BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

APPLICATION FOR LICENSE FOR MAJOR PROJECT

SUSITNA HYDROELECTRIC PROJECT
DRAFT LICENSE APPLICATION

VOLUME 12

EXHIBIT E
CHAPTER 4 - HISTORIC & ARCHAEOLOGICAL RESOURCES
CHAPTER 5 - SOCIOECONOMIC IMPACTS
CHAPTER 6 - GEOLOGICAL AND SOIL RESOURCES

November 1985

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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1 - INTRODUCTION AND SUMMARY (**)

Six field seasons of cultural resource studies have been conducted for the Susitna Hydroelectric Project. Between 1980 and 1984, an intensive effort was made to locate historic and archeological sites within, and immediately adjacent to, the Watana and Devil Canyon impoundments and their associated construction areas. Additional investigations were conducted within proposed recreation areas and along the Project's access roads, railroad, and transmission lines. Cultural resource studies during 1985 concentrated on the development and testing of a model used to predict the occurrence of archeological and historic sites along unsurveyed portions of the Project's linear features and in indirect impact areas. Annual reports covering the results of investigations through 1983 have been submitted to FERC (Dixon et al. 1980, 1982, 1983, 1984).

The cultural resource program developed for the Susitna Hydroelectric Project is designed to ensure compliance with all relevant federal and state laws and regulations dealing with the consideration and protection of cultural resources. Between 1980 and 1984 the University of Alaska Museum (UAM) executed a five-step program of investigation and study for the Applicant. These steps (listed in Section 1.1) were designed towards meeting the goals of identifying archeological and historical resources within pre-selected survey areas (survey locales) and gathering information about those resources necessary to evaluate their potential eligibility for the National Register of Historic Places. Data collected by the UAM comprise the majority of information used to prepare the evaluation of project impacts to cultural resources and the cultural resources mitigation plan presented in Sections 3.2 and 4.2.

Prior to each year's field investigations, all necessary state and federal permits were obtained. Literature pertaining to the archeology, ethnology, history, geology, paleoecology, paleontology, flora and fauna in and near the project area was reviewed prior to field work, and annual updates were conducted. These data were used to develop a tentative cultural chronology to assist in ordering the information collected through field studies. They also provided the basis for identifying the potential of various areas for containing cultural resource sites, and the definition and selection of survey locales within those areas.

To date, studies carried out in connection with the Susitna Project have identified a total of 297 historic and prehistoric archeological sites. An additional 22 sites, within or near the project area have been previously recorded in the files of the State of Alaska Office of History and Archeology. Wherever possible, sites identified during the Project were classified into one (or more in the case of sites containing multiple components) culture-historical periods: Euro-American (ca. A.D. 1900 - present), Athabaskan (ca. 1,500 B.P.[1] - ca. 100 B.P.), Lake Denali (ca. 3,500 B.P. - ca. 1,500 B.P.), Northern Archaic (ca. 5,200 B.P. - 3,500 B.P.), and/or American Paleoarctic (ca. 5,200 B.P. - ca. 10,500 B.P.). The assignment of chronological position to many of the prehistoric sites found was aided by the presence of a series of volcanic tephras over much of the project area.

Specialized geoarcheological studies have been conducted as an adjunct to the cultural resources program. These geoarcheological studies employed methods and involved a study area distinct from that of the historic and archeological investigations. These are discussed in more detail in Sections 1.2.2 and 2.1.2.

Cultural resource field investigations utilized both surface inspection and sub-surface testing within preselected survey locales to locate historic and archeological sites. More extensive excavation was then undertaken at a sample of identified sites to gather information needed to assess their potential eligibility for the National Register of Historic Places and to develop a data base that could be used to prepare a mitigation plan. All artifactual specimens collected to date have been accessioned into the UAM and all sites have been assigned Alaska Heritage Resources Survey numbers.

Analyses have indicated that most cultural resources sites identified in connection with the Project may not individually meet the criteria for eligibility for the National Register of Historic Places. However, when considered collectively as part of a district or districts, these same sites may be eligible. Implementation of the cultural resources mitigation plan would result in the Project having no adverse affect on National Register eligible properties.

The nature and extent of project impacts to cultural resources vary widely. Sites which would be directly impacted include those within the proposed impoundments, utilized borrow areas, and areas of physical ground disturbance associated with construction activities (e.g. dam sites, construction camps and village, permanent village, airstrip, and transmission lines, assess roads, and railroad construction rights-of-way).

1/ B.P. stands for Before Present

Sites located within 500 feet of a reservoir's maximum extent may be indirectly impacted since such areas may be prone to slumping due to shore erosion or they may be adversely affected by recreation-related activities. Indirect impacts to cultural resources may also result from vandalism occurring as a result of increased access to the project area. However this is not expected to be a major problem given the nature of the majority of sites involved.

The preponderant majority of the cultural resources sites identified consist of small scatters of prehistoric lithic debitage (debris from the manufacture and use of stone tools) and in some cases small quantities of burned and unburned animal bone. A total of 37 sites are located within the proposed minimum pool which would result from the construction of Stage I of the Project. An additional 24 sites would be within the Stage I drawdown area. Four sites would be located within the permanent pool formed by construction of the Devil Canyon Dam (Stage II); three would be within the drawdown area. Construction of Stage III of the Project would permanently inundate two sites in addition to all sites within the Stage I permanent pool and drawdown areas. Nineteen additional sites would be located within the Stage III drawdown area.

No sites are located at the designated construction camps and villages, permanent village, airstrips, intake structures, dams, spillways, switchyards, powerhouses or cofferdams for any stages of the Project. However, six sites are located within 500 feet of these features and are likely to be adversely affected.

A total of 32 sites are located within proposed Borrow Areas A through L. An additional 13 are located within 500 feet of these areas. Of the 32 sites within borrow areas, 6 are in Borrow Area J which is within the Watana Reservoir and 3 are in Borrow Area I which is within the Devil Canyon Reservoir.

No prehistoric sites are presently known to be located within the anticipated construction rights-of-way for the proposed railroad, access roads, or transmission lines. A single historic resource (HEA 096), although within the right-of-way for the Healy-to-Anchorage transmission line segment, would not be adversely affected by the Project.

A cultural resources mitigation plan has been developed in consultation with the State Historic Preservation Officer. The provisions of this plan are presented in Section 4 of this chapter. Implementation of this plan would result in the Project having no adverse effect upon archeological, historic, or architectural properties listed in or eligible for the National Register of Historic Places. Components of the mitigation plan would include avoidance, preservation in place, data recovery, monitoring and a public interpretation and education program.

1.1 - Program Objectives (**)

To ensure compliance with laws and regulations relating to the consideration of cultural resource issues in project planning and development, a multi-phase program was developed. The three principal phases include data collection and analysis, impact assessment, and mitigation planning and implementation. The first phase includes separate approaches for proposed reservoirs and dam sites, and for the Project's linear features.

Data collection and analysis within the area which would be directly affected by construction and operation of the dams and reservoirs for all three proposed construction stages began in 1980 and was completed in early 1985. Surveyable portions of these areas were examined by field crews from the UAM (Dixon et al. 1985).

Engineering and logistic considerations have rendered it impossible to effectively survey actual construction rights-of-way along the Project's linear features. With the concurrence of the State Historic Preservation Officer (SHPO) and the National Park Service, an alternative data collection strategy was developed (Smith & Dilliplane 1984 pers. comm., Sharrock 1984 pers. comm.). Existing data about the distribution of known historic and archeological sites in the project vicinity were used to develop a predictive model of site distribution and density. This model was tested during the 1985 field season through an intensive survey of selected tracts located along the corridors associated with the Project's transmission lines, railroad, and access roads.

Generic aspects of the proposed mitigation plan have been developed. They fall into five categories of activities: avoidance, preservation in place, data recovery, monitoring, and a public interpretation and education program. The specific mitigation measures to be implemented at particular sites and within particular direct and indirect impact areas are presently being developed.

1.2 - Program Specifics (**)

1.2.1 - Archeology (Dam Sites, Impoundments, Associated Construction and Borrow Areas) (**)

Data collection and analyses for this portion of the cultural resources program were conducted between 1980 and 1985 by the UAM. UAM employed a five-step approach to meet the objectives of this portion of program.

(a) Step 1: Study Design and Field Study Preparation (**)

Step 1 included all pre-field tasks. Required state and federal archeological permits were applied for and obtained. A comprehensive literature review was undertaken.

This included an examination of literature pertaining to the archeology, ethnography, history, geology, paleontology, flora and fauna of the project area and adjacent regions. Archeological, ethnographic, and historical data were employed to develop a tentative culture-historical chronology for the project region. This information, together with that on the area's natural history and supplemented by an examination of aerial photographs and maps of known cultural resources sites were used to identify areas that were believed to have no or only very low potential for containing cultural resources (e.g. steep canyon walls, areas of standing water, exposed gravel bars). These areas were eliminated from reconnaissance level testing.

(b) Step 2: Reconnaissance Level Testing (**)

The purpose of this step was to locate cultural resources sites within the study area. The results of Step 1 were used to define areas which were believed to have a potential for containing cultural resources. These areas were designated as survey locales. A total of 186 survey locales encompassing approximately 33,000 acres were examined between 1980 and 1984. Reconnaissance level testing was also conducted at geotechnical test sites, proposed borrow areas, helicopter landing zones, and other areas scheduled for ground disturbance during construction, even if those areas fell outside designated survey locales. Maps showing the location of all survey locales and areas subjected to reconnaissance level testing are contained in Dixon et al. (1985).

(c) Step 3: Systematic Testing (**)

Systematic testing consisted of a more intensive investigation of cultural resource sites identified during reconnaissance testing. Its purpose was to gather enough data about a site to allow assessment of its significance and potential eligibility for the National Register of Historic Places. Systematic testing included determining a site's size, preparing a topographic map, and excavating a small number of test units to examine stratigraphic relationships and gather an artifact sample.

(d) Step 4: Analyses and Report Preparation (**)

This step included the preparation of individual site reports, annual synopses of field investigations, and a final compendium presenting the results of all field work and analyses as of 1984 (Dixon et al. 1985).

(e) Step 5: Curation (**)

Recording of recovered artifactual material and associated contextual data has gone on throughout the cultural resource program. The UAM is the designated repository for all archeological materials recovered. Artifacts recovered to date have been accessioned into the UAM.

1.2.2. - Geoarcheology (**)

Information on the geology of the project region was collected during the pre-field literature review and updated annually. Data on surficial geological deposits and glacial events of the last glaciation of North America, in conjunction with data on more recent volcanic ashes were used to estimate limiting dates for human occupation of the Middle Susitna River valley. Analysis of the volcanic ashes (tephras) found at archeological sites throughout much of the project vicinity assisted in the relative chronological placement of many prehistoric components.

1.2.3 - Archeology (Linear Features) (***)

Exact construction rights-of-way for the project's transmission lines, access roads, and railroad would not be accurately marked on the ground until just prior to construction. The Alaska SHPO and National Park Service personnel have agreed that a field-verified predictive model can be used to assess cultural resource impacts associated with the construction of these features (Smith & Dilliplane 1984 pers. comm., Sharrock 1984 pers. comm.). A predictive model based upon a study of the association of various types (chronological and functional) of historic and prehistoric archeological sites with vegetative and geomorphical zones has been developed (Greiser et al. 1985) and field tested.

2 - BASELINE DESCRIPTION (**)

2.1 - The Study Area (**)

2.1.1 - Archeology (**)

The cultural resources study area was defined at the beginning of investigations in 1980 as those lands within approximately three km of the proposed reservoirs from just below Devil Canyon to the mouth of the Tyone River (Figure E.4.2.1). Also included (for literature reviews and evaluations of archeological sensitivity) were corridors associated with proposed access roads, and transmission lines from Fairbanks to Healy and Anchorage to Willow (Figure E.4.2.2). In addition, areas outside this defined study area were examined to gather information needed to evaluate data from within the study area and to assist in the evaluation of indirect project impacts which might extend beyond the study area.

The area of direct cultural resource impacts associated with the Project was defined in consultation with the Alaska State Historic Preservation Officer (Johannsen 1984). This area is defined to include the area of the Watana and Devil Canyon impoundments at maximum high water, all borrow and construction areas, and construction rights-of-way associated with the project's linear features. To ensure that the impact assessments presented in Section 3.2 are conservative, the direct impact area was expanded to include the area within 500 feet of maximum impoundment limits.

The area within which indirect impacts to cultural resources were considered included: a) areas where vandalism of cultural resources is likely to increase because of improved access or increased visitation, b) places outside the direct impact area that may be affected by mitigation activities for other resources; and c) areas where undertakings associated with the Project's recreation plan may adversely affect cultural resources.

2.1.2 - Geoarcheology (*)

The study area for geoarcheological studies included the area within 16 km on either side of the Susitna River from Portage Creek to the Maclaren River (Figure E.4.2.1). This area was selected to provide information on the Susitna River Canyon, the area between the canyon rim and the foothills of the Talkeetna Mountains and the Alaska Range, and the foothills themselves.

2.2 - Methods - Archeology and History (**)

A research design was developed to guide the cultural resource survey of the project area. The following sections discuss the research strategy and its implementation.

2.2.1 - Application of Data Base (**)

A review of literature on geoarcheology, archeology, ethnography, and history (Dixon et al. 1982, Appendices A and B, Greiser et al. 1985) formed the basis for the research design, which began by delimiting the potential time period of past occupation in the project area and constructing a cultural chronology. The research design included a survey strategy based on geoarcheological and paleoecological data and the distribution of known cultural resource sites in the project region. Areas with little or no potential for finding sites, given current survey methods, were eliminated from further consideration. Survey locales were distributed throughout the project area in settings considered to have moderate or high potential for finding cultural resource sites, with an emphasis on landforms known to contain sites in the project region.

2.2.2 - Permits (**)

Permits to conduct the archeological survey and test excavations were obtained from the Bureau of Land Management, Department of Defense, and the Alaska Department of Natural Resources Office of History and Archeology for each field season.

2.2.3 - Literature Review (**)

Published and unpublished literature on the archeology, history, ethnography, geology, flora, and fauna of the project area and the surrounding region was reviewed and used in formulating the research design. The library, collections, and data files of the UAM and the University's Rasmuson Library were searched extensively. Archives at the Rasmuson Library and the Alaska Native Language Center provided many valuable unpublished references. Additional sources of information included the Alaska Heritage Resources survey files of the State Office of History and Archeology and maps published by the U.S. Geological Survey. Summaries of the literature reviewed and resulting information can be found in a number of project reports including those by Dixon et al. (Appendices A and B. 1982.) and Greiser et al. (1985).

2.2.4 - Cultural Chronology (**)

Prehistory. The prehistory of the project region and of interior Alaska in general is not well known. Most work has focused on chronology and other questions related to culture history instead of questions related to environmental adaptation such as those concerning settlement patterns and subsistence systems. Thus, this overview of the project region's prehistory focuses primarily on chronology.

Most archeological sites consist of surface or shallow subsurface deposits with primarily lithic assemblages characterized by relatively few artifact forms. These limitations make dating by comparison of artifact style, radiocarbon analysis, and geological context difficult. The typological comparisons that form the basis for the many technological complexes defined for interior Alaska are limited to a few artifact classes as shown in Table E.4.2.1 (Bacon and Greiser 1985).

The project region has been discussed in terms of three physiographic subareas: 1) a northern subarea between the Alaska Range divide and the Tanana River, 2) a central subarea, including the middle and upper Susitna Basin, and 3) a southern subarea, including the lower Susitna Basin and upper Cook Inlet (Bacon and Greiser 1985). Most archeological work prior to that conducted as part of the Susitna Project has been concentrated in the northern subarea, while the central subarea has been investigated by the UAM for the Susitna Project (Dixon et al. 1985), and the southern subarea is least known. Bacon proposed using a framework of three postglacial subperiods to organize the prehistory of central Alaska according to major environmental changes as shown in Figure E.4.2.3 (Bacon et al. 1983). These include: 1) a Tundra Period, ending ca. 8,000 B.P., 2) an Early Taiga Period, ca. 8,000-4,500 B.P., and 3) a Late Taiga Period, ca. 4,500 B.P. to historic contact.

A number of chronologies that have been constructed for various parts of the study region are shown in Figure E.4.2.4. These chronologies generally agree in placing the earliest occupation of the region in the northern subarea about 11,000 B.P., closely followed by occupation in the central and southern subareas. Bacon's designation of this period as Early Tundra reflects the replacement of steppe vegetation by tundra to which early occupations were adapting. The earliest documented cultures utilized a core and blade technology with microblades and burins. This has been designated as the Denali Complex of the American Paleo-Arctic Tradition by a number of investigators. The Denali Complex may have been preceded by a bifacial technology containing large blades but lacking microblades, termed the Chindadn Complex (Cook 1969) and the Nenana Complex (Hoffecker 1979). It is not clear whether the lack of microblades in the earliest assemblages results from sampling bias or whether it accurately reflects the earliest technology. Hoffecker (1979) has suggested that the Nenana Complex may represent the northern extension of Paleo-Indian big game hunting or was ancestral to it.

Beginning about the time of early forest development in the project region, side-notched projectile points appear in archeological assemblages which have been designated the Northern Archaic Tradition by numerous investigators. These assemblages sometimes include microblades and cores and have been identified as Denali Complex-derived or early Northern Archaic Tradition or Late Denali by several investigators. It is unclear whether the association of these two technologies represents acculturation of the Denali and Northern Archaic Traditions or a mixing of their assemblages.

A cooling of the climate was accompanied by some retreat in forest margins, a period Bacon has identified as Late Taiga. Boreal Choris Tradition assemblages appear in western Interior Alaska and are characterized by large lanceolate and large bifacially flaked projectile point forms, but lack the microlithic technology evident at the same time in Arctic Small Tool Tradition sites on the western coast and northern interior of the state. The Minchumina Tradition (Holmes 1974, 1977, 1982, 1984) has been defined from excavations at Lake Minchumina where three phases contained flaked burins and microblade technology in addition to lanceolate point forms. This tradition dates from 2,600 to 1,000 B.P., documenting the persistence of Northern Archaic Tradition tools, particularly large side-notched points, along with microblades until about 1,000 B.P.

Researchers have forwarded various opinions regarding the origin and arrival date of archeological assemblages representing prehistoric Athapaskan occupation of the northern subarea. Cook (1969) suggests that an Athapaskan Tradition began about 11,000 B.P., while some other researchers (e.g., Dumond 1969) have suggested that the arrival of Athapaskan groups in parts of Alaska and northwestern Canada is indicated by the spread of the Northwest Microblade Tradition by 6,000 B.P. Linguists have suggested that the Athapaskan language originated in an area encompassing eastern interior Alaska and moved west through the project region before 1,500 B.P. Excavations have yielded assemblages, including contracting-stemmed projectile points, flaked end and boulder spall scrapers, tabular bifaces, hammerstones, whetstones, copper tools, and unilaterally barbed bone points with distinctive designs (Bacon and Greiser 1985). The differences between these assemblages and both Northern Archaic Tradition and Denali Complex materials have led some researchers to suggest that the Athapaskan tradition replaced the earlier core and microblade technology by about 1,000 B.P. (Bacon 1977; Bacon and Holmes 1980; Shinkwin 1975).

As stated above, little is known about the prehistory of the central subarea beyond investigations for the Susitna Project, which are discussed below. Information for the central subarea is generally consistent with that of the northern subarea. From research in the Copper River drainage, Workman (1977) has traced Ahtna prehistory to approximately A.D. 1000, identifying a settlement pattern of winter hunting camps and summer fishing stations similar to that found during the early historic period. The few data available for the southern subarea also are generally consistent with the northern subarea; the Long Lake site in the southern Talkeetna Mountains produced an assemblage derived from the Denali Complex, while the Beluga Point site on Cook Inlet produced an assemblage derived from the Ocean Bay I phase of the Koniaq Tradition (Bacon and Greiser 1985).

<u>Ethnography</u>. The project region includes portions of the territories of three Athapaskan-speaking groups: the Tanaina (Dena'ina), Ahtna, and Tanana, each of which consisted of a number of bands distributed across a broad geographic area and unified by similar dialects or languages (Caywood 1985). Specific groups that occupied the project region included the Upper Inlet Tanaina, Western Ahtna, and Lower Tanana. Figure E.4.2.5 shows the approximate distribution of these groups over the project area. Small, local bands were supported by hunting and gathering economies involving seasonal transhumance; differences in the availability and distribution of plant and animal resources resulted in differences among groups in the types and amounts of resources exploited along with variations in settlement patterns. Trade was important and found to be widespread at the time of Euroamerican contact. Figures E.4.2.6, E.4.2.7, and E.4.2.8 show generalized annual settlement and subsistence cycles for each of these groups and include the types of settlements and environmental settings in which they were located along with the types of resources exploited and the habitats where they were found.

<u>History</u>. The historic period opens with Russian exploration and subsequent establishment of fur trade outposts in the mid-1700s. Russian presence in the Susitna region, however, was limited to several scantily documented explorations commencing with Malakoff's ascent of the drainage in 1834. Interaction with Native groups occurred principally at the trading posts on Cook Inlet, and there is no evidence that the Russians ever seriously exploited opportunities within the Susitna region.

The Russians, followed by Americans and British, also explored the Yukon River region throughout the period from 1840 to 1870.

The survey of this drainage in 1842-44 by Alexander Zagoskin (1967) prompted additional investigation by the Russian American Company. American expeditions, such as the one led by Robert Kennicott in 1865 to establish a route for a proposed Western Union Telegraph Company line, served to familiarize the American government with the potential of Alaska (Gallacher 1985). The Susitna region, however, remained remote and undeveloped.

Activities within the Susitna drainage remained limited after the American purchase of Alaska in 1867. Prior to the mid-1890s founding of a trading post by the Alaska Commercial Company at Susitna Station in the lower valley, only a few trappers and prospectors ventured into the area. An outpost of the Alaska Commercial Company reportedly served the lower portions of the drainage by 1875 (Cambell 1875), but did not prove a major venture.

Although the Susitna Station post, which was the company's northernmost trading outlet in the Cook Inlet region, was built to support the fur trade, events soon transpired that changed the character of regional development. Gold was discovered in 1895 on the Kenai Peninsula near Turnagain Arm, which brought a rush of over 3,000 prospectors (Bacon et al. 1983). Some, like William Dickey and his partner Allen Monks, struck out up the Susitna River hoping to establish another strike. Dickey and Monks ascended the river as far as Portage Creek and, although unsuccessful in their prospecting, provided a popular account of the region (Dickey 1897). In addition, the Klondike Gold Rush of 1897-98 and discoveries near Fairbanks provided national exposure to the potential riches of Alaska. Alerted by the discoveries, the federal government significantly increased the funding for mineral exploration of the territory and establishment of routes to the interior. Expeditions investigated the lower Susitna and Tyonek Rivers, and the Copper River drainage, touching on portions of the study region. In 1898, G.H. Eldrige and Robert Muldrow ascended the Susitna River and crossed overland to the Nenana drainage (Bacon et al. 1983). A USGS survey party under the direction of Alfred Brooks also explored the Susitna drainage in 1902. The Brooks party discovered and mapped Rainy Pass before crossing into the Kuskokwim drainage.

The first major placer gold strike in the drainage occurred in 1903 in the upper Susitna along Valdez Creek (Dessauer and Harvey 1980). The Alaska Commercial Company stocked its Susitna Station post and established another site at Talkeetna to capitalize on the strike. The venture was not successful, however, because freighting up the Susitna River to the deposits was too difficult. Most supplies came via routes through the Copper River basin from Valdez. Other mining districts established during this period include those at Cache Creek, Willow Creek, and in the Yentna region.

Mining stimulated development of improved transpor- tation systems (Gallacher 1985). The Alaska Road Commission (ARC) established and maintained numerous overland trails, and many of the frozen rivers were sledded during the winter. In 1918, the ARC began construction of a wagon and sled road from Talkeetna to Cache Creek, which provided cheaper transportation and enabled the ARC to abandon a number of older trails. Continued demand for reliable transportation also initiated development of the Alaska Railroad (ARR) system. A Congressional commission was established in 1912 to study Alaska transportation needs and recommended construction of a railroad to Fairbanks. The present ARR, which follows the Susitna River to Gold Creek, crosses into the Chulitna Valley, and continues down the Nenana River was selected in 1915 (Gallacher 1985). Small railroad towns sprang up along the route, with Talkeetna becoming the major supply point for the region after completion of the rail line in 1923.

The influx of miners into the region increased the awareness of abundant furbearing animals. In some cases, miners conducted limited trapping to supplement mining operations. With a dramatic rise in the market price for furs in the early 1920s, trapping and commercial fur farms became a major pursuit. Main and line camps were scattered throughout the upper Talkeetna and Susitna Rivers. Although prices declined in the 1930s, fur activity continued well into the 1950s.

The hydroelectric potential of the Susitna basin was first investigated in the late-1940s by Bureau of Reclamation survey parties (Dixon et al. 1985). Three potential dam sites were identified in the Susitna River. Additional feasibility and engineering studies were conducted by the Corps of Engineers prior to actual program development in 1979 by the Applicant.

2.2.5 - Research Design and Strategy (**)

The review of literature on archeology, ethnography, history, geology, and flora and fauna indicated that cultural resource sites in the project region appear preferentially distributed with regard to physical, topographic, and ecological features. Based on an analysis of site locational data from the project region, certain areas were eliminated from the testing program as having little to no potential for cultural sites. These areas included steep (greater than 15 degrees) slopes such as the walls of Devil Canyon; areas of standing water, such as the Susitna River and its tributary streams, lakes, and swampy areas; and areas of geomorphic instability, such as gravel bars along the river. Even though no survey locales were designated areas of low potential, limited survey was conducted in some low potential areas. For example, low-level helicopter reconnaissance, surface reconnaissance, and subsurface testing were conducted where possible when geotechnical activities such as auger holes, bore-holes, and seismic testing took place in areas of low potential. In addition, the Watana airstrip was planned for a low potential area, and both surface survey and subsurface testing were conducted.

Survey locales were distributed throughout the project area in settings considered to have moderate or high potential for finding cultural resource sites, with an emphasis on landforms known to contain sites in the project region. Such landforms include overlooks, lake margins, stream and river margins, topographic constrictions, and mineral licks. Overlooks are areas of higher topographic relief that command a view of the surrounding region and usually are well drained. Such locations appear to have served as hunting lookouts and possibly also as temporary campsites. Because these locations are elevated, soil deposition is generally thin, and archeological sites often can be discovered through examination of natural exposures.

The margins of larger lakes appear to have served as seasonal base camps, with access to fishing, other aquatic resources, and large mammal hunting. Because these locations occur in lower topographic positions, lake margins may exhibit deeper soils than overlooks, often requiring subsurface testing. Stream and river margins appear to have served frequently for activities associated with temporary campsites and seasonally reoccupied base camps. Because of stream flooding, these locations may exhibit deeper soils than lake margins or overlooks, often requiring subsurface testing.

Topographic constrictions are places where the terrain tends to funnel game animals moving through the area. Usually, steep-walled mountains or buttes converge in such locations, concentrating game (especially herd) animals and affording more efficient and effective exploitation by hunters. Such locations appear to have served as lookouts, kill sites, and temporary campsites. Soil conditions and requirements for survey methods vary depending on local topography.

Mineral licks are natural geologic exposures containing minerals, primarily sodium, that draw large mammals. These locations also appear to have served as lookouts, kill sites, and temporary campsites, with soil conditions and requirements for survey methods depending on local topography.

2.2.6 - Data Collection and Field Procedures (**)

This section discusses procedures used by the UAM for cultural resources inventory primarily in the Susitna Basin project area from 1980 through 1984 (Dixon et al. 1985). A predictive model was constructed of cultural resources distribution across terrain and vegetation units along the project's linear features and was tested through an environmentally-controlled sampling survey of 15 percent of the linear features' rights-of-way. An intensive pedestrian examination with subsurface shovel tests was used to refine the predictive model. This model would facilitate avoidance of cultural resources during final design, identification of additional survey needs, and designation of the types, amounts, and costs of necessary mitigation measures.

The objectives of the Susitna Basin field program included conducting: 1) intensive examination of survey locales placed throughout the project area; 2) intensive examination of geotechnical test areas prior to ground disturbance; and 3) test excavations at cultural resources sites located during survey. A Procedures/Quality Assurance Manual was developed and used to standardize fieldwork and laboratory methods and techniques throughout the course of the multi-year research project. This manual discusses when and how to implement appropriate procedures including documentation of them through a number of specialized data-recording forms.

Intensive survey consisted of visual surface examination and subsurface shovel testing of each survey locale by crews consisting of about three archeologists. The sizes and locations of survey locales were selected to sample the various project features and terrain units throughout the project area, ensure coverage of geomorphic settings found to contain cultural resources in the project region, and facilitate access by helicopter.

When cultural resource sites were discovered, an initial test pit was placed within the site, followed by shovel testing at grid coordinates to provide information on site size and relative artifact density as well as to obtain a sample of cultural materials and enable planning of any additional test activities. Altimeter measurements were made to determine the elevation of each site associated with the Watana and Devil Canyon reservoirs.

Systematic testing was undertaken at selected sites based on their potential for project impacts and their likelihood of contributing information to research questions in the culture history of central Alaska. Testing was conducted in five-cm arbitrary levels in one-m squares after sites were gridded and mapped. Systematic testing was used to obtain more detailed information on site components and stratigraphy as well as to increase samples of cultural materials.

Records included detailed daily notes in field books kept by each crew member. Information was summarized on survey locale, site survey, and other forms. With attached maps and photographs, survey locale forms recorded observations on environmental characteristics and cultural remains within each locale. Site survey forms recorded detailed information on the cultural material and environmental setting of each site and were accompanied by maps, photographs, and soil profiles. A variety of standard forms were used to record information during systematic test excavations. Summary reports were prepared on each site and included in Appendix D of the summary report of investigations conducted by the UAM (Dixon et al. 1985).

Artifacts, faunal remains, and carbon samples and other samples were cataloged and accessioned into the UAM. Carbon samples were submitted to commercial laboratories for radiometric dating. Analyses undertaken on lithic collections included artifact form and raw material type. Twenty-four types of lithic artifacts were defined and their frequencies were plotted across project area environments and through regional stratigraphic units to suggest changes in settlement patterns through time. Eight types of lithic raw materials were defined, and their frequencies were plotted across project area environments and through regional stratigraphic units to suggest technological changes through time. Possible correlations between lithic artifact types and raw material use also were examined.

Analysis of faunal materials included identifying bone fragments to skeletal element and species where possible. Bones were examined for evidence of cultural modification including burning, butchery marks, and tool manufacture as well as animal processing activities. Numbers of faunal taxa were plotted by site through regional stratigraphic units to suggest changes in subsistence through time. The results of the analyses are presented and discussed in the summary report of investigations (Dixon et al. 1985).

2.3 - Methods - Geoarcheology (**)

Geoarcheological studies were conducted to develop a regional stratigraphic chronology and to identify the distribution, composition, and variability of surface landforms and deposits. The studies provided baseline and feedback information for selection of survey units, analysis of site distribution patterns, and development of depositional contexts for cultural stratigraphic units. Activities included a review of existing literature, air photo mapping of terrain units, field investigation and sample collection, and analysis.

2.3.1 - Literature Review (*)

All published geologic reports with potential bearing on the project area were reviewed to provide a framework for further investigation. Because specific geoarcheological data were not available for the study region, information from adjacent regions was synthesized to provide a contextual framework. The literature review concentrated on studies that included the correlation of stratigraphic components with radiocarbon dates. Studies of the Glacier Bay - Boundary Range region of southeast Alaska and the Brooks Range were included also because climatic sequences are fairly well known in these areas.

2.3.2 - Geoarcheological Terrain Unit Mapping (**)

Existing landforms within 10 to 20 km of the Susitna River were identified and mapped using air photo interpretation. Terrain units, defined as consisting of expected landforms occurring between the surface and 7.6 m in depth formed the basic mapping unit. Although generally employed for engineering purposes, terrain unit mapping helped identify potential locations of human activity as well as define the physiographic attributes of areas of known cultural activity.

2.3.3 - Field Study (**)

Geological field reconnaissance was conducted to groundtruth and refine terrain unit mapping, to map and sample exposures that contained a sequence of depositional stratigraphy, and to characterize critical glacial-geomorphological features within the region. Additional geoarcheological data were provided from profiles exposed during excavation of archeological test units.

Aerial reconnaissance was used to evaluate the accuracy and applicability of the terrain unit mapping to cultural resource investigations and to familiarize project personnel with regional topography. Information from reconnaissance was used to refine terrain unit maps to increase their applicability to archeological problems. In addition, river bluff exposures within the drainage between the Chulitna and Tyone Rivers were examined from helicopters to select a sample with the potential to provide regional stratigraphic sequences. Twenty-five exposures were selected for detailed documentation including description and measurement of stratigraphic units, sampling of organics for radiocarbon dating and paleobotanical analysis, and collection of sediment and tephra samples to define structural composition.

2.3.4 - Investigation and Dating of Samples

(This section deleted)

2.3.5 - Methods - Geoarcheology 1981

(This section deleted)

2.4 - Known Archeological and Historic Sites in the Project Area (**)

2.4.1 - Introduction (**)

This section includes a summary of the results of cultural resource investigations completed to date. Detailed descriptions of cultural resource sites presently known to exist in the project area are contained in Dixon et al. (1985). Investigations carried out between 1980 and 1984 by the UAM for the Project located 297 previously unknown historic and prehistoric sites. An additional 22 sites had been previously documented in the files of the Alaska Heritage Resource Survey. Additional summary data on the chronological placement, physigraphic setting, size, and artifact inventories associated with these sites are presented in Section 3.1.

2.4.2 - Watana Dam and Impoundment (**)

A total of 61 historic and archeological sites have been located within the area to be inundated by the reservoir associated with Stage I of the Project. (Separate loci of a single site as designated by Dixon et al. (1985) are treated here as separate sites, e.g. Loci A, B, and C of site TLM 222 are considered to be three separate sites.) An additional 6 sites are located within 500 feet of the Stage I maximum pool. A total of 82 sites would be located within the reservoir formed by Stage III of the Project. These include the 67 sites within and immediately adjacent to the Stage I reservoir. Nineteen additional sites would be located within 500 feet of the Stage III reservoir. No sites are situated at the locations of proposed power intakes and outlets, spillways, cofferdams, or diversion intakes.

2.4.3 - Devil Canyon Dam and Impoundment (**)

A total of seven sites - (TLM 023, 034, 178, 252, 253, 258, 259) would be located within the Devil Canyon impoundment. An additional five sites (TLM 022, 024, 027, 029, 030) are located within 500 feet of the reservoir maximum limits. No sites are situated at the location of the dam itself or associated structures.

2.4.4 - Borrow Sites (**)

A total of 32 sites have been identified within proposed borrow areas. Seven of these are located in borrow areas that are within either the Devil Canyon (six) or Watana reservoirs (one). Seventeen are located within Borrow Area C, and eight are within Borrow Area F.

2.4.5 - Access Routes (**)

No sites have been identified to date within the construction right-of-way of the access roads. A model for evaluating the archeological sensitivity of unsurveyed portions of access routes was developed and tested.

2.4.6 - Transmission Lines (**)

No archeological sites have been identified to date along the routes of proposed transmission lines. One historic period site, HEA 91, the Stampede Trail, crosses the proposed transmission line from Healy to Fairbanks. The trail has been converted into a road. A model for evaluating the archeological sensitivity of unsurveyed portions of transmission line routes was developed and tested.

2.4.7 - Other Areas (**)

During the course of studies conducted for the Project, a number of historic and archeological sites were located outside the anticipated impact area. A total of 35 such sites were found through literature checks or were reported by helicopter pilots and geologists. However, sites have been located at the proposed locations for project airstrips, construction camps or villages, or the permanent village. Five sites have been identified within 500 feet of these features.

2.5 - Geoarcheology (**)

2.5.1 - Introduction (**)

Geoarcheological data from literature reviews, aerial mapping, and field studies provided background information used to develop archeological field strategies and to provide a geological framework for site interpretation. Aspects of the geoarcheological baseline studies are presented below.

2.5.2 - Geoarcheologic Terrain Unit Mapping (**)

Geomorphic analysis included the identification of 26 geological/morphological units, called terrain units, which were mapped from air photo analysis and verified during field survey. It was initially expected that identification of these units would serve to develop a stratified random sampling program for archeological site survey. This expectation was modified due to the complex sequence of deglaciation in the region and the fact that important environmental variables for site locations crosscut the units. Terrain unit mapping, however, provided information on landform variability that was useful in selecting survey locales and evaluating site distribution patterns.

2.5.3 - Stratigraphic Framework (**)

Baseline studies augmented by information from archeological test excavations provided a basis for development of a generalized regional depositional chronology. The derived profile represents a complex history of glacial advance, stagnation, and retreat; fluvial reworking of sediments; alluvial deposition, soil development; and tephra falls. Sixteen major stratigraphic units can be recognized within the project area (Figure E.4.2.9). Depositional chronology was established using radiocarbon dates obtained from in-situ organic deposits.

2.5.4 - Glacial-Geomorphologic Mapping General Comments (**)

Investigation and mapping of glacial geomorphology assisted interpretation of the complex glacial history of the project area and provided a framework for environmental variables affecting prehistoric exploitation of the region. Mapping of features indicates that numerous valley glaciers with variable patterns of development interacted differentially within the drainage. Extensive glaciolacustrine plains exist within the study area and in some areas lacustrine conditions persisted until approximately 3,500 years ago (Woodward-Clyde Consultants 1982). Kames, kettles, and eskers associated with ice disintegration are distributed across the plains. Erosion, redeposition, and periglacial action have modified glacial landforms since the Pleistocene.

2.5.5 - The Last Glaciation (**)

Glaciers apparently covered much of the lowland areas of the Susitna drainage during the last glaciation, which spans the period between 32,000 and 13,000 B.P. During initial glaciation, major ice masses developed in three locations: the southern Alaska Range, and the northern and southern Talkeetna Mountains (Dixon et al. 1985). Ice from these areas advanced through adjacent valleys resulting in a complex interaction among merging glaciers. The coalescence of the valley glaciers formed a piedmont glacier extending across the Susitna valley floor.

Following the glacial maximum, lobes withdrew at different rates; in addition, evidence suggests that some of the valley glaciers experienced readvances. The piedmont glacier retreated north of the Susitna River by approximately 13,000 years ago, and valley glaciers were generally confined within their specific valleys. Large areas of stagnant ice, however, persisted in most of the broad lowland regions until about 9,000 years B.P. Glacial activity since that time has been limited to minor oscillations of existing valley glaciers.

Environmental conditions associated with glacial development and retreat influenced the potential use of the area by humans. Ice masses blocked access to areas and influenced drainage and vegetation patterns. An inferred chronology of glacial patterns and associated conditions is presented in Table E.4.2.2.

2.5.6 - Archeological Stratigraphy (**)

Examination of stratigraphic units from archeological sites has generally corroborated the regional depositional sequence discussed in Section 2.5.3. Although no individual archeological site contains all units, many have at least ten. The generalized sequence represented in the sites consists of glacially-scoured bedrock overlain by a discontinuous cover of weathered glacial sediments. These are overlain by a series of volcanic tephra units separated by contact units of weathered horizons and soils. Upper units consist of windblown sandy silt sediments with decomposed organics and an organic mat. Most archeological materials are associated with contact units between lithologic units.

2.5.7 - Cultural Horizons (**)

Nine discrete cultural horizons have been identified within the regional stratigraphy. All but two are associated with contact units (Figure E.4.2.9). While the temporal limits of the stratigraphic units can be correlated throughout the region, and intrasite sequences can be established, it is difficult to correlate intersite dating of archeological materials based on geological contexts. No one site contains more than five of the cultural horizons, with the majority containing only one or two.

2.5.8 - Chronology and History (**)

The regional stratigraphic profile presented in Figure E.4.2.9 can be divided into four major intervals which have different implications for human occupation and the project area's archeological record:

- o the period before the last glaciation, represented by Unit 15, approximately 32,000 to 25,000 B.P.; human occupation could have occurred, but archeological remains may have been destroyed by subsequent glaciation and no sites are known.

- the period during the last glaciation, represented by Unit 14, approximately 25,000 to 12,000 B.P.; human occupation was precluded or severely restricted by the presence of ice, and no sites are known.

- the period after deglaciation but before the first recognized tephra, represented by Unit 13, approximately 12,000 to 6,000 B.P.; archeological remains from this unit represent the earliest documented human occupation of the project area, ca. 7,000-8,000 B.P.

- the period of recurrent volcanic ash deposition and soil formation, represented by Units 1-12, approximately 6,000 B.P. to historic contact; evidence for human occupation occurs throughout the sequence.

The Oshetna tephra was deposited between 5,100 and 5,900 B.P., probably shortly before 5,100 B.P., and vegetation covered the area during the 2,400-year interval that lasted until the Watana ash fall. Analysis of radiocarbon dates from the paleosol occurring between the Oshetna and Watana tephras suggests two periods of soil development, one of which may correlate with the Neoglacial expansion of alpine glaciers in central Alaska. The Watana tephra was deposited between 1,850 and 2,700 B.P. and may have involved two or more depositional episodes. The Devil tephra was deposited between 1,400 and 1,500 B.P. Units 1 through 4, overlying the Devil tephra, represent soil development and deposition of organics during the last millenium.

2.5.9 - Mammoth/Mastodon Fossil Discovery (**)

A portion of the right femur of a proboscidean (likely mammoth) femur was found in fluvial gravels at Tyone Bluff. Dating to 29,450±610 B.P., this fossil represents the first documented occurrence of terrestrial Pleistocene mammals in southern Alaska. The find implies nonglacial conditions at that time and suggests that mountain passes in the Alaska Range may have been deglaciated, possibly providing some areas suitable for human habitation during mid-Wisconsinan time. No archeological sites have been found dating to this period.

2.5.10 - Summary of Geologic History (**)

The Susitna Valley has been covered several times by extensive valley glacier systems that coalesced to form a minor mountain ice sheet. One or more pre-Wisconsinan glaciations have been recognized. Much of the present valley was carved to the present river level before mid-Wisconsinan time (31,000 B.P.). The valley bottom was modified extensively during the last glaciation which began after about 31,000 B.P. in the Fog Creek area and after about 22,000 B.P. in the Tyone River area.

During deglaciation, stagnant ice covered large areas, and meltwater drained freely below the surface, forming complex esker systems. Progressive glacial retreat across many areas left a number of spaced massive recessional moraines. Deglaciation of the Tyone River area, which had been covered by a large piedment ice lobe, was complete by at least 11,500 B.P. Much of the Susitna valley may have been deglaciated before about 12,000 B.P., and stagnant ice may have persisted for several thousand years over much of the valley floor.

During the Holocene, the Susitna River has widened its valley bottom slightly through lateral planation; the valley has not deepened much in most areas. Low-level alluvial terraces and tributary mouth alluvial fans have formed in widened portions of the valley. Many small tributary streams have greatly incised their channels, resulting in steep, irregular profiles characterized by waterfalls and rapids. Intervals of volcanic ash deposition have alternated with intervals of weathering, soil formation, and erosion.

3 - EVALUATION OF AND IMPACT ON HISTORIC AND ARCHEOLOGICAL SITES (**)

3.1 - Evaluation of Selected Sites Found: Prehistory and History of the Middle Susitna Region (**)

3.1.1 - Introduction (**)

This section focuses on sites discovered in the middle Susitna Basin. Most of the sites are single component; i.e., the sites are associated with only one time period. Many have been dated through their relative stratigraphic relationship to three volcanic tephras or through radiocarbon analysis of organic samples. Site components have been placed into five periods: 1) Euro-American Tradition, 2) Athapaskan Tradition, 3) Late Denali Complex, 4) Northern Archaic Tradition, and 5) American Paleoarctic Tradition. The Euro-American Tradition is further divided into contemporary, trapping, and exploration/gold rush periods. The following paragraphs and tables present information on the environmental setting and size of the Euro-American sites and also include information on the faunal remains and artifacts for sites in the four earlier periods based on survey results reported by Dixon et al. (1985).

3.1.2 - Contemporary Sites: 1945 to Present (**)

A number of contemporary cabins represent modern recreational use of the project area, primarily for sports hunting and fishing. These structures were not included in the cultural resources inventory. Only one recorded site falls within this period: TLM 204, a campsite used by the Corps of Engineers for studies of the area's hydroelectric potential (see Table E.4.3.1). Located on an upland above the Susitna River, this large site contains surface debris dating to the late 1950s.

3.1.3 - Trapping Period: 1920-1945 (**)

Several sites, consisting of standing or collapsed cabins with artifacts of Euro-American manufacture, represent use of the project area during this period. Table E.4.3.1 includes these sites and provides information on their environmental setting and size. These sites all occur along lowland river or stream margins, a setting that was probably favored because of its access to fur bearers, the ease of travel along frozen waterways during winter, and the availability of supplies of wood for heat. This setting contrasts markedly with the location of prehistoric sites, the majority of which occur in upland areas, which probably reflects use of the project area primarily for large mammal hunting.

3.1.4 - Exploration/Gold Rush: 1897-1920 (**)

Two recorded sites were assigned to this period: (1) TLM 020, which consists of a rock inscription recording the visit of William Dickey and three other travelers to Devil Canyon in 1897; and (2) TLM 248 which consists of a wood-cribbed pit and a possible burial, which may represent placer gold mining in the project area. These early Euro-American Tradition sites are both small and located along lowland stream margins.

3.1.5 - Athapaskan Tradition: ca. 1500 B.P. - ca. 100 B.P. (**)

Site components attributed to the Athapaskan Tradition occur in and above the Devil Tephra. Some contain historic trade items, while others do not and likely predate Euro-American contact.

Table E.4.3.2 provides a key to the abbreviations used in subsequent tables on the Athapaskan Tradition and earlier archeological assemblages. Table E.4.3.3 lists the relevant Athapaskan Tradition sites and provides information on their environmental setting, size, faunal remains, and lithic artifact types. Several faunal species are represented, however, caribou constitute the most frequent remains, and moose are limited to this tradition. In addition to Euro-American trade goods, characteristic artifact types include:

- tci thos (boulder spall scrapers)
- high frequencies of firecracked rock
- flake cores
- bifaces
- scrapers
- modified and unmodified flakes
- native copper artifacts
- conical-based bone projectile points
- bone fleshers
- straight-based lanceolate points
- hammerstones
- cobble fragments

Features include hearths, small circular depressions that probably represent cache pits, small rectangular and larger circular depressions that probably represent house pits, and a single postcontact coffin burial. Most sites occur on overlooks, although a number also occur in low topographic settings. Mean site size is 58.9 square meters, much smaller than that of Euro-American Tradition sites.

3.1.6 - Late Denali Complex: ca. 3500 B.P. - ca. 1500 B.P. (**)

Site components attributed to the Late Denali Complex occur on contacts beginning with these between the Devil and Watana tephras, through the Watana tephra, to a paleosol at the contact between the Watana and Oshetna tephras. Table E.4.3.4 lists the

Late Denali sites and provides information on their environmental setting, size, faunal remains, and lithic artifact types. Preservation of faunal remains is generally poor, but caribou is dominant. Late Denali components differ from Athapaskan components in exhibiting a core, blade, and burin technology. Characteristic artifact types include:

- unmodified and modified flakes
- scrapers
- blades and microblades
- burin spalls
- bifaces
- preforms
- rejuvenation flakes
- flake cores
- hammerstones
- ochre

Almost all site components occur on overlooks, most in association with water bodies, and occasionally in association with mineral licks or natural topographic constrictions. Mean site size is 36.8 square meters, the smallest of all the prehistoric periods.

3.1.7 - Northern Archaic Tradition: ca. 5200 B.P. - ca. 3500 B.P. (**)

Site components attributed to the Northern Archaic Tradition occur at the contact between the Watana and Oshetna tephras. Table E.4.3.5 lists the sites and provides information on their environmental setting, size, faunal remains, and lithic artifact types. Preservation of faunal remains is poor, however, caribou bones have been identified in two sites. Features include hearths and an arrangement of cobbles. Characteristic artifact types include:

- unmodified and modified flakes
- scrapers
- bifaces
- preforms
- notched projectile points
- rejuvenation flakes
- hammerstones
- abraders
- firecracked rocks
- cobble fragments
- flake cores

All site components occur on overlooks, most in association with water bodies. Mean site size is 727.4 square meters, the largest for all periods.

3.1.8 - American Paleoarctic Tradition: ca. 5200 B.P. - ca. 10,500 B.P. (**)

Site components attributed to the American Paleoarctic Tradition occur below the Oshetna tephra. The beginning date for this tradition was extrapolated from other dated sites near the project area. Human occupation could have begun shortly following deglaciation ca. 11,500 B.P. The earliest dated occupation in the project area is ca. 7,000 B.P. Table E.4.3.6 lists the sites and provides information on their environmental setting, size, faunal remains, and lithic artifact types. Preservation of faunal remains is poor and could only be identified as those of medium-large mammals. Lithic assemblages differ from those of the Northern Archaic Tradition in exhibiting a blade, microblade, and burin technology. Characteristic artifact types include:

- modified and unmodified flakes
- scrapers
- blades
- microblades
- burin spalls
- bifaces
- preforms
- triangular points
- microblade cores
- blade cores
- rejuvenation flakes
- flake cores
- cobble fragments

All site components occur on overlooks, and one is associated with a mineral lick. Mean site size is 76 square meters, larger than those of the Athapaskan Tradition and Late Denali Complex but smaller than that of the Northern Archaic Tradition.

3.1.9 - Early Period: ca. 30,000 B.P. - ca. 20,000 B.P. (**)

A portion of the right femur of a proboscidean (probably Mammuthus sp.) was recovered from a geologic exposure near the confluence of the Susitna and Tyone Rivers. A radiocarbon date on bone collagen yielded a date of $29{,}450 \pm 610$ B.P. This date, coupled with others from the same stratigraphic section, demonstrates that at least some portions of the project area were ice-free during mid-Wisconsin times. The occurrence of the proboscidean fossil also documents that at least one of the passes through the Alaska Range was ice-free during this time. These data indicate that there is a potential for archeological sites dating to this period in the project area.

3.1.10 - Summary

(This section deleted)

3.2 - Impact on Historic and Archeological Sites (**)

3.2.1 - Introduction (**)

The Susitna Hydroelectric Project would impact a large number of historic and archeological sites. However, the nature of most of these sites is such that a mitigation program incorporating a combination of data recovery, avoidance, preservation in place, monitoring, and a public interpretation and education program would result in project impacts classified as being non-adverse. The areas of direct and indirect impact associated with the Susitna Project have been defined in consultation with the State Historic Preservation Officer (Johannsen 1984).

Sites directly impacted by the Project include those which would be destroyed by ground disturbance associated with construction, borrow and quarrying operations or which would be intermittently or permanently inundated by project reservoirs. Sites affected by project operation would include those subject to erosion in reservoir drawdown areas.

Indirect impacts are those which are reasonably foreseeable but which would occur outside areas of direct impact and can be reasonably defined as to location. These include a) areas immediately adjacent to impoundments which may be subject to increasing rates of erosion, b) areas where vandalism of cultural resources may occur because of improved access or increased visitation, c) areas outside the direct impact area which may be affected by non-cultural resource mitigation activities (e.g. the creation of wildlife habitat through controlled burning), and d) areas where undertakings associated with the Project's recreation plan may adversely affect cultural resources.

3.2.2 - Significance (**)

Federal regulations (36 CFR 800) require that FERC identify, or cause to be identified, all cultural resources listed in or eligible for inclusion in the National Register of Historic Places which may be affected by issuance of a license for the Susitna Project. The National Register eligibility of a site or group of sites is dependent upon its (their) significance. A site is significant if it meets certain criteria set forth in 36 CFR 60. The Applicant is in the process of compiling the documentation necessary for determinations of National Register eligibility for sites in the project impact area. Determination of National Register eligibility would be made by the Secretary of the Interior after FERC has solicited the opinion of the State Historic Preservation Officer and requested final determinations from Interior.

3.2.3 - Watana Dam and Impoundment (**)

The Stage I minimum operating level for the Watana reservoir would be 1,875 feet. The following sites (ranked by elevation) located below this elevation would be permanently inundated: TLM 080, TLM 050, TLM 063, TLM 230, TLM 233, TLM 257, TLM 199, TLM 058, TLM 250, TLM 043, TLM 040, TLM 256, TLM 102, TLM 079, TLM 241, TLM 239, TLM 242, TLM 249, TLM 238, TLM 247 (Locus C), TLM

077, TLM 232, TLM 240, TLM 247 (Locus B), TLM 247 (Locus A), TLM 200, TLM 104, TLM 228, TLM 072, TLM 062, TLM 248, TLM 033, TLM 229, TLM 235, TLM 234 (Locus B), TLM 194, and TLM 236. The effects of permanent fresh-water inundation on archeological sites are poorly understood (Lenihan et al. 1981). Organic remains present in sites (20 of the 37 sites in the permanent Stage I pool are known to contain faunal material) may be preserved as a result of the anaerobic conditions produced. Sites located in the upstream reaches of the reservoir may be affected by siltation, the effects of which are not presently known. Another effect associated with permanent inundation is the removal of flooded sites from the archeological data base for the foreseeable future. While it would be possible to conduct studies of some of these sites after inundation, costs and technical difficulties associated with underwater excavations make it highly unlikely that such studies would be undertaken.

A total of 24 sites would be located between the Stage I minimum operating level of 1,875 feet and the maximum reservoir surfaces of 2,020 feet. These sites in order of elevation are TLM 234 (Locus A), TLM 222 (Locus B), TLM 222 (Locus A), TLM 243, TLM 246, TLM 223, TLM 065 (Locus B), TLM 075, TLM 225, TLM 065 (Locus A), TLM 222 (Locus D), TLM 224, TLM 220, TLM 115, TLM 216, TLM 222 (Locus C), TLM 226, TLM 221, TLM 227, TLM 231, TLM 215, TLM 237, and TLM 184. These sites would be affected by erosion associated with reservoir drawdown. The 17 of these sites known to contain organic material (faunal remains) would be most severely affected since alternating wet and dry conditions would accelerate the deterioration of these remains.

Five sites (TLM 174, TLM 244, TLM 126, TLM 169, and TLM 218) are located within 500 feet of the maximum limits of the Stage I reservoir. These sites may be directly affected by wave activity or ice movement, or indirectly by slumping associated with shoreline erosion.

Raising the height of Watana Dam during Stage III would result in the permanent inundation of two sites (TLM 175 and TLM 061) at elevations below the 2,065-foot level (the Stage III minimum operating level) in addition to all the sites located within the Stage I maximum pool.

The following sites located between elevation 2,065 and 2,201 (Stage III maximum water surface) would be affected by erosion associated with fluctuating reservoir levels: TLM 174, TLM 244, TLM 126, TLM 217, TLM 048, TLM 173, TLM 039, TLM 169, TLM 182, TLM 171, TLM 206, TLM 251, TLM 119, TLM 196, TLM 060, TLM 059, TLM 130, TLM 218, and TLM 159. Nine of these sites are known to contain faunal remains, which would be subject to accelerated deterioration from alternating wet and dry conditions.

Nineteen sites are located within 500 feet of the maximum limits of the Stage III reservoir. These are TLM 130, TLM 131, TLM 133, TLM 127, TLM 132, TLM 120, TLM 125, TLM 123, TLM 124, TLM 207, TLM 073, TLM 026, TLM 074, TLM 042A, TLM 042B, TLM 145, TLM 018, TLM 148 and TLM 139.

3.2.4 - Devil Canyon Dam and Impoundment (**)

Four sites (TLM 253, TLM 252, TLM 178 and TLM 259) would be located within the permanent pool created by construction of the Devil Canyon Dam. Three additional sites (TLM 034, TLM 258, and TLM 023) are situated at elevations between 1,405 feet and 1,466 feet, the minimum and maximum pool elevations. Five sites (TLM 022, TLM 029, TLM 024, TLM 030, and TLM 027) are located within 500 feet of the maximum limits of the impoundment.

3.2.5 - Proposed Borrow Areas (**)

Only Borrow Areas D and E would be needed to satisfy fill and concrete aggregate construction requirements for Stage I of the Project. Sites TLM 022, TLM 023 and TLM 258 are located in Borrow E. No sites are located in Borrow D.

No sites are located within Borrow Areas B, D, G, H, and K and Quarry Areas A and L.

The extent to which other borrow areas would be used during Stages II and III is not precisely known at this time, but it is unlikely that all would be totally utilized. Borrow Areas C and F are located along Tsusena Creek and it is expected that only portions of them would be used in conjunction with the construction of the access road to the Denali Highway. A total of 17 sites (TLM 078, TLM 095, TLM 084, TLM 085, TLM 087 TLM 094, TLM 096, TLM 054, TLM 086, TLM 081, TLM 088, TLM 097, TLM 055, TLM 056, TLM 201, TLM 213, and TLM 211) are located within Borrow Area C. Eight sites (TLM 209, TLM 210, TLM 176, TLM 202, TLM 203, TLM 214, TLM 212, and TLM 188) are located in Borrow Area F. Impacts to these sites would be dependent on the amount of borrow material actually required and the manner in which the borrow area is developed. It should be feasible to avoid several of the sites in this area.

No sites are located in Borrow Areas B, G, H, and K and Quarry Areas A and L.

3.2.6 - Access Roads (**)

A sample of access road rights-of-way has been surveyed to date and no sites have been identified. Analyses of the archeological sensitivity of the corridors associated with the project's access roads suggest that large portions of them are unlikely to contain significant cultural resources. A model designed to quantify and refine these earlier analyses was developed (Greiser et al. 1985) and field tested. Field survey of archeologically sensitive portions of construction rights-of-way would precede construction. Routing or construction techniques would be modified to avoid identified sites to the extent possible. A data recovery program would be instituted in other cases.

3.2.7 - Transmission Lines (**)

A sample of construction rights-of-way for project transmission lines has been surveyed to date. Only one site, HEA 91 (the Stampede Trail), is known to exist. Because the trail is linear and crosses the right-of-way in a limited area, no adverse effect from the Project is expected.

Analyses of the archeological sensitivity of the corridors associated with the project's transmission lines suggests that large portions of them are unlikely to contain significant cultural resources. A model designed to quantify and refine these earlier analyses was developed and field tested. Field surveys of archeologically sensitive portions of construction rights-of-way, with special attention being paid to tower location and sub-station sites, would precede construction. Routing, tower placement, and modification of construction techniques should permit the avoidance of all cultural resources. Where this may not be feasible (e.g., substation locations), a data recovery program would be instituted.

3.2.8 - Other Areas (**)

Archeological and historic sites located in indirect impact areas may be affected by project construction and operation. For purposes of this analysis, a potential for vandalism of cultural resource sites is believed to exist only within one-half mile of proposed project features. This potential could be created by increased access to, and recreational use of, the project vicinity. Even within this area, the actual likelihood for vandalism of prehistoric archeological sites, which are primarily subsurface in nature and not readily visible to the untrained eye, is considered to be very low. According to the State Historic Preservation Officer, known cases of vandalism of archeological sites in Alaska have been confined to sites containing objects with value on the ethnographic art/or antiquities markets. None of the archeological sites identified in the Susitna area meet this criterion. They consist almost exclusively of scatters of lithic debitage (debris from the manufacture and use of stone tools), and, in some instances, burned and unburned faunal (bone) remains. Such sites would usually not be detected by an untrained observor.

Cultural resource survey of the area within one-half mile of the Devil Canyon and Stage III Watana impoundments was completed in 1984 (Dixon et al. 1985). Ten sites (TLM 029, TLM 024, TLM 030, TLM 027, TLM 118, TLM 035, TLM 017, TLM 167, TLM 166, and TLM 155) are located within one-half mile of the Devil Canyon reservoir limits.

Forty-seven sites are located within one-half mile of the Watana-Stage I reservoir limits. Sixteen of these would be inundated if Stage III is constructed. A total of 57 sites are located within one-half mile of the Stage III maximum pool limits.

As part of the present wildlife mitigation program, a large undefined area in the project vicinity would be modified to create moose habitat. This action may require controlled burning. Such an activity would have both positive and negative effects upon archeological sites. Burning can result in the modification of both lithic and faunal remains. Studies of both lithic tool manufacturing techniques and prehistoric subsistence practices could be adversely effected. However, the removal of a portion of the vegetative ground cover in an area by burning improves surface visibility. This makes archeological survey and the identification of archeological sites considerably easier until the vegetative cover regenerates.

4 - MITIGATION OF IMPACT ON HISTORIC AND ARCHEOLOGICAL SITES (**)

4.1 - Mitigation Policy and Approach (**)

It is the position of the Applicant that the cultural resources mitigation plan presented here for the Susitna Hydroelectric Project would result in no adverse effect upon historic, archeological or architectural sites and districts potentially eligible for the National Register of Historic Places. The plan as presently conceived is based upon formal and informal consultations with the State Historic Preservation Officer, the National Park Service, the Federal Energy Regulatory Commission, the Bureau of Land Management, the Advisory Council on Historic Preservation, and members of the professional archeological community in Alaska.

The site-specific details of mitigation plan implementation, consistent with the plan presented in Section 4.2, are presently being developed. Sections of that detailed plan concerning archeology are being developed in accordance with principles contained in the Advisory Council on Historic Preservation's Treatment of Archeological Properties: A Handbook (1980). This document elaborates on Supplementary Guidance published on November 26, 1980 (45 FR 7808) under the authority of the Executive Director of the Council as set forth in 36 CFR 800.14. The principles are:

1. Archeological research, addressing significant questions about the past, is in the public interest.

2. Archeological properties may be sites, buildings, structures, districts, and objects.

3. Archeological properties are important wholly or in part because they may contribute to the study of important research problems.

4. Not all research problems are equally important; hence not all archeological properties are equally important.

5. Treatment of an archeological property depends on its value for research, balanced against other public values.

6. Eligibility for the National Register suggests, but does not define, how an archeological property should be treated.

7. If an archeological property can be practically preserved in place, it should be.

8. If an archeological property is to be preserved in place, extensive excavation of the property is seldom appropriate.

9. Both data recovery and destruction without data recovery may be appropriate treatments for archeological properties.

10. Once a decision is made to undertake data recovery, the work should be done in the most thorough, efficient manner.

11. Data recovery should be based on firm background data and planning.

12. Data recovery should relate positively to the development of State Historic Preservation Plans.

13. Completion of an approved data recovery plan consummates an agency's data recovery responsibilties.

4.2 - Mitigation Plan (**)

As presently envisioned, the final mitigation plan for the Project includes avoidance, preservation in place, data recovery, monitoring, and a public interpretation and education program. With the concurrence of the State Historic Preservation Officer and the National Park Service, the mitigation plan would also include a procedure for identifying, evaluating, and treating cultural resources discovered after the issuance of a license for the project. It is anticipated that this latter procedure would only be necessary in regard to unsurveyed portions of construction rights-of-way associated with the project's access roads, transmission lines, and railroad.

4.2.1 - Details of Plan (**)

The vast majority of the cultural resource sites which would be impacted by the Susitna Hydroelectric Project are relatively small prehistoric archeological sites. Avoidance, the preferred mitigation technique, would normally be feasible only for those sites located in direct impact areas other than impoundments and associated erosion areas and dam sites. Avoidance may be feasible for some sites within designated borrow areas depending on borrow requirements and the amounts of borrow available within a given area. Access to cultural resource sites within or in close proximity to construction laydown areas would, wherever possible, be restricted during project construction.

Data recovery (excavation) would be the principal mitigation technique employed. The nature of the known archeological data base in the Susitna Project area suggests that there are a large number of redundant site components (according to age and function). For this reason it is anticipated that data recovery would be undertaken at a sample of sites scheduled to be directly impacted by the project. The selection of sites for data recovery would be determined by a number of site factors, including but not limited to site condition, the nature and degree of impact to the site, and the site's ability to contribute to the solution of important research questions.

Sites which would be destroyed by ground-disturbing activities associated with construction would be given priority, followed by sites which are located within reservoir drawdown areas. The latter would be subjected to steady erosion. Sites within the permanent pools would then be selected to fill any remaining requirements of the site selection sample procedure.

Some sites located along reservoir margins in close proximity to construction activities or within permanent reservoir pools may be selected for preservation in place. This may take the form of construction of protective barriers to minimize erosion, controlled burial, or fencing of the site to restrict access.

The monitoring program for the Project would include several components. Limited monitoring of construction activities would be implemented to ensure that compliance with the mitigation program occurs. Long-term monitoring involving regularly scheduled inspections of sites along reservoir margins would be undertaken to ascertain if these sites are being adversely affected. In addition, a public interpretation and education program about the project area's cultural resources would be developed for the benefit of site visitors and the public in general.

An adjunct to the education program would include an orientation for all construction and supervisory personnel to inform them about, a) reasons for the presence of restricted areas, b) restrictions on the vandalism of archeological or historic sites and on the collecting of artifacts, c) the nature of cultural resources sites in the project area and how to recognize them, and d) procedures to be followed in the event that cultural resources are discovered or disturbed during construction.

Pre-construction cultural resources surveys would be conducted along the rights-of-way for the project's railroad, transmission lines, and access roads as part of the overall mitigation plan. The Applicant would, in consultation with the State Historic Preservation Officer, determine which portions of these areas are likely to contain cultural resources. Selection of areas would be based upon the tested model of cultural resources distribution (Greiser et al. 1985). If cultural resources are located in any survey area, appropriate mitigation would be considered. The latter may include things such as changes in tower placement or movement of project centerlines. If neither of these procedures is feasible, data recovery would be undertaken. The scope of any data recovery activities conducted in such circumstances would be developed in consultation with the State Historic Preservation Officer.

4.2.2 - Cost (**)

The total estimated cost (exclusive of logistical support) of cultural resources mitigation and monitoring measures could require up to $3,900,000 for Stage I, $227,000 for Stage II, and $1,460,000 for Stage III. The Applicant would provide facilities and support services as appropriate and feasible in conjunction with this program. It should be noted that the cost estimates assume a maximum level of effort and do not account for cost savings that may actually be available through means such as the use of volunteer labor for excavation (within guidelines established by the Advisory Council on Historic Preservation) and advances in archeological excavation technology that may become available.

4.2.3 - Statement of Sources and Extent of Financing (**)

The Applicant would provide all funds necessary to carry out the requirements of the final mitigation plan approved by FERC.

5 - AGENCY CONSULTATION (**)

All required state and federal permits were obtained prior to each year's field studies. The SHPO, the State Archeologist, and archeologists with the National Park Service and the Bureau of Land Management have been consulted throughout the development and execution of the cultural resources program for the Project. Copies of annual field reports and reports on other aspects of the cultural resources program have been provided to these agencies on a regular basis. Consultation with these agencies is continuing regarding the evaluation of the significance of sites in the project area; the development, testing, and implementation of the model to assess the archeological sensitivity of unsurveyed areas of the corridors associated with project transmission lines, access roads, and the railroad; and the details of the Applicant's proposed mitigation plan.

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7 - GLOSSARY

Bifacial knives - a knife flaked on both sides

Bone collagen - fibrous protein in bones which holds cells and tissue together.

Burin - a stone artifact defined on the morphological characteristic of a blow(s) struck along one or more edges, generally believed to be used in working antler, ivory and bone.

Burin spalls - thin, curved, and sharp-edged pieces of rock.

Calcareous concretionary - material of limestone origin which has developed by localized deposition of material in solution.

Chert flake - small piece of compact rock, such as flint or silica

Chert point - a small piece from a compact and siliceous rock; flint is a variety of chert

Cobble spall - a thin, curved piece of rock 64-256 mm in diameter

Cryoturbation - frost heaving

Cryptocrystalline flake - material so fine-grained that individual components cannot be seen without a magnifying lens.

Debitage - waste material from the manufacture of tools.

Distal end - the end farthest from the point of attachment.

Eskers - stratified accumulations of gravel, sand, and stone, usually occurring in long, sinuous ridges.

Humic zone - the organic layer of soil, composed of material derived from decomposing plants.

Kame ridges - a ridge of sand or gravel deposited in contact with glacier ice.

Kettle lake - a bowl-shaped lake resulting from the melting of a huge mass of ice.

Lanceolate - tapering to a point; shaped like a spear.

Lithic - rocks containing rock fragments

Lithology - the study of the physical characteristics of rock

Moraine - non-sorted, non-stratified drift deposited by glacial processes, with resulting topography independent of the underlying surface.

Rhyolite flakes - small pieces of dense, homogeneous rock

Tephra - solid material, including ash, ejected during an eruption of a volcano and transported through the air.

Tuffacious flake - small pieces from compacted volcanic rock

TABLES

TABLE E.4.2.1: PREHISTORIC TECHNOLOGIES OF ALASKA

Name	Associated Dating	Artifacts	Reference
Historic Athepaskan (Dixthada)	1000 B.P. to Present	Contracting-stemmed points, boulder-spall and end scrapers, tabular bifaces, hammerstones, whetstones, copper implements, unilaterally barbed bone points	Rainey 1939
Minchumina Tradition	2600 B.P. to 950 B.P.	Falke burines, microblades and cores, lanceolate points	Holmes 1984
Northern Archaic Tradition	6000 B.P. to 4400 B.P.	Side-notched and oblanceolats, elongate and semi-lunar bifaces, large unifaces, notched pebbles, cobble choppers	Anderson 1968a
Northwest Microblade Tradition	7500 B.P. to 1650 B.P.	Boulder-spall scrapers, large blades, blade tools, microblades and cores, straight and round-based oblanceolate points, split pebble and bifacial choppers, notched pebbles	MacNeish 1964
Susitna Complex	ca 9000 B.P.	Concave-based points on flakes, microblades, modified bifacial thinning flakes	Dixon et al. 1984
Athapaskan Tradition	12,000 B.P. to Present	Microblades and cores, transveres burines, side-notched and stemmed points, square and round-based oblanceolate points	Cook and McKennan 1970

Source: Bacon and Greiser 1985

TABLE E.4.2.1 (Page 2 of 2)

Name	Associated Dating	Artifacts	Reference
Denali Tradition	12,000 B.P. to 1000 B.P.	Bifacial biconvex knives, microblades and cores, large blades and blade-like flakes, burins, and scrapers, worked flakes	Bacon and Holmes 1980
American Paleo-Arctic	13,000 B.P. to 6000 B.P.	Blades and bade cores, microblades and cores, blade tools, burins, discoidal bifaces	Anderson 1968a
Denali Complex	13,000 B.P. to 8000 B.P.	Microblades and cores, large blades and blade-like flakes, burins, bifacial biconvex flakes, and scrapers, worked flakes	West 1967
Nenana Complex	pre-11,000 B.P.	Bifacial knives, lanceolate points, transverse scrapers	Hoffecker 1982
Amphitheater Mountain Complex	pre-13,000 B.P.	Bifaces, burins, large blades, boulder-sall scrapers, end scrapers, flake cores	West 1972
Chindadn Complex	11,000 B.P. to 10,000 B.P.	Subtriangular knives, small triangular points, basally thinned concave-based points	Cook 1969

TABLE E.4.2.2: INFERRED GLACIAL, CLIMATOLOGICAL, AND VEGETATIONAL REGIMES IN THE MIDDLE AND UPPER SUSITNA BASIN

TIME (years B.P.)	GLACIATION	CLIMATE	VEGETATION
100			
1000			
2000			
3000	Minor ocillations of valley glaciers during neoglacial	Neoglacial Interval (cooler)	Boreal Forest
4000			
5000			Decline in Spruce(?)
6000	Susitna River valley ice free		Boreal Forest
7000			
8000		Hypsithermal Interval (warmer)	Invasion by Spruce (picea)
9000	Deglaciation essentially complete		Shrub - tundra
10,000			
11,000	Continued deglaciation of smaller valleys	Post-Wisconsinan warming trend	
12,000	Main Valley and lowlands ice free		Tundra - Steppe
13,000	Oscillatory glacial retraction and stagnation		
14,000	Ice-covered Susitna River valley		

Source: Dixon et al. 1985

TABLE E.4.3.1: EURO-AMERICAN TRADITION SITES (ADAPTED FROM DIXON ET AL. 1985:8-172)

AHRS-No.	Site Type	Setting	Date	Size (m2)
TLM 020	Rock Inscription	SR	1897	1
TLM 023	Cabin	SR	1930-1950	90
TLM 056	Cabin	SM, NTC	--	225
TLM 071	Cabin	SS	1930-1950	960
TLM 079	Cabin	SR	1930-1950	2100
TLM 080	Cabin	SR	1940s	36
TLM 178	Cabin	RM	--	150
TLM 204	Camp	OL	Late 1950s	4900
TLM 212	Cabin	SM	--	96
TLM 248	Pit, Burial(?)	SM	--	25

TABLE E.4.3.2: KEY FOR TABLES E.4.3.3 THROUGH E.4.3.6

Key to Artifact Type Abbreviations

1.	unmodified flakes	UF
2.	modified flakes	MF
3.	scrapers	SC
4.	blades	B
5.	microblades	MB
6.	burins	BU
7.	burin spalls	BUS
8.	bifaces	BI
9.	preforms	PR
10.	notched points	NP
11.	leaf shaped points	SP
12.	lanceolate points	LP
13.	triangular points	TP
14.	microblade cores	MC
15.	microblade tablet	MT
16.	blade core	BC
17.	rejuvenation flakes	RF
18.	flake cores	FC
19.	hammerstones	H
20.	abraders	A
21.	tci thos	T
22.	notched pebbles	NPE
23.	thermally altered rock	TAR
24.	ochre	O
25.	cobble fragments	CO

Key to Faunal Abbreviations

1.	caribou	CR
2.	moose	MS
3.	Dall sheep	SH
4.	ground squirrel	GS
5.	canid	CN
6.	medium-large mammal	M-L
7.	mammal	MA

Key to Site Setting Abbreviations

1.	overlook	OV
2.	lake margin	LM
3.	stream margin	SM
4.	river margin	RM
5.	stream/river confluence	SR
6.	stream/stream confluence	SS
7.	natural topographic constrictions	NTC
8.	mineral lick	ML
9.	quarry	Q

Source: Dixon et al. 1985: 8-181

TABLE E.4.3.3: SITES ATTRIBUTED TO THE ATHAPASKAN TRADITION

Site Number	Over-look	Lake Margin	Stream Margin	River Margin	Stream/ River Conflu-ence	Stream/ Stream Conflu-ence	Natural Topo-graphic Constric-tion	Mineral Lick	Quarry	Faunal Species	Observed Site Size (m^2)	Lithic Artifacts
TLM 018	X										171	UF,MF
TLM 021B	X					X					25	--
TLM 022					X					CR,MS,GS	57	UF,TAR,CO
TLM 026	X			X							75	UF
TLM 027	X				X						105	UF
TLM 030	X				X						--	UF,MF,SC,BI,O
TLM 039	X	X									75	UF
TLM 040	X			X							--	UF,TAR
TLM 043					X					CR	--	UF,TAR,CO
TLM 048	X	X								CR	50	UF,MF,FC,TAR
TLM 050					X					CR	51	UF,MF,TAR
TLM 052A	X										--	UF
TLM 054	X					X					4	UF
TLM 055	X					X	X				8	UF,SC,TAR
TLM 058	X				X						4	UF,MF
TLM 059	X									CR	41	UF,TAR
TLM 061	X					X					21	UF
TLM 062	X			X						CR	384	UF,MF,SC,BI,FC
TLM 064B	X										9	UF,BI,LP
TLM 065	X		X							CR	552	UF,TAR
TLM 069	X	X									225	UF
TLM 072				X						MS	28	--
TLM 075A	X										4	UF,RF
TLM 077	X		X							CR	46	--
TLM 078	X		X				X				39	UF
TLM 084	X		X				X				12	UF
TLM 087	X		X				X				28	UF
TLM 088	X		X				X				4	--
TLM 089	X						X			CR	375	UF
TLM 093	X	X					X				30	UF,MF

Source: Dixon et al. 1985.

TABLE E.4.3.3 (Page 2 of 4)

Site Number	Over-look	Lake Margin	Stream Margin	River Margin	Stream/ River Conflu-ence	Stream/ Stream Conflu-ence	Natural Topo-graphic Constric-tion	Mineral Lick	Quarry	Faunal Species	Observed Site Size (m^2)	Lithic Artifacts
TLM 094	X		X				X				20	UF,BI
TLM 096	X		X				X				410	UF
TLM 097	X						X			CR	185	UF,MF,SC,FC,TAR
TLM 100	X	X									4280	--
TLM 102	X			X							8	UF,MF
TLM 104	X	X									24	--
TLM 105	X	X	X								150	UF
TLM 111	X	X									4	--
TLM 123	X									CR	75	--
TLM 127	X		X								4	UF
TLM 128	X							X			600	UF,MF,BI
TLM 129A	X										150	UF
TLM 129B	X										4	UF
TLM 130	X										12	UF
TLM 139	X		X					X			4	UF
TLM 140	X		X					X			800	UF,MF,BI
TLM 141	X							X			25	UF,BI
TLM 143	X		X					X			844	UF,TAR,CO
TLM 148	X		X					X			4	UF
TLM 150	X							X			4	UF
TLM 151	X							X			4	UF
TLM 153	X		X								16	--
TLM 154	X	X									400	UF
TLM 165	X										16	UF,MF,FC
TLM 171	X	X									--	UF
TLM 173B	X			X							28	--
TLM 175	X	X	X								34	UF,TAR
TLM 184	X									CR	93	UF
TLM 186	X					X					35	UF,BI
TLM 187	X					X					16	UF

TABLE E.4.3.3 (Page 3 of 4)

Site Number	Over-look	Lake Margin	Stream Margin	River Margin	Stream/ River Conflu-ence	Stream/ Stream Conflu-ence	Natural Topo-graphic Constric-tion	Mineral Lick	Quarry	Faunal Species	Observed Site Size (m^2)	Lithic Artifacts
TLM 188	X	X									4	UF
TLM 189	X			X							300	UF
TLM 199	X				X						46	UF
TLM 201	X		X								43	UF
TLM 203	X					X	X				40	UF
TLM 206	X			X							15	UF
TLM 207					X						35	UF
TLM 209	X			X			X				24	UF
TLM 210	X			X			X				8	UF
TLM 211	X			X			X				4	UF
TLM 214B	X		X				X				12	UF
TLM 215	X									CR	52	UF,MF
TLM 217	X		X								22	UF,MF,BI,LP
TLM 220	X									CR	145	UF,MF,T,TAR
TLM 221	X									CR	28	UF,TAR
TLM 222A	X		X							CR	87	TAR
TLM 222B	X		X							CR	531	TAR,CO
TLM 222D	X		X								36	UF
TLM 222E	X		X								4	--
TLM 223	X		X								40	UF
TLM 224	X										16	UF
TLM 225	X										31	UF
TLM 226A	X										58	UF
TLM 226B	X		X							CR	32	UF,T
TLM 226D	X		X							CR	16	--
TLM 226E	X		X							CR	32	--
TLM 227	X										4	--
TLM 230	X				X						66	0
TLM 231	X		X							CR	19	UF,CO
TLM 232A					X					CR,MS	439	T,H

TABLE E.4.3.3 (Page 4 of 4)

Site Number	Over-look	Lake Margin	Stream Margin	River Margin	Stream/ River Conflu-ence	Stream/ Stream Conflu-ence	Natural Topo-graphic Constric-tion	Mineral Lick	Quarry	Faunal Species	Observed Site Size (m^2)	Lithic Artifacts
TLM 232B					X						33	UF,T,CO
TLM 233					X						4	--
TLM 234A	X									CR,MS,GS	104	TAR
TLM 234B	X									CR,CN	56	TAR
TLM 235C	X		X								33	UF,BI
TLM 236	X					X					30	UF
TLM 237	X		X								4	UF
TLM 238	X		X								26	--
TLM 240					X					CR,MS	314	--
TLM 242	X		X							CR	49	UF
TLM 244	X										4	--
TLM 246	X				X						4	UF
TLM 247A	X				X					MS	232	UF,TAR
TLM 247B	X				X					CR	344	UF,MF,H,TAR
TLM 247C	X				X						16	--
TLM 247A					X					CR	20	MF,TAR
TLM 249B										CR	4	TAR
TLM 250					X					MS,SH	4	TAR
TLM 252				X						CR,MS	25	H,CO
TLM 253				X						CR	4	TAR
TLM 256				X						CR	6	--
TLM 257					X						4	--
TLM 258					X						12	--
TLM 259				X					X		123	UF,FC,CO

TABLE E.4.3.4: SITES ATTRIBUTED TO THE LATE DENALI COMPLEX (Page 1 of 2)

Site Number	Site Setting OV	LM	SM	RM	SR	SS	NTC	ML	Q	Species	Observed Faunal Size (m^2)	Site Artifact Types
TLM 027	X				X						105	UF, MF, B, CO
034	X	X									6	UF
038	X		X							CR	62.5	TAR
039	X	X									75	UF, O
040	X			X							144	UF, B
063	X			X						CR	15	UF
074	X			X							10	UF
077	X		X								46	UF, BI
078	X		X				X				39	
097	X				X		X				185	UF, SC, TAR
130	X									CR	12	UF, MF, BUS
136	X		X				X			CR	6	UF
142	X							X		CR	4	UF, TAR
143	X		X					X		M-L		UF, MF, BI
149	X							X		CR	4	UF
159	X					X					16	FC, CO, UF, MF, MB, BI
164	X	X	X								4	UF
169	X		X							MA	45	UF
171	X	X									9	UF
173B	X		X							M-L	28	UF
181	X		X								4	UF

TABLE E.4.3.4 (Page 2 of 2)

Site Number	Site Setting OV	LM	SM	RM	SR	SS	NTC	ML	Q	Species	Observed Faunal Size (m^2)	Site Artifact Types
184	X									CR	93	UF, MF, SC B, BI, PR, RF, FC, A, 0
190	X			X							12	UF
202	X					X	X				4	UF
213	X		X				X				4	UF
216	X	X								CR	27	UF, MF, CO
217	X		X							CR	22	UF
218B	X					X					4	BI
220	X									CR, CN	145	UF, MF
222C	X		X							M-L	4	
225	X									M-L	31	UF
226A	X		X							M-L	58	UF, MF
226C		X		X						M-L	16	
228	X	X	X								4	UF
229	X									CR	24	UF, CO
230	X				X						66	UF, MF, NPE, CO
246	X				X					M-L	4	
HEA 181	X	X	X									UF

*Observed site size based on grid shovel test expansion. n = 22
x = 36.8

Source: Dixon et al. 1985: 8-179 and 8-180

TABLE E.4.3.5: SITES ATTRIBUTED TO THE NORTHERN ARCHAIC TRADITION

Site Number	Site Setting: OV	LM	SM	RM	SR	SS	NTC	ML	Q	Species	Observed Faunal Size (m^2)	Site Artifact Types
TLM 017	X										6	UF
029	X				X					M-L	31	UF, SC, O CO
030	X				X					CR	2571	RF, FC, H, TAR, O, CO, UF, MF, SC, BI, PR, NP, SP, LAP
097	X					X	X				185	UF, MF, SC, NP, FC
143	X		X					X			844	UF, MF, SC, BI, NP, FC, A, TAR, O
144*	X		X									UF

*Observed site size based on grid shovel test expansion. n = 5
x = 727.4

Source: Dixon et al. 1985: 8-183

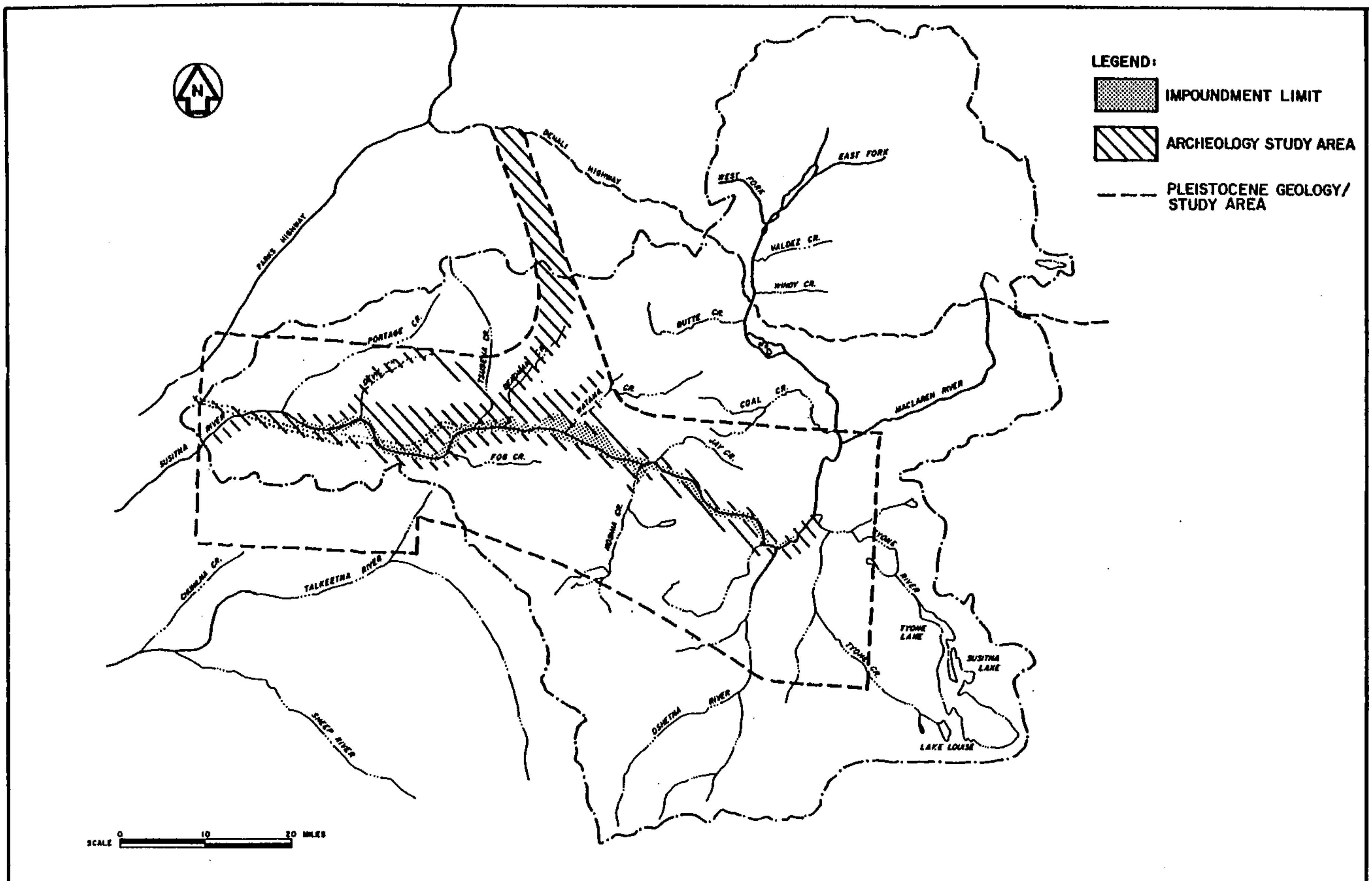
TABLE E.4.3.6: SITES ATTRIBUTED TO THE AMERICAN PALEOARCTIC TRADITION

Site Number	Site Setting									Species	Observed Faunal Size (m^2)	Site Artifact Types
	OV	LM	SM	RM	SR	SS	NTC	ML	Q			
TLM 027	X										105	UF, MF, B, BI, RF, FC, CO
039	X	X									75	UF, MB, BUS
040	X			X						M-L	144	UF, SC, B, FC, O, CO
061	X					X				M-L	21	UF, BI
128	X							X				UF, MF, SC, B, BI, PR, TP, FC
180	X		X									UF, MF, B, BC, RF
207	X				X					M-L	35	UF, SC, MB, MC, RF, CO

*Observed site size based on grid shovel test expansion. n = 5
x = 76

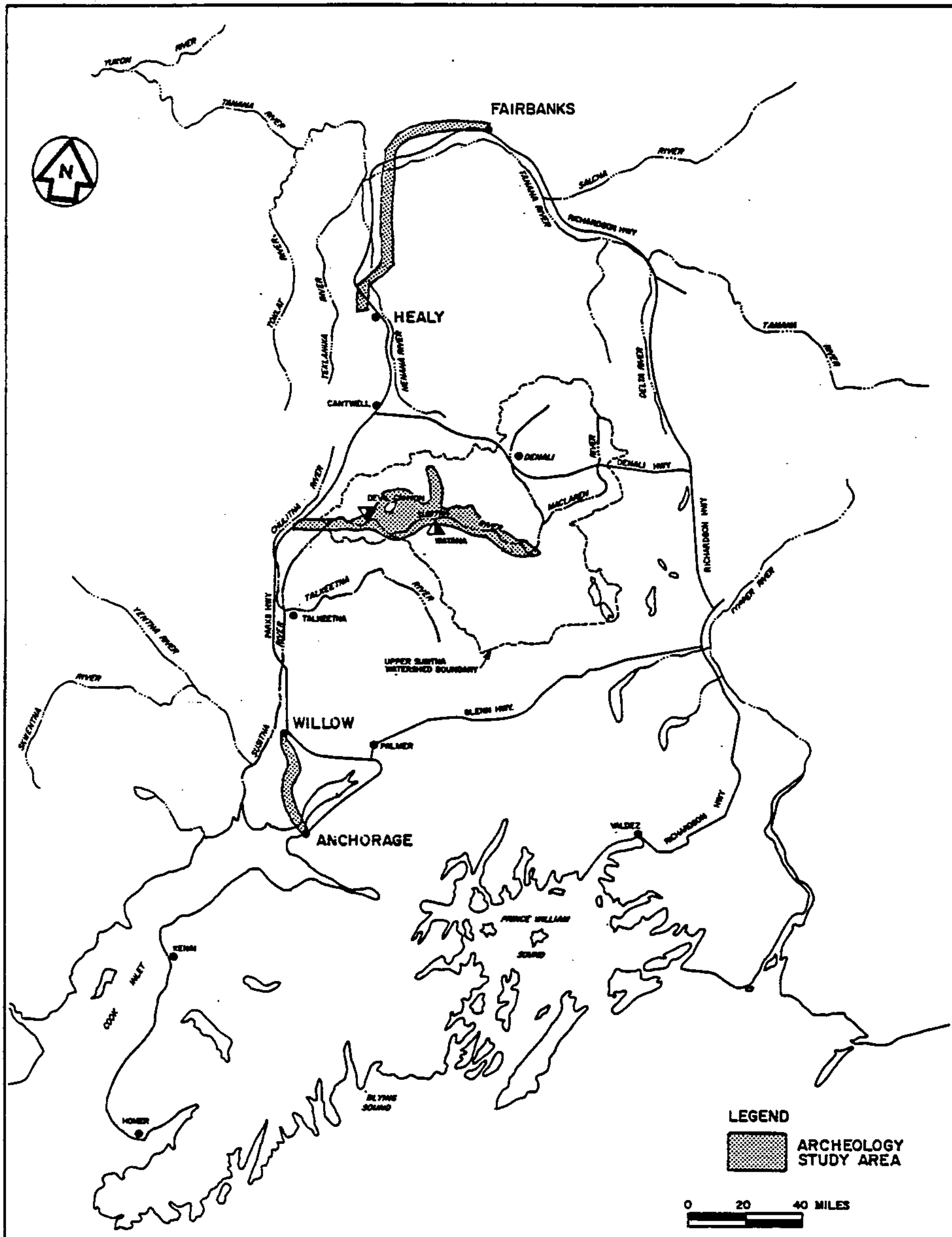
Source: Dixon et al. 1985: 8-186

FIGURES



STUDY AREA FOR CULTURAL RESOURCES AND ASSOCIATED ACTIVITIES - SUSITNA RIVER

FIGURE E.4.2.1



STUDY AREA FOR CULTURAL RESOURCES - TRANSMISSION CORRIDORS

FIGURE E.4.2.2

	Cultural Chronology	Period		Associated Technology
100 B.P.	Recent Historic	Recent Modern	Expansion of Taiga Forests	Copper implements, stemmed stone projectile points, flaked end scrapers, bounder chip tools
1000 B.P.	Athapaskan	Late Taiga		
2000 B.P.				Large bifacially chipped forms, microliths, large lanceolates
6000 B.P.		Early Taiga (shrub tundra dominates)		Side-notched projectile points, stone end scrapers, elongated stone bifaces, boulder chip scrapers, unifacially chipped forms, notched pebbles, stone axes, hammerstones, choppers
8000 B.P.	American Paleo-Arctic	Early Tundra (grassland tundra dominates)		Stone cores and microblades, burins, bifacial stone knives, stone end scrapers
14,000 B.P.	Early Sites?			

FIGURE E.4.2.3

CULTURAL CHRONOLOGY, (FROM BACON AND GREISER 1985:3-6).

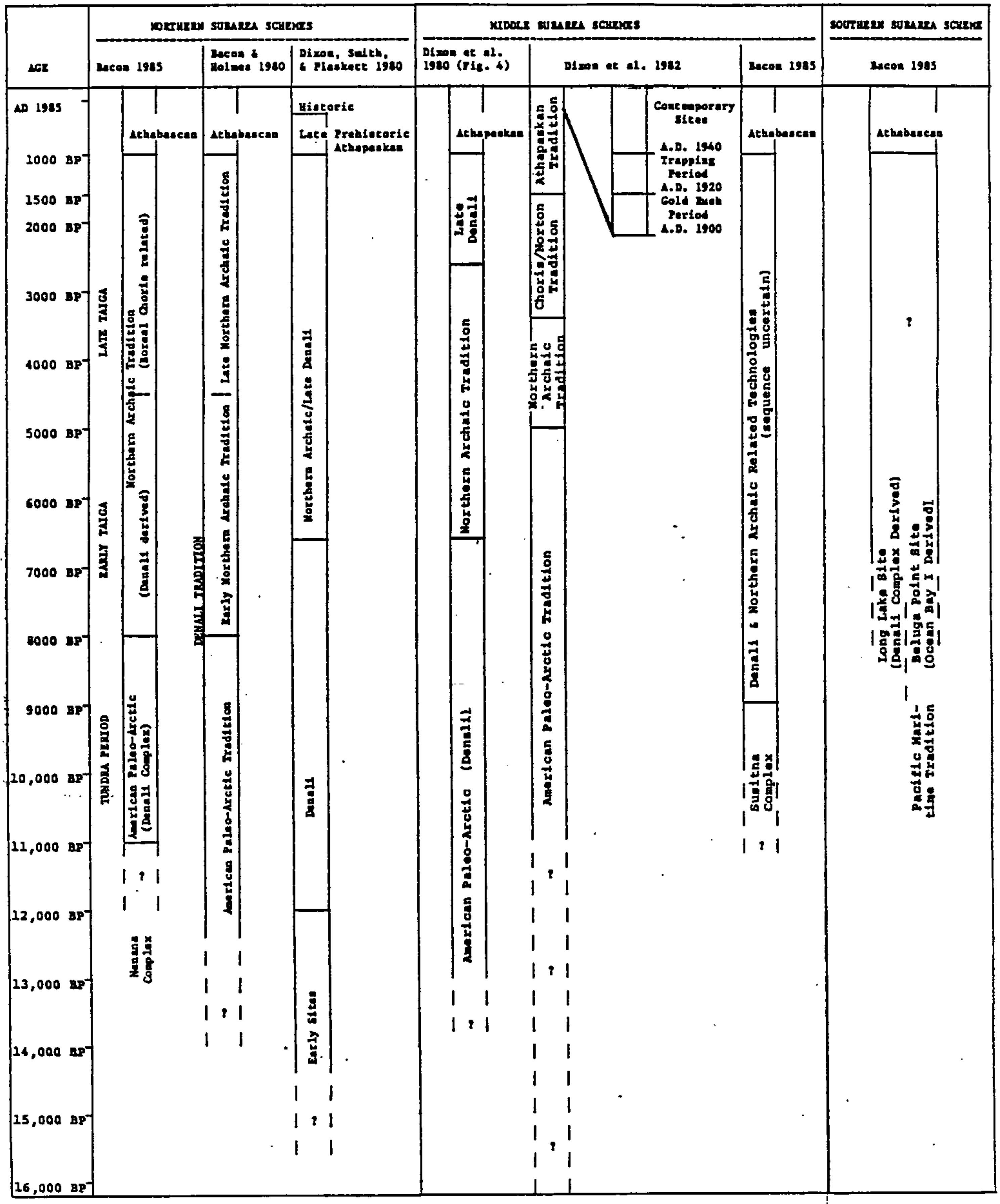


FIGURE E.4.2.4 SPECULATIVE CULTURAL CHRONOLOGIES FOR THE SOUTH-CENTRAL INTERIOR OF ALASKA (FROM BACON AND GREISER 1985:3-26)

SOURCE: GREISER et al. 1985

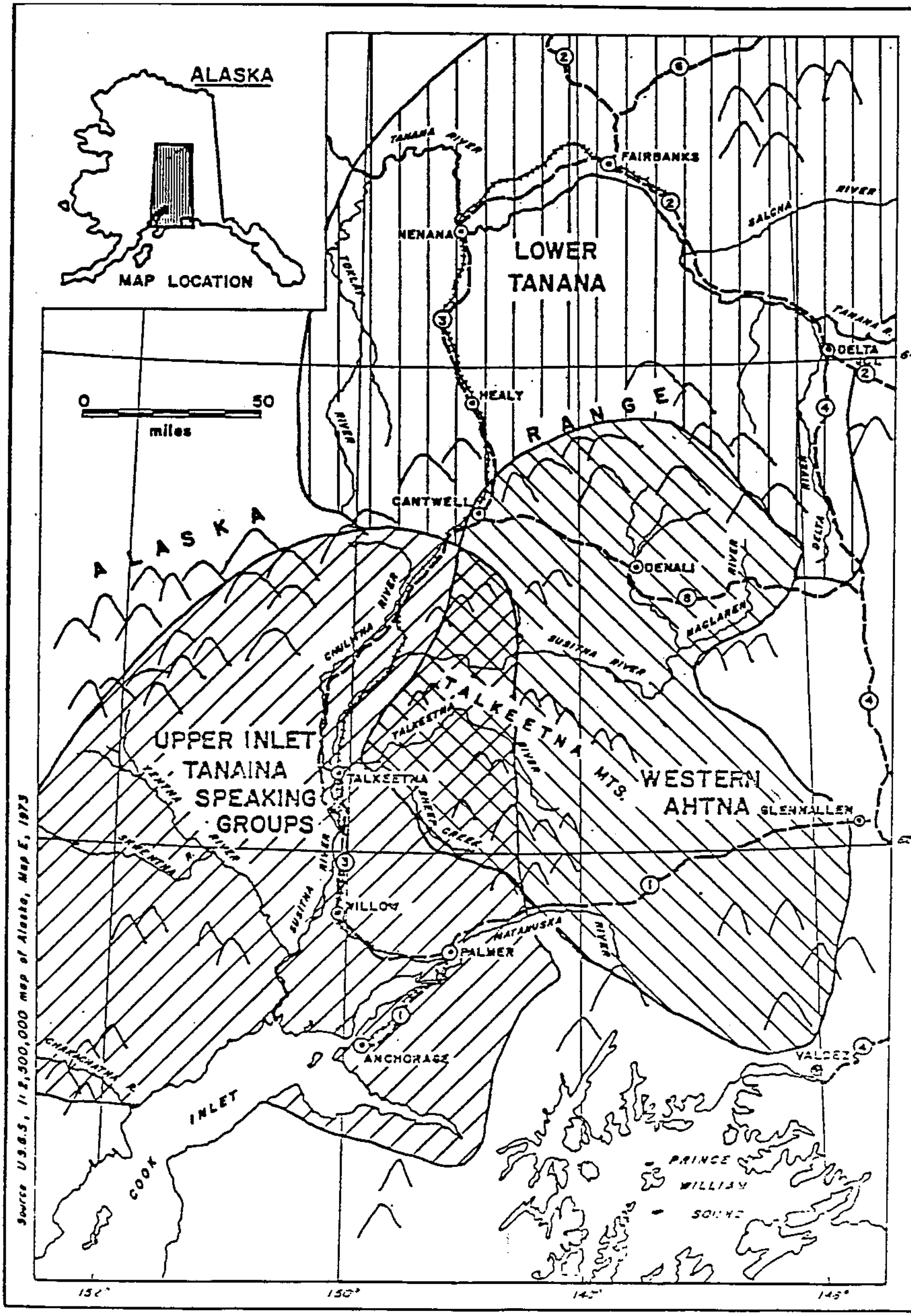


FIGURE E.4.2.5

APPROXIMATE DISTRIBUTION OF TANAINA, AHTNA, AND TANANA GROUPS OVER THE PROJECT AREA (FROM CAYWOOD 1985:3-29)

SEASONS	WINTER	SPRING	SUMMER	FALL
	Early Middle Late	Early Middle Late	Early Middle Late	Early Middle Late
Settlement	Winter villages ---------------> Overlooks near rivers or trails with reliable fuel and water	Temporary settlements of local bands (trading expeditions by interior groups -------------->	Fish camps (near winter villages) --->	Temporary hunting camps Winter villages
Subsistence	Stored and dried foods, moose, bear and freshwater fish ---->	Migratory water fowl and beaver Seals, beluga, candle fish, Indian potatoes	Salmon ------>	Freshwater fish, beaver, moose, caribou at low elevations Bear, mountain sheep, ground squirrel, marmot at high elevations Stored and dried foods, moose, bear, freshwater fish
Habitat	Forested areas along Susitna River or main tributaries --->	Cook Inlet and mouths of major rivers ---->	Flood plain/ terraces of main Susitna, clear-water tributaries	Mountains and interior lakes Forested areas along Susitna River or main tributaries

FIGURE E.4.2.6

GENERALIZED UPPER INLET TANAINA ANNUAL SETTLEMENT AND SUBSISTENCE

SEASONS	WINTER	SPRING	SUMMER	FALL
Settlement	Temporary camps (Western Ahtna) ----->	Fishing camps --------------------------------->		Temporary hunting camps
	Villages (Lower and Upper Ahtna) --------->			
Subsistence	Numerous animal and fish species --------->	Salmon on main rivers ----------------------->		Mountain sheep, caribou and other large game
		White fish on Upper Susitna and Upper Nanana Rivers ---------------------->		
		Various plants --------------------------------->		
			Caribou (Western Ahtna)	
Habitat	Forested areas near available water ----->	High points near main views or their tributaries ------------------------->		Upland areas for sheep and ground squirrels
			Foot of glaciers for caribou -------------->	Lowland areas, especially near lakes, for caribou --------->

FIGURE E.4.2.7

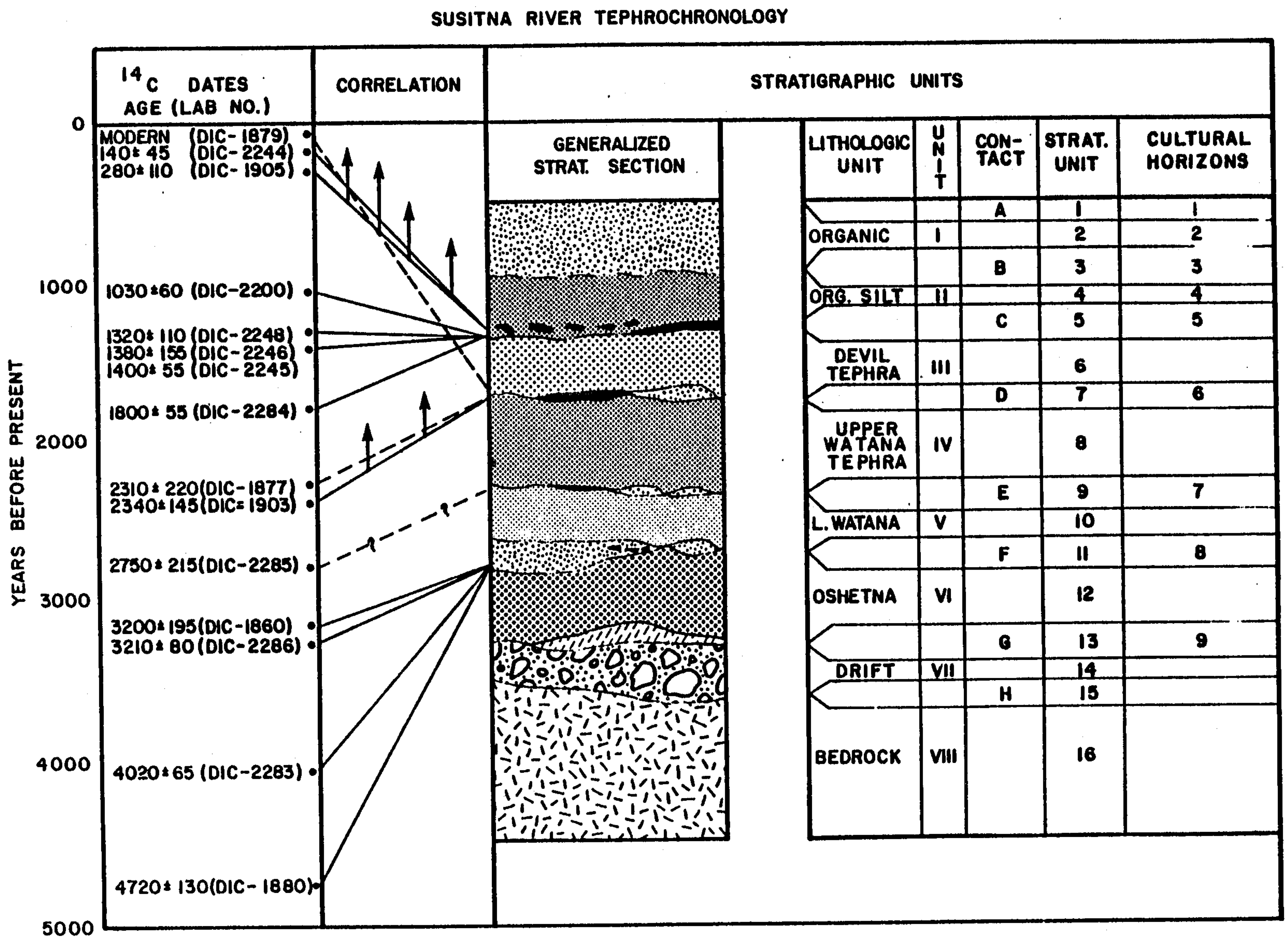
GENERALIZED AHTNA ANNUAL SETTLEMENT AND SUBSISTENCE CYCLE (FROM CAYWOOD 1985:3-45)

SEASONS	WINTER (Early, Middle, Late)	SPRING (Early, Middle)	SPRING (Late) / SUMMER (Early, Middle)	SUMMER (Late)	FALL (Early, Middle, Late)
Settlement	Semi-permanent hunting camps ------->	Temporary camps ------->	Fish camps ---------------->	Fish camps (continued); Temporary hunting camps	Semi-permanent hunting camps ------->
Subsistence	Caribou ------------>	Moose, muskrat, beaver and caribou	Salmon and other freshwater fish, berries, roots, ducks, and other birds after salmon run --------------->	Salmon run (continued); Sheep, marten, marmot, ground squirrels in mountains	Caribou ------------>
Habitat	Uplands near near timberline ----->	Lowlands near fish camps -->	Clearwater tributaries and lakes ---------->	Streams; Mountains	Uplands near timberline

FIGURE E.4.2.8

GENERALIZED LOWER TANANA ANNUAL SETTLEMENT AND SUBSISTENCE CYCLE

(FROM C[illegible]W[illegible]D [illegible]85[illegible]51)



SUSITNA RIVER
STRATIGRAPHIC UNITS AND TEPHROCHRONOLOGY

FIGURE E.4.2.9

CHAPTER 5
SOCIOECONOMIC IMPACTS

SUSITNA HYDROELECTRIC PROJECT
LICENSE APPLICATION

EXHIBIT E - CHAPTER 5
SOCIOECONOMIC IMPACTS

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SOCIOECONOMIC IMPACTS

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EXHIBIT E - CHAPTER 5
SOCIOECONOMIC IMPACTS

1 - INTRODUCTION (**)

The approach used in the socioeconomic analysis involved four steps. The steps were 1) defining impact areas, 2) describing present and past socioeconomic conditions, 3) developing and comparing projections of socioeconomic conditions with and without the construction and operation of project facilities, and 4) developing an impact management program.

Efforts were devoted to identifying and analyzing factors that would substantially influence the magnitude and geographic distribution of project-induced changes. A computerized socioeconomic model was developed to forecast and analyze the effects of changing key project factors such as: project schedules; leave, shift and shift rotation schedules; locally available supply of labor; housing and related facilities at the construction sites; and worker access to the sites. The estimated project-induced changes provided in the following sections are based on one of several possible specifications for these key factors. In general, it is projected that socioeconomic impacts would be insignificant for the Railbelt region of Alaska. However, there may be project-induced changes in communities located near facility construction sites that are significant. For example, the population of Cantwell is projected to increase substantially during railhead construction and by the peak year of the Watana-Stage I construction activity. Potential changes associated with these population increases would cause subsequent facility and service impacts in Cantwell.

An impact management program would help minimize project-induced changes for small communities located near the construction sites. It would include updating and using the results of the impact assessment, in combination with a monitoring program and with the input of community and agency members, to develop, implement, and evaluate the results of a mitigation program.

This chapter on socioeconomic impacts was prepared in accordance with the Federal Energy Regulatory Commission's rules and regulations for preparation of Chapter 5 of Exhibit E. In addition, supplementary information is provided in several sections to allow a better understanding of project-related socioeconomic impacts.

2 - BASELINE DESCRIPTION (**)

2.1 - Identification of Socioeconomic Impact Areas (**)

The selection of socioeconomic impact areas was influenced by the following factors: anticipated worker transportation time, mode and route; physical barriers; population concentrations and the indigenous labor force; political jurisdictions; and community amenities. The identification and rationale for selecting impact areas are described below.

2.1.1 - Local Impact Area (**)

After considering the above factors, it was concluded that most of the project-induced population changes and associated impacts would occur in the Matanuska-Susitna (Mat-Su) Borough and nearby communities such as Cantwell. Subsequent analysis demonstrated that the communities of Healy and Nenana also have the potential to be affected by the Project. By varying the mode for transporting workers to the project site, Anchorage, Fairbanks, Wasilla, and Palmer increase their potential to receive project impacts (FOA 1985a). Accordingly, the Mat-Su Borough, including the lands in and around the project site, selected communities within the Mat-Su Borough, Healy, Nenana, Cantwell, Anchorage, and Fairbanks are designated as the Local Impact Area for the purposes of this analysis (see Figure E.5.2.1)(FOA 1982, 1984b 1985a and FERC 1984).

2.1.2 - Regional Impact Area (**)

The Regional Impact Area, also referred to as the Railbelt, includes the Local Impact Area and the remainder of the Railbelt; i.e., the census divisions of Kenai-Cook Inlet, Seward, and Valdez-Chitina-Whittier (see Figure E.5.2.1). Project-induced employment changes could occur in all eight Census Divisions, particularly Anchorage and Fairbanks.

For analytical purposes, the Regional Impact Area is divided into two subareas: Anchorage and Fairbanks. The Anchorage, Kenai-Cook Inlet, Seward and Mat-Su Census Divisions comprise the Anchorage subarea; the Fairbanks-North Star, Southeast Fairbanks and Yukon-Koyukuk Census Divisions comprise the Fairbanks subarea.

2.1.3 - State

(This section deleted)

2.2 - Description of Employment, Population, Personal Income and Other Trends in the Impact Areas (**)

The information in this section was drawn from a review of literature and surveys conducted from 1981 through 1985. The surveys were of residents (households), businesses, facility and services providers (public sector), and community leaders.

2.2.1 - Local Impact Area (**)

Recent trends in population, employment, and per capita income in the Mat-Su Borough, the Municipality of Anchorage, and the Fairbanks-North Star Borough are presented below. Details for these trends are not available for all smaller communities within the area. The Local Impact Area contains both rural areas with few public facilities and services and no local government, and urban areas with a full range of facilities and services and large local governments.

(a) Employment (**)

Employment in the Local Impact Area is reflected in Table E.5.2.1. Employment has increased steadily in each jurisdiction in the area from 1970 to 1980 and continued to increase into 1984. Under baseline conditions, this is expected to gradually increase through the year 2005. Unemployment rates varied from 6 percent to 15 percent in the 1970s. In 1984 it ranged from 7 to 13 percent. Generally, unemployment rates have been greater in rural areas than in urban areas and, in the 1980s, have been greater in Fairbanks than Anchorage. These trends are expected to continue through the year 2005. The rural areas are also more likely to have a higher percentage of its population depending on seasonal employment. This relatively high level of dependence on seasonal work in rural areas is likely to continue under baseline conditions.

Employment opportunities are few in the communities closest to the damsites (Talkeetna, Trapper Creek, Healy, Nenana, and Cantwell). Because of the limited number of local jobs, many residents leave the area for periods of time each year to work on the North Slope or in Anchorage or Fairbanks. Except for Healy (where many coal miners live), retail businesses associated with tourists, some government agencies, guiding, and arts/crafts businesses provide the majority of available jobs in those communities.

(b) Population (**)

Population in the Mat-Su Borough has grown rapidly since 1970, largely reflecting construction of the Trans-Alaska Pipeline and recent suburbanization of the Palmer and Wasilla areas. Cantwell, Healy, Nenana, Anchorage, and

Fairbanks have also grown substantially since 1970. Table E.5.2.2 shows population by community in the Local Impact Area. Palmer and Wasilla are the Mat-Su Borough's largest communities, with estimated 1985 populations of 2,876 and 3,814, respectively. These two communities, the Municipality of Anchorage, and the Fairbanks-North Star Borough contain most of the Local Impact Area's population.

Most of the remaining population is distributed along the Parks Highway and the Alaska Railroad. In addition, several hundred inhabitants are scattered throughout the area's less developed regions accessible primarily by water or air; these inhabitants include a few residents of the middle Susitna River Basin.

The U.S. Department of Commerce, Bureau of the Census (1980) indicates that the Mat-Su Borough's population is 51 percent male and 49 percent female. Ninety-seven percent of the residents are Caucasian, two percent American Native, and one percent Black.

The Mat-Su Borough, like other areas of the state, is expected to continue growing during the remainder of the 1980s. As a result of Anchorage residents moving to the southern Mat-Su Borough and commuting to Anchorage to work, strong growth is also projected to continue into the 1990s. Under baseline conditions (which describe conditions without the Susitna Project), population of the borough is expected to reach almost 42,000 in 1990, the year before Project construction begins. Baseline population would grow to over 53,000 by 1997 (the peak year of employment of the Project's Stage I of construction) to nearly 64,000 in the year 2003, (the peak employment for Stage II), and nearly 76,000 by 2009 (the peak employment year for Stage III).

Without the Susitna Project, Palmer is expected to more than double its population to approximately 6,400 people by 2009. During the same period, Wasilla and Houston are expected to grow 5 to 10 times (respectively) over their present population; e.g., 21,600 and 8,000, respectively (FOA 1985b).

Trapper Creek, a community of about 240 in 1985, is projected to increase its baseline population size by the year 2003 to approximately 410. Its population is expected to reach 490 by 2009. Under baseline conditions it is assumed that growth in Trapper Creek would be constrained by a lack of employment opportunities. The Talkeetna area, containing about 288 inhabitants in 1985, is expected to reach population levels of around 460 in 1997, 580 in 2003, and 740 in 2009 (FOA 1985b).

Recent studies from 1982 to 1984 have shown the Cantwell population to be approximately 190. Approximately 20 percent of the population is Native American. Cantwell's baseline population is expected to be 250 in 1997, 280 in 2003, 320 in 2009 (FOA 1985a, 1985b).

Healy's population grew from 79 in 1970 to 333 in 1980. A survey conducted in 1984 (Harza-Ebasco 1985a) showed the population to be 565. Healy's baseline population is forecast to be 760 in 1990, 940 in 1997, 1,120 in 2003, and 1,340 in 2009. Only 3 percent of Healy's population was Native American in 1984 (Harza-Ebasco 1985a).

Nenana had a population of 286 in 1960, 382 in 1970, and 471 in 1980 (U.S. Department of Commerce, Bureau of the Census 1980). The 1985 estimated population is approximately 570 and is expected to increase to about 710 in 1990, 960 in 1997, 1,240 in 2003, and 1,610 in 2009 (FOA 1985a). About half of Nenana's population is Native American.

The Municipality of Anchorage had a population increase from 126,385 in 1970 to 174,431 in 1980. The 1985 population is estimated to be 247,000 and is forecast to continue increasing to 249,000 in 1990, 260,000 in 1997, 266,000 in 2003, and 274,000 in 2009 (FOA 1985a).

The Fairbanks-North Star Borough's population was 45,864 in 1970, 57,366 in 1980, and is estimated to be approximately 67,400 in 1985. The borough's population is forecast to be about 73,800 in 1990, 80,100 in 1997, 85,300 in 2003, and 90,600 in 2009 (FOA 1985a).

(c) Sociocultural Setting (**)

Talkeetna, Trapper Creek, Cantwell, Healy, and Nenana have experienced considerable population influx in recent years. This is noteworthy because the communities are too far from Anchorage or Fairbanks to serve as bedroom communities and because they offer fewer economic opportunities. Most residents in these communities share the desire to live in a non-industrial, relatively rural setting.

Talkeetna, located 114 miles north of Anchorage, is the former site of an Indian village. It became a mining community after the discovery of gold in 1886, serving as a base of operations for prospectors in the Yentna Mining

District. Some miners spent the winter trapping, which was an important part of the local economy until the 1940s. Construction of the Alaska Railroad spurred growth by increasing access to the area by miners, travelers, and trappers. Upon construction of the Talkeetna airfield and associated Federal Aviation Administration (FAA) facility in 1940, young families began moving into the area to work for the government.

Talkeetna became the center for expeditions to Mt. McKinley in the 1950s. By 1971, completion of the Parks Highway and Talkeetna Spur Road gave Talkeetna road access for the first time. Recreational use of the area increased, as did land sales and home construction for a growing population of young families.

Trapper Creek was settled after 1950, initially by homesteaders. Upon construction of the Parks Highway and the operation of the state's Open-to-Entry (OTE) land disposal program during 1968-1973, a new group of residents moved to the area, some acquiring five-acre parcels for recreational use, others seeking a year-round life in an undeveloped area.

Cantwell is an unincorporated community in which approximately 20 percent of its residents are Native Americans belonging to the Ahtna regional corporation, Ahtna, Inc. (Harza-Ebasco 1985a, FOA 1984a). The non-Native portion of the community has increased substantially since the completion of the Parks Highway in the mid-1970s. Cantwell is located about ten road miles north of the Mat-Su Borough's northern boundary.

Healy is located approximately 125 miles south of Fairbanks on the Parks Highway and 9 miles north of the Denali National Park entrance. Healy was founded as a mining camp in 1905, and was named Healy Creek. After completion of the Alaska Railroad, Healy became a railroad station and supply point for local residents. Today Healy is a major coal mining supply and shipping center for the Nenana coal fields. The town is also the residence for many mine employees. About three percent of the population is Native American (Harza-Ebasco 1985a).

Nenana is located 53 miles south of Fairbanks on the Parks Highway on the confluence of the Nenana and Tanana Rivers. Nenana was established in 1902 as a roadhouse and trading post and grew as a railroad construction base. Nearly half of the residents of Nenana are Native Americans (U.S. Department of Commerce, Bureau of Census 1980).

Anchorage (established in 1915 and incorporated in 1920) is located at the northern end of Cook Inlet in Alaska's southcentral region. It is Alaska's largest city and the center of the state's commercial activity. Anchorage's population is more heterogeneous than most Alaskan communities, composed of about 85 percent white, 5 percent Native American, 5 percent Black, and 4 percent other races.

Fairbanks is Alaska's second largest city and serves as a commercial and transportation center. The city is located in the Alaskan interior at the confluence of the Tanana and Chena Rivers. Fairbanks was established as a temporary trading post in 1901 and its future was assured by the gold rush in 1903.

(d) Income (**)

Trends in per capita personal income are shown in Table E.5.2.1. Personal income rose substantially in the Mat-Su Borough, Anchorage and Fairbanks in the 1970s and early 1980's. Per capita income for the state rose from $3,765 in 1970 to $12,916 in 1980 and to $16,598 in 1982. The figures for Anchorage, Fairbanks, and the Mat-Su Borough reflect similar trends.

(e) Housing (**)

Table E.5.2.3 shows current and baseline projections of housing stock, estimates of housing demand, and forecasts of vacancy rates for selected places in the Local Impact Area. The Mat-Su Borough's baseline housing stock is projected to increase from about 15,500 units in 1985 to 33,760 in 2009. Vacancy rates are forecast to decrease from 25 percent to 16 percent over this time period. The greatest density of housing units in the Mat-Su Borough is now and would continue to be in the Palmer-Wasilla area. As of 1980, single-family houses predominated in the borough, representing 83 percent of the total; mobile homes and multifamily units accounted for 11 and 5 percents, respectively (Policy Analysts 1980).

Baseline housing stock in Palmer is forecast to increase from 1,000 units in 1985 to approximately 2,600 units in 2009. In the same period, vacancy rates are expected to remain at about eight percent. Wasilla housing stock is forecast to increase from about 1,350 units in 1985 to approximately 8,880 units in 2009. Vacancy rates are expected to remain at about nine percent over these years. Houston housing stock is expected to increase from about 360 units in 1985 to 3,870 units in 2009. This period shows vacancy rates decreasing from 27 percent in 1985 to 23 percent in the year 2009. From 1985 to 2009, housing units in Talkeetna and Trapper Creek are projected to increase from about 170 to 320 and from 105 to 215, respectively. During this time, vacancy rates in Talkeetna are forecast to decrease from 33 to 12 percent and in Trapper Creek from 27 to 15 percent (FOA 1985a).

In 1981, there were approximately 78,960 acres of unimproved subdivided land in the Mat-Su Borough. Assuming an average of one acre per home, this amount of private land would be sufficient to provide for the increased number of households under baseline conditions. There are no zoning regulations that would affect settlement in areas around Talkeetna and Trapper Creek.

In 1985, there are an estimated 103 housing units in the Cantwell area, of which 70 were occupied. Some of the vacant units in Cantwell do not have dependable sources of water or electricity, and thus could be termed marginal, year-round housing. To some extent, settlement in Cantwell has been limited by the availability of land for development. Non-Native private land is scarce in Cantwell and plots that are available are relatively expensive. Approximately 25 plots of subdivided land are currently available for sale. In addition, Ahtna, Inc., which represents Natives living in Cantwell, owns almost 54,000 acres of land in and around the community. Of this amount, approximately 10,000 acres are patented; the remainder are in interim conveyance.

Cantwell is forecast to increase the number of housing units by 37 percent to nearly 150 units by the year 2009. Vacancy rates are expected to decrease from 32 percent in 1985 to 22 percent in 2009.

In 1985, Healy is estimated to have 218 housing units and Nenana 227 units, with an approximate 10 percent vacancy rate in each community. By the year 2009, Healy is forecast to have 530 housing units and Nenana 640 units. Vacancy rates are expected to remain constant in both communities.

Anchorage has an estimated 95,637 housing units in 1985 and Fairbanks has 11,430. Vacancy rates are 13 percent in Anchorage and 7 percent in Fairbanks. Both cities are expected to increase the number of housing units by the year 2009; Anchorage to approximately 114,250 units and Fairbanks to about 13,650 units. Fairbanks is expected to continue to have a 7 percent vacancy rate while the Anchorage rate is expected to decrease to about 10 percent by 2009 (FOA 1985b).

(f) Local Government Structure (**)

(i) Matanuska-Susitna Borough (*)

The Matanuska-Susitna Borough was incorporated as a second class borough on January 1, 1964. At the time of incorporation, the borough automatically assumed three area-wide powers: taxation; education; and planning, platting, and zoning. In 1966, borough residents voted to add parks and recreation to the borough's powers. The borough operates solid waste disposal sites and libraries on an area-wide basis (outside incorporated cities). In addition, the borough administers 10 fire service areas and 17 road service areas.

The Mat-Su Borough has a Mayor-Manager-Assembly form of government. Borough administration, working under the direction of the manager, currently comprises five departments: finance, public works, assessment, planning, and engineering. The Mat-Su Borough School District operates schools throughout the borough and is directly responsible to the borough assembly.

(ii) Communities in the Mat-Su Borough (*)

There are three incorporated communities within the Mat-Su Borough: Palmer, Wasilla, and Houston. Palmer is a first-class, home-rule city, and as such has all legislative powers not prohibited by law or charter. The City of Palmer has a Mayor-Manager-City Council form of government, with a part-time mayor and full-time city manager. The city operates a police station, water and sewer system, library, fire station, and garbage collection service. Wasilla is a second-class city, and has a part-time mayor and city council with a full-time city clerk. The second-class city of Houston has a part-time Mayor-City Council form of government with a part-time city clerk.

The Mat-Su Borough also contains several unincorporated communities within its 23,000 square mile area. These include Talkeetna and Trapper Creek, located along roads, in addition to small population clusters in roadless areas.

(iii) Yukon-Koyukuk Communities (***)

Cantwell is an unincorporated community outside any organized borough. Residents of Cantwell formed a non-profit corporation called The Community of Cantwell, Inc. to qualify for state grants for communities. Healy is also unincorporated and outside of any organized borough. Facilities and services are provided by the state; there is no local government. Nenana is an incorporated city outside of any organized borough. The town offers a variety of services and has an operating government structure.

(iv) Anchorage and Fairbanks (***)

Anchorage is an incorporated municipality, but is not within a borough. The municipal government is a Mayor-City Council form. The municipality provides a full range of services, including police, fire, water, recreation, sewer, telephone, electrical, and road construction and maintenance.

Fairbanks is an incorporated city (since 1903) in the Fairbanks-North Star Borough and is governed by a Council-Manager form of government with a mayor and six council members. The services provided by the city include police and fire protection; road construction and maintenance; and water, sewer, telephone and electrical services.

(v) Native Corporations (**)

CIRI has selected much of the land in the middle and upper Susitna Basin, including land in and around the damsites. Another regional corporation, Ahtna Inc., owns approximately 54,000 acres of land around Cantwell and the Denali Highway. Approximately 40 members of Ahtna, Inc., live in Cantwell (which in 1971 was identified by the U.S. Department of the Interior as a Native village) (Harza-Ebasco 1985a). Further information on land holdings and selections by Native corporations is found in Chapter 9.

Both the CIRI and Ahtna regional corporations have separate non-profit organizations that manage the social, educational, health, and welfare concerns of Natives in their regions. The CIRI and Ahtna non-profit organizations are called the Cook Inlet

Native Association and Copper River Native Association, respectively.

(g) Public Facilities and Services (**)

This section describes existing public services, describes current demand for the services, and forecasts future baseline demand for the services at the community and borough level. The detail is appropriate to allow projections of probable impact of the Susitna Project. The services addressed include water supply, sewage treatment, solid waste disposal, transportation, police and fire protection, health care services, education, and recreational facilities. Table E.5.2.4 summarizes the facilities available by community, and Table E.5.2.5 compares use ratio and capacities for facilities and services in selected communities.

Many of the communities in the Local Impact Area have few public services. Public facilities and services in the Local Impact Area would need to be expanded considerably to provide current per capita levels of service to a population that would be growing rapidly over the next twenty years, even without the construction and operation of the Susitna Project. In several areas, expansion is already being planned to accommodate this anticipated growth.

(i) Water Supply and Sewage Treatment (**)

Communities within the Local Impact Area that provide water supplies and chlorination treatment systems include Palmer, Wasilla, Nenana, Anchorage, and Fairbanks. Palmer and Wasilla have peak capabilities of 1,030,000 gallons per day (gpd) and 900,000 gpd, respectively. These capabilities are used at about 40 percent capacity by Palmer and 60 percent capacity by Wasilla, based on average daily consumption. Palmer is not forecast to exceed current capabilities under baseline conditions until several years after 2009, but Wasilla would in the early 1990s (FOA 1985b). Other areas in the borough are provided with water on an individual basis by wells or by a community water system that serves a specific subdivision. Most have sufficient water availability. In the Trapper Creek area, potable water is sometimes difficult to obtain because of permafrost and dissolved minerals.

Palmer has a city-wide sewage facility in the form of a two-cell lagoon. It currently processes 300,000 gpd of sewage with an average 30-day detention time. City officials indicate that the present facilities are being used at or near capacity. The system's capacity would need to be augmented by adding at least a third cell before 1990. Wasilla's facility has a 1985 capacity of 177,000 gpd. This facility is already used beyond capacity and despite planned expansion in the immediate future, it would require additional expansion before 1990.

Residents of other Mat-Su Borough areas rely on septic tanks. Since in most parts of the borough residents live on plots of one acre or more, it is probable that residents would continue to rely on individual septic tanks. Community sewage systems are generally feasible only in areas of greater population density. Currently, septic tank waste is trucked to Anchorage for disposal by private companies. Mat-Su Borough voters have authorized construction of a treatment plant in the borough. Some subdivisions and trailer parks are served by small public sewage systems.

Nenana provides residents a water system, with a supply capacity of 430,000 gpd. Their system is only used at 12 percent capacity and would have sufficient capacity until after the year 2009 under baseline conditions. Nenana's sewage system has a capacity to process 60,000 gpd and is currently used at 88 percent capacity. Under baseline conditions, the system would need to be expanded prior to 1990.

The Anchorage water system has an average daily supply capacity of 22,000,000 gallons. Demand currently exceeds this supply by 34 percent. Planned expansion to 36,000,000 gallons would create capacity which would be sufficient until after the year 2009. The Anchorage sewage system has a capacity of 34,000,000 gpd and is used at 81 percent capacity. The system has sufficient capacity to be adequate until after the year 2009.

Fairbanks has a water system capable of supplying 4,000,000 gpd. Current use is at 60 percent of capacity and use in the year 2009 is forecast to be 77 percent of capacity. The sewage system's daily capacity is 6,500,000 gpd. Current utilization is at 54 percent; utilization in the year 2009 is estimated at only 74 percent of capacity.

(ii) Solid Waste (**)

The Mat-Su Borough has area-wide (i.e., outside incorporated communities) solid waste management authority and operates 9 landfills comprising 212 acres. Each incorporated community contracts with the borough for use of the closest landfills. Existing facilities are used at less than 10 percent capacity and would not require expansion until about the year 2005.

The borough intends to close most of these sites by 1987 and set up transfer stations. Final disposal would then take place at an 80-acre central site near Palmer (Arctic Environmental Engineers 1978).

Residents of the Cantwell area use a two-acre landfill site that is not maintained by any public authority and is on privately owned land. This area is used at about 6 percent capacity and is sufficient to serve the baseline population until after the year 2009.

The Muncipality of Anchorage has an approximately 100-acre land fill that is projected to be filled by July 1986. A new 535-acre site is being acquired with a projected capacity in excess of 40 years based on medium population and waste quantity projections.

The Fairbanks-North Star Borough provides a 75-acre disposal site that is currently used at about 13 percent capacity. By the year 2009, this site would not exceed 76 percent capacity of utilization under baseline conditions (FOA 1985b).

Palmer operates a collection and disposal system for city residents. In Cantwell and in the rest of the Mat-Su Borough, it is the responsibiliy of individuals to transport waste to landfills.

(iii) Transportation (**)

- Road and Highway (**)

The Alaska Department of Transportation and Public Facilities (ADTPF) is responsible for maintenance of highways that run through the Local Impact Area, including portions of the Parks, Denali, and Alcan Highways and the Talkeetna Spur Road. The department currently operates year-round maintenance stations at Cantwell, Chulitna, Talkeetna and Willow.

The Parks Highway is the principal surface transport route for the Local Impact Area, linking Fairbanks to Anchorage. This highway was built with a large amount of excess capacity; present use levels constitute approximately ten percent of capacity. Without the Susitna Project, the highway is projected to have excess capacity through the year 2010.

During the summer, the 135-mile Class 2 gravel Denali Highway is open to traffic between the Parks and Richardson Highways. In the winter, snow is not plowed by the ADTPF on the Denali Highway, and it is closed to traffic.

Most roads not constructed or maintained by the ADTPF in the Local Impact Area are not paved. In the Mat-Su Borough, there is currently a high demand for improved maintenance of existing roads and expansion of maintenance to rural roads not currently maintained by the borough. In Cantwell, Healy and Nenana, local roads are largely unmaintained.

Average annual daily traffic (AADT) data were collected from ADTPF and used to estimate trips to or from Local Impact Area communities (FOA 1985b). Trips important to this analysis are those occurring along the Parks Highway between Fairbanks and its junction with the Glenn Highway north of Anchorage, and a few other roads connecting Local Impact Area communities to the Parks Highway. Trip counts in 1985 are:

o Anchorage to Palmer or Wasilla	14,716
o Palmer to Anchorage or Wasilla	7,998
o Wasilla to Anchorage or Palmer	12,570
o Wasilla to Houston	6,630
o Houston to Talkeetna Spur Road	1,898
o Talkeetna Spur Road to Trapper Creek	1,486
o Talkeetna Spur Road	704
o Trapper Creek to Cantwell	1,136
o Cantwell to Healy	1,508
o Healy to Nenana	1,038
o Nenana to Fairbanks	1,310
o Cantwell to Paxson	74

Trips along these road segments are forecast to increase substantially by the year 2009 under baseline conditions. The increases range from a high of over 400 percent from Wasilla to Houston to a low of about 100 percent along the Denali Highway. Most increases over the 24-year period are between 200 and 300 percent. Increases are due to population increases and shifting residential patterns.

The percent of total AADT that is truck traffic ranges from a high of 17 percent on the Trapper Creek to Cantwell road segment to a low of 5 percent on the Anchorage to Palmer or Wasilla segment. Most segments average from 10 to 13 percent truck traffic. The current percentage is forecast to remain constant in baseline conditions.

Most of the highway segments analyzed are currently used well below their designed capacity. There are, however, intersections and short segments, such as the Parks and Glenn Highway intersection, that experience excessive short-term use during rush hour or on holiday weekends. Generally, these highways would not have design capacities exceeded under baseline conditions over the next 25 to 30 years.

As the Local Impact Area population grows under baseline conditions, the road system would need to be expanded to meet increased demand. As new subdivisions are created, additional roads would be required. In addition, upgrading of some roads would be necessary and collector roads would be required.

- Rail (**)

The Alaska Railroad runs 470 miles from Seward through Anchorage to Fairbanks. It is state owned and operated, having been transferred from federal ownership in early 1985. Many communities in the Local Impact Area are connected by the Alaska Railroad, including several which have no road access. Annual freight traffic volume varied in the 1970's between 1.8 and 2.3 million tons. It is estimated that the system is working at only 20 percent capacity. Starting in 1984, three additional trains per day began delivering coal shipments from Healy to Seward for shipment to Korea. Daily Anchorage to Fairbanks passenger service is provided during the summer months, with service being reduced to once weekly during the winter. The passenger train stops on a limited basis at any location for embarking or disembarking passengers (FOA 1985c).

- Air (**)

As shown in Table E.5.2.4, many communities have active airstrips designed for light propeller aircraft. Float planes are also common in areas with lakes. Most public airports in the Local Impact Area are expected to have sufficient present or planned capacity to accommodate additional demands of a growing population. There is, however, need for a new air facility to serve Wasilla. The existing facility is not easily expanded because of terrain and lack of available land.

Anchorage and Fairbanks both have international airports that handle large numbers of jet aircraft. Both cities also have light aircraft facilities for both land and float planes.

(iv) Police (**)

Police protection in the Mat-Su Borough, Cantwell, Healy, and Nenana is provided by the Alaska State Troopers. Of the 30 troopers serving the borough, three are in Trapper Creek. In addition, five other troopers are responsible for fish and wildlife protection and enforcement within the borough and nearby communities. Furthermore, Palmer has police powers and maintains a police force of nine officers and several civilian support personnel. There are three state detention and correctional facilities in the Mat-Su Borough. These facilities serve the entire Anchorage region.

Healy, Cantwell, and Nenana each has one trooper serving the community. Under baseline conditions Nenana will need additional personnel by the year 1990 and Healy by about the year 2000.

The Municipality of Anchorage is served by 393 police officers, a number insufficient for the current population. At current staff levels, the baseline population would exceed the service capacity by over 40 percent in the year 2009.

The City of Fairbanks has 46 police officers for about 90 percent service capacity utilization. The city would need to add additional officers in the year 1995 under baseline conditions. The remainder of the Fairbanks-North Star Borough is served by State Troopers or, in the case of incorporated towns, city police. Since over half of the project-related population in-migrating into the borough is expected to live in the City of Fairbanks, only law enforcement services for the city are analyzed.

(v) Fire (**)

There are 10 operating fire service areas in the Mat-Su Borough and each area has one or more fire stations for a total of 14. In addition, Houston and Palmer, which have their own fire protection service, each has stations. In 1984, a borough fire protection plan was adopted calling for all 10 fire service areas to have approximately 40 pieces of fire apparatus (trucks of all kinds) by the end of 1985. Two new stations are also planned for 1986. Costs of fire protection are funded by special millage rates on assessed valuations within the service areas.

Residents of the Mat-Su Borough not within the boundaries of a fire service area rely on their own resources and neighbors' volunteer assistance for fire protection. Trapper Creek has no fire protection service available.

Talkeetna has excess capacity in its fire protection service and under baseline conditions through the year 2005 should not need expansion. Palmer and Wasilla both currently need additional capacity for fire protection to be adequate. With baseline forecasts predicting rapid growth for these two communities, facilities would need periodic expansion and additional firefighters would be needed.

Cantwell currently has excess capacity in its fire protection system which consists of a fire hall, a 1,000 gallon pumper, a four-wheel drive vehicle, a two-ton pick-up, and 7 volunteer firefighters. No additions in personnel should be required until 1994 under baseline conditions. Healy and Nenana also currently have adequate fire protection that would not need expansion through the year 2010 under baseline conditions.

Anchorage and Fairbanks currently have insufficient capacities in their fire protection services. Under baseline conditions both cities would require substantial service expansion.

(vi) Health Care (**)

The 30-bed Valley Hospital, built in Palmer in 1954, with a staff of 8 doctors provides acute and long-term care to residents of the Mat-Su Borough. This facility is adequate for a population of about 30,000. There is a satellite facility in Wasilla. Another addition of 30 beds may be built at a later date to serve the expanding population. The majority of the funds for this project were obtained from the state.

In Alaska, the recommended occupancy rates are 80 percent for urban hospitals and 55 percent for rural hospitals. Using these formulas to project the requirements for hospital beds, the Mat-Su Borough may need additional beds around the year 2000.

Ambulance service in the borough is provided through the Palmer Fire Center on a 24-hour basis. Each fire hall in the Mat-Su Borough, including the one at Talkeetna, has an ambulance for emergency service and individuals who have received Emergency Medical Training (EMT). Trapper Creek is served by an ambulance dispatched from the trooper station in the community.

Public health centers are located in Palmer and Wasilla. There are also facilities in Wasilla which provide individual and group therapy, family and marital counseling, and alcohol and drug consultation. The Palmer Pioneer Home provides long-term nursing and non-nursing care for the elderly.

Cantwell has no medical care in the community, with the exception of an ambulance and several EMTs. The closest medical expertise is a doctor's assistant in Healy; most residents go to Anchorage or Fairbanks for medical care.

Healy is served by a medical clinic that is staffed with a doctor's assistant. Patients from surrounding areas, such as Cantwell and Denali National Park, also utilize the clinic. Nenana also has a general practice medical clinic staffed by a physician's assistant and a registered nurse. Patients from Healy and Nenana who require specialized care or hospitalization most frequently go to either Anchorage or Fairbanks.

Anchorage has two medical-surgical hospitals, three hospitals for special populations (884 beds), and five long-term care facilities (266 beds). Fairbanks has two hospitals (227 beds) and two long-term care facilities (155 beds). Since these cities serve as the centers of medical treatment for much of Alaska, judging their adequacy with a local standard is not useful. These facilities can be expected to expand if bed occupancy rates become very high, but occupancy rate variation would depend to some extent on factors occurring outside the Local Impact Area such as North Slope oil field activity (FOA 1982; FERC 1984).

(vii) Education (**)

The Mat-Su Borough operates 22 schools, ranging from kindergarten through grade 12, and a home correspondence program. At the beginning of the 1985-1986 school year, enrollment totaled nearly 8,800 students. Under baseline conditions the system would need to be expanded between 1986 and 1988. Plans call for expansion of existing facilities and construction of new schools as demand occurs.

Trapper Creek and Talkeetna each has elementary schools. Junior and senior high school students from both communities attend Susitna Valley High School. The capacities and 1985 enrollments of these schools are displayed in Table E.5.2.6.

The Railbelt School District (serving Cantwell and Healy) has a current enrollment of about 350 students and operates at about 85 percent of capacity. Under baseline conditions the district's capacity would not be exceeded until after the year 2009. In Cantwell, there is only one school serving 36 primary school students and operating at 60 percent capacity. By the year 2009, the school is expected to serve 57 students and be utilized at 95 percent capacity. Total school enrollment in Healy is currently expected to rise to 267 students by the year 2009. Present enrollment utilizes school facilities at 64 percent of capacity while enrollment under baseline conditions in the year 2009 is expected to exceed capacity by 34 percent.

Nenana City Public School has a current enrollment of over 229 students and operates at about 57 percent capacity. Under baseline conditions, the school would exceed current capacity by about 1998.

Anchorage has a school enrollment of about 44,700 students, a number that is about 19 percent above the system's capacity. The system would require gradual expansion to accommodate enrollment under baseline forecasts. Much of this expansion is planned by the municipality.

The Fairbanks-North Star Borough has a school enrollment of approximately 10,800 and operates at 5 percent above capacity. Without expansion (under baseline conditions) the system would be operating at 41 percent above capacity by the year 2009.

(viii) Recreational Facilities (**)

Opportunities for outdoor recreation abound in the Local Impact Area. The largest attraction is the Denali National Park and Preserve. The park entrance is located 26 miles north of Cantwell on the Parks Highway. Other outdoor recreation areas include Denali State Park and Chugach State Park, both offering a variety of summer and winter recreational activities. Nancy Lake Recreation Area south of Willow, the Lake Louise area in the southeastern part of the borough, and the Big Lake area between Willow and Wasilla are other popular recreational sites. Heavy seasonal use also occurs at popular hunting and fishing locations surrounding Anchorage and Fairbanks.

The Mat-Su Borough has nearly 237 acres of community parks. These parks are utilized at 24 percent capacity. Within the borough, Talkeetna, Trapper Creek, and Houston have few developed facilities. Palmer and Wasilla have a greater variety of recreation areas classified as playgrounds and neighborhood parks. In Palmer there are approximately 4 acres of playgrounds and 31 acres of neighborhood parks. In Wasilla the acreages are 1 and 19, respectively.

The Municipality of Anchorage has 910 acres of community parks with a capacity utilization rate of 68 percent. Overall, the municipality has extensive developed public recreational facilities, including tennis courts, golf courses, softball-baseball fields, bike trails, and ski areas (downhill and cross country). A variety of privately supplied resources also exists, such as gymnasiums, racketball courts, skating rinks (roller and ice), and tour services. Anchorage also serves as the cultural center for the region and has museums, theaters, and art galleries.

The Fairbanks-North Star Borough has 6,000 acres of community parks which are utilized at approximately 3 percent capacity. The City of Fairbanks also has museums, theaters, art galleries, and a variety of private and public recreational facilities.

(h) Fiscal Status of Local Governments (**)

(i) Mat-Su Borough (**)

Mat-Su Borough finances can be divided into three funds (not including schools): general fund, service area fund, and land management fund. The general fund is derived from local property taxes, state municipal assistance funds, and state and federally-shared revenues, and is used to provide administrative, road maintenance, library, landfill, and ambulance services. In 1985, the general fund revenues of about $34.4 million are expected to be below expenditures of $35.0 million for a negative fiscal balance of $0.6 million. Under baseline conditions, the fiscal balance is forecast to remain negative through 1988, but then to gradually increase from a positive balance of about $0.5 million in 1989 to $61 million in 2009. These estimates were based on the assumptions outlined in Section 3.6.1(a). Over the same time period, revenues and expenditures are forecast to be more than triple their current levels.

The Mat-Su Borough service area fund is derived from property taxes and municipal assistance and other state-shared funds, and is used to provide police and fire protection. In 1985, service area revenues of about $3.3 million exceeded expenditures of about $3.1 million for a fiscal balance of about $0.2 million. The service area fund fiscal balance is forecast to increase steadily from its current level to about $4 million in the year 2009.

The land management fund is derived from state grants and land management fees. While smaller than the service area fund, it is expected to exhibit similar trends over the forecast period.

(ii) Local Communities (***)

Palmer's revenues are derived from property taxes, a two percent sales tax, and borough and state sources. In 1985, Palmer's estimated revenues of $4.7 million exceeded expenditures of about $4.1 million, for a fiscal balance of $0.6 million. Baseline revenues and expenditures in Palmer are forecast to grow steadily through the year 2009, when revenues of $26.9 million would exceed expenditures of $23.9 million, for a fiscal balance of $3.0 million.

Wasilla and Houston's revenues are derived primarily from borough and state sources. Wasilla's 1985 estimated revenues of $1.6 million are expected to exceed expenditures of $1.0 million for a fiscal balance of $0.6 million . The fiscal balance is expected to increase to $4.7 million by the year 2009. Houston's estimated 1985 revenues of $271 thousand were below estimated expenditures of $278 thousand for a negative fiscal balance of $7 thousand. The baseline fiscal balance is forecast to be a negative $346 thousand by the year 2009.

The Community of Cantwell Inc. has estimated 1985 revenues of $24,000. These revenues are expected to exceed expenditures of $23,000, for a fiscal balance of $1,000. The Cantwell fiscal balance is expected to grow to $40,000 by the year 2009. Revenues and expenditures in Nenana in 1985 were approximately equal at $2.5 million. The baseline Nenana fiscal balance is forecast to decrease steadily to a negative $375 thousand by the year 2009.

(iii) Anchorage and Fairbanks (***)

Anchorage's 1985 estimated revenues of $220 million are expected to exceed expenditures of $219 million for a small positive fiscal balance. Baseline revenues in Anchorage are forecast to increase steadily to $466 million in the year 2009, when they should exceed expenditures of $349 million for a fiscal balance of $117 million.

Fairbanks' 1985 estimated revenues of $21 million are expected to be below estimated expenditures of $31 million for a negative fiscal balance of $10 million. Under baseline conditions, Fairbanks revenues are expected to grow faster than expenditures, causing the negative fiscal balance to decrease and become positive in 1996, growing to $12.7 million by the year 2009.

(iv) School Districts (***)

In 1985, it is estimated that the Mat-Su Borough School District revenues of $51 million would be exceeded by expenditures of $52 million. The slightly negative baseline fiscal balance is forecast to increase to a peak of -$2 million per year between 1991 and 1994, and then decrease and become positive by the year 1997. In 2009, the fiscal balance is forecast to be over $13 million.

The Railbelt School District's 1985 revenues of $3.8 million are expected to exceed expenditures of $3.7 million, for a fiscal balance of about $0.1 million. The district's revenues, expenditures, and fiscal balance are forecast to remain relatively constant throughout the forecast period.

The Nenana City Public School's estimated 1985 revenues of $2.6 million are expected to be below estimated expenditures of $2.8 million for a fiscal balance of $0.2 million. Over the forecast period, expenditures are forecast to increase slightly faster than revenues. As a consequence, the fiscal balance is forecast to continue declining and become negative by 1997. In 2009, the fiscal balance is forecast to be a negative $690 thousand.

(i) Electric Power (**)

The Matanuska-Susitna Borough is served by power from the Matanuska Electric Association (MEA), a cooperative located in Palmer. As of May 1985, the MEA served 23,367 residential and 3,902 industrial and commercial customers in 3,360 square miles of southcentral Alaska. Wholesale power is purchased primarily from Chugach Electric Association's (CEA) natural gas-fired turbines at Beluga and Bernice Lake, as well as from the Alaska Power Administration's Eklutna hydroplant and a small hydroelectric operation at Cooper Lake located on the Kenai Peninsula. The MEA sold about 345 million kilowatt hours of electricity in 1983. The MEA currently has an "all requirements" contract with the CEA. Under this agreement, CEA sells all the power MEA needs, to the extent it can. The Municipality of Anchorage is served by two utilities, the Anchorage-Municipal Light and Power Department and Chugach Electric Association. The Fairbanks-North Star Borough and the communities of Nenana and Healy (outside the borough) are served by Golden Valley Electric Association, Inc. (GVEA). GVEA also provides a small amount of power to the City of Fairbanks whose primary supplier is the Fairbanks Municipal Utilities System. As of January 1985, Cantwell has access to electric power via an Alaska Power Authority intertie substation. Exhibit B, Volume 2A, Chapter 5, provides detailed information on Railbelt electric systems.

2.2.2 - Regional Impact Area (**)

Recent trends in the population, employment, and per capita income of the Regional Impact Area are discussed below.

(a) Employment (**)

Tables E.5.2.1 and E.5.2.7 present data on nonagricultural employment for the Regional Impact Area. Employment increased by 39 percent between 1970 and 1975, and by an additional 14 percent between 1975 and 1979. Employment in 1985 is estimated to be over 179,000, an increase of 40 percent over 1979. By the year 2009, the peak year of Susitna Project employment, employment is forecast, under baseline conditions, to increase by 34 percent to almost 240,000. Construction, service and support sectors represent large percentages of employment in the region. Employment in the Municipality of Anchorage accounted for 60 percent of Regional Impact Area employment in 1980 and 64 percent in 1984.

(b) Population (**)

Population in the Regional Impact Area rose from 204,523 in 1970 to 284,166 in 1980. The 1985 population estimate is 400,049 and is forecast to increase to nearly 25,000 by the year 2009. The Regional Impact Area contains over 70 percent of the state's population; the majority is centered in the greater Anchorage area. Within the greater Anchorage area, there has been a gradual shift in the relative shares of population that live in the Municipality of Anchorage and in nearby areas. The Kenai and Mat-Su Borough Census Divisions have grown more rapidly than has Anchorage and they now account for 12.5 and 11.0 percent of the Anchorage subarea, respectively.

The population in the Fairbanks subarea is estimated to be 67,435 in 1985 and is projected to be over 90,000 in the year 2009. This population accounts for 17 percent of the Regional Impact Area population in 1985 and is forecast to account for over 20 percent in 2009.

The Anchorage subarea would experience a pattern similar to the Regional Impact Area as a whole; that is, relatively gradual growth, resulting in a subarea regional population of over 420,000 in the year 2009. This population accounts for 83 percent of the Regional Impact Area's population in 1985 and is forecast to account for nearly 80 percent in 2009.

(c) Income (*)

In the Regional Impact Area, personal income on a per capita basis rose from $4,940 in 1970 to $11,243 in 1976 and remained close to that level in 1978. While per capita income figures for the Regional Impact Area were not derived for years after 1978, the Regional Impact Area includes most of the state's population. It can therefore be assumed that since the state per capita income has continued to rise after 1978, Regional Impact Area per capita income also continued to rise.

(d) Housing (**)

The Regional Impact Area is estimated to contain approximately 135,215 households and 162,122 housing units in 1985. Anchorage and Fairbanks represented the largest concentrations of housing in the region.

As shown in Table E.5.2.3, the Municipality of Anchorage is estimated to contain 95,637 civilian housing units in 1985. This number represents an increase of 28 percent over 1980 units. The vacancy rate in Anchorage has in recent years fluctuated from a low of one percent in 1975 to a high of about 13 percent in 1985. The number of units is forecast to increase to over 114,000 units in the year 2009 and the vacancy rate is expected to be about 10 percent.

In the City of Fairbanks, housing stock is estimated in 1985 to be 11,430 units (see Table E.5.2.3). Vacancy rates have risen during the post-pipeline period, but not as dramatically as in Anchorage. The overall vacancy rate rose from a low of 0.4 percent in 1976 to 9.1 percent in 1980 and is estimated to be about 7 percent in 1985. By the year 2009 the number of housing units is forecast to be about 13,650 and the vacancy rate is forecast to be about 7 percent.

2.2.3 - State (**)

Recent trends in the population, employment, and per capita income of the state are displayed in Tables E.5.2.1 and E.5.2.2.

(a) Employment (**)

Alaska's economy has historically been dependent upon development of its natural resources, primarily fisheries, minerals and timber. As a result, employment has been oriented toward these consumptive and extractive industries. The military has played a major role since World War II. In recent years, employment in state and local government has increased dramatically. In addition, employment in service and support sectors of the Alaskan economy is increasing, reflecting the maturation of the state's economy.

Impact of the Trans-Alaska Pipeline is evident in the employment figures shown in Table E.5.2.1. Between 1970 and 1975, pipeline-induced growth caused employment to increase by 75 percent. From 1975 to 1980, however, total employment increased by only six percent. In 1985, Alaskan employment is estimated to be 249,029.

(b) Population (*)

The population of Alaska has risen steadily since the 1940s; yet it is still the least populous state with a 1980 population of nearly 402,000 (ADOL 1985). Alaska's population grew by 32 percent between 1970 and 1980, rising by 50,000 between 1975 and 1976 alone. Most of the population is in the Regional Impact Area described in Section 2.2.2; half of the state's residents lived in Anchorage in 1980.

(c) Income (**)

The average per capita personal income in the state rose from $3,765 in 1970 to $9,554 in 1975. This rapid rate of growth increased through the 1970s and by 1982 had reached $16,598. These figures demonstrate that per capita income continued to rise, even after the completion of the pipeline in the mid 1970s.

3 - EVALUATION OF THE IMPACT OF THE PROJECT (**)

Portions of this section are organized differently than they were in the License Application of February 1983. The reorganization is, in part, necessary to reflect the revised definition of the Local Impact Area. This area now contains additional jurisdictions, each requiring detailed analysis. The reorganization also introduces an additional construction stage i.e., Watana - Stage III.

Several sections are shortened and one is eliminated to reflect refinements in the socioeconomic model that occurred since the License Application was submitted to FERC. These refinements are discussed in the model's documentation report (FOA 1985a). In general, the socioeconomic model refinements reflect changes in assumptions that: 1) make it more consistent with the Institute for Social and Economic Research (ISER) MAP Model; 2) simplify assumptions about the project's labor mix and its change over time; 3) change assumptions to reflect Alaska's maturing economy; and 4) incorporate information gained from surveying selected Local Impact Area communities in 1983 and 1984.

Finally, Section 3.5.2 has been shortened to reduce the overlap with the detailed analysis of fish and wildlife resources in Chapter 3. Section 3.5.2 now concentrates on business activities that are dependent on these resources and subsistence activities. Detailed information contained in Chapter 3 about harvests, success rates, and changes in the density of species are only referenced. In addition, detailed recreational activity information contained in Chapter 7 is also only referenced in Chapter 5.

Tables E.5.3.1 through E.5.3.13 present a forecast of project impacts on the Local Impact Area and on the Regional Impact Area. Emphasis is placed on 1997, 2003, and 2009, peak years of construction for each stage of the Project. Though these years are the construction activity peaks, they are not necessarily the years of peak in-migration for some jurisdictions. The peaks sometimes shift because of the balance between in- or out-migrating direct and support workers. In general, jurisdictions that are primary relocation choices for direct workers (Mat-Su Borough communities and Yukon-Koyukuk CD communities) have peak in-migrations that correspond to peak construction activities. Jurisdictions that are primary relocation choices for support workers (Anchorage and Fairbanks) do not have that correspondence. In most cases, the difference between in-migration peaks and construction activity peaks do not create differences in the magnitude of impacts on jurisdictions. Therefore, Tables E.5.3.1 through E.5.3.13 will use construction activity peaks but the text will note significant variation in impacts caused by a different in-migration peak.

Project impacts were evaluated by comparing projected conditions without the Project (i.e., baseline conditions) to anticipated project-induced changes. Baseline conditions were projected to put changes due to the Project into perspective, and to estimate when threshold levels of public facilities and services (i.e., levels of population at which additional facilities are required) would be reached as a result of cumulative impacts of other projects plus the Susitna Project.

3.1 - Impact of In-migration of People on Governmental Facilities and Services (**)

3.1.1 - Introduction (**)

In the following sections, the anticipated impacts of the Project on key public facilities and services in the Local Impact Area are discussed. Information is given on the impacts of both the population influx associated with the direct construction work force and the in-migrating population associated with support workers (i.e., workers employed by private suppliers of equipment or materials for the Project and workers employed by service industries whose increase in business is related to increased demands for goods and services by construction workers). The population influx includes workers and their dependents for all project facilities (including the dams, access roads, railhead and transmission lines).

In general, the impacts of the Project on local facilities and services would be mitigated by the provision of worker housing and associated facilities and services at the work sites. Thus, impacts on nearby communities would be limited primarily to effects related to direct and support workers who choose to relocate their permanent residence and families to those communities. In addition, there would be a minor amount of economic contraction in the Local Impact Area as construction of each stage of the Project is completed. This small contraction would be due to the buffering effect of the expected continued increase of the population that would occur as a result of other projects and continued suburbanization of the southern Mat-Su Borough.

3.1.2 - Methodology (**)

The following is (a) an overview of the approach to conducting the impact assessment; (b) an overview of the impact (accounting) model; and (c) an elaboration of several assumptions used in the impact model. Further information can be found in Frank Orth and Associates (1984b, 1985a).

(a) Approach (***)

After the impact areas were defined, and as a precursor to making baseline forecasts, recent and current socioeconomic conditions were analyzed. These included employment, population, housing, public facilities and services, local governments' budgets, land use, and other socioeconomic elements. Baseline forecasts were then made for selected socioeconomic elements. A brief description of the forecasting techniques used for the years 1985-2010 is:

ELEMENT	FORECASTING TECHNIQUE
EMPLOYMENT	
State and Regional	Time-series economometric[1/]
Census Division	Linear regression
POPULATION	
State and Regional	Time-series econometric[1/]
Census Division	Linear regression
Community	Population Share (judgemental)
HOUSING	
Regional and Census Division	Person per household trend multiplier
FACILITIES AND SERVICES	
Census Division and Community	Per capita planning standards
FISCAL	
Census Division and Community	Per capita multiplier

Next, impact forecasts were made. An "accounting model" was developed to handle the several labor categories and geographic disaggregations. This model was computerized to provide for efficient analysis and to make sensitivity analysis feasible. Techniques used for the impact forecasts for 1985-2012 are:

ELEMENT	FORECASTING TECHNIQUE
EMPLOYMENT	
State, Regional and Census Division	Gravity Model Accounting Model
State and Regional	Time-series econometric[1/]
POPULATION	
State, Regional and Census Division	Accounting Model
State and Regional	Time-series econometric[1/]
HOUSING	
Regional and Census Division	Person per household trend multiplier

ELEMENT (cont.) | FORECASTING TECHNIQUE (cont.)

ELEMENT (cont.)	FORECASTING TECHNIQUE (cont.)
FACILITIES AND SERVICES	
Census Division and Community	Per capital planning standards
FISCAL	
Census Division and Community	Per capita multiplier

Baseline and impact forecasts were compared and contrasted to identify project-induced changes in the base case. Next, the changes were analyzed and discussed.

(b) Impact Model (***)

A model was developed that could take into account settlement and travelling/commuting patterns of construction workers. It was specified to allow for in-migration and out-migration of workers and their dependents for each Local Impact Area Community. These elements were emphasized because they will be the source of most of the project-induced changes. The model was computerized to make calculations more quickly and to allow for sensitivity analysis.

(c) Assumptions (***)

The projections of population influx associated with the Project rely on several important assumptions regarding work force characteristics, distribution of workers' settlement, and policy decisions related to the Project. Population influx estimates were calculated by using the following assumptions.

(i) Baseline Population Projections (**)

Population projections were made using percentage growth measures developed by examining growth trends over the past 15 years and modifying them to reflect the probability of growth in the future. These projections relied to a large extent on projections made by ISER of growth in the state, the Railbelt, and the Anchorage and Fairbanks subareas (Goldsmith 1985).

1/ Includes results from Institute of Social and Economic Research's Man-in-the-Arctic Model.

(ii) Population Influx Associated with the Direct Work Force (**)

It was assumed that 90 percent of the direct workers who would in-migrate to the Local Impact Area communities would be accompanied by dependents. Since housing would be provided onsite, there would be little incentive for most single workers to establish a residence in a nearby community. On the other hand, in-migrating direct workers with families who cannot obtain family housing onsite would be likely to seek housing for their dependents in the Regional Impact Area. It should also be noted that a large percentage of the work force for this project would be skilled tradesmen. According to worker surveys, skilled tradesmen are more likely to have families than are unskilled construction laborers.

An assumption of 2.3 dependents per accompanied construction worker was used to calculate the population influx associated with the direct work force. This figure is an average derived from a survey of construction projects throughout the United States U.S. (U.S. Army Corps of Engineers 1981). While the resulting population-per-household figure (3.3) differed from the household size projected for the state of Alaska, the 3.3 number was used since construction workers often have characteristics slightly different from the population as a whole.

Further explanation of the methodology used to determine the number and distribution of in-migrating direct workers can be found in the socioeconomic model documentation report (FOA 1985a).

(iii) Population Influx Associated with the Support Work Force (*)

To calculate the population influx associated with the support work force, the population-per-household numbers projected for the state under baseline conditions (declining at a constant rate from 2.829 in 1988 to 2.657 in the year 2000) were multiplied by the estimated number of in-migrating support workers. It was assumed that these workers would have the same general demographic characteristics as present residents.

The population-per-household estimates were derived from a study done by ISER to project electricity demand in the Railbelt. In the ISER model, the average number of people per household was estimated to decline by 20 percent over the next 20 years and was consistent with the projected national decline in the number of persons per household (Goldsmith 1985).

Further explanation of the methodology used to determine the number and distribution of in-migrating support workers can be found in Section 3.3.

(iv) Public Facilities and Services (*)

Public facility and service impacts were estimated using the following approach: (1) appropriate per capita standards were developed; (2) the adequacy of existing facilities and services were assessed; and (3) estimates of future needs related to baseline growth and to project-induced population influx were compared with present and planned capacities. Details of the methodology used can be found in the socioeconomic model documentation report (FOA 1985a). Literature reviewed in the course of this work included Anderson and Chalmers (1977), Burchell and Listokin (1978), Leistritz and Murdock (1981), and Stenehjem and Metzger (1980).

3.1.3 - Watana - Stage I Construction (***)

The facilities and services impact discussion presented in this section is grouped by Local Impact Area jurisdiction, including the Mat-Su Borough, selected Mat-Su Borough communities, selected Yukon-Koyukuk communities, Anchorage and Fairbanks, and by the Regional Impact Area. Specific impacts to communities or regions are presented by type of facility or service. This organization differs from the organization of the supporting tables which summarize impact data. That is, the tables show facilities and services impacts by community and region. The year 1997 is emphasized in the analysis since it is the year of peak construction activity. The peak year for in-migration is sometimes different because of support worker movement. When the peak in-migration year shows impacts significantly different from those for the peak construction year, the impacts will be discussed.

(a) Local Impact Area (***)

(i) Mat-Su Borough (***)

Tables E.5.3.1 through E.5.3.8 (population/facility/service impacts on the borough and its communities and project impacts on traffic and accidents) summarize the data referred to in this subsection.

As shown in Table E.5.3.1 and compared to the 1984 population of 34,118 the project-related population influx to the Mat-Su Borough as a whole would be small. Table E.5.3.2 summarizes the slight effect this project-related population would add to the substantial increases in the need for public facilities and services that would result from the population growth projected under baseline conditions. In contrast, the larger project-related population increase in Talkeetna would have greater impacts on the need for public facilities and services (See Table E.5.3.3). These impacts are discussed in detail in the sections that follow, along with population and facilities and services impacts to other affected borough communities.

- Magnitude of Population Influx (***)

  As a result of construction of the Project, the population of the Mat-Su Borough would be expected to increase by about 5 percent (2,873) in 1997, including new onsite and offsite residents. It is forecast that 374 people would resettle in borough communities by 1997. Of this offsite in-migrant population, approximately 50 people (13 percent) would be direct workers and their families, and about 324 (87 percent) would be support workers and their dependents. As shown in Table E.5.3.2 the new offsite population would represent an increase of about 1 percent over baseline population projections for 1997, and would result in a total borough population of 53,680 in that year (excluding the work camp and village). The in-migration peak for the borough occurs in 1998, when 2,934 (onsite and offsite) borough residents would be associated with the Project. Nearly 750 of these people would live offsite, causing the borough population to increase by 1 percent.

  The Susitna Project would be only one of several factors contributing to the borough's projected rapid rate of growth during the 1990-1998 period. With construction of the Project, population in the borough would increase by about 14,117 between 1990 and 1998 of which approximately 13,325 would be related to baseline growth and 792 would be project-related. Spillover growth from Anchorage is expected to be one of the most important factors behind the borough's baseline growth.

The project-related population influx into the incorporated communities of Palmer and Wasilla is expected to be small between 1990 and 1997. During this period, the Project would result in an increase of approximately 40 people in Palmer and about 45 in Wasilla (106 and 117, respectively, in 1998). About 23 percent of the in-migrant population in the borough is expected to settle in the two communities. The remainder would probably establish homes in unincorporated borough areas.

After its peak in 1997, the direct project-related population in the borough is expected to decline along with a decline in the work force at the Watana damsite. Overall, however, the population of the borough is expected to continue increasing throughout the life of the Susitna Project.

As shown in Table E.5.3.1, Talkeetna is the only borough community to have peak impacts sufficient to increase its population to at least 10 percent above baseline in 1997 or 1998. Talkeetna's with-project population in 1997 is forecast to be 532, a 15 percent (71 people) increase over baseline.

Table E.5.3.1 also shows the lesser population effects in 1997 for Trapper Creek, Palmer, Wasilla, and Houston. Trapper Creek's forecast for 1997 is 358, an 3 percent (11 people) increase over baseline. Palmer, Wasilla, and Houston are forecast to have minor (1 percent) peak population impacts in 1997. Palmer is forecast to have a population of 4,282, a 1 percent (40 people) increase over baseline. Wasilla's forecast population of 9,129 is 45 people over baseline and Houston's forecast population of 2,572 is 21 people over baseline.

These five borough communities account for about 50 percent (188 people) of the off-site population impacts of the Project on the borough. The remaining 50 percent would be dispersed among rural/remote (29 people) and suburban (157 people) areas of the borough.

- Water Supply and Sewage Treatment (***)

Water supply and sewage treatment needs of the on-site project residents at the Watana site would be provided by project contractors. Thus, there would be no impact on Mat-Su Borough water supply and sewage treatment facilities from on-site residents.

The population influx associated with in-migrating workers who establish residences in the borough would have only a slight impact on the public water and sewage systems. The community receiving the heaviest impacts, Talkeetna, is not served by public water or sewage facilities, nor are Trapper Creek and Houston. In Palmer, however, water consumption at the peak of construction of Watana-Stage I (1997) would rise by 1 percent over the baseline projection of 629,602 gpd. Water usage requirements in Palmer were projected using the average daily water consumption per capita in 1984, based on the total daily consumption rate of 400,000 gallons. Based on this standard, the baseline and with-project population would utilize 62 percent of Palmer's water service capacity in 1997.

Wasilla's water consumption under with-project conditions would exceed baseline consumption by less than 1 percent in 1997. Since the existing water supply would become inadequate in 1992 even without the Project, project impacts would simply increase over utilization of the water supply; e.g., the with-project population would utilize 151 percent of the water supply compared to 150 percent under baseline conditions. Per capita use requirements were based on the community's 1984 average water consumption rate of 500,000 gpd.

As with water supply, Palmer and Wasilla are the only cities that provide sewage treatment. The project-related population influx into Palmer would result in an average increase in sewage treatment requirements that would be 1 percent above the 1997 baseline projection level. The population influx would occur after the time when existing facilities have already reached their limits, and a third sewage treatment cell would be required (with or without the Project). These projections were based on a per capita standard derived from the 1984 rate of community use of 300,000 gpd.

Wasilla's with-project demand for sewage treatment in 1997 is forecast to be less than 1 percent above demand under baseline conditions. This increase means that with-project demand would be 42 percent above current capacity rather than 41 percent under baseline conditions.

- Solid Waste (***)

The solid waste requirements of personnel and dependents living at the construction work sites would be accommodated at the camp and village, and would have no impacts on solid waste facilities in the Mat-Su Borough.

It is estimated that the population influx into borough communities would increase annual landfill needs of the borough by a cumulative amount of 0.5 acres over baseline in 1997. This represents a one percent increase over the baseline projection for that period. This increased demand contributes only slightly to requirements for landfill acreage, which is expected to be utilized at about 51 percent capacity under with-project or baseline conditions. The per capita standard used to analyze demand was based on the 1984 borough yearly use rate of 6.8 acres.

- Law Enforcement (***)

Law enforcement provided by the Project and by the Cantwell State Trooper station can be expected to handle the population at the project site. Although the onsite population would be located in the Mat-Su Borough, the Cantwell station would be the closest law enforcement station by road.

Analysis of project impacts on law enforcement is appropriate for the Mat-Su Borough, Palmer, and Trapper Creek. In the borough, the 1997 requirement for police officers under with-project conditions is 1 percent (one officer) higher than baseline requirements. This requirement, like the baseline requirement, is over 200 percent greater than the current number of officers available. In other words, to serve even baseline forecasts of population at current standards, the number of officers would need to be doubled. With-project demands would require only one additional officer over the number required for baseline conditions.

The number of officers required in Palmer in 1997 does not increase under with-project conditions over requirements with baseline forecasts. With-project and baseline demand therefore becomes 71 percent of the service capability (using 1984 state per capacity levels). Under either condition, no new officers would be necessary.

There are three State Troopers serving the Trapper Creek area. This number far exceeds the 0.4 trooper required to serve with-project and baseline demand forecast for 1997 (using state per capita recommendations of 1 per 1000 population for rural areas).

An average rural standard of one officer per thousand population was used to project law enforcement requirements in the Mat-Su Borough.

- Fire Protection (***)

The project facilities, work camp and villages would be protected from fire by firefighting equipment and personnel at the work sites. Thus, there would be little impact on existing fire protection service areas.

Fire protection in rural areas such as the Mat-Su Borough is more dependent on the distance of facilities from population centers than on population size. Since in-migrants are expected to settle into existing housing or housing on land that is already subdivided, there would be little impact on fire protection facilities in most communities. Firefighters would continue to be, for the most part, volunteers.

- Health Care (***)

The work camp and village at the construction site would provide facilities for health care, including a 20-bed hospital. It is expected that there would be little impact by the project's site population on the Mat-Su Borough's health facilities except in the provisions for major illness or accidents.

The project-related population influx into Mat-Su Borough communities is expected to raise the number of hospital beds needed in 1997 by about one percent (1 bed). Under the baseline or with-project case, the number of beds needed in 1997 is about 280 percent greater than is currently available. Hence, the population influx associated with the Project only adds slightly to increases in the number of beds needed by 1997.

Social impact research has been conducted which suggests that rapid growth in a community and the stress associated with rapid change can result in increases in the incidence of problems such as divorce, alcoholism, child abuse, and suicide. In most parts of the borough, however, increased population due to the Susitna Project would only represent a fraction of the growth and change that are expected to take place. Thus, impacts of the Project on social services in the southern part of the borough are expected to be minimal. In the areas surrounding Trapper Creek and Talkeetna, the need for social services should not become more pronounced since, by baseline standards, growth in these communities is not extraordinary either in amount or rapidity.

- Education (***)

School-age children at the construction site would be educated at facilities that would be built as part of the project facilities but would be operated as part of the Mat-Su Borough School District. It is estimated that by 1997 there would be approximately 300 school children living at the family village. The Applicant would provide sufficient classrooms and teachers to meet Mat-Su Borough School District planning standards.

Within the Mat-Su Borough, there would be project-related effects on schools in the borough as a whole as well as in Talkeetna, Trapper Creek, Houston, Palmer, and Wasilla. In 1997, project effects would create increases in the number of primary students, ranging in magnitude from a high of 13 percent (8 students) in Talkeetna to 2 percent (1 student) in Trapper Creek and about 1 percent in all other schools. In the borough as a whole the increase is also 1 percent (88 students).

Trapper Creek, Palmer, Wasilla, Houston, and Talkeetna are forecast to have excess primary school capacity in 1997, with or without the Project. Overall, however, borough primary schools aside from those at the damsite would exceed the 1984 capacity by nearly 45 percent without the Project and 46 percent with the Project. This forecast is explained by the influx of people under both baseline and with-project conditions into areas outside the above communities, but still within the borough.

In summary, the Project would have no significant effect on primary school in 1997 in Trapper Creek, Palmer, Wasilla, Houston, and Talkeetna. Other borough schools would require a small amount of additional expansion beyond necessary without-project requirements.

For secondary schools, the most important impact is on the borough where existing capacity would be exceeded under baseline conditions in 1988. By 1997, the schools' capacities would be exceeded by 46 percent under baseline and 47 percent with the Project. No secondary school is available in Trapper Creek or Talkeetna, but the number of secondary students living in these communities would increase over baseline in 1997 by 3 percent (1 student) and 15 percent (6 students), respectively. In Houston, Wasilla, and Palmer, there would be increases in the number of students over baseline of one percent. Schools in these communities would not exceed their capacity under with-project conditions.

- Public Recreation Facilities (***)

Chapter 7, Recreational Resources, provides a description of the recreation plan that would be part of the Project. This plan includes provision of recreational facilities at project work camps and villages as well as the development of new recreational opportunities for the public. The intent of the recreation plan is to satisfy recreational demand created by hydroelectric development and to offer compensation for recreational opportunities lost as a result of the development. Chapter 7 also describes the impacts of the Project (both positive and negative) on existing recreational resources in the upper Susitna Basin.

The project-induced population influx into borough communities would represent less than 1 percent of the borough's population in 1997. This additional population would have no measurable impact on the requirements for public recreational facilities in the borough, such as parks, and athletic fields. Available park acreage would easily absorb this low level of additional demand.

Both Wasilla and Palmer have an abundant supply of park lands available, sufficient to satisfy demand by the forecast with-project population. However, both communities would exceed the demand for public playgrounds, even under baseline conditions. The lack of playgrounds is especially critical in Wasilla. The Project would simply add to the over use of these facilities by a small increment.

No park lands or playgrounds are provided by Houston, Trapper Creek, or Talkeetna. Generally, while undeveloped outdoor recreational opportunities are plentiful for residents of these communities, there are few developed recreational facilities.

- Transportation (***)

The Susitna Project includes the construction of a road from the Denali Highway to the Watana damsite, an area that currently has no access. This road would be open to the public upon completion of Watana - Stage I. In addition, the portion of the Denali Highway linking the project access road to the Parks Highway would be kept open year-round, which would provide additional road access during the winter.

Almost all of the Watana - Stage I project-related supplies and equipment would be transported by the Alaska Railroad to Cantwell, and then by truck to the Watana work site. The rail system is currently underutilized and increased project-related revenues are expected to benefit the railroad.

An increase in vehicular traffic on the Parks Highway, the Denali Highway and nearby roads would result, to the extent that workers commuting to and from the site would drive to points where they would utilize project-provided transportation. In general, the Parks Highway is currently only 10 percent utilized, and project-related increases in traffic are not expected to create any adverse impacts.

Projected traffic estimates were developed based on the following assumptions: a single-status camp would be provided for laborers and most of the semi-skilled/skilled workers; a village with family housing facilities would be provided for some of the semi-skilled/skilled workers and all of the engineering/administrative workers who desire it; there would be recreational and other facilities at the work camp and village that would help provide workers with a pleasant environment; the rotation schedule would be approximately two weeks on and one week off, but the number of shifts per day would be unspecified; and most of the work force would travel to and from by transportation provided by the Applicant. (FOA 1985b and FOA 1985d).

Table E.5.3.8 shows the estimated annual average daily traffic (AADT) volumes for important road segments. Projected traffic increases as well as human- and animal-related accidents were also estimated for several segments of the Parks Highway. Results of these analyses are also included in Table E.5.3.8.

The traffic analysis shows that with-project AADT volumes and accidents would increase over baseline by less than 6 percent for any road segments found in the borough. Increases in AADT are insufficient to approach any of the road segments' designed capacities to carry traffic. The additional accidents would not increase accident rates to a level beyond that found in the area now.

(ii) Yukon-Koyukuk Communities (***)

Tables E.5.3.8 through E.5.3.11 (population/facility/service/traffic impacts in Cantwell, Healy, and Nenana) summarize the data referred to in this subsection. In the year 1997, the peak occurs for both project construction activity and in-migration.

- Magnitude of Population Influx (***)

As shown in Table E.5.3.1, Cantwell receives the most relative impacts over baseline (47 percent) of any Local Impact Area community in 1997. Initial impact forecasts for Cantwell were high relative to baseline forecasts (FOA 1984a), indicating that Cantwell housing stocks might not be capable of absorbing in-migrants. An analysis of existing housing, previous housing construction rates, and construction potential was conducted to assess the need to restrict in-migration forecasts in the socioeconomic model. The analysis identified a limit at which in-migration should be diverted from Cantwell to nearby communities (FOA 1985c). A mechanism was inserted into the model to make the population allocation adjustment if these prescribed limits were exceeded (FOA 1985a). The amount of in-migration identified in Tables E.5.3.1 and E.5.3.9 was not sufficient to trigger the reallocation mechanism. In other words, Cantwell housing potential would be sufficient to house the in-migrating population if the housing industry mobilized to construct units at the rate for which it is capable. This high rate of construction would only be likely under favorable financial conditions discussed in the (FOA 1985c) report.

Early in the Project, the largest component of the project-related population influx into Cantwell would be railhead workers for whom single-status quarters would be provided by the Project. After 1992, most impacts would be from workers at the damsites who establish homes in the Cantwell area.

Population forecasts are based on the assumption that single-status housing would be provided for railhead workers. Any in-migrating workers who wish to bring their families would need to obtain other housing in Cantwell or nearby. These workers are included in the projections in Table E.5.3.9.

Railhead construction would result in a rapid increase in population beginning in the summer of 1991 and peaking in the summer of 1992 with 321 and 375 people, respectively. Almost all of this total would be related to the direct construction work force employed at the railhead and to a small number of workers at the Watana site who choose to move their families to Cantwell. The remainder would comprise support workers and their families. The influx would represent about a 166 percent population increase over the baseline population of 226 that was projected for Cantwell in 1992.

After 1992, there would be a sharp decline in the number of workers needed at the railhead. However, as the work force at the Watana site increases, there would be an influx of families for a portion of those workers that would partially offset the decline related to the railhead. It is projected that the number of project-related people in Cantwell could rise in 1997 to about 118, about 47 percent above baseline. Approximately 69 percent of this project-related in-migrant population would be related to the direct work force.

Nenana is forecast to receive minor impacts from the Project, amounting at peak in 1997 to a 1 percent (5 persons) increase in population over baseline forecasts. All of this influx is associated with project support employment. Project impacts would build gradually to this peak level over a six-year period; thus, an abrupt increase in community population is not anticipated.

Healy is also forecast to receive minor impacts from the Project. Over a six-year period, the project-related in-migration gradually reaches its peak of less than 1 percent (3 persons) over 1997 baseline forecasts.

- Water Supply, Sewage Treatment and Solid Waste Disposal (***)

Residents of Cantwell and Healy rely upon individual wells and septic tanks for their water supply and sewage treatment needs. This is likely to continue under either baseline or with-project conditions.

The additional population in Cantwell is not expected to affect the community landfill. Under baseline conditions in 1997, only 30 percent of the landfill's capacity would be utilized. With the Project, the percent of utilization would increase to 40 percent (FOA 1985d).

Nenana provides its residents with water, sewage treatment, and solid waste disposal. Under baseline conditions in 1997, the water system's capacity would be utilized (on a daily average) at about 22 percent. The with-project population would be slightly higher, but would leave the utilization rate at 22 percent. The sewage treatment facility is expected to be over-utilized under baseline conditions by 1989. By 1997, if unimproved, it would be over-utilized at over 150 percent of capacity, with or without the Project.

The current landfill is of sufficient size to easily accommodate demand from either baseline or with-project populations. Both baseline and with-project utilization would be about 4 percent.

- Transportation (***)

The traffic analysis for 1997, which assumes a project-provided worker transportation program, shows that with-project AADT volumes would increase over baseline by five percent or less for all road segments except from Cantwell to the project access road and along the access road. From Cantwell to the access road, AADT would increase from 104 to 202, a 98 percent increase. AADT along the access road is forecast to be 202. Accidents on all project roads are forecast to increase over baseline by six percent or less. An increase in animal kills, almost always moose, is not expected to occur on any of the road segments.

The Denali Highway would be upgraded to handle the increased traffic of an estimated 30 to 35 project trucks a day and use by workers commuting via the transportation program.

Additional snow clearing equipment and labor would be required to serve the Denali Highway and project access road during the winter. Highway maintenance division equipment would maintain these two roads during the spring and summer. The access road's gravel surface would require frequent grading because of heavy truck traffic. The extent of maintenance impacts of servicing the Denali Highway section of the route was examined in terms of resurfacing costs in 1985. The segment of road between Cantwell and the project access road is the only existing segment forecast to require substantial increases in maintenance costs, primarily resurfacing.

A substantial increase in traffic caused by the Susitna Project is expected at the Cantwell intersection of the Parks and Denali Highways. Traffic patterns in this area would need to be monitored to determine necessary traffic control aids.

- Police Protection (***)

There is currently one state trooper and one ADF&G officer at the Cantwell station. Healy and Nenana are each served by one state trooper. The increased population in Cantwell in 1997 and at the damsites would result in an increased need for police protection of approximately three to four officers (based upon average standards of about one officer per thousand population). Provision of police protection at the Watana site by the Applicant would remove the need for additional state troopers at Cantwell. Cantwell and Healy have a sufficient number of officers to serve their 1997 forecast population, either with or without the Project. Nenana's forecast population would exceed what their one officer should serve in 1989, creating slight pressure to increase the number of officers after that year under baseline conditions. By 1997, the need for additional protection becomes more critical for baseline conditions and is insignificantly affected by the addition of project-related population.

- Fire Protection (***)

Increased population is not expected to affect the firefighting facilities in Cantwell, Healy or Nenana. These are planned on the basis of distance between the station and population centers and on the availability of pumped water. The fire halls and equipment should be sufficient to serve these communities as they grow. Adequate water is available from wells, creeks, and lakes to serve the station.

The number of firefighters in Healy and Nenana would be sufficient to serve either baseline or with-project populations. Cantwell would need additional volunteers under with-project conditions. The number of additional volunteers could be as many as 13 in 1991 and 1992, if the current population- to-firefighter ratio is maintained. This would be a short-term need since the population is expected to decrease after railhead construction. By 1997, two or three additional volunteers should be sufficient.

- Health Care (***)

With the exception of an ambulance, no formal health care facilities or social service organizations are currently available in Cantwell. Growth of the community may result in an increased need for emergency medical care. Growth may also help attract some private medical care to the area. Healy and Nenana are both served by clinics. Project-related population increases in Nenana may create the need for expanded hours of operation or additional personnel. Healy's clinic would also require similar expansion of services since it serves its own and Cantwell's population.

- Education (***)

It is estimated that between 36 and 41 school children would be added to the enrollment of the school in Cantwell as result of the project's railhead construction between 1991 and 1992. At the construction peak at the Watana site in 1997, the project-related number of school children in Cantwell is expected to be 28. In the years between 1992 and 1997, the number of project-related students would be less than at peak.

Total enrollment at the Cantwell school (including enrollment expected under the base case and the addition induced by the Project) would thus equal about 81 in 1992 and about 73 in 1997. This would be beyond the capabilities of the existing school in either year, and an addition to the school of up to three classrooms would need to be added to accommodate the increase in enrollment. The present school at Cantwell has capacity for about 55 to 60 children and can handle as many as 75 on a short-term basis. The increase in enrollment would also result in requirements for up to 2 additional teachers, based upon an average teacher-to-student ratio of 15 to 1.

In Healy, the current school system is barely sufficient to accommodate primary and secondary students under the baseline forecast in 1997. With-project population has no effect on either the primary or the secondary school.

In Nenana, the school situation is nearly identical to the situation in Healy. That is, capacity for baseline or with-project secondary students is slightly exceeded, but there would be little effect on this overutilization created by the Project in 1997.

(iii) Anchorage and Fairbanks (***)

Tables E.5.3.12, E.5.3.13 and E.5.3.8, (population/-facility service impacts in Anchorage and Fairbanks and project impacts on traffic and accidents) summarize the data referred to in this subsection.

- Magnitude of Population Influx (***)

The population of the Municipality of Anchorage is forecast to receive an in-migration of about 2,000 people from the Project in 1998 through 1999, all years after Watana - Stage I peak employment. This in-migration represents approximately a one percent increase over baseline forecasts. This 1998 in-migration is the sum of nearly 3,600 support workers and their families moving into the municipality, while nearly 2,400 direct construction workers and their families would out-migrate. Most out-migrating workers would be moving to communities closer to the Project or to the Project site while in-migrants would generally come from outside Alaska. This pattern is expected to continue throughout Watana - Stage I construction. These movements of people to and from Anchorage are much like existing dynamics and are insignificant compared to changes in baseline conditions.

The Fairbanks-North Star Borough is forecast to receive population impacts similar in type and magnitude to Anchorage. Between 1998 and the year 2000, the borough would receive a net in-migration of between 500 and 700 people, about 1 percent over baseline for each of these years. Each year, the net in-migration is the product of direct construction out-migration and support in-migration.

- Facilities and Services (***)

As shown in Table E.5.3.12, the relative increase in population related to the Project is not sufficient in the Municipality of Anchorage (less than 1 percent) to create measurable impacts on any of the facilities and services provided by the municipality. Effects on these facilities and services from baseline population changes are far more important than the small incremental addition in demand related to the Project.

Fairbanks would receive about the same proportional impacts from the Project as would Anchorage, with a 1 or less percent increase over baseline for most of the services provided by the city. This incremental increase is not significant since most services are forecast to have substantial excess capacity in 1997. Of those services not projected to be adequate in 1997 with current personnel, such as police and fire protection, it is baseline demand that provides 99 percent of the utilization.

(b) Regional Impact Area (***)

The population of the Regional Impact Area is expected to increase to approximately 460,222 by 1997, of which only 2,523 in-migrants (or about 1 percent) would be related to the Project. The project-related population increases to its peak of nearly 4,000 in 1998, still 1 percent over baseline. This represents such a small percent of current and projected population in the region, that impacts on facilities and services outside the Local Impact Area communities already examined are expected to be negligible.

3.1.4 - Watana Stage - Stage I Operation Phase and Devil Canyon - Stage II Construction Phase (***)

The Watana - Stage I operations phase and Devil Canyon - Stage II construction phase would occur from 1999 through 2005. The Devil Canyon construction activity occurring prior to 1999 is examined as part of the previous phase. The year 2003 is emphasized in the analysis of this phase because that is the year when the peak construction work force (1,572) and the highest annual average work force (932) would occur. The assumptions used in the projections of socioeconomic impacts in this phase are identical to those used in the previous phase (FOA 1985a) with one exception. An air/bus combination transportation program was assumed for the Watana - Stage I construction phase. After Watana - Stage I, no transportation program is planned since the peak and yearly average work force would be substantially less (about one-half) than in the first phase.

(a) Local Impact Area (***)

(i) Matanuska-Susitna Borough (***)

- Magnitude of Population Influx (***)

Project-induced population is expected to increase by 2,515 (4 percent) in the borough by the year 2003 as construction of Devil Canyon Dam reaches its peak. It is probable that the available work force in the Railbelt, including those who worked on the construction of the Watana Dam, would fill all direct construction jobs. Some secondary population influx would occur as income from Stage II construction is spent. As shown in Table E.5.3.1 only 35 percent (871) of this total population increase would live in the borough outside the construction site (off-site). Nearly 43 percent (377) of the off-site population is related to support employment.

Since the baseline population of the borough would continue to increase while project employment decreases, the relative impact of project-induced, off-site population would be much smaller in the year 2003 than in 1997. In the year 2003, the project-induced population of 2,515 people (including on-site people) would account for only 3.8 percent of total borough population, a 4 percent increase over baseline. The off-site project-induced population of 871 would account for 1.3 percent of the total population.

Project impacts, when considered as a percent increase over baseline, are the same in the year 2003 as in 1997 in all borough communities except Palmer and Trapper Creek where project impacts increase over 1997 figures by 1 percent and 4 percent, respectively. Project impacts by community in 2003 are forecast to be: 87 people (15%) in Talkeetna, 27 people (7%) in Trapper Creek, 116 people (2%) in Palmer, 60 people (1%) in Houston, and 128 (1%) in Wasilla. From 1997 to

2003, the project-related populations in borough communities except Talkeetna are forecast to at least double. Since baseline populations would also continue to increase, populations in Trapper Creek, Palmer, Houston, and Wasilla would continue to grow rapidly. Talkeetna's population would remain more stable.

- Water Supply and Sewage Treatment (***)

  Of the communities forecast to receive measurable project-related impacts in 2003, only Wasilla and Palmer provide water and sewage treatment services. As shown in Tables E.5.3.5 and E.5.3.6, only 2 percent of Palmer's and 1 percent of Wasilla's demand for these services are project-related. The adequacy of these services for either city would not be affected by project-related demand.

- Solid Waste Disposal (***)

  The cumulative landfill acreage needed by the borough in the year 2003 would increase by about 2 acres or 1 percent as the result of project-related population in borough communities. The borough would not need to provide additional landfill acreage based on this demand since total demand represents only about 85 percent utilization of available acreage.

- Police Protection (***)

  The need for law enforcement in the Mat-Su Borough outside Palmer is expected to continue to increase in the late 1990s as the baseline population continues to grow. At the peak of Devil Canyon construction in the year 2003, it is expected that there would be a need for 77 officers in the borough, compared to a projected need for 76 officers under baseline conditions.

  In both Palmer and Trapper Creek, the current number of officers would continue to be sufficient to serve both baseline and with-project population.

- Fire Protection (***)

  The project facilities, work camp and village would be protected by fire fighting equipment and services at the work site. There would be little impact on existing fire service during this period.

- Health Care (***)

  No adverse impact on the borough's health care facilities is expected during this period as a result of the Project since only 2 percent of the total demand comes from project-induced population. This percentage is inconsequential compared to increased baseline demands.

- Education (***)

  As Tables E.5.3.2 through E.5.3.7 show, the percentages of increase over baseline for primary and secondary students are at about the same level as overall population increases. These increases range from a high of 14 percent (11 primary students) in Talkeetna to a low of only 1 to 2 percent (21 primary and 18 secondary students) in Wasilla. By 2003, baseline and with-project forecasts exceed capacities in Trapper Creek, Wasilla, and Houston. Under baseline conditions, the size of the Trapper Creek primary school would be adequate until the year 2000. Wasilla primary and secondary schools would be adequate until 2001 and 2005, respectively, and Houston primary schools would be adequate until 2002.

  Baseline and with-project demand created the earlier need (see Section 3.1.3(a)) for expansion of educational facilities. The continued increase in baseline demand for facilities indicates that the earlier expansion should provide the kind of facilities appropriate to meet long-term demand for some borough schools but would be insufficient for others. The major portion of the demand would continue to come from baseline population increases, especially in the Palmer-Wasilla area.

- Transportation (***)

Stage II would include construction of a railroad spur from Gold Creek to the Devil Canyon damsite. Additional effects on borough transportation systems would occur from AADT volumes and traffic accidents. However, these effects would continue to be minor and at levels similar to those which occurred in 1997 (see Section 3.1.3(a)).

(ii) Yukon-Koyukuk Census Division Communities (***)

- Magnitude of Population Influx (***)

Upon completion of Watana - Stage I, out-migration from the Cantwell area occurs. The initial out-migration of 108 people would occur between 1997 and 2000 before a minimal in-migration between 2000 and 2003 brings the population to 294 people (5 percent or 13 people over baseline).

In the year 2003, with-project populations in Nenana and Healy are estimated at 1,310 and 1,140, respectively. These represent a 5 percent increase in Nenana and 2 percent increase in Healy over baseline levels. These population figures are higher than those in 1997 because there were few project-related people in the communities in 1997, baseline increases continued, and no project-related out-migration occurred.

- Impact on Public Facilities and Services (***)

The project's impacts on community facilities and services in Cantwell, Healy, and Nenana are shown in Tables E.5.3.9 through E.5.3.11.

The decline in population in Cantwell associated with the completion of Watana - Stage I would have the most relevance to capacity utilization of the school. It is expected that the number of project-related students enrolled in the school would decline by about 14 upon 1999 completion of Watana Stage I. To the extent that additional classrooms are used to accommodate the Stage I peak number of students, there may be some overcapacity to meet demand requirements of Stage II. It is expected that potential problems can be avoided through careful planning and communication about the Project (see Section 4 on mitigation measures).

In Nenana and Healy , the Project would not seriously affect the timing or sizing of facility and service expansion. Nenana's primary school, secondary school, sewage treatment, and law enforcement services would need expansion under baseline conditions as would similar facilities and services in Healy. The with-project population would have only small incremental effects on the size of these expansions.

(iii) Anchorage and Fairbanks (***)

- Magnitude of Population Influx (***)

In the Municipality of Anchorage, in the year 2003, the with-project impact population is forecast to be 882 (less than 1 percent) higher than under baseline conditions. This increase, like that of the preceeding 4 years, is due to a larger in-migration of support workers than an out-migrating of direct workers. The in-migration peak for Stage II occurs in 2002, but the 1,048 in-migrants in that year do not change the magnitude of impacts on Anchorage.

In the year 2003, project-related population in the Fairbanks-North Star Borough is forecast to be 577 people (1 percent) higher than the baseline forecast. Though the in-migration peak in 2001 is greater than in 2003 (657 people), the effect on the borough is still minimal. These numbers are slightly more than they were in 1998, the previous in-migration peak. The migration pattern seen in Anchorage is also evident in the Fairbanks-North Star Borough, i.e., a larger in-migration of support workers than out-migration of direct workers.

- Impact on Public Facilities and Services (***)

As shown in Tables E.5.3.12 and E.5.3.13 the impact population demand in Anchorage and Fairbanks never amounts to more than one percent over baseline for any facility or service. These effects are insufficient to warrant changing the size or schedule for facility and service expansion. By the year 2003, most Anchorage and Fairbanks facilities and services would require expansion even without the Project.

(b) Regional Impact Area (***)

The population of the Regional Impact Area is expected to increase to approximately 492,000 by 2003, of which only 3,487 in-migrants (or about 1 percent) would be project-related. The peak project-related population increase of 3,807 (in 2001), is also only 1 percent over baseline. This represents such a small percent of current and projected population in the region that impacts on facilities and services outside the Local Impact Area already examined would be negligible.

As a result of the relatively small population influx (less than 1 percent over baseline) into the Regional Impact Area and the large projected baseline population increase, no measurable impacts on public facilities and services in the region outside the Local Impact Area are expected during the Devil Canyon - Stage II.

3.1.5 - Watana - Stage I and Devil Canyon - Stage II Operation Phases and Watana - Stage III Construction Phase (***)

This phase would occur from the year 2006 through 2011, with peak construction activity occurring in 2009. Emphasis is on the project's impacts in 2009 since this is the year of the peak direct work force and highest yearly average direct work force. All assumptions used in the preceeding phase (FOA 1985a) are continued for this phase.

(a) Local Impact Area (***)

(i) Matanuska-Susitna Borough (***)

- Magnitude of Population Influx (***)

The peak population influx into the borough (offsite) for Stage III would be in the year 2009. Even though the project-related population (1,178) in the borough would be slightly higher than it was in the year 2003 (the peak year for Stage II), the baseline population would have grown to the point that the project-related influx would represent an increase over baseline of only 2 percent.

Communities within the borough would also experience relatively low population increases related to the Project: 8 percent (39 people) in Trapper Creek; 5 percent (36 people) in Talkeetna; 3 percent (174 people) in Palmer; 1 percent (184 people) in Wasilla; and 1 percent (89 people) in Houston. The increases over baseline are slightly more in some communities but less in others than they were for the Stage II peak (see Section 3.1.4).

- Impact on Public Facilities and Services (***)

In the year 2009, project-related impacts on facilities and services in the borough range from 1 percent (parks,police, and solid waste) to 2 percent (schools and hospital beds) in Stage III. These impacts are insufficient to affect facility and service expansion requirements caused by substantial increases in the baseline population (19 percent in the previous 5 years). Project-related changes (off-project site) would result in the need to expand landfill acreage three years earlier, add one additional police officer, add 8 classrooms for primary and 8 for secondary schools, and add 13 primary and 11 secondary teachers. Any expansion based on this peak demand should be done with the knowledge that project-related demand would disappear three years later.

As seen in Tables E.5.3.5 through E.5.3.7, project-related demand for facilities and services in Palmer, Wasilla and Houston do not exceed 3 percent over baseline. In Trapper Creek and Talkeetna, the project impacts on the primary schools would be slight. No other impacts on Trapper Creek or Talkeetna are discernible (Tables E.5.3.3 and E.5.3.4).

(ii) Yukon-Koyukuk Census Division Communities (***)

- Magnitude of Population Influx (***)

During Stage III, Nenana and Healy would receive a similar magnitude of project impacts as occurred in the peak of Stage II. Project-related population would be about 6 percent (94 people) in Nenana and 2 percent (26 people) in Healy.

The project-related population increase in Cantwell in Stage III is above the level for the year 2003, but is far short of the railhead construction peak in 1992 or the 1997 construction peak. The increase over baseline would be 22 percent (69 people).

- Impact on Public Facilities and Services (***)

Project-related impacts on Healy's facilities and services are not expected to exceed eight percent for any category during Stage III (Table E.5.3.11). Healy's schools would be operating at or beyond capacity without the Project. The addition of five primary and four secondary students would not affect the timing or magnitude of required expansions.

In Nenana, project-related population may affect the size of expansion for the primary and secondary schools. Even though expansion would be necessary under baseline condition, project impacts may create the justification for one teacher and one classroom, in addition to baseline requirements, for each of the two school levels.

Cantwell's with-project population would not affect the adequacy of solid waste acreage or requirements for police protection. It would, however, require at least one additional teacher and classroom until the year 2011.

Increased traffic, particularly on the Denali Highway between Cantwell and the project access road, would result from the construction of Stage III. For this road segment AADT volume would increase over baseline by 96 percent, the highest increase since Watana - Stage I construction. Increases would also occur on Parks Highway segments around Cantwell; however these increases would only represent a one or two percent change. Increases in accidents and animal road kills would not be expected to rise substantially.

(iii) Anchorage and Fairbanks (***)

- Magnitude of Population Influx (***)

In the year 2009, the project-related population influx into the Municipality of Anchorage and the Fairbanks-North Star Borough would be insignificant. The increase over baseline is forecast to be 876 people (less than one half of 1 percent) in

Anchorage and 622 people (about 1 percent) in the Fairbanks-North Star Borough. These increases are, as in previous peak years, the product of direct employment out-migration and a higher level support employment in-migration. Support workers would continue to in-migrate even after direct workers begin out-migrating, causing project-related population to be as high or higher for several years after peak construction activity in these two jurisdictions.

- Impact on Public Facilities and Services (***)

As shown in Tables E.5.3.12 and E.5.3.13, these relatively small impacts on population are hardly measurable as an increase in facility and services demand. The demand increases are not important in light of increases in demand from the baseline population.

(b) Regional Impacts (***)

As a result of the relatively small population influx (approximately 1 percent over baseline) into the Regional Impact Area and the large projected baseline population, no measurable impacts on public facilities and services in the region outside the Local Impact Area are expected during the Watana - Stage III construction.

3.1.6 - Watana - Stage I, Devil Canyon - Stage II, and Watana - Stage III - Operation Phase (***)

(a) Magnitude of Population Change (***)

There would be some expected out-migration of population from the Local Impact Area as construction of Stage III is completed. However the effect of this out-migration on community population is expected to be minimal since the off-site population influxes during Stages II and III were not large, and they kept out-migration low. Additionally, in years of out-migration after Stage III's peak, baseline population is expected to keep increasing, thereby resulting in all communities (except Trapper Creek and Cantwell) to show yearly population increases from the year 2009 to 2012.

In Trapper Creek, the balance of project-related out-migration and baseline increases would cause the population to grow slowly from the year 2007 to 2011. During the year 2011, growth in population would reach a level higher than experienced during any of the impact years, then decrease in 2012.

Cantwell is forecast to have an out-migration of about 60 people during the years 2011 and 2012. The baseline growth during these years would only offset a portion (about 10 percent) of this loss. After the year 2012, Cantwell is expected to gradually increase in population, but would not be expected to regain the year 2009 levels until several years beyond the forecast period.

(b) Impact on Public Facilities and Services (***)

Since none of the Local Impact Area communities, except Talkeetna, Trapper Creek, and Cantwell, show an interruption in population growth due to project-related out-migration, capacity problems would not be encountered. In Talkeetna and Trapper Creek, the interruption in growth is so minor and short-term that no facility and service capacity problems would be created. In Cantwell, the primary school might exceed demand by approximately one teacher and one classroom. This would not be a burden to the community if a mobile classroom were used through the year 2011 and then removed when no longer needed.

During the operation phase of the Project, most project workers and their families would live in the onsite village where housing and other community facilities would be available. No impacts on public facilities and services in the Local and Regional Impact Areas are expected during this period.

3.2 - On-site Worker Requirements and Payroll, by Year and Month (**)

3.2.1 - Worker Requirements (**)

Table E.5.3.14 shows the projected monthly average number of onsite construction and operations workers for the Watana and Devil Canyon Dams from 1991 through 2011. These estimates include all workers required for the construction of the access road and camp/village, power facilities, and transmission facilities, and all management and administrative personnel. Labor for offsite activities such as procurement, manufacturing, shipping, and a portion of the engineering staff are not included in these estimates.

For the construction period, the work force is divided into laborers, semi-skilled/skilled workers, and engineering/administrative employees. As shown in Table E.5.3.14, the peak demand for labor occurs in 1997 with an estimated peak construction work force of 2,946, 89 percent (2,625) working on Watana - Stage I and the remainder working on Devil Canyon - Stage II. The work force would be an average 1,936 during that year.

The Watana Dam would be constructed in two stages, with an ultimate generating capacity of 1,020 MW. Most of the first stage construction activity would be completed in 1998. The additional stage would be completed by 2011. Nearly 90 people would be required to operate Watana - Stage I and support facilities.

Analysis of construction labor requirements for the 600 MW Devil Canyon - Stage II dam is based on construction of access facilities beginning in 1996 and site facilities construction beginning in 1998. This dam would come on-line in 2005. The work force requirements would peak at 1,572 in the year 2003. The average work force for that year would be 932. The total onsite operations work force for both dams would equal a little over 90 during 2005 and thereafter until Watana - Stage III is completed. During part of 1996 and through 1999, construction activities related to both dams would occur.

Watana - Stage III would require a peak work force of 1,510 in 2009, assuming 2006 is the year for starting construction. The average work force for that year would be 1,015. Work on Stage III would not overlap with the construction of Devil Canyon - Stage II.

It is apparent from Figure E.5.3.1 that the first stage of the Watana Dam requires a substantially greater number of workers than either the second stage of Watana or Devil Canyon. This difference can be attributed to the additional labor requirements in the initial years for construction of the work camp and village, the access road, and to the more labor-intensive nature of a gravel-fill dam (Watana) than a concrete thin arch dam (Devil Canyon).

3.2.2 - Seasonality of Labor Requirements (**)

The demand for labor would vary during any given year. Figure E.5.3.1 shows the distribution for the three peak years of 1997, 2003 and 2009. Labor requirements rise from lows in November through February to peaks during May through October. Labor requirements would be between 10 and 20 percent of the peak during December and January for these years.

Table E.5.3.14 shows the construction and operations labor requirements by month and year. The figures in this table were derived during the project cost analysis conducted in 1985. All labor categories used in the analysis were combined into Table E.5.3.14.

It is clear from Table E.5.3.14 that a substantial number of workers would not be employed on the Project for several months each year. During months when labor demand is low, it is likely that a substantial portion of the peak annual work force would return to their permanent residences. Some workers might travel to another job for which they have already been hired. Some workers, who do not already have non-project-related jobs during this low-demand period, may seek employment while based at their permanent residences; others might not seek work for a period of time.

3.2.3 - Project Effects on Unemployment (**)

The effects of the Project on unemployment rates and levels in the region and communities of the region are difficult to predict. The increased availability of jobs may lower both unemployment rates and levels; however this might not be the case. It must be kept in mind that it is not solely the number of jobs available that determines unemployment. The number of job seekers relative to the number of jobs available is the main determinant of unemployment.

A report published in 1985 (Harza-Ebasco 1985f) estimated the Project's effect on unemployment, for the Regional Impact Area (the railbelt) and for the Anchorage and Fairbanks subareas of the railbelt. The report's conclusion is that the Project would generally create modest decreases in net unemployment during periods of rising construction activity and increase net unemployment by a similar amount following the peak construction periods. The decreases in unemployment at peak would be about 1.0 percent for the Anchorage subarea and over 1.5 percent for the Fairbanks subarea. These same subareas would experience increases in unemployment after construction peaks of about .5 percent and 1.0 percent, respectively.

3.2.4 - Payroll (**)

Payroll is the source of impacts resulting from direct onsite construction and operations work force expenditures. Based on the above onsite construction and operations labor requirements, the total yearly project payrolls from 1991 to 2011 were derived and are shown in Table E.5.3.15. These totals were determined by matching wages to respective labor categories used to estimate the monthly labor requirements in Table E.5.3.14. It was assumed that for laborers and semi-skilled/skilled workers, there are 1,825 worker hours per year (54 hours per week and an average of 29 weeks per year) and for administrative, engineering and operations/maintenance personnel, these are 2,496 working hours per year (48 hours per week and 52 weeks per year).

Wage rates for laborers and semi-skilled/skilled workers were obtained from the Alaska Department of Labor (ADOL). These wage rates are routinely collected by ADOL through industry surveys, and are the workers' Alaskan base rate of pay exclusive of any fringe benefits and prior to standard deductions. Wage rates for engineering/administrative and operations/maintenance personnel were derived from Harza-Ebasco Susitna Joint Venture detailed cost estimates and are the workers' Alaskan base rate of pay exclusive of any fringe benefits and prior to standard deductions. In all labor categories, wage rates used in computing on site payroll do not include such added benefits as travel allowances, housing allowances, and other highly variable items.

The construction payroll in 1997, the peak year of construction for Watana - Stage I, would total $190.0 million. The peak for Devil Canyon - Stage II (in 2003) would be $91.4 million and for Watana Stage III (in 2009) would be $99.6 dollars. All payroll forecasts are in 1985 dollars. Table E.5.3.15 shows payroll by year and month for construction workers and by year for operations workers.

3.3 - Residency and Movement of Project Construction Personnel (**)

The principal objectives of this section are to provide (1) a statement of and rationale for the assumptions used to project the residency and movement of workers and the resultant population influxes and effluxes, and (2) an overview of the results of these projections. This is done by discussing probable geographic sources of direct workers, residency and movement of direct workers support employment generated by the direct construction work force, and dependents associated with in-migrating workers. In this context, support employment includes workers employed by private suppliers of equipment or materials for the Project and workers employed by service industries whose increase in business is related to increased demands for goods and services by construction workers.

Estimations for several elements of the work force were made, including: (1) number of workers that would reside in the region at the beginning of the construction at Watana; (2) number of workers that would relocate their residences within or to the region; and (3) number of workers that would maintain their residences within the region after project construction ends. Estimates of population influxes and effluxes for major jurisdictions in the region are also included.

Assumptions and methods used in the analysis are discussed throughout this section, but details are contained in Socioeconomic Model documentation reports. (FOA 1984b, 1985a). Sources reviewed that contributed substantially to the development of assumptions and methods include U.S. Army Corps of Engineers (1981); Denver Research Institute (1982); Metz (1981a); Metz (1981b); Holmes & Naver (1981); University of Alberta (1980); and Harza-Ebasco (1985b).

3.3.1 - Regional Impact Area (**)

(a) Geographic Sources of Workers (**)

Most of the labor for the project's construction would be supplied from within the Railbelt. The percentage of jobs that could be filled by the regionally available work force is assumed to be 100 percent since the small number from other origins has no significant consequences for the forecasting of socioeconomic impacts. Within the region (Railbelt), estimates for employment were made for the Anchorage and Fairbanks subregions.

These subregion estimates reflect a project hiring ratio that reflects the current ratio of Anchorage to Fairbanks work forces - 77 percent in Anchorage to 23 percent in Fairbanks. Using the yearly average work force required in the peak employment year of 1997, 1,936 residents of the region would be employed as onsite construction workers. About 1,491 of these are forecast to be residents of the Anchorage subregion and 445 of the Fairbanks subregion.

The Anchorage subregion consists of the Mat-Su Borough, Municipality of Anchorage, Kenai-Cook Inlet Borough, and Seward Census Division. The Fairbanks subregion consists of the Fairbanks-North Star Borough, the railbelt portion of the Yukon-Koyukuk Census Division, and the Southeast Fairbanks Census Division.

Support employment would originate within the region when labor is available. Since much of the available regional labor is assigned to direct employment, much of the support employment would come from outside the region. At the peak of project construction, over 2,000 employees are expected to in-migrate to the region.

(b) Residency and Movement of Workers (**)

It is expected that workers living in the region before 1991 and becoming employed on the Project during or after 1991 would in some cases move their residences closer to construction sites during the Project. This movement would occur when the closer communities are equally attractive or more attractive than more distant communities. Each community's attractiveness is determined by measuring its availability of housing, commercial services, public facilities and services, land, recreational opportunities and school quality (FOA 1985a). These factors are applied to all direct workers, except at the Cantwell railhead and the transmission lines. Exceptions were made for those workers because they are short-term and, for most of the workers, their work area is at a location other than at the Watana or Devil Canyon Sites. These attractiveness factors and distance from the construction sites are the pull-factors in the computer gravity model used to distribute project impacts.

In years where labor requirements decline from the previous year, it is likely that some workers who relocated would no longer be employed on the Project. This lack of project employment could be temporary or permanent between 1991 and 2011, and permanent after 2011 (to the extent that these workers do not fill the operations jobs). It was assumed that of the workers who relocated, only those would remain at their new residences after the Project's completion if other work is available. This assumption was made to remain consistent with ISER forecasts in the MAP Model. Out-migration, caused by lack of available jobs, would be back to the employees' place of origin, if employment there is sufficient to accommodate employees. If no employment is available at the origin, then migration can be out of the Regional Impact Area or the state (FOA 1985a).

Table E.5.3.16 shows the results of applying the above assumptions to direct workers. It shows in-migration to and out-migration from communities, cities and census divisions by direct workers, all of whom lived in the region prior to obtaining employment on the Project. The socioeconomic model identifies in-migration into the region but does not segregate origin of workers at the community or census division level. The multipliers used to determine the ratio of support workers to direct workers and the rules for assignment to census divisions and communities within the region are detailed in the model documentation report (FOA 1985a).

(c) Relocating Workers and Associated Population Influx and Efflux (**)

Population influx and efflux would result from in-migration and out-migration of direct construction and support workers and their dependents. The numbers of in- and out-migrating workers are shown in Table E.5.3.16.

The total in- and out-migrating population associated with direct and support workers is shown in Table E.5.3.17. The number of in-migrating people was determined by estimating the number of dependents for each category of worker and multiplying that number by in-migrating workers at jobs accruing to each place. These multipliers are discussed in model documentation reports (FOA 1984b, 1985a). During peak of in-migration (1 year after peak construction activities) in 1998, 3,967 direct and support workers and their families would reside in the Regional Impact Area. This total is the product of a large in-migration of support workers and out-migration of direct workers. As labor requirements fluctuate during the remainder of construction, the number of these in-migrants who remain in the area would also fluctuate.

After construction activity is completed in 2011, the percentage of in-migrant direct construction workers who remain in the region gradually becomes nearly zero. By 2012, there are only 63 direct and 491 support workers and their families remaining in the Regional Impact Area.

Within the Regional Impact Area, the settlement of in-migrants is determined by applying the gravity (attraction) factors discussed in Section E.5.3.3.1(b) to direct and support employment and then multiplying by the number of dependents. Migration estimates for all years are shown in Table E.5.3.17.

Table E.5.3.17 shows estimates of total population influx and efflux for selected portions of the Regional Impact Area. Cumulative population influx (net of direct and support) into the region during the three peak direct employment periods (1997, 2003, 2009) equals respectively: 2,526, 3,487, and 3,929. These years are not necessarily peak in-migration years since peak support employment does not always correspond to peak direct employment. Most of the offsite net population influx associated with support work forces would relocate to the Municipality of Anchorage and the Fairbanks-North Star Borough.

It is expected that the Kenai-Cook Inlet, Seward, and Southeast Fairbanks Census Divisions would experience slight out-migrations of population during various stages of construction activity, since out-migration to other areas in the region exceeds in-migration from outside the region. The net totals return to about zero as the construction activities end because a portion of the out-migrating workers and their families are expected to return to their origins.

3.3.2 - Local Impact Area (***)

During the peak construction year at Watana - Stage I (1997), the total project-induced population increase to the Mat-Su Borough (off-site) would total 374. The year of peak in-migration into the borough would be 2009, when 1,178 people would move into the borough. In 2009, this accounts for 28 percent of the total population influx into the region. Most project-related population is expected to leave the borough after 2011.

In 2009, the peak year of in-migration, the northern portion of the borough would experience only 6 percent of the total population influx to the borough with Trapper Creek and Talkeetna each receiving 3 percent of the influx. These projections represent small population increases relative to the baseline forecasts for each of these areas. Palmer, Wasilla and Houston would also experience moderate increases in population, representing nearly 40 percent of the increase in the borough. At the end of construction, total population increases to all borough communities are expected to become nearly zero.

Within the Railbelt portion of the Yukon-Koyukuk Census Division a small portion of project-related in-migration would occur. At peak in 2009, 189 people (5 percent of total regional in-migration) would reside in the census division. Most of these would in-migrate to Cantwell (69 people), Healy (26 people), and Nenana (94 people).

Cantwell represents a special case within the socioeconomic model because it was assigned in-migrating workers outside of gravity-factor rules. This exception was made to account for railhead construction and operations workers and some transmission line construction workers. These workers were assigned to Cantwell because single-status housing would be supplied at Cantwell for the railhead construction workers. Different assumptions were made about local hiring (9 to 10 locals for construction and 43 percent for operations). As a result, peak in-migration into Cantwell was forecast at 321 in 1991 and 375 in 1992. Aside from the assignment of a small number of railhead operations workers and transmission line construction workers, Cantwell receives no other special exemption from gravity factors for the remainder of the project period.

3.4 - Adequacy of Available Housing in Impact Areas (**)

3.4.1 - Watana Stage I - Construction Phase (***)

(a) Local Impact Area (***)

In the following sections, the adequacy of available housing is analyzed by comparing projected future housing availability in the Local and Regional Impact Areas with the demand for housing related to the Project. Housing facilities would be provided at the work camps and family villages for all workers desiring housing and for the families of administration/engineering personnel. (Workers would not be allowed to bring in their own housing to the work site.) In addition, there would be housing provided for construction and operation workers at the railhead in Cantwell. Thus, the probable impacts of the Project on housing conditions in the Local Impact Area would be limited to direct and support workers who choose to move their place of residence into the communities.

Projections of future housing stock in the Local Impact Area were developed based upon the following methodology. The projected growth in the number of households, under the base case, was calculated by dividing population projections of each community by population-per-household measures which were assumed to decline gradually over time to converge with national and state averages. As discussed in Section 3.1, the population-per-household measures were derived from a study done by ISER to project electricity demand in the Railbelt. In the ISER model, the average number of people per household is estimated to decline by 20 percent over the next 20 years and is consistent with the projected decline in the national level of the number of persons per household (Goldsmith 1985).

For communities in the Local Impact Area other than Cantwell, Talkeetna, Healy, Nenana, Wasilla, Houston, and Palmer, housing stock was assumed to increase in direct proportion to the growth in the number of households. For these communities, a more complete analysis was conducted to determine housing supply potential. This potential was determined by identifying supply constraints caused by local contractor participation, local construction capacity, and financial institutions' willingness to finance housing in each community. This analysis is summarized in the Housing and Residential and Commercial Land Use Constraints Report (FOA 1985b).

(i) Matanuska-Susitna Borough (***)

As indicated above, housing would be provided at the project site for all construction workers and for families of administrative/engineering personnel. Nearly all project construction workers are expected to use the onsite housing facilities when on rotation. Many workers would in-migrate to established communities to live during their off-rotation time and provide housing for their families and, therefore, would have impact on the housing market in the Mat-Su Borough.

There would be an impact on the availability of housing in the borough to the extent that workers decide to establish residence in any nearby community. The impact of in-migrating workers (including support workers as well as direct employees) on the housing market in the borough is displayed in Table E.5.3.18. The Watana - Stage I construction period would be characterized by an influx of workers and their families between 1991 and 1998, and fluctuation in in- and out-migration of people from the area after 1998.

A total of approximately 300 project-induced households are expected to settle in the Mat-Su Borough (off-construction site) by 1998, the height of in-migration during Watana - Stage I. Of this number, most would be households of direct project workers. There is projected to be over 4,000 vacant housing units in the borough in 1998, or over 10 times as many units as in-migrant households. With-project vacancy rates would not be lower than 15 percent. Thus, the in-migration is not likely to cause any dislocations in the borough's housing market as a whole. The demand for housing would decrease in 1999, but would increase again in 2000.

The figures above represent an overview of the Mat-Su Borough housing market. Specific impacts can be judged best by looking at the community level.

Vacancy rates in Trapper Creek have been about 26 to 27 percent in 1984 and 1985. In 1984 and 1985, Trapper Creek contained roughly 77 households and 106 housing units. Similar vacancy rates are expected to be the norm in the future, as additional housing is built only to satisfy demand. As Table E.5.3.18

shows, it is projected that the number of households and housing units in Trapper Creek would reach about 150 in 1997 (without the Susitna Project). It is expected that an additional 4 households (8 in 1998) related to the Project would settle in Trapper Creek, if the housing were available. Housing demand in the area would thus increase by 3 percent (7% in 1998).

It is possible that speculative activity prior to the construction peak period would result in additional housing units being available to meet part of the increase in demand. Some families may reside temporarily in cabins or rooms owned by lodges in the area, and part of the housing demands may be met quickly by the purchase of mobile homes or trailers to be used on individual lots or in trailer parks. Mobile homes and trailers are a common form of housing for construction workers. There is a sufficient amount of private land in Trapper Creek to support the expected population influx.

As in Trapper Creek, the availability of vacant housing in the area of Talkeetna has been adequate, with a rate of over 30 percent in 1984 and 1985. In 1984, the housing stock consisted of 168 units, of which 54 were vacant. It is expected that this trend in vacancy rates would continue under baseline conditions, gradually decreasing through 1998.

The population influx related to the Watana construction phase would result in additional demand for housing by about 40 households coming into the area in 1997. Under baseline forecast conditions, about 49 vacant housing units are expected to be available to accommodate this demand. This would reduce the with-project vacancy rate to only 4 percent.

Houston had 361 housing units available in 1984, 112 of which were vacant, for a 31 percent vacancy rate. In 1997, Houston is forecast to have 1,140 housing units, 882 baseline households and 7 with-project households. Under with-project conditions, the vacancy rate would be over 20 percent at peak demand.

In Palmer, there were approximately 1,000 housing units available in 1984. About 922 of these units were occupied, for an 8 percent vacancy rate. The 1997 forecast shows 1,570 units available, 1,451 baseline households and 12 project-related households (40 in 1998), creating a 5 percent vacancy rate at worst.

Wasilla had about 1,300 housing units and 1,193 households in 1984, for a 9 percent vacancy rate. By 1997, the number of housing units is expected to reach over 3,400, the number of baseline households 3,123, and the number of project-related households 11 (44 in 1998). The 1998 with-project vacancy rate is forecast to be 8 percent.

(ii) Yukon-Koyukuk Communities (***)

In 1984, Nenana had 217 housing units, 197 of which were occupied (a 9 percent vacancy rate). With a peak project-related housing demand of only 2 units, neither the number of vacant units nor the vacancy rate is expected to be negatively affected.

Healy had 197 households in 1984. That same year there were 178 households, resulting in a 10 percent vacancy rate. By 1997, Healy is forecast to have 345 units, 313 baseline households, and no project-related households. This with-project condition would not affect the vacancy rate.

In 1984, there were 33 vacant housing units in Cantwell. Some of these could be considered marginal as year-round housing. The number of vacant housing units is expected to remain constant under the base case.

Single-status housing would be provided for workers at the railhead, but not for families of those workers. The demand for housing is expected to increase by approximately 65 households between 1991 and 1992, as result of the Project. This demand would exceed supply by 33 housing units. Since this demand is short-term (2 years), it may be difficult to meet through normal private entrepreneurial activity.

Land availability is currently a minor constraint to growth in Cantwell. Most of the privately owned land in the Cantwell area is owned by the Ahtna Native Corporation. Development of this land for housing for in-migrant households related to the Susitna Project would be subject to Ahtna, Inc.'s appraisal of the economic feasibility of this development.

It should be stressed that all the housing required by single-status railhead workers would be supplied by the project contractor at the railhead in Cantwell. Housing development by Ahtna, Inc. is not necessary for railhead construction. Housing development is likely, however, to affect the decisions of project workers regarding the establishment of residences for their families. Housing development could also be an important variable affecting the amount of growth that Cantwell would experience as a result of railhead construction.

Upon completion of the railhead, the number of construction workers living in Cantwell would decline, as would the demand for housing. Starting in 1995, demand would increase again from incoming families of additional workers at the Watana site. By 1997, approximately 54 project-related households are expected to be living in Cantwell.

Housing shortages would return in 1995. It is possible that speculative activity during the railhead construction peak period might result in additional housing units being available to meet a portion of the increased demand. Part of the housing needs may be met quickly by purchase of mobile homes and trailers to be used upon individual lots or trailer parks. The railhead construction workers who bring families would be more likely to seek rental housing or mobile homes/trailers because of their shorter stay in the area. Entrepreneurial capabilities and attitudes toward risk would be important factors influencing the amount and rate at which housing becomes available. Some families may reside temporarily in rooms owned by lodges in the area, although in the summer these families would potentially compete for rooms with the tourists. It is likely that this increase in demand for housing would lead to increases in land and housing prices.

(iii) Anchorage and Fairbanks (***)

In 1984, the Municipality of Anchorage contained about 94,087 housing units and 82,166 households, for a vacancy rate of 13 percent. The 1997 forecast is for 103,490 housing units and 91,714 baseline households. With the forecast addition of 226 Project-related households in 1997 and 445 in 1998, the vacancy rate would be 11 percent for each year.

In 1984, the Fairbanks-North Star Borough contained 28,352 housing units, 11,349 of which were in the City of Fairbanks. The borough had 23,090 households (19 percent vacancy rate) and the city 10,509 (7 percent vacancy rate). By 1997, the borough is forecast to have 33,880 housing units and 28,762 baseline households. The city's forecast is for 12,860 units and 11,905 baseline households. By adding nearly 250 project-related households (at peak in 1998) to the borough, (almost all located in the city) vacancy rates would be reduced to about 15 percent in the borough and 6 percent in the city.

(b) Regional Impact Area (***)

No significant impacts are expected on housing conditions in the Railbelt outside the Local Impact Area. At the peak of construction of the Watana Stage I (1997), the cumulative number of in-migrant households into the Regional Impact Area is expected to total approximately 1,000 (1,400 by 1998). This represents less than 1 percent of the projected number of households in the Railbelt in 1997 or 1998. Based on assumptions that the housing stock keeps pace with baseline forecast housing demand and vacancy rates average about 15 percent, the estimated number of vacant housing units in the Regional Impact Area in 1997 of over 27,000 would be more than sufficient to accommodate the in-migrants.

3.4.2 - Watana - Stage I Operation Phase and Devil Canyon - Stage II Construction Phase (***)

(a) Local Impact Area (***)

Table E.5.3.18 displays the impact of the Project on housing demand in the Local Impact Area during the Devil Canyon - Stage II construction phase. The peak construction year of 2003 is used to illustrate the peak impacts from this stage.

(i) Mat-Su Borough (***)

As during the first phase of construction, direct workers on the Project would have onsite housing provided by the contractor, and there would be housing available for the families of the administrative/engineering personnel. To the extent that direct or support workers choose to establish residences in borough communities, local housing would be affected.

As construction activity on the Devil Canyon Stage II portion of the Project peaks, 264 project-related households are expected to reside in the Mat-Su Borough. This number is less than forecast for the previous peak in 1997 and also less than the 310 in 1998, the in-migration peak year. Existing housing is expected to be more than adequate to accommodate these workers since over 5,000 units are expected to be vacant under baseline conditions.

At the Devil Canyon Stage II construction phase peak (2003), approximately 9 project-related households are expected to reside in Trapper Creek, bringing to 158 the number of households. As this would be below the number of housing units available, adequate housing is expected. After the year 2003, project-related households are again expected to move out of the area.

In the year 2003, approximately 45 project-related households are expected to reside in Talkeetna, bringing the cumulative number of households in the community to 271. Housing may or maynot be adequate given a forecast vacancy rate of zero.

In the year 2003, housing demand in Houston related to the Project would be 20 units. Since baseline availability is forecast to be 2,123 units and households to be 1,643, vacancy rates would be 22 percent under with-project conditions.

In Palmer, the forecast for project-related demand is 39 units in the year 2003. With baseline availability being 2,042 units and demand being 1,885, with-project vacancy rates would be 6 percent.

Wasilla is forecast to have 5,581 housing units available and 5,079 households under baseline conditions in the year 2003. The additional 42 households created by the Project added to baseline demand, would create an 8 percent vacancy rate.

(ii) Yukon-Koyukuk Communities (***)

Upon completion of the Watana Stage I portion of the Project, it is expected that approximately 50 project-related households would gradually move out of the area, and this could result in an oversupply of housing in Cantwell. The projected decline in housing demand would not be replaced by Stage II households in the community. Only four project-related households are expected to reside in Cantwell during Devil Canyon Stage II peak construction. This would create a vacancy rate of nearly 10 percent by the year 2003.

Housing demand created by the Project in Nenana is forecast at 21 units in the year 2003. This demand would be sufficient to reduce the vacancy rate to 5 percent of the 500 available housing units.

In Healy, project-related demand is forecast to be 6 units in the year 2003. Since baseline housing units are forecast to equal 429 and households 388, the additional demand would create an 8 percent vacancy rate under with-project conditions.

(iii) Anchorage and Fairbanks (***)

In Anchorage, Devil Canyon - Stage II construction activity in the year 2003 would change forecasted vacancy rates slightly from the 11 percent experienced in 1997 to 10 percent. The Fairbanks-North Star Borough and the City of Fairbanks were forecast to have 16 percent and 7 percent vacancy rates, respectively, in 1997. These rates would also change slightly to 14 percent and 8 percent, respectively in the year 2003 under with-project conditions.

(b) Regional Impact Area (***)

No measurable impacts on housing in the Regional Impact Area are expected during this phase of construction. In the year 2003, the peak year of Devil Canyon - Stage II construction, a cumulative total of 1,266 project-related households would have moved into the region, and stayed, representing 0.7 percent of the total number of households in the area. Adequate housing is expected to be available, since a 13 percent vacancy rate is forecast.

3.4.3 - Watana Stage I and Devil Canyon - Stage II - Operation Phases and Watana - Stage III Construction Phase (***)

(a) Local Impact Area (***)

(i) Mat-Su Borough (***)

As construction of the Devil Canyon - Stage II facilities is completed, some of the households of project-related workers would leave the area. As Watana Stage III construction activity increases, demand would begin to increase again, peaking in 2009. In 2009, the demand for housing units is forecast to be 394. In that year, baseline housing units are forecast to be nearly 34,000 and households are forecast to be about 28,000. Under with-project conditions, the vacancy rate would be 15 percent.

Among borough communities, the 2009 project-related demand ranges from a high of 61 units in Wasilla to a low of 12 units in Talkeetna. Vacancy rates would range from a high of 22 percent in Houston to a low of 6 percent in Palmer. Vacancy rates are the same in 2009 as they were in 2003 for all communities except in Trapper Creek and Talkeetna where the rates change to four and nine percent, respectively.

(ii) Yukon-Koyukuk Communities (***)

For the year 2009 forecasts of project-related housing demand would not create housing shortages in Nenana and Healy. Forecast for the year 2003 show with-project vacancy rates to be 5 percent in Nenana and 8 percent in Healy. Therefore, housing in both communities is sufficient to meet project-related and baseline demand.

Cantwell is forecast to receive project-related demand for 23 housing units in 2009. Since with-project demand is for 137 units and 147 are forecast to be available, there would be a 7 percent vacancy rate. This vacancy rate is down from the 22 percent forecast for the year 2003.

(iii) Anchorage and Fairbanks (***)

Project-related housing demand in the Municipality of Anchorage (394 units), in the Fairbanks-North Star Borough (240 units) and in the City of Fairbanks

(119 units) is insufficient to affect vacancy rates. Housing would be sufficient in each of these jurisdictions to easily meet project-induced demand.

(b) Regional Impact Area (***)

No measurable impacts on housing in the Regional Impact Area would result from the Project. In 2009, project-related demand would be only about 1,435 units, resulting in a 13 percent vacancy rate under with-project conditions.

3.4.4 - Project Operation Phase (***)

(a) Local Impact Area (***)

In the Mat-Su Borough and all of its communities, project-related housing demand would become nearly zero by the year 2012, 3 years after peak demand. This represents an out-migration of over 350 households. The borough housing vacancy rate would be unaffected by this out-migration, but some communities would show increases. The greatest increase among borough communities would be in Trapper Creek, from 9 percent in 2009 to 14 percent in 2012.

In the Railbelt portion of the Yukon-Koyukuk Census Division, all communities would experience out-migration. Healy and Nenana would have 8 and 30 households, respectively, out-migrate between 2009 and 2012. Cantwell would have 23 households out-migrate. These departures would result in vacancy rates increasing from 7 to 21 percent in Cantwell, 8 to 10 percent in Healy, and 5 to 9 percent in Nenana.

In the Municipality of Anchorage, the Fairbanks-North Star Borough, and the City of Fairbanks, the end of project construction would not lead to total out-migration of workers previously working on the Project. In Anchorage the demand from project-related in-migrating households would still be over 600 by the year 2012, leaving vacancy rates 1 percent lower than in 2009. In the Fairbanks-North Star Borough, nearly 200 of the in-migrating households would remain in 2012 and vacancy rates would be 1 percent less than in 2009.

In the City of Fairbanks, about 25 in-migrating households would remain in the year 2012 and vacancy rates would remain at 7 percent, the same as in the year 2009.

(b) Regional Impact Area (***)

Nearly 1,000 of the project-related in-migrating households would remain in the Regional Impact Area in the year 2012. This remaining household demand is about 70 percent of the 2009 level. Out-migration occurring after project construction ends is insufficient to raise the 2009 vacancy rate.

The combined operation phase of the Project would require a direct work force of about 90. Most of these workers and their families would have housing provided by the Applicant at the site. There would be no impacts on housing conditions in communities in the area.

3.5 - Displacement and Influences on Residences and Businesses (**)

The potential for displacement of residences and businesses by project facilities and for changing business activity are discussed in this section. As can be seen from the following discussion, displacement impacts would be very small.

3.5.1 - Residences (*)

Although some cabins used intermittently by hunters, trappers, and recreationists would be displaced by the Project, no permanent residences are expected to be inundated or otherwise displaced. Some residents of the middle and upper Susitna Basin may voluntarily leave the area for other sparsely developed regions in response to increased construction and recreational activities.

The transmission line is currently routed to avoid all known residences and other improvements; however, there are a few privately owned parcels of land that may have improvements on them. Chapter 9, Land Use, presents more detailed information on structures and land uses potentially affected by project facilities.

3.5.2 - Businesses (**)

There are no known businesses that would be physically displaced by the reservoirs, the transmission lines, the rail spur, or other project-related structures or activities. However, there are businesses that would be affected in other ways by the Project. Through its impact on the distribution of fish and wildlife and increases in area access, the Project may affect certain aspects of business activity. The possible effects are discussed below in regard to major natural resource-dependent businesses of guiding operations, air taxi operations, lodges, and trapping.

(a) Natural Resource-Dependent Businesses (**)

Natural resource-dependent businesses that are examined in this section are businesses that consume resources or serve people who use resources in the project area. The users of resources may be consumptive (hunters, anglers) or nonconsumptive (photographers, hikers). The list of businesses examined includes big game guides, air taxi operators, lodge operators, trappers, and miners. Also examined are potential Native businesses, some of these being the same as those listed above.

During 1984 and 1985, research was conducted to identify the number of guide, air taxi, lodge, and trapping businesses that might be affected by the Project. Baseline conditions were identified in several reports (Harza-Ebasco 1985b; 1985c; 1985d; Woolington 1985). These reports identify the number and magnitude of business operations in or near the project area and, therefore, the potential for impacts on those businesses. Conclusions about project impacts were summarized in Position Paper S-3, presented in the April 22, 1985 settlement meeting held by the Applicant.

(i) Big Game Guides (***)

The survey of licensed big game guides was conducted in October 1984. The 1984 Guide Register (ADCED 1984) was used to determine that 20 licensed guides have guiding privileges in the resource use area shown in Figure E.5.3.2. Contacts with the 20 guides found that only 12 guide business (involving 15 guides) regularly operated in the resource use area. Of the 11 businesses that could provide information about clients, 308 clients were served in 1984. The number of clients served by guides ranged from 4 to 80 persons in the resource use area. The most heavily used areas (shown in Figure E.5.3.2) that would contain project facilities were Subunits 8, 10, and 11. All of these were along the Susitna River, with areas 8 and 10 being a corridor along the south of the river from Gold Creek eastward beyond Fog Lakes. Area 11 is a corridor that includes both sides of the river from Watana Creek eastward to the Tyone River. Up to six guiding businesses operated in any one of these subunits.

Seven guide businesses served mostly hunters, but only 4 of these took over 50 percent of their hunters to the resource use area. Three guide businesses served mostly clients who fish, but only one took a majority of clients to the resource use area. Four businesses guide over 10 percent of their clients on river float or sightseeing trips, or conducted activities other than hunting and fishing. Of those four, none utilized the resource use area with their clients.

In conclusion, fewer than 10 guiding businesses operated in areas where their guided activities and clients could be affected by project facilities. Of these 10, no more than five businesses guided the majority of their clients to such areas. These five guiding operations, depending on the locations of activities, might be affected through redistribution or loss of targeted animals, inundation of camps or hunting areas, and increased competition for animals because of new road access to unguided hunters. Additionally, the remote nature of a portion of their operating area could be lost due to the building of project facilities.

The five businesses might want to adjust their operations in response to impacts. Responses could involve changing the type of access provided to clients, shifting the location for base camps, changing the emphasis on species hunted or fished, or seeking clientele who want less remote experiences.

Air taxi operations are often closely associated with guiding. Nine of the guides owned air taxi businesses, each had from one to five planes. The air tax survey was conducted separately from the guide survey and is summarized below.

(ii) Air Taxi Operators (***)

A series of air taxi surveys was conducted from October 1984 to April 1985. The portion of the resource use area that is relevant for determining effects of the Project on air taxi business is approximated by Subunits 2 through 11 shown in Figure E.5.3.2. The analysis of preliminary surveys determined that of the 220 certified air taxi operations in Alaska, 47 had destinations within the resource use area.

Twenty-five air taxi services making trips into the resource use area attributed less than 10 percent of their business to trips to that area. Twenty other services attributed 10 percent or more of their business to their trips into the area. This latter category of 22 services constituted those with the potential to be affected by the Project because 10 percent or more of their business was in the project area. Their trips served about 1,850 clients in contrast to about 680 clients served by the former category. Two of these 22 air taxi services made trips to the area, but solely served project-related or state resource agency clients. More detailed surveys were conducted with 14 of the remaining 20 businesses. Conclusions from those 14 surveys follow.

A majority (8) of the 14 services which could be reached for a detailed survey reported that all their hunting and fishing clients were Alaskans. Eight services primarily served hunters, five primarily fishermen, and one an even mix of hunters and fishermen. The nine services conducting cargo transport trips reported that all their cargo business is with Alaskans. Four of the eight services that conducted sightseeing trips reported that 100 percent of their sightseers were from the Lower 48 states.

All 22 of these air taxi businesses would likely be affected by the Project. These effects may not result in a reduction in volume, but rather a shift in type of clientele, activity of clients, or primary destinations. For instance, a greater percentage of clients may be project-related and cargo transport could become more important. More sightseers might want to fly over the construction sights or the completed dams. There would probably be less demand for flights to places served by access roads after they are opened to the public. Float planes may use the more sheltered portions of the reservoir to land in areas where the river could not previously be used.

(iii) Lodge Operators (***)

Lodge operations might also be affected by the Project and are sometimes related to air taxi and guiding operations. To identify lodges that have potential for being affected, a survey was conducted in August 1984. The survey was limited to businesses near the project site that offer indoor, overnight accommodations and where the owner/operator had some knowledge of where overnight customers recreate. The area defined as near the site included establishments in Paxson, around Lake Louise, along the Denali Highway, along the Parks Highway from Healy to the Talkeetna Spur Road, in Talkeetna, and any remote, fly-in establishments less than 20 miles from the proposed impoundments. A total of 38 lodges were identified within this area and attempts were made to contact all 38 to determine whether they received benefits from the resource use area or have customers using their lodge as a base for using the resource use area (Subunits 1 through 12 of Figure E.5.3.2). One of these conditions was necessary to demonstrate an economic tie with the area where project effects might occur.

The findings from the 38 lodges were:

- o Eleven lodge operators had knowledge of customers' activities in the resource use area.
- o Eleven lodge operators had no knowledge of customers going into the resource use area while staying at the lodge and felt that if any customers did, the number was extremely small.
- o One lodge was no longer operating and six lodges were not renting cabins/rooms at the time of the survey.
- o Four remote lodges were strictly associated with guiding businesses and therefore were included in the study of guides and guide businesses.
- o Three lodges identified through secondary sources either no longer existed or could not be found by the name or location listed in the reference materials.
- o One remote lodge had been leased for Susitna project-related studies for the last five years; therefore, the owner could not contribute information useful for predicting project impacts.
- o One lodge owner along the Denali Highway refused to participate in the survey.

The following are conclusions from the 11 full interviews.

Lodges varied greatly in size and types of facilities, but averaged a capacity of 30 people and typically had a lounge, bar, and restaurant. Lodges located on the Denali Highway were not open in the winter, but those located on the Parks and Richardson Highways, in Talkeetna, and at Lake Louise were open year-round. The number of employees (not counting owner/operator) varied greatly among lodges, but together they totaled 24 full-time year-round, 28 full-time seasonal, and 4 part-time seasonal. Most lodges used some combination of full- and part-time workers.

The amount of income provided by the lodge business for each owner varied from 8 to 100 percent, with five owners stating that all of their income came from the lodge. The number of yearly guests was estimated to be from 100 to 3,725. Intertie transmission line workers constituted all or most of the customers at two lodges.

Most (8) of the 21 interviewed lodge operators felt that a majority of their guests were sightseeing or touring. When asked to indicate where their customers recreated, Subunit 1 (the corridor along the Denali Highway) was identified twice as often as any other subunit.

Each lodge was unique; therefore, project impacts on their operations would vary. Clientele might change for some because temporary project employees may remain in the area when shifts change (rotated out). These lodges would become more affiliated with the Project and more often serve Alaska residents than under baseline conditions. There might become less seasonal variation in business volume and guest activities could change because of shifts in clientele. The changes that would come from the Project are not likely to decrease the business volume for lodges.

(iv) Trappers (***)

Trapping is another business enterprise that could be affected by the Project. Impacts to this group could be direct, such as a reduction in furbearer species and their habitat or the inundation of traplines. Indirect impacts could include increased competition among trappers because of better access to trapping areas.

Two surveys were conducted to better determine potential impacts on trappers: a preliminary survey in the spring of 1984 (Gibson 1984) and a more comprehensive survey in the spring of 1985 (Woolington 1985), The primary value of these studies was to identify the amount of trapping occurring near the project site and the economic importance of the activity for the trappers.

Of the 26 trappers contacted, 20 had trapped in or near Subunits 1 through 13 during the 1984-1985 trapping season, shown in Figure 5.3.2. The highest density of trapping occurred in Subarea 13, north of Talkeetna, an area that is unlikely to be affected by project facilities. Only four ground-based trappers were contacted who had traplines in the inundation zones or along access roads. Six others were identified who were primarily trapping/hunting by airplane and the project facilities would be within the area they commonly fly over in search of furbearers. According to interviewed trappers, a few other trappers who could not be contacted probably used areas potentially impacted by the Project. Probably less than 20 trappers, including those using airplanes, would be affected by the Project.

The type of project effects on trappers would vary, depending on where traplines are located, and the mode of access used by the trapper. The airplane trappers would be least affected because of their flexibility and large area of operation. The 10 or fewer trappers operating in or near the inundation zone would be most affected since they would be partially or totally displaced.

(v) Miners (***)

One active mining claim, No. 1 Moose Creek, would be totally inundated but no commercially productive mine is in the inundation area. The Project may be beneficial to other mining activities by improving access, which would allow existing claims to be worked more profitably and would facilitate the discovery of new deposits. Most of these benefits would begin to accrue when miners are permitted to use project access routes.

(vi) <u>Native Businesses</u> (***)

It should be noted that Cook Inlet Region, Inc. (CIRI), a regional Native corporation, and its village corporations have claimed a substantial amount of land in the proposed project development area, some of which has been conveyed.

The conveyance of land to Native ownership would affect resource-related businesses and, in some cases, the effects would be greater than those due to the Susitna Project. Land conveyance would likely affect businesses (guides and trappers) operating on Native land or businesses (lodges and air taxis) who have clients using the land. These changes would occur if Natives determine that business operators are trespassing on their lands and prohibit entry or if they institute fees for surface use of their lands. Native developments, such as lodges and services (guiding or air taxi) might also compete with existing businesses.

Native corporations, especially CIRI and its village corporations, could be affected by the Project since they own or will own land around the impoundment areas. CIRI villages have expressed an intention to develop their land's mineral, timber and recreation resources, with or without the Project. Types of Native development that could be affected by the Project include facilities and services which could be provided by the private sector to both residents of, and visitors to, the project area. The facilities and services that could be developed on Native lands are those not usually provided by public agencies or construction camps: recreation, lodging, food, shopping, and guide services. CIRI representatives have indicated an interest in providing these types of facilities and services in the vicinity of the construction camp, permanent village, and impoundments (Brown 1984a). Many of the development plans depend upon road access to the southern side of the impoundments, which would be provided by the Project (Brown 1984b).

The position of CIRI about development of their land surrounding the project area is that they have considered the effects of development, decided that the effects would not be significant, and noted that Congress intended the land conveyance process to allow development. Furthermore, since the land will be privately owned after conveyance of all rights and privileges to the land, any attempt to restrict development would be illegal (Brown 1984a). The project applicant would have no jurisdiction over Native lands and could not legally restrict Native use of their land.

During Stage I construction, the Susitna Project would have only minor impacts on development on Native corporation land in the project area since the access road would not be open for public use and the use of private vehicles would be restricted. The opportunity for project personnel to purchase products or services that Natives might provide would therefore be limited to the construction camp and village areas. During Stage II and Stage III, project access roads would be open to the public and workers would be allowed to bring personnel vehicles onsite. Therefore, project personnel and the general public could purchase goods and services provided by Native businesses such as food, lodging, gasoline and gifts. If visits to the area follow current patterns, purchases would be seasonal, being higher in the summer.

The Project would have no negative impact on Native plans to develop the recreation potential of their lands since it would not provide competition for development. Nor would the Project remove existing access or in any way obstruct development. Moreover, the Project would not substantially affect wildlife and fish resources important to recreation. The Project would however, enhance the Native corporations' ability to develop their lands by providing new access, both to the Natives and to the public.

(b) General Businesses (**)

In general, business activity would increase along the Parks Highway between Anchorage and Fairbanks beginning in the late 1980s and early 1990s as a result of project construction. In general, it is expected that the construction, transportation, wholesale and retail trade, real estate, and services sectors would benefit from the Project. Businesses that are contracted to provide specific goods or services such as fuel, communications, housekeeping, trucking, helicopter or airplane support would benefit. Existing support sector businesses such as restaurants, service stations, lodging establishments, and retail food stores would expand and new businesses would be started. Table E.5.3.16 shows the estimated number of support jobs that would be created by the Project in the Regional Impact Area and in selected jurisdictions within that area.

The Project is expected to have a substantial impact on business activity in Cantwell, but lesser impacts on Trapper Creek, Healy, Nenana, Talkeetna, Houston, Wasilla, Fairbanks, Anchorage, and Palmer. Cantwell's businesses would have increased sales because a relatively large population would relocate there and because it is the community along the access route located nearest to the construction site. Native Alaskans in Cantwell, who are shareholders of Ahtna, Inc., would stand to benefit substantially from this increased business. Many of the Natives and non-Native in the town lack employment during some or most of the year.

The new residents would have spending patterns similar to those residents now living in Cantwell; workers who pass through Cantwell are expected to concentrate their expenditures on food, beverages, lodging and gasoline. Each of the other cities or communities mentioned above would experience the same types of impacts as Cantwell, but the impacts would be less pronounced.

(c) Employment (**)

The estimated number of support jobs created by the Project in the Regional Impact Area is shown in Table E.5.3.16. Most of the support jobs would be located in the Municipality of Anchorage. It is estimated that most of the direct jobs, but few of the support jobs, would go to residents of communities in the Regional Impact area. These support sector jobs would not have a substantial impact on the communities and areas because they mostly occur in Anchorage, where the baseline work force is large. There are a large number of these jobs and their distribution is such that they do not encourage large in-migrations to small communities. They would therefore create beneficial economic impacts because they would add to a community's economic base without adding substantially to the population.

The Susitna Project would create a substantial number of direct jobs for the Regional Impact Area. These are shown in Table E.5.3.16. As shown in this table, during construction the number of jobs created is substantial, though the degree of impact varies greatly among communities. During peak construction, the Project would increase the total number of direct jobs available in the Regional Impact Area by one percent.

3.6 - Fiscal Impact Analysis: Evaluation of Incremental Local Government Expenditures and Revenues (**)

3.6.1 - Watana - Stage I Construction Phase (***)

This section discusses budget forecasts for 1997, the peak of Watana - Stage I construction activity. In other years, the annual effects would generally be of the same direction (positive or negative), but a lesser magnitude than shown here. As shown in Tables E.5.3.19, E.5.3.20, and E.5.3.21, most of the growth in borough, community, and school district revenues and expenditures is forecast to increase under baseline conditions. The Project, in most cases, would have an equally proportional incremental effect on both revenues and expenditures in each jurisdiction. In most cases, these effects tend to increase fiscal balances by amounts of less than ten percent. In a few cases, the Project would have a small, negative effect on fiscal balances.

(a) Mat-Su Borough (***)

The expenditures by the Mat-Su Borough with and without the Project have been projected on a per capita basis in 1985 dollars. It was assumed that current per capita expenditures would be applicable to the future. Other major assumptions regarding revenue projections include: (1) that there would be real growth in property values; (2) future increases would be realized in the mill rates; and (3) certain per capita receipts of state shared funds, federally shared funds, and municipal assistance funds would be forthcoming. Additional information regarding methodology may be found in Frank Orth & Associates, Inc. (1982).

Currently, and in recent history, the borough has spent more than has been raised conventionally. Thus, per capita spending levels used in these projections assume that the borough would be able to continue meeting local needs and wants through state grants. To the extent that the borough is unable to obtain state grants at the same levels as in the past, the projected level of disparity between revenues from conventional sources and expenditures may not be realized.

When interpreting Table E.5.3.19 and comparing these figures to subsequent school district forecasts, it is important to note that many of the funds are interrelated. For instance, some of the school district funding is derived from the general fund. Hence, any aggregation of impacts on all borough funds would lead to some double counting of revenues and is, therefore, avoided.

All impacts mentioned are based on total population influx estimates including the population associated with both direct construction workers and support workers. All Mat-Su Borough fund forecasts presented in the tables and discussed in the text include the effect of the construction camp. In all cases, the construction camp increases both revenues and expenditures by the same amount (approximately 2 to 3 percent) and as a consequence has a negligible effect on the next fiscal balance. As shown in the table, 1997 general fund revenues of $66.8 million are forecast to exceed expenditures of $54.7 million under with-project conditions. These forecasts are 5 percent higher than the baseline forecasts and would increase the overall fiscal balance by $0.6 million over baseline in 1997.

The Project's effect on the 1997 service area fund would be slightly positive. The 1997 revenues of $6.9 million would exceed expenditures of $5.8 million and the fiscal balance with the Project is forecast to be about $90,000 more than the fiscal balance under baseline conditions.

Finally, the Project would have a positive effect on the much smaller land management fund, increasing both revenues and expenditures by small amounts, and yielding a 1997 fiscal balance that would be about $27,000 above the baseline level.

Implicit in the projections is the assumption that property taxes would grow because of both an expanding tax base and increased mill rates, and may constitute more than the 30 percent share of the service area's fund revenues. If this were to happen, the problem of time lags could become even more acute. There is usually a lag between the time property is assessed and put on tax rolls and the receipt of tax dollars. In the meantime, new services may be required, but there is a funds shortfall.

(b) Local Communities (***)

The budget forecasts for selected local communities and for Anchorage and Fairbanks are presented in Table E.5.3.20. Talkeetna is not incorporated and does not collect taxes. The effect of the Project on revenues collected by the Mat-Su Borough on behalf of Talkeetna in 1997 is shown in the lower left-hand corner of the table. As shown, revenues of $1.4 million would exceed baseline revenues by $192,000 or 16 percent.

Cantwell has no local government and is located in an unorganized borough. As shown in Table E.5.3.20, the Project would increase revenues and expenditures for the Cantwell operations budget by $24,000 and $16,000, respectively, in 1997. While these forecasts are well above baseline levels, the net effect on the 1995 fiscal balance would only be $8,000. However, if the community felt that additional expenditures were needed for community facilities (such as a new solid waste disposal area) because of the population influx related to the Project, it is probable that the additional revenue would be sought by way of state grants. At some point in the future, Cantwell may decide to incorporate to widen its revenue base and provide more facilities and services for residents.

In Palmer, the Project would increase 1997 revenues by about $120,000 and expenditures by $107,000. Both impacts represent a 1 percent increase over baseline levels. The project's impact on the net fiscal balance in 1997 would be about $13,000. In Wasilla, the Project would increase 1997 revenues by $23,000 and expenditures by $13,000 for a positive effect on the net fiscal balance of $10,000. In Houston and Nenana, 1997 fiscal balances are forecast to be negative under both baseline and with-project conditions. The Project would increase revenues and expenditures by about 1 percent in Houston and less than 1 percent in Nenana, having virtually no effect on the net fiscal balance in either community.

(c) Anchorage and Fairbanks (***)

As shown in Table E.5.3.20, the Project is expected to increase 1997 revenues and expenditures in Anchorage and decrease revenues and expenitures in Fairbanks by less than one percent. In Anchorage, the with-project fiscal balance of $62.9 million would be about $129,000 above baseline. In Fairbanks the Project would decrease the fiscal balance by $6,000.

(d) School Districts (***)

Table E.5.3.21 presents budget forecasts for the Mat-Su Borough, Railbelt, and Nenana School Districts. As shown, the Project would increase revenues and expenditures in the Mat-Su Borough School District by 4 percent causing the negative fiscal balance of $2.0 million under baseline conditions to decrease by $389,000 to a negative $1.6 million under with-project conditions. In the Railbelt School District, 1997 revenues and expenditures would both increase by about 8 percent for an almost negligible effect on the net fiscal balance. In Nenana, revenues and expenditures would increase by less than one percent over baseline, for a very small negative effect of $1,000 on the 1997 fiscal balance.

3.6.2 - Watana - Stage I Operation Phase and Devil Canyon - Stage II Construction Phase (***)

This section discusses budget forecast for the year 2003, the year of peak construction activity on Devil Canyon - Stage II, and the fourth year of operations employment on Watana - Stage I. In other years the annual effects would generally be of the same direction (positive or negative), but a lesser magnitude than shown here.

As shown in Tables E.5.3.19, E.5.3.20, and E.5.3.21, most of the growth in borough, community, and school district revenues and expenditures is forecast to increase under baseline conditions. The Project in most cases would have an equally proportional, incremental effect on both revenues and expenditures in each jurisdiction. In most cases, these effects tend to increase fiscal balances by amounts of less than ten percent. In a few cases, the Project would have a small, negative effect on fiscal balances.

(a) Mat-Su Borough (***)

As shown in Table E.5.3.19, general fund revenues in the year 2003 of $101.1 million would exceed expenditures by $69.4 million for a fiscal balance of $31.7 million, which would be approximately $1.2 million above the year 2003 baseline fiscal balance. The Project would have a similar effect on the small service area and land management funds. The year 2003 service area fund fiscal balance would be about $131,000 above baseline. The year 2003 land management fund fiscal balance would be about $17,000 above the baseline level.

(b) Local Communities (***)

As shown in Table E.5.3.20, Mat-Su Borough revenue collections on behalf of Talkeetna in the year 2003 are forecast to be $1.8 million, about $234,000 or 15 percent above baseline collections. Cantwell operations revenues of $72,000 are forecast to exceed expenditures of $42,000 for a fiscal balance of $30,000, which would equal the baseline fiscal balance. The project effects would be similar in Palmer and Wasilla where the year 2003 revenues, expenditures and fiscal balance would all be less than three percent above baseline. In Houston and Nenana, where baseline fiscal balances are forecast to be negative, the Project would increase the magnitude of the negative fiscal balances by one and six percents, respectively.

(c) Anchorage and Fairbanks (***)

As shown in Table E.5.3.20, the Project would increase the year 2003 revenues and expenditures in Anchorage by less than one percent and decrease Fairbanks revenues and expenditures by less than one percent. In Anchorage, the with-project fiscal balance of $91.8 million would be about $304,000 above baseline. In Fairbanks, the year 2003 fiscal balance of $8.1 million would be about $86,000 below baseline.

(d) School Districts (***)

As shown in Table E.5.3.21, the Project would have a similar effect on the Mat-Su Borough and Railbelt School District fiscal balances, causing the balances to increase by 5 and 4 percents, respectively. The Project would have a very small negative effect on the year 2003 fiscal balance in the Nenana School District.

3.6.3 - Watana - Stage I and Devil Canyon Operation Phases and Watana - Stage III Construction Phase (***)

This section discusses budget forecasts for the year 2009, the year of peak construction activity on Watana - Stage III, and a year of full operations employment on Watana - Stage I and Devil Canyon - Stage II. In other years, the annual effects would generally be of the same direction (positive or negative), but a lesser magnitude than shown here.

As shown in Tables E.5.3.19, E.5.3.20, and E.5.3.21, most of the growth in borough, community, and school district revenues and expenditures is forecast to increase under baseline conditions. The Project in most cases would have an equally proportional, incremental effect on both revenues and expenditures in each jurisdiction. In most cases, these effects tend to increase fiscal balances by amounts of less than ten percent. In a few cases, the Project would have a small, negative effect on fiscal balances.

(a) Mat-Su Borough (***)

As shown in Table E.5.3.19, the year 2009 general fund revenues of $148.1 million would exceed expenditures of $84.1 million for a fiscal balance of $64.0 million, which would be approximately $2.4 million above the year 2009 baseline fiscal balance. The Project would have a similar effect on the smaller service area fund. The year 2009 service area fund fiscal balance would be about $223,000 above baseline. The 2009 land management fund fiscal balance would be about $9,000 above the baseline level.

(b) Local Communities (***)

As shown in Table E.5.3.20, Mat-Su Borough revenue collections on behalf of Talkeetna in the year 2009 are forecast to be $2.1 million, about $97,000 or 5 percent above baseline collections. Cantwell operations revenues of $118,000 are forecast to exceed expenditures of $58,000 for a fiscal balance of $60,000, which would be 50 percent above the baseline fiscal balance. The project effects would be similar in Palmer and Wasilla where the year 2009 revenues, expenditures and fiscal balance would all be about 20 percent above baseline. In Houston and Nenana, where baseline fiscal balances are forecast to be negative, the Project would increase the magnitude of the negative fiscal balances by 1 and 27 percents, respectively.

(c) Anchorage and Fairbanks (***)

As shown in Table E.5.3.20, the Project would increase the year 2009 revenues and expenditures in Anchorage and Fairbanks by less than one percent. In Anchorage, the with-project fiscal balance of $117.6 million would be about $375,000 above baseline. In Fairbanks, the year 2009 fiscal balance of $15.1 million would be about $14,000 above baseline.

(d) School Districts (***)

As shown in Table E.5.3.21, the Project would have a similar effect on the Mat-Su Borough and Railbelt School District fiscal balances, causing the year 2009 fiscal balances to increase by 4 percent and 6 percents, respectively. The Project would have a very small negative effect of about $35,000 on the year 2009 fiscal balance in the Nenana School District.

3.6.4 - Project Operations (***)

As described earlier in Section 3.1.6, the Stage III operations phase of the Project would have a negligible effect on population and demand for facilities and services in Local and Regional Impact Area communities. As a consequence, the operations phase of the Project would also have a negligible effect on revenues, expenditures, and fiscal balances of the Mat-Su Borough, and local communities and school districts. While small differences between with-project and baseline fiscal conditions are forecast to occur in the year 2012, these differences are not expected to be more than one-half of one percent for any jurisdiction. Hence, fiscal forecasts for the project operations phase are not presented in tabular format or discussed in any more detail here.

3.7 - Local and Regional Impacts on Resource User Groups (**)

This section describes how the Project would affect consumptive and nonconsumptive users of project area resources. Amounts and locations of impacts to users are provided where possible. This section differs from the same section in the License Application. The primary difference is that information about fish and wildlife species is referenced to other appropriate chapters. In addition, some details about use of fish and wildlife, such as harvest data, have also been removed from this chapter. The changes eliminate redundant information that is presented elsewhere and concentrates on the greater volume of information now available about the users of these resources. Accordingly, the organization of the section now reflects characteristics of use or users, rather than the type of animal consumed.

3.7.1 - Commercial Use of Fish and Wildlife Resources (***)

ADF&G (1984a, 1984b), Woodward-Clyde (1984), and Gipson (1984) address two types of commercial uses of the Susitna Basin fish and wildlife resources (see Chapter 3 for details). The first type of use is the direct harvest and sale of the resource by commercial fishermen and trappers. The second type is the provision of facilities and services for consumptive and nonconsumptive recreational use of the resource, e.g.; guiding services, lodges, and air taxis. It is this first type of resource use that is discussed in this section. (The second type of commercial use and trapping were discussed in Section 3.5.2. Trapping was also discussed in Section 3.5.2.) Since fresh water commercial fishing is prohibited, only salt water fishing is considered.

The major and best documented commercial consumption of Susitna River fish resources occurs in upper Cook Inlet. Five of the six Pacific salmon species are harvested in the upper Cook Inlet fishery. The majority of the chum, coho, and pink salmon harvested in the upper Cook Inlet originate in the Susitna Basin. The Susitna River system serves as a migrational corridor, spawning area, and juvenile rearing area for the five salmon species. The migrational corridor is from river mile (RM) zero at the point of discharge into Cook Inlet, to RM 152 at Devil Canyon. Sloughs and tributaries below RM 152 provide most of the spawning habitat. Mainstem, upland sloughs, side sloughs, and side channels below RM 152 provide overwintering habitats. Some juvenile rearing also occurs in these locations, primarily in tributaries and side channels (Woodward-Clyde 1984, ADF&G 1984a, ADF&G 1984b).

The value placed on the upper Cook Inlet fishery varies each year, but has averaged about $17.9 million per year (1983 dollars) over the past 30 years. During 1982 and 1983, the value was nearly double the long-term average because of large harvests of record runs. The Susitna River contribution to the upper Cook Inlet salmon harvest can be presented by percentages. Such harvest approximations for individual salmon species range from 10 percent for chinook to about 85 percent each for chum and pink salmon (Woodward-Clyde 1984).

Impacts from the Project on commercial fishing could only result from alteration of the population of fish species harvested, since participants in the commercial fishery are limited to the number of permits issued. Details of project impacts on this population can be found in Chapter 3. In summary, with regard to salmon, even without mitigation, the Project would only slightly reduce populations downstream from the dams; with mitigation, these reductions would be avoided. Thus, the Project would have no measurable adverse effect on commercial salmon fishing.

3.7.2 -Non-commercial Use of Fish and Wildlife Resources (***)

Two types of non-commercial use of the resource are discussed in this section: sport hunting and fishing. For details about the project's impacts on species hunted or fished, see Chapter 3. The important sport fishing species are Arctic grayling, rainbow trout and the five salmon species (Woodward-Clyde 1984). Only Arctic grayling and rainbow trout are available in areas where the project facilities could affect the opportunity to sport fish.

(a) Sport Hunting and Fishing (***)

Information in Chapter 3 concludes that the Project would have only minor effects on rainbow trout populations. Therefore, sport fishing opportunities for rainbow trout would not substantially decrease. Arctic grayling populations would be reduced in the impoundment area by habitat loss, but mitigation measures would prevent a substantial reduction of their numbers within or near the project area. Thus, sport fishing opportunities for Arctic grayling would also not substantially decrease.

Of the big game species found in the project area, there would be a loss of habitat for black bear, brown bear and moose. A habitat enhancement program would result in no net loss of carrying capacity for moose in or near the Susitna Basin. Black and brown bear losses would be minimized by mitigation to the extent practical, but within the project area there would be a reduction in the bear population.

These effects on these species are unlikely to affect the number of people sport hunting or fishing in the area where project facilities are located to a measurable degree. Research by ISER (1985) estimates that of the approximately 31,000 households hunting in the middle and lower Susitna Basin, only about 700 (2%) hunt within or near areas where there would be habitat loss from project facilities. Within this same portion of the basin, approximately 55,000 households fished; but only about 800 (2%) fished in or near where facilities would be located.

The Project could also have an effect on sport hunting and fishing by increasing access to a portion of the basin's fish and wildlife resources. After the project road is opened to the public around the year 2000, some new hunting areas would be available to sport hunters who use roads for access to hunting areas. This new access could redistribute hunters slightly, but is unlikely to change the number hunting within the lower and middle Susitna Basin. As the ISER (1985) report shows, many more people hunt along the Denali Highway than in the area where the access road would be constructed. It is likely that the number of hunters along the access roads would not reach the number using the Denali Highway since the number of road miles is less and the distance from population centers is slightly greater. Nevertheless, the number of hunters in the area where the road would be constructed would increase substantially over present levels.

No roads or other features associated with the Project are located in the lower Susitna River Basin or in Cook Inlet where most of the sport salmon fishing is known to occur. The proposed railroad spur between Gold Creek and Devil Canyon is unlikely to provide new access to anglers since trains would only transport freight and perhaps some construction workers. However, the Project would enhance access to sport fishing for resident species in inland lakes and streams at a time when sport fishing for rainbow trout and grayling is gaining prominence. This increase would occur in streams and lakes located along the access road.

(b) Subsistence Hunting and Fishing Generally (***)

There are three types of publications by ADF&G that pertain to subsistence use of fish and wildlife resources. The first type is published by the Alaska Board of Game and consists of the Alaska Game Regulations (1984a) and Alaska Game Management Units (1984b). (See also Subsistence Finfish Fishery, 5 Alaska Admin. Code, ch. 01; Subsistence Uses, 5 Alaska Admin. Code, ch. 99) The Alaska Game Regulations (Alaska Board of Game 1984a, pp 66-67) defined subsistence, listed the eight criteria for subsistence, and described the Joint Boards of Fisheries and Game procedures for determining subsistence communities. When a need for determination arose, the criteria were applied to communities on a case-by-case basis.

The second type of publication developed by the ADF&G Subsistence Division describes particular wildlife and fishery resources, such as the Nelchina and Mentasta caribou herds (Stratton 1983), the Copper River fishery (Stratton 1982), or the Copper River Basin fish and wildlife resource (Stratton and Georgette 1984). These publications provide historical harvests of the resource by the subsistence population.

The third type, also developed by the ADF&G Subsistence Division, describes wildlife and fishery use by particular villages or in particular geographic areas, such as the Tyonek Village, and the upper Yentna area (Fall et al. 1983) These three types of publications are particularly relevant to understanding the historical context of subsistence definition in the state.

In late 1984, an Alaska State Supreme Court ruling determined that previous subsistence regulations were unconstitutional and, in effect, extended subsistence rights to all Alaska residents. The Alaska Board of Game subsequently released emergency regulations for subsistence hunting and fishing. These regulations are only intended to serve temporarily until the Alaska Legislature can further consider the issue.

Under current interim regulations, project effects on subsistence hunting would be identical to the effects on all other hunting described in the preceding section. That is, neither the project effects on wildlife species nor the additional access would affect the number of subsistence hunters in the middle and lower Susitna Basin. However, the project access road, after being opened to the public, may redistribute some of that hunting to the newly road-accessible area.

(c) <u>Effect of the Project on Local Subsistence Uses of Fish and Game</u> (***)

An activity warranting particular note is the local subsistence use of fish and game. The following section discusses the effect of the Project on local subsistence uses of fish and game and identifies proposals to mitigate any significant effects of the Project on the limited local subsistence activity in the Project area.

Residents of Cantwell are the most likely of any community to have subsistence activities affected by the Project. The existing environment and baseline forecasts are presented in Section 2. Stratton and Georgette (1984) conducted research in 1983 to document fish and game resource utilization by Cantwell's residents. The study shows big game, especially moose and caribou, to be relatively important to Cantwell residents' subsistence activity while fish are relatively unimportant. These relative importances are due to the community's location and locally available species. Of the households interviewed, 35 percent (15) harvested at least one moose or caribou and 44 percent (19) received road-killed or train-killed moose or caribou. Most hunting for moose and caribou occurred in the nearby Talkeetna Mountains, using a variety of vehicles. Only 14 percent (6) reported that they trapped but most households picked berries and hunted birds.

The Susitna Project's major facilities (dams and reservoirs) would not be located where most of Cantwell's subsistence activity occurs. Linear facilities (the access roads and a portion of the transmission line) would pass through areas of activity but the transmission lie would parallel the existing (Intertie) line. The access road would have little effect on these species' habitat or the number of animals and would therefore not decrease opportunity. During Watana - Stage I the number of people working in or passing through a portion of the harvesting area would offer little competition to subsistence users. After Watana - Stage I more competition might occur from project personnel and from the public who would have use of the access road. Access to harvest areas would not be affected during Stage I of the Project. During later project stages access would be enhanced to a small portion of the existing harvest area because the project access road would be open to public use. The interim subsistence regulations, which give preference to local resource users, would diminish the importance of competition if the regulations are still in effect when later stages of project construction occurs. These linear facilities are not expected to create more than local disturbances that would affect the distribution, migration, or location of moose or caribou (see Chapter 3).

(i) Alternatives for Minimizing Impacts on Local Subsistence Activity (***)

Two alternatives (mitigations) would be adopted by the applicant to minimize potential for project impacts on subsistence activity. The first is directed towards maintaining or increasing the number of animals and fish available for harvest and the second is to reduce the effects of and competition from project-related personnel.

The first type of mitigation, fish and wildlife protection and enhancement, consists of several measures detailed in Chapter 3. In particular, the measures would be directed to preventing any reduction in species that are important for subsistence by preventing loss of habitat, replacing habitat, minimizing loss of critical habitat and disruption of seasonal movement.

The second type of mitigation, reducing the effects of project personnel, consists of providing worker housing for the entire construction period and a worker transportation program during the construction period from 1992 to 1999. These mitigations are detailed, along with other socioeconomic mitigations, in Section 4 of this chapter. In general, these mitigations restrict activity to a small area, prevent uncontrolled movement of people and decrease individuals' resources (transportation and recreational equipment) for utilizing fish and wildlife resources.

(ii) Summary (***)

Information from the preceding section shows that subsistence activity from residents of Cantwell has the potential to be affected by the Project in a small portion of the area used for subsistence harvests. The portion of the harvest area would be where the project access road leaves the Denali Highway and where the transmission line passes close to the community. Mitigations provided in Chapter 3 (Fishery and Wildlife) and in Section 4 of this chapter would reduce this potential to an insignificant level.

3.7.3 - Nonconsumptive Use of Resources (***)

Nonconsumptive uses of resources include activities such as off-road vehicle use, boating, skiing, backpacking, picnicking, sightseeing, photographing, and other activities where fish, wildlife, mineral, or timber resources are not consumed. This category was found by ISER (1985) to represent a high rate of use of the middle and lower Susitna Basin. More households used this portion of the basin for nonconsumptive purposes than for either fishing or hunting. About 88 percent of the households using the area stated that one of their activities was non-consumptive. This high rate of nonconsumptive use was equally prevalent for urban, rural, or small town residents.

Nonconsumptive use patterns are much like hunting and fishing use patterns, with less than 2 percent (about 1,200 households) of the lower and middle Susitna Basin's use occurring in areas where project facilities would be located. Additional access provided by the project access road after 1999 would be expected to attract some of the Denali Highway users. This increase in use of the area where no road now exists would be substantial as a percentage over baseline (several hundred percent) but in absolute numbers would not represent heavy use. For details about recreational amenities that would be provided by the project recreational plan, see Chapter 7.

4 - MITIGATION (**)

4.1 - Introduction (**)

This section describes measures to mitigate direct socioeconomic impacts of the Project. Section 4.2 discusses the background and approach to mitigation and Section 4.4 is a statement of mitigation objectives and measures that are designed to meet those objectives. Section 4.5 presents a mitigation program based upon mitigation objectives and forecast community impacts.

4.2 - Background and Approach (**)

The order of mitigation priorities presented by the Council on Environmental Quality include (1) avoiding impacts, (2) minimizing impacts, (3) rectifying impacts, (4) reducing or eliminating impacts over time, and (5) compensating for impacts. The objective of mitigation is to avoid or minimize impacts perceived to be costly, disruptive, or otherwise undesirable. Mitigation measures are proposed when the private sector (market mechanism), existing local and state government mechanisms, and social assimilation mechanisms (such as social service organizations and churches) do not have the capacity, capability or responsibility to adequately mitigate adverse impacts.

It is important to recognize that labeling a project-induced change as adverse is based on values held by those applying the label. Individuals in a community are likely to represent a variety of values and therefore there would be a variety of views about the impact of a change. Likewise, community members may appear to reach consensus or may disagree in their opinions, or labels about the change.

The process used to develop the mitigation program is:

- o Estimate project-related changes in communities (see Section 3);
- o Determine which changes would require the community to expend money for adjustment to that change;
- o Identify measures to avoid being required to expend money for adjusting to project-related impacts;
- o Identify measures to minimize, rectify, reduce or eliminate, and/or compensate for any remaining project-related impacts; and
- o Develop an impact management program.

4.3 - Attitudes Toward Changes

(This Section Deleted)

4.4 - Mitigation Objectives and Measures (**)

The following mitigation objectives for socioeconomic impacts are largely based upon the Council on Environmental Quality's definition of mitigation (40 CFR 1508.20):

- o Avoid large and rapid population influxes into communities, especially small communities such as Cantwell, Trapper Creek, Talkeetna, Healy, and Nenana. This would result in avoiding substantial shortages of housing and community facilities and services, cost of living increases, and changes in lifestyle/way-of-life;

- o Avoid large traffic increases on the Denali and Parks Highways which would avoid increasing accidents and animal road kills.

- o Minimize, reduce or eliminate over time, or compensate for, significant adverse impacts caused by construction worker-related population influxes and effluxes.

Section 3 contains an analysis of project impacts on Local Impact Area communities. This analysis was conducted under the assumption that several mitigation measures would be adopted to avoid impacts. Section 4.4.1 details these measures, which include selection of an employee shift rotation schedule, provision of housing for employees, and provision of a worker transportation program.

Adopting these avoidance mitigations, refining the project's cost analysis, and refining the socioeconomic computer model have greatly reduced the forecast population influx into small communities in the Regional Impact Area. The reduction in population influx produces a commensurate reduction in demand on these communities' housing, facilities and services, and fiscal resources. While all project impacts cannot be avoided, one goal of mitigation is to reduce impacts to a reasonable level, one that would allow existing mechanisms and institutions to react successfully to the changes. If this goal is achieved, additional mitigation would be to provide resources (money, information or technical personnel) to existing institutions, a much simpler task than creating institutions and infrastructure.

The analysis of project-induced changes in Section 3, when compared to forecast historical and baseline changes, is not of such great magnitude that new infrastructure would be needed. Rather, the changes are forecast to be moderate when compared to changes that communities have been experiencing over the past 10 years. Accordingly, appropriate mitigation measures, beyond avoidance measures, would consist of coordinating with and supplying resources to existing institutions designed to accommodate change. This coordination and supply of resources is discussed in Section 4.4.2.

4.4.1 - Mitigation Measures that Would Help Avoid Significant Adverse Project-Induced Impacts (**)

These impact avoidance mitigation measures would become part of the project design or Applicant policy on project construction procedures. Some design and policy elements cannot be finalized until a short time prior to project construction because their finalization is subject to negotiations with labor representatives and contractors. While details about policies would emerge from contract negotiations, the Applicant can set mitigation principles. The following is a statement of these principles and a brief summary of each measure's effectiveness for avoiding impacts.

(a) Leave, Shift, and Shift Rotation Schedules (**)

Different leave, shift, and shift rotation schedules would result in different amounts and patterns of residence relocation and commuting by workers. They would also result in different costs for transportation programs since more frequent rotations increase the number of trips per worker. These amounts and patterns can be predicted accurately enough to indicate that a rotation schedule of at least two weeks between each off period would be necessary for the worker transportation program to be economically feasible.

Prior to labor contract negotiations, the Applicant would determine which schedules appear to be most consistent with the preferred transportation programs. The preferred program would minimize impacts on communities, workers, and fish and wildlife resources, while constituting an acceptable cost to the Project. This determination would be made through an analysis of these considerations and other mitigation measures discussed below. To the extent possible, the Applicant would negotiate labor contracts to conform to schedules that help avoid significant adverse impacts on communities, workers, and fish and wildlife resources.

(b) Housing and Related Facilities (*)

The availability, siting, type, quality, and administration (including camp policies, rules and regulations) of housing and related facilities would greatly affect workers' residence preferences. Experience at projects comparable to the Susitna Project has shown that there is a tendency for many workers, especially those with families, to relocate to nearby communities if housing is not available at the construction site. Because communities located near the Susitna construction sites do not have the capacity nor the desire to have their populations increase several-fold in a two or three year period, it is appropriate that the Project provide acceptable housing for the workers at the Watana and Devil Canyon Dam construction sites and the Cantwell railhead.

Furthermore, projects located at semi-remote or remote construction sites with variable and frequently unfavorable weather conditions making commuting difficult, and near small communities with little infrastructure require adequate worker housing and related facilities onsite. If housing is available at the construction site and if the leave and other schedules are developed appropriately, workers would tend to maintain their pre-project family residences and reside at the work site during shifts. This should result in minimizing resettlement by workers in communities located near the construction sites.

As a measure to avoid large population influxes into nearby communities, the Applicant would provide single status accommodations at the dam and Cantwell railhead construction sites for shift workers. Family accommodations and related facilities would be provided for workers who would be at the work sites on a more permanent basis. These arrangements, together with appropriate leave and other schedules, would reduce resettlement by workers in nearby communities. Detailed planning for the siting, type, quality, and administration of housing and related facilities for workers would occur during the project design period.

(c) Transportation Program for Workers (**)

The impacts discussed in Section 3 were forecast under the following assumptions about the worker transportation program. During Watana - Stage I, some mix of air and bus transportation would be provided for workers. Travel along the access road would be prohibited to people not associated with the Project. Project personnel would have limitations placed on the use of private vehicles on the access road. Most would be prohibited from commuting by private vehicle.

Details of this transportation program would be finalized after negotiations with contractors and labor are complete. The negotiations would help determine acceptable transportation modes as well as all related considerations that determine a transportation program's economic viability. These considerations would include shift rotation schedules, housing, access road and camp restrictions and travel time compensation.

During Devil Canyon - Stage II and Watana - Stage III, the impact analysis assumes that there would be no transportation program. This assumption was based upon the changing circumstances at the construction sites that would greatly reduce the benefits of transporting workers. These include: (1) The work force peaks for Stages II and III are projected to be about one half of what they are for Stage I; and (2) The access road would be open to the public after the first stage of construction ends. The first of these two changes removes much of the benefit derived from transporting workers. That is, impacts on communities are slight without a transportation program; therefore, instituting a program results in only small community impact reductions. The second change, opening the access road to the public, makes enforcement of restricted access to workers, an essential element of a transportation program, less practical. The change also reduces one of the benefits of transporting workers; namely, decreasing impacts on fish and wildlife resources. By controlling access and transporting workers, there would be little increase in hunting and fishing pressure on resources near the access road. With access allowed, either project personnel or non-project people could hunt or fish near the road and a continuing transportation program would not prevent this activity.

The presence of a transportation program in Stage I has the general effect of decreasing population influxes into small communities located nearest to project facilities. These employees and their families, who would otherwise in-migrate to small communities, would retain their residences in or near Anchorage and Fairbanks. The reduction of in-migrating direct workers would also result in a decrease in support workers. The type of transportation program instituted would affect the degree to which the project-related population is shifted from small towns to larger cities. Air transportation from Anchorage and Fairbanks would create the largest shift. Bus or van programs that serve small towns would result in little decrease in in-migration to those towns. The assumption used in the Stage I impact analysis is that a near equal mix of air and bus/van transportation would be used, resulting in a mid-range shift of population from small towns to larger cities. If the actual mix is predominantly air, the analysis probably overestimates in-migration into small towns; if it is predominantly bus or van, the in-migration is probably underestimated.

The shift of project-related population to Anchorage and Fairbanks is desirable because they are the cities in Alaska most able to absorb population influxes. For example, Anchorage has experienced an influx of up to 1,000 persons per month during the early 1980's. It is projected that during 1991-1997, the net project-related population influx into Anchorage would total about 3,000 (this takes into account people moving from Anchorage to the Local Impact Area as well as people moving into Anchorage). Thus, it is unlikely that Anchorage would be significantly affected, even if more than the forecast amount of persons were to relocate to Anchorage.

(d) Summary (**)

Through its plans for housing and related support facilities at the construction sites, its commitment to support a worker transportation program that helps avoid adverse impacts in communities and on workers, as well as fish and wildlife resources, and its commitment to develop leave, shift, and shift rotation schedules to help meet socioeconomic mitigation objectives, the Applicant would aid in meeting the following mitigation objectives:

- o Avoid large and rapid population influxes into nearby communities such as Cantwell, Trapper Creek, Talkeetna, Healy, and Nenana.
- o Avoid large traffic increases on the Denali and Parks Highways, especially during summer months;

During detailed project design, the Stage I worker transportation program would be negotiated and details determined. Onsite housing plans would be refined. This would be done in coordination with planning of leave, shift, and shift rotation schedules and timing of labor demand. This coordination would help ensure that the most cost-effective means of achieving socioeconomic objectives are chosen. The overall goals are to meet socioeconomic mitigation and other project objectives that are not in conflict with one another, make trade-offs where objectives are in conflict, impose a minimum of constraints upon workers, and implement the plans at an acceptable cost. Prior to Stage II, the need for continuing the worker transportation program would be evaluated.

4.4.2 - Mitigation of Significant Adverse Impacts that Remain in Communities (**)

After the mitigation measures discussed above have been implemented, forecasts show that the private sector and local and state government mechanisms would be able to adequately meet remaining demands. Additional mitigation measures required to reduce project-induced changes would likely involve only the provision of resources to private and government entities. These measures would be place-specific and the probable effects and costs of each measure would be estimated before implementation.

There are several means by which the private sector, local and state governments, social service organizations, and if appropriate, the Applicant can reduce disruptions and adverse budget impacts. These include project-community interaction, subdivision development, temporary offsite housing, assistance to social organizations, house financing, and others. Within each of these categories, technical and financial assistance may be available. The magnitude of impacts forecast in Section 3 is not great, implying that project-community interaction and minor, occasional financial help with community facilities and services may be sufficient community-based mitigation.

The Applicant would implement project-community interaction among the Applicant, local and state agencies, and affected communities. Information about anticipated project-induced changes would be disseminated to communities, agencies, and other appropriate entities in a timely manner, and these entities' attitudes toward and concerns about these changes would be communicated back to the Applicant. Timeliness is important, because one goal of the mitigation program is to anticipate and prescribe mitigation measures in advance of the predicted impacts rather than to react to impacts. Communication among entities is discussed further in the presentation of the Impact Management Program below.

4.5 - Impact Management Program (**)

The goal of the impact management program is to reduce adverse socioeconomic impacts caused by the Project. This would be done by:

- Developing and providing impact information to communities, individuals, and agencies in a timely manner. This information is intended to assist them in planning for and adjusting to project-induced changes. It is also provided so that concerns can be identified and planning can be based upon the best available information.

- Refining and implementing cost-effective mitigation measures to reduce adverse impacts that cannot be adequately handled by existing private, government, and social mechanisms.

- Evaluating the effectiveness of mitigation measures.

- Making adjustments to these measures, or adding or deleting measures to achieve desired mitigation objectives.

4.5.1 - Developing Impact Information (**)

Updated information about project features, labor needs, and schedules as they become better defined would be made available to all concerned parties. Any information about project impacts on communities would also be made available to these parties as impacts are discovered in the monitoring program (see Section 4.5.3). Both project construction information and community impact information would be assessed for variation from forecasts presented in the License Application. Variations from forecasts would be used to adjust the projection of impacts for the remainder of the Project. In other words, the definition of the existing environment would be periodically updated to serve as the basis for predicting future project effects.

An update of the baseline would not be required unless ISER forecasts are shown to be in error. Even if an update becomes necessary, it would probably only entail an estimation of proportional decrease or increase of in-migration for communities within Railbelt subareas. This lower level estimate is all that would be necessary because ISER (1985) and FOA (1985a) socioeconomic projections are identical down to the subarea level.

Socioeconomic conditions, including the availability of housing and facilities and services, would be monitored in affected communities during construction. Monitoring activities would be more extensive in the nearby communities, especially those communities found to receive in-migration from direct workers, as determined by work force monitoring. The monitoring program would include a determination of seasonal effects of the Project.

In addition, the work force would be monitored starting in the first year of construction. Factors such as workers' residence before and during construction, numbers of workers with dependents, and numbers of dependents per worker would be monitored. This information would help identify project-induced impacts.

4.5.2 - Providing Impact and Other Information (*)

Information about the Project has been and would continue to be provided to communities, individuals, agencies, and other parties through public meetings and workshops, newsletters, press releases, teleconferences, briefing packets, and other means.

These parties would have opportunities to express concerns about impacts and mitigation measures through the public meetings and workshops, teleconferences, writing to the Applicant, or by direct consultation with the Applicant.

4.5.3 - Refining and Implementing Mitigation Measures (**)

During the design phase, the mitigation measures discussed in Section 4.4.1 (those designed to avoid adverse socioeconomic impacts) would be refined. This would be done by an interdisciplinary task force in a multi-objective context. Changes in the assumptions used for forecasting impacts would be assessed for their effect on in-migration into Local Impact Area communities. Different transportation and onsite housing options would be developed if changing assumptions warrant such changes.

If existing forecasts of in-migration remain valid, little anticipatory mitigation of the type discussed in Section 4.4.2 would be necessary. Only in Cantwell, because of railhead construction, would impacts occur so quickly and be of sufficient magnitude to warrant mitigation in advance of impact. The primary need in Cantwell would be to increase school capacity. This increase would be accomplished through negotiations with appropriates state and local officials.

The monitoring programs would provide information that identifies the need for in-community mitigation and allows for evaluation of the performance of mitigation measures. Mitigation measures would be adjusted, added, or deleted as required throughout construction to meet the mitigation objectives.

Before and during construction activities, the Applicant would interact with the communities, the private sector, state and local government institutions, and human service organizations. Representatives of state and local government institutions and other appropriate entities would be requested to review and comment upon annual mitigation reports, including recommended mitigation measures for future implementation.

5 - MITIGATION MEASURES RECOMMENDED BY AGENCIES (**)

Written comments regarding the November 15, 1982 draft Exhibit E are contained in Exhibit E, Chapter 11 of the original License Application filed before FERC in February 1983. A response is provided for each comment. Some responses refer the reader to sections of Chapter 5 where appropriate changes have been made. Other responses fully address issues raised with no reference to Chapter 5.

Several agency comments contained recommendations for mitigation. The main purpose of this section is to summarize these recommendations, and identify sections in Chapter 5 that address these recommendations. A secondary purpose is to summarize agency suggestions for further mitigation work.

5.1 - Alaska Department of Natural Resources (DNR) (**)

Source: Letter to Mr. Eric Yould from Esther Wunnicke, January 13, 1983.

- A location with more physical amenities, such as in the Fog Lakes area south of the Susitna River on privately owned land, is recommended for the permanent townsite. The DNR feels that the tendency for workers to reside on-site (Exhibit E emphasizes that a high amenity site will minimize adverse impacts to nearby communities) depends on the quality of housing and other amenities.

  This mitigation recommendation is discussed in Section 4.4.1(c) and Section 4.5.

- A more comprehensive approach to ensuring "that the local unemployed get a chance at project-related jobs" is recommended. DNR feels that "it will be necessary to develop a clearly defined and legal program" to encourage local hire.

  This mitigation recommendation is discussed in the Applicant's written response to DNR's letter. The Applicant's position on the issue of local hiring is that to enhance the employment opportunities associated with the Project the Applicant would: 1) facilitate, to the extent legally feasible, the hiring of workers from area communities: and 2) facilitate the transportation of workers from the communities in conjunction with a proposed worker transportation program. Overall, the Applicant would fully comply with employment legislation in effect at the time of project hiring. Therefore positive employment impacts are expected to occur in the state and in area communities.

5.2 - Alaska Department of Fish and Game (ADF&G) (*)

Source: Letter to Mr. Eric Yould from Mr. Don Collinsworth (including Appendix C), January 13, 1983.

- The ADF&G would like "some indication as to what can be done to resolve the impacts" (to resource users).

  This information is provided in Section 4.4.

5.3 - U.S. Fish and Wildlife Service (FWS) (*)

Source: Letter to Mr. Eric Yould from Mr. Keith Bayher (including attachment), undated (received by the Applicant on January 14, 1983).

- The FWS states that "avoidance of adverse impacts should be given priority as a mitigation measure", and gives examples such as "mode, timing, and routing of construction access; schedule of work; type and siting of the construction camp/village;...".

  This recommendation is discussed in Section 4.4.

- The FWS stresses the need for an effective monitoring program and "believe the program should provide for participation by representatives of appropriate state, Federal, and local agencies and be financed by the project. This panel should have the authority to recommend modification of how activities are conducted to assure that mitigation is effective".

  This recommendation is discussed in Section 4.4.

- The FWS would like construction camp alternatives such as siting, type of camp, and administration considered as a means to minimize adverse impacts to fish and wildlife resources and their use.

  This recommendation is discusssed in Section 4.4 of Chapter 5 and in Chapter 3.

5.4 - Summary of Agencies' Suggestions for Further Studies that Relate to Mitigation (**)

The FWS suggests that the base case (baseline projections) be updated. They feel that the data base should be broadened for the update. The FWS also expressed the opinion that the size of impacts, and therefore the mitigation requirements, are directly related to the base case. This suggestion was incorporated into plans of study in 1984 and 1985. The data collected from the subsequent research was incorporated into the socioeconomic model (FOA 1985a).

The FWS states that "to evaluate impacts to users of fish and wildlife resources, the impacts to resources must first be assessed. In that many of these resource impacts have not been sufficiently quantified, one could not expect an acceptably quantified socioeconomic analysis. This could only have lead to a highly general mitigation plan, which is what we find here." In addition, both the FWS and the ADF&G suggest that more data and information about current and recent use of fish and wildlife resources in the project area could be collected.

In response to this comment, research was conducted from the perspective of the biological sciences (see Chapter 3) and of the social sciences (see Section 3 of Chapter 5). Social science research was conducted by ISER (1985) and Harza-Ebasco (1985e).

Measures designed to protect or minimize adverse impacts on existing users are discussed in Section 4. These measures would help avoid losses of the remote attributes of the middle Susitna Basin, and worker impacts on fish and wildlife, including animal road kills by vehicles and consumptive use of fish and wildlife by workers.

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TABLES

TABLE E.5.2.1: HISTORICAL EMPLOYMENT AND PER CAPITA INCOME 1970 TO 1984

Place	Employment (Unemployment Rate)				Per Capita Income (Dollars)			
	1970	1976	1980	1984	1970	1975	1980	1982
State	92,467 (7.1)	150,000 (8.5)	169,000 (9.6)	225,000 (9.8)	3,765	9,554	12,916	16,598
Regional Impact Area	79,347 (9.9)	110,283[1/] (6.1)	126,110[2/] (9.0)	176,500 (NA)	NA	NA	NA	NA
Anchorage	51,398 (8.3)	63,184 (7.2)	75,616 (7.4)	112,100 (7.3)	4,242	NA	14,400	18,429
Fairbanks	18,003 (10.4)	22,917 (7.6)	17,982 (12.2)	27,700 (12.4)	3,982	NA	13,991	18,381
Mat-Su Borough	NA	4,683 (14.8)	7,723 (15.4)	6,400 (12.5)	2,894	NA	10,693	13,874

Sources: Alaska Department of Labor 1985; Huff 1985

1/ For 1975
2/ For 1979
NA Not Available

TABLE E.5.2.2: HISTORICAL AND BASELINE POPULATION IN SELECTED JURISDICTIONS
1960, 1970, 1980, 1985, 1990, 1997, 2003, 2009

Community	1960 1/	1970 1/	1980 2/	1985 3/	1990 3/	1997 3/	2003 3/	2009 3/
Mat-Su Borough	5,188	6,509	17,816	35,721	41,976	53,306	63,824	75,996
Talkeetna	76	182	265	288	350	461	584	738
Trapper Creek	NA	NA	NA	243	282	347	414	494
Palmer	1,181	1,140	2,143	2,876	3,334	4,242	5,214	6,410
Houston	NA	69	325	813	1,309	2,551	4,520	8,007
Wasilla	112	376	1,559	3,814	5,476	9,084	14,020	21,637
Nenana	286	382	471	573	711	961	1,244	1,611
Healy	NA	79	333	639	763	938	1,120	1,337
Cantwell	85	62	182	197	217	250	281	317
Anchorage	82,833	126,385	174,431	247,237	248,767	259,451	266,123	274,110
Fairbanks	13,311	14,771	22,645	27,574	29,824	31,807	33,327	34,890
Fairbanks - North Star Borough	NA	45,864	57,366	67,435	73,839	80,138	85,257	90,647

NA Not Applicable

1/ Source: U.S. Department of Commerce, Bureau of the Census 1985
2/ Source: Alaska Department of Labor 1985a
3/ Source: Frank Orth & Associates Inc. 1985b

TABLE E.5.2.3: BASELINE HOUSING STOCK ESTIMATES AND VACANCY RATES FOR SELECTED JURISDICTIONS 1985, 1990, 1997, 2003, 2009

Community	1985 Units	1985 Vacancy Rate	1990 Units	1990 Vacancy Rate	1997 Units	1997 Vacancy Rate	2003 Units	2003 Vacancy Rate	2009 Units	2009 Vacancy Rate
Mat-Su Borough	15,500	25%	18,211	22%	23,055	20%	28,300	18%	3,360	16%
Talkeetna	170	33%	190	27%	225	22%	270	17%	320	12%
Trapper Creek	105	27%	120	24%	150	21%	180	18%	215	15%
Palmer	1,000	9%	1,200	9%	1,570	8%	2,050	8%	2,600	8%
Houston	360	27%	570	23%	1,140	23%	2,125	23%	3,870	23%
Wasilla	1,350	9%	1,999	9%	3,430	9%	5,600	9%	8,880	9%
Nenana	230	9%	285	9%	385	9%	500	9%	640	9%
Healy	220	10%	270	10%	345	10%	430	10%	530	10%
Cantwell	103	32%	110	30%	125	28%	135	25%	145	22%
Anchorage	95,640	13%	98,040	12%	103,490	11%	109,970	11%	114,250	10%
Fairbanks	11,430	7%	12,310	7%	12,860	7%	13,350	7%	13,650	7%
Fairbanks - North Star Borough	28,670	18%	31,520	17%	33,880	16%	36,090	15%	37,820	14%

Source: Frank Orth & Associates Inc. 1985b

TABLE E.5.2.4: COMMUNITY FACILITIES SUMMARY FOR LOCAL IMPACT AREA COMMUNITIES 1985

	Schools																									Government				
	Elementary	Secondary	Higher	Water	Sewer	Solid Waste Disposal	State Trooper Post	Local Police	Court System	Fire Hall	Health Center	Long Term Care Fac.	Mental Health Facility	General Hospital	Roads	Railroad	Public Transportation	Airstrip	Library	Community Building	Post Office	Park System	Power	Telephone Service	Communication/Media	Home Rule	First Class	Second Class	Unincorporated	Unified Home Rule
Nenana	*	*		*	*	*	*			*	*				*	*		*		*	*	*	*	*	*		*			
Cantwell	*					*	*			*					*	*		*		*	*		*	*	*				*	
Trapper Creek	*					*	*								*						*		*	*	*				*	
Talkeetna	*					*				*					*	*		*	*	*	*	*	*	*	*				*	
Houston						*				*					*	*							*	*	*				*	
Palmer	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*				
Wasilla	*	*	*	*		*				*	*		*		*	*		*	*	*	*	*	*	*	*			*		
Healy	*	*		*	*	*	*				*				*	*		*			*		*	*	*				*	
Anchorage	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*					*
Fairbanks	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				

Sources: Harza-Ebasco Susitna Joint Venture 1985a

Frank Orth & Associates Inc. 1985a

TABLE E.5.2.5: BASE YEAR PUBLIC FACILITIES AND SERVICES USE RATES AND CAPACITIES[1/] LOCAL IMPACT AREA COMMUNITIES AND SCHOOL DISTRICTS 1984

Area/Community	Solid Waste		Police Services		Fire Services		Hospital Services		Recreation Facilities		Water Services		Sewer Services		Schools	
	Use Rate	Capa-city	Use Rate	Capa-city	Use Rate	Capa-city	Use Rate	Capa-city	Use Rate	Capa-city	Use Rate	Capa-city	Use Rate	Capa-city	Use Rate	Capa-city
Anchorage Subarea																
Anchorage	17.0	100	366	393	N/A	211	310	449	610	910	29.3	22.0	28.4	34.0	41855	37440
Mat-Su Borough	6.8	212	34	30	N/A	N/A	20	30	56	237	N/A	N/A	N/A	N/A	7985	8915
Palmer	0.6	80	4	8	N/A	N/A	N/A	N/A	4	7	0.4	1.0	0.3	0.3	653	2325
Wasilla	0.7	40	N/A	N/A	N/A	N/A	N/A	N/A	6	5	0.5	0.9	.2	.2	830	2850
Houston	0.1	6	N/A	N/A	N/A	18	N/A	N/A	4	200	N/A	N/A	N/A	N/A	0	0
Talkeetna	N/A	N/A	N/A	N/A	N/A	12	N/A	N/A	1	0	N/A	N/A	N/A	N/A	65	100
Trapper Creek	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	0	0	N/A	N/A	N/A	N/A	55	50
Fairbanks Subarea																
Fairbanks	0.8	75	41	46	N/A	46	85	147	167	6000	2.4	4.0	3.5	6.5	10676	10267
Railbelt Sch. Dist.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	345	410
Cantwell	0.0	2	0	1	N/A	7	N/A	N/A	0	0	N/A	N/A	N/A	N/A	40	60
Healy	0.1	0	1	1	N/A	20	N/A	N/A	1	0	N/A	N/A	N/A	N/A	173	200
Nenana	0.1	35	1	1	N/A	13	N/A	N/A	1	0	0.1	0.4	0.1	0.1	218	400

N/A Not Applicable

1/ The following units are used for use rates: solid waste (acres filled per year); police services (number of officers needed based on per capita standard); fire service (not applicable); hospital services (average daily number of occupied beds); recreation facilities (acres of community park needed based on per capita or per household standards); water service (millions of gallons per day); sewer service (millions of gallons per day); and schools (number of students). The following units were used to measure capacity: solid waste (acres of land fill); police services (number of officers currently employed); fire service (number of paid or volunteer firefighters); hospital services (number of hospital beds); recreation facilities (number of acres in community parks); water service (millions of gallons per day) sewer service (millions of gallons per day); and schools (number of students).

Sources: Frank Orth & Associates Inc. 1985a

TABLE E.5.2.6: CHARACTERISTICS OF PUBLIC SCHOOLS: MATANUSKA-SUSITNA BOROUGH SCHOOL DISTRICT 1985

School	School Type	School Grade	Capacity	Enrollment	Condition/Plans for Expansion
Big Lake	E	K-6	550	468	No plans.
Butte	E	K-6	500	400	No plans.
Glacier View	E/J/S	K-12	75	50	Currently consists of portables.
Iditarod	E	1-6	400	465	No plans.
Sherrod	E	3-6	450	498	No plans.
Skwentna	E/J/S	K-12	25	12	No plans.
Snowshoe	E	K-6	500	595	New facility. No plans.
Swanson	E	K-2	350	428	No plans.
Talkeetna	E	K-6	100	72	No plans.
Trapper Creek	E	K-6	100	37	New facility. No plans.
Wasilla Elementary	E	K	120	111	Lease expires in 1986 and cannot be renewed. The city (owner) will occupy building.
Willow Elementary	E	K-6	125	136	Expansion to accommodate 200 students will occur in 1 to 2 years.
Palmer	J	7-8	800	466	Recently renovated. No plans.
Wasilla	J	7-8	600	809	Recently completed addition to Facility. No plans. School is on double shifts.
Palmer	S	9-12	800	871	Major addition to increase capacity to 1,200 is planned in 1 to 2 years.
Susitna Valley	J/S	7-12	150	159	Addition to increase capacity to 200 students is planned in 1 to 2 years.
Wasilla	S	9-12	1,200	1,255	Recently completed addition to the facility. No plans.

TABLE E.5.2.6: Page 2 of 2

School	School Type	School Grade	Capacity	Enrollment	Condition/Plans for Expansion
Pioneer Peak	E	K-6	500	473	No plans.
Tanaina	E	1-6	500	534	No plans.
Cottonwood	E	K-6	500	586	No plans.
Pt. Mackensie	E/J	K-8	50	26	Presently uses 2 portables. No plans.
Sutton	E	K-6	100	100	Presently all portables (7). New school with capacity of 200 students has been approved. Will open in 2 or 3 years.
Knik/Greater Wasilla	E	K-6	500	0	Approved new school.
Colony Sr. High	S	9-12	1,200	0	Approved new school.
Colony Jr. High	J	7-8	800	0	Approved new school.
Houston Jr./ Sr. High	J/S	7-12	600	0	Approved new school.
Finger Lake	E	K-6	500	0	Approved new school.

Note: Mat-Su School District has 67 portable classrooms which are used as permanent schools or additional classrooms to alleviate crowding at schools where there are no present plans for expansion but where capacities are exceeded.

E = Elementary; J = Junior; S = Senior

Source: Matanuska-Susitna Borough School District 1985

TABLE E.5.2.7: BASELINE EMPLOYMENT FORECASTS
1985, 1990, 1997, 2003, 2009

	1985	1990	1997	2003	2009
State	249,902	267,910	306,395	316,760	337,217
Regional Impact Area	179,234	189,912	210,395	222,393	239,699
Anchorage	122,615	127,817	141,132	148,385	159,505
Kenai-Cook Inlet	11,026	11,776	13,445	14,541	16,071
Seward	1,480	1,559	1,734	1,835	1,985
Mat-Su Borough	6,590	7,351	8,870	10,015	11,515
Fairbanks-N. Star	34,746	38,374	41,931	44,189	47,009
City of Fairbanks	14,208	15,499	16,642	17,273	18,094
SE Fairbanks	1,891	2,046	2,170	2,228	2,308
Yukon-Koyukuk	867	977	1,099	1,186	1,291

Source: Frank Orth & Associates Inc. 1985b

TABLE E.5.3.1: IMPACT OF THE PROJECT ON POPULATION IN SELECTED JURISDICTIONS 1997, 2003, 2009

Region/ Borough/Community	1997 Baseline Forecast	1997 With Project Forecast	1997 % Increase over Baseline	2003 Baseline Forecast	2003 With Project Forecast	2003 % Increase over Baseline	2009 Baseline Forecast	2009 With Project Forecast	2009 % Increase over Baseline
Regional Impact Area	457,699	460,222	1	488,779	492,266	1	524,532	528,461	1
Mat-Su Borough (off-site)	53,306	53,680	1	63,824	64,695	1	75,996	77,174	2
Talkeetna	461	532	15	584	671	15	738	774	5
Trapper Creek	347	358	3	414	441	7	494	533	8
Palmer	4,242	4,282	1	5,214	5,332	2	6,410	6,584	3
Houston	2,551	2,572	1	4,520	4,580	1	8,007	8,096	1
Wasilla	9,084	9,129	1	14,020	14,148	1	21,637	21,821	1
Nenana	961	966	1	1,244	1,310	5	1,611	1,705	6
Healy	938	941	0	1,120	1,140	2	1,337	1,363	2
Cantwell	250	368	47	281	294	5	317	386	22
Anchorage	259,451	259,984	0	266,123	267,005	0	274,110	274,986	0
Fairbanks	31,807	31,741	0	33,327	32,983	0	34,890	34,924	0
Fairbanks - North Star Borough	80,138	80,494	0	85,257	85,834	1	90,647	91,269	1

Source: Frank Orth & Associates Inc. 1985b, 1985d

TABLE E.5.3.2: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON THE MAT-SU BOROUGH (Off-site)[a/]

Population/ Facility/Service	1984 Population, Housing Vacancy, and Capacities	1997 Baseline Forecast	1997 With Project Forecast	1997 % Increase over Baseline	2003 Baseline Forecast	2003 With Project Forecast	2003 % Increase over Baseline	2009 Baseline Forecast	2009 With Project Forecast	2009 % Increase over Baseline
Population	34,118	53,306	53,680	1	63,824	64,695	1	75,996	77,174	2
Housing Vacancy Rate	25%	20%	19%	NA	18%	17%	NA	16%	15%	NA
Water (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Solid Waste Disposal (cumulative acres)	212.0	107.8	108.3	1	181.8	183.8	1	270.9	273.3	1
Sewage Treatment (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Police (number of officers)	30	61	62	1	76	77	1	94	95	1
Education										
(primary students)	4,835	6,995	7,043	1	8,375	8,514	2	9,972	10,162	2
(secondary students)	4,080	5,959	5,999	1	7,134	7,253	2	8,495	8,656	2
Hospital Beds	30	83	84	1	107	109	2	128	130	2
Community Parks (b) (acres)	236.5	89	89	0	112	113	1	136	138	1

NA = Not Applicable

(a) With-Project population increase, vacancy rates, and service demands refer to Mat-Su Borough communities and do not include population, vacancy rates, and service demands at the work camp/village.

(b) Community parks generally contain facilities such as tennis courts, ball diamonds, play apparatus, basketball courts, nature walks, and swimming pools.

Source: Frank Orth & Associates Inc. 1985b, 1985d.

TABLE E.5.3.3: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON TALKEETNA

Population/ Facility/Service	1984 Population, Housing Vacancy, and Capacities	1997 Baseline Forecast	1997 With Project Forecast	1997 % Increase over Baseline	2003 Baseline Forecast	2003 With Project Forecast	2003 % Increase over Baseline	2009 Baseline Forecast	2009 With Project Forecast	2009 % Increase over Baseline
Population	277	461	532	15	584	671	15	738	774	5
Housing Vacancy Rate	32%	22%	4%	NA	17%	0%	NA	12%	9%	NA
Water (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Solid Waste Disposal (cumulative acres)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Treatment (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Police (number of officers)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Education										
(primary students)	100	60	68	13	77	88	14	97	102	5
(secondary students)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hospital Beds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Community Parks (a) (acres)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not Applicable

(a) Community parks generally contain facilities such as tennis courts, ball diamonds, play apparatus, basketball courts, nature walks, and swimming pools.

Source: Frank Orth & Associates Inc. 1985b, 1985d

TABLE E.5.3.4: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON TRAPPER CREEK

Population/ Facility/Service	1984 Population, Housing Vacancy, and Capacities	1997 Baseline Forecast	1997 With Project Forecast	1997 % Increase over Baseline	2003 Baseline Forecast	2003 With Project Forecast	2003 % Increase over Baseline	2009 Baseline Forecast	2009 With Project Forecast	2009 % Increase over Baseline
Population	236	347	358	3	414	441	7	494	533	8
Housing Vacancy Rate	27%	21%	18%	NA	18%	13%	NA	15%	9%	NA
Water (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Solid Waste Disposal (cumulative acres)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Treatment (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Police (number of officers)	3	0.4	0.4	0	0.4	0.4	0	0.5	0.5	0
Education										
(primary students)	50	46	47	2	54	59	9	65	71	9
(secondary students)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hospital Beds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Community Parks (a) (acres)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not Applicable

(a) Community parks generally contain facilities such as tennis courts, ball diamonds, play apparatus, basketball courts, nature walks, and swimming pools.

Source: Frank Orth & Associates Inc. 1985b, 1985d

TABLE E.5.3.5: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON PALMER

Population/ Facility/Service	1984 Population, Housing Vacancy, and Capacities	1997 Baseline Forecast	1997 With Project Forecast	1997 % Increase over Baseline	2003 Baseline Forecast	2003 With Project Forecast	2003 % Increase over Baseline	2009 Baseline Forecast	2009 With Project Forecast	2009 % Increase over Baseline
Population	2,792	4,242	4,282	1	5,214	5,332	2	6,410	6,584	3
Housing Vacancy Rate	8%	8%	7%	NA	8%	6%	NA	8%	6%	NA
Water (gallons per day)	1,030,000	629,602	635,538	1	782,100	799,800	2	961,500	987,600	3
Solid Waste Disposal (cumulative acres)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Treatment (gallons per day)	300,000	495,644	500,317	1	625,680	639,840	2	769,200	790,080	3
Police (number of officers)	9	6.4	6.4	0	7.8	8.0	3	9.6	9.9	3
Education										
(primary students)	1,225	557	562	1	684	704	3	841	869	3
(secondary students)	1,600	474	478	1	583	600	3	717	741	3
Hospital Beds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Community Parks (a) (acres)	30.5	5	5	0	6	6	0	8	8	0

NA = Not Applicable

(a) Community parks generally contain facilities such as tennis courts, ball diamonds, play apparatus, basketball courts, nature walks, and swimming pools.

Source: Frank Orth & Associates Inc. 1985b, 1985d

TABLE E.5.3.6: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON WASILLA

Population/ Facility/Service	1984 Population, Housing Vacancy, and Capacities	1997 Baseline Forecast	1997 With Project Forecast	1997 % Increase over Baseline	2003 Baseline Forecast	2003 With Project Forecast	2003 % Increase over Baseline	2009 Baseline Forecast	2009 With Project Forecast	2009 % Increase over Baseline
Population	3,548	9,084	9,129	1	14,020	14,148	1	21,637	21,821	1
Housing Vacancy Rate	9%	9%	8%	NA	9%	8%	NA	9%	8%	NA
Water (gallons per day)	900,000	1,348,256	1,354,935	0	2,103,000	2,122,200	1	3,245,550	3,273,150	1
Solid Waste Disposal (cumulative acres)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Treatment (gallons per day)	441,000	1,061,393	1,066,651	0	1,682,400	1,697,760	1	2,596,440	2,618,520	1
Police (number of officers)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Education										
(primary students)	1,550	1,192	1,198	1	1,840	1,861	1	2,839	2,868	1
(secondary students)	1,800	1,015	1,020	1	1,567	1,585	2	2,419	2,445	1
Hospital Beds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Community Parks (a) (acres)	19.0	10	10	0	17	17	0	27	27	0

NA = Not Applicable

(a) Community parks generally contain facilities such as tennis courts, ball diamonds, play apparatus, basketball courts, nature walks, and swimming pools.

Source: Frank Orth & Associates Inc. 1985b, 1985d

TABLE E.5.3.7: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON HOUSTON

Population/ Facility/Service	1984 Population; Housing Vacancy, and Capacities	1997 Baseline Forecast	1997 With Project Forecast	1997 % Increase over Baseline	2003 Baseline Forecast	2003 With Project Forecast	2003 % Increase over Baseline	2009 Baseline Forecast	2009 With Project Forecast	2009 % Increase over Baseline
Population	739	2,551	2,572	1	4,520	4,580	1	8,007	8,096	1
Housing Vacancy Rate	31%	23%	22%	NA	23%	22%	NA	23%	22%	NA
Water (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Solid Waste Disposal (cumulative acres)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Treatment (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Police (number of officers)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Education										
(primary students)	525	335	338	1	593	603	2	1,051	1,066	1
(secondary students)	600 (b)	285	287	1	505	514	2	895	908	2
Hospital Beds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Community Parks (a) (acres)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not Applicable

(a) Community parks generally contain facilities such as tennis courts, ball diamonds, play apparatus, basketball courts, nature walks, and swimming pools.

(b) Planned capacity for 1986 and later. Current capacity is zero.

Source: Frank Orth & Associates Inc. 1985b, 1985d

TABLE E.5.3.8: PROJECT IMPACTS ON TRAFFIC AND ACCIDENTS 1997 AND 2009

Road Segments	Baseline Forecast						Number (% increase) Project Impacts		Number (% increase over baseline) Project Impacts in 2009	
	AADT		Accidents		Animal[a/] Kills		AADT	Accidents	AADT	Accidents
	1997	2009	1997	2009	1997	2009				
Anchorage to Palmer or Wasilla	29,266	50,272	205	352	29	50	392 (1%)	3 (1)	358 (1%)	2 (1)
Palmer to Anchorage or Wasilla	14,872	25,150	30	50	4	8	266 (2)	1 (3)	206 (1)	0 (0)
Wasilla to Anchorage or Palmer	24,582	43,739	25	44	1	2	406 (2)	0 (0)	336 (1)	0 (0)
Wasilla to Houston	15,220	35,746	61	143	8	43	368 (2)	1 (2)	280 (1)	1 (1)
Houston to Talkeetna Road	3,496	6,012	10	18	3	6	96 (3)	0 (0)	92 (2)	0 (0)
Talkeetna Road to Trapper Creek	2,580	4,269	21	34	8	13	76 (3)	1 (5)	88 (2)	1 (3)
Talkeetna Spur Road	1,328	2,348	11	19	4	7	56 (4)	0 (0)	24 (1)	0 (0)
Trapper Creek to Cantwell	1,954	3,210	16	26	4	6	48 (2)	0 (0)	78 (2)	1 (4)
Cantwell to Healy	2,760	4,861	14	23	1	2	80 (3)	0 (0)	96 (2)	0 (0)
Healy to Nenana	1,790	3,086	21	37	1	2	30 (2)	0 (0)	54 (8)	1 (3)
Nenana to Fairbanks	2,044	3,337	14	23	0	0	36 (2)	0 (0)	62 (2)	0 (0)
Cantwell to Project Access Road	104	150	1	2	0	0	102 (98)	1 (100)	144 (96)	2 (100)
Project Access Road to Paxson	104	150	1	2	0	0	2 (2)	0 (0)	2 (1)	0 (0)
Project Access Road	0	0	0	0	0		202 (NA)	0 (NA)	235 (NA)	0 (NA)

NA = Nonapplicable because baseline is zero

[a/] Project related animal road kills were also forecast as part of the traffic module of the socioeconomic model. No additional kills are forecast to occur from project-related traffic.

Source: Derived from Frank Orth & Associates Inc. 1985b, 1985d

TABLE E.5.3.9: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON CANTWELL

Population/ Facility/Service	1984 Population, Housing Vacancy, and Capacities	1997 Baseline Forecast	1997 With Project Forecast	1997 % Increase over Baseline	2003 Baseline Forecast	2003 With Project Forecast	2003 % Increase over Baseline	2009 Baseline Forecast	2009 With Project Forecast	2009 % Increase over Baseline
Population	193	250	368	47	281	294	5	317	386	22
Housing Vacancy Rate	33%	28%	-16%	NA	25%	8%	NA	22%	8%	NA
Water (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Solid Waste Disposal (cumulative acres)	2.0	0.6	0.8	40	0.9	1.1	22	1.3	1.6	23
Sewage Treatment (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Police (number of officers)	1	0.3	0.4	33	0.3	0.3	0	0.3	0.4	33
Education (total students)	60	45	73	62	50	54	8	57	77	35
Hospital Beds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Community Parks 1/ (acres)	0.0	0.3	0.5	67	0.3	0.4	33	0.4	0.5	25

NA = Not Applicable

1/ Community parks generally contain facilities such as tennis courts, ball diamonds, play apparatus, basketball courts, nature walks, and swimming pools.

Source: Frank Orth & Associates Inc. 1985b, 1985d

TABLE E.5.3.10: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON NENANA

Population/ Facility/Service	1984 Population, Housing Vacancy, and Capacities	1997 Baseline Forecast	1997 With Project Forecast	1997 % Increase over Baseline	2003 Baseline Forecast	2003 With Project Forecast	2003 % Increase over Baseline	2009 Baseline Forecast	2009 With Project Forecast	2009 % Increase over Baseline
Population	549	961	966	1	1,244	1,310	5	1,611	1,705	6
Housing Vacancy Rate	9%	9%	9%	NA	9%	5%	NA	9%	5%	NA
Water (gallons per day)	430,000	94,582	95,074	1	124,400	131,000	5	161,100	170,500	6
Solid Waste Disposal (cumulative acres)	35.0	1.9	1.9	0	3.3	3.4	3	5.1	5.2	2
Sewage Treatment (gallons per day)	60,000	94,582	95,074	1	124,400	131,000	5	161,100	170,500	6
Police (number of officers)	1	1.4	1.5	7	1.9	2.0	5	2.4	2.6	8
Education										
(primary students)	200	208	209	1	269	281	4	348	365	5
(secondary students)	200	177	178	1	229	240	5	296	311	5
Hospital Beds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Community Parks (a) (acres)	1.7	1.2	1.2	0	1.5	1.6	7	1.9	2.0	5

NA = Not Applicable

(a) Community parks generally contain facilities such as tennis courts, ball diamonds, play apparatus, basketball courts, nature walks, and swimming pools.

Source: Frank Orth & Associates Inc. 1985b, 1985d

TABLE E.5.3.11: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON HEALY

Population/ Facility/Service	1984 Population, Housing Vacancy, and Capacities	1997 Baseline Forecast	1997 With Project Forecast	1997 % Increase over Baseline	2003 Baseline Forecast	2003 With Project Forecast	2003 % Increase over Baseline	2009 Baseline Forecast	2009 With Project Forecast	2009 % Increase over Baseline
Population	581	938	941	0	1,120	1,140	2	1,337	1,363	2
Housing Vacancy Rate	25%	10%	9%	NA	10%	8%	NA	10%	8%	NA
Water (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Solid Waste Disposal (cumulative acres)	0.0	1.9	1.9	0	3.2	3.2	0	4.8	4.8	0
Sewage Treatment (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Police (number of officers)	1	0.9	0.9	0	1.1	1.1	0	1.3	1.4	8
Education										
(primary students)	100	101	101	0	121	124	3	144	149	3
(secondary students)	100	86	86	0	103	106	3	123	127	3
Hospital Beds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Community Parks[1] (acres)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not Applicable

1/ Community parks generally contain facilities such as tennis courts, ball diamonds, play apparatus, basketball courts, nature walks, and swimming pools.

Source: Frank Orth & Associates Inc. 1985b, 1985d

TABLE E.5.3.12: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON ANCHORAGE

Population/ Facility/Service	1984 Population, Housing Vacancy, and Capacities	1997 Baseline Forecast	1997 With Project Forecast	1997 % Increase over Baseline	2003 Baseline Forecast	2003 With Project Forecast	2003 % Increase over Baseline	2009 Baseline Forecast	2009 With Project Forecast	2009 % Increase over Baseline
Population	244,026	259,451	259,984	0	266,123	267,005	0	274,110	274,986	0
Housing Vacancy Rate	13%	11%	11%	NA	11%	10%	NA	11%	10%	NA
Water (gallons per day x 1,000)	36,000[2/]	31,134	31,219	0	31,935	32,076	0	32,893	33,033	0
Solid Waste Disposal (cumulative acres)	535.0[2/]	289.0	289.2	0	399.8	400.2	0	513.3	513.9	0
Sewage Treatment (gallons per day x 1,000)	34,000	28,955	29,037	0	29,699	29,836	0	30,591	30,726	0
Police (number of officers)	393	519	519	0	532	533	0	548	549	0
Education										
(primary students)	22,100	24,259	24,148	0	24,893	24,898	0	25,629	25,540	0
(secondary students)	15,340	19,848	19,757	0	20,358	20,417	0	20,969	20,951	0
Hospital Beds	578	407	408	0	416	418	0	433	435	0
Community Parks[1/] (acres)	910.2	649	650	0	665	667	0	685	688	0

NA = Not Applicable

1/ Community parks generally contain facilities such as tennis courts, ball diamonds, play apparatus, basketball courts, nature walks, and swimming pools.

2/ Planned Capacity in 1990.

Source: Frank Orth & Associates Inc. 1985b, 1985d

TABLE E.5.3.13: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON FAIRBANKS

Population/ Facility/Service	1984 Population, Housing Vacancy, and Capacities	1997 Baseline Forecast	1997 With Project Forecast	1997 % Increase over Baseline	2003 Baseline Forecast	2003 With Project Forecast	2003 % Increase over Baseline	2009 Baseline Forecast	2009 With Project Forecast	2009 % Increase over Baseline
Population	27,574	31,807	31,741	0	33,327	32,983	0	34,890	34,924	0
Housing Vacancy Rate	7%	7%	7%	NA	7%	8%	NA	7%	7%	NA
Water (gallons per day x 1,000)	4,000	2,799	2,793	0	2,933	2,903	0	3,070	3,073	0
Solid Waste Disposal (b) (cumulative acres)	75	36.7	36.8	0	44.1	44.2	0	56.9	57.1	0
Sewage Treatment (gallons per day x 1,000)	6,500	4,207	4,232	1	4,476	4,516	1	4,759	4,803	1
Police (number of officers)	46	48	48	0	50	50	0	52	52	0
Education (Fairbanks-North Star Borough)										
(primary students)	4,851	6,924	6,898	0	7,366	7,393	0	7,832	7,835	0
(secondary students)	5,416	5,898	5,875	0	6,275	6,299	0	6,672	6,675	0
Hospital Beds (Fairbanks-North Star Borough)	147	129	131	2	138	139	1	147	149	1
Community Parks (a) Fairbanks North Star Borough (acres)	6,000	200	201	0	213	215	1	227	228	0

NA = Not Applicable

(a) Community parks generally contain facilities such as tennis courts, ball diamonds, play apparatus, basketball courts, nature walks, and swimming pools.

(b) Forecasts are for the entire Fairbanks-North Star Borough.

Source: Frank Orth & Associates Inc. 1985b, 1985d.

TABLE E.5.3.14: ONSITE CONSTRUCTION AND OPERATIONS WORK FORCE REQUIREMENTS 1991 to 2011

Project Phase	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
<u>Construction</u>																					
January	45	434	488	339	563	420	443	636	526	247	522	229	154	101	87	156	240	412	364	259	253
February	45	434	488	339	563	420	443	636	526	247	522	229	154	101	87	156	240	412	364	259	253
March	120	536	682	662	1180	1243	1856	1631	585	627	923	768	1078	552	108	250	467	575	949	847	757
April	120	536	682	662	1180	1243	1856	1631	585	627	923	768	1078	552	108	250	467	575	949	847	757
May	390	813	913	1185	1518	1895	2832	2299	714	906	1181	1098	1572	747	126	396	644	1055	1470	1434	1057
June	390	813	913	1185	1518	1895	2832	2299	714	906	1181	1098	1572	747	126	396	644	1055	1470	1434	1057
July	637	825	960	1331	1550	1899	2946	2076	422	1182	1173	1196	1462	747	126	400	677	1055	1493	1446	868
August	637	825	960	1331	1550	1899	2946	2076	422	1182	1173	1196	1462	747	126	400	677	1055	1493	1446	868
September	612	825	1020	1268	1530	1983	2920	2047	439	975	1121	1196	1130	649	90	410	842	1028	1510	1420	344
October	612	825	1020	1268	1530	1983	2920	2047	439	975	1121	1196	1130	649	90	410	842	1028	1510	1420	344
November	434	564	394	625	718	549	619	614	215	544	387	280	194	158	0	201	460	323	303	253	0
December	434	564	394	625	718	549	619	614	215	544	387	280	194	158	0	201	460	323	303	253	0
Peak Construction during year	637	825	1020	1331	1550	1983	2946	2299	714	1182	1181	1196	1572	747	126	410	842	1055	1510	1446	1057
Average Construction during year	376	666	744	902	1176	1343	1936	1551	484	747	885	795	932	492	90	302	555	741	1015	943	547
<u>Operations</u>																					
Average Yearly Employment	0	0	0	0	0	0	0	0	87	87	87	87	87	87	92	92	92	92	92	92	92
Total Average Yearly Const. & Operations	376	666	744	902	1176	1343	1936	1551	571	834	972	882	1019	579	182	394	647	833	1107	1035	639

TABLE E.5.3.15: ONSITE CONSTRUCTION AND OPERATIONS PAYROLL 1991 TO 2011 (IN MILLIONS OF 1985 DOLLARS)

Project Phase	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
<u>Construction</u>																					
January	0.4	3.5	4.0	2.8	4.6	3.4	3.6	5.2	4.3	2.0	4.3	1.9	1.3	0.8	0.7	1.3	2.0	3.4	3.0	2.1	2.1
February	0.4	3.5	4.0	2.8	4.6	3.4	3.6	5.2	4.3	2.0	4.3	1.9	1.3	0.8	0.7	1.3	2.0	3.4	3.0	2.1	2.1
March	1.0	4.4	5.6	5.4	9.6	10.2	15.2	13.3	4.8	5.1	7.5	6.3	8.8	4.5	0.8	2.0	3.8	4.7	7.8	6.9	6.2
April	1.0	4.4	5.6	5.4	9.6	10.2	15.2	13.3	4.8	5.1	7.5	6.3	8.8	4.5	0.8	2.0	3.8	4.7	7.8	6.9	6.2
May	3.2	6.6	7.5	9.7	12.4	15.5	23.1	18.2	5.8	7.4	9.7	9.0	12.8	6.1	1.0	3.2	5.3	8.6	12.0	11.7	8.6
June	3.2	6.6	7.5	9.7	12.4	15.5	23.1	18.2	5.8	7.4	9.7	9.0	12.8	6.1	1.0	3.2	5.3	8.6	12.0	11.7	8.6
July	5.2	6.7	7.9	10.9	12.7	15.5	24.1	17.0	3.4	9.7	9.6	9.8	12.0	6.1	1.0	3.3	5.5	8.6	12.2	11.8	7.1
August	5.2	6.7	7.9	10.9	12.7	15.5	24.1	17.0	3.4	9.7	9.6	9.8	12.0	6.1	1.0	3.3	5.5	8.6	12.2	11.8	7.1
September	5.0	6.7	8.3	10.4	12.5	16.2	23.9	16.7	3.6	9.2	9.2	9.8	9.2	5.3	0.7	3.4	6.9	8.4	12.3	11.6	2.8
October	5.0	6.7	8.3	10.4	12.5	16.2	23.9	16.7	3.6	8.0	9.2	9.8	9.2	5.3	0.7	3.4	6.9	8.4	12.3	11.6	2.8
November	3.5	4.6	3.2	5.1	5.9	4.5	5.1	5.0	1.8	4.4	3.2	2.3	1.6	1.3	0.0	1.6	3.8	2.6	2.5	2.1	0.0
December	3.5	4.6	3.2	5.1	5.9	4.5	5.1	5.0	1.8	4.4	3.2	2.3	1.6	1.3	0.0	1.6	3.8	2.6	2.5	2.1	0.0
<u>Operations</u>	0	0	0	0	0	0	0	0.0	6.0	6.0	6.0	6.0	6.0	6.0	6.3	6.3	6.3	6.3	6.3	6.3	6.3

TABLE E.5.3.16: TOTAL REGIONAL EMPLOYMENT: DIRECT CONSTRUCTION AND OPERATION EMPLOYMENT BY PLACE OF RESIDENCE

Community	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Mat-Su Borough																						
(Off-site) Direct	9	22	39	33	64	91	127	104	50	136	197	157	221	74	7	27	92	141	243	195	90	0
Support	8	20	35	30	58	82	114	94	48	129	184	148	206	74	15	33	92	136	228	185	90	9
Yukon-Koyukuk CD																						
Direct	186	226	18	18	46	51	56	52	23	22	33	22	32	8	0	16	30	37	56	47	30	0
Support	37	45	4	4	9	10	11	10	7	7	10	7	10	2	0	5	9	11	17	14	9	0
Municipality Of Anch																						
Direct	125	288	196	160	210	435	451	-487	6	243	282	166	70	-672	-142	-194	162	171	356	359	160	-83
Support	361	631	590	841	964	396	-174	1,854	539	503	591	555	437	-263	-143	-175	208	380	717	922	838	346
City of Fairbanks																						
Direct	17	39	48	23	63	93	22	-209	-10	39	28	8	-43	-212	-42	-66	28	14	36	48	27	-24
Support	16	35	43	21	43	80	77	-20	-74	57	47	22	-174	7	11	26	34	24	52	81	69	82
Fairbanks-North Star Borough																						
Direct	41	97	119	57	116	222	211	-56	12	99	108	68	36	-180	-41	-54	73	75	133	126	71	-24
Support	-117	-90	194	306	273	86	-32	529	198	238	285	261	260	10	19	35	141	198	315	342	295	136
Regional Impact Area																						
Direct	373	664	743	635	807	1,203	1,296	33	451	878	1,012	791	746	-408	67	150	726	802	1,187	1,113	717	63
Support	295	621	834	1,190	1,315	600	-33	2,520	797	892	1,093	986	934	-171	-108	-99	461	741	1,305	1,484	1,241	491

Source: Frank Orth and Associates Inc. 1985b, 1985d

TABLE E.5.3.17: TOTAL PROJECT RELATED POPULATION IN-MIGRATION AND OUT-MIGRATION FOR SELECTED JURISDICTIONS, 1991-2012

Community	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Mat-Su Borough (off-site)	214	376	388	507	709	549	374	792	372	709	970	751	871	-163	-135	-95	407	643	1,178	1,099	646	43
Talkeetna	5	11	11	13	76	73	71	80	11	21	26	69	87	44	-5	-5	-12	18	36	32	21	0
Trapper Creek	5	11	11	13	19	13	11	21	12	24	30	24	27	-6	-6	-6	13	21	39	35	21	0
Palmer	32	56	56	75	96	72	40	106	54	105	146	104	118	-34	-22	-15	59	96	174	162	94	6
Wasilla	35	62	62	83	104	77	45	117	57	111	154	111	128	-34	-22	-15	65	99	184	175	101	6
Houston	19	29	29	40	51	37	21	56	26	53	74	52	60	-21	-14	-11	28	49	89	84	50	3
Nenana	0	3	3	5	5	5	5	3	10	49	75	49	66	10	0	3	33	52	94	75	33	0
Healy	0	3	3	3	3	3	3	3	3	13	23	13	20	3	0	0	10	13	26	23	10	0
Cantwell	321	375	50	50	107	114	118	113	54	10	13	10	13	3	0	54	60	64	69	66	59	0
Municipality of Anchorage	348	793	97	322	587	725	533	1,197	885	863	996	1,048	882	68	562	200	433	580	876	1,246	1,486	1,617
Fairbanks-North Star Borough	-151	-43	370	453	511	476	356	702	460	591	657	623	577	80	219	177	391	447	622	677	692	551
City of Fairbanks	-102	-66	186	320	319	165	-66	-45	-160	85	21	-24	-344	-193	-536	-283	59	-10	34	96	88	52
Regional Impact Area	754	1,555	2,017	2,443	3,064	2,996	2,523	3,967	2,835	3,308	3,807	3,571	3,487	1,013	1,304	1,326	2,389	2,851	3,929	4,255	3,998	2,714
Mat-Su Borough Rural/Remote	16	27	29	37	48	37	29	56	24	47	65	44	53	-12	-8	-2	29	45	80	73	46	3
Mat-Su Borough Suburban	102	180	190	246	315	240	157	356	188	348	475	347	398	-100	-58	-41	201	315	576	538	313	25

Source: Frank Orth and Associates Inc. 1985b, 1985d

TABLE E.5.3.18: BASELINE AND WITH PROJECT HOUSING SUPPLY AND DEMAND FORECASTS FOR SELECTED JURISDICTIONS 1997, 2003, 2009

Borough/Community	1997			2003			2009		
	Housing Stock	Baseline Demand	With Project Demand	Housing Stock	Baseline Demand	With Project Demand	Housing Stock	Baseline Demand	With Project Demand
Mat-Su Borough(off-site)	23,055	18,481	18,612	28,300	23,291	23,555	33,760	28,342	28,736
Talkeetna	225	176	217	270	226	271	320	278	292
Trapper Creek	150	118	122	180	149	158	215	185	197
Palmer	1,570	1,451	63	2,050	1,889	1,922	2,600	2,394	2,442
Houston	1,140	882	889	2,125	1,646	1,663	3,870	2,992	3,014
Wasilla	3,430	3,123	3,134	5,600	5,091	5,121	8,880	8,082	8,116
Nenana	385	348	350	500	453	475	640	581	613
Healy	345	313	313	430	390	394	530	479	484
Cantwell	125	89	144	135	102	106	145	114	137
Anchorage	103,490	91,714	91,954	109,970	98,123	98,531	114,250	102,603	103,066
Fairbanks	12,860	11,905	11,978	13,350	12,366	12,319	13,650	12,633	755
Fairbanks - North Star Borough	33,880	28,762	28,596	36,090	30,765	31,002	37,820	32,692	32,960

Source: Frank Orth & Associates Inc. 1985b, 1985d

TABLE E.5.3.19: MAT-SU BOROUGH BUDGET FORECASTS (IN THOUSANDS OF 1985 DOLLARS)

		GENERAL FUNDS			SERVICE AREA FUNDS			LAND MANAGEMENT FUNDS		
		Revenues	Expenditures	Fiscal Balance	Revenues	Expenditures	Fiscal Balance	Revenues	Expenditures	Fiscal Balance
Baseline	1997	66,839	54,764	12,075	6,592	5,535	1,057	1,406	901	505
	2003	97,235	66,739	30,496	9,395	7,288	2,107	1,787	1,350	437
	2009	142,613	80,946	61,667	13,641	9,655	3,986	2,259	2,010	249
With	1997	70,439	57,716	12,723	6,981	5,834	1,147	1,482	950	532
Project	2003	101,065	69,370	31,695	9,812	7,574	2,238	1,857	1,403	454
	2009	148,083	84,052	64,031	14,235	10,026	4,209	2,346	2,088	258
Project	1997	3,600	2,952	648	389	299	90	76	49	27
Impact	2003	3,830	2,631	1,199	417	286	131	70	53	17
	2009	5,470	3,106	2,364	594	371	223	87	78	9

Source: Frank Orth & Associates Inc. 1985b, 1985d

TABLE E.5.3.20: BUDGET FORECASTS FOR SELECTED COMMUNITIES 1997, 2003, 2009 (IN THOUSANDS OF 1985 DOLLARS)

		PALMER			WASILLA		
		Revenues	Expenditures	Fiscal Balance	Revenues	Expenditures	Fiscal Balance
Baseline	1997	12,800	11,082	1,718	4,362	2,542	1,820
	2003	20,061	17,569	2,492	7,180	3,999	3,181
	2009	26,892	23,868	3,024	10,088	5,411	4,677
With Project	1997	12,920	11,189	1,731	4,385	2,555	1,830
	2003	20,520	17,969	2,551	7,246	4,035	3,211
	2009	31,984	28,625	3,359	12,091	6,340	5,751
Project Impact	1997	120	107	13	23	13	10
	2003	459	400	59	66	36	30
	2009	5,092	4,757	335	2,003	929	1,074
		HOUSTON			NENANA		
Baseline	1997	811	874	-63	2,753	2,865	-112
	2003	1,406	1,552	-146	3,975	4,223	-248
	2009	2,441	2,749	-308	5,104	5,479	-375
With Project	1997	819	883	-64	2,767	2,881	-114
	2003	1,424	1,572	-148	4,186	4,448	-262
	2009	2,467	2,779	-312	6,131	6,606	-475
Project Impact	1997	8	9	-1	14	16	-2
	2003	18	20	-2	211	225	-14
	2009	26	30	-4	1,027	1,127	-100
		ANCHORAGE			FAIRBANKS		
Baseline	1997	342,609	279,824	62,785	41,356	39,577	1,779
	2003	404,231	312,707	91,524	51,843	43,687	8,156
	2009	466,474	349,235	117,239	63,184	48,096	15,088
With Project	1997	343,313	280,399	62,914	41,269	39,496	1,773
	2003	405,571	313,743	91,828	51,307	43,237	8,070
	2009	467,965	350,351	117,614	63,245	48,142	15,103
Project Impact	1997	704	575	129	-87	-81	-6
	2003	1,340	1,036	304	-536	-450	-86
	2009	1,491	1,116	375	61	47	14
		FORECASTS OF MATSU-BOROUGH COLLECTIONS ON BEHALF OF TALKEENTA[1/]			CANTWELL (Operations Only)		
Baseline	1997	1,238			48	32	16
	2003	1,569			69	39	30
	2009	1,983			86	46	60
With Project	1997	1,430			72	48	24
	2003	1,803			72	42	30
	2009	2,080			118	58	60
Project Impact	1997	192			24	16	8
	2003	234			3	3	0
	2009	97			32	12	20

1/ Expenditure forecasts were not prepared for Talkeetna.

Source: Frank Orth & Associates Inc. 1985b, 1985d

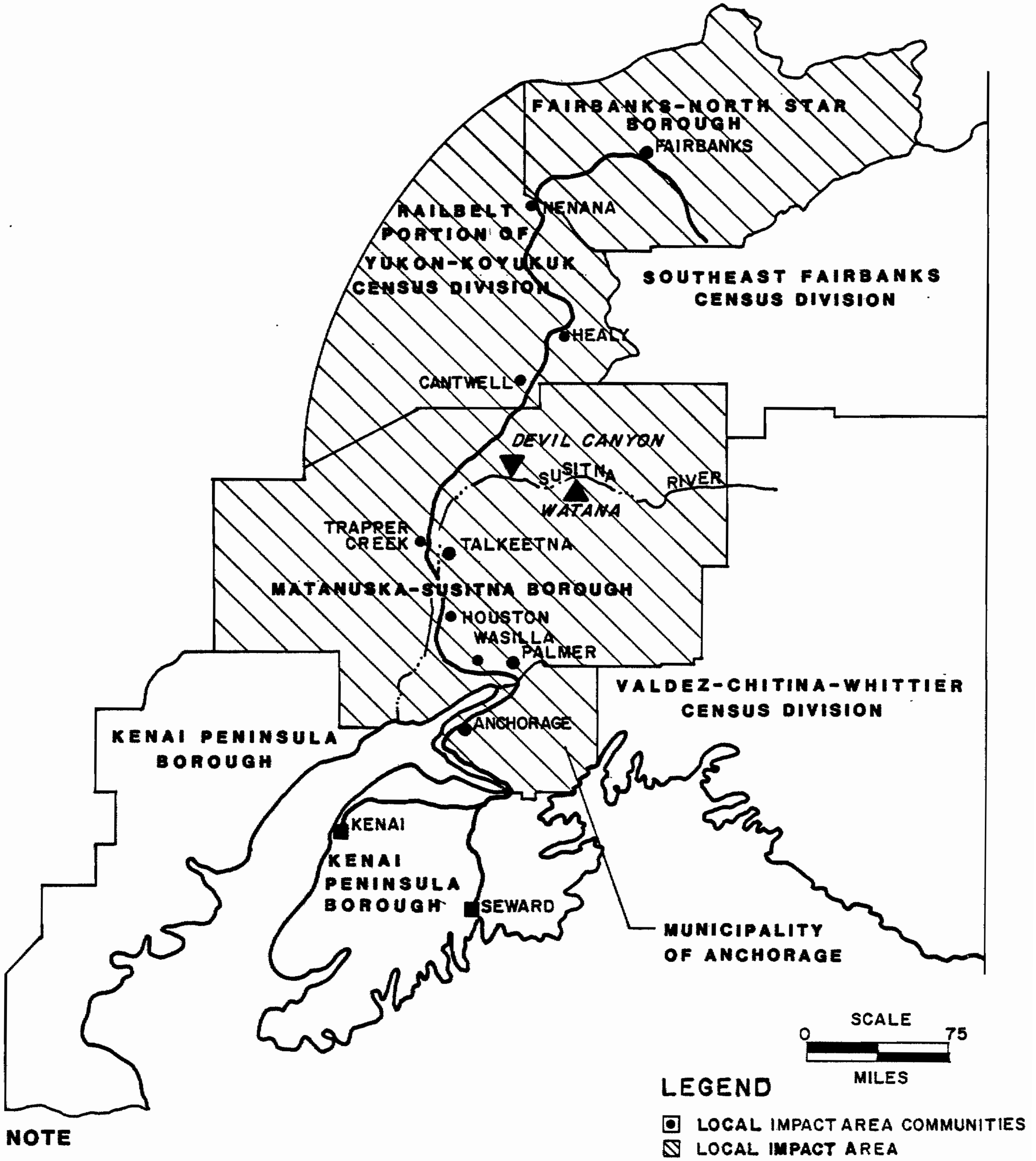
TABLE E.5.3.21: SCHOOL DISTRICT BUDGET FORECASTS (IN THOUSANDS OF 1985 DOLLARS)

		MAT-SU BOROUGH			RAILBELT			NENANA		
		Revenues	Expenditures	Balance	Revenues	Expenditures	Balance	Revenues	Expenditures	Balance
Baseline	1997	75,940	77,977	-2,037	3,908	3,734	174	4,204	4,574	-370
	2003	95,701	93,357	2,344	3,852	3,682	170	5,375	5,880	-505
	2009	124,688	111,163	13,525	3,918	3,745	173	6,868	7,558	-690
With	1997	79,345	80,993	-1,648	4,216	4,029	187	4,226	4,597	-371
Project	2003	99,453	96,999	2,454	3,963	3,787	176	5,622	6,152	-530
	2009	129,404	115,281	14,123	4,128	3,945	183	7,209	7,934	-725
Project	1997	3,405	3,016	389	308	295	13	22	23	-1
Impact	2003	3,752	3,642	110	111	105	6	247	272	-25
	2009	4,716	4,118	598	210	200	10	341	376	-35

Source: Frank Orth & Associates Inc. 1985b, 1985d

FIGURES

SUSITNA HYDROELECTRIC PROJECT
REGIONAL IMPACT AREA

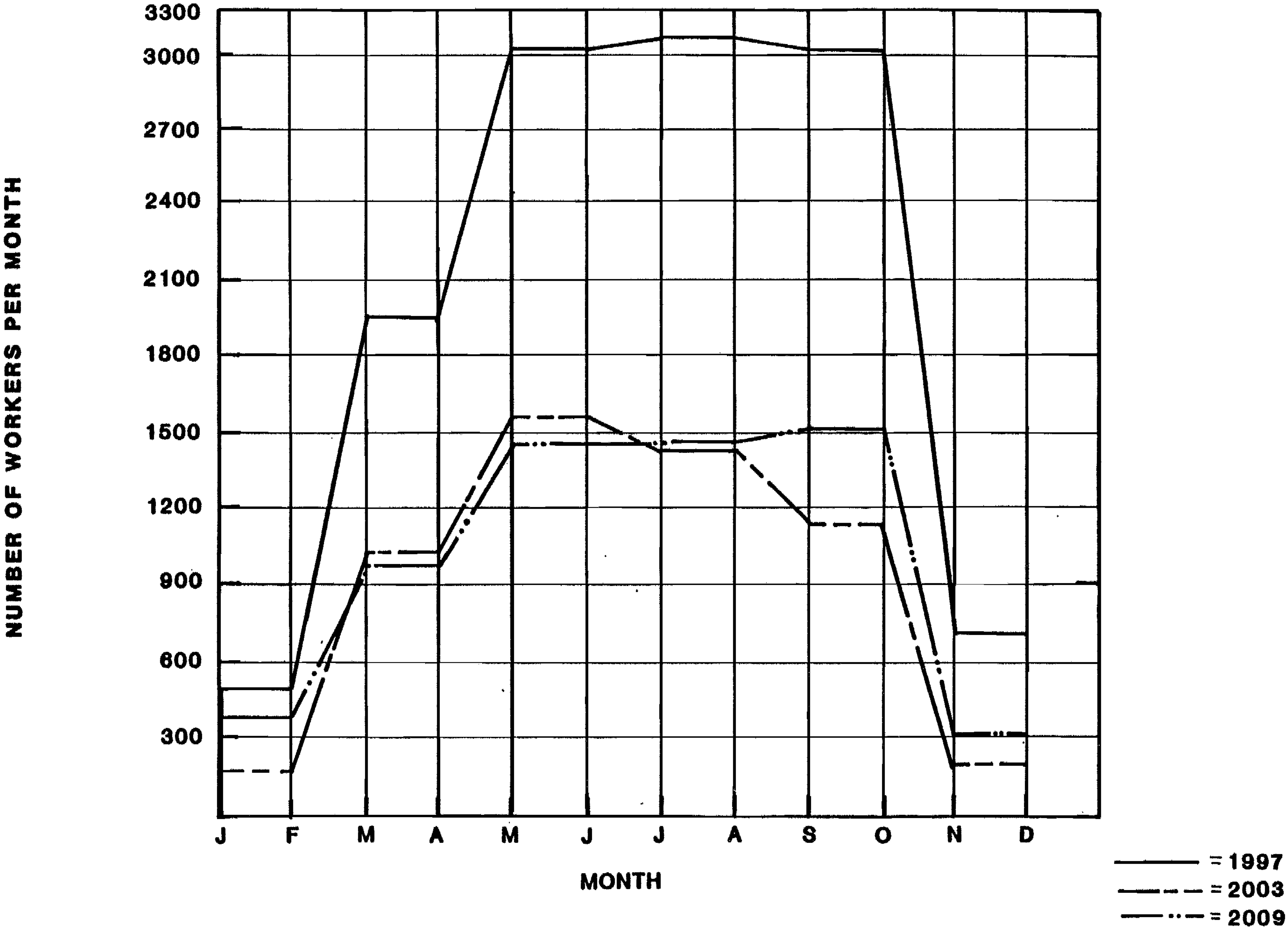


NOTE

SOURCE: ALASKA DEPARTMENT OF LABOR, RESEARCH AND ANALYSIS SECTION, U.S. CENSUS MAPS PROVIDED IN 1983 POPULATION OVERVIEW, JANUARY 1985

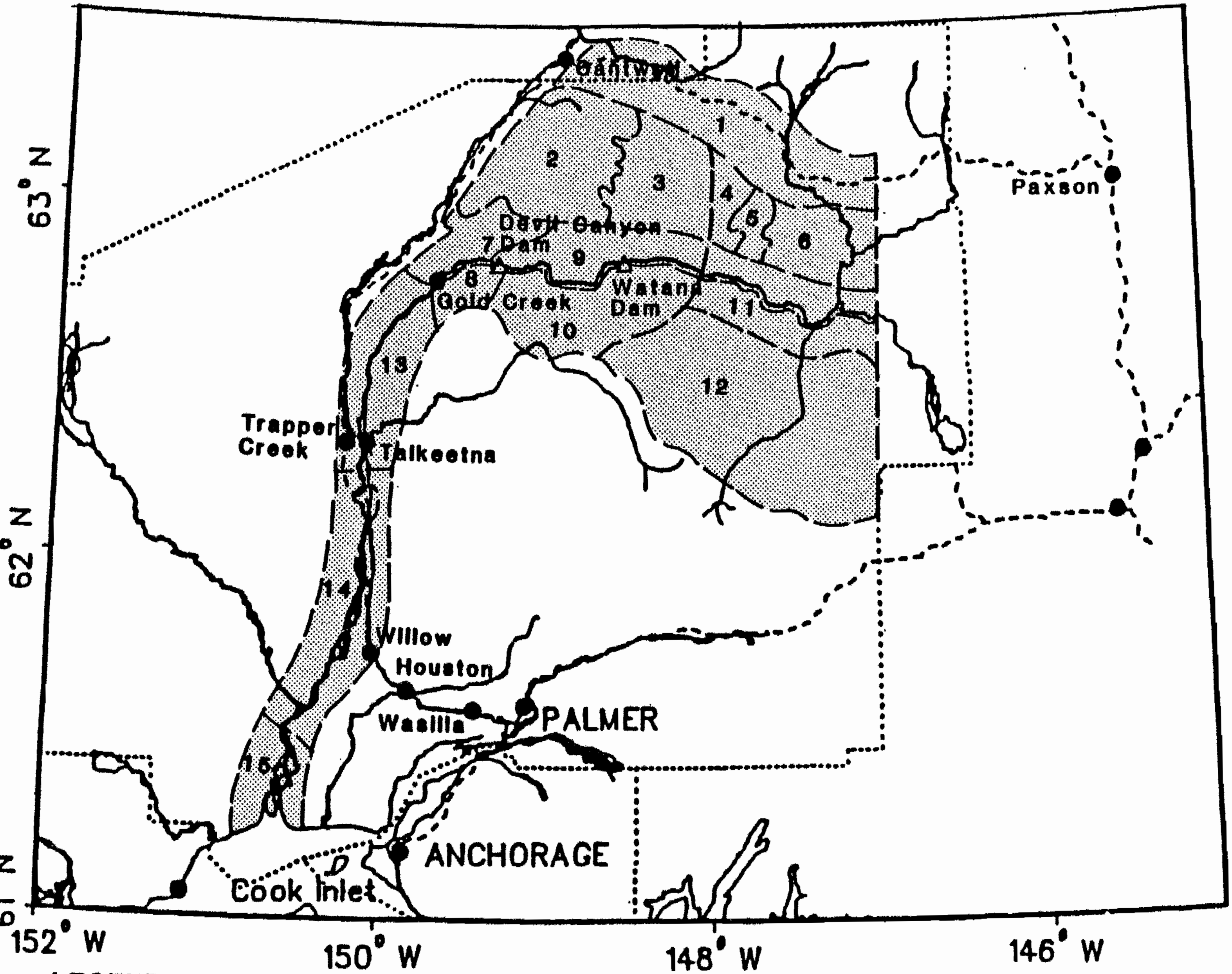
FIGURE E.5.2.1

061285



SEASONAL LABOR CURVE PEAK CONSTRUCTION YEARS

SUSITNA HYDROELECTRIC PROJECT
SUBUNITS OF RESOURCE USE AREA



LEGEND

2 RESOURCE USE AREA, NUMBER DENOTES SUBUNIT

— — SUBUNIT BOUNDARY

SCALE 0 40 80 MILES

FIGURE E.5.3.2

CHAPTER 6
GEOLOGICAL AND SOIL RESOURCES

SUSITNA HYDROELECTRIC PROJECT
LICENSE APPLICATION

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GEOLOGICAL AND SOIL RESOURCES

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GEOLOGICAL AND SOIL RESOURCES

1 - INTRODUCTION (**)

The Devil Canyon and Watana damsites are located on the Susitna River within the Talkeetna Mountains in south-central Alaska. The geologic setting of the Talkeetna Mountains and the Sustina River basin is in a tectonic mosaic of separate continental structural blocks and fragments. The geology and soil resources, stratigraphy, structure, and glacial history are described in this section as well as regional tectonics and seismic geology. Details of the geotechnical and seismic investigations conducted for the Susitna Hydroelectric Project are included in the 1980-81 Geotechnical Report (Acres 1982a), 1982 Supplement to the 1980-81 Geotechnical Report (Acres 1982b), Susitna Hydroelectric Project Feasibility Report (Acres 1982c), Watana Development Winter 1983 Geotechnical Exploration Program (HE 1983), 1984 Geotechnical Exploration Program Watana Damsite (HE 1984), Interim Report on Seismic Studies for Susitna Hydroelectric Project (WCC 1980), and Final Report on Seismic Studies for Susitna Hydroelectric Project (WCC 1982). These documents stand as references to this chapter and should be consulted as required to provide detailed discussions and supplemental information.

2 - BASELINE DESCRIPTION (*)

2.1 - Regional Geology (*)

2.1.1 - Stratigraphy (*)

The oldest rocks which outcrop in the region are a metamorphosed upper Paleozoic (Table E.6.2.1) rock sequence which trends northeastward along the eastern portion of the Susitna River basin (Figure E.6.2.1). These rocks consist chiefly of coarse to fine grained clastic flows and tuffs of basaltic to andesitic composition, locally containing marble interbeds. This system of rocks is uncomformably overlain by Triassic and Jurassic metavolcanic and sedimentary rocks. These rocks consist of a shallow marine sequence of metabasalt flows, interbedded with chert, argillite, marble, and volcaniclastic rocks. These are best exposed in the project area around Watana and Portage Creeks. The Paleozoic and lower Mesozoic rocks are intruded by Jurassic plutonic rocks composed chiefly of granodiorite and quartz diorite. The Jurassic age intrusive rocks form the batholithic complex of the Talkeetna Mountains.

Thick turbidite sequences of argillite and graywackes were deposited during the Cretaceous. These deposits form the bedrock at the Devil Canyon site. These rocks were subsequently deformed and intruded by a series of Tertiary age plutonic rocks ranging in composition from granite to diorite and include related felsic and mafic volcanic extrusive rocks. The Watana site is underlain by one of these large plutonic bodies. These plutons were subsequently intruded and overlain by felsic and mafic volcanics. The mafic volcanics at the Watana site consist primarily of andesite porphyry.

2.1.2 - Tectonic History (*)

At least three major episodes of deformation are recognized for the project areas:

- A period of intense metamorphism, plutonism, and uplift in the Jurassic;

- A similar orogeny during the middle to late Cretaceous; and

- A period of extensive uplift and denudation from the middle Tertiary to Quaternary.

The first period (early to middle Jurassic) was the first major orogenic event in the Susitna River basin as it now exists. It was characterized by the intrusion of plutons and accompanied by crustal uplift and regional metamorphism.

Most of the structural features in the region are the result of the Cretaceous orogeny associated with the accretion of northwest drifting continental blocks into the North American plate. This plate convergence resulted in complex thrust faulting and folding which produced the pronounced northeast/southwest structural grain across the region. The argillite and graywacke beds in the Devil Canyon area were isoclinally folded along northwest-trending folds during this orogeny. The majority of the structural features, of which the Talkeetna Thrust fault is the most prominent in the Talkeetna Mountains, are a consequence of this orogeny. The Talkeetna Thrust represents an old suture zone, involving the thrusting of Paleozoic, Triassic and Jurassic rocks over the Cretaceous sedimentary rocks (WCC 1980). Other compressional structures related to this orogeny are evident in the intense shear zones roughly parallel to and southeast of the Talkeetna Thrust.

Tertiary deformations are evidenced by a complex system of normal, oblique slip, and high-angle reverse faults. The prominent tectonic features of this period bracket the basin area. The Denali fault, a right-lateral, strike-slip fault 40 to 43 miles north of the damsites on the Sustina River, exhibits evidence of fault displacement during the Holocene. The Castle Mountain- Caribou fault system, which borders the Talkeetna Mountains approximately 70 miles southeast of the sites, is a normal fault which has had fault displacement during the Holocene.

2.2 - Quaternary Geology (*)

A period of cyclic climatic cooling during the Quaternary resulted in repeated glaciation of southern Alaska. Little information is available regarding the glacial history in the upper Susitna River basin. Unlike the north side of the Alaska Range, which is characterized by alpine type glaciation, the Susitna Basin experienced coalescing piedmont glaciers that originated from both the Alaska Range and the Talkeetna Mountains which merged and filled the upper basin area.

At least three periods of glaciation have been delineated for the region based on the glacial stratigraphy. During the most recent period (Late Wisconsinan), glaciers filled the adjoining lowland basins and spread onto the continental shelf (Figure E.6.2.2). Waning of the ice masses from the Alaska Range and Talkeetna Mountains formed ice barriers which blocked the drainage of glacial meltwater and produced proglacial lakes. As a consequence of the repeated glaciation, the

Susitna and Copper River basins are covered by varying thicknesses of till and lacustrine deposits.

Within the site region, the late Quaternary surfaces include those of Holocene and Pleistocene age (including the Wisconsinan and Illinoian stages). These surfaces range from a few years to approximately 120,000 years before present.

As a consequence of these repeated glaciations the existing landscape was modified and resulted in many of the distinct landforms found within the project area. Terrain unit maps developed for the project area from aerial photo interpretation are presented in Appendix J of the 1980-81 Geotechnical Report (Acres 1982a), while detailed Quaternary maps of the regions are presented in Section 3 of Final Report on Seismic Studies for Susitna Hydroelectric Project (WCC 1982).

2.3 - Mineral Resources (o)

Mineral exploration and mining have been limited in the immediate project area. Typical of the mining done on the upper Susitna River basin since 1930 is a low density of claims characterized by intermittent activity. Although mining has played an active roll in portions of the Susitna River basin, no mining activity has been undertaken in the immediate project area. Examination of mining records for the project area show only several inactive claims within the proposed Watana and Devil Canyon Reservoir impoundments that would be affected by the project. No evidence of any mineral potential has been found within the project area nor has any interest been expressed by outside parties to further explore mineral potentials within the project area during the duration of this project.

Placer mines working alluvial deposits for minerals are found in sites throughout other parts of Mat-Su Borough. Active mining has been more concentrated in Gold, Chunilna (Clear), and Portage creeks than in other areas of the upper Susitna basin with some other active claims around Stephan and Fog Lakes, Jay Creek, and the Watana Hills east of Jay Creek. Mining at Gold Creek was active from the early 1950s through the late 1970s; most claims were gold, copper, and silver placer mines. A concentration of at least six mining claims has existed on Chunilna Creek where gold placer claims have been worked since the late 19th century. Mining has occurred in the Portage Creek area since the late 19th century, but only one claim remains active.

Coal is the major mineral resource in Mat-Su Borough. Although extensive deposits of varying quality are located in the river valley areas, no coal mining activity occurs in the project area. Most coal is mined to the south and west of the project area; much of it is used for household fuel.

2.4 - Seismic Geology (*)

2.4.1 - Introduction (o)

A detailed seismologic study for the Susitna project was undertaken by the Applicant. The study, performed over a two-year period, included:

- o Detailed literature research
- o Interpretation of remote sensing data
- o Geologic mapping of faults and linears
- o Microseismic monitoring
- o Ground motion studies
- o Analysis of dam stability

Details of the study are presented in Interim Report on Seismic Studies for Susitna Hydroelectric Project (WCC 1980) and Final Report on Seismic Studies for Susitna Hydroelectric Project (WCC 1982).

2.4.2 - Conceptual Approach (*)

According to present understanding of plate tectonics, the earth's lithosphere, which contains a thickness of approximately 12 to 19 miles of rigid crust, overlies the denser and more viscous mantle. Observed major horizontal movements of the crustal plates are considered to be related to, or caused by, thermal convective processes within the mantle.

Within this plate-tectonic framework, faults that have the potential for generating earthquakes have had recent displacement and may be subject to repeated displacements as long as they are in the same tectonic stress regime. In regions of plate collision such as Alaska, the tectonic stress regime is the result of one plate being subducted, or underthrust, beneath an adjacent plate. Within this environment, primary rupture along fault planes can occur: within the downgoing plate where it is decoupled from the upper plate; along the interface between the upper and lower plates where they move past each other; and within the overriding plate. In the site region, faults with recent displacement are present in the overriding (upper) plate and at depth in the downgoing plate where it is decoupled from the upper plate.

Faults with recent displacement in the downgoing plate and in the upper plate can generate earthquakes which result in ground motions at the surface. These earthquakes are considered for seismic design purposes. The faults in the downgoing plate are considered not to have the potential for surface rupture. In the upper plate, if the rupture that occurs on these faults is relatively small and relatively deep, then rupture at the ground surface is likely not to occur. If the rupture along the fault plane is at sufficiently shallow depth and is sufficiently large, then surface rupture can occur.

The criteria for this study were that faults that have been subject to surface displacement within approximately the past 100,000 years were classified as having recent displacement.

Inherent with this concept of "fault with recent displacement" was the basic premise that faults without recent displacement would not have surface rupture nor be a source of earthquakes. Faults without recent displacement (as determined during this investigation) were considered to be of no additional importance to project feasibility and dam design.

2.4.3 - Tectonic Model (*)

An understanding of the regional geologic and tectonic framework is essential for: the assessment of fault activity; estimation of preliminary maximum credible earthquakes; evaluation of the potential for surface fault rupture; and evaluations of the potential for reservoir-induced seismicity.

The site region is located within a tectonic unit defined here as the Talkeetna Terrain. The Terrain boundaries are the Denali-Totschunda fault to the north and east, the Castle Mountain fault to the south, a broad zone of deformation with volcanoes to the west, and the Benioff zone at depth (Figure E.6.2.3). All of the boundaries are (or contain) faults with recent displacement except for the western boundary which is primarily a zone of uplift marked by Cenozoic age volcanoes. The Terrain is part of the North American plate.

Results of this study show that the Talkeetna Terrain is a relatively stable tectonic unit with major strain release occurring along its boundaries. This conclusion is based on: the evidence for recent displacement along the Denali-Totschunda and Castle Mountain faults and the Benioff zone; the absence of major historical earthquakes within the Terrain; and the absence of faults within the Terrain that clearly have evidence of recent displacement. Record of historical seismicity in and around the project area is presented in the 1980 study (WCC 1980). None of the faults and lineaments found within the Talkeetna Terrain were observed to have strong evidence of recent displacement.

Strain accumulation and resultant release appears to be occurring primarily along the margins of the Terrain. Some compression-related crustal adjustment within the Terrain is probably occurring as a result of the proposed plate movement and the stresses related to the subduction zone.

This tectonic model serves as a guide to understanding tectonic and seismologic conditions in the site region.

2.4.4 - 1980 Program (o)

(a) Candidate Features (o)

The application of the "fault with recent displacement" concept for this investigation involved:

- Identification of all faults and lineaments in the site region that had been reported in the literature and/or were observable on remotely sensed data.

- Selection of faults and lineaments of potential significance in developing design considerations for the project, from the standpoint of seismic source potential and/or potential surface rupture through a site. These faults and lineaments were selected using a length-distance criteria set forth in Section 3 of the 1980 study (WCC 1980). These faults and lineaments were designated as candidate features.

- Evaluation of the candidate features during the geologic field reconnaissance studies. On the basis of this field work, the micro-earthquake data, and application of the preliminary significance criteria, those faults and lineaments were designated as candidate-significant features. These features were subjected to additional evaluation using refined analyses, as described below, to select those features or potential significance to project design considerations.

- Refinement of the evaluation process, using the significance criteria. On the basis of this evaluation, significant features were selected for continued studies in 1981.

(b) Significant Features (o)

Of 216 candidate features identified at the outset of the study, a total of 48 candidate-significant features were identified in the site region on the basis of the initial length-distance screening criteria, their proximity to the site, their classification in the field, and application of preliminary significance screening criteria (WCC 1980).

Candidate-significant features are those faults and lineaments which, on the basis of available data at the end of the field reconnaissance, were considered to have a potential effect on project design. Subsequent evaluation, using a refined, systematic ranking methodology, resulted in the identification of 48 significant features.

The 48 candidate-significant features were subsequently evaluated by making detailed analyses regarding their seismic source potential and surface rupture potential at either site. For the evaluation of seismic source potential, the analyses included: an assessment of the likelihood that a feature is a fault with recent displacement; a preliminary estimation of the maximum credible earthquake that could be associated with the feature; and an evaluation of the peak bedrock accelerations that would be generated by the preliminary maximum credible earthquake at either site.

To evaluate the potential for surface rupture at either damsite, the analyses included: an assessment of the likelihood that a feature is a fault with recent displacement; an assessment of the likelihood that a feature passes through either site; and an evaluation of the maximum amount of displacement that could occur along the feature during a single event (e.g., the preliminary maximum credible earthquake).

The evaluation of the 48 candidate significant faults, applying the judgments described above, resulted in the selection of 13 features, designated significant features, that should have additional studies to understand and more fully evaluate their significance to the project (Figure E.6.2.4).

Of these 13 features, four are in the vicinity of the Watana site including the Talkeetna Thrust Fault (KC4-1), Susitna feature (KD3-3), "The Fins" feature (K-27), and lineament KD3-7. Nine of the features are in the vicinity of the Devil Canyon site including an unnamed fault (designated KD5-2) and lineaments KC5-5, KD5-3, KD5-9, KD5-12, KD-5-42, KD5-43, KD5-44, and KD-45 (the alpha-numeric symbol [e.g., KC4-1] has been assigned to each fault and lineament). Detailed discussion of these 13 features are presented in Section 8 of the 1980 study (WCC 1980).

These significant features were delineated for study during the 1981 program.

2.4.5 - 1981 Program (o)

The 1981 study of the 13 significant features identified during 1980 involved the following objectives.

- o Assessing the likelihood that each of the 13 features is a fault;
- o Assessing the age of the sediments overlying each of the 13 features;
- o Selecting and excavating trenches across topographic features that resembled topographic expression of faults in the young geologic deposits;
- o Evaluating the likelihood that each of the 13 features is a fault with recent displacement using the guideline established for the project, i.e., rupture of the ground surface during the past 100,000 years;
- o Assessing the detectability of faults that may have ruptured the ground surface during moderate to large earthquakes in the past 100,000 years and estimating a detection-level earthquake that could theoretically occur on a fault that might be below the detection level of geologic investigation;
- o Evaluating seismological records of moderate-to-large historical earthquakes in the project region to estimate focal mechanism parameters and assess the relation of the earthquakes to recognized faults with recent displacement;
- o Applying judgment and experience gained from the study of other faults with recent displacement in Alaska and in similar tectonic environments (e.g., Japan and South America);
- o Estimating the maximum credible earthquake and recurrence interval (1) for each fault that is considered to be a seismic source; (2) for the Benioff zone; and (3) for a detection-level earthquake;
- o Estimating the potential for surface rupture on any faults with recent displacement within 6 miles of the damsites; and
- o Estimating the values of ground-motion parameters for the maximum credible earthquake.

2.4.6 - Results of Study (o)

Faults for which evidence of recent displacement was found were considered to be potential seismic sources. Each potential seismic source was evaluated to estimate its potential seismic ground motions at the Watana and Devil Canyon sites and its potential for surface rupture within 6 miles of the sites.

On the basis of the 1980 study, the Talkeetna Terrain boundary faults were identified as seismic sources that need to be considered as potential sources of seismic ground motion at the sites. These include: the Castle Mountain Fault, the Denali Fault, the Benioff zone interplate region, and the Benioff zone intraplate region (Figure E.6.2.3). These sources are considered to be or to contain faults with recent displacement that could cause seismic ground motions at the Watana and Devil Canyon sites; however, because of their distance from the sites, these faults do not have the potential for rupture through the sites. The 1980 study also identified 13 features near the sites that required detailed evaluation during the 1981 study to assess their importance for seismic design (WCC 1980).

On the basis of the 1981 study, no evidence for faults with recent displacement other than the Talkeetna Terrain boundary faults has been observed within 62 miles of either site, and none of the 13 features near the sites are judged to be faults with recent displacement. Therefore, when applying the guideline defining faults with recent displacement to the results of the investigation, the 13 features are considered not to be potential seismic sources that could cause seismic ground motions at the sites or surface rupture through the sites.

Interpretation that none of the 13 features are faults with recent displacement is based on data collection during the investigation. The data are limited in the sense that a continuous 100,000-year-old stratum or surface was not found along the entire length of each of the features. For this reason, the available data were analyzed and professional judgment was applied to reach conclusions concerning the recency of displacement of each of the 13 features. Detailed discussions of these 13 features are presented in Section 4 the 1981 study (WCC 1982).

As discussed previously, earthquakes up to a given magnitude could occur on faults with recent displacement that might not be detectable by this geologic investigation. The size of such an earthquake, designated the detection-level earthquake, varies according to the degree of natural preservation of fault-related geomorphic features and from one tectonic environment to another.

The detection-level earthquake has been estimated by: (1) evaluating the dimensions of surface faulting associated with worldwide historical earthquakes in tectonic environments similar to the Talkeetna Terrain; (2) identifying the threshold of surface faulting using a group of thoroughly studied earthquakes in California; and (3) evaluating the degree of preservation of fault-related geomorphic features in the Talkeetna Terrain. For this project, it has been judged that the detection-level earthquake is magnitude (M_S) 6 (WCC 1982).

2.4.7 - Design Level Earthquake (*)

(a) Maximum Credible Earthquakes (MCEs) (*)

Maximum Credible Earthquakes (MCEs) were estimated for the boundary faults (in the crust and in the Benioff zone) and for the detection-level earthquake. The MCEs for the crustal faults (the Castle Mountain and Denali Faults) were estimated using the magnitude-rupture-length relationships (WCC 1982).

Sources for moderate earthquakes appear to exist within the Talkeetna Terrain, although no faults with recent displacement were detected by this investigation. Therefore, an MCE was estimated for the detection-level earthquake that would be associated with a fault along which no surface rupture was observed. In summary, the MCEs for the crustal and Benioff zone seismic sources are estimated as follows:

		Closest Approach to Proposed Damsites	
Source	MCE (M_S)	Devil Canyon miles	Watana miles
Castle Mountain fault	7-1/2	71	65
Denali fault	8	40	43
Benioff zone (interplate)	8-1/2	57	40
Benioff zone (intraplate)	7-1/2	38	31
Detection-level earthquake	6	<6	<6

Estimated mean peak horizontal ground accelerations and duration of strong shaking (significant duration) at the sites as the result of the governing maximum credible earthquake are as follows:

Earthquake Source	Maximum Magnitude	Mean Peak Acceleration Watana Site	Mean Peak Acceleration Devil Canyon Site	Significant Duration (sec)
Benioff Zone	8-1/2	0.35g	0.3g	45
Denali Fault	8	0.2g	0.2g	35
Terrain Earthquake	6	0.5g	0.5g	6

The probabilities of exceedance of peak ground accelerations at the sites were estimated. The Benioff Zone was found to dominate the contributions to the probabilities of exceedance. Other sources of earthquakes, including the Denali Fault and the detection-level earthquake, contributed only slightly to the probabilities of exceedance.

These ground motions were used as a guideline in developing the engineering design criteria.

(b) Reservoir-Induced Seismicity (RIS) (*)

The studies concluded that there would be a likelihood for reservoir-induced earthquake as a result of impoundment. However, such an event is not expected to cause an earthquake larger than that which could occur in a given region "naturally." A detailed discussion of RIS for the Susitna Project is presented in Section 10 of the 1980 study (WCC 1980).

2.5 - Watana Damsite (**)

2.5.1 - Introduction (**)

A detailed discussion of the Watana site geology is presented in reports by Acres Amercian (1982a), and Harza-Ebasco (1983, 1984). A summary of the site geotechnical conditions are summarized in the following sections.

2.5.2 - Geologic Conditions (**)

A summary of site overburden and bedrock conditions is presented in the following paragraphs. A geologic map of the damsite area is shown in Figure E.6.2.5 with a top of rock map shown in Figure E.6.2.6.

(a) Overburden (***)

Overburden thickness on the dam abutments may reach 70 feet or more. Above elevation 1,900 feet, overburden depth averages 20 feet with local zones to 50 feet on the south abutment. On the north abutment, this thickness reaches 50 to 60 feet. The upper areas of the abutments, near the top of the slopes, overburden consists of till, alluvium, and talus. Below elevation 1,900, overburden consists primarily of talus with an average thickness of 10 feet. Subsurface investigations show the contact between the overburden and bedrock to be relatively unweathered.

The river alluvium beneath the proposed dam is up to 140 feet deep, averaging about 80 feet (Figure E.6.2.6). The alluvium is thickest within the two large bedrock depressions beneath the upstream shell and toe of the dam. The material in the river channel is comprised primarily of well graded coarse-grained gravels, sandy gravels, and gravelly sands (HE 1983).

(b) Bedrock Lithology (**)

The damsite is primarily underlain by an intrusive dioritic body which varies in composition from granodiorite to quartz diorite to diorite. The texture is massive and the rock is hard, competent, and fresh except within locally developed sheared and altered zones. These rocks have been intruded by mafic and felsic dikes which are generally only a few feet thick. The contacts are healed and competent. The rock immediately downstream and south of the damsite is an andesite porphyry. This rock is medium to dark gray to green and contains quartz diorite inclusions. The nature of the contact zone of the andesite with the diorite is poorly understood. However, where mapped or drilled, the contact zone is generally weathered and fractured up to 10 to 15 feet. Detailed discussions of the andesite porphyry/diorite contact are presented in Section 6 of Acres (1982a) report.

(c) Bedrock Structures (*)

(i) Joints (*)

There are two major and two minor joint sets at the site. Set I, which is the most prominent set, strikes 320° and dips to 80° NE to vertical. This set is found throughout the damsite and parallels the general structural trend in the regions. Set I has a subset, which strikes 290° to 300° with a dip of 75° NE. This subset is localized in the downstream area near where the diversion tunnel portals are proposed. This subset also parallels the shear zones in the downstream area of the site. Set II trends northeast to east and dips vertically. This set is best developed in the upstream portion of the damsite area, but is locally prominent in the downstream areas. Sets III and IV are minor sets but can be locally well developed. Set III trends N-S with variable dips ranging from 40° east to 65° west, while Set IV trends 090° with subhorizontal dips. Set III forms numerous open joints on the cliff faces near the "Fingerbuster," and several fracture zones and occasional shears parallel this orientation. Set IV appears to have developed from stress relief from glacial unloading and/or valley erosion.

Figure E.6.2.7 is a composite joint plot for the Watana damsite.

Table E.6.2.2 details the joint characteristics.

(ii) Shears and Fracture Zones (*)

Several shears, fracture zones, and alteration zones are present at the site (Figure E.6.2.5). For the most part, they are small and discontinuous. All zones greater than 10 feet in width have been delineated as GF on the geologic map (Figure E.6.2.5).

Shears are defined as having breccia, gouge, and/or slickenslides indicating relative movement. Two forms of shearing are found at the site. The first type is found only in the diorite and is characterized by breccia of sheared rock that has been rehealed into a matrix of very fine grained andesite/diorite. These healed shears have high rock quality designations (RQDs) and the rock is fresh and hard. The second type is common to all rock types and consists of unhealed breccia and/or gouge. These shears are soft, friable, and often have secondary mineralization of carbonate and chlorite showing slickenslides. These shears are generally less than one foot wide.

Fracture zones are also common to all rock types and range from 6 inches to 30 feet wide (generally less than 10 feet). These zones are closely spaced joints that are often iron oxide stained and/or carbonate coated. Where exposed, the zones trend to form topographic lows.

Alteration zones are areas where hydrothermal solutions have caused the chemical breakdown of the feldspars and mafic minerals. The degree of alteration encountered is highly variable across the site. These zones are rarely seen in outcrop as they are easily eroded into gullies, but were encountered in all the boreholes. The transition between fresh and altered rock is gradational. The thickness of these zones range up to 20 feet but are usually less than 5 feet.

2.5.3 - Structural Features (**)

The Watana site has several significant geologic features consisting of shears and fracture, and alteration zones as described previously (Figure E.6.2.5).

The two most prominent areas have been named the "Fins" and the "Fingerbuster." The "Fins" is located on the north bank of the river upstream from the diversion tunnel intake. The area is characterized predominantly by sound, jointed bedrock. The rock mass also contains steeply inclined northwesterly trending zones of closely fractured rock up to 15-20 feet wide, 5-10 foot wide zones of weak, friable altered rock, and shears which measure one inch to approximately one foot in thickness. These zones have contributed to the erosion of steep gullies, which are separated by intact rock ridges. There is no evidence indicating continuity of the zones although the zones are difficult to trace due to the steepness of the terrain, talus cover, and the thick overburden deposits above approximately elevation 2,000 feet. At the upstream end of the "Fins," coincidental with a steep, narrow gulley, the contact between the diorite and quartz diorite pluton and a large andesite porphyry dike outcrops. Above the "Fins," a zone of highly weathered to decomposed diorite exists locally at the bedrock surface, beneath a thick cover (70-80 feet) of glacial overburden. The high groundwater levels indicate a low transmissibility throughout the rock mass.

The "Fingerbuster" is located downstream from the damsite and is exposed in a 40-foot-wide, deep, talus-filled gully just upstream of the andesite porphyry/diorite contact (Figure E.6.2.5). The rock is moderately close to closely fractured rock with local shears and alteration zones which trend parallel to Set I (330°) and Set III (0°). Slickenslides indicate vertical displacement. The degree of rock fracturing varies widely in this area, and is influenced by structural control and near surface stress relief fracturing. Because of the lack of exposure, and the variability of the features, no major structural features were identified. A detailed discussion of the "Fins" and "Fingerbuster" is presented in the Harza-Ebasco (1984) report.

A prominent alteration zone was encountered on the south bank where a drill hole encountered approximately 200 feet of hydrothermally altered rock. Although core recovery in this boring was good, the quality of rock was relatively poor.

2.5.4 - Groundwater Conditions (***)

The groundwater regime in the bedrock is confined to movement along fractures and joints. In general, the water table is a subdued replica of the surface topography. The groundwater table on the north abutment is generally from 5 to 30 feet below the surface except in areas with steep terrain, i.e. the "Fingerbuster", where it reaches depths of 60-90 feet. Numerous icing can be found on both abutments in the winter, particularly on the steep slopes of the south abutment. At the present time there is no instrumentation to monitor groundwater on the south abutment. Groundwater conditions on the south abutment and on the lower north abutment are further complicated because of the existence of permafrost, discussed below.

2.5.5 - Permafrost Conditions (**)

Permafrost conditions exist on the north-facing slopes and below approximately elevation 1,750 feet on the north abutment of the damsite area. Measurements indicate that permafrost exists to a depths of approximately 120 feet on the south abutment and up to 60 feet on the north abutment. Temperature measurements show the permafrost to be "warm" (within 1°F [1°C] of freezing).

2.5.6 - Bedrock Transmissability (o)

Transmissability of water through the bedrock does not vary significantly within the site area, generally ranging between 3.28×10^{-6} ft/sec to 3.3×10^{-8} ft/sec. Transmissability is controlled by a degree of fractures within the rock, with the higher seepage occurring in the more sheared and fractured zone. Seepage tends to decrease with depth (Figure E.6.2.8).

2.5.7 - Relict Channels (*)

(a) Watana Relict Channel (*)

A relict channel exists north of the Watana damsite. The location of this preglacial feature is shown in Figure E.6.2.9. The maximum depth of overburden in the thalweg channel, as shown in Figure E.6.2.9, is approximately 450 feet.

The stratigraphy in the channel has been differentiated into a number of stratigraphy units as shown in Figures E.6.2.10

and E.6.2.11, units A through K. A detailed discussion of theWatana Relict Channel is presented in Section 6 of the Harza-Ebasco (1983) report .

(b) Fog Lakes Buried Channel (*)

In the area between the Watana damsite and the higher ground some 5 miles to the southeast, the bedrock surface dips to 350 feet below ground surface, or 174 feet below maximum pool elevation. The channel is overlain by glacial deposits (Figure E.6.2.12). A discussion of the Fog Lakes Buried Channel is presented in Section 7 of Acres (1982b) report.

2.5.8 - Borrow Sites (**)

Extensive investigations have been conducted both prior to and during the current studies to identify quantities of suitable materials for the construction of an embankment dam and for concrete aggregate. Detailed discussion of these borrow and quarry sites is presented in both Acres (1982a, 1982b) reports.

A total of seven borrow sites and three quarry sites have been identified for dam construction material delineated as sites A, B, C, D, E, F, H, I, J, and L (Figure E.6.2.13). Of these, Borrow Sites D and H are considered as potential sources for impervious material; Sites C, E, and F for granular material; Sites I and J for pervious gravel; and Quarry Sites A, B, and L for rockfill. Of these sites, Quarry Site A and Borrow sites D and E are considered as the primary material sites for this project based on the exploration investigations to date. Quarry Site L and Borrow sites C,F,H, and I are considered as secondary (back-up) sources of material because of the lengthy haul distance to the damsite, adverse environmental impacts, insufficient quantities, and poor quality material. Due to the lack of bedrock outcrops, Quarry Site B is no longer considered as a viable material site. Borrow Site J would likely not be used because the water level in the river would be higher due to the damming and diversion of the river, which would not coincide with excavation of borrow material. Rockfill for the dam will come from required excavation such as the spillway and intake approach channels for Stage I and from Quarry A for Stage III. Detailed discussion of material properties, geology, and quantities are addressed in the Acres (1982a, 1982b) and Harza-Ebasco (1983) reports.

In summary, estimated reserves of borrow and quarry materials from the primary sources are:

- o Quarry Site A = 70-100 million cubic yards
- o Borrow D = 180 million cubic yards
- o Borrow E = 80-90 million cubic yards

2.6 - Devil Canyon Damsite (o)

2.6.1 - Introduction (o)

A detailed description of the site investigations and the geologic and geotechnical conclusions at the Devil Canyon site is provided in the Acres reports (1982a, 1982b). The following is a brief summary and interpretation of the findings presented in those reports.

2.6.2 - Geologic Conditions (o)

The overburden and bedrock conditions at the Devil Canyon site are summarized in the following paragraph. A geologic map of the damsite area is shown in Figure E.6.2.14 in this section.

(a) Overburden (o)

The valley walls at the Devil Canyon site are very steep and are generally covered by a thin veneer of overburden consisting primarily of talus at the base. A top of bedrock map is shown in Figure E.6.2.15. The flatter upland areas are covered by 5 to 35 feet of overburden of glacial origin. A topographic depression along the elongated lakes on the south bank has an overburden cover in excess of 85 feet of glacial materials. The overburden on the alluvial fan or point bar deposit at the Cheechako Creek confluence thickens from 100 feet to more than 300 feet over a distance of less than 400 feet.

The river channel alluvium appears to be composed of cobbles, boulders, and detached blocks of rock and is inferred to be up to 30 feet thick.

(b) Bedrock Lithology (o)

The bedrock at the Devil Canyon site is a low-grade, metamorphosed sedimentary rock consisting predominantly of argillite with interbeds of graywacke (Figure E.6.2.14). The argillite is a fresh, medium to dark gray, thinly bedded, fine grained argillaceous rock with moderately well-developed foliation parallel to the bedding. The graywacke is a fresh, light gray, mainly fine grained sandstone within an argillaceous matrix. The graywacke is well indurated and exhibits poorly developed to nonexistent foliation. The graywacke is interbedded with the argillite in beds generally less than six inches thick. Contacts between beds are tight, and both rock types are fresh and hard. Minor quartz veins and stringers are commonly found in the argillite. These are generally less than one foot wide and unfractured with tight contacts. Sulphide mineralization is common, with pyrite occurring in as much as five percent of the rock.

The area has also been intruded by numerous felsic and mafic dikes ranging from 1 inch to 60 feet wide (averaging 20 feet). The dikes have northwest to north orientation (Figure E.6.2.14) with steep dips. When closely fractured they are easily eroded and tend to form steep, talus-filled gullies, some of which exhibit shearing with the host rock. The felsic dikes are light gray and include aplite and rhyolite. The mafic dikes are fine grained and appear to be of diorite to diabase composition.

(c) Bedrock Structures (o)

(i) Bedding (o)

The argillite/graywacke has been severely deformed as evidenced by refolded folds and the development of multiple foliations. The primary foliation parallels the bedding at 035° to 090°, subparallel to the river, and dips 45° to 80° SE (Figure E.6.2.14). Where exposed, the foliation planes appear slaty and phyllitic. The north canyon wall at the damsite appears to be controlled by the bedding planes and dips 45° to 80° SE. Where exposed, the foliation planes appear slaty and phyllitic. The north canyon wall at the damsite appears to be controlled by the bedding planes.

(ii) Joints (o)

Four joint sets have been delineated at Devil Canyon. Set I (strikes 320° to 355° and dips 60° to 70° NE) and Set II (strikes 040° to 065° and dips 40° to 60°S) are the most significant. A composite joint plot is shown in Figure E.6.2.16. Set I joints are the most prominent with spacing of 15 feet to 2 feet, and on the upper canyon walls of the south bank these joints are open as much as 12 inches. Set II is subparallel to the bedding/ foliation and, when it intersects with Set I, can cause the formation of loose blocks. Set III joints (strikes 005° to 030° and dip 85° NW to 85° SE) are also often open on the south bank and where they dip towards the river they may create potential slip planes. This set has variable spacing and sporadic distribution. The fourth set is a minor set with low dip angles and variable strike orientation.

Joint spacings measured from the borehole cores range from less than 1 foot to more than 10 feet for the most part. Based on RQD measurements and water pressure test data, the spacing and tightness of the joints increase with depth (Section 7, Acres 1982a).

Tables E.6.2.3 and E.6.2.4 characterize the joints at Devil Canyon.

(iii) Shears and Fracture Zones (o)

Shears and fracture zones were encountered in localized areas of the site in both outcrops and boreholes (Figure E.6.2.14). Shears are defined as areas containing breccia, gouge, and/or slickenslides indicating relative movement. The shears are soft and friable and are characterized by high permeability and core loss during drilling. Fracture zones, often encountered in conjunction with the shears, are zones of very closely spaced joints. With depth, these zones become tighter and more widely spaced. Where exposed, they are eroded into deep gullies.

The most common trend of these features is northwest, parallel to Joint Set I. These zones have vertical to steep northeast dips and are generally less than one foot wide. Northwest trending shears are also associated with the contacts between the argillite and mafic dikes and are up to 1 foot wide.

A second series of shears trend northeasterly, subparalleling the bedding/foliation and Joint Set II, with high angle southeasterly dips. These average less than 6 inches in width.

2.6.3 - Structural Features (o)

Several structural features at the Devil Canyon site were investigated during the 1980-1981 program (Acres 1982a).

In summary, these included the east-west trending sheared and fractured zone beneath the proposed saddle dam area; a bedrock drop-off beneath Borrow Site G; and bedrock conditions beneath the Susitna River.

Seismic refraction and drilling data confirm the existence of a highly sheared and fractured zone on the left bank beneath the proposed saddle dam that generally trends parallel to the river. The dip on this feature is inferred to be parallel or subparallel to the bedding/foliation at approximately 65° to the south. The linear extent of the feature has not been determined but may be up to 2,500 feet. No evidence was found during the 1980-81 program to suggest movement along this feature. This conclusion was confirmed during the seismic investigations (Acres 1982a). Further investigation of this feature will be required to define its extent and to determine the type of foundation treatment that will be required beneath the saddle dam.

Upstream from the damsite, a dropoff of several hundred feet was detected in the bedrock surface under the alluvial fan by seismic refraction surveys. Land access restrictions imposed during the study prohibited any further investigation of this area. Possible explanation for this apparent anomalous dropoff could be attributed to misinterpretation of the seismic data or else the lower velocity material could be either a highly fractured rock in lieu of soil or an offset of the rock surface caused by faulting. The latter interpretation is unlikely, in that work performed in this area gave rise to the conclusion that there was no compelling evidence for a fault. Future work remains to be done in this area to define this feature more clearly.

Detailed examination of rock core and mapping in the river valley bottom showed no evidence for through-going faulting in the riverbed.

2.6.4 - Groundwater Conditions (o)

Groundwater migration within the rock is restricted to joints and fractures. It is inferred that the groundwater level is a subdued replica of the surface topography with the flow towards the river and lakes. Measured water levels in the boreholes varied from ground surface to 120 feet deep.

2.6.5 - Permafrost (o)

No permafrost has been found in either the bedrock or surficial material at or around the damsite, additional instrumentation will be required to accurately define the subsurface thermal regime. Aerial photo interpretation suggests the potential of permafrost in some areas of the south abutment (see Section 2.7).

2.6.6 - Bedrock Transmissability (o)

Transmissability of water through the bedrock ranges from approximately 3.28 x 10^{-6} ft/ sec to 3.3 x 10^{-8} ft/sec with lower permeabilities generally at depth. Higher seepage occurs in the more weathered fractured rock zones (Figure E.6.2.17).

2.6.7 - Geology - Tailrace Tunnel (o)

(a) Introduction (o)

This section discusses the lithology and structure along the proposed tailrace tunnel for the Devil Canyon damsite. Reconnaissance mapping was done along the Susitna River from about 2,500 feet to 10,000 feet downstream from the site. Rock exposures are nearly continuous from the damsite to the bend in the river where the proposed portal area is located. From that point downstream, outcrops are scattered and poorly exposed.

(b) Lithology (o)

As in the area of the main dam, the lithology along the proposed tailrace consists of interbedded argillite and graywacke which have been intruded by mafic and felsic dikes. The argillite is medium to dark gray, very fine to fine grained argillaceous rock with occasional grains of fine to medium sand. The graywacke is medium grained, light to medium gray within a matrix of very fine grained argillite. The interbeds of argillite and graywacke are generally 6 inches thick. Contacts between beds are sharp and tight.

Bedding is parallel to weakly developed foliation. Bedding foliation strikes generally northeast with moderate dips to the southeast. A secondary foliation (which is poorly developed at the damsite) is locally well developed near the proposed tunnel portal. The secondary foliation strikes nearly north-south with high angle dips to the northwest. The argillite and graywacke have been intruded by numerous quartz veins and stringers at the damsite.

Felsic and mafic dikes were mapped in outcrops along the river and to the north of the tunnel route. The lithology and structure of these dikes are similar to those found at the damsite. The felsic dikes consist of two varieties: rhyolite and granodiorite. The rhyolite dikes are light yellowish gray to gray. The texture is aphanitic to fine grained with fine to medium grained quartz phenocrysts. The granodiorite dikes are primarily medium grained plagioclase phenocrysts in a fine grained groundmass of plagioclase, orthoclase, biotite, and quartz. The felsic dikes are generally slightly to moderately weathered, medium hard, with very close to closely spaced joints. Iron oxide staining is common. Widths are generally 10 to 20 feet. Contacts with argillite and graywacke are generally fractured and/or sheared. Up to 3-foot-wide contact metamorphic zones are common in the adjacent argillite and graywacke. The felsic dikes strike northwest and northeast.

Mafic dikes are generally dark green to dark gray. These dikes are fresh to slightly weathered and hard. Mafic dikes are composed of feldspar in a fibrous groundmass with accessory pyroxene, biotite, hornblende, and calcite. These dikes are generally 2 to 10 feet wide and trend northwest with high angle vertical dips. Like the felsic dikes, the mafic dike contacts are generally sheared and/or fractured. Joint spacing is very close to closely spaced.

(c) Structures (o)

Joints sets and shear/fracture zones similar to those mapped at the damsite are likely to occur along the tailrace tunnel (Figure E.6.2.18).

The four joint sets identified at the damsite continue downstream; however, variations in orientation and dip occur. Table E.6.2.4 contains a list of joint characteristics for joints along the tailrace tunnel.

Joint Set I is northwest trending with moderate to high angle dips to the northeast and southwest. The average strike and dip of this set in the tailrace area are 325° and 70° northeast, respectively, which differ slightly from its average orientation in the damsite of 340° and 80° northeast. Spacings are highly variable but average about 1.5 feet. The river flows parallel to this set in the vicinity of the outlet portal.

Joint Set II includes joints parallel and subparallel to the bedding/foliation planes. This set strikes 065° with moderate (60°) dips to the southeast. The strike is essentially the same as at the damsite, although the dip is slightly steeper.

Joint Set III strikes nearly north-south at an average of 022°. Dips are variable from 63° east to 84° west. The strike of Set III is similar to that found on the south bank of the damsite; but about 30° more northerly than the average strike found on the north bank. Dips are generally similar to those at the damsite. Set III joints are well developed in the vicinity of the outlet portal.

Joint Set IV consists of low-angle (dipping less than 40°) joints of various orientations.

Although no shears or fracture zones were found during the reconnaissance mapping downstream from the damsite, it is anticipated that several such features will be encountered along the tunnel. These shears and fracture zones will likely be less than 10 feet wide and spaced from 300 to 500 feet apart. Preliminary investigations suggest that the tailrace tunnels will intersect any shear/fracture zones at near right angles thereby minimizing support requirements.

2.6.8 - Borrow Sites (o)

Borrow Site G, the floodplain depost immediately upstream from the dam (Figure E.6.2.14), has been identified as a source of granular material for filters and concrete aggregate.

A reserve of about 3 mcy, with an additional 3 mcy potential reserve, has been estimated for this borrow source. Details of material properties have been included in Acres (1982a, 1982b) reports. Tests performed during 1980-82 indicate a variation of material properties within the borrow site. Therefore, additional testing will be required to confirm adequate source of suitable materials.

A rock quarry area designated as Quarry Site K has been identified approximately 5300 feet south of the saddle dam. This area contains a granodiorite similar to rock found at the Watana damsite.

2.7 - Reservoir Geology (*)

2.7.1 - Watana (*)

(a) General (*)

The topography of the Watana Reservoir and adjacent slopes is characterized by a narrow, V-shaped, stream-cut valley superimposed on a broad, U-shaped, glacial valley. Surficial deposits mask much of the bedrock in the area, especially in the lower and uppermost reaches of the reservoir. A surficial geology map of the reservoir, prepared by the COE, and airphoto interpretation performed during this study identified tills, lacustrine and alluvial deposits, as well as predominant rock types. Details of this photoanalysis are contained in Appendix J of Acres (1982a) report. Additional geologic and surficial mapping in the Watana damsite areas are contained in Acres (1982b) report.

(b) Surficial Deposits (*)

Generally, the lower section of the Watana Reservoir and adjacent slopes are covered by a veneer of glacial till and lacustrine deposits. Two main types of till have been identified in this area: ablation and basal tills. The basal till is predominately over-consolidated, with a fine grain matrix (more silt and clay) and low permeability. The ablation till has fewer fines and a somewhat higher permeability. Lacustrine deposits consist primarily of poorly graded fine sands and silts with lesser amounts of gravel and clay, and exhibit a crude stratification.

On the south side of the Susitna River, the Fog Lakes area is characteristic of a fluted ground moraine surface. Upstream in the Watana Creek area, glaciolacustrine material forms a broad, flat plain which mantles the underlying glacial till and the partially lithified Tertiary sediments. Significant disintegration features such as kames and eskers have been observed adjacent to the river valley.

Permafrost exists in the area, as evidenced by ground ice, patterned ground stone nets, and slumping of the glacial till overlying permafrost. Numerous slumps have been identified in the Watana Reservoir area, especially in sediments comprising basal till. In addition, numerous areas of frozen alluvium and interstitial ice crystals have been observed in outcrops and identified from drill hole drive samples. Areas of potential permafrost and current slope instability for the Watana and Devil Canyon Reservoirs are shown in Figures E.6.2.19 to E.6.2.45.

(c) Bedrock Geology (*)

The Watana damsite is underlain by a diorite pluton. Approximately three miles upstream from the Watana damsite, a nonconformable contact between argillite and the dioritic pluton crosses the Susitna River. An approximate location of this contact has also been delineated on Fog Creek, four miles to the south of the damsite. Just downstream from the confluence of Watana Creek and the Susitna River, the bedrock consists of semiconsolidated, Tertiary sediments and volcanics of Triassic age. These Triassic rocks consist of metavolcaniclastics and marble. Just upstream from Watana Creek to Jay Creek, the rock consists of a metavolcanogenic sequence predominantly composed of metamorphosed flows and tuffs of basaltic to andesitic composition. From Jay Creek to just downstream from the Oshetna River, the reservoir is underlain by a metamorphic terrain of amphibolite and minor amounts of greenschist and foliated diorite. To the east of the Oshetna River, glacial deposits are predominant (Figure E.6.2.1).

The main structural feature within the Watana Reservoir is the Talkeetna Thrust fault, which trends northeast-southwest and crosses the Susitna River approximately eight miles upstream from the Watana damsite. The southwest end of the fault is overlain by unfaulted Tertiary volcanics (Figure E.6.2.1).

2.7.2 - Devil Canyon (*)

(a) Surficial and Bedrock Geology (*)

The topography in and around the Devil Canyon Reservoir is bedrock-controlled. Overburden is thin to absent, except in the upper reaches of the proposed reservoir where alluvial deposits cover the valley floor.

A large intrusive plutonic body, composed predominantly of biotite granodiorite with local areas of quartz diorite and diorite, underlies most of the reservoir and adjacent slopes. The rock is light gray to pink, medium grained and composed of quartz, feldspar, biotite, and hornblende. The most common mafic mineral is biotite. Where weathered, the rock has a light yellow-gray or pinkish yellow-gray color, except where it is highly oxidized and iron stained. The granodiorite is generally massive, competent, and hard with the exception of the rock exposed on the upland north of the Susitna River where the biotite granodiorite has been badly decomposed as a result of mechanical weathering.

The other principal rock types in the reservoir area are the argillite and graywacke, which are exposed at the Devil Canyon damsite. The argillite has been intruded by the massive granodiorite, and as a result, large isolated roof pendants of argillite and graywacke are found locally throughout the reservoir and surrounding areas. The argillite/graywacke varies locally to a phyllite of low metamorphic grade, with possible isolated schist outcrops.

The rock has been isoclinally folded into steeply dipping structures which generally strike northeast-southwest. The contact between the argillite and the biotite granodiorite crosses the Susitna River just upstream from the Devil Canyon damsite. It is nonconformable and is characterized by an aphanitic texture with a wide chilled zone. The trend of the contact is roughly northeast-southwest where it crosses the river. Several large outcrops of the argillite completely surrounded by the biotite granodiorite are found within the Devil Creek area.

3 - IMPACTS (*)

3.1 - Reservoir-Induced Seismicity (RIS) (*)

3.1.1 - Introduction (*)

The potential for the possible future occurrence of reservoir-induced seismicity (RIS) in the vicinity of the proposed reservoirs was evaluated. Reservoir-induced seismicity is defined here as the phenomenon of earth movement and resultant seismicity that has a spatial and temporal relationship to a reservoir and is triggered by nontectonic stress.

Several reservoir-induced seismic events (at Kremasta, Greece; Koyna, India; Kariba, Zambia-Rhodesia; and Xinfengjiang, China) have exceeded magnitude (Ms) 6. Damage occurred to the dams at Koyna and Xinfengjiang, and additional property damage occurred at Koyna and Kremasta.

Studies of the occurrence of RIS (WCC 1980), have shown that RIS is influenced by the depth and volume of the reservoir, the filling history of the reservoir, the state of tectonic stress in the shallow crust beneath the reservoir, and the existing pore pressures and permeability of the rock under the reservoir. Although direct measurements are difficult to obtain for some of these factors, indirect geologic and seismologic data, together with observations about the occurrence of RIS at other reservoirs, can be used to assess the potential for the possible effects of the occurrence of RIS at the proposed project reservoirs.

The scope of this study included: (a) a comparison of the depth, volume, regional stress, geologic setting, and faulting at the Devil Canyon and Watana sites with the same parameters at comparable reservoirs worldwide; (b) an assessment of the likelihood of RIS at the sites based on the above comparison; (c) a review of the relationship between reservoir filling and the length of time to the onset of induced events and the length of time to the maximum earthquake; (d) an evaluation of significance of these time periods for the sites; (e) the development of a model to assess the impact of RIS on groundmotion parameters; (f) a review of the relationship between RIS and method of reservoir filling; and (g) an assessment of the potential for landslides resulting from RIS.

For this study, the two proposed reservoirs were considered to be one hydrologic entity (designated the proposed Devil Canyon-Watana Reservoir), because the hydrologic influence of the two proposed reservoirs is expected to overlap in the area between the Watana site and the upstream end of the Devil Canyon

Reservoir. The proposed Devil Canyon-Watana Reservoir will be approximately 87 miles long. The following parameters were used:

	Devil Canyon	Watana	Combined
Max. Water Depth	551 ft	725 ft	725 ft
Max. Water Volume	1.09×10^6 ac-ft	9.52×10^6 ac-ft	10.61×10^6 ac-ft
Stress Regime	Compressional	Compressional	Compressional
Bedrock	Metamorphic	Ingneous	Ingneous

The combined body of water, as proposed, would constitute a very deep, very large reservoir within a primarily igneous bedrock terrain that is undergoing compressional tectonic stress.

Details of this study are presented in the reports (WCC 1980, 1982). A summary of this study is presented in the following sections.

3.1.2 - Evaluation of Potential Occurrence (*)

(a) Likelihood of Occurrence (o)

For comparative purposes, a deep reservoir has a maximum water depth of 300 feet or deeper; a very deep reservoir is 492 feet deep or deeper; a large reservoir has a maximum water volume greater than 1×10^6 acre-feet; and a very large reservoir has a volume greater than 8.1×10^6 acre-feet. Twenty-one percent of all deep, very deep, or very large reservoirs have been subject to RIS. Thus, the likelihood that any deep, very deep, or very large reservoir will experience RIS is 0.21. However, the tectonic and geologic conditions at any specific reservoir may be more or less conducive to RIS occurrence. In a review of worldwide case histories of RIS, it was found that there is a negative correlation between significant RIS and recent loading and unloading as a result of glaciation (Packer et. al 1977; 1979).

Models have been developed by Baecher and Keeney in Packer et al. (WCC 1980) to estimate the likelihood of RIS at a reservoir, characterized by its depth, volume, faulting, geology, and stress regime. The models from which the likelihoods are calculated are sensitive to changes in data classification for the geologic and stress regime. The calculations from models, however, do not significantly influence the basic relatively high likelihood of RIS at the

Devil Canyon-Watana Reservoir considering its depth and volume.

(b) Location and Maximum Magnitude (o)

Woodward-Clyde Consultants (1980), among others, has discussed the concept, based on theoretical considerations and existing cases of RIS, that an RIS event is a naturally occurring event triggered by the impoundment of a reservoir. That is, reservoirs are believed to provide an incremental increase in stress that is large enough to trigger strain release in the form of an earthquake. In this manner, reservoirs are considered capable of triggering an earlier occurrence of an earthquake (i.e., of decreasing the recurrence interval of the event) than would have occurred if the reservoir had not been filled. In this regard, reservoirs are not considered capable of triggering an earthquake larger than that which would have occurred "naturally."

The portion of crust that a reservoir may influence is limited to the area affected by its mass and pore pressure influences. This area of influence is often referred to as a reservoir's hydrologic regime. Documented cases of RIS (WCC 1980) indicate that the RIS epicenters occur within an area that is related to the surface area that the reservoir covers. For the purposes of this study, the hydrologic regime of the proposed reservoir has been described as an envelope with a 19-mile radius that encompasses the reservoir area, as discussed in WCC 1980.

Previous studies (WCC 1980) present evidence that strongly suggests that moderate to large RIS events are expected to occur only along faults with recent displacement. Among the reported cases of RIS, at least 10 have had magnitudes of (Ms) 5. Field reconnaisance and information available in the literature indicate that Quaternary or late Cenozoic surface fault rupture (i.e., rupture on faults with recent displacement) occurred within the hydrologic regime of eight of these ten reservoirs (WCC 1980).

On the basis of this investigation, it has been concluded that there are no faults with recent displacement within the hydrologic regime of the proposed reservoir. Therefore, the maximum earthquake which could be triggered by the reservoir is an earthquake with a magnitude below the detection level of currently available techniques (i.e., the detection-level earthquake). Thus, the magnitude of the largest earthquake that could be triggered by the proposed reservoir is judged to be (M_s) 6, which is the maximum magnitude of the detection level earthquake.

Based on model studies (WCC 1982), this event is most likely to occur within a 20-mile belt on either side of the reservoir.

3.2 - Seepage (*)

As the result of construction of the Watana and Devil Canyon Dams and the impoundment of the reservoirs, there will be the tendency for seepage through the foundation rock. The potential for seepage in the foundation of both dams is not high and the bedrock foundations are amenable to grouting.

Buried channels which bypass the dam present the only other potential seepage paths at either of the two damsites. At the Devil Canyon site, the channel on the south bank does not present a problem, since the saddle dam will be constructed across it with adequate foundation preparation and grouting.

At the Watana site the Fog Lakes area is not expected to pose seepage problems because of the low gradient and long travel distance (approximately 4-5 miles) from the reservoir to Fog Creek.

During early evaluations, the relict channel north of the Watana site was presumed to pose the greatest potential for seepage, through the overburden deposits from the reservoir to Tsusena Creek. Preliminary evaluations also indicated seepage through the buried channel area could result in piping and erosion of materials at the exit point on Tsusena Creek.

A further potential impact was felt to be saturation of the various zones in the buried channel combined with the thawing of permafrost in this area. The stratigraphy of the relict channel was defined during 1980-82-83 explorations. The results of these explorations indicated that there are no apparent widespread or continuous units within the relict channel that are susceptible to liquefaction. In addition, it appears that multiple periods of glaciation resulted in overconsolidating the overburden deposits within the relict channel, thereby minimizing their potential for liquefaction.

3.3 - Reservoir Slope Failures (**)

3.3.1 - General (o)

Shoreline erosion will occur as a result of two geologic processes: beaching and mass movement. The types of mass movement expected to occur within the reservoirs will be:

- o Bimodal flow;
- o Block slide;
- o Flows;
- o Multiple regressive flow;
- o Multiple retrogressive flow/slide;
- o Rotational slides;
- o Skin flows;
- o Slides; and
- o Solifluction flow.

Aside from the formation of beaches resulting from erosion, instability along the reservoir slopes can result from two principal causes: a change in the groundwater regime and the thawing of permafrost. Beach erosion can give rise to general instability through the sloughing or failure of an oversteepened backslope, thereby enlarging the beach area.

(a) <u>Changes in Groundwater Regime</u> (o)

As a reservoir fills, the groundwater table in the adjacent slope also rises. This may result in a previously stable slope above the groundwater table becoming unstable because of increased pore pressures and seepage acting on the slope. Rapid drawdown of a reservoir may also result in increased instability of susceptible slopes.

(b) <u>Thawing of Permafrost</u> (o)

Solifluction slopes, skin flows, and the lobes of bimodal flows are caused by instability on low-angle slopes resulting from the thawing of permafrost. Mobility is often substantial and rapid, as the movements are generally distributed throughout the mass.

(c) <u>Stability During Earthquakes</u> (o)

Submerged slopes in granular materials, particularly loose, uniform fine sands, may be susceptible to liquefaction during earthquakes. This is one example where a small slide could occur below the reservoir level. In addition, areas having a reservoir rim where the groundwater table has reestablished itself could have a greater potential for sliding during an earthquake because of increased pore water pressures.

Thawing permafrost could generate excess pore pressures in some soils. In cases where this situation exists in liquefiable soils, small slides on flat-lying slopes could occur. The existence of fine-grained sands, coarse silts, and other liquefaction susceptible material does not appear extensive in the reservoir areas. Therefore, it is considered that the extent of failures caused by liquefaction during earthquakes will be small and primarily limited to areas of permafrost thaw. No evidence of liquefaction was noted within the project area. Some slides could occur above the reservoir level in previously unfrozen soils as the result of earthquake shaking.

3.3.2 - Slope Stability Models for Watana and Devil Canyon Reservoirs (*)

Following a detailed evaluation of the Watana and Devil Canyon reservoir geology, four general slope-stability models were defined for this study. These models are shown in Figures E.6.2.19 and E.6.2.20 and consist of several types of beaching, flows, and slides that could occur in the reservoir during and after impoundment for both Stage I and III. Based on aerial photo interpretation and limited field reconnaissance, potentially unstable slopes in the reservoir were classified by one or more of these models as to the type of failure that may occur in specific areas. In addition to identifying potential slope-instability models around the reservoir, attempts were made to delineate areas of existing slope failures and permafrost regions. These maps are shown in Figures E.6.2.21 through E.6.2.45. As stated above, these maps are based on photo interpretation and limited field reconnaissance and are intended to be preliminary and subject to verification in subsequent studies.

Further details of the slope stability of the reservoirs is presented in Appendix K of the 1980-81 Geotechnical Report (Acres 1982a).

3.3.3 - Devil Canyon Slope Stability and Erosion (*)

The Devil Canyon Reservoir will be entirely confined within the walls of the present river valley. This reservoir will be narrow and deep with minimal seasonal drawdown. From Devil Creek downstream to the damsite, the slopes of the reservoir and its shoreline consist primarily of bedrock with localized areas of thin veneer of colluvium or till. Upstream from Devil Canyon Creek, the slopes of the reservoir are covered with increasing amounts of unconsolidated materials, especially on the south abutment. These materials are principally basal tills, coarse-grained floodplain deposits, and alluvial fan deposits.

Existing slope failures in this area of the Susitna River, as defined by photogrammetry and limited field reconnaissance, are skin and bimodal flows in soil and block slides and rotational slides in rock. The basal tills are the primary materials susceptible to mass movements. On the south abutment, there is a slight possibility of sporadic permafrost existing within the delineated areas.

Downstream from the Devil Creek area, instability is largely reserved to small rock falls. Beaching will be the primary process acting on the shoreline in this area. Although this area is mapped as a basal till, the material is coarser grained than that which is found in the Watana Reservoir and is, therefore, more susceptible to beaching.

In areas where the shoreline will be in contact with steep bedrock cliffs, the fluctuation of the reservoir may contribute to rockfalls. Fluctuation of the reservoir and, therefore, the groundwater table, accompanied by seasonal freezing and thawing, will encourage frost wedging as an erosive agent to accelerate degradation of the slope and beaching. These rock falls will be limited in extent and will not have the capacity to produce a large wave which could affect dam safety. In Devil Creek, a potential small block slide may occur after the reservoir is filled.

Above Devil Creek up to about River Mile (RM) 180, beaching will be the most common erosive process. Present slope instability above reservoir normal pool level will continue to occur, with primary beaching occurring at the shoreline.

Since the maximum pool elevation of 1,455 feet extends only to the toe of this slide, it is unlikely that a large catastrophic slide could result from normal reservoir impoundment. However, potential for an earthquake-induced landslide is possible. A mass slide in this area could result in temporary blockage of river flow.

In summary, the following conclusions can be made regarding the Devil Canyon Reservoir slope stability:

- The lack of significant depths of unconsolidated materials along the lower slopes of the reservoir and the existence of stable bedrock conditions are indicative of stable slope conditions after reservoir impounding.

- A large old landslide in the upper reservoir has the potential for instability, which, if failed, could conceivably create a temporary blockage of the river in this area.

- The probability of a landslide-induced wave in the reservoir overtopping the dam is remote.

3.3.4 - Watana Slope Stability and Erosion (**)

Most of the slopes within the Watana Reservoir are composed of unconsolidated materials. As a generalization, permafrost is nearly continuous in the basal tills and sporadic to continuous in the lacustrine deposits. The distribution of permafrost has been delineated primarily on the flatter slopes below an elevation of 2,300 feet (Figures E.6.2.13 through E.6.2.45). Inclined slopes may be underlain by permafrost, but based on aerial photo reconnaissance, the active layer is much thicker indicating that permafrost soils are thawing, and/or that permafrost does not exist. Existing slope instability within the reservoir (as defined by aerial photographic interpretation and limited field reconnaissance) indicates that the types of mass movement are primarily solifluction, skin flows, bimodal flows, and small rotational slides. These types of failure occur predominantly in the basal till or areas where the basal till is overlain by lacustrine deposits. In some cases, solifluction, which originated in the basal till, has proceeded downslope over some of the floodplain terraces.

During Stage I of the project, the normal maximum operating level (NMOL) at elevation 2,000 feet, will lie within the general confines of the river valley. As a result, the drawdown zone will generally be in contact with bedrock controlled slopes with thin to no overburden. This does not preclude the potential for slope instability along the shoreline of the reservoir, but it is anticipated that there could be less potential for rotational or block slides. In addition, after the raising of the reservoir for Stage III, the area of slope instability which occurred during Stage I will be within the reservoir and, therefore, not of major concern.

During Stage III, the reservoir normal pool level at elevation 2,185 feet will be in contact with the flatter slopes above the river valley, particularly in the lower portion of the reservoir. In these areas, the drawdown zone for Stage III will be in contact with generally thick overburden materials and, therefore, will have a greater potential for slope instability along the reservoir shoreline.

Three major factors which will contribute significantly to slope instability in the Watana Reservoir are changes in the groundwater regime, large seasonal fluctuations of the reservoir level (estimated at 150 feet), and thawing of permafrost.

Because of the relatively slow rate of impounding, the potential for slope instability occurring during flooding of the reservoir will be minimal and confined to shallow surface flows and possibly some sliding. Slopes will be more susceptible to slope instability after impoundment when thawing of the permafrost soils occurs and the groundwater regime has reestablished itself in the frozen soils.

The following is a discussion of the potential reservoir shoreline conditions which might exist during Stage III.

Near the damsite the north abutment will primarily be subject to beaching except for some small flows and slides that may occur adjacent to Deadman Creek. On the south abutment, thawing of the frozen basal tills could result in skin and bimodal flows. There is also a potential for small rotational sliding to occur primarily opposite Deadman Creek.

On the south bank between the Watana damsite and Vee Canyon, the shoreline of the reservoir has potential for flows and shallow rotational slides. In contrast to the north bank, the shoreline is almost exclusively in contact with frozen basal tills, overburden is relatively thick, and steeper slopes are present. Thermal erosion, resulting from the erosion and thawing of the ice-rich, fine grained soils, will be the key factor influencing their stability. On the north bank below Vee Canyon and on both banks upstream from Vee Canyon, the geological and topographic conditions are more variable and, therefore, have a potential for varying slope conditions.

In the Watana Creek drainage area, there is a thick sequence of lacustrine material overlying the basal till. Unlike the till, it appears that the lacustrine material is largely unfrozen. All four types of slope instability could develop here, depending on where the seasonal drawdown zone is in contact with the aforementioned stratigraphy. In addition, slope instability resulting from potential liquefaction of the lacustrine material during earthquakes may occur.

Overall, slopes on the north bank, in contrast with the south bank, are less steep and slightly better drained, which may be indicative of less continuous permafrost and/or slightly coarse material at the surface with a deeper active layer. In general, the potential for beaching in this area is high because of: (a) the wide seasonal drawdown zone that will be in contact with a thin veneer of colluvium over bedrock; and (b) the large areas around the reservoir with low slopes.

In the Oshetna-Goose Creeks area, there is a thick sequence of lacustrine material. Permafrost appears to be nearly continuous in this area based on the presence of unsorted polygonal ground and potential thermakarst activity around some of the many small ponds (thaw lakes/ kettles). The reservoir in this area will be primarily confined within the floodplain, and therefore, little modification of the slopes is expected. Where the slopes are steep, there could occur thermal niche erosion resulting in small rotational slides.

Studies performed show that the potential for a large block slide occurring and generating a wave which could overtop the dam is very remote[1/] (Acres 1982c Appendix A). For a large slide to occur of significant size, a very high, steep slope with a potentially unstable block of large volume would need to exist adjacent to the reservoir. This condition has not been observed within the limits of the reservoir. For Stage III the shoreline of the first 16 miles of the reservoir upstream from the dam will be in contact with the low slopes of the broad, U-shaped valley. Between 16 and 30 miles upstream from the dam, no potentially large landslides were observed. Beyond 30 miles upstream, the reservoir begins to meander and narrows; therefore, any wave induced in this area by a large landslide would, in all likelihood, dissipate prior to reaching the dam.

In general, the following conclusions can be drawn about the slope conditions of the Watana Reservoir after impounding:

- The principal factors influencing slope instability are the large seasonal drawdown of the reservoir and the thawing of permafrost soils. Other factors are the change in the groundwater regime, the steepness of the slopes, coarseness of the material, thermal toe erosion, and the fetch available to generate wave action;

- The potential for beaching is much greater on the north abutment of the reservoir;

- A large portion of the reservoir slopes are susceptible to shallow slides, mainly skin and bimodal flows, and shallow rotational slides;

- The potential for a large block slide that might generate a wave that could overtop the dam is remote.

In general, most of the reservoir slopes will be totally submerged. Areas where the filling is above the break in slope will exhibit less stability problems than those in which the reservoir

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[1/] At the present time, the largest block slide that has been identified in the proposed reservoir (Watana Creek) was approximately 1.8×10^6 yd^3 and would have occurred within either the Stage I or III Watana Reservoir.

is at an intermediate or low level. Flow slides induced by thawing permafrost can be expected to occur over very flat-lying surfaces.

3.4 - Permafrost Thaw (*)

The effect of thawing permafrost will primarily affect reservoir slope stability and liquefaction potential.

In addition to these two impacts, thawing can also induce settlement to surface facilities constructed in areas of deep overburden north of the Watana damsite.

With regard to settlement, it is anticipated that the airstrip, and the camps, as well as site roads, will all encounter areas of permafrost. Although the soils in this area are not ice rich, some settlements may occur because of thawing of the permafrost.

Since fractures in the rock on the north and south abutment of the Watana dam are ice-filled to approximately 60 and 120 feet respectively, thawing of this permafrost may influence seepage (thawing will more than likely occur prior to grouting of the cutoff below the core). This thawing will be generated because of the thermal effect of the large reservoir which will remain several degrees above freezing throughout the year.

3.5 - Seismically-Induced Failure (*)

Details of seismically-induced failures in the reservoir are addressed in Section 3.3.

The potential for seismically-induced failure in the relict channel area is considered low because the deposits are either well graded, dense to very dense or cohesive. Work performed in the relict channel during 1980-82 indicates there are no continuous liquefiable soils in the relict channel.

The access route and transmission lines between the Watana site and Gold Creek, and between the Watana site and the Denali Highway, cross areas which have the potential for liquefaction, or for landslides which could occur during earthquakes. The same is true of the north and south transmission corridors, particularly in the area near Anchorage. Areas of high potential in the Stephan and Fog Lakes areas south of the Susitna River have been avoided.

3.6 - Reservoir Freeboard for Wind Waves (**)

Studies were undertaken to determine freeboard requirements for wind-induced waves for the Watana and Devil Canyon damsites (Appendix A of

Acres 1982c). Two effects of wind were considered: wave run-up and wind set-up. Wave run-up is the height above the still reservoir level to which the waves will run-up the slope. Wind setup is the piling-up of water at the dam due to wind forces at the water surface. The sum of wave run-up, wind setup, and some additional height for added safety, above the normal maximum reservoir level, is defined as the minimum allowable freeboard. The PMF level also must be considered to ensure that it is below the top of the dam.

The wave heights in both Watana and Devil Canyon Reservoirs are governed by the respective effective fetch (maximum line-of-sight across the reservoir) lengths and design wind velocities. The narrowness and bends in the reservoirs reduce the effective fetch length, and thus reduce wind-induced wave heights.

The wind setup plus wave run-up for Watana (Stage I and III) are estimated to be approximately 3.5 feet. An additional safety margin of 2 feet is judged adequate, resulting in a total minimum Watana freeboard requirement of 5.5 feet.

For Devil Canyon (Stage II) the wind setup plus wave run-up is estimated at about 2.5 feet. An additional height of 1.0 foot is judged sufficient, for a resulting total Devil Canyon minimum freeboard of 3.5 feet.

The PMF level at each site is well below the crest of the respective dam.

3.7 - Development of Borrow Sites and Quarries (**)

For Watana Stage I, the primary borrow sites to be developed for construction material will be Borrow Sites D and E. Localized construction material for auxiliary facilities such as airstrips and camps may be provided from Borrow Sites D and F. At the present time, Borrow Sites C, H, I and J are considered as secondary sites to provide additional material if required. Rockfill material for the dam will come from required excavations for the spillway and approach channels. Quarry Sites A and L are secondary sites which are available if additional material is needed.

For Watana Stage III, Borrow Sites D and E will be reopened to provide the impervious and granular materials required. In addition, Quarry Site A will be opened to provide the necessary rockfill for the dam. Borrow Sites C,H, I, and J are considered to be secondary sites which could supply additional construction materials if unsuitable material and/or insufficient quantities are available from the primary sites.

Development of these sites will result in disturbance of the natural terrain and impact on aesthetics, noise levels, and air quality. Impacts of Borrow Site E (and Borrow Sites I and J, and Quarry Site L, if required) would be minimal during Stage I as it would ultimately be inundated by the Devil Canyon Reservoir. In addition, these sites are sufficiently removed from the camp facilities to minimize noise and air quality impacts. Therefore, the principal impact will be in the development of Borrow Site D and Quarry Site A (Stage III). Although the method of excavation in Borrow Site D will be developed in the subsequent design phases, it is anticipated that the upper 2-3 feet of soil and organic material will be stripped and stockpiled. Trenching and ditching will likely be required throughout the borrow site to provide for free drainage and rapid run-off of surface water. The borrow site will be developed in stages using high soil cuts to allow for selective mixing of material.

4 - MITIGATION (**)

4.1 - Impacts and Hazards (o)

Five impacts which will or could be generated because of construction of the Susitna project are:

- Reservoir-induced seismicity;
- Seepage;
- Reservoir slope failures;
- Permafrost thaw; and
- Seismically-induced failure.

The effect of these impacts on the project and mitigating measures are discussed in this section. In addition to the above impacts, the avoidance of geologic hazards is also addressed.

4.2 - Reservoir-Induced Seismicity (o)

The magnitude of an earthquake generated by the effect of the reservoir will not exceed the magnitude of any earthquake which would normally occur in the Talkeetna Terrain. Therefore, the detection-level earthquake developed for the project will provide the design criteria for any reservoir-induced earthquakes.

In order to monitor the effect of reservoir-induced earthquakes, a complete long-term monitoring program will be instituted in the region which will be installed prior to completion of the project. This system will provide earthquake data on all earthquakes in the region including all those induced by the effect of the reservoir. Considerations of the correlations between filling curves and seismicity for other cases of RIS has been reviewed, and it appears that sudden changes in water levels and sudden deviations in rate of water level change can be triggers of induced seismicity. A controlled, smooth-filling curve, with no sudden changes in filling rate, should be less likely to be accompanied by induced seismicity than rapid, highly fluctuating filling rates.

The filling rate for the Watana Reservoir covers three years, which is relatively slow. Seasonal variations are steady and do not fluctuate rapidly. The Devil Canyon Reservoir fills more rapidly, but is held steady with very little seasonal variation.

4.3 - Seepage (**)

Seepage normally occurring through the foundation rock below each of the dams will be controlled by two means: the installation of a grout curtain and by a pattern of drain holes drilled from the gallery below the dams. This treatment would reduce or prevent seepage as well as controlling the downstream internal pressures in the rock by the pressure relief affected by the drain holes.

Should excessive seepage develop during impoundment, provisions have been made by virtue of the grouting and drainage galleries beneath the dam foundation, to allow for remedial grouting and additional drain hole installations. In addition, extensive instrumentation of the dam and abutments will be placed during construction for long-term, post-construction monitoring of seepage.

Preliminary assessment of seepage rates through the Watana Relict Channel, assuming conservative permeability rates, indicate that the total seepage quantity during Stage III is negligible and that there appears to be no impact on project operation. Nevertheless, since some uncertainties still exist, remedial measures have been planned to control seepage. First, a drainage gallery would be constructed in overburden across the relatively narrow relict channel exit area at Tsusena Creek. Additionally if required, a positive seepage barrier similar to an I.C.O.S. wall would be built across the throat of the relict channel where the width of unit 'K' is minimal.

During Stage I, seepage potential through the Watana Relict channel is negligible to non-existent, because of an even lower hydraulic gradient between the reservoir and Tsusena Creek.

4.4 - Reservoir Slope Failures (**)

Some amount of slope failure will be generated in the Watana and Devil Canyon Reservoirs as a result of reservoir filling and seasonal fluctuation. The principal slope failures will occur in the Watana reservoir where there are greater amounts and thicknesses of surficial deposits and permafrost. It is anticipated that skin flows, minor slides, and beaching will be a long-term progressive activity as a result of seasonal fluctuation of the reservoir and thawing of permafrost. Tree root systems, left from reservoir clearing, will tend to hold shallow surface slides and, in some cases where permafrost exists, may have a stabilizing influence, since the mat will hold the soil in place until excess pore pressure has dissipated. Many of the slides will occur underwater, thereby leaving no impact on the project area. Other slides occurring along the rim of the reservoir are expected to be localized. After failure, wave action will likely result in the creation of new beaches along these new slopes.

It is anticipated that during Stage I, the amount of instability along the reservoir shoreline as well as the quantity of material which will be introduced into the reservoir will be less than Stage III conditions because of the following:

- o the reservoir level is generally within the confines of the river valley; i.e. steep slopes with a thin overburden cover over bedrock and bedrock outcrops,
- o shoreline length is less.

The magnitude of waves generated in the reservoir because of slides has been evaluated and found to pose no threat to the safety of the dams.

Additional freeboard has also been provided at the Watana dam so that the effect of slides into the reservoir is further minimized. Normal freeboard at normal maximum water surface elevation at Watana is 22 feet.

The relatively small fluctuation in the reservoir levels at the Devil Canyon site will mitigate against ongoing slope failures.

Monitoring of key slopes will be initiated prior to impoundment, particularly the large slide mass identified in the upper reaches of the Devil Canyon Reservoir as well as areas having the potential for larger slides in the Watana reservoir.

4.5 - Permafrost Thaw (**)

Possible impacts because of permafrost thaw at the Watana site could result in settlement of facilities in areas of deep overburden. Adequate structural design is possible to mitigate against the hazards of settlement in permafrost areas. In the case of the main construction camp, a large pad of granular material will be provided which will evenly distribute the load and insulate the subsoil, hence, retarding thaw. Regrading of the airstrip will be necessary as a maintenance program to offset the effects of differential settlement in these areas.

4.6 - Seismically - Induced Failure (*)

An assessment of the liquefaction potential of the relict channel area indicates that 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 planned for the relict channel with respect to potential liquefaction. Seismically-induced failure of reservoir slopes, although possible, will not be hazardous to the project.

The design of the main structures have been analyzed to accommodate the ground motions induced by the maximum credible earthquake. Therefore, the overall safety of the project is assured with the safety of the major structures.

4.7 - Geologic Hazards (*)

There are only three main geologic structures which can have an affect on the construction and operation of the power facilities at the two sites. These are the short shear zone south of and parallel to the river at Devil Canyon, the "Fins" feature upstream from the Watana site, and the "Fingerbuster" zone downstream from the Watana site.

At the Watana site, all of the main project features have been located between the two features, the "Fins" and the "Fingerbuster," thus avoiding the need to tunnel through these shear zones.

Since the main concrete dam does not cross potentially hazardous geologic features at Devil Canyon, no danger to the structure is posed. Tunneling through such a feature could pose problems with large tunnels. However, only the small drainage gallery is planned to pass beneath the saddle dam.

4.8 - Borrow and Quarry Sites (*)

All temporary access roads will be graded, recontoured, and seeded following abandonment. Areas near streams or rivers, where erosion may occur, will be protected during the construction period and reseeded when construction is complete. Borrow sites will be excavated only as necessary and will either be regraded and seeded with appropriate species, or, if excavation is deep enough, converted to ponds.

Rock excavated and not used in construction will be placed as riprap, used as backfill in the borrow site, or stockpiled out of the areas for later use during operation and maintenance of the project.

5 - REFERENCES

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6 - GLOSSARY

Andesitic - from andesite rock which is fine-grained, extrusive rock.

Aphanitic - pertaining to a texture of rocks in which the crystalline constituents are too small to be distinguished with the unaided eye.

Argillite - a compact rock which has undergone a somewhat higher degree of induration (hardening) than mudstone, claystone but is less indurated than shale.

Breccia - fragmented rock whose components are angular; may be rock which is crushed due to shearing.

Chert - a variety of quartz, a compact siliceous rock.

Clastic - rocks composed of fragments of existing rocks.

Felsic - a general term applied to igneous rock having light-colored minerals; the opposite of mafic.

Gouge (shears) - rock material that has been ground to a uniformly fine particle size of clay or silt.

Graywackes - a gray or greenish gray, very hard, coarse-grained sandstone with dark rock and mineral fragments.

Kame - a long low hill, mound, or ridge composed chiefly of poorly sorted, stratified sand and gravel; ice contact deposit.

Lithosphere - the earth's crust and the upper portion of the mantle.

Mafic - an igneous rock having dark colored minerals; the opposite of felsic.

Metabasalt - a basalt which has undergone some degree of metamorphism.

Metamorphic - rocks which have formed in the solid state in response to pronounced changes of temperature, pressure, and the chemical environment.

Orogeny - the processes (including folding and thrusting) by which mountains are formed.

Orthoclase - a mineral; a member of the feldspar group commonly seen in granitic rocks.

Phenocrysts - the relatively large crystals which are found set in a fine-grained ground mass.

Phyllite - an argillaceous rock which has undergone regional metamorphism and is intermediate in grade between slate and mica schist.

Plagioclase - a mineral group; members of the feldspars, one of the most common rock-forming minerals.

RQD - Rock Quality Designation. This is a form of recording rock core recovery; the RQD is the ratio of the total length of core pieces four inches and longer to the length of the coring run actually drilled, expressed in percent.

Slickenslides - a polished and smoothly striked surface that results from friction along a fault/shear plane.

Stoss and lee bedrock forms - asymmetric hills in a strongly glaciated area, each hill having a gently upgraded slope on the stoss side (side to the ice), and a steeper and rougher quarried slope on the lee side.

Tectonic - of, pertaining to, or designating the rock structure and external forms resulting form the deformation of the earth's crust.

Thalweg - the line connecting the lowest or deepest points along a stream, valley, or reservoir, whether underwater or not.

Thermakarst - settling or caving in of the ground due to melting of ground ice.

Tuff - a rock formed of compacted volcanic fragments, generally smaller than 4 mm in diameter.

Turbidite - a deposit formed by a highly turbid and relatively dense current which moves along the bottom of a body of standing water.

Volcaniclastic rock - a sedimentary rock composed primarily of volcanic rock fragments.

TABLES

TABLE E.6.2.1: GEOLOGIC TIME SCALE

ERA	PERIOD	EPOCH	GLACIATION	MILLION OF YEARS AGO
Cenozoic	Quaternary	Holocene Pleistocene	Wisconsinan Illinoian Kansan Nebraskan	1.8
	Tertiary	Pliocene Miocene Oligocene Eocene Paleocene		70
Mesozoic	Cretaceous Jurassic Triassic			230
Paleozoic	Permian Pennsylvanian Mississippian Devonian Silurian Ordovician Cambrian			600
Precambrian				

TABLE E.6.2.2: WATANA JOINT CHARACTERISTICS*

Joint Set	Site Quadrant	Strike (Range)	Strike (Avg.)	Dip (Range)	Dip (Avg.)	Spacing** (Range)	Spacing** (Avg.)	Surface Conditions: Texture	Surface Conditions: Coating	Remarks
I	All	290°-330°	320°	75°NE-80°SW	90°	1"-15'	2')		Carbonate locally	Parallel to major shears, fracture zones and alteration zones
	NE, SE				80°NE	2"-10'	2')		Carbonate at WJ-6 and WJ-7	
	NW, SW		320°		90°	1"-15'	2')	Planar, smooth to locally rough, continuous	Major carbonate at WJ-4	
	I6 NW, SW		295°		75°NE	1"-15'	2')		Minor carbonate at WJ-9	
II	All	045°-080°	060°	80°SE-80NW	90°	1"-5'	2'	Planar, smooth to rough	Carbonate locally	No shears or alteration zones, minor fracture zone
	NE, SE		050°		85°NW	1"-5'	1.5'	Planar to irregular, smooth to slightly rough	Carbonate at WJ-5	
	NW, SW		065°		90°	2"-5'	2'	Planar, smooth to rough	Carbonate at one outcrop	
III	All	340°-030°	0°	40°E-65°W	60°E	0.5"-5'	1.5'	Planar to irregular, rough	Carbonate locally	Parallel to minor shears and fracture zones
	NE		005°		60°E	2"-2'	1'	Curved, rough	--	Weakly developed
	SE		350°		65°W	6"-4'	1.5'	Planar to irregular, smooth to rough	--	Weakly developed
	NW, SW		345°		60°E	0.5"-5'	2'	Planar to irregular, rough	Carbonate locally	Strongly developed
IV		Variable orientations		Shallow to moderate						
	Strongest Concentrations:									
	NE		080°		10°N	2"-3'	1')	Planar to irregular, smooth to rough, discontinuous	--	Probably stres s relief, near surface
	SE		090°		25°S)		)			
			310°		40°NE)		)			
	NW		090°		10°S	1"-3'	2')			
	SW		0°		05°E)	6"-10'	2')			
			090°		25°N)		)			

* Surface data only

** When set is present

TABLE E.6.2.3: DEVIL CANYON JOINT CHARACTERISTICS*

Joint Set	Location	Strike (Range)	Strike (Avg.)	Dip (Range)	Dip (Avg.)	Spacing** (Range)	Spacing** (Avg.)	Surface Conditions: Texture	Surface Conditions: Coating	Remarks
I	North Bank	320°-0°	345°	60°NE-70°SW	80°NE	0.5"-10'	1.5'	Planar, smooth, occasional rough, continuous	Occasional iron oxide and carbonate	Parallel to shears, fracture zones and most dikes. Major stress relief, open joints on south bank. Ib found locally
	Ib DCJ-4		320°		55°NE					
	South Bank	310°-350°	340°	60°NE-75°SW	90°	0.5"-5'	2'			
II	North Bank	040°-090°	065°	40°-75°SE	55°SE	6"-3'	2'	Planar to curved, smooth to rough	None	Parallel and sub-parallel to bedding/foliation. Some open to 6" near river level. Parallel to major and minor shears. IIb is found locally.
	IIb DCJ-4		015°		85°SE					
	South Bank	020°-100°	075°	30°-75°SE	55°SE	2"-6'	1'			
	IIb DCJ-1		015°		75°SE	2"-5'	1.5'			
III	North Bank	045°-080°	060°	50°NW-70°SE	80°NW	4"-10'	3'	Planar to irregular, smooth to rough, tight to open joints	Occasional iron oxide and carbonate	Occurs locally, cliff former above Elevation 1400 on the north bank
	South Bank	015°-045°	025°	68°-80°NW	65°NW	6"-10'	3'			Locally open joints
IV	North Bank	Variable orientations		Shallow to moderate		3"-8'	2'	Planar, rough, discontinuous	Occasional iron oxide and carbonate	Probably stress relief, near surface
	Strongest Concentrations:									
	Composite		060°		15°SE					
	DCJ-2		060°		30°NW					
	DCJ-3		090°		10°S					
	DCJ-4		045°		25°NW					
	South Bank	Variable orientations		Shallow to moderate						
	Strongest Concentrations:									
	Composite		050°		25°NW					
			330°		20°NE					
			330°		15°SW	1"-8'	2'			
			060°		40°NW					
	DCJ-1		345°		15°NE					

* Surface joints only

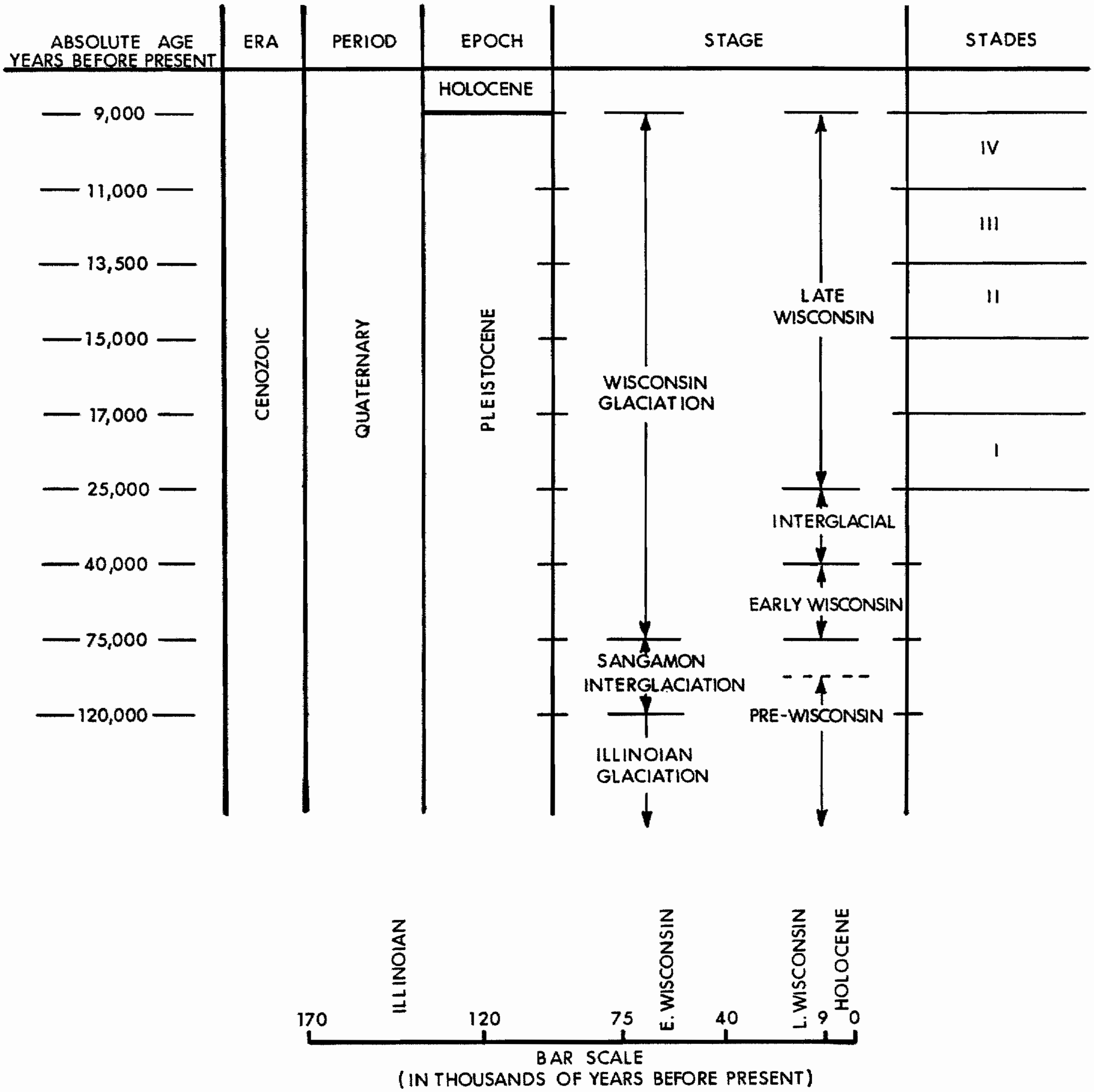
** Where present

TABLE E.6.2.4: DEVIL CANYON TAILRACE TUNNEL - JOINT CHARACTERISTICS*

Joint Set	Strike (Range)	Strike (Avg.)	Dip (Range)	Dip (Avg.)	Spacing** (Range)	Spacing** (Avg.)	Surface Conditions: Texture	Surface Conditions: Coating	Remarks
I	284°-355°	325°	50°NE-55°SW	70°NE	0.5"-10'	1.5'	Planar, smooth, occasional rough, continuous	Occasional iron oxide and carbonate	Parallel to shears, fracture zones and most dikes
II	052°-085°	065°	37°SE-80°SE	60°SE	2"-5'	2'	Planar to curved, smooth to rough	None	Parallel and subparallel to bedding/foliation. Minor shears
III	006°-038°	022°	63°E-84°W	--	4"-10'	3'	Planar to irregular, smooth to rough	Occasional iron oxide and carbonate	Locally well developed
IV***	Variable		less than 40°				Planar, rough, discontinuous	Occasional iron oxide and carbonate	Probably stress relief, near surface

* Surface joints only
** When present
*** See Table 7.2

FIGURES

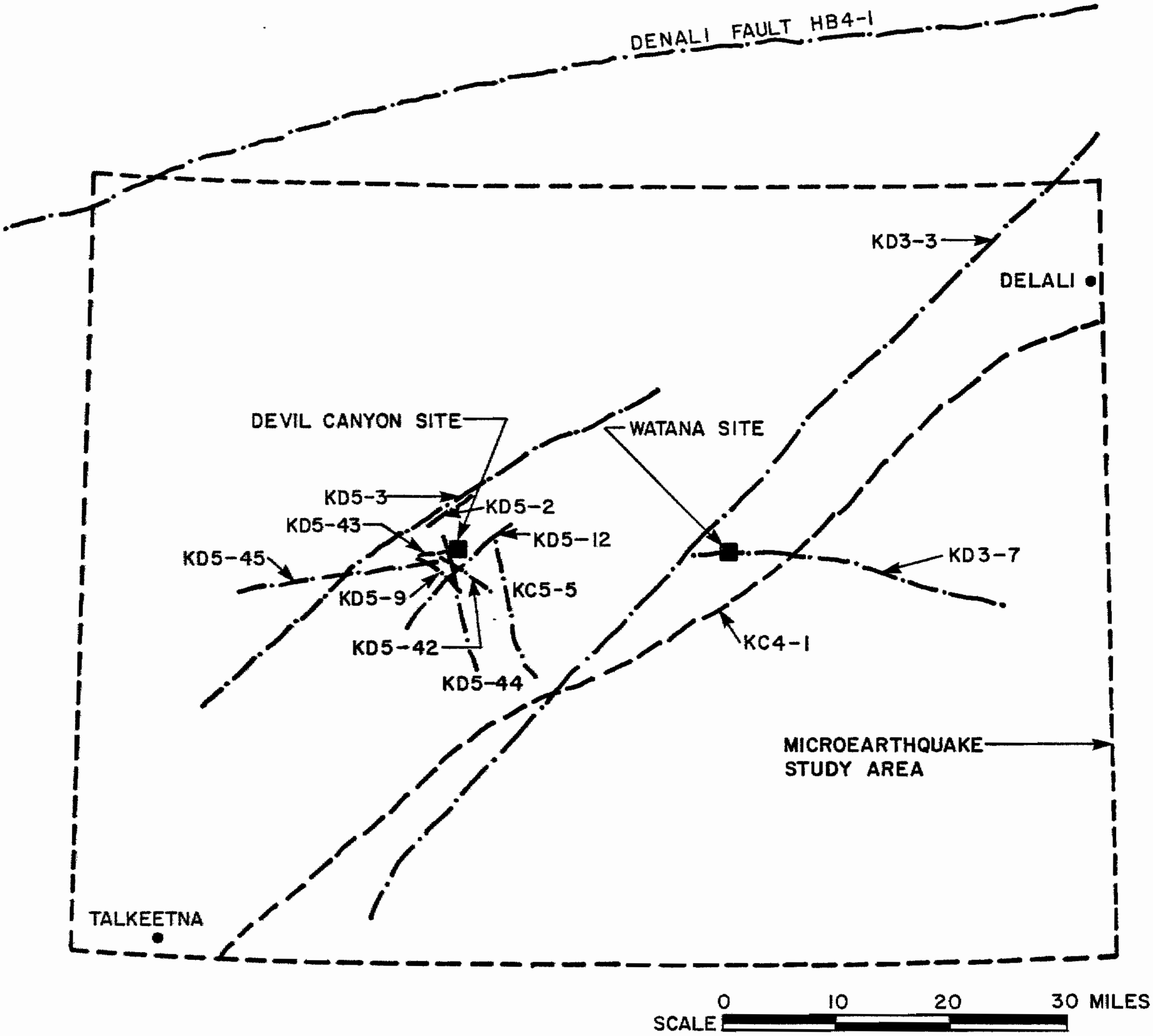


NOTES:

1. ERA THROUGH EPOCH TERMINOLOGY AND ABSOLUTE AGES ARE AFTER VAN EYSINGA (1978).
2. STAGE TERMINOLOGY AND AGE ARE AFTER PEWE' (1975).
3. STADE AGE ARE MODIFIED AFTER TEN BRINK AND WAYTHOMAS (IN PRESS)

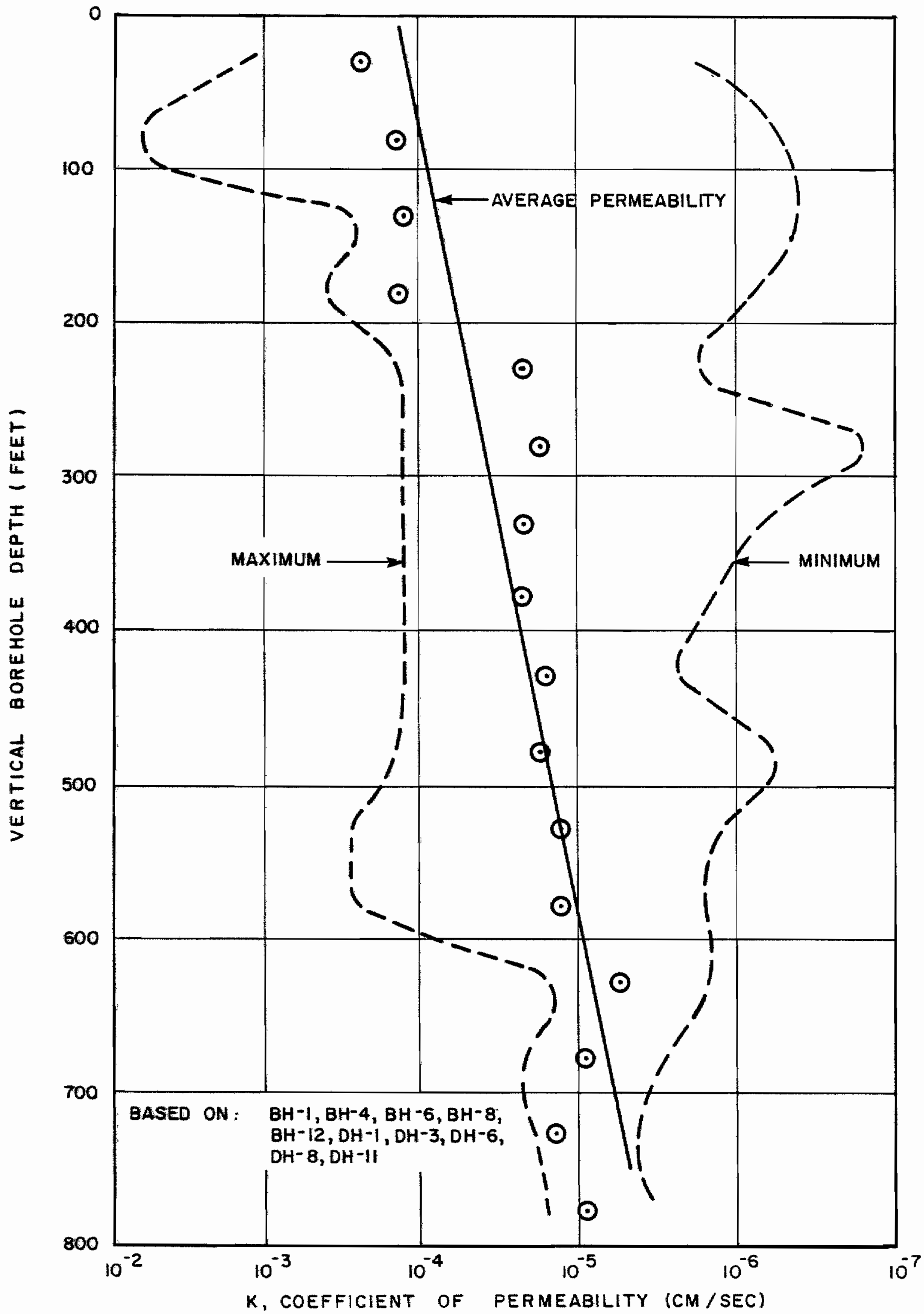
QUATERNARY STUDY REGION TIME SCALE

FIGURE E.6.2.2



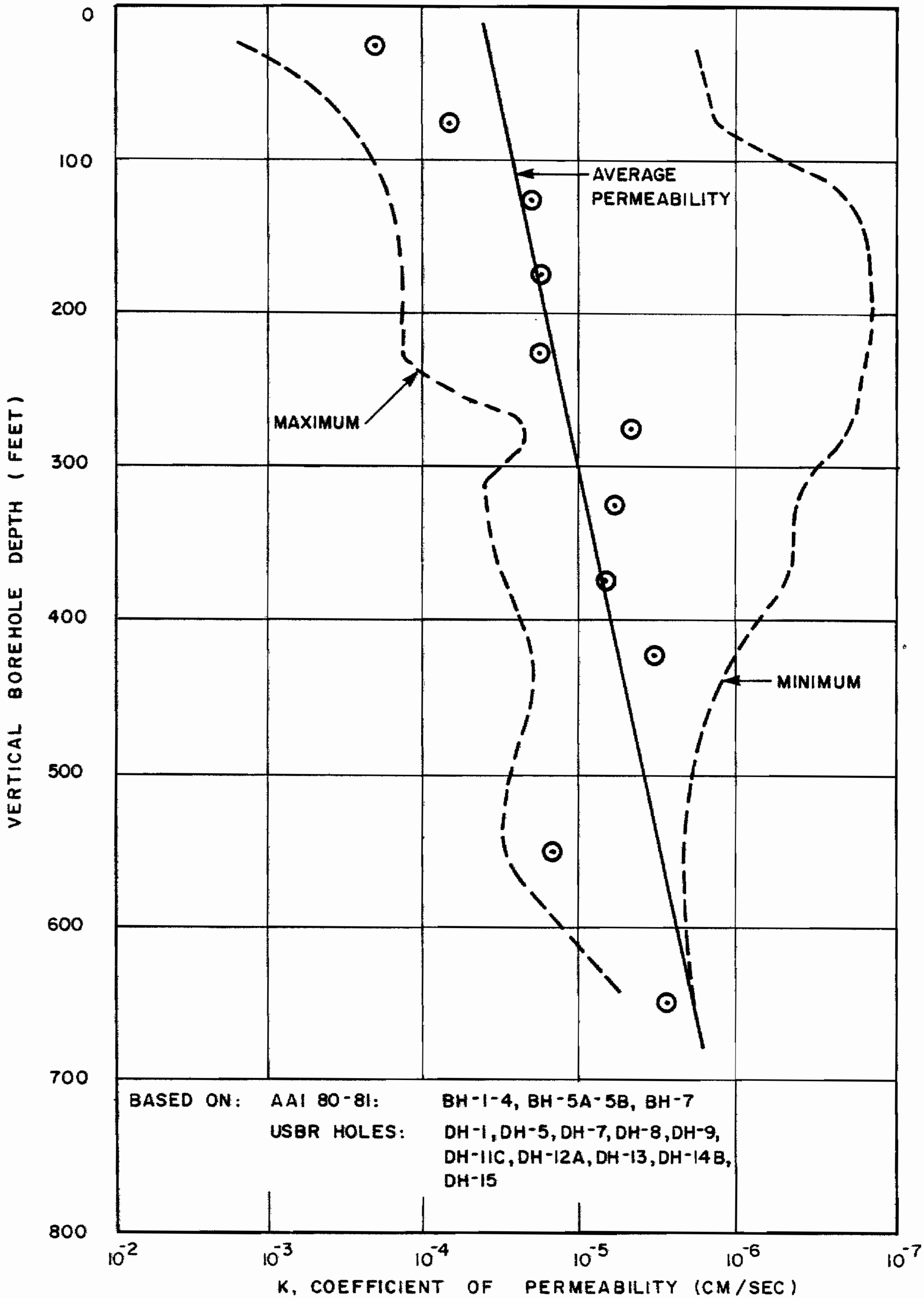
FEATURES SELECTED FOR 1981 STUDIES

FIGURE E.6.2.4



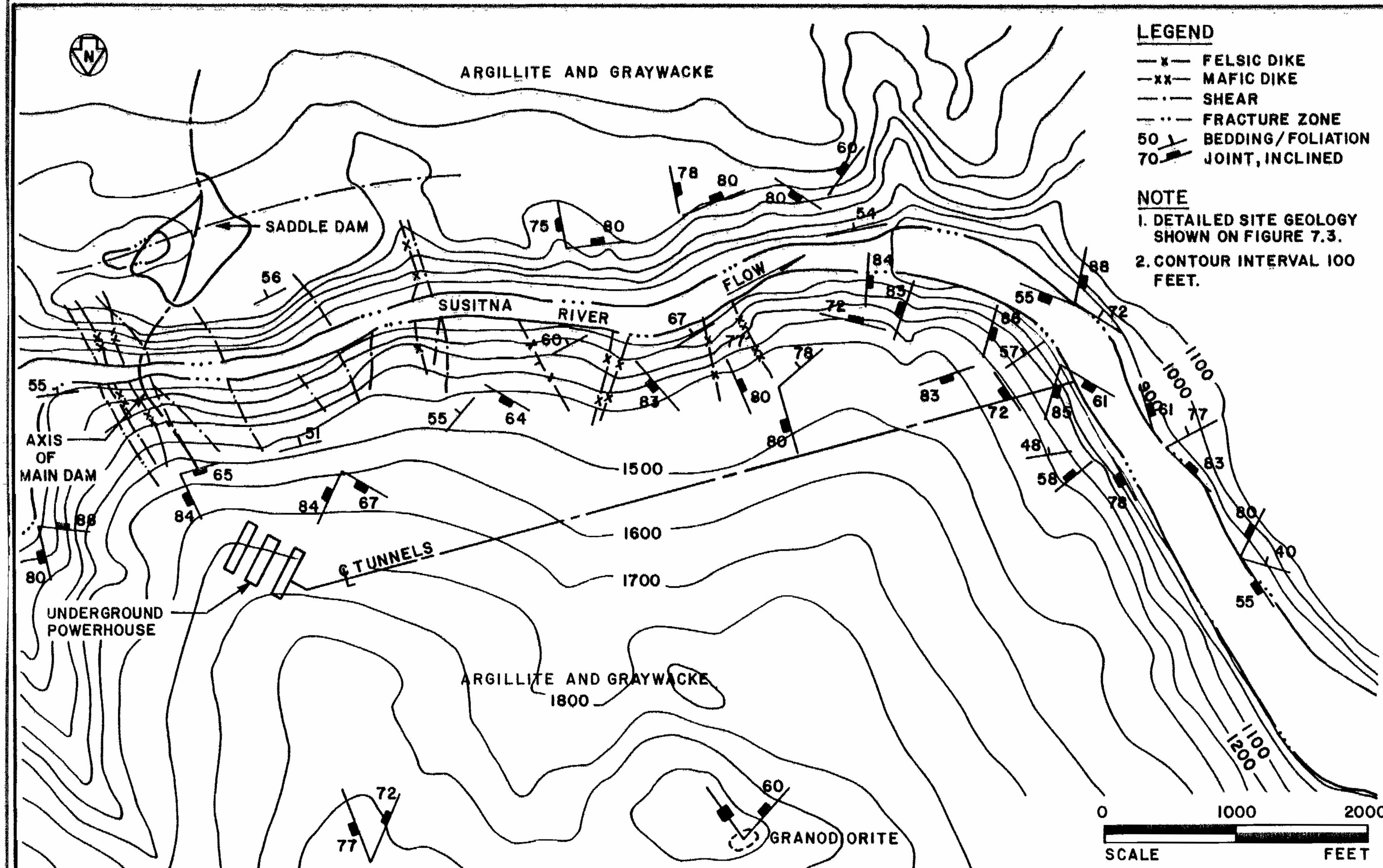
WATANA ROCK PERMEABILITY

FIGURE E.6.2.8



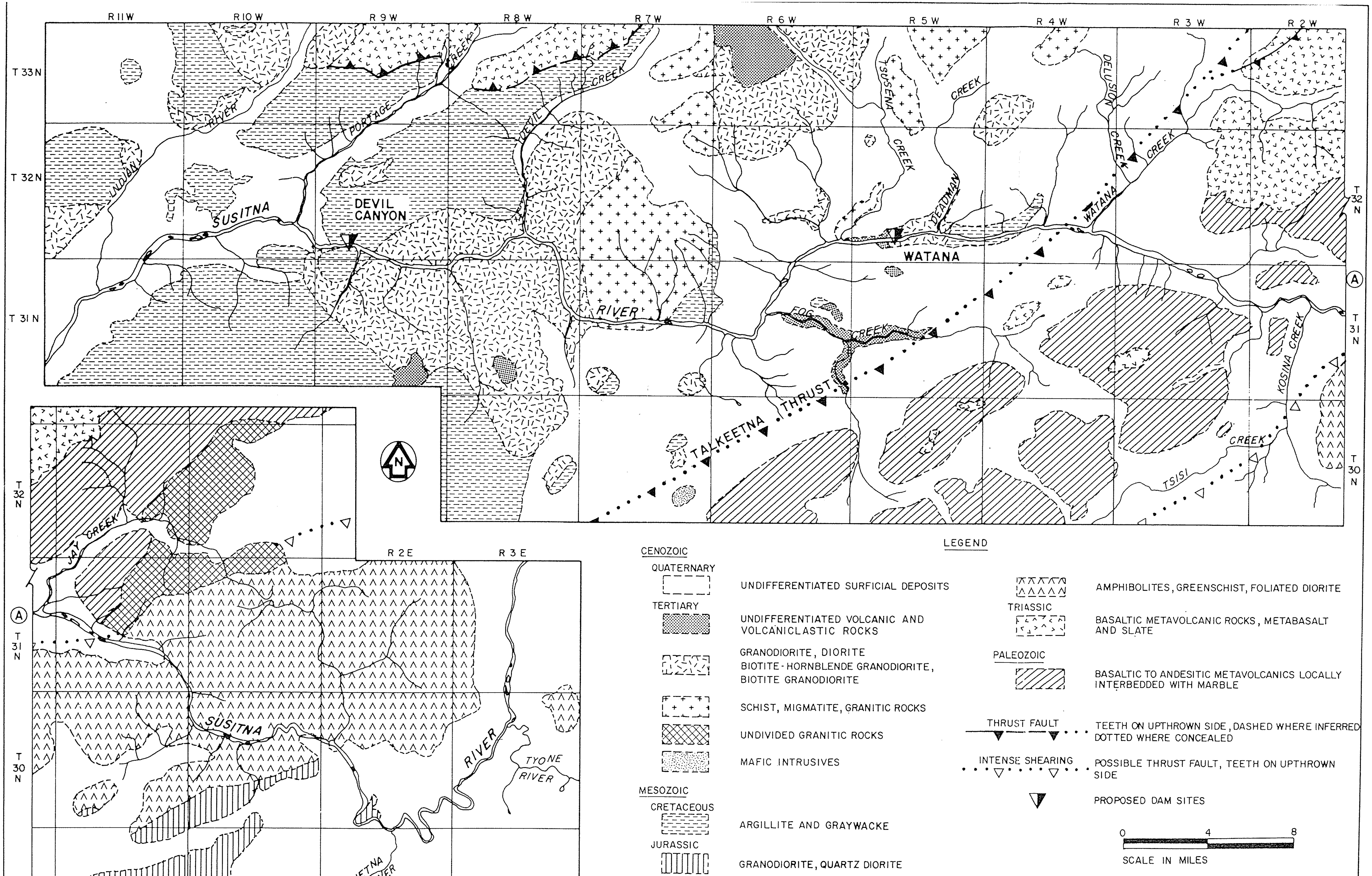
DEVIL CANYON ROCK PERMEABILITY

FIGURE E.6.2.17



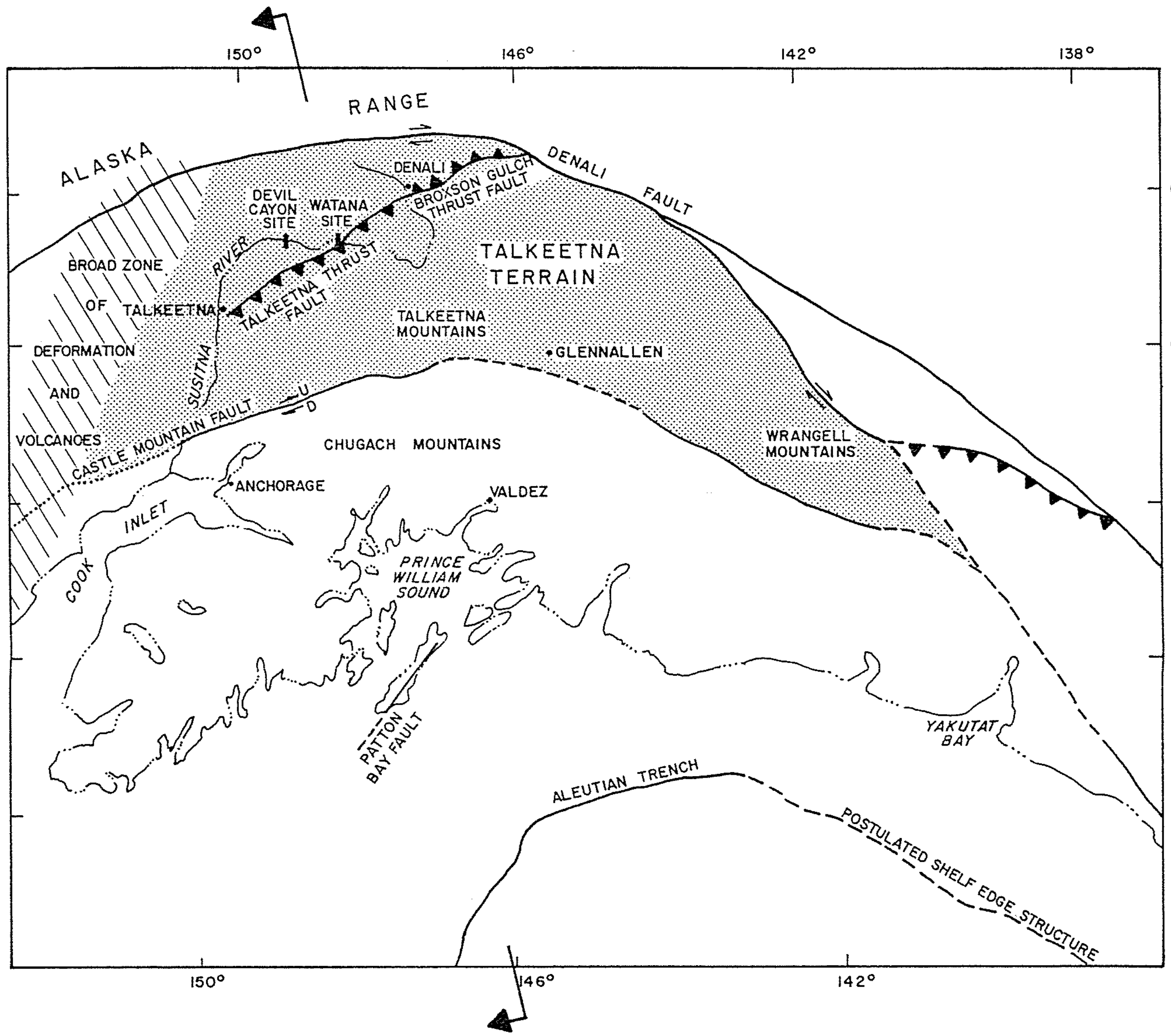
DEVIL CANYON
TAILRACE GEOLOGIC MAP

FIGURE E.6.2.18

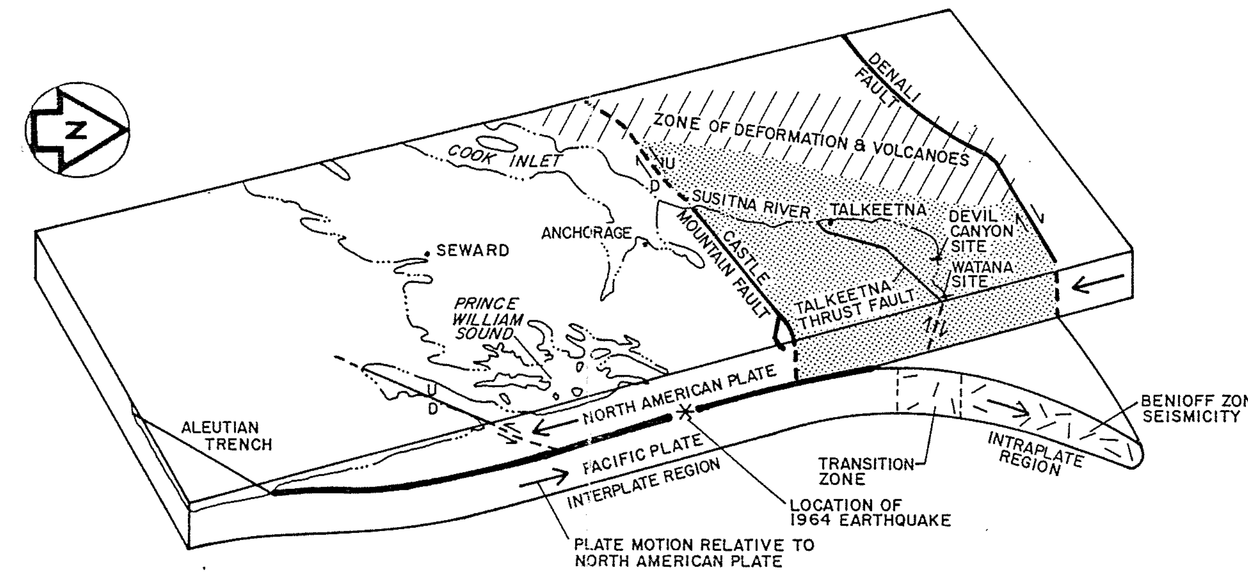


REGIONAL GEOLOGY

FIGURE E.6.2.1



TALKEETNA TERRAIN MODEL



SCHEMATIC TALKEETNA TERRAIN SECTION

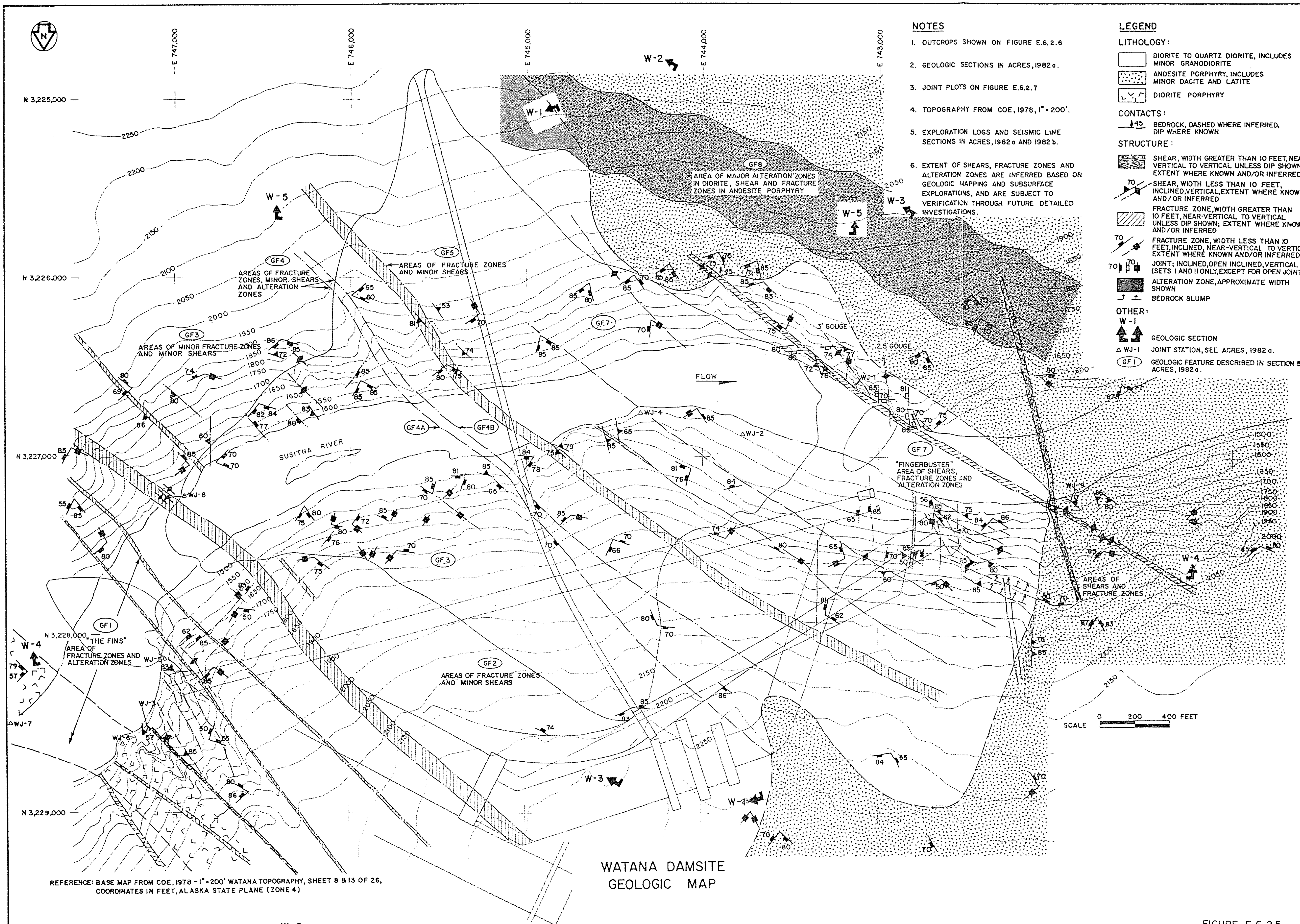
LEGEND:

- MAPPED STRIKE-SLIP FAULT, ARROWS SHOW SENSE OF HORIZONTAL DISPLACEMENT.
- MAPPED STRIKE-SLIP FAULT WITH DIP SLIP COMPONENT, LETTERS SHOW SENSE OF VERTICAL DISPLACEMENT: U IS UP, D IS DOWN.
- MAPPED FAULT, SENSE OF HORIZONTAL DISPLACEMENT NOT DEFINED.
- INFERRED STRIKE-SLIP FAULT.
- MAPPED THRUST FAULT, SAWTEETH ON UPPER PLATE.

SCALE 0 50 100 MILES

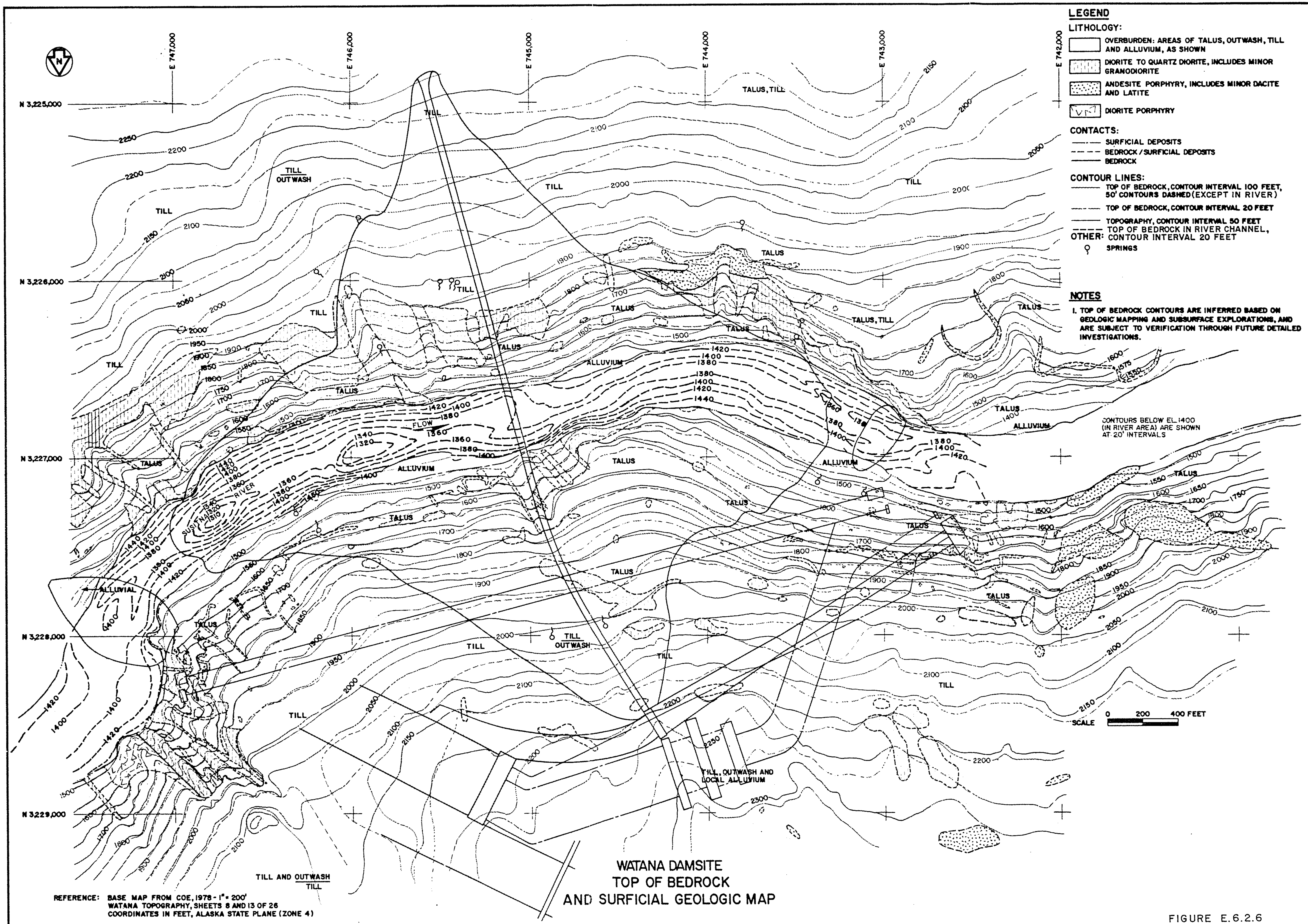
TALKEETNA TERRAIN MODEL AND SECTION

FIGURE E.6.2.3



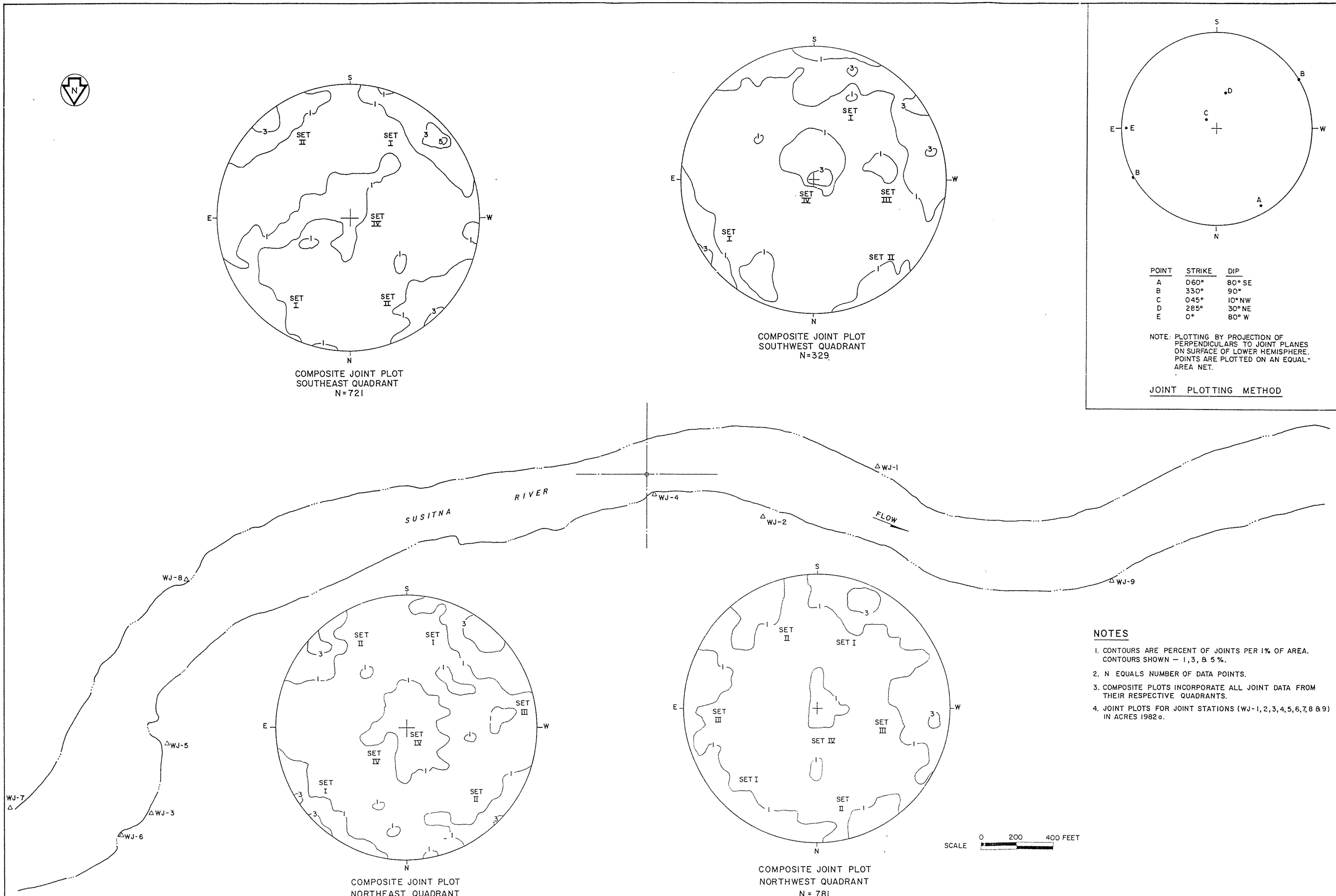
WATANA DAMSITE
GEOLOGIC MAP

FIGURE E.6.2.5



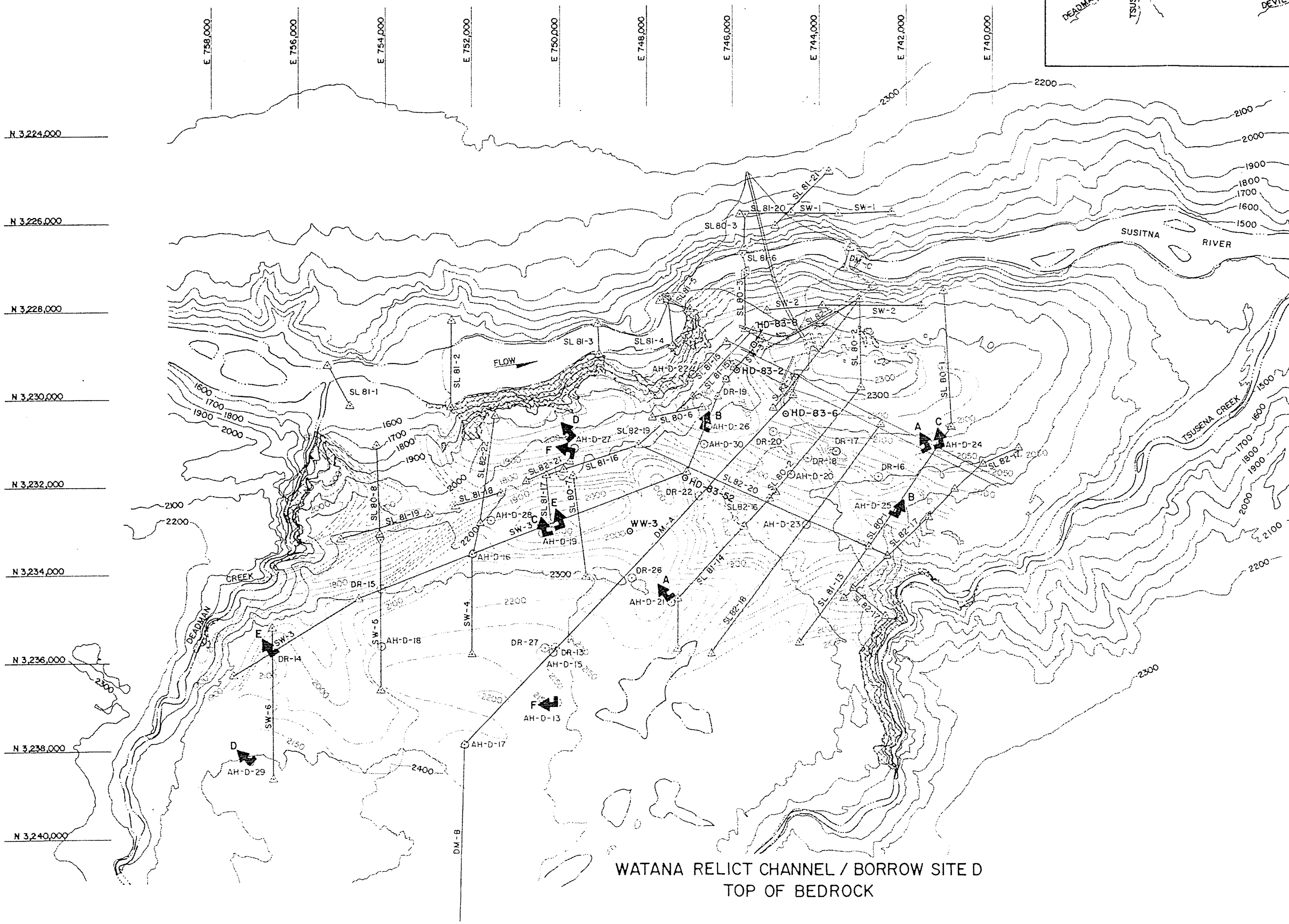
WATANA DAMSITE
TOP OF BEDROCK
AND SURFICIAL GEOLOGIC MAP

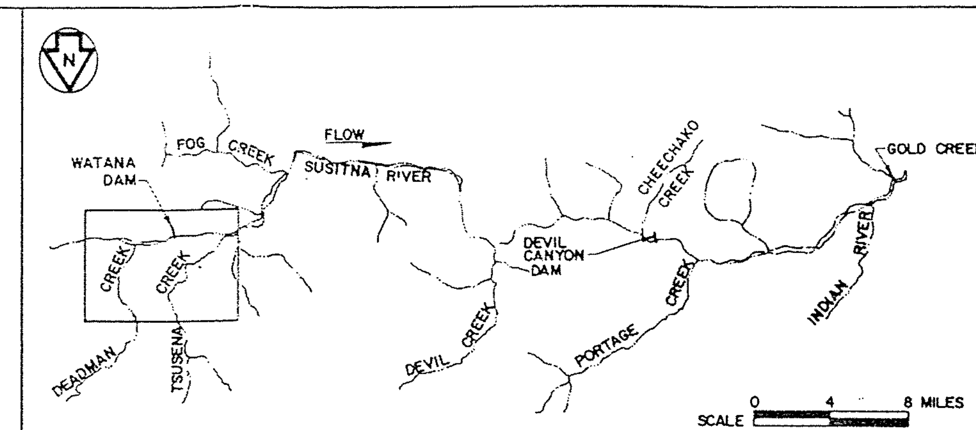
FIGURE E.6.2.6



WATANA DAMSITE
COMPOSITE JOINT PLOTS

FIGURE E.6.2.7





LOCATION MAP

LEGEND

LITHOLOGY:

BEDROCK OUTCROP, UNDIFFERENTIATED.

CONTACT:

BEDROCK / SURFICIAL DEPOSITS APPROXIMATE.

CONTOUR LINES:

TOP OF BEDROCK, CONTOUR INTERVAL 50 FEET.

50 FOOT CONTOURS DASHED.

TOPOGRAPHY, CONTOUR INTERVAL 100 FEET.

OTHER:

A A GEOLOGIC SECTION LOCATION.

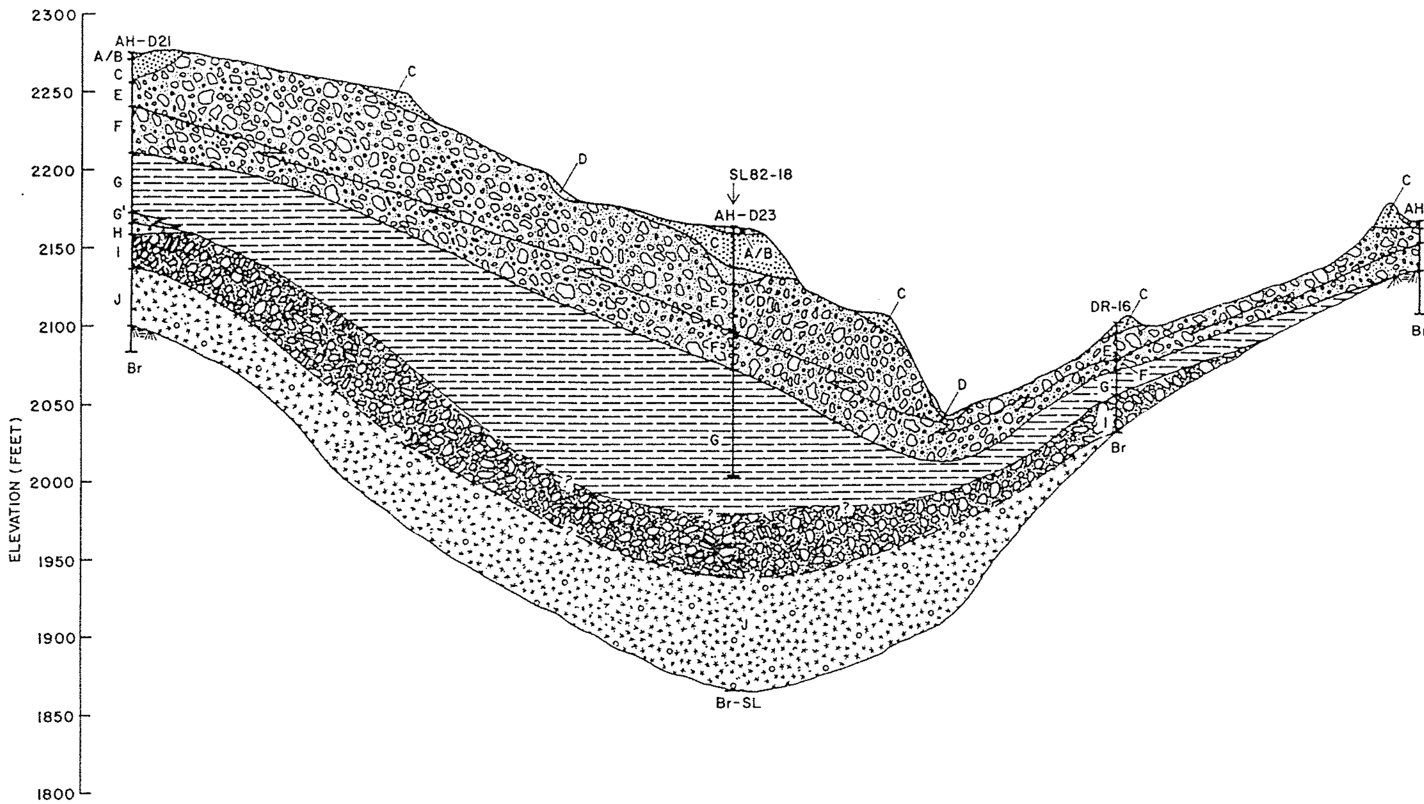
NOTES:

1. EXPLORATION LOGS AND SEISMIC LINE SECTIONS SHOWN IN APPENDICES A AND D, ACRES, 1982b AND ACRES, 1982a; HARZA/EBASCO, 1983
2. DETAILED TOP OF BEDROCK IN DAMSITE AREA SHOWN ON FIGURE E.6.2.6
3. GEOLOGIC SECTIONS SHOWN ON FIGURE E.6.2.10

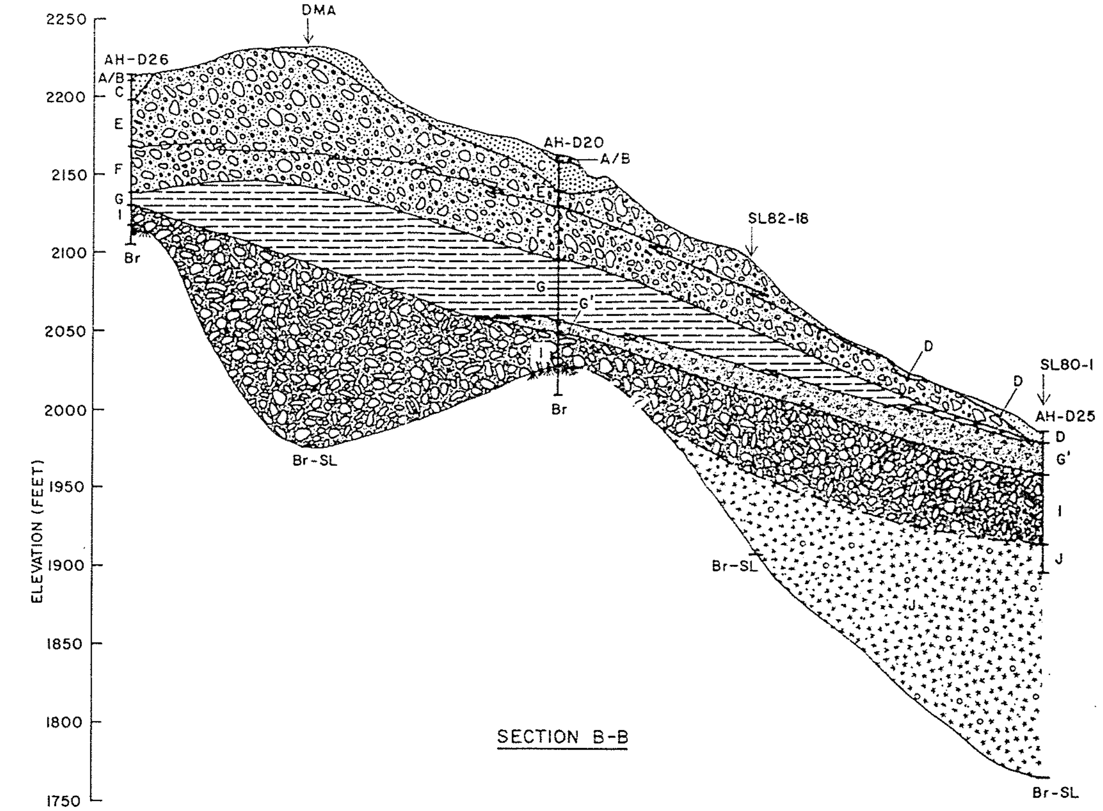
SCALE 0 1000 2000 FEET

WATANA RELICT CHANNEL / BORROW SITE D
TOP OF BEDROCK

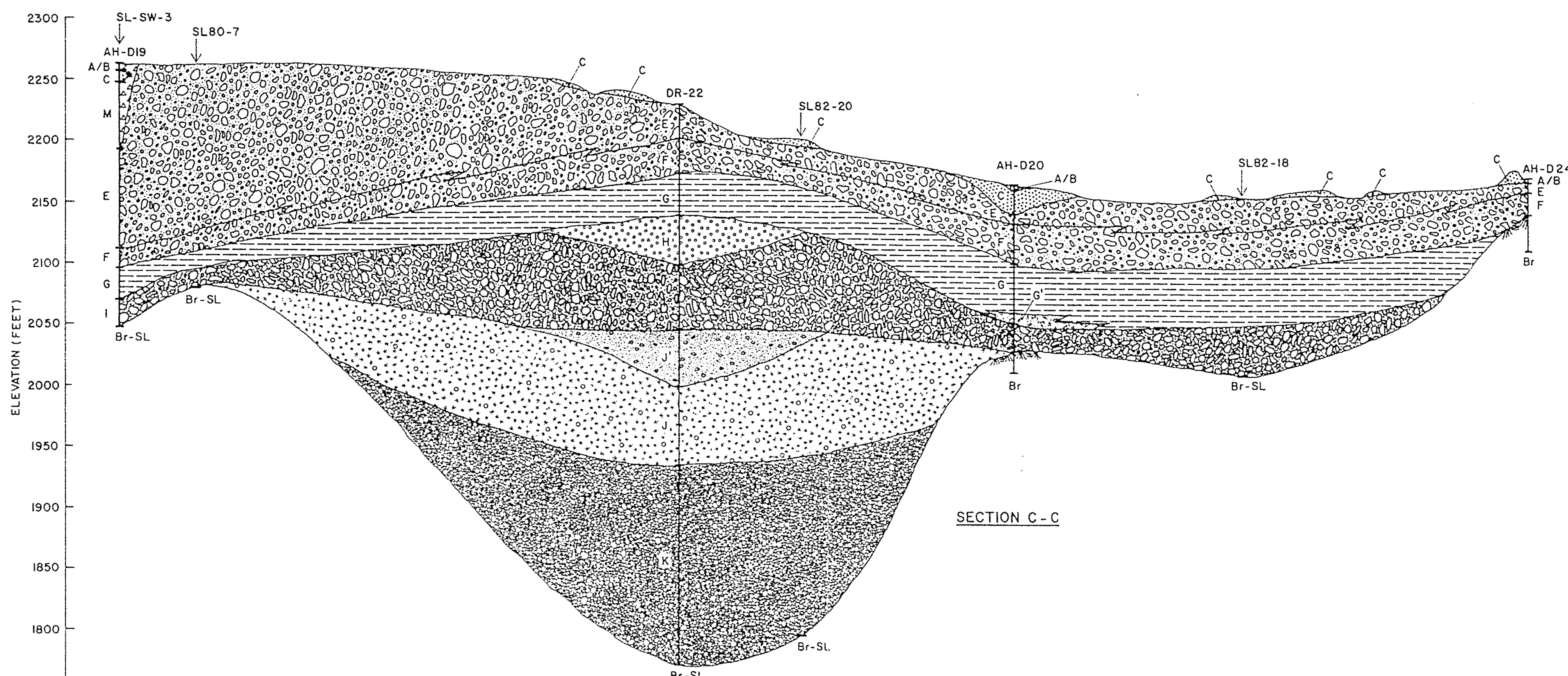
FIGURE E.6.2.9



SECTION A-A



SECTION B-B



SECTION C-C

LEGEND

- A/B — SURFICIAL DEPOSIT
- C — ICE DISINTERGRATION DEPOSITS
- M — BASAL TILL
- D — ALLUVIUM
- E — OUTWASH
- G — LACUSTRINE
- G' — BASAL TILL
- H — ALLUVIUM
- I — OUTWASH
- J — TILL
- J' — ALLUVIUM AND LACUSTRINE DEPOSITS
- K — ALLUVIUM
- Br — BEDROCK

NOTES:

1. FOR DETAILS OF STRATIGRAPHY SEE FIGURE E.6.2.11
2. FOR LOCATION OF SECTIONS SEE FIGURE E.6.2.9
3. EXTENT OF STRATA AND CONTACTS ARE INFERRED BASED ON INTERPRETATION OF SUBSURFACE EXPLORATIONS AND ARE SUBJECT TO VERIFICATION BY FUTURE INVESTIGATIONS.

HORIZ. SCALE 0 400 800 FEET

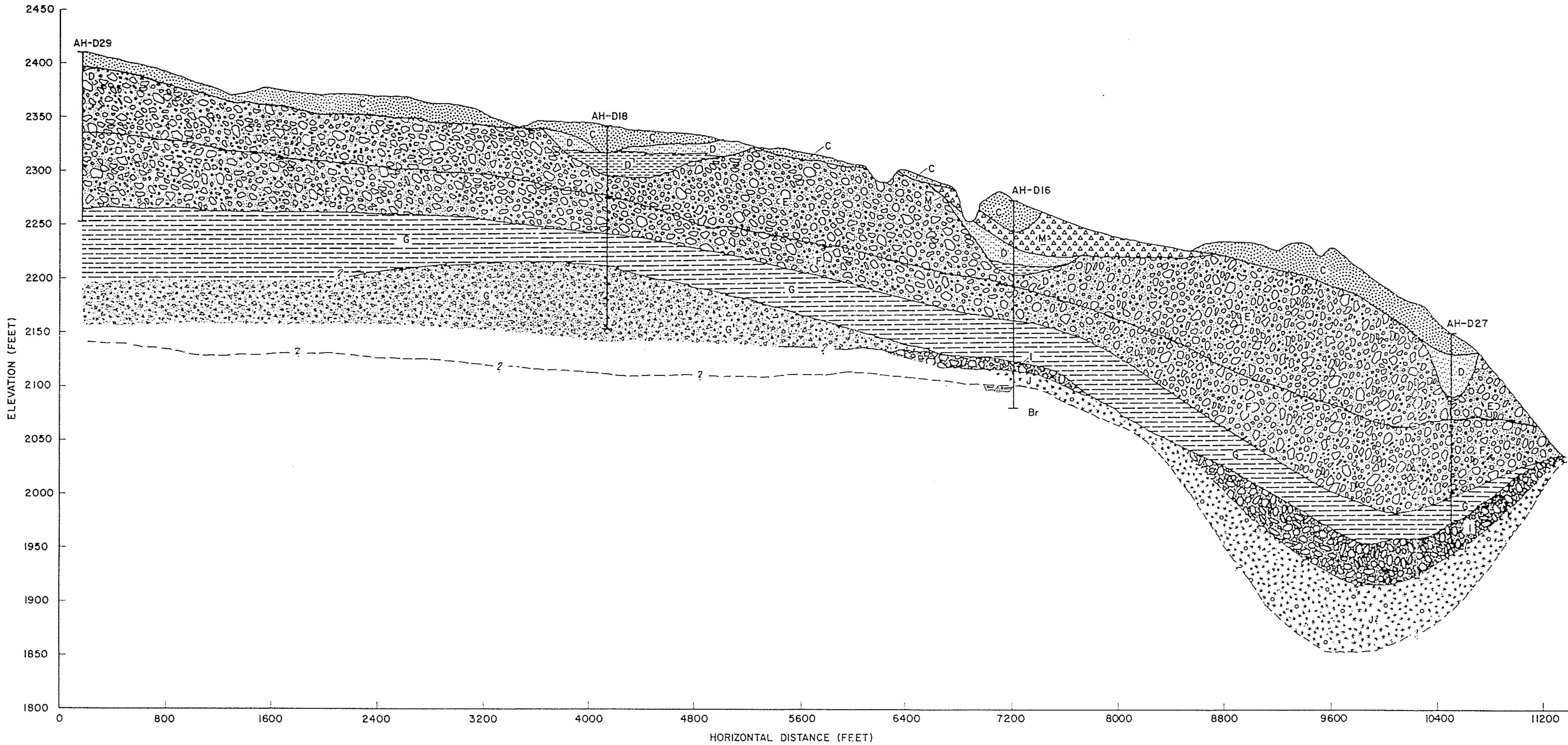
VERT. SCALE 0 50 100 FEET

WATANA RELICT CHANNEL CROSS SECTIONS
SHEET 1 OF 3

FIGURE E.6.2.10

LEGEND:

- A/B — SURFICIAL DEPOSIT
- C — ICE DISINTEGRATION DEPOSITS
- M — BASAL TILL
- D — ALLUVIUM
- D — LACUSTRINE
- F — OUTWASH
- G — LACUSTRINE
- G — BASAL TILL
- H — ALLUVIUM
- I — OUTWASH
- J — TILL
- Br — BEDROCK



SECTION D-D

NOTES:

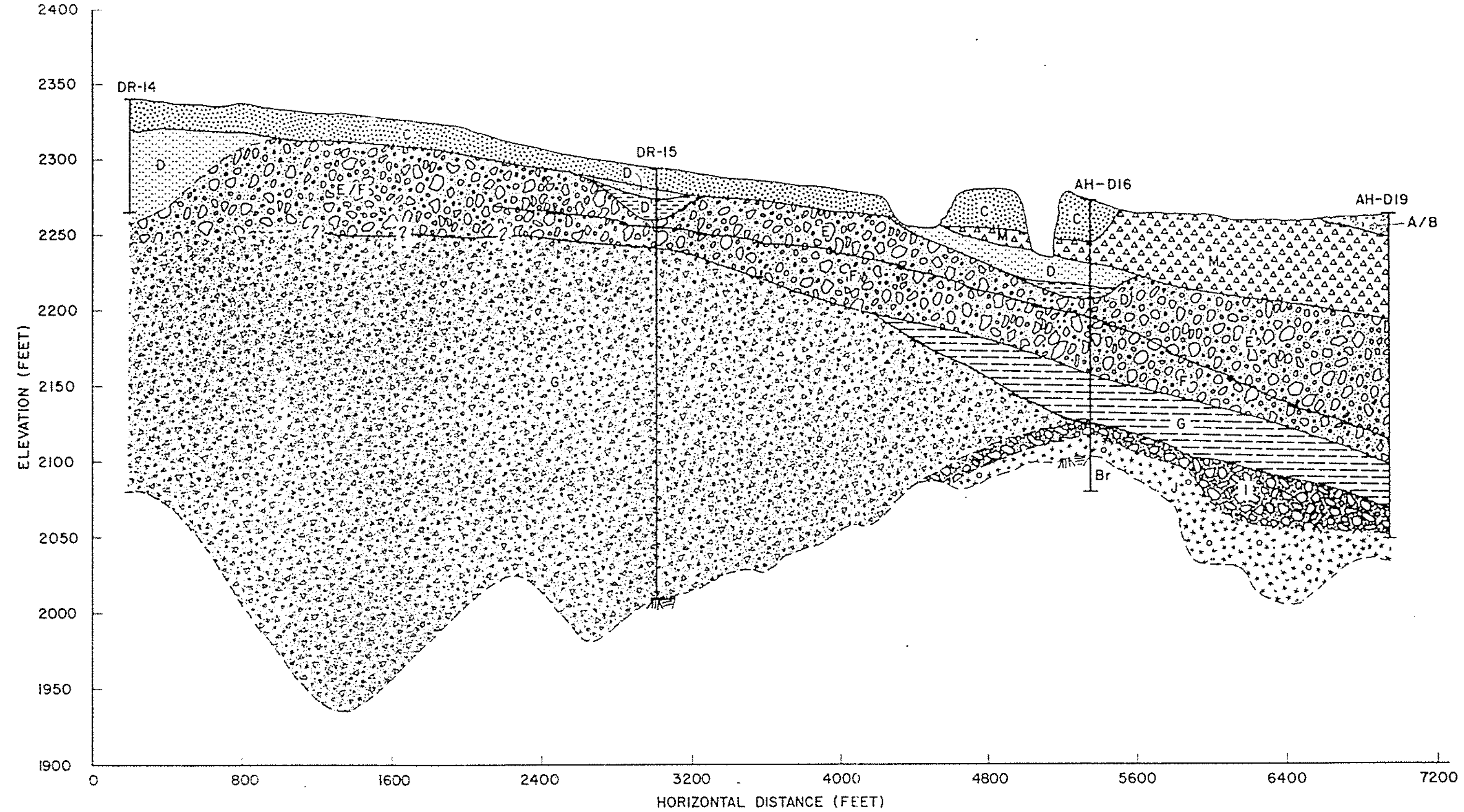
1. FOR DETAILS OF STRATIGRAPHY SEE FIGURE E.6.2.11
2. FOR LOCATION OF SECTIONS SEE FIGURE E.6.2.9
3. EXTENT OF STRATA AND CONTACTS ARE INFERRED BASED ON INTERPRETATION OF SUBSURFACE EXPLORATIONS AND ARE SUBJECT TO VERIFICATION BY FUTURE INVESTIGATIONS.

HORIZ. SCALE 0 400 800 FEET

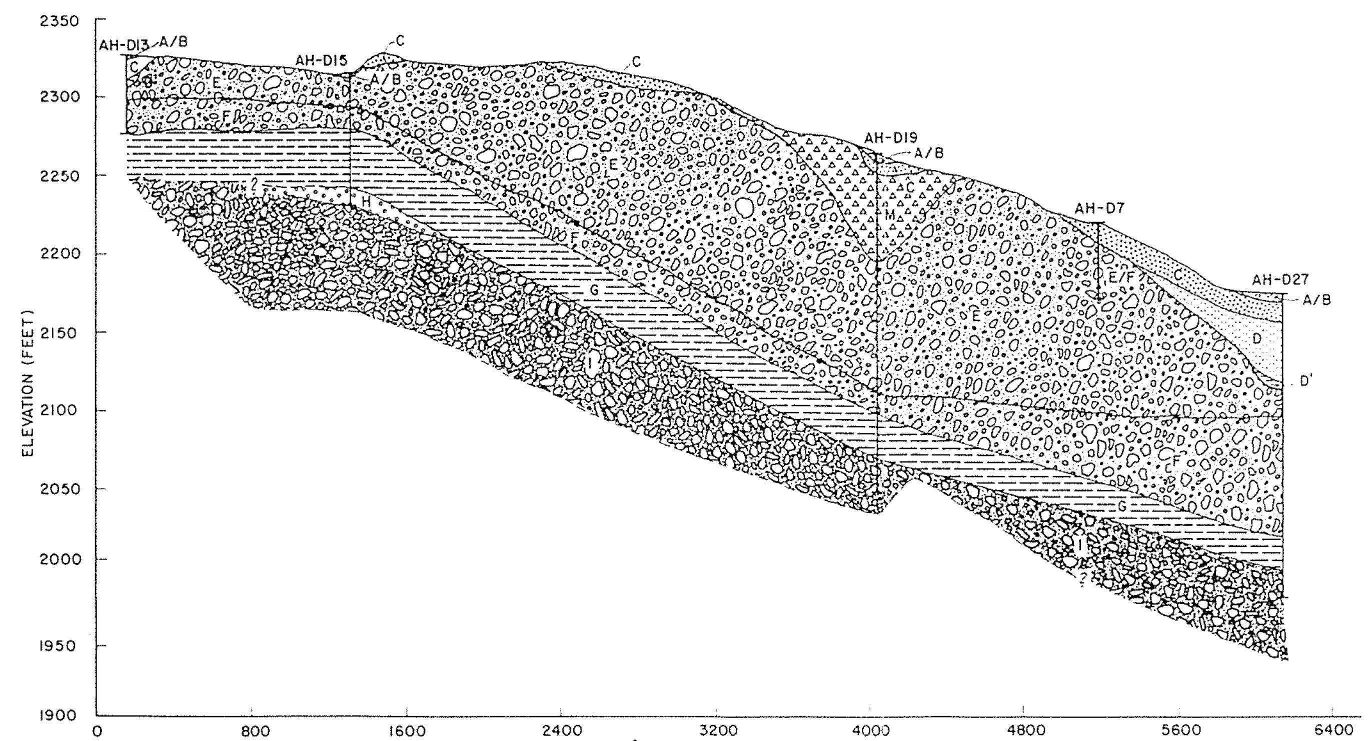
VERT. SCALE 0 50 100 FEET

WATANA
BORROW SITE D
CROSS SECTION
SHEET 2 OF 3

FIGURE E.6.2.10



SECTION E-E



SECTION F-F

LEGEND:

- A/B — SURFICIAL DEPOSIT
- C — ICE DISINTEGRATION DEPOSITS
- M — BASAL TILL
- D — ALLUVIUM
- D' — LACUSTRINE
- E/F — OUTWASH
- G — LACUSTRINE
- G' — BASAL TILL
- H — ALLUVIUM
- I — OUTWASH
- J — TILL
- Br — BEDROCK

NOTES:

1. FOR DETAILS OF STRATIGRAPHY SEE FIGURE E.6.2.11
2. FOR LOCATION OF SECTIONS SEE FIGURE E.6.2.9
3. EXTENT OF STRATA AND CONTACTS ARE INFERRED BASED ON INTERPRETATION OF SUBSURFACE EXPLORATIONS AND ARE SUBJECT TO VERIFICATION BY FUTURE INVESTIGATIONS.

HORIZ. SCALE 0 400 800 FEET

VERT. SCALE 0 50 100 FEET

WATANA
BORROW SITE D
CROSS SECTIONS
SHEET 3 OF 3

FIGURE E.6.2.10

GRAPHIC SYMBOL	UNIT	TYPE OF DEPOSIT	DESCRIPTION	GEOLOGICAL AND ENGINEERING REMARKS [2]	UNIFIED SOIL CLASSIFICATION [3]	THICKNESS RANGE IN FEET [4]
	A/B	Surficial Deposit	Organics, peat, silt and boulders raised by frost action.	Organic mat which includes localized boulder fields and bogs. Within the active layer/seasonal frost penetration zone.	OL, PT, SM	0.5 - 8.0
	C	Ice Disintegration	Grey brown, gravelly sand to silty sand with little to some gravel and cobbles. Coarse fraction subangular to subrounded.	Hummocky, knob and kettle topography. Variable density Permafrost detected in 1 out of 16 possible borings. No groundwater detected.	SM, SC	2.5 - 38.0
	M	Basal Till	Grey to dark grey silty sand to clay with little angular to subrounded gravel and cobbles, occasional boulder. Very dense, hard. Poorly sorted.	Gravel and cobbles are striated. Limited in areal extent to near the Susitna River Valley. Similar to unit G', it is overconsolidated. Permafrost detected in 1 out of 4 possible borings. No groundwater detected.	SM, SC, CL	14.5 - 79.0
	D	Alluvium	Grey stratified sand, gravel and cobbles. Very dense.	Localized fluvial event, reworking of the underlying outwash, unit E/F, found in topographic lows on top of outwash. No permafrost or groundwater detected.	SM, SP, SC	1.5 - 55.0
	D'	Lacustrine	Grey to dark greyish brown, laminated clayey silt to clayey silty sand. Very dense, hard. Sorted to partly sorted.	Thin laminated deposit, limited in areal extent. Permafrost detected in 1 out of 4 possible borings. No groundwater detected.	ML, CL, (SC, SM)	3.5 - 23.0
	E/F	Outwash	Olive brown to grey brown, silty sand with little gravel and cobbles to a silty sandy gravel with occasional cobbles and boulders. Coarse fraction subangular to subrounded. Dense to very dense. Poorly sorted.	In places the unit gets coarser with depth, higher energy environment. Thick continuous deposit. Density is loose to medium dense in active frost zone, up to 15 feet deep. Permafrost detected in 3 out of 31 borings. Groundwater detected in 4 out of 15 possible borings.	SM, GM, SC	10.0 - 131.0
	G	Lacustrine and/or Waterlain Till	Dark grey to olive grey, laminated, sandy silt to silty clay, little or no gravel, little to some sand. Very dense. Poorly sorted.	Thin clay, silt and sand interlaminations. Organics and wood present. Overconsolidated. Permafrost detected in 2 out of 17 possible borings. No groundwater was detected. Together with unit G', forms a prominent marker bed.	ML, CL, SM	8.3 - 73.5
	G'	Basal Till	Olive grey to very dark grey, clayey silty sand with trace to little gravel to gravelly silty or clayey sand. Coarse fraction subangular to subrounded and includes occasional cobbles and boulders. Very dense. Poorly sorted.	Gravels and cobbles are striated and polished. Overconsolidated. Permafrost detected in 1 out of 15 possible borings. Groundwater was detected in 1 out of 9 possible borings. Forms a marker bed with unit G.	SM, SC, (ML, CL, GC)	7.0 - 231.0
	H	Alluvium	Grey brown to olive grey, silty sand and sand with little or no gravel to sandy gravel. Coarse fraction subangular to rounded, slightly oxidized. Very dense. Sorted to partly sorted.	Rounded particles, sorted, relatively clean lenses or layers, possibly stratified. Localized fluvial event, reworking of the underlying outwash, found in topographic lows of unit I. Groundwater detected in 4 out of 6 possible borings. No permafrost detected.	SM, SP, GW-GM	2.0 - 41.0
	I	Outwash	Olive grey, silty sand with little gravel to sandy gravel with little fines. Coarse fraction subangular to subrounded trace rounded; some cobbles, particles oxidized. Very dense. Poorly sorted.	Oxidation on particles, indicative of age and weathering. Organics found in the upper horizon. Trace striations on gravel. Thick nearly continuous deposit. Groundwater detected in 3 out of 6 possible borings. No permafrost detected.	SM, GW-GM, SW, GM, (CL, ML)	6.0 - 77.0
	J'	Lacustrine and/or Stratified Deposits	Olive grey to olive brown, silty sand, trace subangular gravel with some sandy gravel (?). Oxidized and weathered particles, some cobbles and boulders(?). Very dense. Sorted to partly sorted.	Moderately oxidized and weathered, generally sorted, possibly stratified. Overconsolidated. Localized deposit. No permafrost or ground water detected. Mud loss of 50 gals/ft over 25 foot interval in DR-22.	SM, SW, SC	3.0 - 57.7
	J	Basal Till	Olive grey to dark grey, clay to clayey sand little to no subangular to subrounded oxidized(?) gravel. Dense, very hard. Poorly sorted.	Gravels are striated and polished. Overconsolidated. Probable lacustrine or waterlain till at base of unit. No permafrost or groundwater detected.	CL, SM, SC	6.0 - 62.0
	K	Alluvium	Olive grey, silty sandy gravel to sandy gravel with cobbles and boulders (?) Coarse fraction subangulars to rounded, oxidized. Very dense. Sorted.	Rounded particles, sorted, relatively clean. Found only along the main thalweg to date. No permafrost or groundwater detected. Mud loss of 14 gal/ft over an 85 foot interval in DR-22.	GM, GP, GW	36.0 - 161.0

1 Modified After Acres, 1982b.

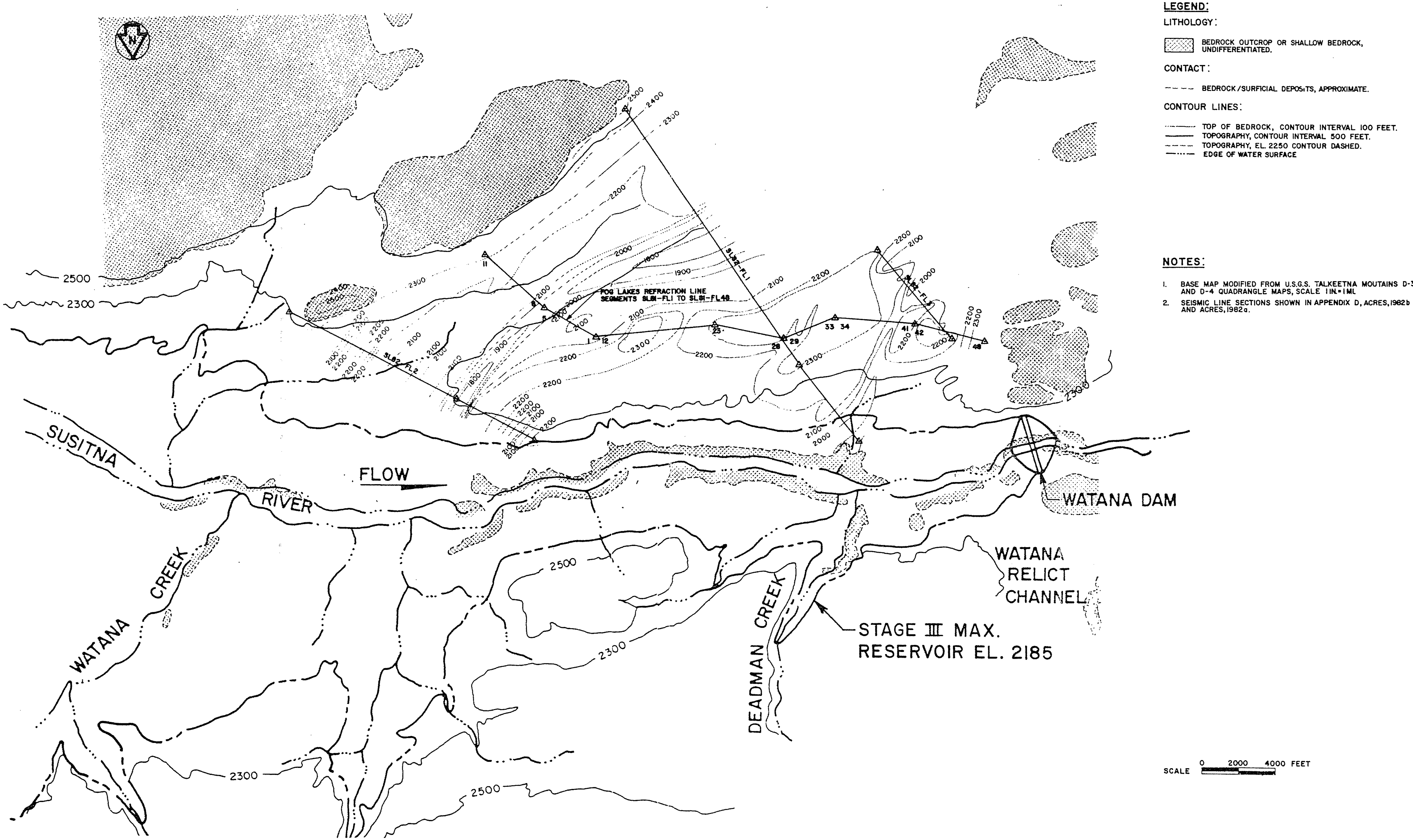
2 Remarks on permafrost are based on Acres Summer 1982b and Harza-Ebasco, 1983. Remarks on groundwater are based on Harza-Ebasco, 1983.

3 Classification is based on the primary soils types in decreasing order of occurence. Those in parentheses are key secondary types.

4 [illegible] Thickness ranges are based on outcrop exposures and drilled thicknesses.

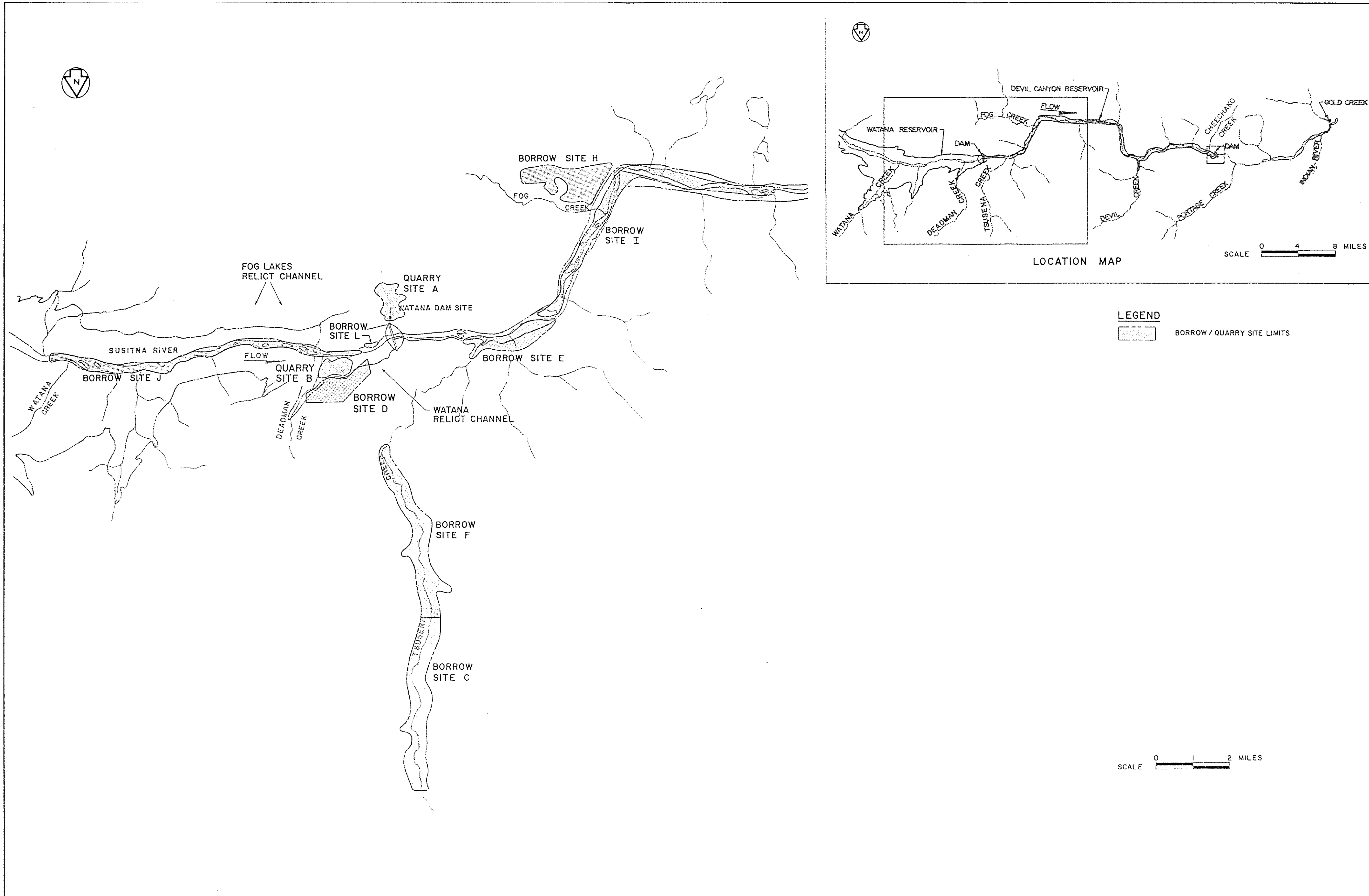
GENERALIZED STRATIGRAPHIC COLUMN
WATANA RELICT CHANNEL AND BORROW SITE D AREA

FIGURE E.6.2.11



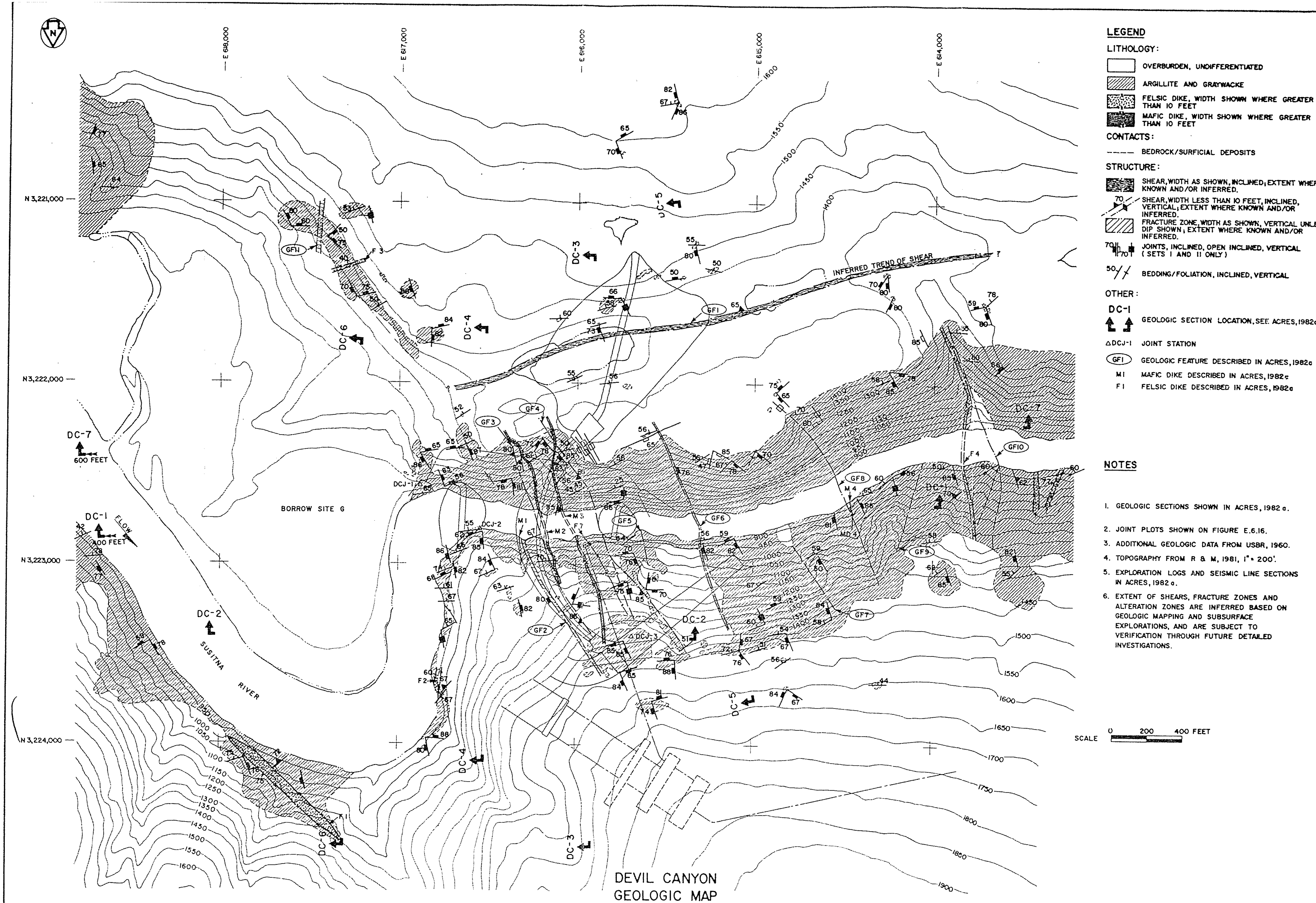
WATANA
FOG LAKES RELICT CHANNEL
TOP OF BEDROCK

FIGURE E.6.2.12



WATANA
BORROW SITE MAP

FIGURE E.6.2.13

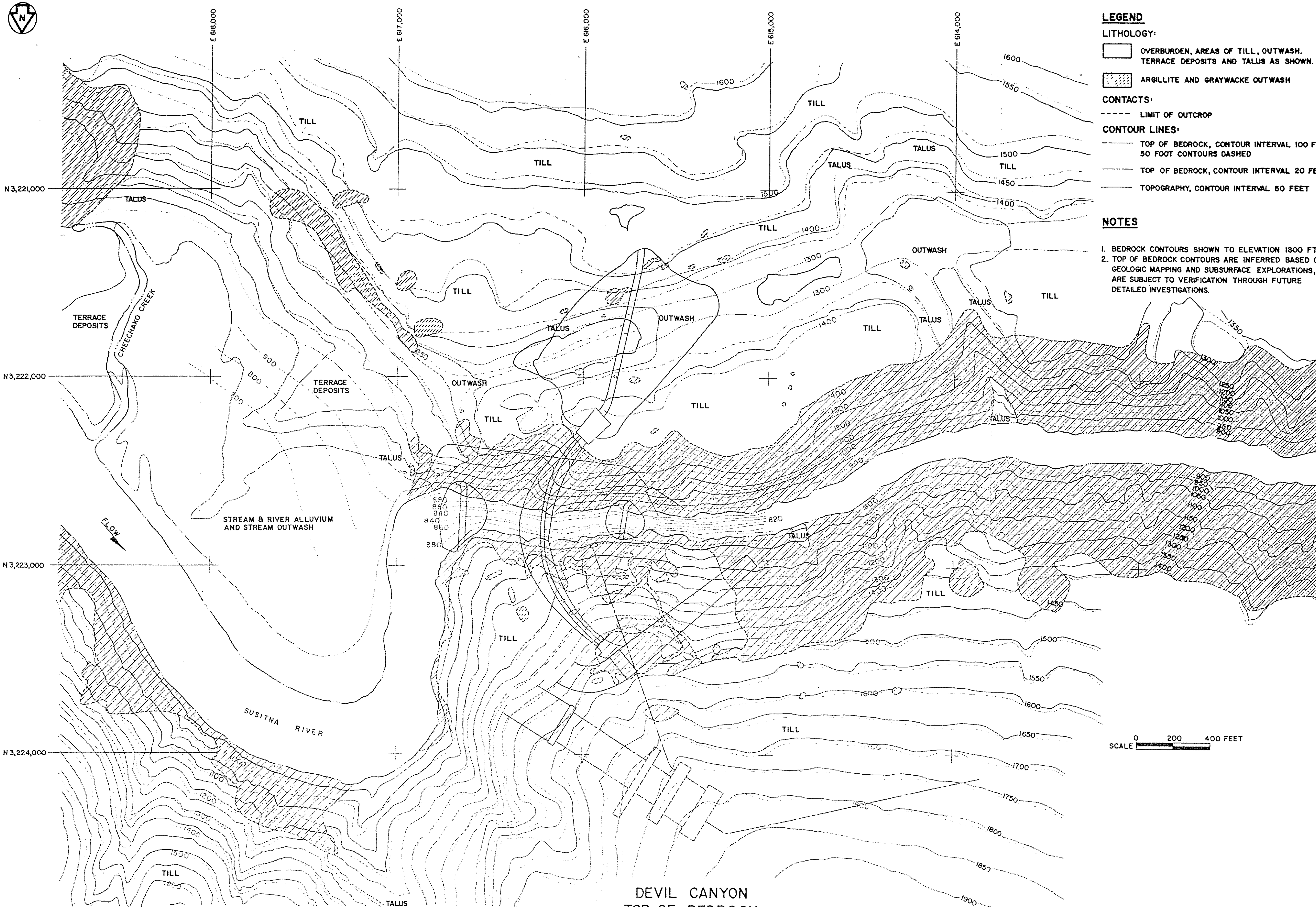


NOTES

1. GEOLOGIC SECTIONS SHOWN IN ACRES, 1982 a.
2. JOINT PLOTS SHOWN ON FIGURE E.6.16.
3. ADDITIONAL GEOLOGIC DATA FROM USBR, 1960.
4. TOPOGRAPHY FROM R & M, 1981, 1" = 200'.
5. EXPLORATION LOGS AND SEISMIC LINE SECTIONS IN ACRES, 1982 a.
6. EXTENT OF SHEARS, FRACTURE ZONES AND ALTERATION ZONES ARE INFERRED BASED ON GEOLOGIC MAPPING AND SUBSURFACE EXPLORATIONS, AND ARE SUBJECT TO VERIFICATION THROUGH FUTURE DETAILED INVESTIGATIONS.

DEVIL CANYON GEOLOGIC MAP

FIGURE E.6.2.14



LEGEND

LITHOLOGY:

OVERBURDEN, AREAS OF TILL, OUTWASH. TERRACE DEPOSITS AND TALUS AS SHOWN.

ARGILLITE AND GRAYWACKE OUTWASH

CONTACTS:

LIMIT OF OUTCROP

CONTOUR LINES:

TOP OF BEDROCK, CONTOUR INTERVAL 100 FEET, 50 FOOT CONTOURS DASHED

TOP OF BEDROCK, CONTOUR INTERVAL 20 FEET

TOPOGRAPHY, CONTOUR INTERVAL 50 FEET

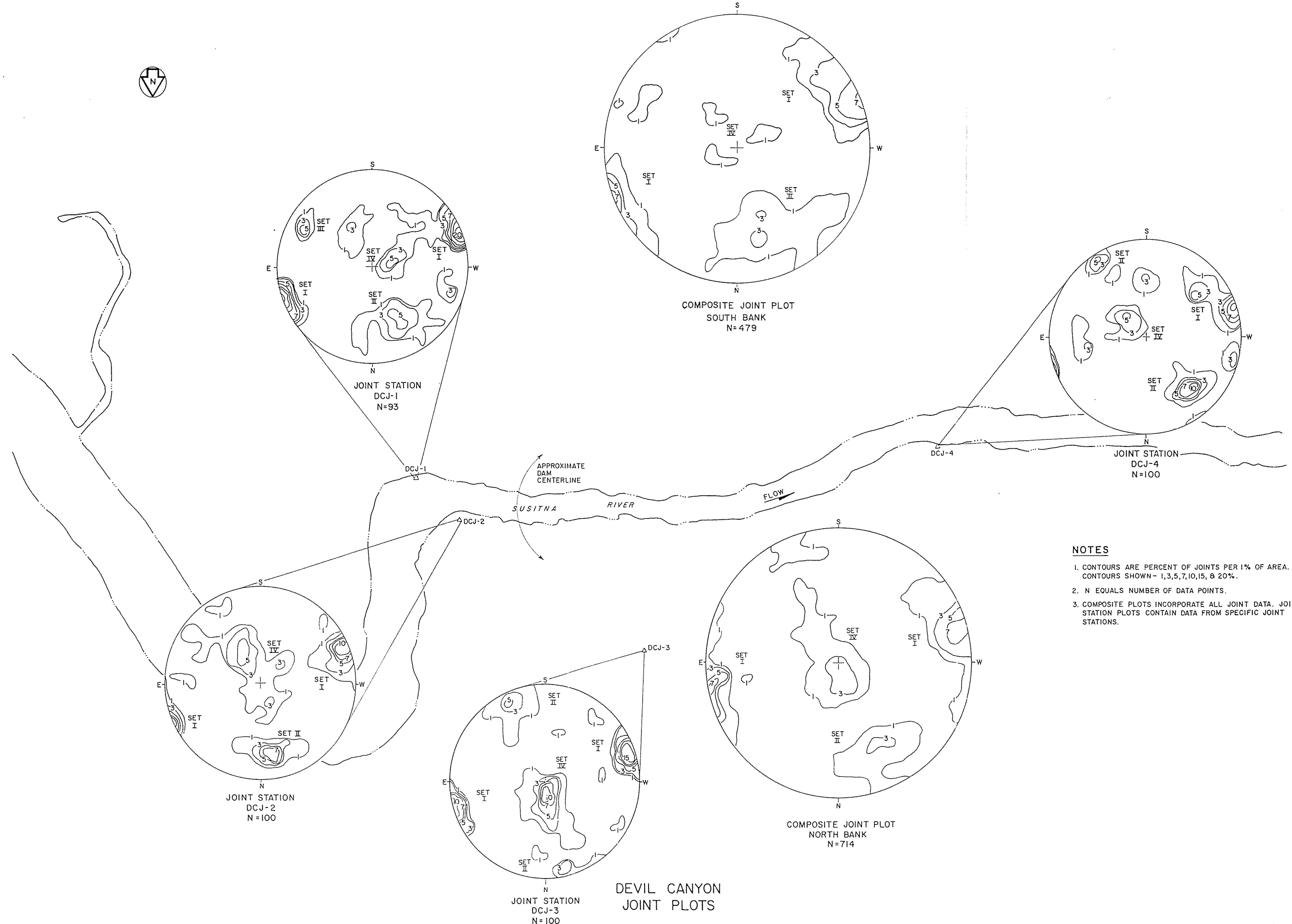
NOTES

1. BEDROCK CONTOURS SHOWN TO ELEVATION 1800 FT.
2. TOP OF BEDROCK CONTOURS ARE INFERRED BASED ON GEOLOGIC MAPPING AND SUBSURFACE EXPLORATIONS, AND ARE SUBJECT TO VERIFICATION THROUGH FUTURE DETAILED INVESTIGATIONS.

REFERENCE: BASE MAP FROM R & M, 1981 - 1" = 200'
DEVIL CANYON TOPOGRAPHY.
COORDINATES IN FEET, ALASKA STATE PLANE (ZONE 4)

DEVIL CANYON
TOP OF BEDROCK
AND SURFICIAL GEOLOGIC MAP

FIGURE E.6.2.15



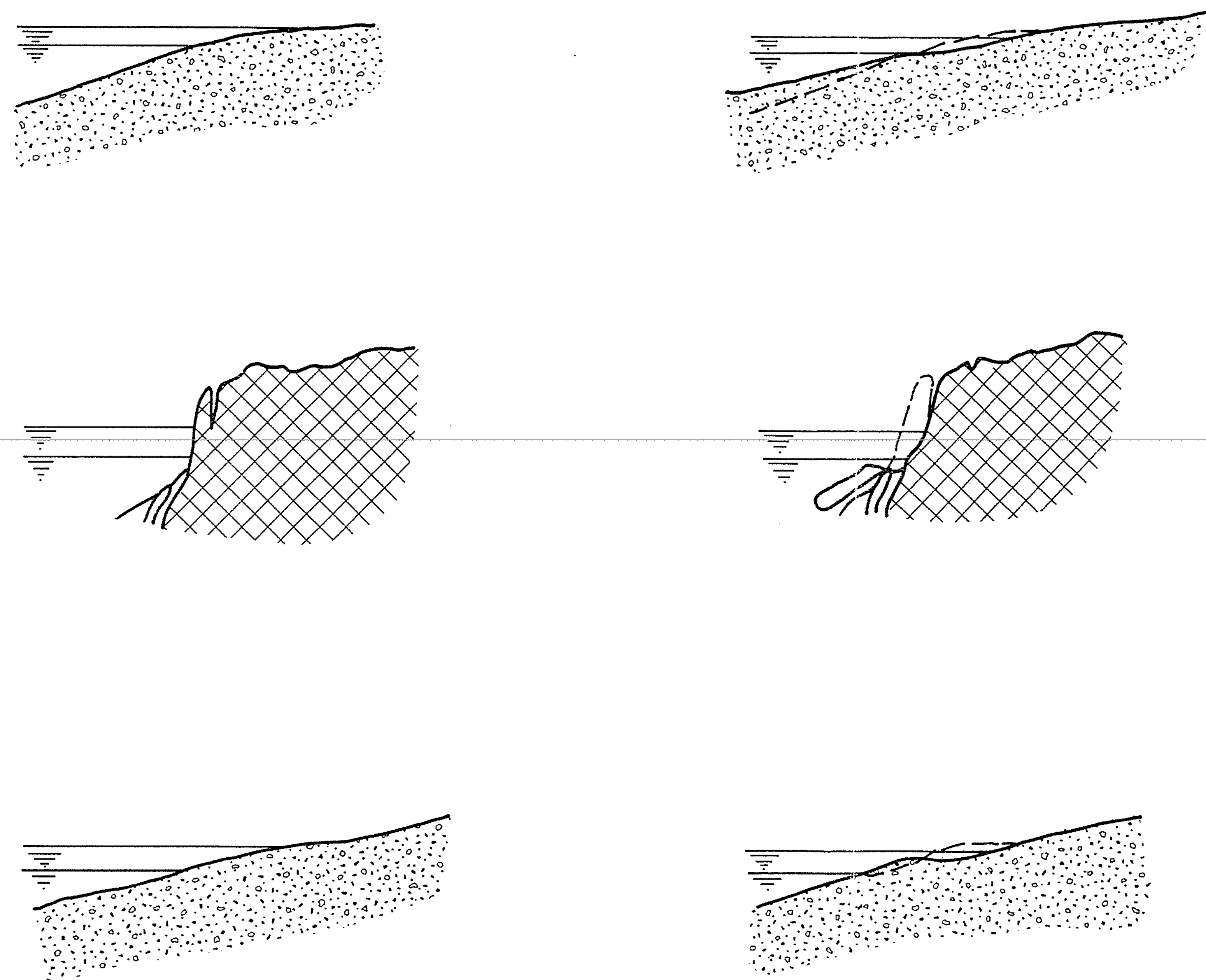
NOTES

1. CONTOURS ARE PERCENT OF JOINTS PER 1% OF AREA. CONTOURS SHOWN - 1,3,5,7,10,15, & 20%.
2. N EQUALS NUMBER OF DATA POINTS.
3. COMPOSITE PLOTS INCORPORATE ALL JOINT DATA. JOINT STATION PLOTS CONTAIN DATA FROM SPECIFIC JOINT STATIONS.

DEVIL CANYON
JOINT PLOTS

FIGURE E.6.2.16

INITIALLY | AFTER SEVERAL YEARS | ASSUMPTIONS:



BEACHING (I)

FLAT SLOPES.
COARSE GRAINED DEPOSITS OR UNFROZEN TILL AND LACUSTRINE DEPOSITS.

BEACHING (I) MINOR

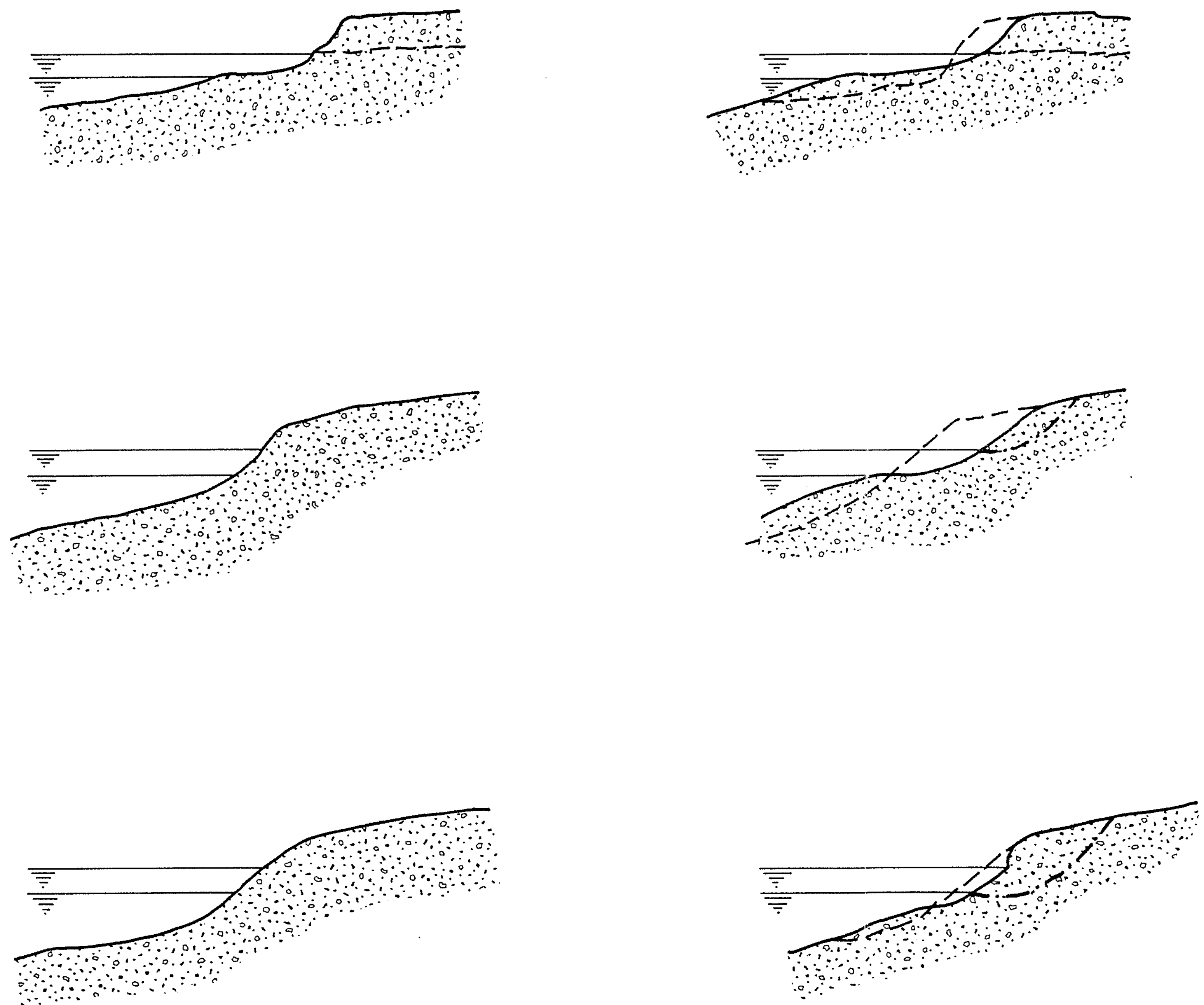
STEEP BEDROCK SLOPES.
FLUCTUATION OF RESERVOIR AND GROUNDWATER TABLE CAUSES FROST WEDGING TO OCCUR CAUSING ROCKFALL.

FLOWS (II)

FLAT SLOPES.
GENERALLY FINE GRAINED DEPOSITS, FROZEN.

SLOPE MODELS FOR THE WATANA AND DEVIL CANYON RESERVOIRS

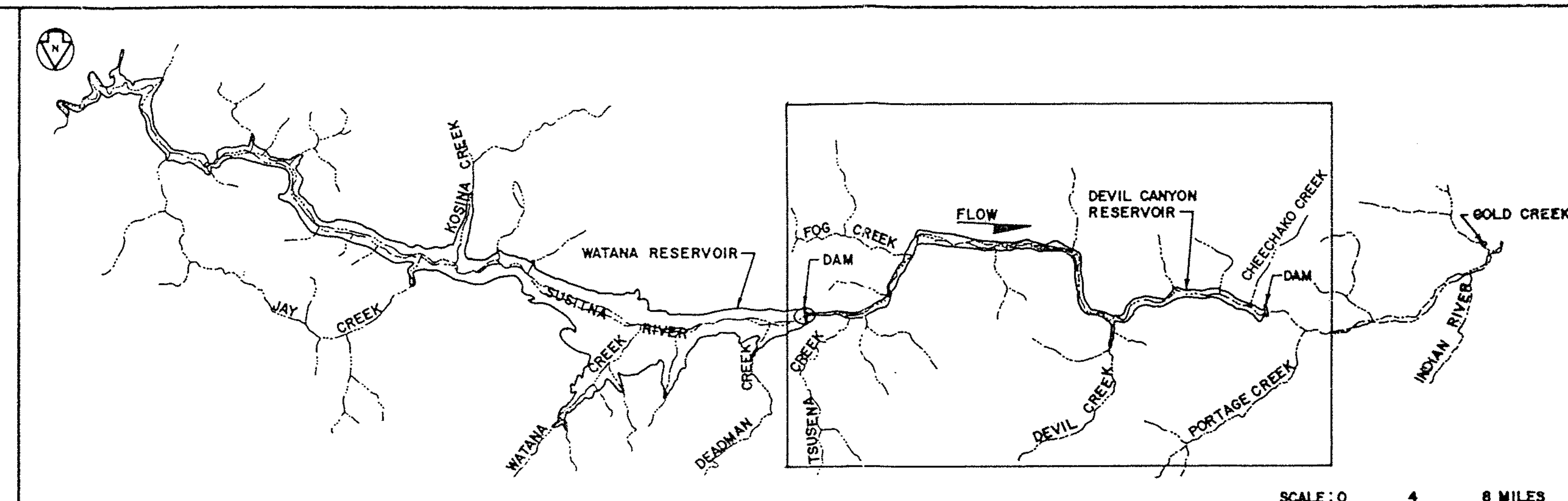
FIGURE E.6.2.19



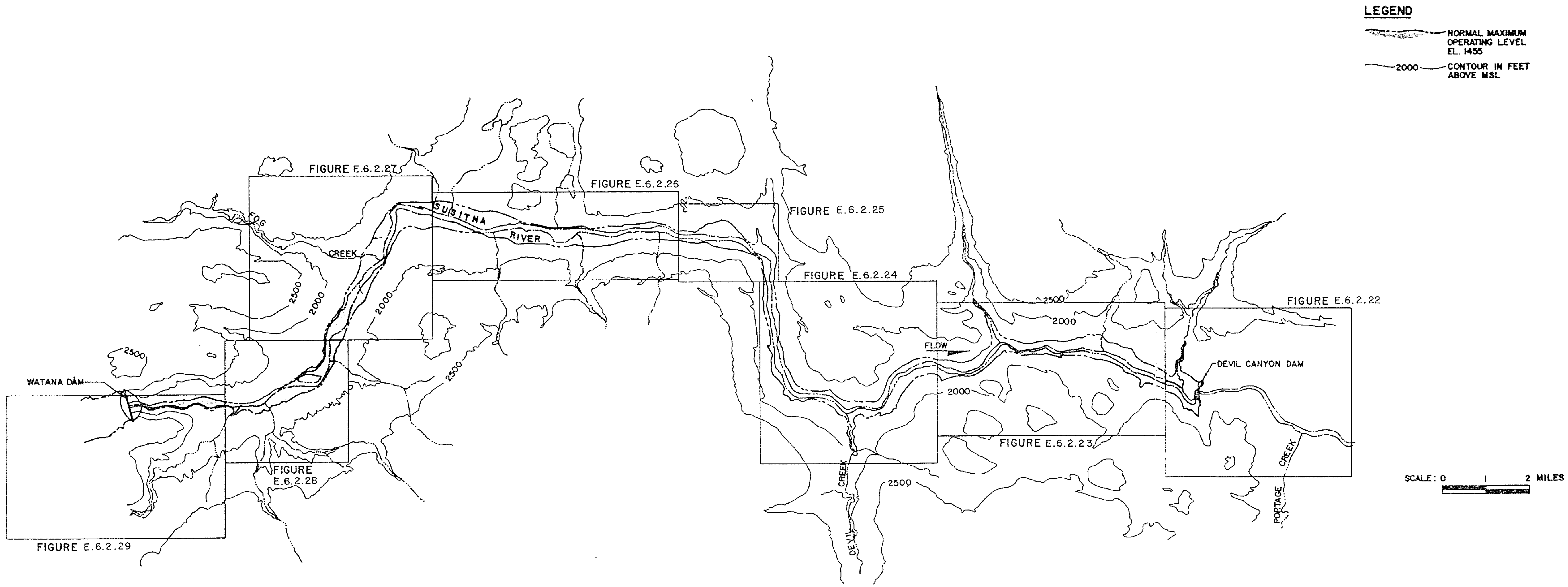
	INITIALLY	AFTER SEVERAL YEARS	ASSUMPTIONS :
SLIDING (III)			STEEP SLOPES. TWO LAYER CASE, LOWER LAYER IS FINE GRAINED AND FROZEN. UPPER LAYER IS COARSER GRAINED, PARTLY TO COMPLETELY FROZEN. FLOWS IN LOWER LAYER ACCOMPANY SLOPE DEGRADATION .
SLIDING (IV)			STEEP SLOPES. FINE GRAINED AND UNFROZEN.
(IV)			STEEP SLOPES. FINE GRAINED AND FROZEN NOTE: POSSIBLE FURTHER SLIDING IF THAW BULB EXTENDS INTO SLOPE WITH TIME .

SLOPE MODELS FOR THE WATANA AND DEVIL CANYON RESERVOIRS

FIGURE E.6.2.20

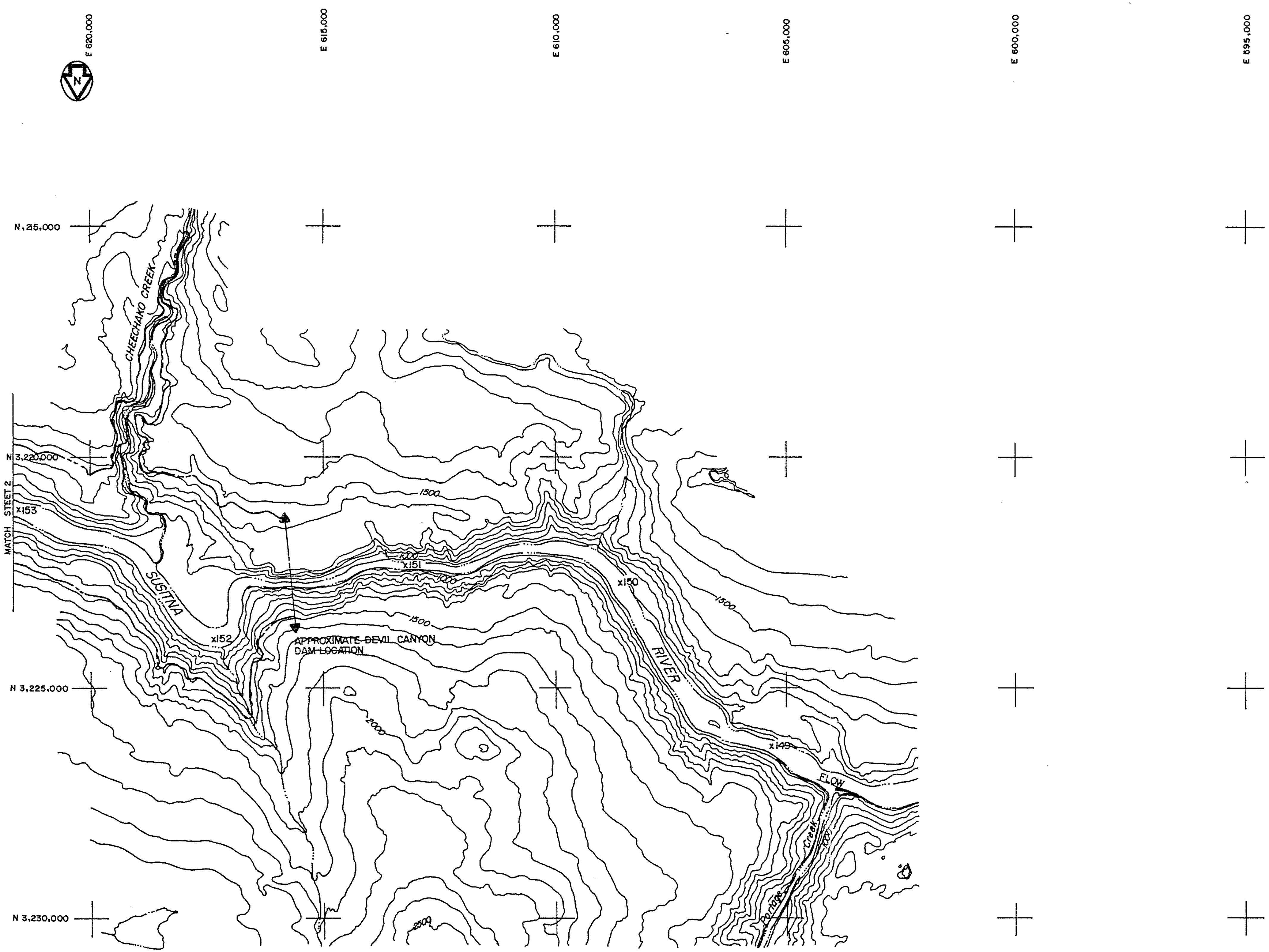


LOCATION MAP



DEVIL CANYON RESERVOIR
INDEX MAP

FIGURE E.6.2.21



LEGEND

[ ] AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABLITY:

I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I (IV)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
—·—·—	NORMAL MAXIMUM OPERATING LEVEL
	RIVER MILES

NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

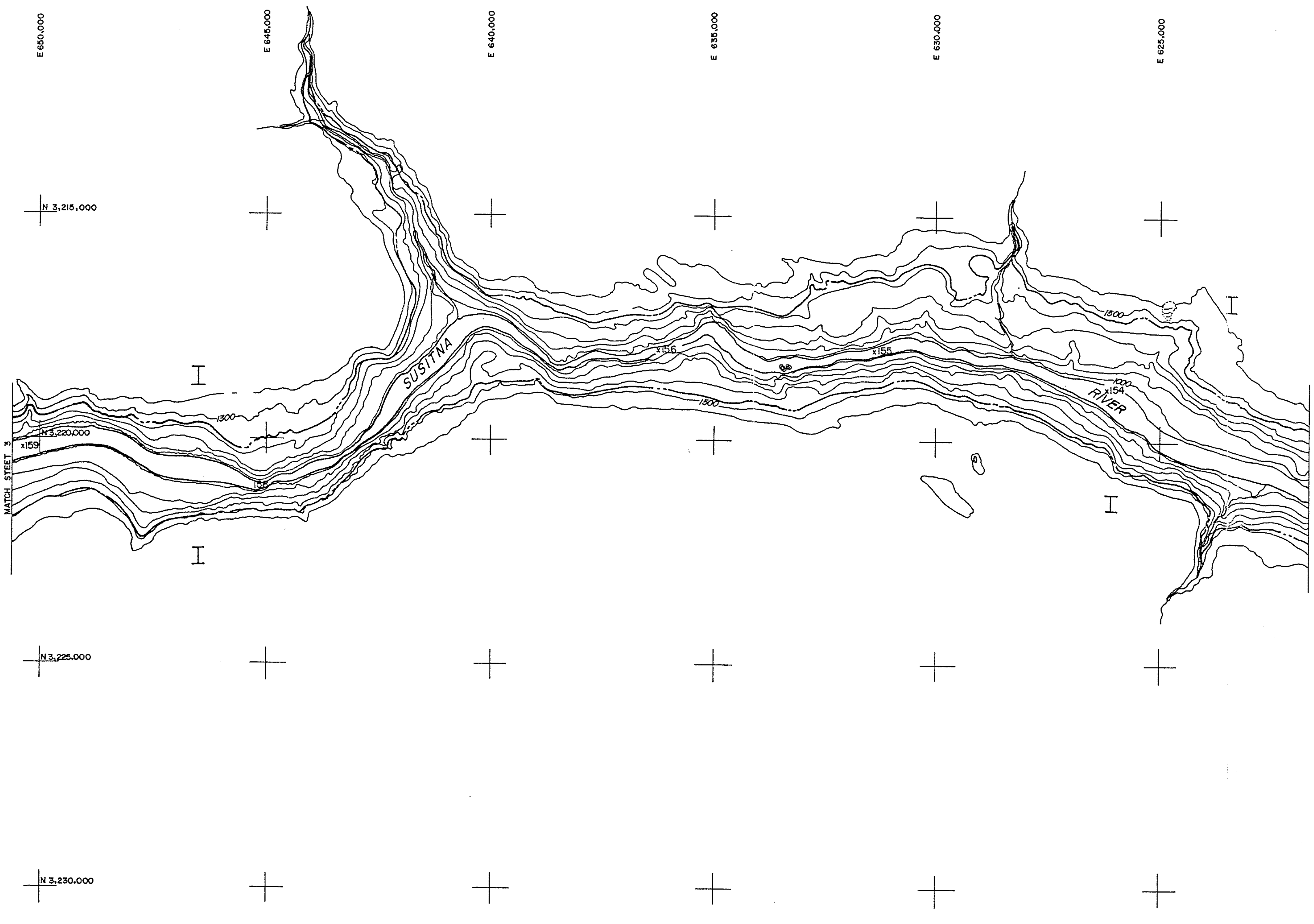
DATE OF PHOTOGRAPHY 7-19-81
SCALE: 1"=1000' CONTOUR INTERVAL 100'

SHEET INDEX

7	5	4		
8	6	3	2	1

DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E.6.2.22



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILTY:

I BEACHING
II FLOWS
III SLIDING (UNFROZEN)
IV SLIDING (PERMAFROST)
/I/ DENOTES AREA EXTENT AND TYPE OF INSTABILTY
I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
NORMAL MAXIMUM OPERATING LEVEL
RIVER MILES

AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

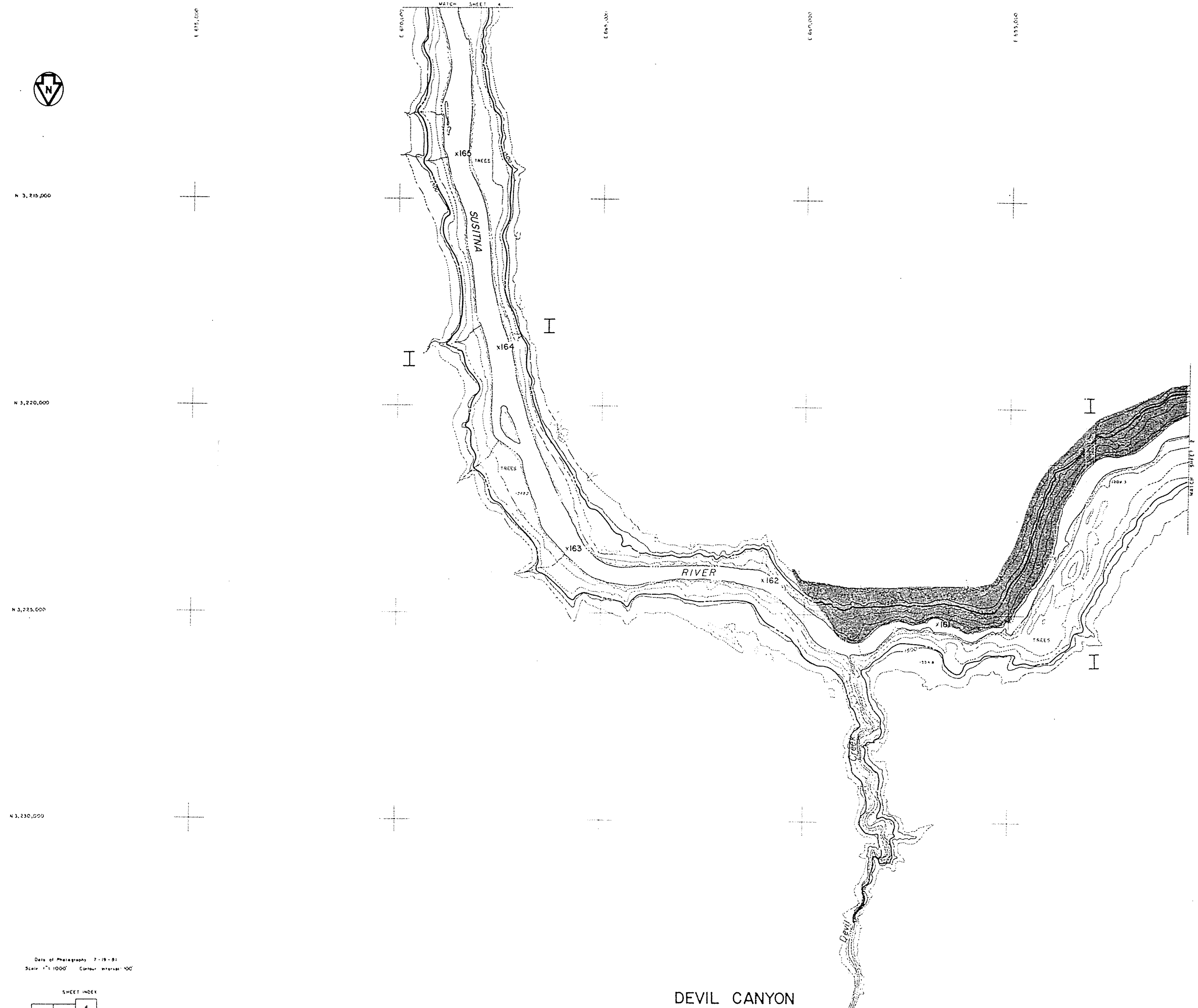
DATE OF PHOTOGRPHY 7-19-81
SCALE:"=1000' CONTOUR INTERVAL 100'

SHEET INDEX

7	5	4		
8	6	3	2	1

DEVIL CANYON SLOPE STABILITY MAP

FIGURE E.6.2.23



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I (IV)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I - II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
——	NORMAL MAXIMUM OPERATING LEVEL
	RIVER MILES

AREA OF POTENTIAL PERMAFROST

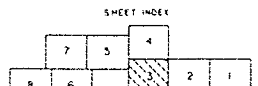
NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

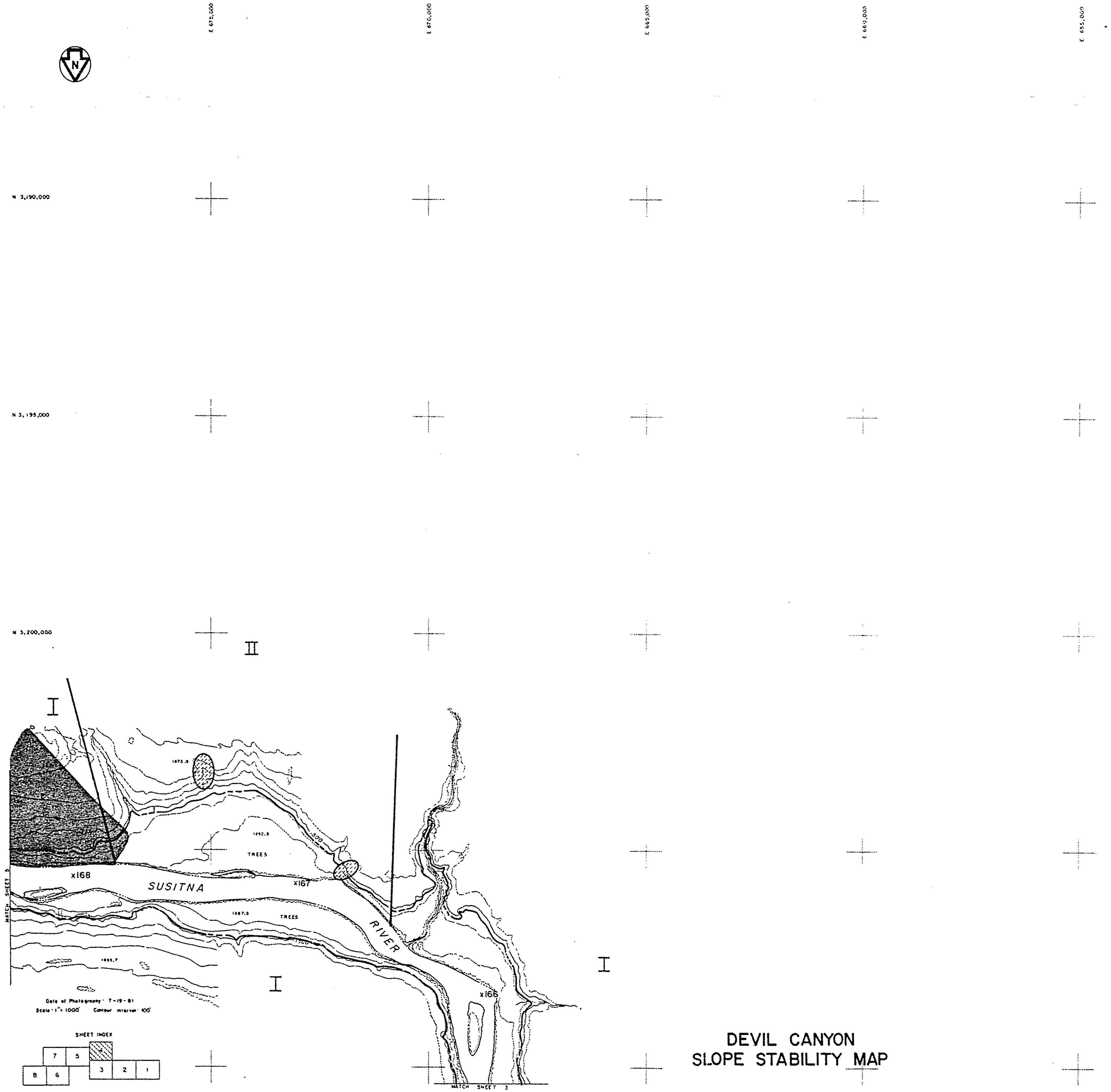
Date of Photography 7-19-81
Scale 1" = 1000' Contour Interval 100'

SHEET INDEX



DEVIL CANYON SLOPE STABILITY MAP

FIGURE E.6.2.24



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I (IV)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
——	NORMAL MAXIMUM OPERATING LEVEL
	RIVER MILES

AREA OF POTENTIAL PERMAFROST

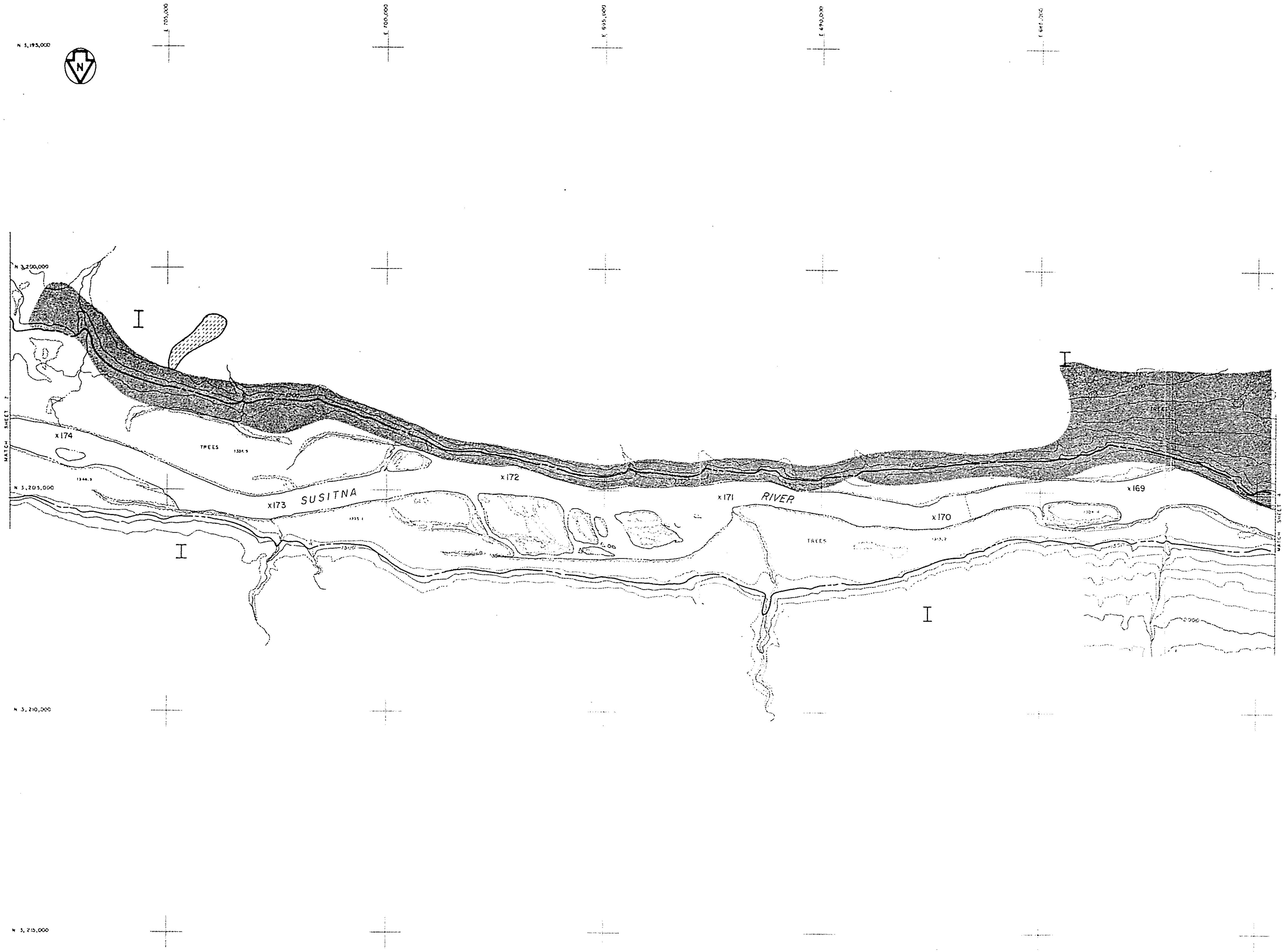
NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E.6.2.25



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

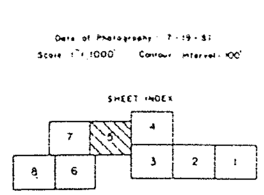
I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I(IV)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
——	NORMAL MAXIMUM OPERATING LEVEL
	RIVER MILES

AREA OF POTENTIAL PERMAFROST

NOTES

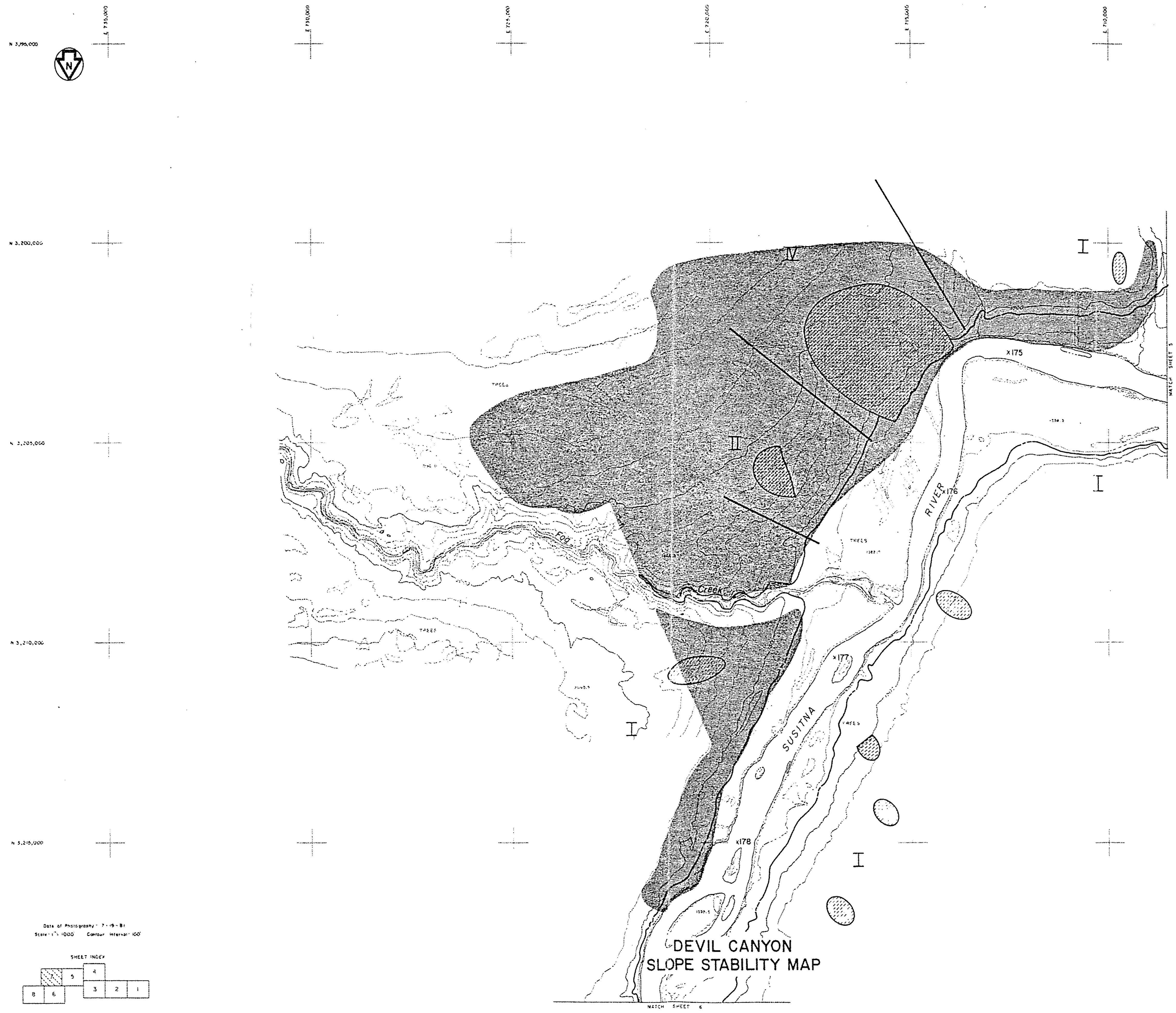
1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET



DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E.6.2.26



DEVIL CANYON
SLOPE STABILITY MAP

LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- RIVER MILES

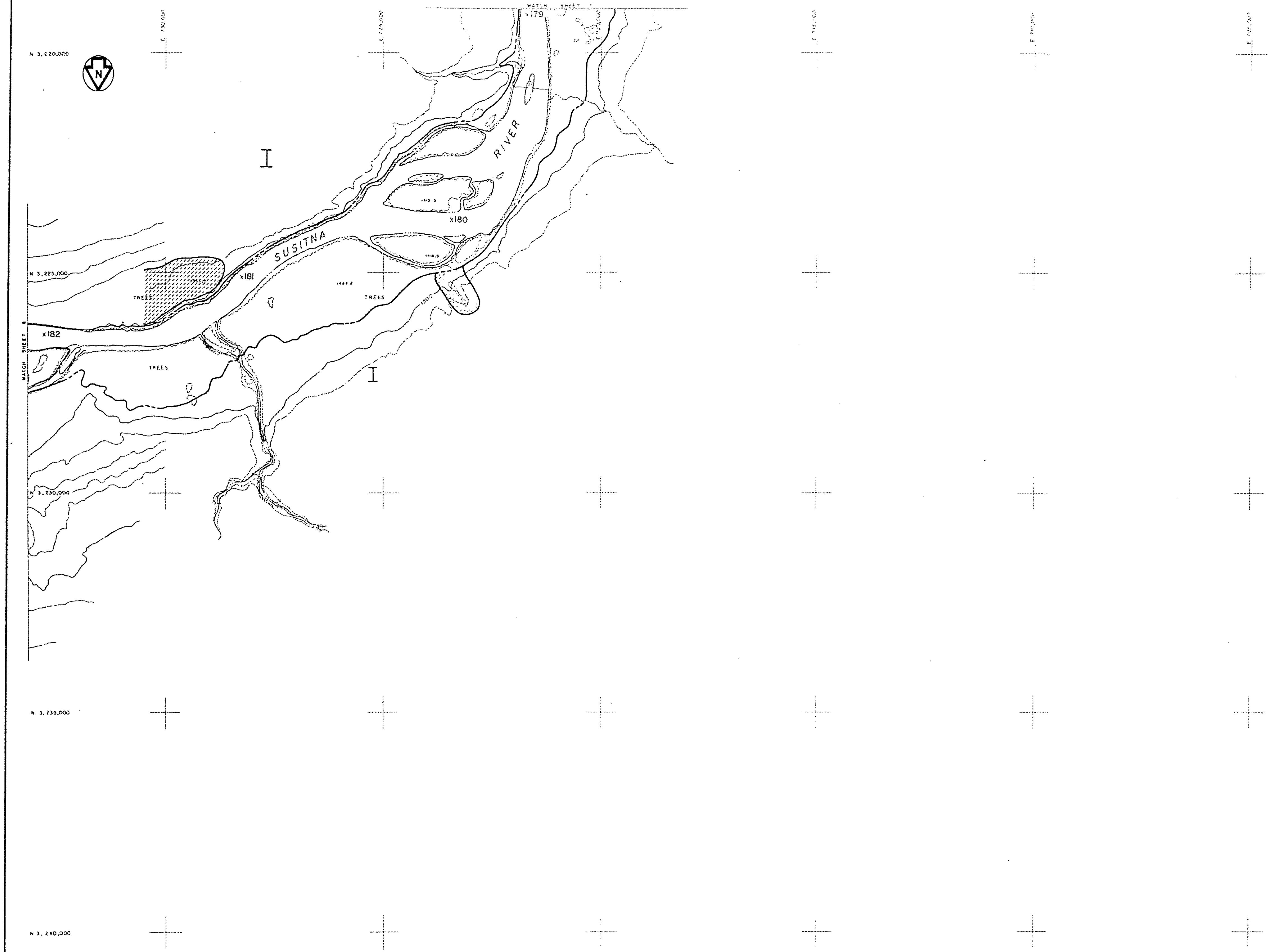
AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION.

SCALE 0 1000 2000 FEET

FIGURE E.6.2.27



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I — BEACHING
- II — FLOWS
- III — SLIDING (UNFROZEN)
- IV — SLIDING (PERMAFROST)
- /I/ — DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I (IV) — PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II — BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- RIVER MILES

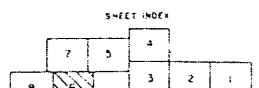
NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

Date of Photography: 7-19-81
Scale 1"=1000' Contour Interval 100

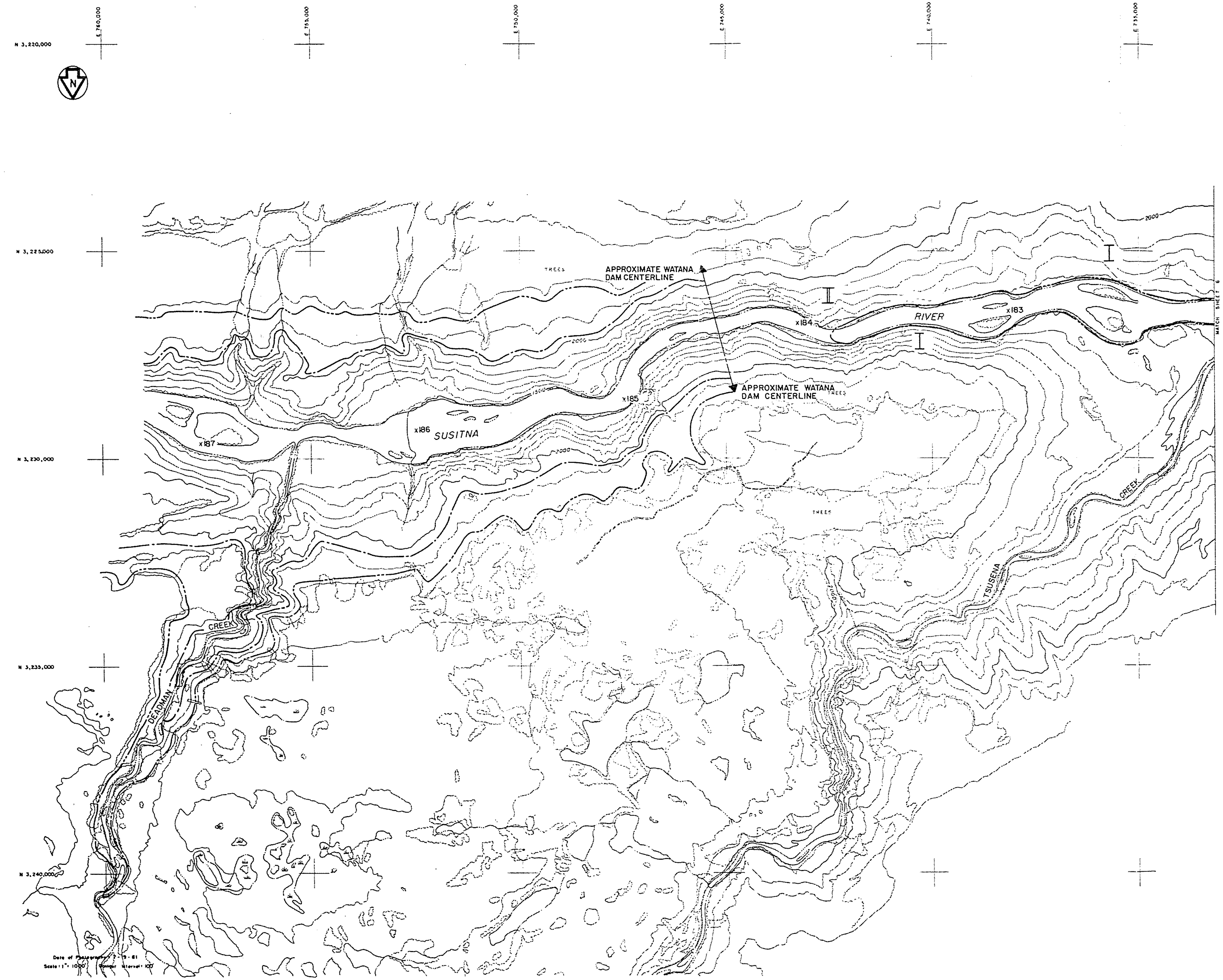
SHEET INDEX



DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E.6.2.28

KUNING 44-132 52512



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

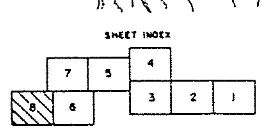
TYPES OF SLOPE INSTABILITY:

- I — BEACHING
- II — FLOWS
- III — SLIDING (UNFROZEN)
- IV — SLIDING (PERMAFROST)
- /I/ — DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) — PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II — BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- NORMAL MINIMUM OPERATING LEVEL
- X — RIVER MILES

NOTES

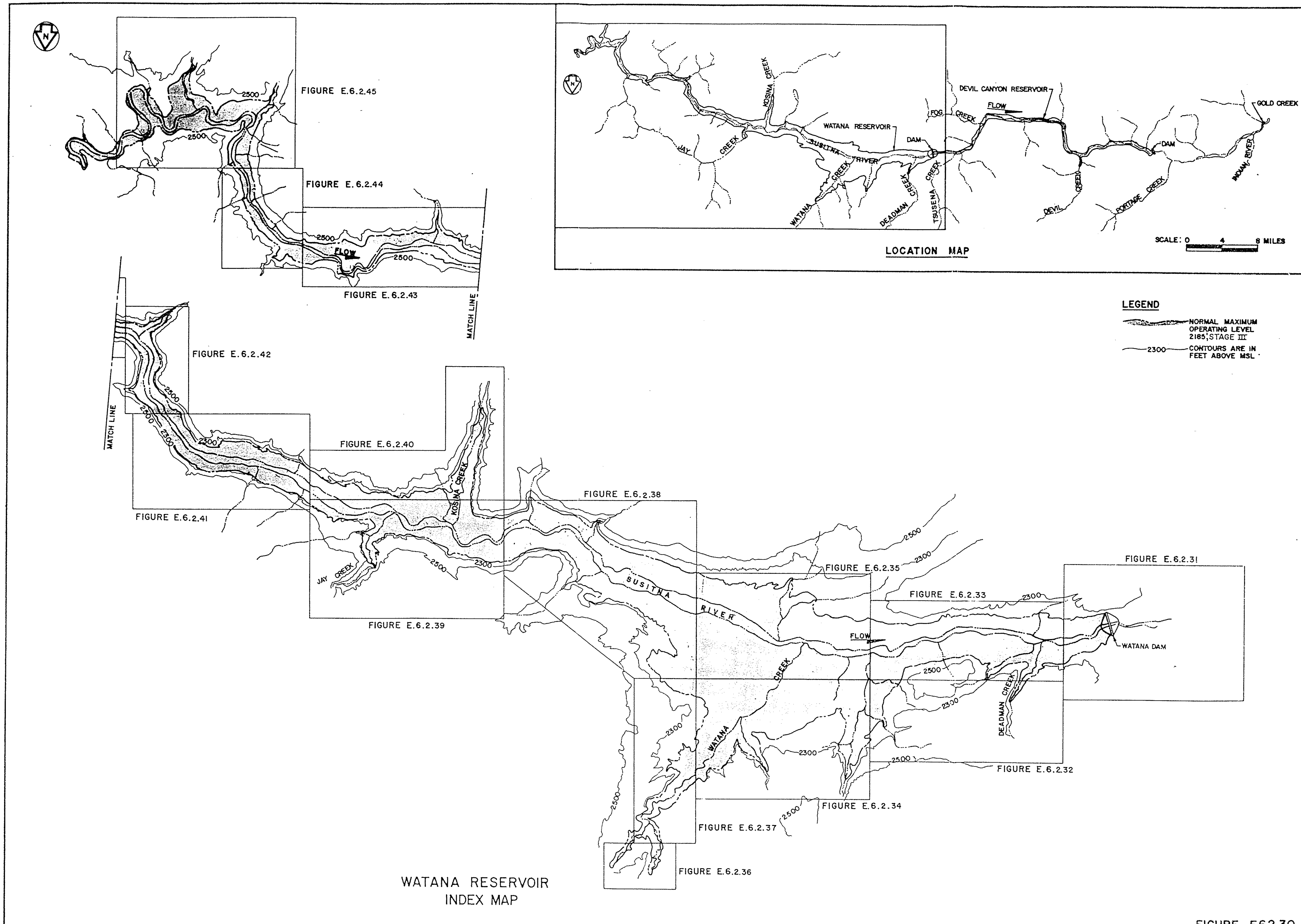
1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET



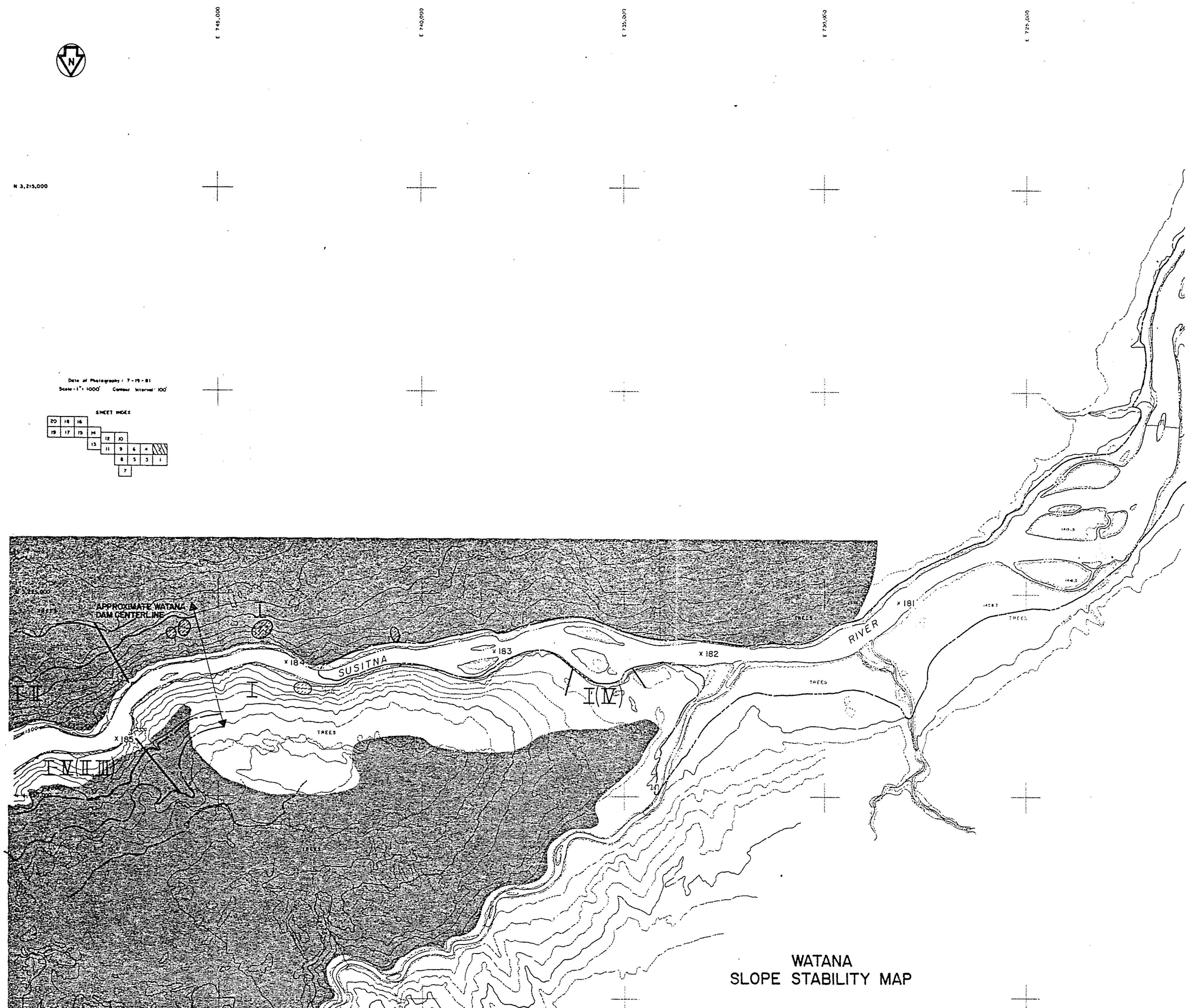
DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E.6.2.29



WATANA RESERVOIR
INDEX MAP

FIGURE E.6.2.30



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL, STAGE III
- NORMAL MINIMUM OPERATING LEVEL
- RIVER MILES

AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E.6.2.31

LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I — BEACHING
- II — FLOWS
- III — SLIDING (UNFROZEN)
- IV — SLIDING (PERMAFROST)
- /I/ — DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I (IV) — PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I - II — BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL, STAGE III
- NORMAL MINIMUM OPERATING LEVEL

AREA OF POTENTIAL PERMAFROST

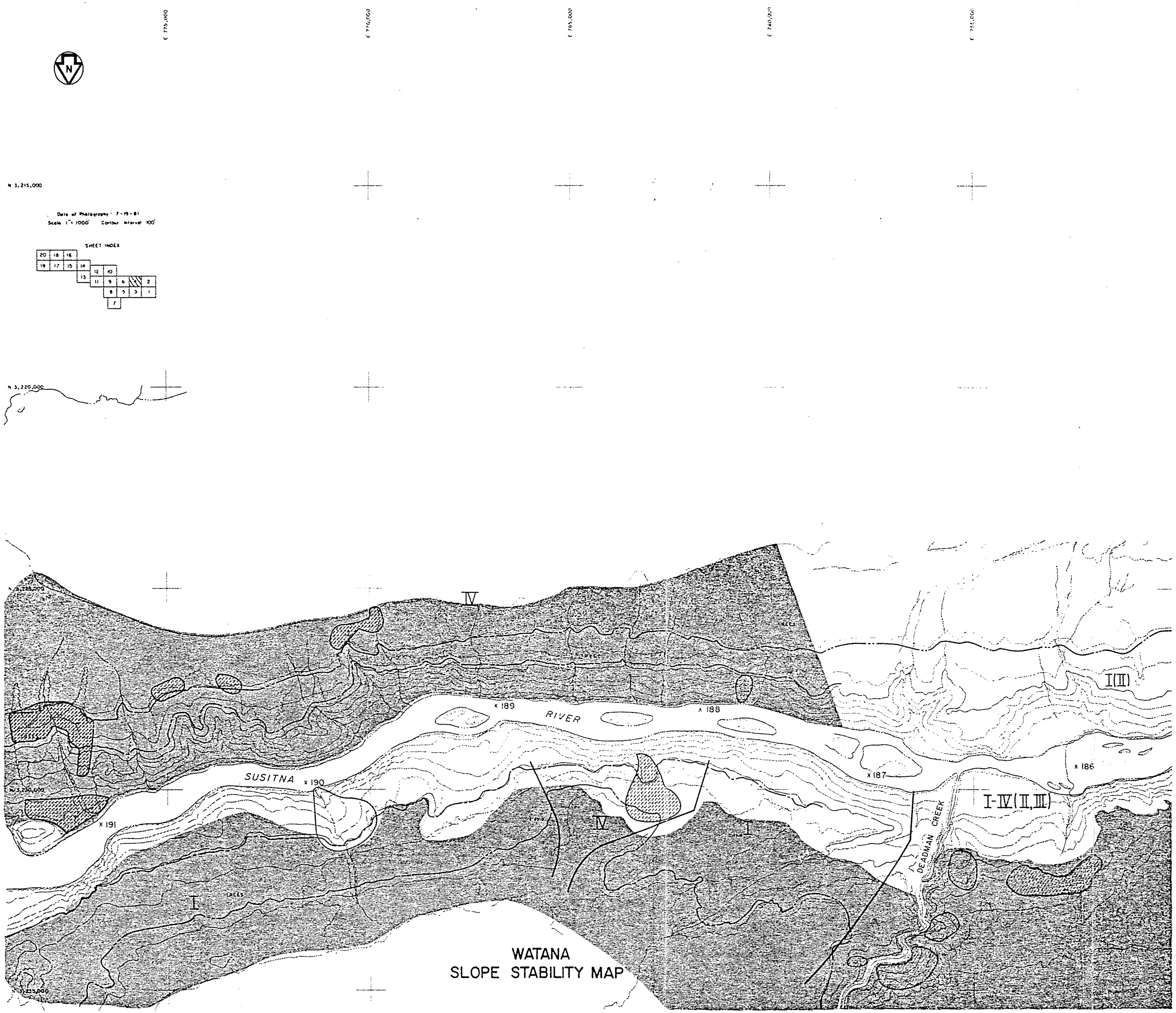
NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E.6.2.32



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I — BEACHING
- II — FLOWS
- III — SLIDING (UNFROZEN)
- IV — SLIDING (PERMAFROST)
- /I/ — DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) — PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II — BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL, STAGE III
- NORMAL MINIMUM OPERATING LEVEL
- RIVER MILES

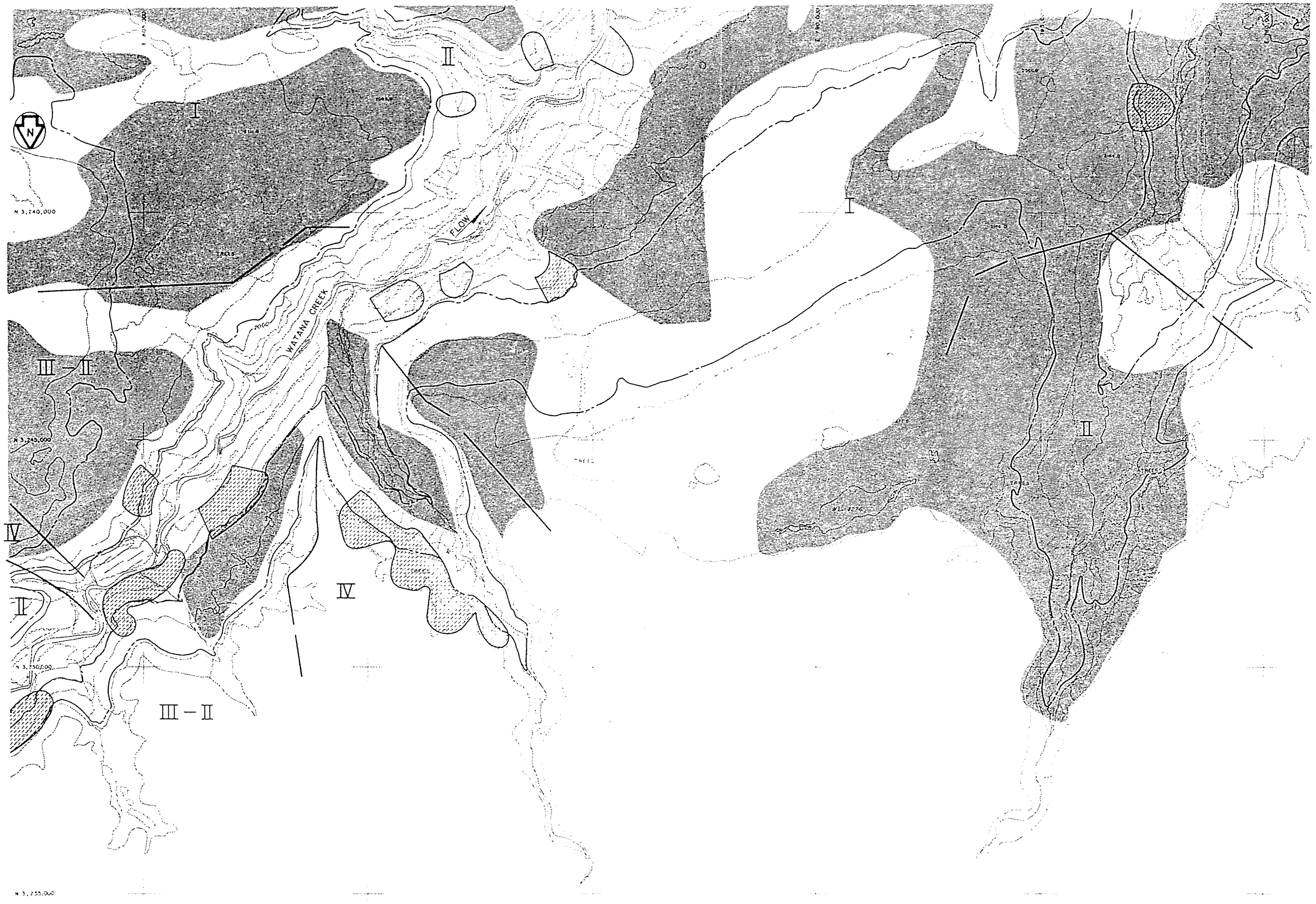
AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

FIGURE E.6.2.33



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I (IV)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I - II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
———	NORMAL MAXIMUM OPERATING LEVEL, STAGE III
—·—·—	NORMAL MINIMUM OPERATING LEVEL
	RIVER MILES

AREA OF POTENTIAL PERMAFROST

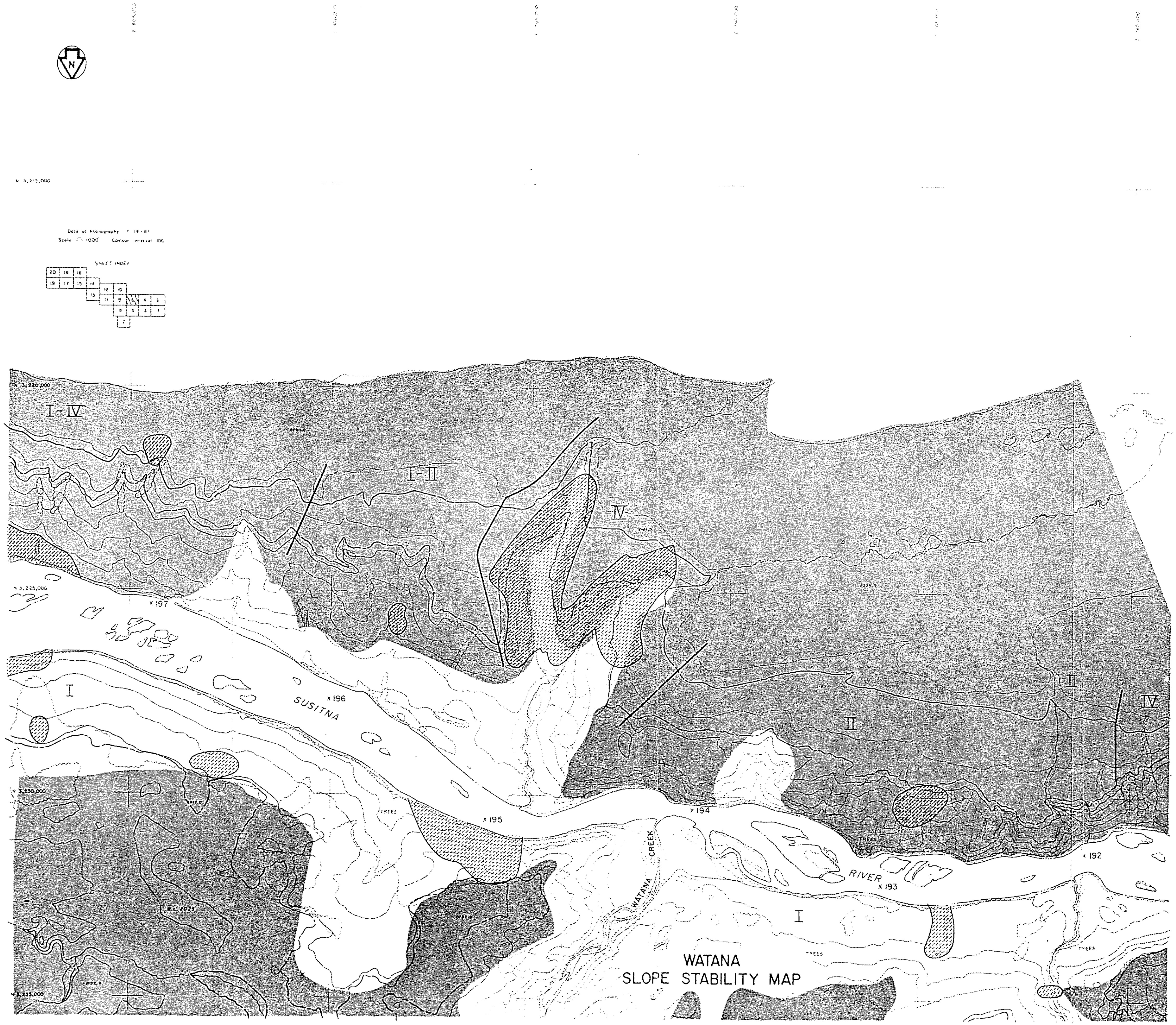
NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E.6.2.34



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I — BEACHING
- II — FLOWS
- III — SLIDING (UNFROZEN)
- IV — SLIDING (PERMAFROST)
- /I/ — DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I (IV) — PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II — BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL, STAGE III
- NORMAL MINIMUM OPERATING LEVEL
- x — RIVER MILES

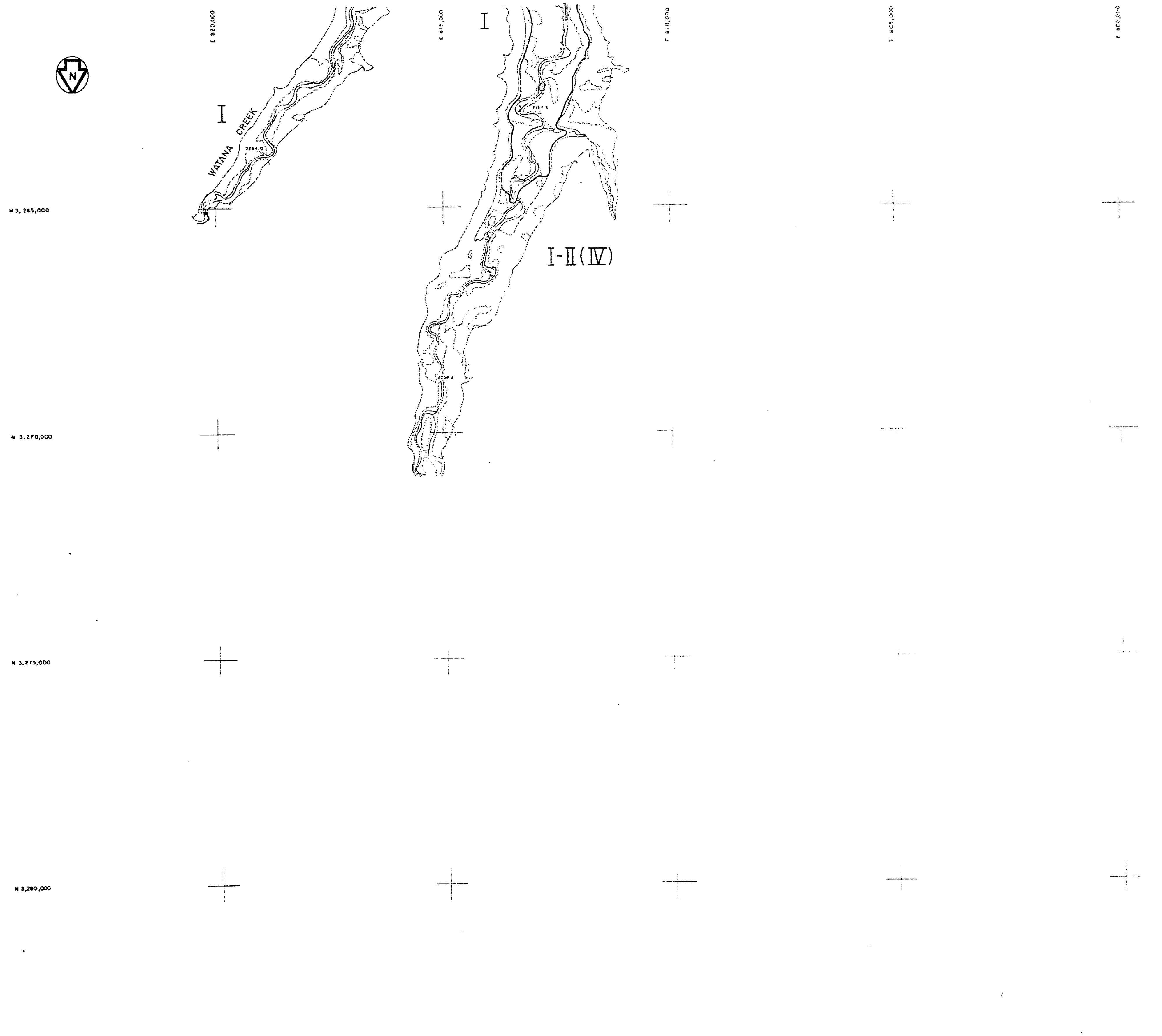
AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

FIGURE E.6.2.35



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I(IV)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
——---	NORMAL MAXIMUM OPERATING LEVEL, STAGE III
--—-—	NORMAL MINIMUM OPERATING LEVEL
	RIVER MILES

NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

Date of Photography: 7-19-81
Scale: 1" = 1000' Contour Interval: 100'

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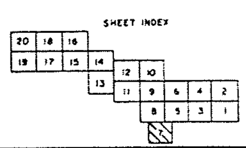


WATANA
SLOPE STABILITY MAP

FIGURE E.6.2.36

LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL, STAGE III
- NORMAL MINIMUM OPERATING LEVEL
- RIVER MILES

AREA OF POTENTIAL PERMAFROST

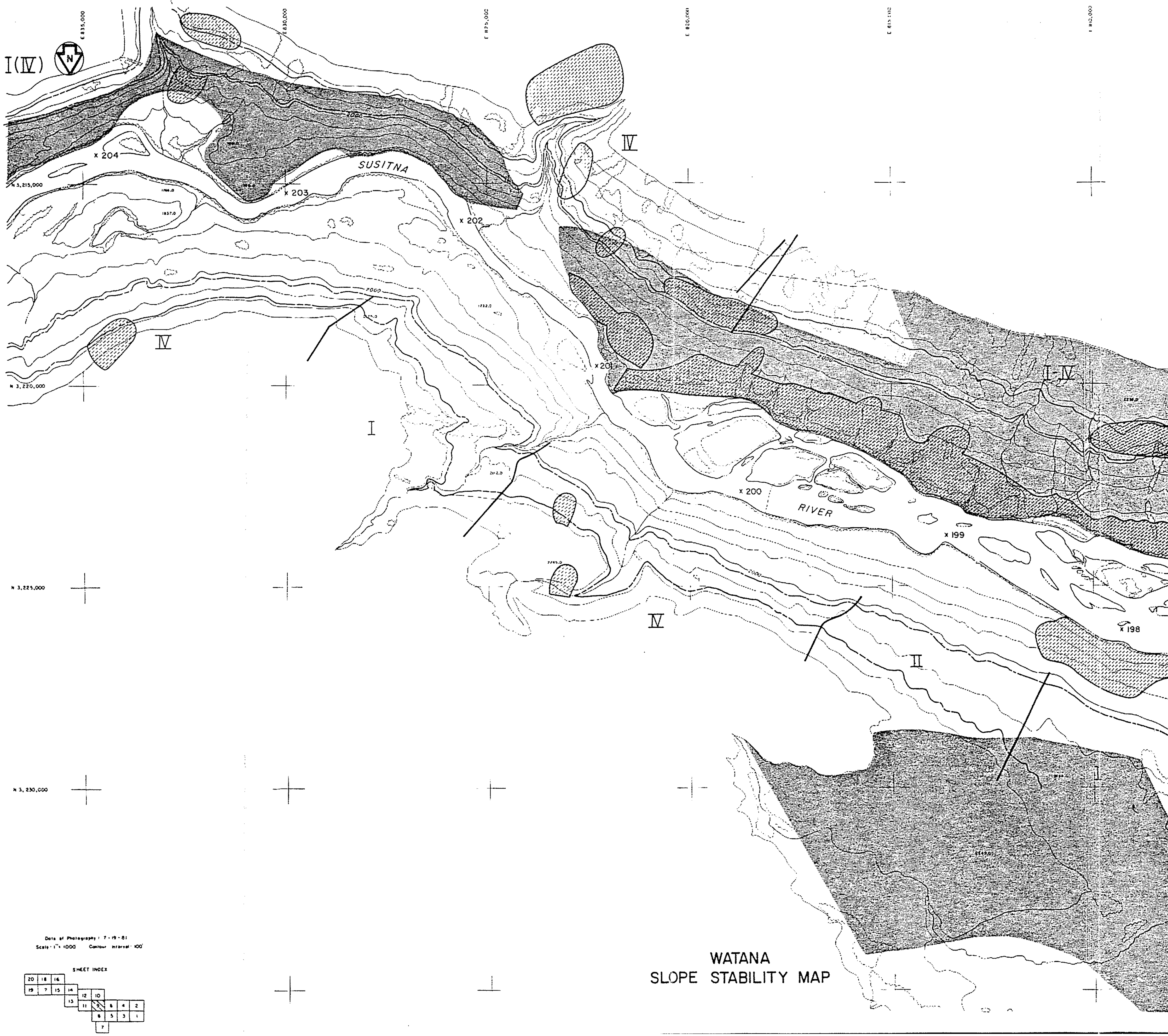
NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION.

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E.6.2.37



WATANA
SLOPE STABILITY MAP

LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I(IV)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
——---	NORMAL MAXIMUM OPERATING LEVEL, STAGE III
--—--—	NORMAL MINIMUM OPERATING LEVEL
X	RIVER MILES

AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

FIGURE E.6.2.38

LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I — BEACHING
- II — FLOWS
- III — SLIDING (UNFROZEN)
- IV — SLIDING (PERMAFROST)
- /I/ — DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) — PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II — BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- —·—·— NORMAL MAXIMUM OPERATING LEVEL, STAGE III
- -·-·- NORMAL MINIMUM OPERATING LEVEL
- x — RIVER MILES

AREA OF POTENTIAL PERMAFROST

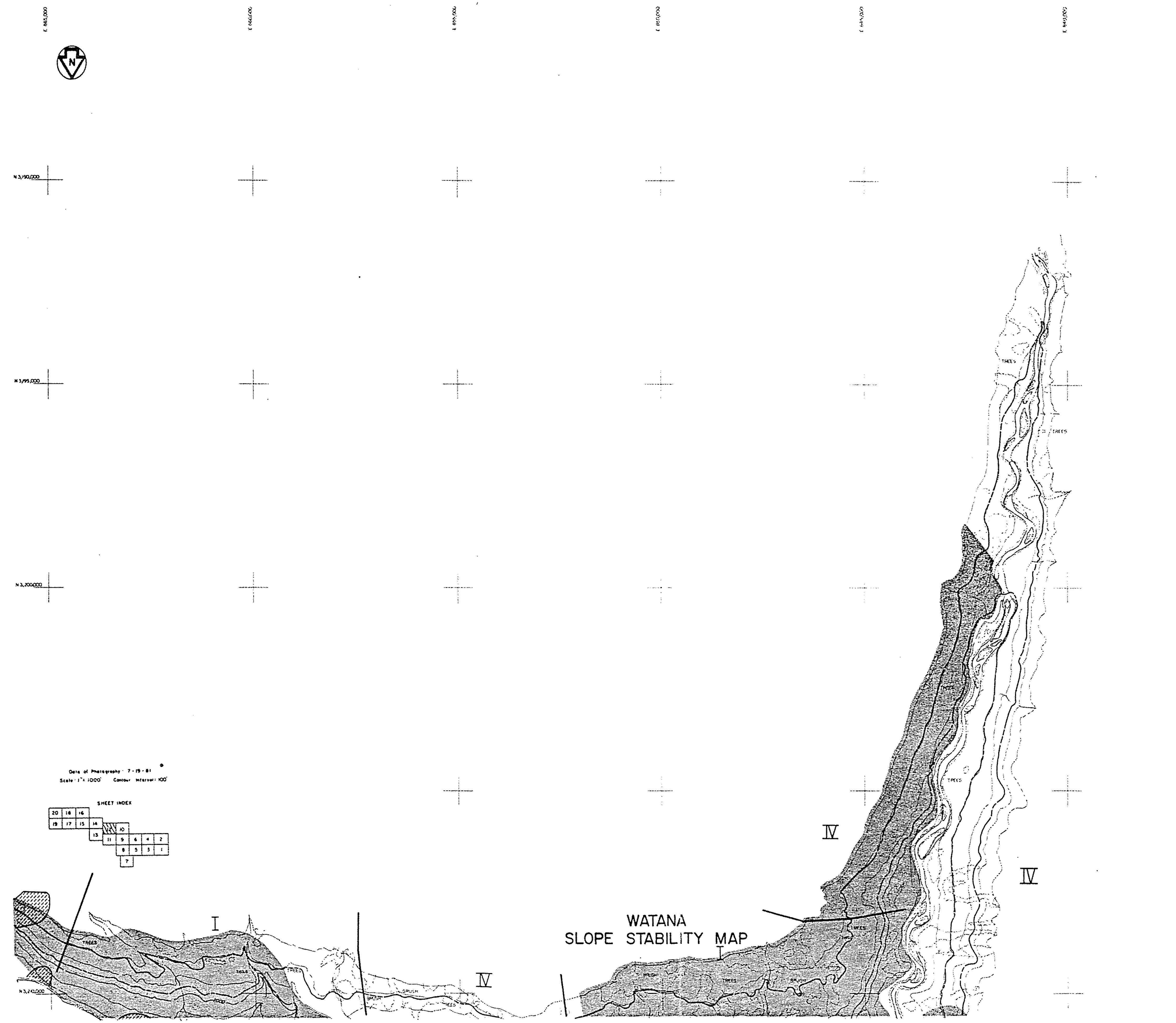
NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E.6.2.39



WATANA SLOPE STABILITY MAP

LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I(IV)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
	NORMAL MAXIMUM OPERATING LEVEL, STAGE III
	NORMAL MINIMUM OPERATING LEVEL
	RIVER MILES

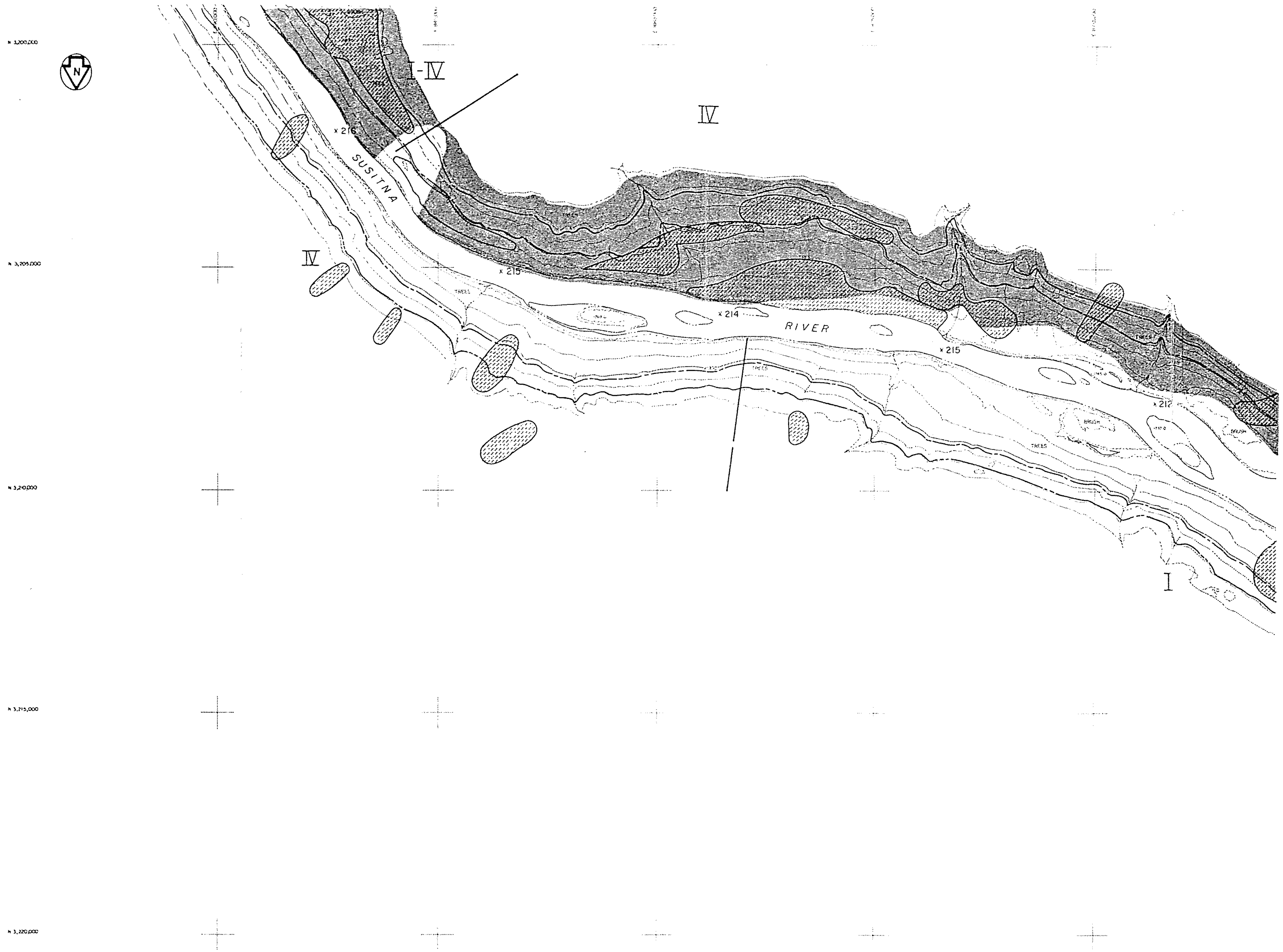
AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

FIGURE E.6.2.40



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I(IV)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
—·—·—	NORMAL MAXIMUM OPERATING LEVEL, STAGE III
-·—·-	NORMAL MINIMUM OPERATING LEVEL
x	RIVER MILES

AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

Date of Photography - 7-19-81

Scale 1" = 1000' Contour Interval 100'

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WATANA
SLOPE STABILITY MAP

FIGURE E.6.2.41

LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I (IV)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
———	NORMAL MAXIMUM OPERATING LEVEL, STAGE III
-·-·-	NORMAL MINIMUM OPERATING LEVEL
X	RIVER MILES

AREA OF POTENTIAL PERMAFROST

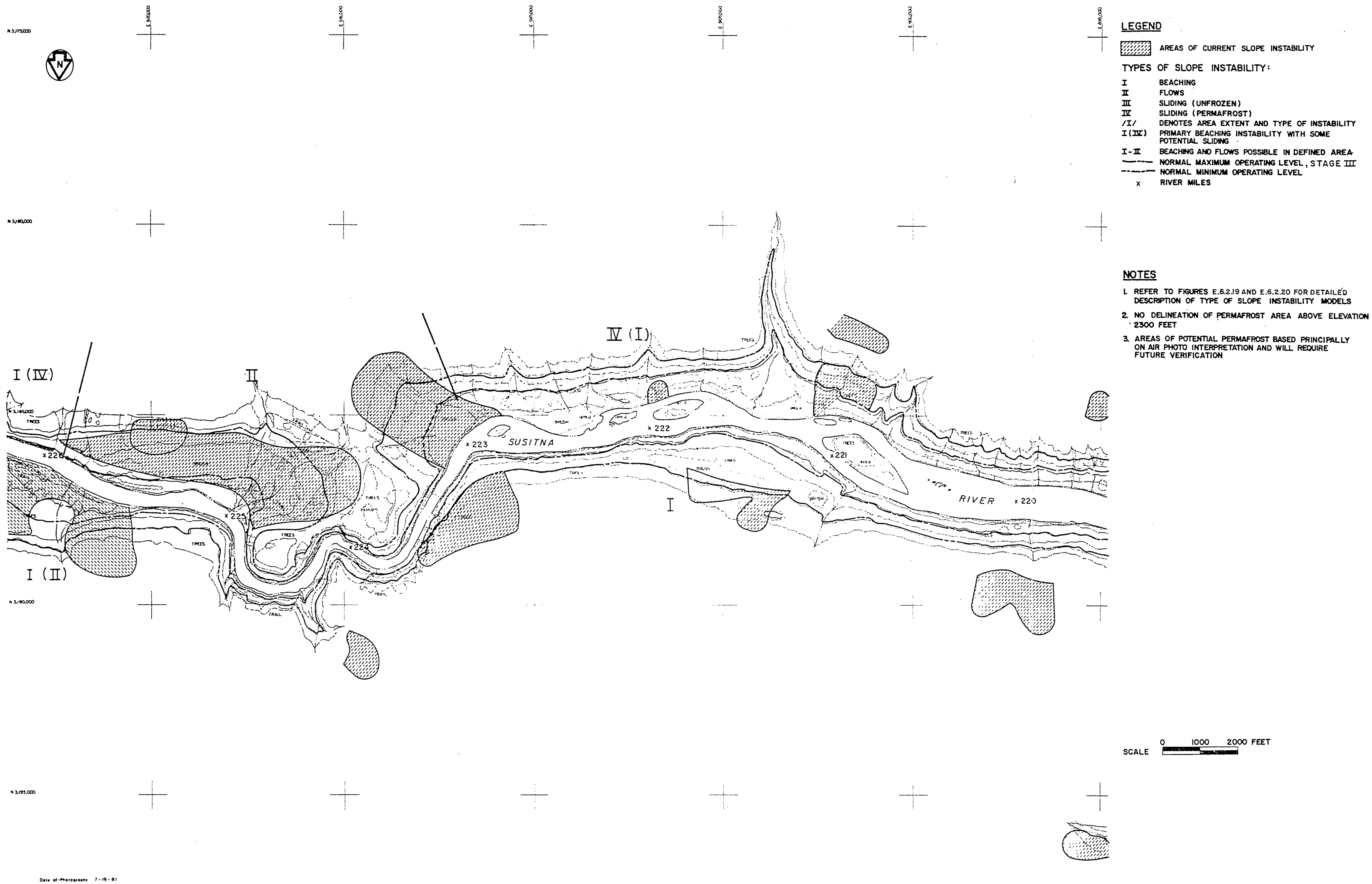
NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

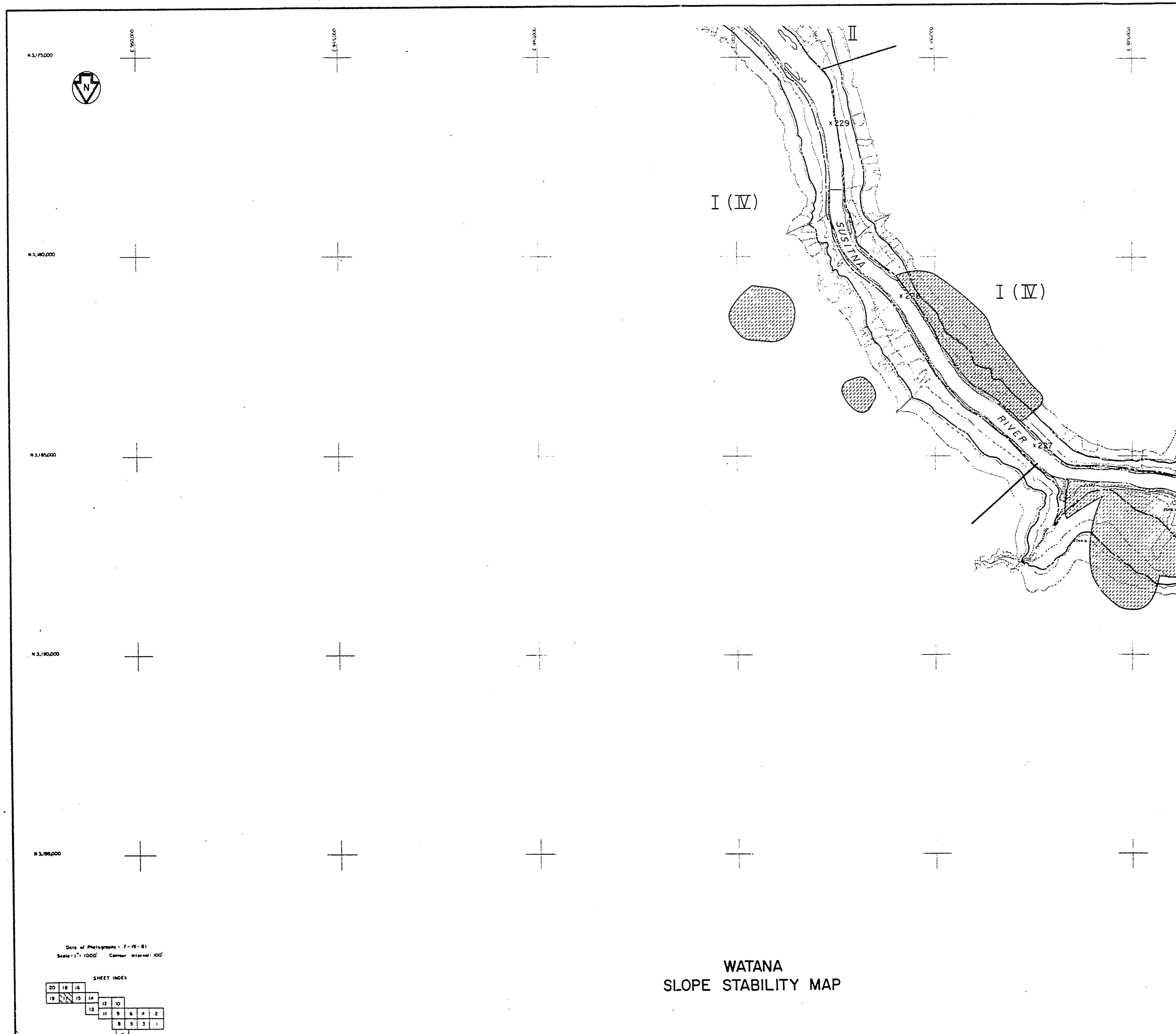
WATANA
SLOPE STABILITY MAP

FIGURE E.6.2.42



WATANA
SLOPE STABILITY MAP

FIGURE E.6.2.43



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I (IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL, STAGE III
- NORMAL MINIMUM OPERATING LEVEL
- X RIVER MILES

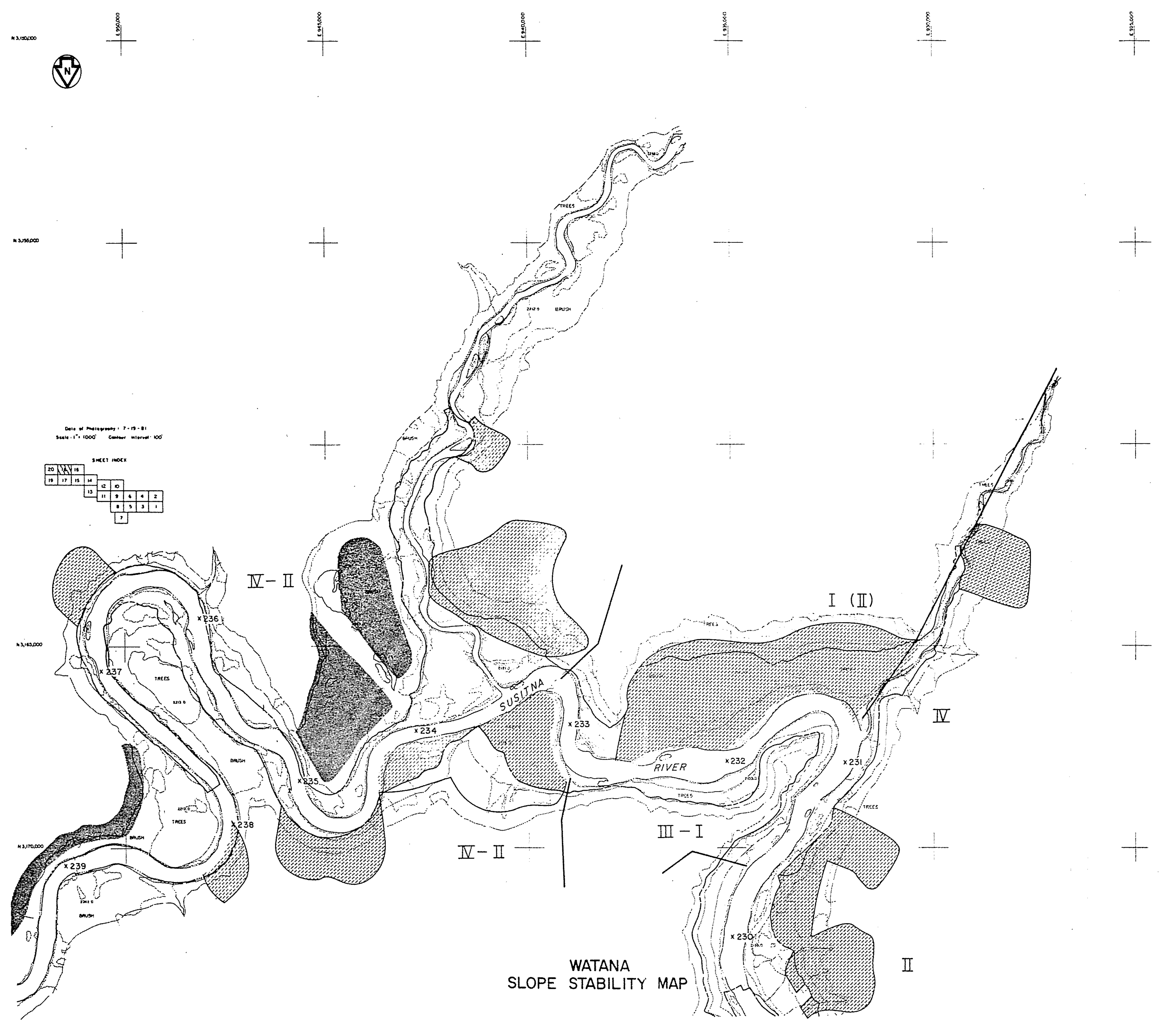
NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E.6.2.44



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I (IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL, STAGE III
- NORMAL MINIMUM OPERATING LEVEL
- X RIVER MILES

AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.2.19 AND E.6.2.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E.6.2.45