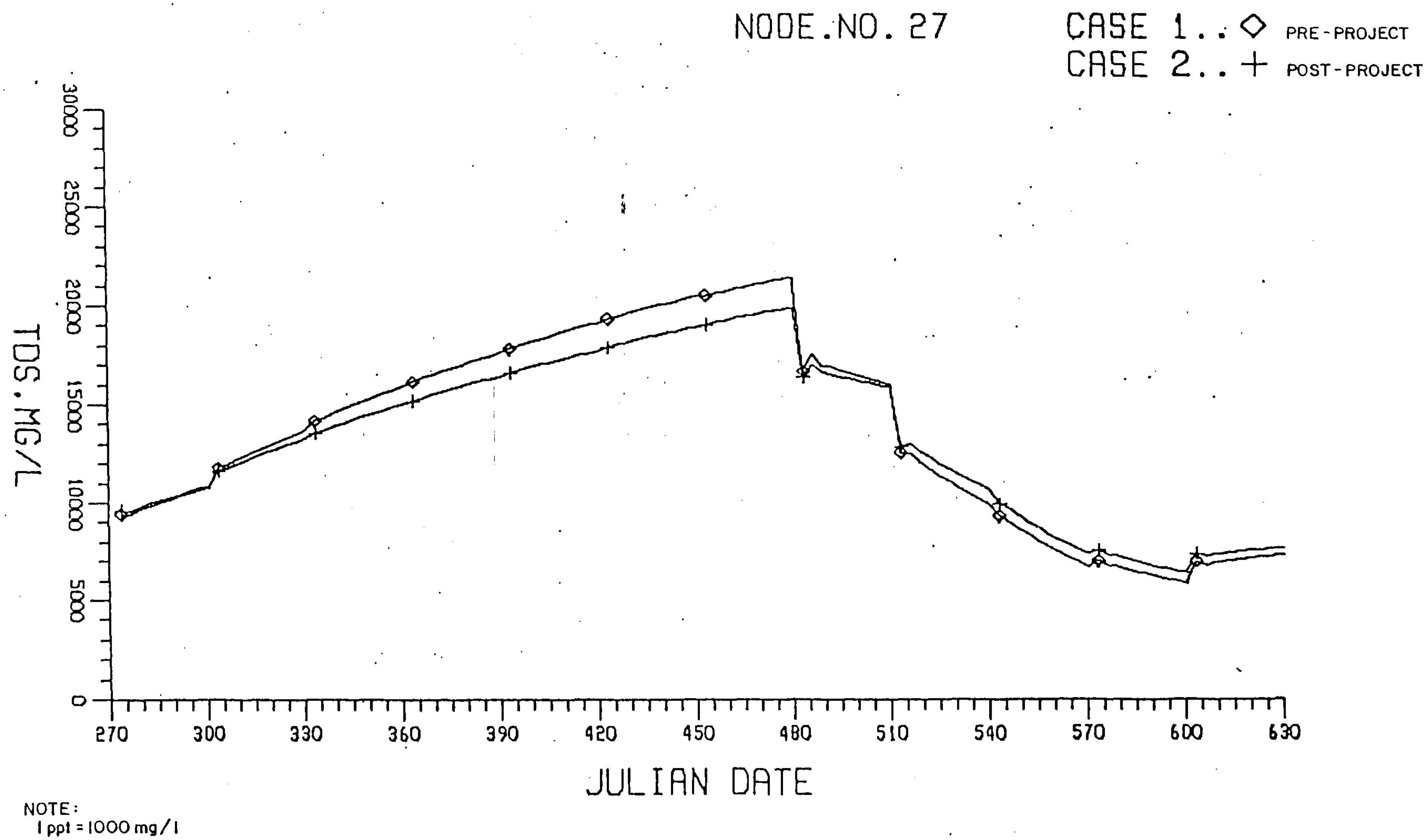
MONTHLY AND ANNUAL
FLOW DURATION CURVES
SUSITNA RIVER AT SUNSHINE

FIGURE E.2.99



MONTHLY AND ANNUAL FLOW DURATION CURVES SUSITNA RIVER AT SUSITNA STATION

FIGURE E.2.100



TEMPORAL VARIATION IN SALINITY WITHIN COOK INLET NEAR
THE SUSITNA RIVER UNDER PRE AND POST
SUSITNA HYDROELECTRIC PROJECT CONDITIONS

FIGURE E.2.101