SUSITNA HYDROELECTRIC PROJECT

FERC LICENSE APPLICATION

EXHIBIT E

CHAPTERS 4, 5 AND 6

DRAFT

NOVEMBER 15, 1982

Prepared by:

ACRES

ALASKA POWER AUTHORITY

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4 - HISTORIC AND ARCHEOLOGICAL RESOURCES

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VOLUME 3 CHAPTER 4

REPORT ON HISTORIC AND ARCHEOLOGICAL RESOURCES

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4 - REPORT ON HISTORIC AND ARCHEOLOGICAL RESOURCES

1 - INTRODUCTION AND SUMMARY

To date three field seasons of reconnaissance level survey and two field seasons of systematic testing have been conducted in association with the Susitna Hydroelectric Project (1980, 1981 and 1982). The results of the first two years of the project are presented in "Cultural Resources Investigation for the Susitna Hydroelectric Project: A Preliminary Cultural Resource Survey in the Upper Susitna River Valley" (Dixon et al. 1982), copies of which are submitted with this application. The final results of the field work conducted in 1982 are not available at this time, but will be submitted to FERC in January of 1983; however, preliminary results on the 52 sites documented in 1982 are presented.

The University of Alaska Museum developed a five-step cultural resource program to assist the Alaska Power Authority and Acres American in complying with federal and state laws and regulations concerning protection of cultural resources for the proposed Susitna Hydroelectric Project. The five steps, listed in Section 1.1, were aimed toward locating and documenting archeological and historical resources within preselected survey locales (areas affected by preconstruction activities were also examined) and testing and evaluating these resources to determine their eligibility to the National Register of Historic Places and proposing mitigation measures to avoid or lessen the adverse impact which may result from the proposed project. This application presents the results of a three-year preliminary cultural resource survey in the Upper Susitna River Region, an impact analysis, and a proposed mitigation plan to mitigate the adverse effects of the proposed project on significant cultural resources.

In preparation for field studies, all necessary permits were obtained, literature pertaining to the archeology, ethnology, history, geology, paleoecology, paleontology, flora and fauna in and near the study area was reviewed, and available aerial photographs were examined. These data were used to develop a tentative cultural chronology for the study area and focused effort toward defining types of archeological site locales for each culture period within the geochronologic units. These data, coupled with paleoecological information, were used to select survey locales, 126 of which were surveyed during the 1980, 1981 and 1982 field seasons. Review of paleontological literature and prefield aerial reconnaissance of the Upper Susitna River valley delineated the area suitable for paleontological investigations. Paleontological studies were designed to determine the types of paleontological specimens that could possibly occur in an archeological context.

The methods and defined study area varied for each aspect of study, i.e., archeology, geology, and paleontology (Figure E.4.3). The archeological and historical reconnaissance implemented surface and subsurface testing within the preselected survey locales in an effort to locate historic and archeologic sites. Survey data were consistently recorded on Site Survey forms which enabled systematic recording of information for each site and survey locale.

For each site located during reconnaissance level testing, regional maps, site maps, soil profiles, photographs, and other data were recorded. All specimens collected were accessioned into the University of Alaska Museum. Sites were given both University of Alaska Museum accession numbers and Alaska Heritage Resources Survey numbers.

Geological studies generated data that were used in selecting archeological survey locales. Data concerning surficial geological deposits and glacial events of the last glaciation as well as more recent volcanic ashes were compiled and provided limiting dates for human occupation of the Upper Susitna River Valley. This information was collected by literature review and field studies. Geological data collected during 1980 were incorporated into the 1981 and 1982 archeological programs.

Archeological reconnaissance in 1980, 1981 and 1982 located and documented 6 historic and 161 prehistoric sites, 5 of which were originally located by other investigators during brief surveys in 1971 and 1978 and 6 sites were documented in the files of the Alaska Office of History and Archeology, bringing the total known to date to 167. It is expected that continued survey will locate additional sites. Sites are also known adjacent to the study area near Stephan Lake, Fog Lakes, Lakes Susitna, Tyone and Louise, and along the Tyone River.

Systematic testing was designed to collect data on which to base the evaluation of significance for cultural resources discovered, which will assist in determining the eligibility of sites for nomination to the National Register of Historic Places, and to assess impact in order to develop mitigation measures and a general mitigation plan for significant sites located to date. Although in most cases systematic testing is necessary to address significance, the fact that many of the sites can be placed stratigraphically in relation to three distinct volcanic ashes makes it is possible to consider the collective significance of all the sites because of the potential they hold for delineating the first cultural chronology for the Upper Susitna Region.
Due to the large size of the study area, number of sites located, available field time and fiscal constraints, it was possible to systematically test only 21 sites to date. Because of the minimal amount of data available pertaining to the culture history of southcentral Alaska and the Upper Susitna River in particular, the primary reason for selecting these 21 sites was that they appeared to have the potential for providing data that could be used to document the cultural chronological sequence for this region of Alaska.

Both reconnaissance and systematically tested sites were evaluated to delineate the previously undocumented prehistory and history of the Upper Susitna River Region. These data enabled a cultural chronology to be developed which includes the following periods: Contemporary (1945 - present), Trapping (1920 - 1945), Exploration/Goldrush (1897 - 1920), Athapaskan Tradition (A.D. 1900 - A.D. 500), Choris/Norton Tradition (ca. A.D. 500 - ca. 1500 B.C.), Northern Archaic Tradition (ca. 1500 B.C. - ca. 3000 B.C.) and the American Paleoarctic Tradition (ca. 3000 B.C.? - ca. 9000 B.C.?).

Impact on cultural resources will vary in relation to the type of activities that occur on or near them. Based on the present two-dam proposal (Devil Canyon and Watana) and the resultant increase in public access, 73 of the sites known to date within the study area will be directly or indirectly impacted, and 86 could potentially be impacted, during construction and subsequent use and operation of the facility. Because of their loctaion away from impact areas, it appears that 8 sites will not be impacted by the project.

The impact of recreational activities, upriver and downriver changes in hydrology, land access and use, and the proposed transmission corridors cannot be assessed at this time due to the lack of information concerning the amount, type and location of disturbances associated with these activities. Once all of the development plans are finalized, those sites in the potential category can be designated as likely to receive direct, indirect, or no impacts by project related activities.

Thirty sites were located and documented in areas that will be affected by the Watana Dam and its impoundment. All 30 sites will be directly impacted.

Seven sites are presently known within the area to be affected by the Devil Canyon dam and its impoundment. All seven sites will be directly impacted by the project.

Seven archeological sites were found and documented in proposed borrow areas, associated facilities, and areas disturbed by geotechnical testing. One will be directly impacted and two have the potential of being impacted. It appears that four sites will not be impacted by the project.

Nineteen sites were located and documented along the proposed access route and associated proposed borrow areas. Fifteen of these sites will be directly impacted, three will receive indirect impact and one has the potential of being impacted.

Twelve sites have been recorded within the proposed transmission corridors. At this time all could be potentially impacted. Impact assessment must await detailed information on these corridors. The transmission corridor from the Watana Dam site was selected after the 1982 field season and remains to be surveyed at the reconnaissance level. Ninety-two sites are presently documented in areas outside the above categories but within the project area. Seventeen sites will be directly impacted and 71 could potentially be impacted. It appears that four sites will not be impacted by the hydroelectric project.

No sites on the National Register of Historic Places were known in the study area prior to this study. Based on the results of the reconnaissance survey and the limited systematic testing of the selected archeological sites, the project area holds excellent potential for addressing many long-standing anthropological questions. Three tephras permit stratigraphic correlation between many sites and site components. This presents a uniquely significant opportunity to define the development of these archeological traditions which has not been possible elsewhere in interior or southcentral Alaska.

No single site has been found which preserves the cultural development to be traced through time based on comparisons of a series of sites which can be clearly documented to be temporally discrete. With all this information it is possible to state that most of the sites found to date in the study area are likely significant and could collectively hold the potential for defining the prehistory for this region of Alaska and, therefore, may be eligible for inclusion in the National Register of Historic Places.

Given this level of significance it may be appropriate to nominate these sites to the National Register as an archeological district because of the unique opportunity the known sites in this area (as well as the yet undiscovered sites) have for addressing questions concerning the prehistory and history of a large portion of interior Alaska which is presently not well defined. If a nomination of this type is made, it should be done in concert with the State Historic Preservation Officer.

Continued reconnaissance and systematic testing is necessary to locate and document as many sites as possible, given the present level of technology, to assist in the mitigation of impacts. A mitigation plan to lessen project impacts on cultural resources is a basic management tool providing options to be considered during the overall decision making and planning process. Although the concept has and is presently undergoing refinement, it clearly consists of three options: avoidance, preservation, and investigation. For all sites to be adversely impacted by the Susitna Hydroelectric Project, either directly or indirectly, systematic testing is currently recommended in order to determine significance and eligiblity to the National Register of Historic Places. Based on this testing level, a decision on the level of investigation required can be made through consultation with the SHPO and the Advisory Council. For all sites that could be potentially damaged, avoidance with an accompanying monitoring plan is currently recommended. This monitoring plan should be developed in concert with the appropriate land managing agency. When all the activities associated with construction and use of the project are identified, it will then be possible to determine whether sites in this category will receive direct impact, indirect impact, or no impact. The appropriate mitigation measures can then be developed.

It is presently estimated that it will take two (2) years to complete the archeological and historical inventory and the necessary systematic testing. The duration of any mitigation program must await evaluation of systematic testing. However, a preliminary estimate for an investigation program to mitigate adverse effect is 5 to 7 years. The estimated cost of completing the cultural resource inventory and the necessary systematic testing is $1,391,152. The cost estimate for mitigating adverse effects to cultural resources can only be made after the cultural resource inventory and systematic testing are completed and the number of sites requiring investigation and/or preservation determined.

1.1 - Program Objectives

In order to comply with cultural resource laws and regulations, and to meet the criterion for the Federal Energy Regulatory Commission license application, a five-step program was developed to document, evaluate, and recommend mitigation measures for these resources. These steps include:

- Step 1: Field Study Preparation
- Step 2: Reconnaissance Level Survey
- Step 3: Systematic Testing
- Step 4: Analysis and Report Preparation
- Step 5: Curation

The five steps outlined above are aimed at fulfilling the two objectives of the project:

(a) Identification of archeological, historical, and paleontological resources found in an archeological context in the defined study area (see Methodology section for definition of study area). This process was implemented during the 1980 field season and continued through the 1981 and 1982 field seasons. However, only a portion of the project area has been examined to date and additional survey is required to complete the cultural resource inventory.

(b) Systematic testing and evaluation of these resources in order to evaluate significance and make recommendations for mitigating potential adverse effects that preconstruction studies, dam construction, and/or dam operation may have on them. Systematic testing conducted in 1981 and 1982 tested 21 sites. Continued systematic testing is required to determine National Register eligibility of the remaining sites that will be adversely impacted by the project.

1.2 - Program Specifics

(a) Archeology

(i) Step 1: Field Study Preparation

Prior to implementing the field program it was necessary to complete the following tasks:

- Federal and state archeological permits were applied for and received.

- Literature pertaining to the archeology, ethnology, history, geology, paleontology, flora and fauna of the study area as well as adjacent regions was reviewed prior to preparing the research design.

- Archeological, ethnological and historical data were synthesized into a regional and local chronology in an effort to predict the types and ages of sites that could be expected to occur within the study area. In addition to cultural data, geological data concerning the last glaciation were also examined in order to establish limiting dates for human occupation of specific areas within the upper Susitna River basin. Objectives of the geoarcheology portion of the cultural resource studies are discussed in this section. Results of 1980, 1981 and 1982 field studies indicate that prefield season projections of site locations and temporal placement provided reliable estimates of what has been subsequently documented.

- Aerial photographs of the study area were examined, the interpretation of which focused on identifying probable areas containing cultural resources as well as supplementing geoarcheological data.

- All previously recorded cultural resources in the study area were plotted on 1:63,360 USGS maps in order to document the location of sites within and adjacent to the study area.

- Areas that had no or very low potential of cultural resources such as steep canyon walls, areas of standing water and exposed gravel bars were identified. These areas were eliminated from reconnaissnce level testing.

(ii) Step 2: Reconnaissance Level Testing

The purpose of this step was to identify, locate and inventory archeological and historical sites within the study area, which can then be systematically tested. Data synthesized and generated about the study area were used to select survey locales for testing. Maps of each survey locale examined in 1980 and 1981 can be found in Appendix E of the 1982 report. Survey locales examined in 1982 will be included in the report documenting this field season.

During the 1980, 1981 and 1982 field seasons 126 survey locales were examined using surface and subsurface testing procedures. In addition reconnaissance testing was conducted as needed at boreholes, auger holes, proposed borrow areas, helicopter landing zones, the proposed Watana airstrip, along seismic lines, and along proposed access routes. The proposed transmission corridors from Fairbanks to Healy and Willow to Anchorage, and the proposed access route have received preliminary reconnaissance survey.

(iii) Step 3: Systematic Testing

The purpose of this step was to test sites located during the reconnaissance level survey in order to collect sufficient data to address site significance, eligibility to the National Register, and impact, in order to develop mitigation measures and a general mitigation plan. Systematic testing, which began in 1982 and continued in 1982, requires transit surveys of sites, topographic mapping, and excavation of selected units using standard archeological methods. In addition, site maps and soil profiles of excavation units producing cultural material were drawn and photographs taken.

(iv) Step 4: Analysis and Report Preparation

This step was an integral part of each step of the project. It entailed compilation of the individual reports for the other steps of the project as well as synthesizing all data recovered and making recommendations for mitigating adverse effects on cultural resources when sufficient data were available to make recommendations.

(v) Step 5: Curation

Recording of recovered artifactual material and associated contextual data was and will be an ongoing program throughout the duration of and after the project. As specified by the Federal Antiquity Permit obtained for this project, materials and supporting documentation must be stored and maintained in a suitable repository. The designated repository is the University of Alaska Museum.

Artifacts and paleontological specimens recovered to date have been accessioned into their appropriate collections at the University of Alaska Museum in accordance with state and federal requirements pertinent to the preservation of antiquities.

(b) Geoarcheology

In order to accomplish the archeological objectives it was necessary to conduct geoarcheological studies to generate baseline data on the surficial geological deposits and glacial events in the study area which provided one of several criteria subsequently applied to the selection of survey locales during 1980, 1981, and 1982. Additionally, geoarcheological studies provide limiting dates for the earliest possible human occupation of specific areas within the region as well as baseline data on volcanic ashes (tephras) within the study area which can be used to provide relative dates for many of the archeological sites.

(c) Paleontology

In connection with cultural resource studies it was necessary to develop baseline paleontological data aimed at defining the type and range of paleontological specimens that could possibly occur in an archeological context within the study area.

The results of archeological, geoarcheological and paleontological studies are discussed in Chapters 3, 4, 5, and 6 in the 1982 report.

2 - BASELINE DESCRIPTION

2.1 - The Study Area

(a) Archeology

The cultural resource study area was defined as those lands within approximately 3 km of the Susitna River from just below Devil Canyon to the mouth of the Tyone River (Figures E.4.1, E.4.2, E.4.3 and E.4.4). Also included were the proposed access corridor and transmission corridors from Fairbanks to Healy and Anchorage to Willow. Areas outside the defined study area were examined when it was necessary to obtain data essential to the cultural resource study, as well as to examine areas that could be impacted by changes in the project and those that would likely be affected by recreational use of the area.

The study area delineated for cultural resource studies included both direct, indirect and potential impact areas. Direct impact is the immediately demonstrable effect of a land modification project on the resource base. Indirect impact relates to adverse effects that are secondary but clearly brought out by the land modification project which would not have occurred without the project. Potential impact is connected with ancillary development which can be predicted to occur as a result of the project.

Direct impact areas include the proposed reservoirs of the Devil Canyon and Watana dams, proposed dam construction sites and associated facilities, proposed borrow areas, proposed access and transmission corridors, and any other areas subject to subsurface disturbance during preconstruction, construction, or operation of the Susitna Hydroelectric Project. Indirect impact areas are those outside the above areas but nonetheless affected by the project due to such activities as increased access to remote areas afforded by roads into the project area, downcutting and erosion caused by changes in stream and river flow resulting from fluctuation of water levels of the reservoir. Potential impact can be expected to occur as a result of recreational development. The exact nature of this impact remains to be demonstrated.

The study area is not static. It has changed and will continue to change in response to modifications in the engineering of the hydroelectric project, as well as to new data provided by ongoing studies associated with the overall project, such as land use analysis and recreation planning.

(b) Geoarcheology

The study area for geoarcheological studies supporting cultural resource analysis was approximately 16 km wide on each side of the Susitna River extending from the Portage Creek area to the mouth of the MacLaren River (Figure E.4.3). When necessary, contiguous areas were examined.

(c) Paleontology

The study area for paleontological studies as they apply to cultural resources was confined to the Watana Creek vicinity. This locale was selected because it was the only area identified within the entire Susitna basin that provided suitable large deposits for pre-Pleistocene paleontological studies (Figure E.4.3).

2.2 - Methods - Archeology and History

In preparation for field studies, a research design based on current data was developed. The research design integrated the current data (Appendices A, B in 1982 report) into a cultural chronological framework, and developed a research strategy that was structured to predict archeological site locations in relation to physical and topographic features within the limits of contemporary archeological method and theory. Based on the delineated cultural chronology, documented site locales for each culture period, geoarcheologic evaluation, and paleoecological data of the project area, survey locales were identified as exhibiting relatively high potential for archeological site occurrence. These locales were subject to preliminary examination for cultural resources representing various periods of Alaska prehistory. Additional high potential areas remain as well as areas that have varying degrees of site potential which must also be examined. The data used in selecting the survey locales are presented below.

(a) Application of Data Base

(i) Cultural Chronology. A tentative cultural chronology was constructed utilizing archeological data from known sites in or adjacent to the study area. Archeological sites of several cultural periods spanning the past ca. 10,000 years and several cultural/historical periods are known. These data assisted in selecting survey locales.

Archeological sites which were expected to occur in the Upper Susitna region were not expected to exceed 9000 B.C. in age, based on the sequence of deglaciation that occurred in the area. The earliest sites that were expected in the study area were those representing the American Paleoarctic Tradition, specifically the Denali Complex for which West (1975) ascribes a date of ca. 10,000 B.C. to 4,500 B.C. This distinctive and long-lasting stone tool industry is characterized by wedge-shaped microblade cores, microblades, core tablets, bifacial knives, burins, burin spalls and end scrapers. Incorporation of Denali into the American Paleoarctic Tradition follows Dumond (1977) who suggests that the Denali Complex is a regional variant of the American Paleoarctic Tradition as defined by Anderson (1968a).

The Denali Complex has been dated to between 8,600 B.C. and 4,000 B.C. in Interior Alaska. There appears to be a hiatus of Denali sites in the interior archeological record after 4,000 B.C.; however, several sites in the Tanana Valley which contain elements thought to be distinctive of the Denali Complex date to between 2,400 B.C. and A.D. 1,000. This may suggest a late persistence of this stone industry. Sites representative of the Denali Complex are located in areas adjacent to the study area. The oldest dated Denali Complex site in the Alaska Range area is Component II, at the Dry Creek site which dates to ca. 8,600 B.C. (Powers and Hamilton 1978:76).

Other sites containing the Denali Complex in surrounding regions are Teklanika 1 and 2 near Mt. McKinley, MMK-004 at Lake Minchumina, the Campus site, the Village site at Healy Lake, site FAI-062 (central Tanana Valley), the Donelly Ridge site, several undated Denali sites on the Ft. Wainwright Reservation in the central Tanana Valley, several sites at Tangle Lakes, two sites near Lake Susitna and upper Cook Inlet, the Beluga Point site, and the Long Lake site in the Talkeetna Mountains. These suggest that the Denali peoples were extremely widespread and occupied both inland and coastal zones. If a continuum beween early and late Denali proves to be real, a time span of over 9,000 years would exist for Denali peoples. The available information suggested that sites representing the Denali period existed within the study area. Sites containing elements associated with the Denali complex were found as a result of surface and subsurface testing in the study area (see Chapters 3, 4, and 7 in the 1982 report).

The question of the late duration of the Denali Complex is not settled. Several sites in regions adjacent to the study area have yielded materials similar to those of the Denali Complex, i.e., microblades, microblade cores, and burins, which have late dates. These are the Village site at Healy Lake with a date of ca. 500 A.D. (Cook 1969), and MMK-004 at Lake Minchumina dated to ca. 800-1000 A.D. (Holmes 1978). At the Dixthada site, similar material has been dated to ca. 470 B.C. Several as yet undated sites containing Denali-like material were also located during a 1979 survey in the central Tanana Valley (Dixon et al.) and could represent late Denali occupation.

Sites potentially of late Denali age in areas near the Upper Susitna study area suggest that late Denali sites could also exist in the study area. Several sites documented during the 1980 and 1981 field seasons may represent this period; however, further testing and evluation are necessary in order to support this hypothesis.

Areas surrounding the study area have produced sites representative of the Northern Archaic Tradition as defined by Anderson (1968b) which date from ca. 4,500 B.C. Northern Archaic sites include Lake Minchumina, Dry Creek, the Campus site, the Village site at Healy Lake, several sites found at Ft. Wainwright in 1979, Tangle Lakes, Lake Susitna, Beluga Point, and the Ratekin site. The distribution of these sites is similar to that for the Denali Complex sites. This tradition is characterized by notched projectile points, notched pebbles, a variety of bifaces, end scrapers, and notched boulder chip scrapers. A site on Stephan Lake (TLM 007) dating to ca. 4000 B.C. suggested the presence of the Northern Archaic Tradition in the study area. Several projectile point types indicative of this tradition were found during the 1980, 1981 and 1982 field seasons and, along with several radiocarbon dates that correspond to the time span for this culture period, indicate that this tradition is present in the Upper Susitna Valley (Section 4.9 and Chapters 3, 4, and 7 in the 1982 report).

The Arctic Small Tool Tradition is characterized by assemblages containing microblade cores, microblades, burins, burin spall artifacts, flake knives, and bifacial end blades. This tradition is represented by coastal and non-coastal sites, several of the latter being known from the Alaska Interior. Dumond (1977) suggests that the Arctic Small Tool Tradition can broadly encompass a Denbigh-Choris-Norton continuum, and this is how the tradition is used here. One site adjacent to the study area, Lake Susitna Site 9, has been suggested as a possible Arctic Small Tool Tradition (Irving 1957). A date of 2200 to 2800 B.C. has been documented for the Artic Small Tool occupation at Onion Portage (Anderson 1968) but may be somewhat later in the southern interior.

Norton period sites, the late end of the Arctic Small Tool Tradition continuum, first appear on the Bering Sea coast about ca. 500 B.C. Norton does not predate 400 B.C. in the upper portion of the Naknek drainage, and lasts to ca. 1000 A.D. around much of the Bering Sea area (Dumond 1977:106-108). Shortly after its appearance (ca. 500 B.C.) Norton may be represented in Interior Alaska archeological sites. This is suggested by artifacts from Lake Minchumina, the Beluga Point site in upper Cook Inlet and possibly one site in the Upper Susitna River Valley.

It should also be noted that Norton period sites in the Bristol Bay region tend to occur well up major salmon streams, presumably exploiting this rich resource (Dumond 1977:113). Inland Norton period sites demonstrate the importance of caribou in the Norton subsistence strategy (Dumond 1977:113). The Beluga Point site in upper Cook Inlet may represent the maritime portion of the Norton subsistence cycle. Norton populations employed a subsistence pattern that included the seasonal exploitation of both coastal resources (sea mammals, shell fish, and fish) and interior resources (caribou, moose, salmon, etc.). This shift in subsistence strategy may have been a response to climatic amelioration which occurred after 1000 B.C. and preceded the "Little Ice Age" (ca. A.D. 1600-A.D. 1800). This change in resource exploitation may be reflected by the occurrence of a possible Norton period archeological site in the Susitna study area.

Late prehistoric Athapaskan and historic period sites have also been documented in areas adjacent to the study area. Late prehistoric Athapaskan sites are presented at Lake Minchumina, the upper component at the Healy Lake Village site, the upper component at Dixthada, several sites at Tangle Lakes, other sites on Lakes Susitna, Louise and Tyone, a eported site on the Tyone River, and another site in the vicinity of upper Cook Inlet. These late prehistoric Athapaskan sites indicate widespread occupation of several regions in Alaska by these groups. Dumond and Mace (1968) have suggested, based on archeological and historical data, that Tanaina Athapaskans may have replaced the Pacific Eskimo in upper Cook Inlet sometime between 1650 A.D. and 1780 A.D. Possibly this replacement occurred somewhat earlier in the study area. Several sites representing this period were documented in the Upper Susitna River Valley during this study (see Chapters 3, 4, and 7 in 1982 report).

The chronology presented here is speculative and was intended to provide a baseline from which archeological sites of different periods in the project area could be expected. This chronology is presently being tested and refined using data from archeological sites located in the study area. The relationship of this chronology to actual sites found is discussed in Chapter 7 of the 1982 report.

In order to evaluate the significance of archeological sites located during survey and testing (with respect to National Register criteria), as well as aid in the analysis of archeological materials collected, it was necessary to explicate hypotheses which could be tested and evaluated utilizing the project data.

A fundamental hypothesis examined in this study was the validity of the cultural chronology which was proposed. To test the cultural chronology, each period must be examined separately against archeological data from sites located during survey. To evaluate a site against a proposed period in the chronology, it is necessary that the full range of artifactual material from the site, not just selected types, and non-artifactual contexts be compared against the known range of artifactual material from sites of the period and the attempt made to explain the range of variability and the anomalies. This should lead to a fuller understanding of periods involved, or the elimination of invalid periods for the study area and possibly the delineation of others presently unknown.

(ii) Geoarcheological Data. Geoarcheological data was reviewed, aerial photographs examined and a preliminary data base developed which provided information on glacial events and surficial geological deposits within and adjacent to the study area (see Chapter 5 in 1982 report). These data were used in conjunction with archeologicl data to select survey locales for testing. Updated geoarcheological data were incorporated into ongoing cultural resource studies during the course of the project.

During the 1980 field season, aerial reconnaissance was conducted in order to outline more specifically the distribution and range of surface landforms and deposits as well as to examine the potential for stratigraphic work. Stratigraphic reconnaissance was conducted in a number of areas in order to generate data on major valley-forming geologic events. Geoarcheological reconnaissance was conducted in order to examine land forms specifically associated with glacial events in the area such as moraines, deltas, lake plains and eskers, in order to suggest limiting data for cultural resources in specific areas.

Based on the analysis of the above data, a preliminary geoarcheological terrain map was developed to assist cultural resource field studies. This map is on file at the University of Alaska, Fairbanks. In addition, organic samples collected and submitted for radiocarbon analysis were used to provide keys to stratigraphic units within the study area, information which was applied to site age whenever possible. Tephra samples were also collected in order to identify ash horizons noted in archeological sites and stratigraphic sections. As with the other geoarcheological data, this information was used to date cultural resources when possible.

(b) Permits

Federal Antiquities permits (#80AK-23, #81AK-209) and State of Alaska Permits (#80-1, #81-11, #82-4) were obtained for the project. Federal permit 81AK-209 is valid through June 1984.

(c) Literature Review

Literature pertaining to the archeology, history, geology, flora and fauna of the study area and surrounding areas was reviewed and incorporated into the research design.

(d) Cultural Chronology

The data resulting from the review of the archeological and historical literature was used to construct a tentative cultural chronology for cultural resources expected in the study area, provide data for the delineation of a predictive model for archeological potential of various project areas, and explicate hypotheses that could aid in the evaluation of sites located during survey and testing. A tentative chronology suggested that sites spanning the past ca. 10,000 years would be found in the study area. Preliminary analysis of cultural resources located during the three field seasons of this project indicates that sites representing all culture periods outlined in the research design occur in the study area.

(e) Research Design and Strategy

An analysis of the data derived from the literature search focusing on site locales has established that archeological sites occur in a non-random pattern in relation to associated physical, topographic, and ecological features. Based on the analysis of site locational data from regions adjacent to the study area, the features characteristically associated with archeological site occurrence are discussed below. All sites located during this study can effectively be placed in one or more of these categories.

(i) Overlooks - Overlooks are areas of higher topograhic relief than much of the surrounding terrain. These areas are characteristically well drained and command a view of the surrounding region. It is generally inferred that overlooks served as hunting locales and/or possibly short term camp sites. Because these sites occur in elevated areas, soil deposition is generally thin and they are frequently easily discovered through subsurface testing or examination of natural exposures. Examples of sites ascribed to the Denali Complex which occur in this setting are the Campus Site, Donnelly Ridge, Susitna Lake, and the Teklanika sites. Northern Archaic Tradition sites also known to occur on overlooks are the Campus Site, some sites in the Tangle Lakes area, Susitna Lake, the Ratekin Site, and a site near the Watana Dam project area. Archeological sites ascribed to the Arctic Small Tool Tradition frequently occur on overlooks; however, no positively identified Arctic Small Tool sites situated on overlooks have yet been reported from the study area or regions immediately adjacent to it. The Nenana River Gorge site, some of the Tangle Lakes sites, and Lake Susitna are all Athapaskan period sites which occur on overlooks.

(ii) Lake Margins - Sites ascribed to all defined traditions have been discovered on the margins of major lakes. It is generally inferred that they are frequently more permanent seasonal camps and that fishing, the exploitation of fresh water aquatic resources, and large mammal hunting were the primary economic activities associated with these sites. These inferences are primarily based on the location of these sites rather than an analysis of faunal and artifactual material. Sites on lake margins may exhibit greater soil deposition than overlooks because of their lower topographic position. Sites in this setting are frequently discovered through subsurface testing, the observation of surface features, or through the examination of natural exposures. Athapaskan sites on lake margins include those at Lake Minchumina, Healy Lake, Tangle Lakes, Lake Susitna, Lake Louise, and Lake Tyone. Archeological sites ascribed to the Arctic Small Tool Tradition are reported to occur on lake margins, and an example is the Norton component reported at Lake Minchumina, Healy Lake, Tangle Lakes, Susitna Lake and Stephen Lake, sites which may be ascribed to the Northern Archaic Tradition are known to occur on lake margins. Denali Complex sites which have been found near lakes include the Tangle Lake sites, Lake Minchumina, Healy Lake, Long Lake, and Lake Susitna.

(iii) Stream and River Margins - Numerous sites have been reported along the banks of abandoned channels of streams and rivers. They vary from large semi-permanent seasonal camps to what appear to be brief transient camps. Soil deposition at such locales may be greater than either lake or overlook sites because of the low topographic setting of streams and an active agent (the stream or river) for soil deposition. Sites may be discovered through the examination of natural exposures, subsurface testing, and visual observation of cultural features. Denali Complex sites reported along stream and river margins or abandoned channels include Dry Creek, Carlo Creek, and the Campus site. Northern Archaic Tradition sites found in this type of locale are Dry Creek and the Campus site. The Merrill site, which is ascribed to the Norton period of the Arctic Small Tool Tradition, is a former meander of the Kenai River. Athapaskan sites on stream and river margins include Dixthada, Dakah De'nin's Village and the Nenana River Gorge site.

(iv) Natural Constructions - Areas where the topographic setting and surrounding terrain form natural constrictions tend to funnel game animals using the area. Lakes, rivers, streams, incised abandoned channels, as well as mountains and hills can produce, either singularly or in combination, natural funnels, concentrating game animals (especially herd animals) into areas that afford more efficient and effective exploitation of this resource by human populations. Sites in the form of "lookouts" or actual kill sites could be associated with these areas. In the Upper Susitna River Valley extant caribou herds presently use the area for summer and calving ranges and are subject to this funneling. Presumably this was the case in the past.

(v) Areas Eliminated from Testing Program - In addition to those areas mentioned above, areas that appeared to have no or very low archeological potential were also identified. These include areas of steep slopes (greater than 15 degrees) such as the walls of Devil Canyon; areas of standing water including the Susitna River itself, lakes and low swampy areas; and exposed gravel bars on the Susitna River. These areas were eliminated from survey except when slated for ground-disturbing activities such as auger and boreholes, seismic testing and the proposed Watana airstrip. In these cases, low-level helicopter reconnaissance, surface reconnaissance and subsurface testing were conducted where possible. Numerous reconnaissance surveys were conducted in these types of areas, all with negative results.

It can easily be noted in the review of site locational data that many sites have been subject to reoccupation and share more than one of the defined physical, topographic, or ecological features characteristic of archeological site locales. It would appear that there may be a compounding effect in human utilization of a locale, if more than one of these major variables occur, thus possibly increasing the probability of its use and subsequent reuse. It is also recognized that this analysis is limited because it does not address known chronological and settlement pattern gaps in the archeological record. Additionally, sites such as caves, rock shelters, quarry sites, etc., are not reported immediately adjacent to the study area, although they may occur in the Susitna region. By focusing initial survey efforts in these locales, as well as natural exposures, it was anticipated that most of the archeological sites which can be easily discovered would be found during initial stages of the project, thus providing maximum time for evaluation and planning to ensure their protection. One hundred and sixty-seven archeological/ historic sites were recorded during the 1980, 1981 and 1982 field seasons through implementation of this research design and strategy.

However, a problem in the delineation of the topograhic, physical, and ecological features listed above is that a variety of specific settings are subsumed under these general categories and little precise detail about individual sites is available. One objective of the research design was to attempt to obtain more precise data relevant to prehistoric settlement patterns and the juxtaposition of individual sites in relation to the natural environment. Forms used to compile this data are discussed below and presented in Appendix C in the 1982 report. It is anticipated that analysis of this data will increase predictability for locating archeological sites. Additionally, this examination may permit detailed analysis of shifting subsistence patterns during various cultural historical periods which in turn may enable correlation of changing settlement patterns with environmental change(s).

Field data recording gathered detailed site-specific information such as the geomorphic feature on which sites were located, topographic position and elevation, slope, exposure, view stratigraphy, as well as details about the surrounding terrain and environment. This specific kind of information may enable an analysis of settlement patterns in relation to ecological variables and human response to changes in these variables through time. A Site Survey Form was developed which outlines the specific kinds of information that field personnel were required to record. This form is presented in Appendix C of the 1982 report.

Similar information was also collected at locales where test pits did not yield cultural evidence to facilitate analysis of areas where sites do not occur.

The research design and strategy developed for this project were based on a plan designed to provide feedback data throughout the project so that new data could be used to modify, refine and further develop the cultural resources investigation. Primary objectives of the field research program were: 1) examination of areas which would be immediately affected by the Susitna Hydropower Project (proposed airstrips, borrow areas, drilling locales, etc.); 2) survey and testing of the documented archeological site locales; 3) an on-the-ground survey of preselected survey locales within the study area; and 4) systematic testing of sites discovered to determine spatial limits, depth of deposits, stratigraphic placement of cultural materials, probable age and function of sites, etc.

(f) Data Collection and Field Procedures

(i) Reconnaissance Testing - To insure consistent data collection in the field and provide a systematic format for data retrieval, a Site Survey Form was used for this project (Form 1, Appendix C in 1982 report). The form served as a basis for recording specific information on each site located during the reconnaissance level survey as well as a basis for systematic testing. The form is organized into major categories including: site location, environment, site description and condition, photographic records and additional information such as a site map and location of test pits. Subcategories within each of these headings provide specific data on these topics.

Daily field notes were kept by each crew member. Each page was numbered in the upper right hand corner along with the date or dates included on that page. Each site was noted by bold or underlined numbers (i.e., TLM 027) at the beginning of the notes associated with that site. Field notebooks for survey recorded much of the same information found on the Site Survey Forms, such as site location, topography, vegetation, soils, extent of site, and photographs taken. Field notebooks for systematic testing also recorded a detailed description of soils, drawings stratification of soils, drawings of significant features or artifacts in situ, horizontal and vertical placement of artifacts and features excavated at the site, site maps, methods of excavation and collection of non-archeological samples (soil, pollen, radiocarbon). A space was left on each page for additional notes and corrections. Crew leaders kept a continuous log of all areas surveyed, noting both the location of all test pits and natural exposures and the presence and absence of cultural material.

Once an archeological site was located, additional shovel tests were excavated, when possible, to the north, south, east and west of the test pit which first documented the site. This testing was designed to assist in determining extent of the site as well as to locate additional cultural material. In an effort to keep site disturbance to a minimum, preliminary testing at each site was limited, and the number of tests made at each site varied with the nature of the specific site. All test pits were numbered, mapped and backfilled.

The location of all excavated and surface collected artifacts were recorded. Specimens recovered during reconnaissance level survey were bagged by arbitrary 5-cm levels, unless natural stratification was encountered. Each bag contained the following information: location (i.e., Devil Canyon, Survey Locale 15), date, University of Alaska Site Number or AHRS number (i.e., UA80-23 or TLM 123), name of excavator, test number (as recorded on site map, i.e., Test #1), depth, and specimen(s) in bag. Radiometric samples collected were double wrapped in aluminum foil and placed in ziplock bags with the following data recorded on each: location, date, site number, collector's name, test number, depth, specimen. All individual bags from each test were placed in a larger bag with site number, name, date and location on the outside. All test pit bags were placed in a site bag with the site number and date on the outside. All site bags were organized by survey locale.

A site-specific and regional map was made for each site. Site maps included horizontal and vertical datum points, site grid, all test pits made, location of surface artifacts, features (such as hearths, cabin remains, house pits), distance and direction to other sites or major land features, a scale, date, name of person drawing map, name of person recording data, and reference to pages in field notebooks on which additional information was recorded. Regional maps showed the site in relation to a larger portion of the study area including nearby rivers, lakes, topographic features, vegetation communities, and other sites in the immediate area.

Photographs were taken of each site located. The first picture at each site was an identification shot indicating site number, date and crew. Other photographs recorded the environment around the site, features at the site, soil profiles exposed in test pits, and artifacts or features in situ before removal by excavation. Each photograph was recorded by roll and frame and recorded on the survey form. Direction of view, if applicable, was noted for each photograph taken along with a short statement of content and any other data pertinent to the photograph. When practical, a metric scale or other reference object was included. Photographs are on file at the University of Alaska Museum.

Detailed soil profiles were drawn of soil deposits exposed during excavation. These included a description of color, grain size and consistency. Measurements documenting depth and thickness for each unit were also recorded. Soil profiles are on file at the University of Alaska Museum.

A catalog of all specimens collected in the field during survey or excavation was prepared during Step 5, Curation. Pertinent data was recorded for each specimen, including its Museum accession and catalog number, description of specimen, excavation or collection unit, level or depth from which it was collected, date of collection, and collector or excavator. Site information collected and recorded during survey and testing was recorded on Alaska Heritage Resource Site Survey long forms; a sample of which is presented as Form 3 in Appendix C of the 1982 report. These become a permanent public record of the State of Alaska.

The reconnaissance level survey was directed toward on-the-ground evaluation of preselected survey locales that have been identified for the project area. Along with the evaluation an attempt was made in the field to identify areas that potentially may be eliminated from further survey and the location of as many site locales as possible. Form 2 in Appendix C of the 1982 report was developed to aid this evaluation.

(ii) Systematic Testing - Prior to systematic testing, a mapping crew established horizontal and vertical site datums, topographically mapped each site and superimposed a horizontal grid on each site. To facilitate recording data, the datum was located, when possible, so that the entire site area would fall north and east of the datum point. A 12-inch spike was placed at the datum location with an aluminum tag containing site information including the state AHRS number, the date and "University of Alaska Museum." Two methods were used to establish a site datum elevation. Where it was possible to tie the datum into the elevation of the Susitna River, the datum elevation was determined by its elevation above the Susitna at the closest point of the river to the site. If this was not practical due to the distance from or elevation above the river, half the elevation between the contour line above and below the site was added to the lower contour elevation and this elevation used to establish elevation.

A Sokkisha BT 20 transit, 50 m tape and metric stadia rod were used to establish a base line oriented to conform to local site topography in an effort to facilitate excavation. The northern end of this baseline was estblished as "Grid North"; all subsequent horizontal measurements referenced to grid north. A survey notebook was kept by the mapping crew with all mapping nformation which included magnetic declination, angles between grid north and true north, and triangulation data necessary to relocate datums in the event of disturbance. Wherever topographic considerations allowed, True North was used as Grid North; however, in most cases this was not possible.

Working from the baseline, the mapping crew used the transit and tape to establish a site grid, placing wooden stakes at 5-m or 10-m intervals. An east-west project baseline was established along a line at right angles to the baseline at the datum location. At larger sites additional east/west placed lines at right angles to the baseline were established. All stakes were placed directly at intersecting points of the grid system with the exception of a stake to insure relocation of site datum which was offset 10 cm from the datum spike. Grid coordinates north and east of datum were written on all wooden stakes and elevations in relation to datum recorded for the top of the stake and the ground elevation at the stake location. Additional elevation measurements off the grid were recorded using a stadia rod so that a topographic map with 50-cm or 1-m countour intervals could be drawn.

The mapping crew provided the systematic testing crew with a topographic map of the site vicinity, a grid layout diagram and elevation of all stakes prior to testing of the site.

Placement of test squares was determined by the crew leader in charge in consultation with the project supervisor and principal investigator and was based on the results of preliminary reconnaissance testing, site topography, surface cultural and noncultural features, and additional shovel esting. Coordinates of test squares located off the initial grid system were determined by triangulation from the nearest two grid stakes. Individual test square elevations were established from the closest grid stake elevation by use of a string and line level. After completion of systematic testing, all reconnaissance level test pits, systematic test squares, and shovel test locations were recorded on the site map.

After the site was mapped and gridded a three-person crew began systematic testing. Frequently systematic testing was initiated adjacent to the test which produced cultural material during reconnaissance level testing. Subsequent 1-m by 1-m squares were laid out to assist in determining the spatial extent of the site and to collect information for evaluating and dating the site. Systematic testing was designed to efficiently collect enough data with which to address site significance. Weighted against this consideration was the question of how much testing is necessary to adequately address this problem. An attempt was made to excavate the minimum number of tests needed to address this problem. The average number of tests placed on a site was four. However, in a few cases, additional tests were necessary because of the low frequency, or in some cases the lack of, cultural material in the initial tests.

Excavation of 1-m by 1-m squares was conducted by natural stratigraphic levels when possible. However, in a few cases soil stratigraphy was not conducive to this method and excavation by arbitrary levels was employed. Careful attention ws paid to the identification of tephras in relation to cultural remains because their relationship provided relative dating and intersite correlation. Test squares were excavated with trowels and all dirt was screened through 1/4-inch screen unless the soil was too wet, in which case it was examined by hand. Artifacts were measured from the south and east walls of each test and vertical measurements were made with string and line level tied to the square datum. When possible, tephra samples and organic material for C14 dating were collected. C14 samples were wrapped in two layers of aluminum foil, placed in plastic bags, and oven dried at the University Museum's archeology lab as soon as possible.

Soil profiles for test squares that produced cultural material were drawn. Soil colors were determined using a Munsell color chart on dry samples. Composite soil profiles were also drawn summarizing soil stratigraphy at the site. Composite soil profiles are included with each individual systematic test report (Chapter 4, 1982 report). All artifacts collected were cataloged and accessioned into the University of Alaska Museum. All test squares were backfilled upon completion of testing, and each site was restored as much as possible to the condition in which it was originally found.

During systematic testing, soil profiles were drawn to scale for all four walls of 1 m test squares which produced cultural material. These profiles are on file at the University of Alaska Museum. For the purpose of the 1982 report, however, only a single composite soil profile was included for each site, or site locus, systematically tested. The composite soil profile is schematic and does not necessarily represent any individual test square at the site. Its intent is to graphically represent the sequences of all soil/sediment units which occur at the site because individual tests often do not contain the full range of soil units at a given site.

No standard technique for drawing a composite soil profile was used because test pit placement and soil deposition at each site varied considerably. The method most often utilized to abstract individual test square soil profiles into a composite site profile was to draw a diagram correlating profiles from all individual test squares. This was usually done by selecting the profile from each test square which revealed the greatest number of distinct soil units, which were drawn to scale with similar sections from profiles of all other test squares. Correlations of soil units between test squares were then matched and a composite site profile drawn by determining the average thickness of each soil unit which occurred at the site and drawing all soil units in their correct stratigraphic sequence.

The thickness of soil units sometimes varies greatly even between adjacent squares, as does the occasional presence or absence of specific soil units. The composite soil profile is a generalized profile. Elevation above or below datum and provenience of artifacts from individual test squares cannot be directly correlated with the composite site profiles. However, in a broad sense, associated soil units and contact between soil units are accurate for each site.

Three distinct tephra have been identified in the study area. These units were given regional names for purposes of field identification and nomenclature. The names given the tephra in order of increasing age are as follows: Devil (1800 - 2300 B.P., A.D. 150 - 350 B.C.), Watana (2300 - 3200 B.P., 350 B.C. - 1250 B.C.) and Oshetna (greater than 4700 B.P., 2750 B.C. and possibly as old as 5000 - 7000 B.P., 3050 B.C. - 5050 B.C.). These ash falls have not yet been correlated to tephra from other regions known to date to the last 7000 years. Munsell color designations were used to describe tephra color. Whenever possible, color matching was done using dry samples. For a more detailed discussion of tephra, see Chapter 5 in the 1982 report. The relationship of cultural components to the tephra are indicated in Chapter 7 of the 1982 report.

2.3 - Methods - Geoarcheology 1980

(a) Literature Review

Prior to the 1980 field season, all published geologic reports were collected and reviewed for information relevant to the study.

This literature survey was updated during 1981. Because specific glacial/climatic studies are not available for the immediate study area, literature for the adjacent regions was heavily relied on. The review concentrated on those areas for which radiocarbon dates were available from meaningful stratigraphic contexts. Because of the relatively high quality of climatic sequences from the Glacier Bay-Boundary Ranges region, southeast Alaska, and Brooks Range, these areas were also reviewed. No attempt was made to review the geologic literature for northern and southeast Alaska.

(b) Geoarcheologic Terrain Unit Mapping

During May of 1980, a preliminary regional map of the Susitna Valley was prepared for a first-order interpretation of the geologic history and terrain-units to be studied by the archeologists. The map extended to at least 10 km and usually 15 - 20 km from the Susitna River. Units, which were defined completely from air-photo interpretation, using 1:20,000 false color infrared U-2 flight lines, were subdivided on the basis of age and surface characteristics. This preliminary map, though not detailed in the immediate vicinity of the Susitna Canyon, was used in the archeologic research design. This map is on file at the University of Alaska Museum.

(c) Field Study

Field studies were carried out during June and August, and relied almost completely on helicopters for logistical support. Four major objectives of the field program were to ascertain ground truth and reinterpret the preliminary regional geoarcheologic map, to carry out a regional stratigraphic reconnaissance, to help interpret and describe significant archeologic sites, and to examine some of the more critical glacial-geomorphologic features in the region near the proposed impoundment area.

(i) Aerial Reconnaissance

The first field objective was to get a regional overview of the Susitna Valley in order to become familiar with the distribution and range in surface landforms and deposits, and to examine the potential for stratigraphic work. In addition, this overview was necessary to examine the mapping done from air-photos in order to test its reliability and accuracy. This reconnaissance was done in conjunction with project archeologists in order to provide collective agreement on the basis for revised mapping. This joint examination allowed the geologist and archeologists to define the map units that best accommodate both needs.

(ii) Stratigraphic Reconnaissance

A second objective was to determine the number and quality of river bluff exposures that might provide stratigraphic information needed to interpret and date the major valley-forming geologic events. After a "fly-by" look at all river bluffs along the Susitna and all of the tributaries from the Chulitna River to the Tyone River, 25 exposures were selected for further study. Those not selected for further study were observed from the helicopters, and only briefly described. At each selected exposure, the entire bluff face was examined and a selected stratigraphic section measured. The sediments were divided into significant natural units, and the character and height of each unit was described above "recent high water" which was used as an altitude datum. Study of each exposure resulted in a detailed sketch and description of units, including the character of the surface above the exposure. In addition to measuring and describing all units, as many as possible were sampled for various reasons. Organic matter in key units was sampled whenever possible for radiocarbon dating. Organic horizons with well-preserved plant macrofossils were sampled for paleobotanical analysis. Some sediment units were sampled to obtain a representative sample of the unit lithology. In addition, many exposures contained one or more volcanic ash layers, which were also sampled (see Chapter 5 in the 1982 report).

(iii) Archeologic Sites

During the 1980, 1981 and 1982 field seasons, the geological examination of archeologic sites was conducted, particularly those that were well stratified. Geologic descriptions of the sediment units and regional relationships at the sites greatly aided in site interpretation.

(iv) Geomorphic Reconnaissance

A final field objective was to examine the landforms within the study area. Major glacial moraines, deltas, lake plains, eskers, and terraces were described and their heights and gradients measured. Most examination was done from the air, but many glacial-geologic features were studied on the ground. Also the geomorphic character of each of the geoarcheologic terrain units within the impoundment area were briefly described from the air.

(v) Revised Geoarcheologic Terrain Unit Mapping

A week was spent refining the earlier preliminary map to make it more detailed and, therefore, more useful for archeological purposes. Twenty-six units were defined and mapped directly on the U-2 images. These photographs are on file at the University of Alaska Museum. During map revision, much more attention was focused on surface relief and drainage characteristics of each unit than on its estimated age. This mapping was done during the field season because the archeologists needed to have the best possible data available for the remainder of the season.

(vi) Data Organization and Compilation

Field data was organized, clarified and tabulated where possible. All short written descriptions were transferred to the 1:63,360 scale base maps. All stratigraphic diagrams and descriptions were redrawn and edited. All samples were double-checked and curated, and a detailed sample list was prepared. All photographs were labeled and keyed to geologic steps and exposures.

(d) Investigation and Dating of Samples

Nine organic samples were submitted for radiocarbon dating, and all have provided good dates for key stratigraphic horizons. One faunal sample of a fossil mammoth(?) was examined and identified by University of Alaska scientists. One paleobotanical sample has been tentatively identified by the herbarium staff at the University of Alaska Museum. One tephra sample has been submitted to Pullman, Washington, for bulk- and trace-element analysis, the results of which are not available at this time.

(e) Methods - Geoarcheology 1981

(i) Geoarcheologic Terrain

Considerable effort was expended to revise the geoarcheological terrain unit mapping during the 1981 field season. This mapping proved very useful for the selection of archeological survey locales.

(ii) Glacial-Stratigraphic Mapping

Portions of the 1981 field season were devoted to continuing investigations of the distribution and extent of past glaciers during late Wisconsin time. To assess this, it was necessary to map older glacial sequences as well. This mapping effort consisted of reconnaissance mapping of glacial limits by helicopter, with numerous ground trips during which the surficial character of the glacial landforms was assessed.

(iii) Archeological Stratigraphy

The major effort of the 1981 field season was devoted to interpreting the geological context of the cultural horizons at numerous archeological sites. All important sites were visited and interpreted in the field by the geologist. Sites that were not visited in the field were interpreted by the geologist on the basis of field drawings and descriptions made by the archeologists.

As part of the archeological stratigraphy effort, a major portion of the geologists' time was spent informing and educating the excavators about the landforms, soils and volcanic ash layers found throughout the study area. The standardization of techniques and descriptions which resulted from numerous instructional situations greatly improved the quality of the resulting data collected by all investigators during the field season.

Following the field season, a final interpretation of the archeological stratigraphy was made by synthesizing over 250 stratigraphic drawings made during the field season. This interpretation was supported by some laboratory investigations. Samples for radiocarbon dating were selected, prepared and sent by the geologist on the basis of their stratigraphic importance, the results and interpretation of which are discussed in Chapter 5 of the 1982 report.

2.4 - Methods - Paleontology

As part of the Cultural Resource Inventory, the paleontology of a non-marine tertiary sedimentary basin exposed along Watana Creek was investigated in order to develop baseline data on paleontological specimens, other than faunal remains, that could possibly occur in an archeological context. The deposits crop out locally along the Susitna River near the mouth of Watana Creek and along the course of Watana Creek and adjacent areas for approximately seven miles upstream. The primary focus of the investigation was to identify and collect a representative assemblage of plant fossils from the exposed stratigraphic section and determine the age of the deposits.

Field study consisted of mapping and sampling of the units comprising the sedimentary deposits.

(a) Fossil Leaves

Many bedding horizons exposed along Watana Creek were noted to contain plant material. A number of these units were not suitable for collection of samples (friable siltstones, etc.); however, units which were considered to be of a nature to yield specimens useful for biostratigraphic studies were extensively sampled. These specimens were accessioned to the University of Alaska Museum, Fairbanks.

(b) Pollen

Coal seams throughout the section were sampled for later laboratory preparation to determine the existence of pollen grains which could be used for further biostratigraphic control. Samples of 200 - 300-g were taken normal to bedding within coal seams greater than 0.5 foot thick. Approximately 30 seams were sampled throughout the section (see Chapter 6 in the 1982 report).

Coal samples were prepared for microscopic examination to determine pollen content at the University of Alaska. Specimens considered to be of quality likely to be of aid in biostratigraphic correlation were photographed and identified.

2.5 - Known Historic and Archeological Sites in the Project Area

(a) Introduction

In addition to archeological investigations, geoarcheological and paleontological studies were conducted in order to provide data which would enhance the location and evaluation of cultural resources within the study area. Prior to and during field studies geoarcheological studies were conducted to provide data that would define the ages of surficial deposits and provide limiting dates for human occupation of the area. Paleontological studies were conducted in order to define the types and range of paleontological specimens that could possibly be found in an archeological context. The results of the cultural resources studies are included in this section. Federal law mandates that site locational data not be released if it may create a risk of harm to the site. Therefore, site location maps are not provided with this application but can be found in Appendix E of the 1982 Report.

Surface reconnaissance, subsurface testing and review of records at the State Office of History and Archeology documented 6 historic and 161 prehistoric sites during the three field seasons of the project. One hundred and one historic period cabins were located and recorded by the land use analysis team (subtask 7.07) under the direction of Dr. Alan Jubenville and are described in that report. Of the 101 historic cabins recorded by the land use study only 12 fell within the archeological study area. Of this number only four were older than the 1950s. These sites were recorded by the cultural resource study team.

Cutural resources were located in 36 (29%) of the 126 survey locales examined. A total of 73 sites were documented for these locales. The remaining 94 sites were located in proposed borrow areas, areas disturbed by geotechnical testing, along proposed access routes and transmission corridors and in other portions of the study area. Sites reported to the archeology study team by other project personnel were subsequently documented even if they were outside the study area for cultural resources. Four sites were originally recorded during a 1978 survey (TLM 015, 016, 017, 018) and one during a survey in 1970 (TLM 007), an additional 9 sites (HEA 026, HEA 030, HEA 035, HEA 037, HEA 038, HEA 080, HEA 083, HEA 119, HEA 137) were reported in the files of the State Office of History and Archeology.

The fact that no sites were located during reconnaissance testing in 90 (71%) of the survey locales could be due to the testing level employed, sampling bias, or the fact that site locational data used for selecting survey locales need to be further refined to reflect specific topographic settings in the Upper Susitna River region. Although it is possible that no sites exist within the limits of these selected survey locales, the fact that testing in 29% of the areas did locate cultural resources suggests otherwise. This is also supplemented by the fact that in 1981 archeological sites were found in three survey locales that were reconnaissance tested in 1980 with negative results. This suggests that increased testing levels will increase the number of sites located and documented.

Survey locales examined were selected based on the application of archeologic, ethnographic, historic, and geologic data compiled and refined prior to and during the 1980, 1981 and 1982 field seasons. Maps depicting these locales are presented in Appendix E of the 1982 report. Specific criteria used for defining and selecting survey locales are discussed in Section 4.4.

The sites documented in 1980, 1981 and 1982, as well as the sites located in 1971 and 1978 are discussed below. Each site summary contains information concerning the setting and the results of reconnaissance testing and systematic testing. Detailed site reports can be found in the 1982 report. Maps showing the location of each site on USGS 1:63,360 scale maps are located in Appendix E of the 1982 report. Artifacts specifically discussed in the text are presented in Artifact Photos A through T at the end of Chapter 3 in the 1982 report.

To avoid confusion, the meaning of certain terms as used in this application are discussed below:

Site: Any location with detectable physical evidence of prehistoric and early historic human activity in the Susitna Valley within the confines of a defined topographic setting. Physical evidence deposited as a result of human activity includes but is not limited to tools, lithic debitage, animal bones, and features (including hearths, house pits, cairns, etc.).

Locus:	One of two or more concentrations of cultural material within a site which is spacially discrete from other concentrations of cultural material.
Scatter:	A concentration or cluster of cultural material at a site or within a locus.
Shovel Test:	A subsurface testing method using a shovel. For this project shovel tests were excavated in each survey locale in 5 cm arbitrary levels and were excavated to at least 50 cm where possible.
Test Pit:	A systematic excavation conducted with a trowel. Tests varied in size depending on the terrain but were usually less than 50 cm x 50 cm. In some cases shovel tests were turned into test pits when cultural material was encountered.
1m Test Square:	The standard excavation unit used during systematic testing.
cmbs:	Centimeters below the surface.
asl:	Above sea level.
I.L.:	Impoundment limit. Used on survey locale maps.
Survey Locale:	One of the 119 areas selected for testing during the 1980 and 1981 field seasons based on the application of archeologic, ethnologic, historic, and geologic data.
Flake:	A fragment of rock culturally removed from a parent rock by percussion or pressure flaking. The remains of lithic tool manufacturing or repair, usually characterized by a bulb of percussion, a striking platform, and radiating ripples or force lines from the point of impact or pressure on the ventral surface.
Retouch:	The occurrence of small flake scars along the edge of a lithic artifact.
Component:	The manifestation of a given archeological phase at a site (Willey and Phillps 1958:21). Sites may be single component (representing only one cultural period) or multicomponent (representing two or more distinct cultural periods).

Level: The vertical subdivision of an excavated unit, generally a naturally deposited stratigraphic unit.

Horizon: In soil science, a natural developmental zone in a soil profile.

Tephra: Solid material ejected during the eruption of a volcano and transported through the air. Three tephras have been identified in the Upper Susitna River Valley.

Sites in this section are listed by area: Watana Dam and impoundment; Devil Canyon Dam and impoundment; proposed borrow areas; and areas disturbed by geotechnical testing, access route and associated borrow areas, transmission lines, and other areas outside the above categories but within the study area.

(b) Watana Dam and Impoundment

(i) Archeological Sites

- TLM 017. The site is located east of Tsusena Creek north of the Susitna River. It is situated on a level bench near the top of a northwest slope which descends to Tsusena Creek. A 180° field of view from the southwest to the northwest encompasses the Tsusena Creek drainage although the creek itself is not visible.

  The site was identified during a brief 1978 survey. No surface artifacts were observed at the site but a single subsurface test produced 372 basalt flakes, a large portion of which were cortex flakes. No diagnostic artifacts were recovered from this test and eight additional shovel tests excavated in 1980 failed to produce additional subsurface cultural material. The 1978 test was reopened in 1980 and an additional 285 basalt flakes were recovered during wall preparation for profiling. Cultural material is associated with the contact between the Watana and Oshetna tephra.

- TLM 018. The site is located east of Tsusena Creek north of the Susitna River near the 1978 Corps of Engineers Camp. Situated on an east-west trending ridge, the site is located on a low knoll which forms one of the highest points of relief along this ridge and affords an expansive view of a broad kettle and kame plain extending northeast of the site. Artifacts have been exposed in large blowouts which occur on the northern slope of this knoll.

  The site was identified in 1978 and 29 flakes and a bifacially flaked triangular basalt projectile point were surface collected. An additional 138 flakes were recovered from the single test at the site. In 1980 the site was revisited and three additional artifacts were surface collected. These included a basalt biface, a chert flake with a blade facet and a chert burin spall. Two distinct lithologies were noted among surface artifacts at the site; basalt flakes concentrated on the southwest side of the knoll and chert flakes on the northwest side.

This site was systematically tested in 1981 and all surface artifacts were collected in 1 m square units. Three 1 m by 1 m test squares were excavated at the site. A total of 1414 surface artifats and 570 subsurface aritifacts were collected. The 1981 surface collection, with the exception of a boulder chip scraper and a chert flake core, is composed totally of flakes, consisting of 1078 chert flakes, 332 basalt flakes, 2 rhyolite flakes and 2 flakes of unidentified material.

Subsurface material found in two of the three test squares consisted of 2 basalt biface fragments, an obsidian core fragement, 3 obsidian flakes, 1 chert blade-like flake, 62 chert flakes and 503 basalt flakes. No diagnostic artifacts were recovered from the test squares. Cryoturbation and poor stratigraphy do not allow the clear division of artifacts into separate components although it appears that an upper component, above the Devil tephra, and a lower component, below the Devil tephra, may be present.

- TLM 026. The site is located north of the mouth of Goose Creek on the north side of the Susitna River. The site is situated at the southwestern point of a peninsula around which the Susitna River forms a tight bend. The view both downriver and upriver from the site is excellent for a distance of 3 to 4 km.

The site consists of both surface and subsurface cultural material. Surface artifacts exposed at the top of an eroded bank overlooking the Susitna River consisted of a chert end-scraper, 2 chert flakes and a rhyolite flake. Three test pits and seven shovel tests excavated during initial reconnaissance testing in 1980 did not reveal subsurface cultural material. Continued reconnaissance testing in 1981 involved systematic shovel testing along east-west transects. Eighty-five additional shovel tests were dug, only one of which revealed cultural material consisting of 134 burned bone fragments. This shovel test was not expanded into a test pit and consequently the stratigraphic position of the faunal material is uncertain, although it appeared to be associated with the A horizon directly below the organic mat.

- TLM 033. The site is located downriver from the mouth of Kosina Creek on the north side of the Susitna River near the outlet of a small lake. Situated on the point of a flat terrace, the site overlooks the lake outlet stream. The view from the site is best to the west and northwest overlooking a lower terrace and the stream drainage. The stream itself and its confluence with the Susitna River is not visible.

  There is no surface indication of a site at this location. A total of three test pits and one shovel test were dug during reconnaissance level testing. The only artifact recovered was a brown chert biface fragment of uncertain provienence stratigraphically since it was found during shove testing. Systematic testing at the site included the excavation of six 1 m by 1 m test squares and five shovel tests. No additional cultural material was recovered. Extensive soil movement due to solifluction was noted during systematic testing.

- TLM 039. The site is located on the western margin of a lake east of the mouth of Watana Creek on the north side of the Susitna River. It is situated at the highest elevation of a knoll at the southwestern end of the lake and is the highest point on the perimeter of the lake. The view from the knoll is panoramic, encompassing the entire lake margin.

  No cultural material was observed on the surface. Reconnaissance level testing involved the excavation of three test pits, only one of which revealed subsurface cultural material. A burin spall and 14 quartzite flakes were recovered from this test. Subsequent systematic testing consisted of three 1 m by 1 m test squares all of which produced cultural material. One obsidian and two black chert microblade fragments, along with a tuffaceous flake core fragment and 45 waste flakes were recovered during systematic testing. Lithologies present include basalt, quartzite, chert, tuff and rhyolite. A single fire cracked rock was recovered. Charcoal was present in association with the cultural material. The site appears to be multi-component with a component above the Devil tephra and another component at the contact between the Watana and Oshetna tephra.

- TLM 040. The site is located downriver from the mouth of Kosina Creek on the southern margin of the Susitna River. It is situated on an old river terrace approximately 30 m from the river margin. The view is obstructed in all directions by vegetation although the river is visible through the trees.

There is no surface indication of a site at this location. A shovel test produced a jasper blade-like flake with retouch along two margins and a tuffacious flake. This shovel test was enlarged into a test pit and an additional test pit was also excavated. No additional artifacts were recovered during reconnaissance testing although charcoal was noted in one of the test pits.

Systematic testing of this site included the excavation of five 1 m by 1 m test squares and 10 shovel tests. Lithic material of obsidian, basalt, chert and rhyolite was recovered from three of these five test squares. None of the shovel tests produced cultural material. A total of 182 lithic artifacts were recovered during systematic testing. Artifacts recovered included 22 obsidian microbalde fragments, 4 obsidian blade-like flakes, one chert blade fragments, a possible chert graver, a chert scraper, a rhyolite boulder chip scraper, a chert flake core fragment, a chert core/chopper tool, 29 obsidian flakes and 130 additional flakes of basalt and chert. More than one component appears to be present at this site; however, frost action has mixed the cultural material stratigraphically. Osidian and basalt lithic material including microblades are distributed through seven of the thirteen soil units recognized at the site; whereas the gray-banded chert appears to be associated within or below the Oshetna tephra. Cultural material was recovered from below, within and at the upper contact of the Oshetna tephra and above the Devil tephra.

- TLM 042. This site comprises two loci (A, B) and is located on the north side of the Susitna River on a peninsula across from the mouth of Goose Creek. Both loci are situated on the southeastern crest of a high river terrace which forms the peninsula around which the Susitna River makes a tight bend. Eroded bluffs form the northwest and southeast banks of this terrace; however, the top is relatively level and varies between 100 m and 300 m in width.

Both surface and subsurface cultural material was recovered from this locus. One basalt and one siltstone biface fragment were surface collected, along with two siltstone blade-like flakes and 25 siltstone and basalt flakes. Approximately half of the surface lithic material observed exposed in the eroding bluff edge was collected during the reconnaissance level testing. Two test pits were excavated at the top of the slope, one of which produced five additional siltstone flakes and two siltstone blade-like flake fragments just below the organic horizon.

Three of five test squares and one of four shovel tests dug during systematic testing of this locus yielded cultural material. A total of 151 lithic artifacts and three bone fragments were collected from both surface and subsurface areas of the locus. Soil stratigraphy was dominated by solifluction features and the bulk of the artifacts was collected from the eroding bluff face. Systematic testing yielded three retouched siltstone flakes and one possible siltstone graver in addition to 130 siltstone, 15 basalt and 2 rhyolite flakes. Lithic and faunal material, both in the test squares and in the surface flakes scatters was uncovered in the upper organic-rich layers or an underlying yellow-brown oxidized zone. No diagnostic artifacts were found and the recovered faunal remains were to fragmentary for identification.

Locus B also consists of both surface and subsurface cultural material. Surface artifacts collected during the reconnaissance testing of the site included a side-notched basalt point base, a retouched chert flake, a basalt flake core fragment and a chert flake. Of two test pits excavated at the edge of the eroding fluff face, one produced a basalt endscraper fragment.

Systematic testing at Locus B consisted of excavating six 1 m test squares and one test pit. Five of the six test squares yielded cultural material consisting of 109 flakes, 1 point base, 4 fire-cracked rocks and 5 unidentified bone fragments. Cultural material was recovered from the organic horizon and above the Watana tephra. A radiocarbon determination on charcoal from above the Watana tephra resulted in a modern date (DIC-2282).

- TLM 043. The site is located downriver from the mouth of Watana Creek on the north side of the Susitna River. It is situated west of a tributary creek that joins the Susitna River from the north. Located approximately 400 m north of the river margin, the site sits on a river terrace in a relatively flat open area. The view is restricted to approximately 30 m in all directions by trees which limit visibility to the immediate clearing in which the site is located.

No cultural material was observed on the surface. Reconnaissance level testing consisted of three test pits, two of which revealed subsurface faunal material. A dense concentration of bone fragments directly below the organic horizon yielded 48 long bone fragments, 1 rib fragment, 3 phalanges identified as caribou (Rangifer tarandus) and approximately 380 very small bone fragments too small to identify. No lithic artifacts were recovered during reconnaissance testing.

Systematic testing included the excavation of six 1 m by 1 m test squares and eleven shovel tests. Cultural material was recovered from the upper two organic soil units above the Devil tephra, and consisted of 17 chert flakes, 36 fire-cracked rocks, and burned and unburned bone including 32 large fragments and a large quantity of very small fragments. All cultural material appears to be from a single occupation of the site. None of the shovel tests produced cultural material and no diagnostic artifacts were recovered.

- TLM 048. The site is located at the northern end of a lake east of Watana Creek and north of the Susitna River. Situated at the top of a 20 m high rounded knoll, the site overlooks the lake outlet stream. The view encompasses the outlet stream, the entire northern margin of the lake and a low marshy area to the northeast where the lake outlet stream joins a small slow-moving creek.

  No cultural material was observed on the surface at the site location. Three shovel tests and two test pits were dug during reconnaissance testing with only one of the test pits producing cultural material. A gray chert biface fragment was found in one of the initial shovel tests associated with the lower tephra. This shovel test was expanded to a test pit but no additional cultural material was recovered.

  Systematic testing included the excavation of five 1 m by 1 m test squares four of which contained cultural material. Two components were recognized during systematic testing. The one component above the Devil tephra was represented primarily by a hearth feature containing over 1000 bone fragments and more than 300 fire-cracked rocks. Nine flakes of chert, basalt and quartzite, showing evidence of heat spalling, and a flake core were associated with this hearth. The second component associated with the Oshetna tephra was represented by a single microblade fragment of tuffaceous rock and 12 flakes of chert, rhyolite and tuffaceous rock. The second component is definitely associated with the Oshetna tephra but because of cryoturbation it is not clear whether it is associated with the upper or lower contact of this tephra.

- TLM 050. The site is located upriver from the mouth of Watana Creek near the mouth of an unnamed creek which joins the Susitna River from the northeast. The site is situated on a small alluvial bench on the east bank of the creek approximately 40 m upstream from the creek mouth. The view is limited to the immediate vicinity of the site by dense vegetation, although the Susitna River is visible through the trees.

No cultural material was observed on the surface at this site. Only one of three test pits excavated during reconnaissance level testing revealed cultural material. A concentration of charcoal associated with burned bone and 34 thermally fractured rocks was found between 14 and 30 cms below the surface between the organic mat and a yellow sand. Over 200 burned bone fragments were recovered including three phalanges and two metatarsal fragments identified as caribou (Rangifer tarandus). One tibia fragment identified as possible caribou (Rangifer tarandus) was also recovered. One of the unidentified bone fragments recovered exhibits a distinct butchering mark. No lithic material other than fire-cracked rock was recovered during reconnaissance testing. A radiocarbon determination of 280 $\pm$ 110 years: A.D. 1670 (DIC-1905) was obtained on a charcoal sample.

Systematic testing of this site included the excavation of six 1 m by 1 m test squares and five shovel tests. All five test squares produced cultural material with faunal material, thermally fractured rock and lithic material recovered from two levels of the site. Nineteen flakes and 105 fire-cracked rocks were recovered. Cultural material was associated with a dark brown silt and a very dark brown silt. These two units are separated by a dark grayish brown poorly sorted sand. No diagnostic lithic artifacts were recovered.

- TLM 058. The site is located on a terrace north of the Susitna River downriver from the mouth of Watana Creek and 100 m east of an unnamed creek.

No surface artifacts were observed. A shovel test subsequently widened into Test Pit 1 revealed a black chert flake, two brown chert flakes (one with bifacial end retouch), and a white chalcedony flake. The lithic material is associated with the contact of the humic zone and the Devil tephra. Six additional shovel tests and an additional test pit failed to reveal further cultural material at the site.

- TLM 059. The site is located east of an unnamed creek between the Watana and Deadman Creek drainages, north of the Susitna River. The site is situated on a low rounded knoll which is part of a series of kame ridges which line the eastern boundary of the creek drainage to the west.

The site, discovered during reconnaissance testing and later systematically tested, consists of a rectangular depression at the top of the low rounded knoll. The dimensions of this depression are 2 x 1.8 m across and 35 cm deep. Around the depression is a diffuse berm which is slightly higher than the surface of the knoll top. Test Pit 1 was placed along the southern interior edge of the depression; and decayed logs, charcoal, burned and unburned bone fragments, and some possible fire-cracked rock were observed. Test Pit 2 placed 7.5 m to the northeast of the feature but was sterile, and Test Pit 3 placed 2.1 m west of the feature revealed one small burned bone fragment at the contact of the humic zone and the Devil tephra. Eleven additional shovel tests were dug around the base of the knoll but all were sterile.

Systematic testing of the site involved excavating three 1 m by 1 m test squares, as well as further testing in Test Pit 1. A radiocarbon date on charcoal collected from the charcoal and burned bone level produced a date of 440 ± 70 years: A.D. 1510 (DIC-2253). The depression truncates all three tephra units as indicated by the testing of the berm during systematic testing. The cultural debris outside the depression is characterized by a gravelly sand unit above the Devil tephra which contains some burned bone fragments and a single chert flake. The identifiable faunal material within the feature has been identified as caribou (Rangifer tarandus).

- TLM 060. The site is located on the northern shoulder of the Susitna River canyon west of the mouth of Watana Creek and west of a major unnamed tributary. It is situated on the highest end of a 100 m long ridge.

  The site consists of both surface and subsurface material. A black chert biface fragment was surface collected from an exposed soil slump but no other surface material was observed. Eight shovel tests were placed along the ridge top; one of which revealed a subsurface artifact. This shovel test was expanded into a test pit but no additional artifacts were found. The subsurface artifact was a light olive brown tuff flake with possible retouch along one margin. The flake was found in association with the Devil tephra. Two additional test pits failed to reveal further cultural material.

- TLM 061. The site is located west of Watana Creek on the northern shoulder of the Susitna River canyon. The site is situated at the top of a 20 m high kame knoll which is the highest point of land for 300 m in the vicinity of the site. To the east of the site is a clearwater stream and to the west lies a 1 hectare kettle lake.

  No cultural material was observed on the surface of the knoll but a shovel test near the center revealed charcoal and burned bone during reconnaissance testing. The expanded test revealed a total of 300 burned mammal bone fragments, 15 pieces of fire-cracked rock, and a quantity of charcoal. The material was present in two distinct soil horizons any may represent a multi-component site. A total of 9 shovel tests, one of which was expanded into a test pit, were excavated at the site. Seven of these produced cultural material including the test pit. One soil sample containing bone fragments, 15 fire-cracked rock fragments, 1 basalt flake, and 3 pieces of red ochre were collected during reconnaissance testing. Identified faunal material collected from Test 1 represented caribou (Rangifer tarandus). Cultural material was found above the Devil tephra.

- TLM 062. The site is located on the south margin of the Susitna River west of the mouth of Kosina Creek, on a relatively flat river terrace 50 m above the level of the Susitna. The terrace point is the highest and most prominent landform in the immediate vicinity of the site.

  Eight shovel tests were dug at the site during reconnaissance testing, one of which was expanded into Test Pit 1 when a chert core was recovered. Test Pit 1 revealed two red jasper end scraper fragments which articulated to form a complete tool. These artifacts were associated with the Devil tephra and appear to be from the same stratigraphic context.

  The site was chosen for systematic testing and a total of six 1 m by 1 m test squares were excavated. An additional 49 shovel tests were dug to delineate site boundaries. Two and possibly three archeological components are present at the site. Chert and basalt flakes and burned bone fragments were associated with the Devil tephra and basalt flakes and burned bone fragments were associated with the Oshetna tephra. A third component may be present in the Watana tephra, but the cultural material recovered from this tephra unit may represent mixing due to cryoturbation. A total of 180 basalt flakes, 1 basalt biface, and 4 basalt retouched flakes were recovered during systematic testing. Twenty-five shert flakes and over 1600 burned bone fragments were also recovered.

- TLM 063. The site is located southeast of the Susitna River and southeast of Watana Creek mouth. It is situated on top of a 20 m high, steep-sided, isolated kame knoll. The kame knoll is part of a low glacial outwash terrace. Numerous small streams and a one-hectare kettle lake are located within 300 m of the site.

  No cultural material was observed on the surface of the knoll and only one of eleven shovel tests revealed cultural material during reconnaissance testing. This test was expanded into a test pit, and ca. 700 small burned bone fragments and one jasper flake were collected.

- TLM 064. The site is located on the south side of the Susitna River southeast of the mouth of Watana Creek. Two site loci (A, B) are located on two knolls ca. 90 m apart on a northeast-southwest axis. A small lake and a clear-water tributary are located within 500 m of the site.

  The site contains both a surface lithic scatter and subsurface lithic material. A total of 5 shovel tests and 2 test pits were excavated at the site. Artifacts collected from the surface of the site consisted of 12 basalt flakes and 1 quartz flake. Additional basalt flakes were observed but not collected. Test Pit 2 revealed one brown rhyolite flake and a basalt projectile point base associated with the contact between a black humic soil and the Devil tephra.

- TLM 065. The site consists of two loci (A, B) located on a broad terrace south of the confluence of Kosina Creek and the Susitna River. The terrace is demarcated by a creek drainage to the east.

  The site was discovered during reconnaissance testing and was later systematically tested. Locus A is characterized by a rectangular depression 2.3 m by 2.7 m by 30 cm oriented north-south, a circular depression 1 m in diameter, and an area 2 m by 5 m of sedges, moss and grass comprising a discontinuity in the general site vegetation. None of the features were tested during reconnaissance testing but a 40 by 40 cm test within 6 m of the main feature revealed bone and fire cracked rock located beneath the vegetal mat. Locus B consists of a single circular depression 43 cm in diameter and 20 cm deep which was tested during reconnaissance survey and two unburned innominate fragements of caribou (Rangier tarandus) were collected.

  Systematic testing of the site included excavating four 1 m by 1 m test squares. One test bisects the circular depression at locus A where six bone fragments, one piece of wood, one blue glass bead, three fire-cracked rock fragments, and a sheet of birch bark were recovered. Another test square was positioned to bisect an apparent wall of the rectangular feature. Heavily decayed wooded logs ran parallel to the embankment which may represent wall structures of a house depression. Eight glass beads and four fire-cracked rocks were collected from this unit. Other test squares at the site revealed additional glass beads, flakes, bone fragments, and fire-cracked rocks. Cultural material was found above the Devil tephra.

- TLM 072. The site, a large circular depression, is located northwest of the mouth of Jay Creek. The site is situated at the southwestern end of an isolated low rounded ridge which parallels the general slope of the valley wall.

  The circular depression is 90 cm deep and measures 4.2 m by 4.5 m across. Seven shovel tests were excavated around the outside of the pit, only one of which produced cultural material: large pieces of burned wood and charcoal. An eighth shovel test was begun near the center of the depression and a complete unburned moose metacarpal was exposed in the vegetative mat at the bottom of the pit. This was left in place and the test was discontinued so that that integrity of the feature would be intact until further testing could be carried out. The depression truncates the Devil tephra.

- TLM 073. The site is located east of the Oshetna River and south of the Susitna River on a northwest-southeast oriented river terrace.

  No surface artifacts were observed at the site, but two test pits and one shovel test revealed subsurface lithics during reconnaissance testing. Twelve basalt flakes, 2 brown chert flakes, 2 rhyolite flakes, 1 cryptocrystalline flake, and 1 flake of undetermined lithology were recovered from as many as five soil units. These are: the contact of the Oshetna tephra and the glacial drift; within the Oshetna tephra; at the contact of the Watana and Oshetna tephra; within the Watana tephra; and at the contact of the decomposed organic layer and the Devil tephra.

- TLM 075. The site is located on the south side of the Susitna River southwest of the mouth of Jay Creek. It is situated on a knoll which is part of a ridge system on the north facing slope of the river valley.

  The site comprises two areas of subsurface lithic artifacts; no surface indications were observed at the site during reconnaissance testing. Test Pit 1 produced a black chert flake and a possible black chert core tablet from the contact of the humic mat and the Devil tephra. Test Pit 2 produced two pale brown pyrolite flakes from the Watana tephra.

- TLM 077. The site is located south of the confluence of Kosina Creek and the Susitna River. It is situated on the southern end of an esker which runs north-south across the present Susitna floodplain. The site is located on the highest point of the esker, 5 m above the floodplain.

No surface artifacts were observed at the site during reconnaissance testing. Test Pit 1 produced one basalt flake below the Oshetna tephra at the contact with the glacial drift. Another flake was discovered in the backdirt of the initial shovel test. Five additional shovel tests were excavated but failed to produce further cultural material.

- TLM 102. The site is located on the western end of a ridge crest on the northern side of the Susitna River, downriver from the mouth of Kosina Creek.

  No surface artifacts were observed at the site. A black chert waste flake was found in the backdirt of a shovel test which was then expanded to become Test Pit 1. Three additional waste flakes were located in Test Pit 1. One black chert waste flake was located just beneath the humic mat at the contact of the Devil tephra unit. Two additional flakes were recovered from the Watana tephra unit.

- TLM 104. The site is located northwest of the confluence of Watana Creek and the Susitna River. The site is situated on the south slope of an esker ridge which curves around the northern edge of a 2-hectare lake.

  The site consists of a rectangular depression (Feature 1) of horizontal dimensions 1.4 m by 1.2 m and 65 cm deep. A diffuse berm is visible around the perimeter of the depression. Test Pit 1 was placed 70 cm from the feature and revealed charcoal and partially burned wood in a sand and gravelly matrix beneath the moss cover. Two rib fragments from a large mammal were recovered from the charcoal-wood-sand unit above the Devil tephra. Four additional shovel tests were placed within 20 m of Feature 1 but all were sterile.

- TLM 115. The site is located on a flat bench which occurs on a sinuous finger ridge which descends to the north side of the Susitna canyon northwest of the Kosina Creek mouth. The sides of the bench slope steeply into a tributary ravine to the east and the Susitna canyon to the south. The site is at a point of high relief which overlooks adjacent irregular and deeply incised canyon slopes, the south side of the river valley, and the river bottom, despite some obstruction by present vegetation.

  No surface cultural material was observed at the site. One black basalt projectile point biface was found in place in the sod plug of a shovel test in the Oshetna tephra near its lower contact with glacial drift. Five other shovel tests on the bench failed to produce further artifactual material.

- TLM 119. The site is located on the north side of the Susitna canyon southeast of Watana Creek mouth on a finger ridge which is roughly perpendicular to the river. The east side of the ridge is defined by a deep ravine. The site occurs at a relatively flat point of high relief on the ridge crest. Present vegetation obscures the field of view from the site.

  A diffuse surface lithic scatter was observed at the site on a deflated surface and on a nearby game trail. Three chert flakes were surface collected, and two basalt flakes were observed on a game trail but not collected. One shovel test produced a single subsurface chert flake occurring in a silty-sandy matrix with finely divided organics immediately below the vegetation mat and above a discontinous layer of pure charcoal overlying the Devil tephra. Two test pits, one superimposed on the positive shovel test, were excavated but no additional artifactual material was found.

- TLM 126. The site is located north of the Susitna River and northeast of the Watana Creek mouth of a ridge crest. To the south, east and west, the sides of the ridge drop moderately steeply to marshy ground. To the north, the ridge merges into high ground with further ridge systems. With some obstruction due to present vegetation, the field of view from the site is panoramic, including boggy ground to the edge of the Watana Creek canyon to the west, kame terrain to the south and east, and rising terrain to the north.

  No surface indication of the site was observed. One white rhyolite and one light gray cryptocrystalline flake were found in a test pit, but their stratigraphic provenience is uncertain. They appear to have come from below the Devil tephra and above the glacial drift. No additional artifactual material was found during the excavation of two shovel tests and the examination of soil exposures on the ridge.

- TLM 137. The site is located northeast of the Tsusena Creek mouth near the southeastern end of Seismic Line 82-A on the summit of a discrete kame which is the highest of the small set of kame ridges and knolls which abut the eastern slope of the Tsusena Creek drainage in the vicinity. Field of view from the site encompasses neighboring ridges and knolls and gradually westward descending terrain to the north and northwest, as well as gradual north-facing slopes to the south.

No surface indication of the site was observed. A brown chert flake was found in a shovel test, which was expanded into a test pit which produced a small basalt flake from a lens of coarse sand in a disturbed stratigraphic context. Six other shovel tests on the kame produced no further artifactual material.

(ii) Historic Sites - Results and Discussion

- TLM 079. The site, a trapper's line cabin complex built by Elmer Simo in the mid-1930s is located on a low alluvial plain east of the confluence of Jay Creek and the Susitna River.

  The site consists of a cabin, three outbuildings, a tree cache structure, a garbage dump and associated historic debris. The cabin is a one room (13 by 9 ft.) structure built of horizontally stacked spruce logs. A few supplies present inside the cabin are probably from the late 1950s-1960s and consist of cooking utensils and cans. The cabin is sparsely furnished but is in relatively good condition overall. Outbuilding #1 is an outhouse; Outbuilding #2 is a storage shed but is collapsed and overgrown with vegetation. Outbuilding #3 is probably a dog kennel but has been destroyed by flooding. The tree cache is dilapidated but consisted of two 11-foot vertical beams and a 7-foot long horizontal crossbeam. A deposit of historic debris was found northeast of the cabin including such items as plastic, a sleeping bag, cans, as well as a sheet metal stove and oven.

- TLM 080. The site is a historic trapper's line cabin located on the south side of the Susitna River, east of the mouth of Watana Creek. The cabin is situated on a low flat, poorly drained alluvial terrace 40 m east of a small braided stream. The cabin has one room (7 x 10 feet) and a dirt floor. The structure is built of horizontal moss-chinked spruce logs. Interior furnishings are sparse. A built-in bunk, a low bench, two shelves, a table made of wooden boxes, a rusted stove and pipe make up the furnishings. No outbuildings or historic debris were observed outside the cabin.

(c) Devil Canyon Dam and Impoundment

(i) Archeological Sites - Results and Discussion

- TLM 022. The site is situated east of the confluence of Tsusena Creek with the Susitna River. Located on an alluvial terrace overlooking the creek, the site affords a view of both the north and south banks of the Susitna River for approximately 800 m to the west.

There are no surface indications of a site at this location. Reconnaissance testing consisted of one test pit and four shovel tests which revealed charcoal and burned bone associated with a hearth and fire-cracked rock. Fifty-one burned bone and tooth fragments were collected. Two phalanx fragments were identified as caribou (Rangifer tarandus) and one canine tooth fragment as possibly bear (Ursus spp.). Radiocarbon determinations on charcoal produced modern dates (DIC 1879, DIC-2252).

Systematic testing included the excavation of five 1 m by 1 m test squares and five additional shovel tests. Two components, both represented by hearth features with associated faunal material, were identified. Most of the faunal material (487 pieces) was too fragmentary for identification; however, five phalanges and a portion of a mandible were identified as caribou (Rangifer tarandus). Sixty-two fragments of fire-cracked rock were recovered. No lithic artifacts were recovered. Deposition at the site is fluvial and tephras are not present in the stratigraphy.

- TLM 024. The site is located in proposed Borrow Area E and within the Devil impoundment, northwest of the mouth of Tsusena Creek. It is situated at the end of a ridge overlooking an alluvial terrace to the south. The view from the site is presently restricted by a dense stand of mixed spruce and birch.

  There is no surface indiction of a site at this location; however, a shovel test produced a single basalt cortex flake. Three additional shovel tests and two test pits failed to reveal cultural material. The site is restricted topographically to a small bench below the point of the ridge. The provenience of the basalt flake was uncertain and it is not possible to relate this artifact to the tephra deposits which are present at the site.

- TLM 027. The site is located on the south shore of the Susitna River at the mouth of an unnamed stream which joins the Susitna River upriver from the mouth of Fog Creek. Because the site is situated on the summit of a discrete knoll the view from the site is excellent in all directions except to the south where it is obstructed by dense tree growth. Below the site there is evidence of terracing by the Susitna River.

  Testing at this site included both reconnaissance and systematic testing. No surface artifacts were observed at the site. Three test pits excavated during reconnaissance testing produced 29 light green tuffacious flakes (7 with retouch), 1 tuffacious core and 5 basalt flakes. Systematic testing, consisting of three 1 m by 1 m squares, produced 199 basalt flakes, 5 basalt flakes with cortex, 2 basalt biface fragments, 1 retouched basalt flakes, 1 basalt fragment, 196 tuffacious flakes, 7 tuffacius blades, 5 possible tuffacious blades, 5 tuffacious microblades, 3 tuffacious uniface fragments, 1 tuffacious core, 1 possible tuffacious core tablet, 40 chert flakes, 1 obsidian flake, 1 cobble and 12 flakes of undetermined material type. The site contains several components with artifacts occurring below the Oshetna tephra, at the contact between the Oshetna and Watana tephra, and above the Devil tephra.

A radiocarbon determination of 3210 $\pm$ 80 years: 1260 B.C. (DIC 2286) was obtained on charcoal associated with artifacts at the contact between the Watana and Oshetna tephra deposits.

- TLM 029. The site is located upriver from the mouth of Fog Creek at the mouth of an unnamed stream which joins the Susitna River from the east. The site is situated at the edge of an alluvial terrace on the south side of this stream and overlooks the mouth of the stream. Both the Susitna River and the stream are visible and easily accessible from the site. The view is blocked to the east by topography and somewhat restricted in other directions by fairly dense black spruce.

  There is no surface indication of a site at this location. Four shovel tests and one test pit were excavated. Only the test pit revealed cultural material. A total of 224 flakes were recovered from this test pit and included 213 basalt flakes, 10 chert flakes and 1 chalcedony flake. No diagnostic artifacts were recovered. The site appears to be single components with cultural material occurring at the contact between the Devil and Watana tephra.

- TLM 030. The site is located on the south margin of Fog Creek upstream from the confluence of Fog Creek and the Susitna River. It is situated on the point of an alluvial terrace overlooking Fog Creek. The view is primarily northeast up Fog Creek and west down Fog Creek to the mouth, encompassing a distance of approximately 1.5 km. Visibility in other directions is limited by topography and dense spruce forest.

  The site contains both surface and subsurface cultural material. A side-notched basalt point was surface collected from a game trail that traverses the site. Other observed surface flakes exposed in the game trail were left in place. A total of five test pits were excavated, four of which produced cultural material. Over 500 flakes and 6 tools are included in the assemblage from the site. Diagnostic artifacts associated with charcoal concentrations include a side-notched basalt biface (backed knife), a side-notched point base of chert, 3 basalt blade-like flakes, a basalt blade core fragment and a large argillite blade-like flake. Artifacts occur above the Devil tephra, within the Watana tephra, at the contact between the Watana and Oshetna tephra and below the Oshetna tephra. A radiocarbon determination of 2310 + 220 years: B. C. (DIC-1877) was obtained on charcoal associated with flakes in Test 1. Charcoal from Test 4, also associated with flakes produced a radiocarbon determination of 4730 ± 130 years: 2700 B.C. (DIC-1880).

- TLM 034. The site is located downriver from the mouth of Fog Creek on the west side of the Susitna River on the crest of a low ridge 30 m northwest of a small pond. Scattered spruce and birch cover the slopes of the ridge restricting the view to the immediate vicinity of the site.

  There is no surface indication of a site at this location. Two test pits were excavated, one of which produced 2 rhyolite flakes, including the proximal end of a blade-like flake. Both flakes were excavated from the same soil unit, a brown mottled silt directly under the humus. Additional shovel testing along the ridge away from the immediate vicinity of the site did not produce additional artifacts.

(ii) Historic Sites - Results and Discussion

- TLM 023. The site, a collapsed trapper's cabin, is located in proposed Borrow Area E, west of the mouth of Tsusena Creek, at the mouth of an unnamed creek which joins the Susitna River from the north. The cabin remains, not visible from the river, are located on a relatively flat alluvial terrace 50 m east of the braided mouth of the creek.

  The fallen wall logs are partially decomposed and covered with soil and vegetation. The ground in the immediate vicinity of the cabin is littered with historic cultural debris including the remains of a dog sled. One glass jar was collected and all other historic artifacts were left in place. There is no evidence of outbuildings or a cache in the area. None of the four shovel tests excavated at the site produced cultural material. This cabin may be a line cabin used by Oscar Vogel in the 1930s and 1940s.

(d) Proposed Borrow Areas, Associated Facilities, and Areas Disturbed by Geotechnical Testing

(i) Archeological Sites - Results and Discussion

- TLM 035. The site is located upstream from the mouth of Tsusena Creek on the west side of the creek. It is situated on the point of an older river terrace west of Tsusena Creek. Except for isolated openings in the tree cover, the view in all directions is severely restricted by the existing vegetation and obstructed to the north by intervening topography.

  There is no surface indication of a site at this location. Two of three test pits excavated at this site produced cultural material. Two waste flakes, one of rhyolite and one of basalt, were recovered from these test pits. The cultural material was associated with the contact between a dark brown silt and a gray silt (Devil tephra). No diagnostic artifacts were recovered.

- TLM 068. The site is located on the southeastern slope of a low knoll on the crest of a discontinuous end moraine at the northern terminus of a 2 km wide U-shaped valley east of Stephan Lake.

  The site consists of a surface lithic scatter exposed on the deflated slope of the moraine as well as isolated surface lithics located a long the moraine crest to the north of the main lithic concentration. Artifacts that were collected during reconnasisassance testing include 1 black chert projectile point, 1 burinated gray chert flake, 1 gray chert biface, 1 black chert knife, 1 black chert flake and 1 whitish-gray flake.

- TLM 070. The site is located east of Stephan Lake at the northern end of a 2 km wide glacial valley which is oriented north-south. It is situated on the deflated summit of a low knoll which is part of a lateral moraine system on the eastern side of the glacial valley.

  The site consists of a surface lithic scatter exposed at the summit of the knoll. A gray chert endscraper, two light gray rhyolite flakes, and a black chert flake were surface collected from the exposure during reconnaissance testing. Subsurface testing at the site failed to reveal any additional cultural material.

- TLM 082. The Black River Moraine site consists of two loci (A, B) located on top of a moraine north and parallel to the Black River, upstream from its confluence with the Oshetna River.

  Surface reconnaissance of the moraine resulted in the collection of four out of a total of the seven flakes observed. The material was found in two concentrations located 171 m apart along the axis of the northeast-southwest oriented moraine. A test pit was excavated at each of the two loci but no subsurface cultural material was observed.

- HEA 177. The site consisting of three loci (A, B, C) is located on the east side of a northeast-southwest trending lateral moraine east of where Butte Creek leaves Butte Lake. The top of the moraine offers an unobstructed panoramic view of the large lake plain to the north, Butte Lake to the west and upland hills to the south and southwest.

  Of the two test pits excavated at the site during reconnaissance testing only Test Pit 1 produced cultural material, 1 chert flake. Surface cultural material was present at all three loci and collectively consisted of 1 dark gray chert flake, 25 gray chert flakes, 2 gray chert rocks, and 1 gray chert tabular core.

- HEA 178. The site is located on a moraine running east-west along the north edge of a kettle lake located northeast of the north end of Butte Lake and consists of two loci (A, B). The view from both loci is panoramic.

  The one test pit at locus A excavated at the site during reconnaissance testing did not produce any cultural material. All cultural material collected at the site was collected on the surface and collectively consisted of 4 rhyolite flakes, 23 chert flakes, and 1 basalt blade-like flake with retouch.

- HEA 179. The site is located north of the Denali Highway southeast of the intersection of Canyon Creek and the highway. The view from the site is unobstructed to the northwest, north, and east overlooking the extensive southern drainage of the Alaska Range.

  The one test pit excavated at the site during reconnaissance testing did not produce any cultural material. The only artifact collected at the site was a black chert flake recovered in a blowout.

(ii) Historic Sites - Results and Discussions

None located to date.

(e) Proposed Access Routes and Associated Borrow Areas

(i) Archeological Sites - Results and Discussion

- TLM 051. The site is located near the southeastern boundary of proposed Borrow Area F, east of Tsusena Creek. It is located in kettle and kame topography near the top of the highest knoll in an area of numerous knolls and ridges. Approximately 17 lakes and ponds are located within 1 km radius of the site. The site location provides a view of many of the kettle lakes in the area but the principal view is of a 7 hectare lake with a long finger extending to the northwest.

  No cultural material was observed on the surface. Only one of five reconnaissance level test pits excavated at the site produced cultural material. Five tuffascious rhyolite flakes, one of which exhibits retouch along one margin, were recovered from this test.

- TLM 098. The site is located near the center of an elongated knoll east of a major northern tributary of Deadman Creek and north of the confluence of two streams.

  The site is a surface lithic scatter consisting of two patinated gray chert flakes, one of which was collected. Additional surface reconnaissance and the excavation of a test pit in the vicinity of the surface artifacts failed to reveal cultural material.

- TLM 099. This two loci (A, B) site is located on two adjacent knolls southwest of Deadman Lake and north of the confluence of Deadman Creek and one of its northern tributaries.

  Fourteen black flecked gray rhyolite flakes were located on the surface of locus A, three of which were collected. Two flakes were found at locus B: a white patinated chert flake and a black basalt flake; both were collected. A test pit at each locus failed to produce subsurface cultural material.

- TLM 101. The site is located on the southern edge of a large terrace, north of Devil Creek mouth on the east side of the creek.

The site consists of a single banded chert flake located on the surface of a gravel exposure on the southern end of the terrace. Test Pit 1 revealed no subsurface cultural material and further reconnaissance survey of the exposures failed to reveal any further cultural material.

- TLM 106. The site is located on a prominent knoll located centrally along an esker overlooking the valley of a creek which flows southeast into the Susitna River, east-southeast of Swimming Bear Lake. The site location affords a panoramic view of the creek valley to the east, south and southwest. To the north the uplands are clearly visible.

  One test pit was excavated during reconnaissance testing at the site. However, the only artifact recovered was a gray chert biface fragment recovered on the surface of the large exposure on the southeastern portion of the site.

- TLM 107. The site is located northwest on the confluence of Tsusena Creek and the Susitna River on a west-northwest trending esker. The view from the site is extensive in all directions.

  The site consists of a surface lithic scatter on a deflated surface. Recovered artifacts included 3 chert flakes, 5 rhyolite flakes, 1 basalt flake, 1 quartzite flake, 1 cobble spall (with possible retouch), 1 biface fragment, and 1 chert point fragment (midsection). Additional flakes were observed but were not collected. A test pit was excavated on the knoll top where the vegetation mat provided soil deposition. No subsurface material was located.

- TLM 108. The site is located on a prominent esker feature southeast of Swimming Bear Lake along an unnamed stream drainage. The site itself is located on the flat, oval-shaped exposed top of the high southern end of the esker overlooking the creek and associated marsh areas to the south and west. The gradually rolling and steep uplands to the north, east and west are visible from the site.

  One test pit was excavated at the site during reconnaissance testing, but no subsurface cultural material was found. A surface lithic scatter consisting of more than 100 flakes was noted at the site, but only 16 black basalt flakes and 2 gray chert flakes were collected.

- TLM 109. The site is located on a peninsula at the east end of Swimming Bear Lake north of the narrowest point in the lake. The view from the site includes all of the lake as well as the uplands to the north, south, east and west.

  One test pit and 13 shovel tests were excavated on the site during reconnaissance testing; however, all cultural material recovered was collected on the surface and consisted of 2 gray chert flakes and 2 brown chert flakes.

- TLM 110. The site is located on the top of an east-west oriented ridge northwest of Swimming Bear Lake and is about 30 m above the lake. The view from the site is panoramic with total visibility of the lake and surrounding terrain for approximately 2 km.

  The one test pit excavated during reconnaissance testing, at the highest point of the ridge, produced 20 black basalt flakes, 4 black chert flakes, 2 gray chalcedony flakes and 1 black basalt biface fragment. Surface material collected from the site included 11 black basalt flakes, 2 gray chert flakes, 1 gray rhyolite flake, 1 white rhyolite flake, and 1 chert biface fragment. Subsurface cultural material was fround on the contact between the Watana and Devil tephra, in the Devil tephra, and above the Devil tephra.

- TLM 111. The site is located at the northwest end of Swimming Bear Lake. The site is approximately 10 m above the present lake level on a spit protruding southeast into the lake. The view is extensive in all directions. The site consists of a 1.3 m x 1.5 x 45 cm rectangular depression.

  The one test pit excavated adjacent to the depression and the nine shovel tests excavated during reconnaissance testing did not reveal any cultural material.

- TLM 112. The site, an irregular circle of stones, is located on a dicontinuous ridge overlooking Devil Creek and a major unnamed creek, northeast of the confluence of Devil Creek and the Susitna River, and north of Swimming Bear Lake. The view from the site is good and includes portions of the glacial valley to the north and south. However, a portion of the view to the south is obstructed by slightly higher terrain.

The one test pit placed on the site during reconnaissance testing did not reveal any cultural material. The site consists of 30 stones forming an irregular circle which ranged in size from cobbles to small boulders. The stones were partially embedded in the surrounding soil.

- TLM 113. The site is located along a southeast facing bluff northwest of Devil Creek and northeast of High Lake. From the site a panoramic view of the Devil Creek drainage and associated lower terraces to the east, southeast and south is available.

  The one test pit and eleven shovel tests excavated on the site during reconnaissance testing did not reveal any cultural material. All artifacts were collected on the surface. Artifacts collected included 1 gray rhyolite projectile point, 1 white rhyolite stemmed point, 1 white rhyolite flake and 1 black basalt flake with possible retouch.

- TLM 114. The site is located on the northeastern end of a north-south oriented terrace overlooking Devil Creek, due north of the confluence of Devil Creek and the Susitna River. The site commands a view of Devil Creek and its valley to the east, north, and northwest.

  One test pit and three shovel tests were excavated on the site during reconnaissance testing. However, all cultural material was recovered on the surface and consisted of 5 white rhyolite flakes.

- TLM 153. The site is located in a borrow area along the proposed access route. The site was field visited but has not been recorded.

- TLM 155. The site is located along the proposed access route. It was field visited but has not been recorded.

- HEA 181. The site is located northwest of Deadman Lake outlet at the outlet of a small lake at the southern end of a glacial valley. The view from the site is most extensive to the north, encompassing a small nearby lake and the valley walls.

  The one test pit excavated at the site during reconnaissance testing revealed one chert flake. Three shovel tests in the area did not reveal any additional material. Seven surface flakes were noted at the site four of which were collected: 3 basalt flakes and 1 chert flake. The one subsurface flake was recovered from the contact between the Devil and Watana tephra.

- HEA 182. The site is located northwest of Deadman Lake on the western tip of a glacially formed knoll east of a wide meandering south-flowing creek. The site is located in a deflated area which extends along the western edge of the knoll. The knoll is one of the highest spots in the area affording an excellent panoramic view from the site.

  The one test pit placed on the site during reconnaissance testing did not produce any cultural material. The artifacts collected from the site were recovered from the surface and consisted of 1 rhyolite side-notched point fragment, 2 basalt flakes, and 1 quartz biface fragment.

- HEA 211. The site is located along the proposed access route. The site was field visited but has not been recorded.

(ii) Historic Sites - Results and Discussions

None recorded to date.

(f) Transmission Corridors

Preliminary aerial reconnaissance was conducted of the proposed transmission line routes from Fairbanks to Healy and Willow to Anchorage. The transmission corridor from the Watana Dam to the intertie was selected after the 1982 field season and remains to be surveyed.

(i) Archeological Sites

- HEA 026, HEA 030, HEA 035, HEA 037, HEA 038, HEA 080, HEA 083. The above sites are reported in the files of the Alaska Office of History and Archeology. The sites were not visited by the personnel of the Susitna Archeological Project.

- HEA 119, HEA 137. These sites are reported in the files of the Alaska Office of History and Archeology. The sites were not visited by the personnel of the Susitna Archeological Project.

- HEA 120. The site is located southeast of the confluence of Healy Creek with the Nenana River on the middle terrace of a series of at least three alluvial terraces. View from the site includes hilly uplands north of Healy Creek, the Nenana River valley to the west, and the southward continuation of the terrace system to its terminus against the north facing slope of Healy Creek valley.

During surface reconnaissance, a brown agate flake (Locus A) was found 40 m south of a gray chert retouched flake (Locus B). Locus B in contrast to Locus A is situated on the terrace margin, overlooking Healy Creek. The terrace surface was largely wind-scoured and no subsurface testing was conducted, but extensive additional surface reconnaissance failed to reveal further artifactual material.

- FAI 213. The site is located northeast of the confluence of Birch Creek with the Nenana River. The site is situated on the top of a steep south-facing bluff. At the base of the bluff is a 300 m wide abandoned stream channel which is presently well vegetated. Visibility from the site is excellent to the northwest, where the channel begins to open out onto the Tanana Flats outwash plain. Mountainous uplands are visible to the south and southeast. Visibility in other directions is restricted by brushy ground along the level bluff top.

  Both surface and subsurface cultural material was collected during reconnaissance testing. Twenty-nine flakes were recovered from a deflated area on the edge of the bluff. An additional flake was observed but not collected ca. 50 m to the northeast. Three shovel tests were dug, one of which produced a basalt flake. A test pit was excavated on the north edge of the surface exposure and an additional gray chert flake was recovered. A massive charcoal lens with oxidized soil was observed within this test pit.

- FAI 214. The site is located on the eastern end of a ridge in the hilly uplands forming the west Nenana valley wall southwest of the confluence of Birch Creek and the Nenanan River. The field of view from the site is obstructed to the west by the forested ridge, but is panoramic in other directions encompassing a section of the Tanana Flats, the constricted river valley east of the site, and the widening valley to the south.

  No surface indication of the site was noted. An obsidian flake was found in a shovel test. A test pit superimposed on the shovel test produced 4 basalt flakes from a red-brown silt unit. A second shovel test near the test pit produced 6 basalt flakes from the same stratigraphic unit.

(ii) Historic Sites

None located to date.

(g) Other Areas

During the course of the cultural resource study a number of sites were located outside the areas already addressed in this application by project personnel (helicopter pilots, land use planning team, geologist, etc.). Although no subsurface disturbance was scheduled for these areas, location and documentation of these sites were very important because little is known about the history and prehistory of the Upper Susitna region and each site studied increases the data base. In addition, since these sites were located and could potentially be impacted by future recreation use, it is in the best interest of any cultural resource management plan to include them as part of this study.

(i) Archeological Sites

- TLM 007. The site is reported in the files of the Alaska Office of History and Archeology. The site was not field visited by the personnel of the Susitna Archeological Project.

- TLM 015. The site is located east of Tsusena Creek north of the Susitna River in kettle and kame topography. Located at the top of a kame, the site offers an unrestricted view of numerous knolls, ridges and kettle lakes.

  This site was tested in 1978 and revisited in 1980 without additional testing. In 1978 a single test produced two waste flakes from different soil units suggesting that the site may be multicomponent. No tephra deposits were noted in descriptions of the soil units at the site. No surface artifacts were observed at the site.

- TLM 016. The site is located in an area of kettle and kame topography bordered to the west and east by Tsusena and Deadman Creeks and to the south by the Susitna River. It is situated at the highest elevation of a low rounded kame knoll which is the highest point of relief within a 600 m radius. The view from the site is panoramic but the principal view is to the west and north encompassing portions of four lakes.

Both surface and subsurface cultural material was found at this site in 1978. The site was revisited in 1980 but no additional testing was done. During testing in 1978 six basalt and rhyolite flakes were recovered from a blowout, and five test pits were excavated at the site. Forty bone fragments and six waste flakes associated with charcoal were recovered from Test 1. A radiocarbon date of 3675 ± 160 years: 1725 (B.C. (GX-5630) was obtained from this charcoal. Two other tests produced subsurface cultural material, including a unifacially retouched rhyolite pebble from Test 2 and six waste flakes from Test 5.

- TLM 021. The site, consisting of three loci (A, B, C), is situated on an east-west trending ridge northwest of the confluence of Kosina Creek and Gilbert Creek. The easternmost locus, Locus A, overlooks Kosina Creek which is not visible from the other loci. All three loci are exposed in deflated areas along the crest of the ridge.

Testing was concentrated at Locus A where four surface flake scatters were identified. Two scrapers (chert and rhyolite) and a retouched rhyolite flake were found spacially isolated from the flake scatters. A total of 570 rhyolite flakes, 9 chert flakes and 1 basalt flake were surface collected from this locus, approximately half of the surface flakes observed. Four test pits were excavated, only one of which produced subsurface material consisting entirely of waste flakes.

Locus B consists of six flake scatters from which all observed surface artifacts were collected. Diagnostic surface artifacts included the medial section of a projectile point, a scraper, and a biface, all of rhyolite. A single test pit excavated at this locus produced one chert flake associated with burned bone and charcoal. A radiocarbon detemination of 1160 ± 100: A. D. 790 (DIC-1878) was obtained from this charcoal. One hundred and fourteen rhyolite, 4 chert and 2 basalt flakes were surface collected. Four of the rhyolite flakes showed retouch.

Locus C consists of a single flake scatter containing 21 brown chert flakes, 6 basalt flakes and 2 rhyolite flakes all of which were collected. One test pit was dug which produced a single gray chert flake directly below the vegetative mat.

- TLM 025. The site is located south of the Susitna River and southwest of the mouth of Watana Creek. It is situated at the highest elevation of a glacial crag and tail feature which exhibits sharp relief in relation to the surrounding terrain. The view from the site is excellent in all directons for a distance of over 10 km.

  The site contains both surface and subsurface cultural material. A surface flake scatter is exposed in a blowout covering an area 4 m by 35 m. Diagnostic artifacts collected from the surface include a chert core tablet, a rhyolite bipolar-flaked cylindrical core, a rhyolite core tablet, two rhyolite microblade midsections, a basalt point base, a possible cobble hammerstone, and a chert scraper. In addition 14 waste flakes were surface collected including two obsidian flakes. Three test pits were excavated, two of which produced cultural material. Test 1 produced a single rhyolite flake and Test 2 produced two basalt flakes. No tephra deposits were noted during reconnaissance testing.

- TLM 028. The site, consisting of two loci (A, B), is situated on an esker located west of the mouth of the Tyone River on the north margin of the Susitna River. This esker parallels a bend of the Susitna River for approximately 1 km. Locus A is situated at the highest elevation on the extreme northeast end of the esker and Locus B is located approximately 750 m southwest of Locus A on the level crest of the esker. The view from both loci is good in all directions although limited by the relatively low elevation of the esker.

  The site is surficial, limited to a single isolated flake collected at each locus. At Locus A, a rhyolite flake was found in a blowout. Two test pits and a shovel test did not reveal any subsurface cultural material at this locus. A basalt waste flake was surface collected at Locus B from a game trail which follows the crest of the esker. A single test pit at this locus failed to reveal any additional cultural material. Intensive surface reconnaissance along the entire length of the esker did not produce any additional surface artifacts.

- TLM 031. The site is located on a high plateau on the north side of the Susitna River downriver from the mouth of Kosina Creek. The site is situated in a sytem of hills and ridges surrounding several small lakes.

The site consists of a single isolated surface artifact, a black chert endscraper on a blade. Three test pits excavated at the site failed to reveal additional cultural material. The site is located on an extensively deflated ridge and intensive surface reconnaissance did not produce any further surface artifacts.

- TLM 032. The site is located on a high plateau on the north side of the Susitna River downriver from the mouth of Kosina Creek. It is located south of the southermost point of the largest of three kettle lakes at the eastern end of the plateau. The view from the site is panoramic but somewhat restricted to the south by topography.

  A total of 10 artifacts were surface collected during reconnaissance testing, including 2 quartzite endscrapers, a retouched rhyolite flake, a notched cobble exhibiting battering at one end, and a chalcedony core fragment. In addition 5 flakes were collected with lithologies including basalt, chert and quartzite. A single test pit in the immediate vicinity of the surface scatter did not reveal subsurface artifacts. The entire area around the concentration of surface artifacts consisted of bedrock and deflated ground. All observed artifacts were collected.

- TLM 036. The site is located on a high plateau on the north side of the Susitna River downriver from the mouth of Kosina Creek. It is situated on a small knoll overlooking a south-facing slope leading down to the Susitna River. The knoll and ridge upon which the site is located is part of a system of discontinuous ridges exhibiting numerous bedrock and drift exposures. The view from the site is panoramic ranging from 1 km to 5 km.

  The site consists of a surface lithic scatter exposed in a blowout approximately 8 m by 12 m in size. A unifacially worked chert endscraper was surface collected from this blowout along with a single gray chert flake. No other cultural material was observed on the surface. A single test pit at the site did not reveal any subsurface cultural material and encountered bedrock within 10 cm.

- TLM 037. The site is located on a high plateau on the north side of the Susitna River downriver from the mouth of Kosina Creek. It is situated on one the numerous east-west trending glacially scoured ridges. Exposed bedrock and drift characterize this plateau. The view is panoramic and includes two kettle lakes to the southwest of the site.

This is a surface site consisting of four waste flakes exposed in a blowout measuring approximately 40 m by 50 m. Two of these flakes, one of gray chert and one of basalt, were surface collected and two gray chert flakes were left in place. No diagnostic artifacts were observed. A single test pit did not reveal any subsurface cultural material. Soil deposition in the vicinity of the site is shallow and bedrock was encountered within 10 cmbs.

- TLM 038. The site is located upstream from the mouth of Watana Creek on the eastern edge of a plain overlooking the creek from the west. It is situated on a small discrete lobe of the continuous edge of the plain. Access to Watana Creek is difficult or impossible in place where downcutting has resulted in cliffs and steep bedrock exposures. The view encompasses the relatively level plain west of the site and a lower alluvial terrace along with portions of Watana Creek to the north and northeast.

  There is no surface indication of a site at this location. Reconnaissance level testing included two test pits and three shovel tests. Burned bone associated with charcoal was revealed in one test pit and two shovel tests. Several hundred calcined bone fragments were recovered. Most bone fragments were too small to identify but 12 long bone fragments, 1 carpal, 1 metacarpal and 1 tooth were identified as caribou (<u>Rangifer tarandus</u>).

  Systematic testing of this site included the excavation of five 1 m by 1 m test square and a single 40 cm by 40 cm test pit. An additional 22 bone fragments and 9 thermally fractured rocks were recovered and attributed to a single occupation. Four of the test squares produced cultural material although concentration of faunal material was much less dense that in the rconnaissance test pits. No cultural lithic material other than fire-cracked rock was recovered. The cultural unit is within and above the Devil tephra.

- TLM 041. The site is located on a high flat plain south of the Susitna River, southwest of the confluence of a large tributary of Fog Creek. The site is situated on a low knob on a broad northeast-southwest sloping grassy plain. Despite low topographic relief, the site location affords an unobstructed panoramic view of an open plain 300 m to 400 m wide and approximately 1 km long.

The site was identified by an R&M geologist who collected a tuffacious rhyolite flake from the surface. Subsequent intensive surface reconnaissance and two subsurface tests failed to reveal additional cultural material. The exact location at which the flake was collected was never identified.

- TLM 044. The site is located west of Jay Creek and north of the Susitna River on a high plateau comprising glacially scoured hills and ridges. It is situated on the deflated top of a discrete knoll which affords a panoramic view of the surrounding terrain and a valley to the north which contains several lakes.

  Both surface and subsurface cultural material were present at this site. Surface material consisted of five lithic scatters exposed in blowouts near the highest elevation of the knoll. A complete lanceolate point, a biface fragment, a retouched flake, a uniface fragment, 22 waste flakes and 19 bone fragments were surface collected during reconnaissance level testing. A single test pit produced 15 basalt flakes and 69 bone fragments associated with charcoal. No tephra deposits were encountered. Flake lithologies present at this site include basalt, rhyolite, chert and chalcedony.

- TLM 045. This site, consisting of two loci (A, B), is situated on the south and east facing slopes of a knoll northeast of TLM 044. The view from Locus A is limited by intervening topography to less than 100 m. Locus B is situated on an east facing slope overlooking a small valley and the view from this locus includes both the valley to the north, low marshy areas, and kettle lakes to the southwest.

  Reconnaissance level testing revealed both surface and subsurface cultural material. Surface material was found in three flake scatters comprising two loci (A, B) located 104 m apart. A complete chert point, a chalcedony microblade, a chalcedony microblade fragment, a retouched flake and 62 bone fragments were surface collected along with 63 waste flakes. Approximately 126 surface flakes were left in place. A single test pit produced two basalt flakes and one rhyolite flake, ca. 290 bone fragments and 25 flakes and 16 possible fire-cracked rocks. Faunal material included a phalanx identified as caribou (*Rangifer tarandus*), a tarsal fragment identified as possibly caribou (*Rangifer tarandus*) and a right and left maxilla identified as arctic ground squirrel (*Spermophilus parryi*). Lithologies represented at the site included basalt, rhyolite, chert, chalcedony and obsidian. Subsurface cultural material appeared to be associated with the contact between the Devil and Watana tephra deposits.

- TLM 046. The general location and topographic setting of TLM 046 is similar to that of TLM 044 and TLM 045. TLM 046 is situated on the easternmost and highest of three knolls, the western knolls containing the other two sites. All three knolls are part of the same landform and the western slope of the highest knoll joins the ridge upon which the two lower knolls are situated. TLM 046 is located at the northern end of a north-south oriented knoll which affords the most commanding panoramic view of any of the surrounding terrain features. The view encompasses both the valley to the north with its series of interconnected lakes and lower elevations to the east and southeast with kettle lakes.

Both surface and subsurface cultural material was recovered from four flake scatters during reconniassance testing. Two projectile point bases, one of chert and one of basalt, were surface collected along with a basalt endscraper, a chert endscraper, 48 waste flakes and ca. 200 bone fragments. Some surface bone and 43 observed flakes were left in place. Only one of three test pits produced cultural material: 30 flakes (lithologies including basalt, rhyolite, chert and obsidian) and 8 burned bone fragments associated with charcoal. Subsurface cultural material was associated with the Watana tephra and the contact between the Watana and Oshetna tephra. A radiocarbon determination of 2340 ± 145 years: 390 B.C. (DIC-1903) was obtained from charcoal associated with subsurface cultural material.

Systematic testing included the excavation of five 1 m by 1 m test square, three of which produced cultural material. Two additional surface lithic scatters were identified at the site during systematic testing. Additional surface collection at the site included one point base, 75 flakes and 8 bone fragments. A total of 180 flakes were recovered from the three test squares which produced cultural material. A charcoal concentration interpreted as a hearth feature was encountered 5 cm to 10 cm below the surface in one of the test squares.

- TLM 047. The site is located downriver from Vee Canyon on the west side of the Susitna River. It is situated 800 m west of the river at the north end of a north-south oriented bedrock ridge. The Susitna River valley and the river itself are visible to the north, east and south but the view to the west is blocked by bedrock cliffs and higher terrain.

  The site consists of a 3 m by 10 m surface lithic scatter exposed on the deflated crest of a bedrock ridge. Surface collected artifacts include a chert biface fragment, a chert mircoblade fragment and a re-touched chert flake in addition to 24 rhyolite and basalt flakes. Approximately 70 rhyolite flakes were left in place. Two test pits excavated during recon-naissance level testing failed to reveal subsurface cultural material and the site appears to be limited to the extreme northern end of the ridge.

- TLM 049. The site is located east of the mouth of the Oshetna River on the south side of the Susitna River. It is situated on the summit of a discrete knoll located on a north-south trending continuous ridge overlooking the Susitna River. The site overlooks a broad alluvial terrace to the west, north and east which contains two lakes, only one of which is visible from the site.

  Both surface and subsurface cultural material is present at this site. A total of four test pits were excavated on the knoll, one of which produced a single basalt flake within the organic mat. Two additional surface flakes were observed, but not collected, in a blowout on the ridge top approximately 500 m south of the knoll.

- TLM 052. The site, consisting of two loci (A, B), is located northwest of the mouth of Jay Creek on a southeast-northwest trending ridge. This ridge is the highest of numerous deflated ridges and knolls in this vicinity and affords an excellent vantage point over-looking the largest kettle lake in the area, an 8 hectare lake (Laha Lake) southeast of the site. Locus A is situated at the edge of the deflated crest of the ridge on the southern slope overlooking Laha Lake, and Locus B is located on the northeastern rounded crest of the ridge.

  Both surface and subsurface cultural material was found at this site. Artifacts surface collected from the site include one basalt and two chert point bases and seven basalt and chert waste flakes. Thirty-four basalt and chert flakes were left uncollected. Most of the surface lithic material was observed at Locus A where a single test pit excavated immediately southwest of the largest concentration of flakes produced a black bashalt flake 7 cms below the surface at the contact between the organic horizon and a gray silt (Devil tephra).

- TLM 053. The site, consisting of two loci (A, B), is located northeast of the mouth of Jay Creek. Situated on a deflated ridge, the two site loci are 240 m apart on opposite ends of the ridge.

  Locus A contains both surface and subsurface material. A surface lithic scatter includes a chert flake bifacially retouched on the right lateral margin with a graver spur at the distal end, a whitish-gray chert flake with retouch on the left and right margins and the distal end, a large tuffacious rhyolite flake, a basalt flake and a chalcedony flake. Test Pit 1 revealed a light brown tuffacious rhyolite flake on the contact of the glacial drift and the Devil tephra unit. Locus B consists of a single gray chert flake retouched on the dorsal surface (possibly a scraper). Locus B lacked any soil other than glacial drift and bedrock, and therefore, no subsurface testing was conducted.

- TLM 054. The site is located on a kame or esker remnant east of Tsusena Creek.

  No surface material was observed at the site. Two dark gray chalcedony flakes were recovered from beneath the organic mat during an initial shovel test. This shovel test was expanded into Test Pit 1 and one small bone fragment was recovered. A second test pit 5 m northeast of the first was negative.

- TLM 055. The site is located north of the northwest tip of Tsusena Butte, and west of Tsusena Creek. It is situated on a low knoll which rises approximately 2 m above the surrounding terrain. Tsusena Creek is visible from the site through present vegetation. A very wet area consisting of muskeg and marsh is present between the site and Tsusena Creek, although the immediate vicinity of the site is better drained and covered with spruce forest.

  No surface artifacts were observed at the site. Two shovel tests were placed on this knoll, one of which produced a chert scraper. This shovel test was expanded into a test pit from which four additional chert flakes were recovered. Cultural material occurred above the Devil tephra in a zone of finely divided organics. During the systematic testing of site TLM 097, TLM 055 as revisited and a single 1m test square was excavated at the site in an attempt to obtain additional diagnostic lithic material. Four burned bone graments and five fire-cracked rocks were found associated with a dense concentration of charcoal within the same finely divided organic horizon above the Devil tephra. Three very small chert flakes were the only lithic material recovered from this test square.

- TLM 057. The site is located east of Big Lake overlooking an outlet creek to the north and the lake itself to the west.

  The surface lithic scatter at the site included a chert microblade fragment, two chert flakes, and a quartzite fragment all of which were collected. Several basalt flakes were left uncollected from the surface. Five shovel tests and a single test pit were placed on the flat knoll top but all failed to reveal subsurface material.

- TLM 066. The site is located on the east-southeast slope of a ridgetop plateau east of Watana Creek and northeast of the mouth of Watana Creek. The site overlooks a small unnamed creek to the southeast, mountainous slopes to the northeast, and surrounding lowlying terrain in other directions. Three bifacially chipped tools were recovered from an exposed blowout surface during reconnaissance testing. These include a gray chert lanceolate projectile point found in two pieces, the base of a black chert projectile point with a reworked tip, and a gray chert ovate biface found in two pieces. One test pit excavated near the ovate biface failed to reveal subsurface cultural material.

- TLM 067. The Sonona Creek site is situated on top of a knoll along the east side of Big Bones Ridge, west of Sonona Creek. The knoll is a prominent topographic feature, and the eastern slope drops continuously to the level of Sonona Creek. The site is above treeline and commands a view in all directions.

  The site consists of three surface lithic concentrations and three rock features. The bulk of the cultural material is exposed on the surface but in one of the two test pits excavated at the site a jasper flake was recovered from a dark organic zone. No tephra were associated with the artifact.

  Feature 1 is a 3.3. m by 1 m linear rock pile showing definite stacking and placement of local bedrock boulders. The height of the finished wall is approximately 50 cm. Feature 2 is a smaller "windbreak," 50 cm wide by 50 cm high. A "window" formed by two uprights and a cap stone affords a view to the east.

Cluster 1 consists of 2 chalcedony projectile points, 1 red jasper point, 1 quartz crystal, 2 chert flakes, 1 chalcedony flake, and 1 possible tool. Cluster 2 consists of 5 black basalt flakes. Miscellaneous surface finds included 1 black basalt biface fragment, 2 rhyolite flakes, 2 chalcedony flakes, 1 chert flake, 1 polished green pebble and 1 cobble chopper.

- TLM 069. The site is located east of Jay Creek and north of the Susitna River at the top of an elongated knoll. The knoll is part of a series of glacially scoured bedrock knolls which characterize the topography in the general vicinity of the site. A small pond is located 50 m northeast of the site.

  The site was discovered during reconnaissance testing and was later systematically tested. During reconnaisssance testing 741 flakes of various materials including chert, rhyolite, basalt and obsidian were recovered. Two utilized obsidian flakes and 1 utilized chert flake were also collected. Five pieces of fire-cracked rock and 1539 burned bone fragments were collected. All but three flakes were recovered from three test pits. All bone and fire-cracked rock fragments were collected.

  Systematic testing of the site included the excavation of three 1 m by 1 m test square, three 50 by 50 cm test squares, and a series of shovel tests to help delineate the limits of the site. The cultural material recovered from this testing consisted of 1232 flakes, 4 tool fragments, 3 scrapers, 1 biface, 1 biface fragment, 1 core, 1 point, and numerous burned bone fragments. The cultural material was associated with the contact of the Oshetna tephra and the glacial drift, the contact of the Watana tephra and the Oshetna tephra within the Watana tephra, and on the contact with the decomposed organic layer and the Devil tephra. The site has at least three archeological components, and possibly four.

- TLM 074. The site is located on the rim of the southern upland terrace overlooking the Susitna River on a bend in the river northeast of the mouth of the Oshetna River.

A total of eight shovel tests were dug at the site, one of which was expanded into a test pit after recovering a large quartize flake from the contact of the Devil and Watana tephra. Another test pit was excavated on the site which revealed a concentration of charcoal.

- TLM 076. The site, consisting of three loci (A, B, C), is located on the south side of the Susitna River east-northeast of the confluence of the Oshetna and the Susitna Rivers. The three loci are located on kame knolls and are higher than the surrounding terrain.

  Locus A consists of a lithic scatter and a partially exposed hearth. The hearth contains charcoal, burned bone and fire-cracked rock. An obsidian flake was collected 50 cm north of the hearth. Four chert flakes were collected from a blowout and the two test pits excavated during reconnaissance testing were sterile.

  Locus B consists of an obsidian point fragment and a flake, both found on the surface. No subsurface material was recovered from the test pit at Locus B. Locus C consists of one basalt flake found on the surface. No subsurface material was observed in the test pit excavated at Locus C.

- TLM 078. The site is located on a small kame knoll 8 m above and east of Tsusena Creek, and north of Tsusena Butte.

  Both surface and subsurface material were present at the site. A single basalt flake was observed on the surface. Additional lithic material was recovered in two subsurface tests. One gray chert flake associated with the humic mat was recovered in Test Pit 1 during reconnaissance testing. Test Pit 2 revealed four black basalt and two gray chert flakes associated with the Watana tephra.

- TLM 081. The site is located on a kame knoll southeast of Tsusena Creek and north of Tsusena Butte.

  No surface artificats were observed at the site. An initial shovel test near the center of the kame revealed two brown rhyolite flakes. The shovel test was expanded into a test pit and thirty additional flakes of the same material were recovered. The artifacts appear to be associated with the Watana tephra but cryoturbation has occurred and only a tentative correlation may be made at this time.

- TLM 083. The site is located on a kame knoll east of Tsusena Creek and north of Tsusena Butte. The site is located on a feature of sufficient relative relief to afford a panoramic view of the surrounding region.

  No surface artifacts were observed at the site. A single gray rhyolite flake with retouch was recovered in a shovel test which was expanded into Test Pit 1. No exact provenience is available for the flake and no further subsurface material was observed in Test Pit 1 or in the second shovel test located 2 m to the southeast.

- TLM 084. The site is situated on top of a kame east of Tsusena Creek and north of Tsusena Butte. The site rests on the most northerly tip of a 30 m long by 22 m wide northeast-southwest oriented kame 6 m above the floodplain of Tsusena Creek.

  One hundred eighty black basalt flakes were recovered 4-7 cm below the suface at the contact between the humus and the Devil tephra in Test Pit 1. No surface artifacts were observed. Test Pit 2, 8 m southeast of Test Pit 1, was sterile.

- TLM 085. The site is located on a small kame or esker remnant east of Tsusena Creek and north of Tsusena Butte. The site is situated on the southern end of the kame and commands an extensive view of the creek and its course to the north, and downstream to the south.

  No surface artifacts were observed at the site. Test Pit 1 revealed 69 gray chert flakes from a depth of 2-11 cm below the surface. The flakes were found in a zone of gray to light brown tephra immediately above the glacial drift. Mixing of the soil units was present due to cryoturbation and tentatively the cultural material can be associated with the Watana tephra. Test Pit 2 and two additional shovel tests failed to reveal further cultural material.

- TLM 086. The site is located on the top of a small kame which is 15 m above the level of Tsusena Creek to the west and immediately north of one of its clearwater tributaries.

  A single black chert flake was discovered in a surface exposure on the south slope of the kame. Subsurface testing failed to reveal any cultural material.

A single black chert flake was discovered in a surface exposure on the south slope of the kame. Subsurface testing failed to reveal any cultural material.

- TLM 087. The site is located on the south half of a northeast-southwest oriented kame in the kettle and kame topography which borders Tsusena Creek north of Tsusena Butte.

  No surface artifacts were observed at the site. Test Pit 1, located at the highest point on the kame, produced two gray chert flakes. The context of the flakes appears to be in the Devil tephra unit. A second test pit failed to reveal further cultural material.

- TLM 088. The site is situated on an esker southeast of Tsusena Creek within an area where the creek makes a sharp bend around the northern slopes of Tsusena Butte.

  No surface artifacts were observed at the site. Test Pit 1 revealed 22 black basalt flakes associated with the Oshetna tephra. A small depression, 1 m by 80 cm by 15 cm deep was present at the site and a test pit was excavated in its center. This test revealed evidence of subsurface disturbance in that the strata were mixed and considerably different from the strata present in a test pit outside the depression. No cultural material was encountered in this test pit.

- TLM 089. The site is located on the northern ridge of Tsusena Butte east of Tsusena Creek.

  The site consists of six soil exposures which contain over a hundred basalt flakes, the majority of which were left uncollected. Collected artifacts included a brown chert biface fragment and numerous rhyolite and chert flakes. Test Pit 1 revealed a hearth consisting of a thick charcoal unit with numerous faunal and lithic specimens. Identifiable faunal remains consisted of one calcined caribou 3rd phalanx (<u>Rangifer tarandus</u>), one calcined metatarsal/carpal fragment (possibly caribou), and four tooth fragments (possibly caribou). Lithic material from Test Pit 1 consists of 1 translucent flake, 6 green-gray chert flakes, 10 dark gray chert flakes, 19 tan-gray chert flakes, 36 black basalt flakes, and 498 brown chert flakes. The cultural material from Test Pit 1 is from above the Devil tephra.

- TLM 090. The site is located on a level bench of a north ridge of Tsusena Butte overlooking the Tsusena Creek valley.

Five black basalt flakes, one of which was collected, were found on the surface of a small exposure. Seven shovel tests placed in the vicinity of the exposure were sterile as was Test Pit 1.

- TLM 091. The site, consisting of two loci (A, B), is located on the southern end of a north-south trending narrow bedrock ridge, north of the highest point of Tsusena Butte. The site is located on two sides of a dip which separates the ridge from Tsusena Butte.

  Locus A consisted of ten black basalt flakes located on the surface of a bedrock-soil exposure, in a 30-cm square area. Three of the flakes were collected. Test Pit 1 at Locus A failed to reveal any subsurface artifacts. Locus B consisted of a black basalt point tip. No further testing was conducted at this locus.

- TLM 092. The site is located on a north-south oriented bedrock ridge on the west side of the northern arm of Tsusena Lake.

  The site consists of a surface lithic scatter in a soil exposure measuring 90 cm by 40 cm, on a bedrock outcrop. A total of 3 black fine grained basalt flakes were collected from this exposure. Test Pit 1 failed to produce any subsurface cultural material.

- TLM 093. The site is located southwest of the northern arm of Tsusena Lake and is situated on an exposed bedrock knob occupying an area 20 m by 35 m on the top of this outcrop.

  Both surface and subsurface cultural material are present with three clusters of surface flakes observed in blowouts which occur among the bedrock exposures. Cluster 1 contained 15 flakes of which 7 were collected. Cluster 2 contained 4 flakes, 3 of which (including a retouched basalt flake) were collected. Cluster 3 contained 51 flakes of which 12 were collected. Lithologies represented on the surface were basalt, chert and rhyolite.

  Subsurface testing at the site included one test pit and eight shovel tests. Test Pit 1 was excavated 2 m from Cluster 2 and revealed a total of 33 dark gray basalt flakes associated with the Watana tephra. An additional flake of similar material was recovered from the Oshetna tephra.

- TLM 094. The site is located west of Tsusena Creek and north of Tsusena Butte. It is situated on the southern end of a kame which rises about 5 m above the surrounding marshy floodplain.

  Twelve flakes (six of which were collected) located in a gravel exposure on the southwest end of the kame comprise the surface artifacts at the site and are of chert and basalt. Two articulating fragments of a gray basalt biface fragment were also collected from the exposure. A test pit was excavated 1.5 m northeast of the scatter which produced four translucent flakes from the contact of the humic zone and the Devil tephra, two light chert flakes from the Watana tephra, and one black chert flake from the contact of the Watana tephra and a gray-brown silt at 11 cm below surface. The site may be multicomponent but mixing of the soil units was evident due to cryoturbation, and correlations of cultural material to stratigraphic units is tentative.

- TLM 095. The site is located on the west side of Tsusena Creek north of Tsusena Butte. The site is situated on a 6 m high fame knoll which is part of the general kettle and kame topography of the upper Tsusena Creek drainage.

  No surface artifacts were observed at the site; however, two of seven shovel tests placed at the two areas of highest elevation on the knoll revealed cultural material. Test Pit 1 at the northwest end of the knoll revealed 50 fine grained basalt flakes from within the Oshetna tepha. Test Pit 2 at the southeast end of the knoll revealed 23 fine grained basalt flakes from the Watana tephra. The site may be multicomponent.

- TLM 096. The site is located north of Tsusena Butte and west of Tsusena Creek at the western edge of a marshy alluvial plain. It is situated on the top of a low narrow ridge which trends east to west.

  No surface artifacts were observed at the site. Eight shovel tests were dug at the site, two of which were expanded into test pits, 1 and 2. Test Pit 1 revealed three whitish-gray chert flakes from the Devil tephra. Test Pit 2 was sterile as were the remaining six shovel tests.

- TLM 097. The site is located northwest of Tsusena Butte on the west side of Tsusena Creek. It is situated at the top of an east facing bluff which overlooks Tsusena Creek and passes approximately 50 m east of the site. The field of view is panoramic with the depth of view greatest to the northeast overlooking a broad alluvial plain.

Both surface and subsurface cultural material were collected during reconnaissance level testing of the site. A gray chert lanceolate point was surface collected from the site along with a basalt flake. Twelve shovel tests were dug along the top of the bluff, two of which revealed subsurface cultural material. These two shovel tests were expanded into test pits, one of which produced additional cultural material. This test pit produced a total of 55 flakes, one bone fragment and one fire-cracked rock, all associated with a concentration of charcoal at the contact of the Devil tephra with the zone of finely divided organics (A horizon). Flake lithologies from this test pit include basalt and both black and gray chert.

Systematic testing of the site included the excavation of five 1 m by 1 m test squares and 24 shovel tests. All five of the test squares and four of the shovel tests produced cultural material. Diagnostic lithic material produced by subsurface testing included a basalt side-notched point base, a basalt endscraper, 4 basalt blade-like flakes, a chert endscraper, a possible backed scraper of tuffaceous material, 4 retouched flakes and 2 flake core fragments. In addition, 120 fire-cracked rocks were collected along with more than 400 burned bone fragments. Flake lithologies include basalt, chert, rhyolite, tuff, siltstone, chalcedony and obsidian. Cultural material is present at the contact between the Oshetna tepha and the Watana tephra and above the Devil tephra with a minimum of two components present at this site. A side-notched point base was excavated from the Oshetna tephra in association with charcoal and a dense concentration of basalt flakes. A radiocarbon determination on charcoal from the same stratigraphic level at a nearby test, which was also associated with basalt flakes, produced a date of 3720 $\pm$ 60 C^{14} years B.P.: 1770 B.C. (DIC 2283).

- TLM 100. The site, consisting of two loci (A,B), is located at the western end of Clarence Lake, near Gilbert Creek. The site consists of 13 rectangular, square, or round depressions on terrain features slightly elevated above the lake level and lake margin of the area.

Locus A consists of 11 depressions of variable shape and size on the western shore of Clarence Lake. The largest of these depressions, Feature 1, measures 6 m by 6.5 m. Seven depression features, none larger than 3 m in diameter, are clustered 40 m northeast of Feature 1. All features are between 20 cm and 110 cm deep with fairly vertical walls.

Locus B consists of two depression features; the larger of the two measures 4 m by 4 m and the smaller measures 1.3 m by 1.1 m and is rectangular. No subsurface testing was conducted due to the number and integrity of the extant features.

- TLM 105. The site is located on the top of a broad flattened hill on the north shore of Clarence Lake. Clarence Lake and adjacent low-lying swampland are visible to the south, east and west. Uplands dominate the view to the north.

  Two test pits and one shovel test were excavated at the site during reconnaissance testing. The two test pits collectively produced 1 black basalt and 30 white rhyolite flakes. No additional cultural material was found in the shovel test. Surface material recovered in an area of disturbed sod consisted of 12 black basalt flakes, 1 blue-gray cryptocrystalline flake, 2 white rhyolite flakes, 9 brown chert flakes, 1 quartz flake, 2 gray rhyolite flakes and 3 gray-white chert flakes. It appears that some of the lithic material was recovered from between the Oshetna and Watana tephras.

- TLM 116. The site consists of a rock cairn located on top of a hill southeast of Tsusena Lake. The 1.3-m high cairn rests on an area of exposed bedrock. A panoramic view is available from the site with the greatest depth of view to the south and west.

  No subsurface tests were placed on the site due to the rocky nature of the terrain. The rocks used in construction were generally 50 cm long and there was no evidence of small stones being employed for chinking or leveling. The rocks were stacked into a pyramid arrangement with an open framework. A 15-cm long bone fragment was the only object found at the site.

- TLM 117. The site is located on a north-south oriented ridge which overlooks the confluence of Deadman Creek and one of its tributaries. The ridge is one of several low rolling ridges which border the north side of Deadman Creek and have been truncated by it. A panoramic view is available from the site.

  The one test pit excavated during reconnaissance testing did not produce any cultural material. Surface lithic material consisting of 4 flakes was located on the northern half of the ridge 1 m below the centrally located high point. One black basalt flake and one gray chert flake were collected.

- TLM 118. The site is located north of the Susitna River and west of Devil Creek in an area with kettle and kame topography and deeply incised ravines. The site is situated on the summit of a knoll near a small lake and appears to be primarily oriented toward the lake, because the view to the south is obstructed by the continuation of the knoll and present vegetation.

  No surface material was observed at the site, but a shovel test produced 5 flakes and 3 fire-cracked rocks. A test pit excavated next to the positive shovel test produced 26 chert flakes, 1 microblade-like flake, 1 light gray chert biface and 4 fire-cracked rocks. The cultural layer occurs between the vegetation mat and an underlying pinkish gray fine matrix which may represent the Devil tephra or an ash. Nine other shovel tests failed to reveal further artifactual material.

- TLM 120. The site is located south of the Susitna River, southeast of Watana Creek mouth, on the eastern portion of a glaciolacustrine plane in a low-lying ridge and knoll system. The site occurs on a low, rounded knoll which is situated between 2 small streams. The field of view from the site encompasses nearby flat ground, facing ridge and knoll slopes, hilly uplands to the south and the Susitna valley to the north.

  A surface lithic scatter composed of 16 basalt flakes in a 3-m by 1.5-m area was observed and collected. A test pit excavated on the northeast edge of the scatter produced 7 basalt flakes from the organic mat. Six shovel tests placed on the summit and sides of the knoll were negative.

- TLM 121. The site is located south of the Susitna River, southeast of the Watana Creek mouth, on the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site occurs in a large flat area. A small drainage is located to the west. The field of view from the site includes surrounding ridges and knolls, intervening drainages and boggy areas, hilly uplands to the south and the Susitna valley to the north.

  No surface cultural material was observed. A test pit produced 14 calcined bone fragments, 8 fragments of fire-cracked rock and charcoal from a cultural layer immediately beneath the organic mat and above the Devil tephra. Two shovel tests were negative.

- TLM 122. The site is located south of the Susitna River, southeast of Watana Creek mouth, on the eastern portion of a glaciolacustrine plane in a low-lying ridge and knoll system. The site occurs on the southeastern end of a low ridge at a point where the side of the ridge drops abruptly to adjacent ground to the south and east. Surrounding ridges and knolls, intervening low ground, hilly uplands to the south and the Susitna valley to the north are visible from the site.

A single surface basalt flake was observed in a small deflated area. A test pit placed adjacent to the deflated area was negative. Seven shovel tests were dug on the ridge end and other deflated areas were examined, but no additional cultural material was found.

- TLM 123. The site is located south of the Susitna River, southeast of Watana Creek mouth, on the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system on the crest of a ridge. View from the site is panoramic, encompassing southern uplands, surrounding ridges and knolls, and the Susitna valley, as well as boggy areas and drainages around the ridge.

  Examination of a large 10-m by 15-m deflated area revealed a surface scatter of weathered bone and charcoal. In addition, 2 small rounded depressions were found. Pit 1, 3 m southwest of site datum, is about 1.5 m in diameter and 35 m deep. A test pit placed in the vegetation mat on the margin of the deflated area near the bone and charcoal surface scatter did not yield artifactual material. A shovel test in Pit 2 produced 2 possible birch bark fragments. Seven other shovel tests along the ridge were negative.

- TLM 124. The site is located south of the Susitna River, southeast of Watana Creek mouth, on the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site occurs on a low ridge with a small stream nearby to the east. The field of view from the ridge crest includes surrounding ridges and knolls, adjacent low ground, hilly uplands to the south and the Susitna valley to the north.

  Two surface artifacts were collected from the ridge, including 1 basalt projectile point from a deflated area on the ridge crest and 1 modified brown chert flake found on the surface on an undeflated frost boil on the east face of the ridge near its base and approximately 90 m northwest of the projectile point. A test pit was excavated in the vegetation mat on the margin of the deflated area near the projectile point with negative results. Sixteen shovel tests on the ridge and examination of other soil exposure failed to reveal further artifactual material.

- TLM 125. The site is located south of the Susitna River, southeast of Watana Creek mouth, on the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site occurs on the southwestern end of the summit of a knoll. Field of view from the site includes surrounding ridges and knolls, extensive intervening low ground, hilly uplands to the south and the Susitna valley to the north. Present vegetation causes some local obstruction.

  No surface indications of a site were observed. Of 7 shovel tests, one produced a single basalt flake. Two additional basalt flakes and charcoal were found in a sandy silt with pebbles below the surface organic in a test pit placed adjacent to the positive shovel test.

- TLM 127. The site is located south of the Susitna River, southeast of Watana Creek mouth, on the eastern portion of a glaciolacustrine plain on a low-lying ridge and knoll system. The site occurs on the east end of an elongated knoll. The sides of the knoll are steep to the north and east, but merge with ground of only slightly lower elevation to the south. Field of view from the site is good though limited by present forestation and encompasses other ridges and knolls, intervening low ground, hilly uplands to the south and the Susitna valley to the north.

  No surface indication of the site was observed. Of 11 shovel tests, 2 were positive, 1 producing a single basalt flake and the other revealing 3 basalt flakes. The latter was expanded into a test pit from which 4 additional basalt flakes were recovered from the surface organic mat.

  Two small circular depressions were noted at the site, but no stratigraphic disturbance was noted in the test pit, which was placed on the margin of one of the depressions, and for this reason they are presumed to be of noncultural origin.

- TLM 128. The site is located on the west side of Jay Creek on a distinctive topographic feature formed by the intersection of a major ridge and a minor transverse ridge. In the zone of intersection, the crests combine to form a relatively flat area which is a local point of high relief. Field of view from the site is panoramic, including hilly upland slopes to the north and west, continuing ridge systems to the east and lower Jay Creek valley to the south.

  Both reconnaissance and systematic testing were conducted at this site. The site was initially identified by the presence of artifactual material in association with an erosional feature. This material included rhyolite and chert flakes, and a pentagonal point fragment. A test pit was placed adjacent to the erosional feature and artifactual material was recovered from 2 different stratigraphic levels. This included 6 rhyolite and 5 basalt flakes from the humic layer above the Devil tephra, in addition to an obsidian microblade fragment from a brownish silty matrix well below the Oshetna tephra. Systematic testing included the excavation of four 1-m by 1-m test squares in the vicinity of the test pit. A total of 4,613 lithics and 12 bone fragments were collected and 2 cultural components were defined. Forty-two flakes were recovered in association with the Devil tephra. The remaining artifactual material was located in association with a buried soil below the Oshetna tephra within a fine olive brown silty sediment. The majority of the lithic material from the lower component was of a green chert although black basalt and a brown translucent chert were also represented. Only 11 of the 4,571-lithics from the lower component showed evidence of retouch. Most of these can be described as flakes with either unifacial or bifacial retouch on the flake margins. A biface tip of brown translucent chert and a basalt biface fragment were the only 2 artifacts where modification was not restricted to the margins.

On the western slope of the site, there is a rectangular feature which appears to be the result of a recent excavation. During initial reconnaissance, 5 shovel tests were placed on the level central area of the topographic feature the site is located on, but no further artifactual material was found.

- TLM 129. The site is located south of the Susitna River, southeast of Watana Creek mouth, on the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site consists of 2 loci on 2 points of high relief on a ridge. Locus A is near the northern end of the ridge, while Locus B is ca. 200 m south of Locus A. The fields of view from both loci are panoramic, since they are among the points of highest relief in the vicinity.

  At Locus A, a test pit placed adjacent to a surface lithic scatter produced flakes from within and above the Devil tephra. Thirty-eight basalt flakes were collected. A small circular depression ca. 80 cm in diameter and ca. 15 cm deep was noted 26 m to the east near the base of the slope but was not tested.

Locus B consists of a circular depression ca. 1.4 m in diameter and ca. 30 cm deep which was not tested. Although 27 shovel tests were placed on the ridge around and between Locus A and B, and soil exposures on the ridge were examined, no additional artifactual material was found.

- TLM 130. The site is located on the south side of the Susitna River, southeast of Watana Creek mouth, on the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site occurs on the south end of a relatively small elongated knoll between 2 drainages. Field of view from the site is limited to the east by higher ridges and knolls, but includes knolls, ridges and boggy low ground to the west, the hilly uplands to the south and the Susitna valley to the north.

  No surface artifacts were found. An initial shovel test produced 6 flakes of 5 material types and 15 bone fragments. A test pit superimposed on this shovel test produced 3 flakes of 3 material types from the Devil tephra. One brown chert endscraper, 2 flakes, 4 unburned and 56 burned bone fragments were recovered from the contact between the Devil and Watana tephras, and 2 flakes and 85 burned bone fragments from the Watana tephra. A second shovel test on the northern end of the knoll produced no artifactual material.

  Systematic testing of the site included the excavation of four 1-m by 1-m test squares. Although site stratigraphy has been affected by frost activity, the contrasting vertical distribution of lithic and faunal remains suggests that more than one component is present. The postulated upper component at the site is represented by 96 flakes of various material types and 27 small bone fragments from above the contact between the Devil and Watana tephras. The lower component is distinguished by its stratigraphic position in the Watana tephra and by the predominance of faunal remains. One thousand eighty-two bone fragments, mostly small burned pieces, and 47 flakes of similar material types as those of the upper component were recovered from the lower component.

- TLM 131. The site is located south of the Susitna River, southeast of Watana Creek mouth, in the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site occurs on a low rise in a boggy field. The view from the site includes higher ridges and knolls, intervening boggy ground and hilly uplands to the south.

One brown chert flake was surface collected from a deflated frost boil feature. A test pit was excavated in the vegetation mat at the margin of the frost boil near the location of the flake, but no subsurface artifactual material was found.

- TLM 132. The site is located south of the Susitna River, southeast of Watana Creek mouth, in the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site occurs on the south end of a knoll. Field of view from the site includes adjacent drainages, knolls to the west and northeast, and terrain rising to hilly uplands to the south, as well as Susitna valley to the north.

  One gray chert flake was found in a soil exposure on the knoll, but 13 shovel tests and inspection of other soil exposures nearby failed to reveal further artifactual material.

- TLM 133. The site is located on the south side of the Susitna River, southeast of Watana Creek mouth, in the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site occurs on a ridge crest in a slight saddle formed by the relatively higher ends of the ridge. Immediately to the north of the site, the ground begins to slope steeply down into the Susitna canyon. A small stream flows east of the site. Field of view from the site, which is located on one of the most prominent landforms in the vicinity, is panoramic.

  A single surface brown chert projectile point was found on the surface of a lichen mat on a game trail. A test pit placed adjacent to the location of the point, 12 shovel tests on and around the ridge, and examination of soil exposures on the ridge failed to reveal further artifactual material.

- TLM 134. The site is located on the southern end of a discontinuous ridge west of Jay Creek. The ridge crest descends in an irregular fashion, alternating between sloping and relatively flat areas. The southern end of the ridge is bifurcated by a small swale, and the site occurs on the east facing side of the eastern half of the bifurcation. While the field of view to the west and northwest is obstructed by forested slopes, to the north rising hilly terrain is visible, as are the lower Jay Creek valley and mineral lick area to the south and east.

A compact surface scatter consisting of 3 articulating fragments of a green chert tool was found in a deflated area. Additional surface reconnaissance produced a possible edge-modified gravel. A shovel test near the possible modified gravel and a test pit near the location of the lithic scatter failed to reveal subsurface artifactual material.

- TLM 135. The site is located on a discrete small linear rise associated with the southeastern terminus of a ridge which descends toward the west edge of the Jay Creek canyon. The site appears to be primarily oriented toward the south and southwest, overlooking the Jay Creek mineral lick and its approaches. In other directions, the east side of the Jay Creek valley and rising upland topography to the west and northwest are visible.

  A surface lithic scatter composed of a basalt corner-notched point and 5 basalt flakes was collected from a deflated area on the crest of the linear rise. A test pit placed in the vegetation mat adjacent to the deflated area, and 5 shovel tests on the feature, failed to produce further artifactual material.

- TLM 136. The site is located on a small knoll west of the Jay Creek canyon. Field of view from the site is limited to the north by a large hill. The east side of the Jay Creek valley is visible from the site, as are the slopes descending into Jay Creek canyon from the west.

  During surface reconnaissance, a 2.5-m by 2.5-m lithic scatter was observed in a cryoturbated soil exposure on the summit of the knoll, from which 1 basalt tool fragment, 1 possibly modified rhyolite flake, 1 basalt flake, 2 rhyolite flakes and 3 bone fragments were collected. A test pit excavated northeast of the scatter produced cultural material from 3 stratigraphic units, including 21 flakes and 65 calcined bone fragments from the Devil tephra lower contact and the underlying silt, 22 flakes and 5 bone fragments from the Watana tephra, and 6 flakes from a clayey silt located below the Oshetna tephra.

- TLM 138. The site is located on a short kame ridge on the west side of Jay Creek. The sides of the ridge are defined by deep drainage ravines along the south and west sides, while the Jay Creek canyon is immediately west of the site. Beyond a slightly lower terrace to the north, the terrain rises and merges with hilly uplands. The site is on a local point of high relief with a panoramic field of view.

A single surface basalt flake was recovered from the surface of a frost boil feature. A test pit excavated next to the location of the flake, 5 shovel tests placed on the ridge, and examination of other soil exposures produced no additional artifactual material.

- TLM 139. The site is located on a broad, flat-topped ridge which parallels the west side of the Jay Creek canyon. The sides of the ridge are defined by the canyon and on the west by the ravine of a small creek. Field of view from the site includes the east side of the Jay Creek valley, the lower portion of the valley to the south and rising irregular terrain grading into hilly uplands to the north and west.

  No surface indication of the site was observed. A test pit produced 46 basalt, chert and rhyolite flakes and 7 calcined bone fragments from a charcoal horizon below the organic mat and above (though slightly mixed with) the Devil tephra. In addition, 48 basalt, chert and rhyolite flakes, and a quantity of faunal remains were recovered from the upper portion of a silty matrix underlying the Devil tephra. No other artifactual material was found in 2 shovel tests placed in the vicinity of the test pit.

- TLM 140. The site is located on the southern end of a ridge-like erosional feature formed by the west wall of the Jay Creek canyon and a deeply incised tributary ravine which converges with the canyon from the west. The north end of the ridge-like feature widens and merges with gradually northward rising undulating terrain. The southern portion becomes constricted to a sharp crest. The site is located in an area extending from the south end to 100 m north on the feature.

  Surface material consisting of 2 flakes were found within 50 m of site datum on game trails. At site datum, a basalt biface and 4 flakes of 3 material types were recovered, also occurring on a game trail. A test pit at datum produced a basalt biface and 11 flakes of 3 material types from beneath the organic mat and above the Devil tephra. No further artifactual material was found on the surface or in 8 shovel tests in the site vicinity.

- TLM 141. The site is located on a kame terrace on the west side of Jay Creek. To the east a tributary ravine defines the margin of the kame and subsequently joins southeast end of a small kame. A dense layer of cultural material was encountered in this test pit including 2 projectile points, 1 a complete side-notched point and a lanceolate-shaped point tip. Over 1,300 waste flakes, composed of basalt, rhyolite and chert, and over 800 fragments of calcined bone were recovered from the test pit as well.

Systematic testing of the site included the excavation of five 1-m by 1-m test squares. All 5 of the test squares produced cultural material. Three of the test squares were placed in the location of the reconnaissance test pit. These test squares produced numerous diagnostic artifacts including side-notched projectile points, endscrapers and retouched flakes. Thousands of waste flakes and small calcined bone fragments were also recovered. In addition, large fire-cracked rocks, charcoal and oxidized matrix suggested the presence of a hearth feature. While an exact enumeration of artifacts is not available at this time, at least 2 different components have been identified at the site. The upper component is stratigraphically positioned between a layer of finely sorted organics and an underlying fine gray silty matrix (Devel tephra) and the lower is below a yellowish brown silty unit (Watana tephra).

- TLM 144. The site is located northeast of the mouth of Jay Creek on th west side of the creek. The site includes a prominent elongated knoll and 2 smaller circular knolls. The elongate knoll is the highest point of topographic relief between its location and Jay Creek, and is an excellent vantage point for observing the uplands down to the Jay Creek rim in the area of a mineral lick.

  Both surface and subsurface cultural material was recovered during reconnaissance testing. Three flakes were found on an exposure on the knoll crest. Additional surface reconnaissance located a basalt corner notched projectile point on the southern slope of the knoll. A test pit was placed adjacent to the surface exposure, and 2 flakes and 1 bone fragment were collected from different stratigraphic levels. Artifactual material was also found in 2 of 5 shovel tests placed in the site area with 8 additional flakes recovered.

- TLM 145. The site is located northeast of the confluence of Jay Creek and the Susitna River, on the west side of the creek. It is situated on a ridge which extends eastward from a glaciolacustrine plain toward Jay Creek, with the end of the ridge ca. 100 m east of the site. The ridge is characterized by steep slopes, making the creek relatively inaccessible from the site. In the site vicinity, the ridge slopes at a 4- to 5-deg angle for a distance of 15 m. Visibility is obscured by present vegetation.

Both surface and subsurface material was present at this site. Surface material consisted of a lithic scatter located on a game trail. This game trail follows the ridge crest with the surface material confined to an 8-m segment. Seven waste flakes were surface collected. Additional surface material was observed but not collected. A single test pit placed adjacent to the game trail produced 107 flakes of basalt, rhyolite and chert in addition to 93 calcined bone fragments. Subsurface artifacts were found within a dark brown surface organic layer.

- TLM 146. The site is located north of the confluence of Jay Creek with the Susitna River on the west side of the creek. It is situated on a broad sloping hill that descends to a glaciolacustrine plain. Neither Jay Creek or the Susitna River are visible from the site; however, their valleys can be seen. A narrow, shallow clear water stream, which originates at a kettle lake west of the site, passes south of the site and is easily accessible.

  No surface cultural material was observed at the site. Seven shovel tests were dug during reconnaissance testing with 1 of the shovel tests producing a single basalt flake with retouch along one of its margins. This shovel test was expanded into a test pit, but no additional artifactual material was found.

- TLM 147. The site is located north of the mouth of Jay Creek on the west side of the creek. It is situated on the eastern portion of a broad flat terrace which extends ca. 200 m to the northwest and west, where it merges with undulating kame topography. The view from the site is only limited in a westward direction where it is partially obscured by a small kame feature.

  No cultural material was observed on the surface of this site. Five shovel tests were dug, 1 of which contained a single rhyolite flake. Further surface reconnaissance and the excavation of a test pit, superimposed over the shovel test which contained the rhyolite flake, failed to locate any additional artifactual material. Two distinct tephras were identified at this site although the stratigraphic position of the single flake in relationship to these tephra is unknown.

- TLM 148. This site is located northeast of Jay Creek mouth on the west side of the creek. It is situated on the northwest corner of a roughly triangular, broad, flat terrace, which is part of a gradually sloping undulating glaciolacustrine plain north of the Susitna River. Jay Creek canyon, a tributary valley, and uplands to the north are visible from the site. The view to the west is obscured by spruce forest and intervening hills. A marsh and small creek 100 m to the west of the site provide the nearest easily accessible water.

  Eight shovel tests were dug at the site during reconnaissance testing, 1 of which contained 20 rhyolite flakes. This shovel test was expanded into a test pit and 11 additional rhyolite flakes were recovered. These flakes were stratigraphically positioned in a charcoal unit beneath the organic mat, in a pinkish-gray fine silt unit (Devil tephra), and at the contact between them.

- TLM 149. The site is located north of Jay Creek mouth on the west side of the creek. It is situated on a low crescent-shaped kame knoll which is one of a series of similar kame features on an undulating terrace between Jay Creek and Laha Lake. The knoll is east of Laha Lake and north of a small unnamed creek which provides an easily accessible source of water. Visibility from the site includes similar kame features and upland topography.

  No cultural material was observed on the surface of the knoll and only 1 of 4 shovel tests placed on the knoll revealed cultural material. This shovel test was expanded into a test pit which revealed 990 small burned bone fragments and 2 small rhyolite flakes. A C-14 sample was collected from this test in association with the contact between the Watana and Oshetna tephras.

- TLM 150. The site is located north of the confluence of Jay Creek with the Susitna River in an area of kame ridges and knolls on an undulating terrace between Jay Creek and Laha Lake. The site is situated on a fairly linear ridge, just southwest of the central high point of the ridge. A small clear water creek, the outlet stream from a small pond northeast of Laha Lake, flows 100 m to the north. From the site, there is good visibility of the rolling kames to the east and north. The view south and west is obscured by open spruce woodland and intervening topography.

No surface artifacts were located at this site during resonnaissance testing. Four basalt flakes were found in a shovel test which was expanded into a test pit. Four additional basalt flakes were encountered beneath the organic layer and protruding into the underlying Devil tephra. In addition, 5 fragments of calcined bone were found within or at the contact of the Watana tephra. The spatial distribution of material in the test pit suggests that the site contains more than one component. Eight additional shovel tests placed in the site area were negative.

- TLM 151. The site is located north of Jay Creek mouth in an area characterized by kettle and kame topography on an undulating terrace between Jay Creek and Laha Lake. The kame feature on which this site is situated is approximately 100 m in length with the site located on a circular rise on the southwest end. A narrow clear water stream, which originates at a kettle lake northwest of the site, borders the west side of the kame ridge, and provides an easily accessible source of water. Visibility from the site is partially obscured in all directions by open spruce woodland forest.

  No cultural material was observed on the surface of the kame ridge. Fifteen calcined bone fragments were found in a shovel test which was then expanded into a test pit. Five hundred and twenty-one bone fragments and 13 flakes representing 4 different material types were recovered from this test pit. The cultural material was found beneath a soil unit of dark brown finely sorted organics. It is possible that a pit feature is represented within this test pit. No additional subsurface testing was conducted in the 15-m by 6-m level area on which the site is situated.

- TLM 152. The site is located northwest of the Jay Creek and Susitna River confluence, and east of Laha Lake. It is in an area that is characterized by kettle and kame topography. The site is situated on a prominent elongate kame feature overlooking 2 kettle lakes. An additional 1 hecture kettle lake is located northeast of the site, but is obscured from view by intervening terrain. The view from the site encompasses the entire margin of the lake south of the site in addition to portions of the lake to the west.

  Six shovel tests were dug on the kame feature. One gray chert flake was found in one of the shovel tests which was then expanded into a test pit. The stratigraphy of the test pit revealed 3 distinct tephra units although no other artifacts were present. Surface reconnaissance of the site area failed to locate any additional artifactual material.

- TLM 154. The site is located north of the mouth of Jay Creek and south of Laha Lake. It is in an area of kettle and kame topography with the site located on a kame ridge which is bordered to the south-southeast by a 2-hecture lake. The site is situated on the broad flat crest of a kame ridge. Visibility from the site is obscured by intervening terrain; however, a panoramic view is available from the top of the ridge ca. 5 m higher in elevation than the site.

  An initial shovel test revealed 12 flakes of 2 different material types. This shovel test was expanded into a test pit and 150 additional flakes were recovered. The majority of the flakes were of a gray rhyolite but material also included quartzite. Six subsequent shovel tests were placed in the vicinity of the test pit. A rhyolite lanceolate projectile point was found in one of these shovel tests. In addition, surface reconnaissance revealed 3 rhyolite flakes on the surface of the lichen mat.

- HEA 174. The site is located on top of a 30-m high knoll in glacially scoured terrain at the northeastern end of Deadman Lake, northeast of the point where Deadman Creek enters the lake. The view from the site is extensive and panoramic overlooking Deadman Lake to the west and Deadman Creek to the south.

  The one test pit excavated at the site during reconnaissance testing did not produce any cultural material. The artifacts recovered were collected from the surface of the top, western and southeastern slopes of the deflated knoll on which the site is located. Cultural material collected included: 1 basalt sidescraper, 1 basalt blade-like flake, 1 gray quartzite lanceolate point, 2 black chert endscrapers, 1 black chert scraper fragment, 1 red-brown jasper endscraper fragment, 2 brown jasper retouched flakes, 2 gray chert retouched flakes, 2 gray rhyolite retouched flakes, 1 gray rhyolite flake, 1 gray chert flake and 2 quartz flakes.

- HEA 175. The site is located at the southwest end of Butte Lake and consists of 2 loci (A and B) focused around 2 knolls within 200 m of the Butte Creek outlet and on a ridgeline running along the west shore of the lake. The view from the site includes all of Butte Lake and the uplands to the south, east and west.

Reconnaissance testing and systematic testing were conducted at the site. Six shovel tests and 2 test pits were excavated during reconnaissance testing and collectively produced 1 side-notched point, 1 burinated flake, 1 point base, 2 possible microblades, 3 blade fragments, 25 chert flakes, 13 rhyolite flakes, 6 basalt flakes and 3 microblades. Five 1-m by 1-m squares were excavated at Locus A during systematic testing and collectively produced 2 microblade fragments, 1 basalt microblade, 1 possible basalt core tablet, 1 uniface fragment, 1 possible core chopper, 2 side-notched points, 1 chert biface fragment, 1 siltstone retouched flake, 2 retouched basalt flakes, 1 blade-like flake, 1 burinated flake, 109 chert flakes, 76 basalt flakes, 9 siltstone flakes, 4 rhyolite flakes, 2 obsidian flakes, 5 quartzite flakes, 94 flakes of undetermined material type and 4 bone fragments. Surface artifacts included 1 projectile point base, 1 basalt biface fragment, 1 gray chert flake core, 1 rhyolite uniface fragment and 1 cryptocrystalline core (possible).

- HEA 176. The site consists of 2 loci (A and B) on 2 kame knolls at the eastern end of Deadman Lake southeast of the point where Deadman Creek enters the lake. The view from either locus is panoramic encompassing the eastern end of Deadman Lake and the surrounding low relief terrain for 2 to 3 km in all directions.

  The one test pit excavated at Locus A during reconnaissance testing produced a single red chert flake. No subsurface testing was conducted at Locus B where 1 chalcedony flake and 2 black basalt flakes were collected from the surface. Surface material collected at Locus A was recovered from 2 different clusters and collectively consisted of 1 gray rhyolite flake, 4 gray chert flakes, 1 black basalt flake and 1 white chert flake. The red chert flake from Test Pit 1 at Locus A was recovered from below the Watana tephra which in this test was located directly on top of glacial drift with no intervening lower tephra.

- HEA 180. The site is situated on top of a knoll southeast of the Deadman Lake outlet and north of the confluence of Deadman Creek and a northern tributary. The knoll on which the site is located is a dominant high landform in the region providing a panoramic view from the site.

  The only test pit excavated on the site during reconnaissance testing produced 2 chalcedony flakes. The remainder of the cultural material from the site was collected on the surface at 2 different scatters and consisted of the following: Scatter 1--1 gray chert flake, 2 white chert flakes, 1 black basalt flake, 2 light gray chalcedony flakes and 1 black chert flake; Scatter 2--1 jasper microblade, 1 chert microblade, 1 dark gray chert microblade fragment, 1 brown obsidian burin spall, 1 white chert point base, 1 brown jasper flake, 1 red-brown jasper flake, 1 white chert flake, 1 pale red chert flake with retouch, 1 light red-brown chert flake, 1 red streaked gray chert flake, 1 black speckled white chert flake, 1 pale red rhyolite flake, 1 light red rhyolite flake, 1 gray-white rhyolite flake, 1 black flecked chalcedony flake, 2 brown chalcedony flakes, 1 white-brown chalcedony flake, 1 white-gray chalcedony flake, 1 clear quartz flake, 1 black basalt flake and 1 light brown siltstone flake.

- HEA 183. The site is located on a small low knoll northwest of the outlet stream which drains Deadman Lake. The site is located on a deflated portion of the knoll. The view from the site consists of most of Deadman Lake, as well as the outlet stream.

  The only artifact recovered from the site was 1 gray chert flake collected from the surface of the deflated portion of the low knoll. Due to the rocky nature of the area no subsurface testing was possible.

- HEA 184. The site is located on a blowout northwest of the outlet stream which drains Deadman Lake, on the eastern shore of a small lake west of Deadman Lake. The view from the site includes all of the small lake west of the site, two-thirds of Deadman Lake and a portion of its outlet stream to the south.

  The one test pit excavated at the site during reconnaissance testing did not produce any cultural material. The only artifacts revealed from the site were 2 yellow-brown chert flakes which exhibited retouch and articulated to form a large scraper.

- HEA 185. The site is located on an east-west trending ridge on the west side of Deadman Lake approximately 70 m above the lake. In addition to Deadman Lake, 3 smaller lakes, Big Lake, and an unnamed stream are visible from the site.

  Due to the rocky nature of the site, no subsurface testing was possible. Artifacts were collected from 2 loci (A and B) and collectively consisted of 2 gray chert flakes, 4 basalt flakes, 1 possible scraper preform and 1 brown chert thumbnail scraper.

- HEA 186. The site is located on a knoll east of Deadman Lake. The site is situated primarily on the eastern half of the east-west oriented knoll. The view from the site includes the braided section of Deadman Creek, and several small lakes.

  The one test pit placed on the site during reconnaissance testing produced 1 black basalt flake. Surface artifacts collected at the site consisted of 1 patinated gray chert biface, 1 gray chert projectile point fragment, 2 gray chert blade fragments, 1 gray chert biface fragment, 9 gray chert flakes, 1 white chert flake, 1 black chert flake and 3 black basalt flakes.

(ii) Historic Sites - Results and Discussion

- TLM 020. The site is located on Portage Creek. The site consists of a historic inscription dating to 1897, located on a bedrock exposure overlooking the creek. Four names and the date of July 2, 1897, are included in the inscription.

  Other than the inscription itself, no historic or prehistoric cultural material was observed in the vicinity and no subsurface testing was conducted at the site.

- TLM 056. The site, a partly collapsed log cabin, is near the base on Tsusena Butte. The cabin is situated on a gently sloping terrace 4 m above the level of the creek west of the creek margin.

  The site consists of a dirt floored, 1 room log cabin constructed of unpeeled spruce logs with moss chinking. The west wall of the cabin is collapsed. A door opening is present in the south wall but the door itself is missing. Few interior furnishings were noted; however, a third of the cabin interior is visible due to the collapsed sod-covered roof. The general condition of the cabin is poor with the majority of the log members extensively rotted. There was no collection of cultural material at the site. No associated outbuildings were noted; however, a rectangular 1.3-m by 1.8-m depression is located southwest of the cabin. A recent tool cache was found 2 m east of the cabin under a stand of spruce trees.

- TLM 071. The site was the trapping headquarters of Elmer Simco and was built in the early 1930s. The site complex is located east of Gilbert Creek, a small tributary of Kosina Creek. The cabin is situated on a low, gently sloping shoreline terrace less than 5 m above the creek.

The cabin consists of one room (12 feet by 15 feet) and has a dirt floor. General condition of the cabin is fair to poor. The cabin contains the remains of the original furnishings and supplies used during the period between 1930 and 1950. Leakage from the roof is causing destruction of many interior items. There are 3 associated outbuildings at the site: an outhouse, a dog kennel and a grass-covered structure of unknown function. Other associated features at the site include a garbage dump and a woodpile. No cultural material was collected at the site, nor was any subsurface testing conducted.

2.6 - Geoarcheology

(a) Introduction

Geoarcheology data were used for selecting survey locales, and provided limiting dates for cultural resources on various terrain units associated with the last glaciation. Evaluation of various stratigraphic soil and sediment units, including three volcanic ashes, provided a basis for evaluating cultural resources found in relationship to these units. The various aspects of the geoarcheological studies are presented below.

(b) Geoarcheologic Terrain Unit Mapping

A preliminary terrain unit map of the project area was prepared in 1980 and has undergone two revisions incorporating the results of field studies. Areas of similar geomorphologic character and surficial age are delineated, information which was useful in the selection and evaluation of survey locales.

(c) Stratigraphic Framework

Regional stratigraphic investigation was undertaken with the selection and description of 25 river bluff exposures. Organic samples were collected from four exposures and used to establish a general valley chronology including glacial and depositional history. The stratigraphy of the project area indicates a complicated glacial history with episodes of advance, stagnation and retreat, formation and drainage of proglacial lakes, and fluvial reworking of glacial sediments. Alluvial deposition, soil development and tephra falls are also evident.

(d) Preliminary Glacial-Geomorphologic Mapping General Comments

The investigation and mapping glacial geomorphology in the project area has assisted in the interpretation of the complex glacial history of the project area, which is characterized by the

the interaction of a number of valley glaciers. The valley glaciers were variable in their patterns of advance, stagnation and retreat, as evidenced by the location, orientation, altitude and state of development of moraines, ice marginal meltwater channels, lake shorelines, kame-deltas, eskers and ice flow indicators; the variation is attributed to particular characteristics of the largely independent source areas. During periods of intense glaciation, merging of valley glaciers occurred, resulting in the extension onto the valley bottom of ice lobes. Their subsequent wastage has produced extensive ice stagnation terrain in the project area.

(e) The Last Glaciation

Glaciers are interpreted to have covered much of the lowland region of the study area during the last major glaciation (late Wisconsin time) which occurred over much of Alaska between 32,000 and 13,000 years BP. The Susitna Canyon area was covered by a complex glacier system that resulted from confluent ice tongues and lobes which behaved as individual units. The distribution of glacial terrain features indicates that following the glacial maximum lobes withdrew at different rates. Moraine morphology gives evidence for glacial retreat followed by a series of glacial readvances. Large areas of stagnant ice were present in most of the broad lowland regions during deglaciation. The stagnant ice may have influenced human movements as late as 8-10,000 years BP.

(f) Archeological Stratigraphy

Sixteen major stratigraphic units can be recognized throughout the project area. No individual archeological site contains all recognized units but many have at least ten. In general, the stratigraphy consists of glacially scoured bedrock overlain by a series of volcanic tephra horizons interbedded with weathering horizons and buried soils. A surface organic mat overlies the older sediments. Nonvolcanic eolian sediments occur both as part of the tephra units and as separate subunits between tephra and organic horizons. In the archeological stratigraphy of the project area the contact units are just as, if not more, important as the lithologic units. Sixteen significant intervals of time can be isolated and correlated on the basis of these contact units (Figure E.4.5).

(g) Cultural Horizons

Nine discrete cultural horizons can be identified at the present time from the regional archeological stratigraphy (Figure E.4.5). These can all be correlated throughout the region. Each horizon can be dated within limits, but the time span represented by components varies from a few hundred years to as much as 7-8,000 years. Although a horizon can be identified and correlated and can be dated within limits, there is no proof that cultural materials from the same horizon at different sites are exactly equivalent in age. The volcanic ash/soil sequence provides the framework for this relatively excellent chronology.

Cultural horizons were assigned only where there was demonstrable evidence of human occupation that can be related to the regional stratigraphy. Although artifacts were found in all of the units except bedrock, only 9 horizons could be firmly documented. Downslope reworking, cryoturbation, human alteration and root disturbances all serve collectively to displace artifacts from their orginal contexts.

Evidence for human occupation in subunits associated with the contact units are present. Within any given site these can be arranged in stratigraphic succession, but they were not isolated as horizons, or even formal subhorizons because they cannot be correlated regionally. It is probable that many more than 9 cultural horizons exist. No one site contains more than 4 regional cultural horizons, with the exception of site TLM 030 which contains 5 horizons, one of which occurs in a subunit. Most sites contain 1 or 2 regional archeologic horizons.

(h) Chronology and History

The evolution of the stratigraphic record presented in Figure E.4.5 can be broken into 4 major intervals which have different implications for archeology: (1) the time prior to the last glaciation, represented by Unit 15, (2) the time during the last glaciation, represented by Unit 14, (3) the time following deglaciation but prior to deposition of the first recognized tephra, represented by Unit 13, and (4) the time representing recurrent volcanic ash deposition and soil formation, represented by Units 1 to 12. Eight radiocarbon dates from regional stratigraphic studies and 12 dates associated with the volcanic ash stratigraphy permit the establishment of a reasonably good chronology for the depositional history of the project area. Deposition of the tephra sequence probably occurred within the last 5,000 to 7,000 years. Three distinct tephra have been identified in the study area. These units were given regional names for purposes of field identification and nomenclature. Tentative limiting dates and names given the tephra in order of increasing age are as follows: Devil (1800-2300 BP, AD 150-350 BC), Watana (2300-3200 BP, 350-1250 BC) and Oshetna (greater than 4700 BP, 2750 BC).

(i) Mammoth/Mastodon Fossil Discovery

A mammoth/mastodon fossil was found in situ in fluvial gravels at Tyone Bluff. The fossil, representing the shaft portion of a right femur, was identified by R.D. Guthrie and George S. Smith of the University of Alaska, and is the first documented occurrence for any terrestial Pleistocene megafauna in southern Alaska. It yielded a radiocarbon date of 29,450 $\pm$ 610 BP, and clearly implies nonglacial conditions at the time (Thorson et al. in press). This discovery indicates that the range of mammoth should be extended about 200 km south of its present limit. It also suggests that mountain passes in the Alaska Range may have been deglaciated during mid-Wisconsinan time, and that portions of southern Alaska may have been suitable for human habitation during this time.

(j) Summary of Geologic History

(i) The Susitna Valley has been repeatedly inundated with extensive valley glacier systems that coalesced to form a minor mountain ice sheet. One or more pre-Wisconsinan glaciations have been recognized.

(ii) Much of the present valley was carved to the present river level prior to middle Wisconsinan time (31,000 yr BP). The direction of drainage at that time is presently unknown.

(iii) The valley bottom was extensively modified during the last glaciation which began some time after about 31,000 yr BP in the Fog Creek area, and some time after about 2,000 yr B.P. in the Tyone River region.

(iv) During deglaciation large areas were covered with stagnant ice, and meltwater drained freely below the surface, forming complex esker systems. The direction of meltwater flow and the presence of till at river level suggests that Devil Canyon was carved prior to Holocene time. Glaciers retreated systematically over many areas leaving a number of periodically spaced massive recessional moraines.

(v) Deglaciation of the Tyone River region was complete by at least 11,500 yr BP. Because this area was covered by a large piedmont ice lobe, other areas may have been ice free even earlier. Thus, much of the Susitna Valley may have been deglaciated prior to about 12,000 yr BP. Stagnant ice may have persisted for several thousand years over much of the valley floor.

(vi) During Holocene time, the Susitna River has not greatly deepened its valley in most areas; rather it has widened the valley bottom slightly by lateral planation. Low-level alluvial terraces and tributary mouth alluvial fans have formed in widened portions of the valley. Many small sites tributary to the Susitna have greatly incised their channels during Holocene time, resulting in steep irregular profiles characterized by waterfalls and rapids.

(vii) During the last half of Holocene time, intervals of volcanic ash deposition from distant sources alternated with intervals of weathering, soil formation and erosion.

2.7 - Paleontology

(a) Introduction

Paleontological studies were implemented as part of the cultural resource program in order to identify the types of paleontological specimens that might occur in association with archeological and/or historic sites, and therefore, assist in recognizing them should they occur at a site. Because paleontological specimens representing animal bones (particuarly Pleistocene megafauna) are readily recongizable, emphasis for paleontological investigations were centered on fossil plants and pollen. A preliminary aerial reconnaissance of the study area and a review of the literature indicated that the area within the project study area that had the greatest potential for revealing plant fossils was the Watana Creek area. The information provided by this baseline study was incorporated into cultural resource investigations.

(b) Plant Fossils

The assemblage of fossil leaves collected from the deposits along Watana Creek were chiefly in calcareous concretionary horizons of siltstone to fine sandstone. The assemblage from the sequence is extensive, but is characterized by an extremely low species diversity. The flora from the Watana Creek deposits include: *Metasequoia* sp., *Alnus evidens* (Holl.) Wolfe, *Salis* sp.

(c) Pollen

Pollen grains were extremely depauperate in both quantity and species. Many slides prepared for pollen analysis were found to be totally lacking in grains. A point counting technique was not considered justified to characterize the pollen assemblage of the deposits. The predominant pollen are Betula, conifer-type grains, and trilete spores.

3 - EVALUATION OF AND IMPACT ON HISTORIC AND ARCHEOLOGICAL SITES

3.1 - Evaluation of Selected Sites Found: Prehistory and History of the Upper Susitna River Region

(a) Introduction

Based on the results of this survey, it is probable that no single archeological site in the Upper Susitna River area will provide the basis for defining the Holocene cultural chronology for the region. Because no single site preserves the cultural spectra since late Wisconsin deglaciation, it is necessary to base the culture chronology on a series of individual sites and site components throughout the study area. The 167 archeological sites documented during the course of this survey are primarily single component sites. For the purposes of this presentation, only those sites in which the age of the site, or a component, can be documented with certainty will be used for analysis. The chronological documentation of sites and components are primarily based on two methods: 1) radiocarbon determinations and 2) relative stratigraphic placement in relationship to the three tephra. Typological considerations relating to the chronology (not site function) have been considered secondarily, because of the uncertainty associated with this kind of dating and the differing age determinations proposed by many archeologists.

The sites discussed in this application provide only brief glimpses of prehistoric cultural development in what are, in many cases, very diverse ecological settings. In all probability the sites and their various components represent different facets of the prehistoric subsistence cycle. Consequently, what are presented as "type" sites and components for particular cultural periods, may in fact not "typify" the material cultural remains during specific cultural historical periods. While these limitations are recognized, it is still possible to begin to define the basic cultural chronological skeleton while realizing that during some periods it may contain a considerable amount of "flesh" and during others major "anatomical" elements are missing.

(b) Contemporary Sites: 1945 to Present

A number of contemporary cabins are scattered throughout the study area representing modern recreational use of the project area, primarily for sports hunting and fishing. Because of the contemporary nature of these structures, they have not been included, discussed or analyzed in this report. Suffice it to say that contemporary use of the area will ultimately be documented in the archeological record.

(c) Trapping Period: 1920 - 1945

Four cabins which have been documented as trappers' cabins have been reported in the project area. These cultural remains document economic use of the area for fur trapping during the 1930s, and in this respect the Susitna area reflects many other areas of rural Alaska in that this was a time of relatively high fur prices during a period of international depression. The remains of four cabins dating to this period were located in the project area. However, the cabin of Elmer Simco (TLM 071) may be one of the best remaining examples from this period, because most of the household and trapping equipment are preserved intact.

(d) Exploration/Gold Rush: 1897 - 1920

Gold was discovered in the Cook Inlet region in 1895, shortly after which the first major western population expansion into the Upper Susitna occurred. No historic sites dating to the gold rush in the Upper Susitna have been discovered in the project area to date. Because Devil Canyon is not navigable, early explorers/prospectors may have been discouraged in their attempts to prospect the Upper Susitna. However, an inscription near the mouth of Portage Creek documents that William Dickey and three other travelers ascended the river as far as Devil Canyon in 1897 (TLM 020).

(e) Athapaskan Tradition:
A.D. 1900 - A.D. 500

The Upper Susitno drainage was occupied by Western Ahtna Athapaskans at the time of historic contact. Through implementation of the direct historic approach, it is possible to trace through time Athapaskan occupation of the study area. Several sites in addition to those discussed below may document various periods of cultural historical development throughout this period. However, the subsequent discussion only includes sites subject to systematic testing from which age determinations can be made with certainty.

The Kosina Depression Site (TLM 065) was systematically tested and best exemplifies the later phase of this period. The site consisted of the remains of at least one house and several associated cache pits. Stratigraphic profiles from this site clearly indicate that the house postdates the Devil tephra, and the glass trade beads and bottle glass fragments clearly document the structure's comparatively recent age. While precise dating of the structure is not possible at this time, western trade goods may have penetrated the area as early as the late 1700s and the site may be reasonably estimated to range in age between the late 1700s and 1900.

A pronounced material cultural trait which occurs at TLM 065 is the high frequency of fire-cracked rock and fractured and burned caribou bone. The rock is characteristically uniform in that it originates from fist and slightly smaller-sized, smooth, water-worn cobbles. It is most probable that these cobbles were deliberately selected for stone boiling; a technique commonly employed by Native North Americans in the absence of ceramic cooking vessels. This material cultural trait coupled with abundant fractured long bone fragments suggests preparation of marrow "soup" and possibly bone grease in birch bark cooking containers. These site attributes are commonly associated with archeological sites throughout the Alaskan Interior and through the direct historic approach have been identified as the remains of prehistoric Athapaskan culture (Plaskett, 1977).

This common association is characteristic of a number of sites located throughout the course of the archeological survey. All sites and site components which exhibit this association in a clear stratigraphic context occur above the Devil tephra and consequently are younger than A.D. 200. In addition to the Kosina Depression Site (TLM 065) discussed above, these sites are: 1) Component I, Permafrost Creek (TLM 050) ca. A.D. 1670; 2) two and possibly three components at the Tsusens Creek Site (TLM 022) which date slighly prior to and subsequent to A.D. 1500; 3) a feature at the Little Bones Ridge Site (TLM 059) ca. A.D. 740; 4) Component I at the Red Scraper Site (TLM 062) ca. A.D. 570; 5) Component I at the Tsusena site (TLM 097) ca. A.D. 550; and 6) TLM 130 which produced a radiocarbon date on charcoal of A.D. 530 ±70. Three additional sites which have not been subject to radiometric dating but which exhibit the pronounced association of fire-cracked cobbles and fractured mammal bone, all occur stratigraphically above the Devil tephra. These are: 1) the Upper Watana Creek Site (TLM 038); 2) the No Name Creek site (TLM 043); and 3) Component I at the Duck Embryo North Site (TLM 048). At two of these sites, No Name Creek and Duck Embryo North, evidence for heat treatment of lithics has been recognized based on the vitreous character of the lithic debitage.

While it may appear dubious to define a cultural period primarily on the basis of the association of only two cultural traits, these sites are strikingly similar when viewed collectively and all are restricted temporally. Another striking similarity shared by these sites is the lack of diagnostic artifact types. However, this may partially reflect the comparatively small samples recovered during testing. The sites suggest intensive reliance on caribou hunting, occasionally moose hunting, intensive use of stone boiling for food preparation, and heat treatment of lithics used for tool manufacture.

The sites occur in a variety of ecological locales. Permafrost Creek, Tsusena Creek and No Name all occur adjacent to the junction of clear water tributaries to the Susitna and are situated in the valley bottom. The Upper Watana Creek site occupies an overlook with a panoramic view to the north suggestive of fall caribou hunting. Duck Embryo North is situated adjacent to a lake outlet possibly indicating exploitation of fish and waterfowl. The Tsusena site (TLM 097) is adjacent to Tsusena Creek where constricting topographic features funnel large mammal movements past the site. Sites which contain structural remains; Little Bones Ridge, Kosina Depression, and probably Jay Creek (although this site was not subject to systematic testing) are located in elevated areas which seem to lack attractive ecological factors (such as proximity to significant bodies of fresh water, panoramic views, constricting land forms, etc.). It is possible that these more substantial sites containing features may reflect prehistoric distribution of caribou rather than other ecological variables traditionally associated with site occurrence. Such obscure site locales may also reflect social variables such as defense or ostracism.

Testing and surface features suggest that all sites dating to this time period are comparatively small and probably represent groups of not more than one or two nuclear families or a few hunters. Collectively these sites represent a variety of functions and seasonal occupations, which cannot be accurately defined based on the limited results derived from the systematic testing conducted to date. It is important to reemphasize that this discussion has been limited to only those sites which can be firmly dated, and undoubtedly numerous other sites dating to the Prehistoric Athapaskan Period exist in the project area.

All the sites dating to this period contain faunal remains, and thus present the possibility for documenting the organic component of prehistoric Athapaskan material culture, which is currently poorly understood and represented at only a few archeological sites. The diverse types of sites situated in a variety of ecological locales may enable further research to document shifting subsistence and settlement patterns through time. Collectively these sites are extremely significant, for they hold the potential to define Athapaskan cultural development during the past 1,500 years. This has not been accomplished in Alaska or the Yukon and Northwest Territories, largely because previous research programs have not been able to locate sites conducive to answering these questions, and have lacked the chronological controls essential for defining cultural development through time.

(f) Choris/Norton Tradition:
<u>ca. A.D. 500 - ca. 1500 B.C.</u>

Three archeological sites have yielded artifactual material from stratigraphic contexts which suggest that they may be ascribed to the Choris/Norton tradition. These are Component III at the Tsusena site (TLM 097) and the upper component at the Fog Creek site (TLM 030) which has been radiocarbon dated to 360 B.C. $\pm$220 (DIC-1877), and the Left Fork Site (TLM 069) which was probably occupied immediately prior to deposition of the Watana tephra. The flakes from the upper component at Fog Creek were unfortunately bagged in the field with those from the lower component, thus rendering definition of the lithologic types associated with this component impossible. However, fine grained silicious rock types are represented in this sample and were probably derived from the upper component, while the remainder of the sample is basalt and is probably derived from the lower, Northern Archaic, component. No diagnostic artifacts were recovered from Component I.

Component III at the Tsusena site (TLM 097) was not subject to radiometric dating, but is clearly associated with the contact between the Watana and Devil tephras. This component contained 9 fire-cracked rock fragments, 15 waste flakes of rhyolite and tuff, and 65 tuffacious flakes. Although the assemblage does not provide sufficient data to define the Choris/Norton tradition within the project area, it does, when coupled with data from a number of other sites, provide data which strongly indicate the occurrence of this tradition within the Upper Susitna region between ca. A.D. 500 and ca. 1500 B.C.

The period of occupation of the Left Fork Site (TLM 069) remains problematic, but the preliminary data suggest that it probably occurred immediately prior to the deposition of the Watana tephra. Several artifact types suggest that the material cultural remains from this site are similar to artifacts typologically associated with Choris/Norton period in other regions of Alaska. Bone preservation at this site suggests that it was occupied shortly before deposition of the Watana tephra, because bone preservation is comparatively rare in archeological components predating the Devil tephra in the Upper Susitna region.

Three additional sites (TLM 033, TLM 034, and TLM 053), which have only been subject to reconnaissance testing, indicate cultural components between the Watana and Devil tephras and this suggests that these sites may also be ascribed to this temporal period. In all three sites, no diagnostic artifacts were recovered, and the cultural components were defined on the basis of lithic debitage alone. It is important to note that the debitage in all three cases is fine grained cherts or rhyolite, which may be an indicator of this tradition in the Upper Susitna region.

While it has not yet been possible to unquestionably document diagnostic artifacts dating to this period, several sites in addition to the Left Fork site (TLM 069) in the project area have yielded artifacts characteristic of this tradition. Bacon (1978a:32) suggested possible Norton influence at TLM 018, based on the occurrence of a triangular trending to pentagonal end blade. Irving (1957:43, 47) reported the discovery of three obliquely pressure flaked side blades on an overlook near the Tyone River. The artifacts reported by Irving still represent the best typological indication of the Norton/Choris tradition in the Upper Susitna.

This critical interval in non-coastal Alaskan prehistory is poorly understood, and the Upper Susitna River holds excellent potential for resolving the myriad of problems associated with it. Extensive field investigation of archeological components dating to this interval is essential to: 1) document the material cultural remains dating to this period; 2) elucidate settlement and subsistance patterns; and 3) resolve the problems associated with the postulated late Denali complex.

(g) Northern Archaic Tradition:
<u>ca. 1500 B.C. - ca 3000 B.C.</u>

Component IV at the Tsusena site (TLM 097) best documents the stratigraphic placement of the Northern Archaic Tradition within the project area. The stratigraphic position of this component is clear and is supported by a radiocarbon determination of 2070 $\pm$65 B.C. (DIC-2283). This component contained the base of a black basalt side-notched projectile point and black siltstone flake core along with 312 flakes of basalt and 16 of rhyolite and tuff. Because side-notched projectile points are the hallmark of the Northern Archaic Tradition, it is reasonable to ascribe it to the Northern Archaic Tradition in spite of the small sample size.

The Fog Creek Site (TLM 030) was not subject to systematic testing, but did yield reliable data pertinent to defining the Northern Archaic Tradition in the project area. Two components were recognized during reconnaissance testing of the site. The lower component contained a side-notched projectile point along with lithic debitage consisting primarily of black basalt. A radiocarbon determination for this component, which also occurs between the Watana and Oshetna tephra, is 2770 $\pm$130 B.C. (DIC-1880). While systematic testing is required to further define and clarify this site, the preliminary data is strikingly similar to that recovered from Component IV at the Tsusena Borrow C site. The Fog Creek site is significant because it not only confirms the stratigraphic placement of the Northern Archaic Tradition in the project area, but further defines the temporal span of the tradition.

Component II, which occurs between the Watana and Oshetna tephras, at Tuff Creek North (TLM 027), proably reflects a Northern Archaic use of this site. Alhtough no diagnostic artifacts were recovered, the lithic debitage is black basalt, the most common lithologic type associated with the Northern Archaic occupation at both Fog Creek and the Tsusena site (TLM 097). The stratigraphic placement of this component between the Watana and Oshetna tephra strongly supports this interpretation.

The lower component at TLM 143 produced side-notched points and a radiocarbon determination on charcoal of 2150 B.C. ±60 and is clearly associated with the Northern Archaic Tradition. Although no diagnostic artifacts were found in the lower component at TLM 128, a radiocarbon date (on charcoal from the paleosol on which the artifacts were recovered) of 2630 B.C. ±780 suggests that this component may also represent the Northern Archaic Tradition.

Although a number of sites in the project area have yielded side-notched projectile points and other artifact types commonly associated with the Northern Archaic Tradition, only Fog Creek, the Tsusena site, Tuff Creek North, and Jay Creek have yielded cultural horizons that can be dated with a high degree of certainty. It is probable that Component IV at the Tsusena site is not the latest occurrence of this tradition within the project area and that the lowest component at Fog Creek is probably not the earliest. Additionally, no artifacts characteristic of the Northern Archaic Tradition have been found either above the Watana or below the Oshetna tephra. These data suggest a temporal span between 1500 to 3000 B.C. for this tradition in the Upper Susitna region.

These data concur with archeological data from other Alaskan archeological sites. The upper Northern Archaic component at the Dry Creek Site located near Healy, Alaska, ranges in age between 2400 and 1400 B.C. (Powers and Hamilton, 1978) and data from the Tangle Lakes area suggest a similar temporal span for this tradition (West 1975). These and other sites in the Alaskan interior support Workman's (1978) hypothesis that Northern Archaic Tradition spread through the Yukon Territory and northward along the Brooks Range to the Onion Portage site by 4000 B.C. and later spread into southern Interior Alaska.

As demonstrated by the Fog Creek, Tsusena, and Jay Creek sites, the study area holds high potential for addressing critical questions pertinent to understanding the Northern Archaic Tradition. These are: 1) closely bracketing the temporal span during which the Upper Susitna was occupied by peoples bearing this tradition, 2) the subsistance strategies and settlement patterns implemented by Northern Archaic Peoples; 3) the nature of house forms and other structures associated with this tradition; and most importantly, 4) data essential to explain the rather dramatic appearance and disappearance of this technological tradition in the archeological records. The Upper Susitna is an extremely critical region for addressing these problems, because various manifestations of this tradition, which may lack diagnostic artifacts (such as side-notched projectile points) can be recognized with clarity based on their expected occurrence between the Watana and Oshetna tephras.

(h) American Paleoarctic Tradition: ca. 3000 B.C.? - ca. 9000 B.C.?

The lowest component at Tuff Creek North (TLM 027) best documents the stratigraphic placement of this tradition in the project area. At this site, Component III clearly rests on top of glacial drift and is capped by the Oshetna tephra. The Oshetna tephra was deposited prior to approximately 2700 B.C. and probably during the interval between 3000 to 5000 B.C. Although no organic material suitable for radiometric dating was recovered from this component, the artifactual material is considerably older than the Oshetna tephra. The lithics rest on and are intermixed with the upper portion of the glacial drift, and exhibit considerable weathering. Both these factors suggest that they were exposed on the surface for an extended period, possibly several thousand years, prior to the deposition of the Oshetna tephra.

The assemblage contains several blocky cores which result from the manufacture of blades, microblades and blade-like flakes. Core rotation is common, and no "type" core has been identified in the assemblage. In addition to the cores, the assemblage contains blade-like flakes, blades, microblades, and waste flakes. Some of the blades and flakes exhibit edge retouch along their margins, which is generally restricted to one surface of the specimens. No bifacial stone tools were recovered from Component III. Admittedly, the sample is small when compared to the estimated spatial extent of the site, but it does suggest striking technological similarities to the Ugashik Narrows Phase (Dumond 1977) on the Alaska Peninsula, Locality I at the Gallagher Flint Station (Dixon 1975), and possibly the Anangula site located on an islet (Ananuliak Is.) off Umnak Island in the Aleutians (Aigner, 1978). Although radiocarbon determinations are not available from this component, it is not unreasonable to estimate the period of occupation between approximately 4000 to 5000 B.C. based on its stratigraphic occurrence below the Oshetna tephra, the advanced degree of weathering exhibited by the lithics, and typological comparison with other Alaskan archeological sites which exhibit similar technological characteristics.

Two additional sites (TLM 040 and TLM 048) appear to contain microblade components which occur below the Oshetna tephra, but the results of systematic testing at these sites are not conclusive. It appears a microblade component is represented in Component II at the Duck Embryo North site (TLM 048) which is probably derived from the contact of the glacial drift and the Oshetna tephra. However, only a single microblade was recovered along with the lithic debitage, and further work is required to clarify the age, nature and extent of this component. At TLM 040, the Tephra Site, numerous obsidian microblades and microblade fragments were recovered. Although their stratigraphic position could not be defined with certainty, there is some indication that they may have been deposited below the Oshetna tephra. Although no radiocarbon determinations are available from either of these sites, future work will probably succeed in defining their stratigraphic position and hopefully provide organics suitable for radiometric dating.

The microblades from the Duck Embryo North and Tephra sites appear to be struck from prepared cores and exhibit a uniformity not reflected in the specimens from Component III at Tuff Creek. The morphological characteristics of these microblades (from TLM 040 and 048) suggest greater technological similarity with specimens commonly associated with the Denali Complex and may be of the same age. It is not unreasonable to postulate that all these components may be ascribed to the American Paleoarctic Tradition and probably date to the interval between 3000 and 9000 B.C. It is probable that the blockier rotated blade microblade cores postdate the prepared cores of the Denali complex, and both assemblages appear to deemphasize the manufacture of bifacial stone tools, particularly projectile points.

The potential of the project area to yield data essential to unraveling many of the complex problems associated with the American Paleoarctic Tradition is excellent. The potential of the Upper Susitna Basin to yield data essential to understanding the complex cultural developments associated with this tradition between the time of deglaciation (12,000 to 9000 B.C.) and ca. 3000 B.C. is excellent.

(i) Early Period: ca. 30,000 B.C. to ca. 20,000 B.C.

The midsection, or shaft, of the right femur of a proboscidean (probably Mammuthus sp.) was recovered from an exposure near the junction of the Tyone and Susitna Rivers. A single radiocarbon date run on bone collagen from the femur yielded a date of 27,500 ±610 B.C. (DIC-1819). This age determination coupled with additional dates from the same stratigraphic section demonstrates that at least some portions of the Upper Susitna were deglaciated during mid-Wisconsin times. The occurrence of the proboscidean fossil also documents that at least one of the passes through the Alaska Range was deglaciated during this time. These data indicate potential for the discovery of archeological sites in the study area, dating to this period have been recognized in the project area.

(j) Summary

Five major cultural traditions have been documented within the study area which span the past 11,000 years. These are: 1) Historic 1897 to present; 2) the Athapaskan Tradition ca. 500 A.D. to 1900 A.D.; 3) Choris/Norton Trandition A.D. 500 to 1500 B.C.; 4) Northern Archaic Tradition ca. 1500 B.C. to ca. 3000 B.C.; and 5) the American Paleoarctic Tradition ca. 1500 B.C. to ca. 3000 B.C.; and 5) the American Paleoarctic Tradition ca. 3000 B.C.

to 9000 B.C.? The project area was glaciated between approximately 9000 B.C and 20,000 B.C. and at least partially deglaciated between 30,000 and 20,000 B.C.

Based on the results of the reconnaissance survey and the limited systematic testing of the select archeological sites, the project area holds excellent potential for addressing many long-standing anthropological questions. Three tephras permit stratigraphic correlation between many sites and site components. This presents a uniquely significant opportunity to define the development of these archeological traditions which has not been possible elsewhere in interior or southcentral Alaska. No single archeological site has been found which preserves the cultural chronology from deglaciation to historic times, but the tephra enable cultural development to be traced through time based on comparisons of a series of sites which can be clearly documented to be temporally discrete.

Because the first goal of archeology is to define cultural chronology, the work conducted thus far has been focused primarily toward this objective. Substantial progress has been made, but clearly considerable additional work is essential if this goal is to be fully realized, particularly during the Choris/Norton and American Paleoarctic Tradition periods. Systematic excavation will not only resolve many of the problems relevant to defining cultural chronology, but concurrently will provide extremely valuable data essential to interpreting the past lifeways of the cultural groups which occupied the region prior to historic contact. Better understanding of subsistence, settlement patterns, and social/cultural phenomena will result as a complimentary product of developing the cultural chronology, and future research strategies should attempt to address these problems.

It is already possible to glimpse some of the larger questions which may be addressed as mitigation of adverse impact to cultural resources progresses throughout the project area. Some are: 1) defining and explaining the interrelationship between cultural succession, vulcanism and environmental change; 2) resolution of as yet unresolved questions relevant to firmly documenting, or rejecting, the occurrence of a Late Denali phase; and 3) definition and interpretation of the nature of cultural contacts, or rapid technological change, which occurred during the periods of transition between cultural traditions. Future mitigation of adverse impact to cultural resources must address these and other problems. The legal requirement mandating the preservation of sites is founded on the knowledge that they hold data which may enable potential explanation of such problems. The Upper Susitna River region may be one of the best locales known in Alaska to preserve such information and address these significant scientific and humanistic questions.

3.2 - Impact on Historic and Archeological Sites

(a) Introduction

The level of adverse impact posed by the Sustina Hydroelectric Project on cultural resources is substantial. Consequently, a mitigation effort corresponding to this level of adverse impact is needed to meet mandates of federal and state cultural resource legislation. Mitigation is discussed further in Section 4.1.

The magnitude and nature of adverse impact the Susitna Hydroelectric Project will have on specific sites or groups of sites depend on the location of these cultural resources in relation to areas affected by construction, operation, maintenance, overall land modification and ancillary development of the Sustina Hydroelectric Project and the type of activities which will occur in these areas (Table E.4.1). Three major types of adverse impacts to cultural resources have been defined; they are direct, indirect and potential. Sites directly impacted are those sites which are immediately affected by ground-disturbing activities associated with preconstruction, construction or operation of the project. These include, but are not limited to, dam construction, access roads, borrow areas, camps, transmission lines, staging areas, airstrips, and reservoirs behind the Devil Canyon and Watana dams. Indirect impact will result from adverse effects that are secondary but clearly brought about by the project and which would not occur if the project were not undertaken. Indirect impact will occur on sites affected by altered and/or accelerated erosional processes associated with filling of the reservoirs. Secondary land modifications such as altered drainage and accelerated erosional processes associated with dam and spillway construction, greater access to remote areas, increased number of project personnel in the area during and after construction, activities related to project maintenance and erosion of the impoundment margins resulting from fluctuating water levels all pose very real, though secondary, threats to cultural resources. Potential impact is connected with ancillary development which can be predicted to occur as a result of the project, but which depend on other variables which are unknown at this time. Such variables include future engineering modifications, future recreational use of the area and increased development along access corridors and impoundment margins. Although the specific impact agent(s) that could impact sites in the potential category are not presently known, impact to sites or groups of sites can be predicted to occur as a result of expected recreational use of the area and increased development associated with this activity. Potential impact could become direct impact, indirect impact or no impact depending on how these activities affect the areas containing cultural resources. When the location of all project facilities and recreational development are known and the cultural resource inventory complete, it will then be possible to identify sites in the potential category that will receive direct, indirect or no impact.

(b) Significance

To comply with federal regulations, impact analysis of cultural resources is required for those sites either listed in, or recommended as eligible for the National Register of Historic Places. The eligibility of a site, or group of sites, for inclusion in the National Register of Historic Places is based on the site(s) significance. Therefore, it is first necessary to determine if the site or group of sites is significant. Determination of signifance is based on the application of National Register of Historic Places criteria which define significance "in American history, architecture, archeology, and culture present in districts, sites, buildings, structures, and objects of state and local importance that possess integrity of location, design, setting, materials, workmanship, feeling, and association and/or that are associated with events that have made significant contributions to the broad patterns of history; or are associated with the lives of persons significant in our past; or that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values or that represent a significant and distinguishable entity whose components may lack individual distinction; or have yielded or may likely yield information important in prehistory and history" (36 CFR 60).

A determination of significance must be based on adequate information. For this project, a program of reconnaissance level testing was implemented to locate and document sites. In order to generate sufficient data on which to base an evaluation of significance, systematic testing was employed. In most cases (a notable exception being historic cabins), systematic testing is necessary to assess significance. The 21 sites systematically tested all provided sufficient data to address the question of significance and 20 of these sites appear to be eligible for inclusion in the National Register.

Significance itself is a relative term which is used in a historic context dependent on the current state of knowledge, method and theory employed, and research questions asked. New techniques and methods have enabled archeologists to collect new and different types of data which allow new questions to be formulated and addressed. Although National Register Criteria are subject to ongoing modification, significance pertaining to archeological sites generally emphasize research potential, site integrity and/or public appreciation.

Although all the sites located as a result of this study are related geographically and temporally, the exact relationships await further study. Most of the sites were found associated with one or more of three tephra which provide limiting dates in a restricted geographic context and provide a unique and scientifically important opportunity to construct the first cultural chronology for the Upper Sustina River Valley. Armed with this information, it is possible to state that all sites (with the exception of TLM 033) found to date in the study area are likely significant and collectively hold the potential for defining the prehistory for this region of Alaska and, therefore, may be eligible for inclusion in the National Register of Historic Places. Based on all data collected to date, a preliminary cultural chronology has been developed (see Section 3.1).

Significance must be assessed in adequate data. Only 231 of the sites located and documented during the three field seasons have been systematically tested (due to time and budgetary constraints) and adequate data are available from these 21. Evaluation of specific site significance for the remaining sites must await systematic testing. However, because a majority of the sites occur in relation to three tephra, it is possible to consider the collective significance of all sites for delineating the prehistory and history of the Upper Susitna River Valley. From this perspective, all sites located to date (with the execption of TLM 033) appear to qualify for the National Register of Historic Places.

Given this level of significance, it may be appropriate to nominate these sites to the National Register as an archeological district because of the unique opportunity the known sites in this area (as well as yet undiscovered sites) have for addressing questions concerning the prehistory of a large portion of Interior Alaska which is presently not well defined. If a nomination of this type is made, it should be done in concert with the State Historic Preservation Officer.

(c) Watana Dam and Impoundment

Two historic sites and 28 archeological sites were located and documented in areas to be impacted by the Watana Dam and its impoundment. The two historic sites (TLM 079, TLM 080) will be directly impacted as will the 28 archeological sites (TLM 017, 018, 026, 033, 039, 040, 042, 043, 038, 050, 058, 059, 060, 061, 062, 063, 064, 065, 072, 073, 075, 077, 102, 104, 115, 119, 126 and 137).

(d) Devil Canyon Dam and Impoundment

One historic site and six archeological sites are presently known in areas to be impacted by the Devil Canyon Dam and its impoundment. The one known historic site (TLM 023) and the six archeological sites (TLM 022, TLM 024, TLM 027, TLM 029, TLM 030, TLM 034) will all be directly impacted.

(e) Proposed Borrow Areas, Associated Facilities, and Areas Disturbed by Geotechnical Testing

Seven archeological sites are presently known in the portions of the proposed borrow areas examined to date (A, B, D, E, F, G), and areas disturbed by geotechnical testing. One site will be directly impacted (TLM 035), two sites have the potential of being impacted (TLM 068, TLM 070), and it appears that four sites will not be impacted due to their distance from expected impact areas (TLM 082, HEA 177, HEA 178, HEA 179). Additional potential borrow areas have been identifed (H, I, J, K) and another expanded (F) which remain to be examined for cultural resources. Sites that fall within both an impoundment area and a potential borrow source are included under the appropriate impoundment section. Proposed borrow Areas I and J are located within expected impoundment areas.

(f) Proposed Access Routes

Survey of the proposed access route was cursory and additional survey of the proposed route and associated borrow areas is required to adquately cover the area. It is likely that numerous additional sites will be located during continued survey.

Nineteen archeological sites are presently known along the selected access corridor and/or associated with proposed borrow areas associated with this corridor. Seven are associated with the proposed right-of-way. Three of these sites will receive direct impact (TLM 051, TLM 155, HEA 211), three indirect impact (TLM 101, 103 and 114) and one has the potential of being impacted (TLM 112). Twelve sites are associated with proposed borrow areas for the access corridor and all will be directly impacted if the borrow areas are actually selected (TLM 098, 099, 106, 107, 108, 109, 110, 111, 113, 153, HEA 181 and 182).

(g) Proposed Transmission Corridors

Transmission line corridors were selected very late in the project. The section from the proposed Watana Dam was selected after the 1982 field season and consequently has not been surveyed. Segments of the transmission corridors from Anchorage to Willow and Healy to Fairbanks were examined at the preliminary reconnaissance level. However continued survey is required to adequately cover these proposed corridors as well as the newly selected portion.

No sites are presently known for the portion of the transmission corridor from Anchorage to Willow. Reconnaissance level survey of the Healy to Fairbanks portion of the corridor and examination of the files in the Alaska Office of History and Archeology document twelve sites within the proposed corridor. Until the exact location of the route is known, including access roads, two placements, etc, all of these sites have the potential of being impacted (FAI 213, 214, HEA 026, 030, 035, 037, 038, 080, 083, 119, 137, and 210). When plans for the transmission corridors are finalized and the cultural inventory complete, it will then be possible to determine the effect of this portion of the project on cultural resources.

(h) Other Areas
(areas outside the above categories but within the study area)

Three historic sites and 89 archeological sites are known in this area. One historic site (TLM 020) and 16 archeological sites (TLM 015, 016, 021, 038, 047, 049, 074, 076, 120, 121, 128, 130, 133, 143, 144 and 145) will be indirectly impacted. Two historic sites (TLM 056, TLM 071) and 71 of the archeological sites have the potential of being adversely impacted by the project (TLM 025, 028, 031, 032, 036, 037, 041, 044, 045, 046, 052, 053, 054, 055, 057, 066, 069, 078, 081, 083, 084, 085, 086, 087, 088, 089, 090, 091, 092, 093, 094, 095, 096, 097, 100, 105, 116, 117, 118, 122, 123, 124, 125, 127, 129, 131, 132, 134, 135, 136, 138, 139, 140, 141, 142, 146, 147, 148, 149, 150, 151, 152, 154, HEA 174, 176, 180, 183, 184 and 185). The remaining four sites will not be impacted by the project (TLM 007, TLM 067, HEA 175, HEA 186).

Although 75 sites in this category are presently located outside expected direct and indirect areas, they could be impacted depending on future developments associated with the Susitna Hydroelectric Project. At present, they should be avoided with the exception of the four sites which appear not to have been adversely impacted by the project due to their distance from expected impact areas. However, if and when it is determined that these sites will be either directly or indirectly impacted, it will then be necessary to mitigate this impact. When final plans for the project, including recreational activities are available, it may then be possible to determine specific sites which will not be impacted by the Sustina Hydroelectric Project.

4 - MITIGATION OF IMPACT ON HISTORIC AND ARCHEOLOGICAL SITES

4.1 - Mitigation Policy and Approach

It is mandated by federal law that the effect of any federal project or federally licensed project on cultural resources must be assessed and mitigation measures developed to lessen or avoid the impact on those resources on, or determined to be eligible for inclusion in, the National Register of Historic Places. Mitigation measures are management tools which provide options when making decisions regarding the preservation or reduction of impact to cultural resources. Although the concept has, and is presently, undergoing refinement, it clearly consists of three options: avoidance, preservation, and investigation (preservation through excavation).

(a) Avoidance

Avoidance consists of any measures that avoid adverse effects of a project on cultural resources. Avoidance in and of itself may not be totally effective if not coupled with a monitoring program that will insure that a historic or archeological site protected from the immediate adverse effect (direct and indirect impact) of the project is not inadvertently damaged in the future as a result of the project (potential impact). For the Susitna Hydroelectric Project, potential damage may result from, but is not limited to, operation of the facilities, increased access to remote areas, recreational activities, private development, and the transfer of lands from federal and state governments to corporate or private parties. Therefore, avoidance must be considered in terms of long range and short range goals aimed at protecting cultural resources beyond the immediate construction phase of the dam and its ancillary facilities.

(b) Preservation

Preservation is any measure that results in the reduction or avoidance of impact on cultural resources through physical maintenance or protection aimed at preventing further deterioration or destruction. Preservation, as with avoidance, implies both short-term and long-term measures. Preservation may consist of stabilization, reconstruction, as well as preservation of a site by constructing a barrier around the site, patrolling and monitoring the site, public education, or the establishment of an archeological preserve. Of all the preservation options available for the Susitna Project, monitoring may have the greatest potential for long-term preservation of not only a particular site or group of sites but for cultural resources in general.

(c) Investigation

Investigation refers to a problem-orientated data recovery program aimed at collecting and conserving archeological data in a scientific manner. A program of this type means that data recovery procedures are developed for each site or group of sites, analysis of materials is undertaken, and the results are disseminated to professional and public audiences. In addition to investigation as a method of avoiding adverse impact, a site(s) could be investigated (excavated), either partially or in whole; if a site(s) appears to fit the research needs of the overall cultural resource management program; if a site(s) may contain information critical to the larger mitigation program; or if a site(s) cannot be protected from indirect or potential impact such as increased off-the-road traffic, increased recreational use, an increase in the number of people in the area or increased site visibility. It is recommended that sites actually investigated on this project be selected on the basis of systematic testing and the recommendations of the SHPO and the NPS.

4.2 - Mitigation Plan

Any mitigation plan must be based on an evaluation of project impact on the total resource, including known and undiscovered sites. Therefore, because only a portion of the area to be impacted by the Susitna Hydroelectric Project has been surveyed and investigated, any mitigation plan must include a program to examine the entire surveyable area and mitigate adverse effects on all sites on, or eligible for, the National Register of Historic Places. This program is designed to be complete in two years allowing submittal at this date to FERC prior to final review of the application. Mitigation proposed here will apply to sites located and tested during this two-year period as well as the sites presently known.

(a) Details of Plan

The highest priority toward mitigating adverse impact to cultural resources associated with the Susitna Hydroelectric Project is to complete the archeological and historical survey and thus provide a complete inventory of cultural resources. Portions of the impoundment areas, all of the access corridor and associated borrow pits and haul roads, as well as the transmission corridors between Healy and Fairbanks and Anchorage and Willow have not been subject to thorough on-the-ground survey and subsurface testing. Therefore, continued survey is necessary. As sites are documented during the course of the survey they will be classified into one of the three impact categories: 1) direct impact, 2) indirect impact, and 3) potential impact (see section 3.2 for definitions).

All sites subject to direct impact should be investigated to assess their eligibility for inclusion in the National Register of Historic Places (Table E.4.2). To accomplish this goal these sites will require systematic testing (for a thorough discussion of systematic testing procedures see Chapter 2 of the 1982 cultural resource report). The objective of systematic testing is to obtain sufficient data to assess the spatial limits, stratigraphy, relative age and possible cultural affiliation of a specific archeological site. These data are essential to assess the ability of a site to yield significant scientific information, which is a necessary criterion for determining the signficance of cultural resources under the Advisory Council guidelines as stated in "Procedures of the Advisory Council on Historic Preservation, 36 CFR 800. Following systematic testing, each site will need to be evaluated to determine whether it can provide data relevant to the three major goals of North American archeology: 1) establishment of cultural chronologies; 2) definition of past lifeways; and 3) explanation of cultural process. If, following systematic testing, a specific site is found to hold no potential to address any of these three fundamental scientific questions or research topics addressed in Appendix B of "Treatment of Archeological Properties: A Handbook" (1980) published by the Advisory Council on Historic Preservation, it will be determined not significant and thus not eligible for inclusion in the National Register of Historic Places. Should a determination of nonsignificance be made, no further mitigation efforts should be required. This has already proven to be the case with one site, TLM 033.

Those sites found to hold potential to address humanistic, historical and/or local-interest research questions should be determined significant and thus be considered eligible for inclusion in the National Register of Historic Places. The mitigation measure recommended for these sites should be preservation of information through systematic scientific excavation. The preservation of these sites through investigation (excavation) should be prioritized based upon the immediacy of the threat of adverse impact to each specific site. Thus, in general terms, those which occur in locales slated for construction should be removed through excavation prior to those within the impoundment areas. Within the impoundment areas sites at lower elevations would receive priority above those at higher elevations. Such a prioritization should minimize potential conflicts beteen cultural resources and construction schedule.

The mitigation measure recommended for all sites falling within the indirect impact or potential impact category is avoidance. For those sites subject to potential adverse impact (Table E.4.2) a monitoring plan should be developed in concert with the appropriate and managing agencies (state and federal). The monitoring program should establish a photographic record of each site on an annual basis and should any adverse impact resulting from activities of the Susitna Hydroelectric Project occur, it should be documented. Should any particular site or group of sites experience adverse impact as a result of the project, the appropriate mitigation measure for that particular circumstance should be applied. The monitoring program should be continued throughout the course of the project on an annual basis until the hydroelectric facility is operational. At such time, the monitoring program should become the responsibility of the appropriate land managing agency.

Coupled with the monitoring program shoud be an educational program for all construction and other project personnel, which emphasizes the necessity to avoid cultural resources in and adjacent to the project area. Such a program should stress the importance of the scientific information the sites contain and should discourage looting and artifact collecting.

Analysis of the sites found in 1980 and 1981 and preliminary analysis of the sites located during the 1982 field season as well as sites on record in the Alaska Office of History and Archeology are tabulated in Tables E.4.2 and E.4.3. Of the known sites, 53 will be directly, 20 may be indirectly impacted, and 86 have the potential of being impacted. Based on available data, it appears that 8 sites will not be impacted by the project. However, this is a preliminary evaluation based on the fact that these sites are some distance from expected impact areas. Of the 167 sites presently known 21 have already been systematically tested. Thirty-eight additional sites will require systematic testing to determine their eligibility for inclusion in the National Register. Systematic testing is recommended for only those sites that have been determined to be directly impacted by the project. For those sites on federal or state lands which will not be directly impacted by the project, the cultural resource policies of the appropriate agency should be applied. Of the 21 sites systematically tested to date, 15 have been determined significant and are likely eligible for the National Register, and investigation is recommended after approval of the license application and construction. Five additional sites have been determined to be significant and are likely eligible for the National Register but are outside direct or indirect impact areas and avoidance and monitoring is recommended. One systematically tested site did not produce any cultural material during testing and has been determined to be not significant. No further testing or investigation is recommended for this site.

(b) Schedule

Both state and federal regulations mandate that all cultural resources within the immediate project boundary be considered. Since only a portion of the total project area, the configuration of which is still undergoing modification, has been examined for archeological and historical sites, it is essential that reconnaissance level testing continue in order to document "all" cultural resources in the immediate project area given the present level of technology. In addition, systematic testing is required to address the significance of these sites that will be directly inspected and to determine their eligibility to the National Register. Systematic testing should, therefore, also continue for sites that will be directly impacted.

Based on the field work completed to date, the large number of sites known (167) and the portion of the study area actually surveyed, it is anticipated tht many additional sites remain to be discovered. Most of these sites will likely be subsurface in nature and found by subsurface testing techniques. Based on this information it is anticipated that two (2) additional field seasons of reconnaissance level survey are needed to adequately examine the entire surveyable portion of the study area for cultural resources. In addition to locating and documenting cultural resources, it will be necessary in most cases to conduct systematic testing in order to generate sufficient data on which to determine site size and content and to evaluate significance. Systematic testing requires that a grid be surveyed over the site, maps prepared, and testing units systematically excavated using standard archeological methods. To date only 21 of the sites have been systematically tested. Thirty-eight remain to be systematically tested. Systematic testing of these sites, and an estimated 25 additional ones, located as a result of continued survey, is estimated to take two (2) field seasons. The time actually necessary to test "new" sites can only be estimated following completion of the cultural resource inventory. In order to complete the inventory and systematic testing prior to completion of the license application review period it is recommended that this work take place in 1983 and 1984. Continued reconnaissnce level testing and systematic testing can take place during the same two-year period.

In addition to a program to find and evaluate additional sites in the project area, mitigation measures must be implemented for those sites determined to be eligible for the National Register that will be adversely affected by the project if it is approved and a decision to build the dam is made by the State of Alaska. It is estimated that mitigation will take approximately five (5) to nine (9) field seasons to complete, depending on the number of additional sites discovered and the number that will require investigation or preservation. The amount of time the entire process would take depends on several factors: (1) the number of additional sites found, (2) the number of personnel involved with the project, and (3) the funding level. It is possible to shorten the time frame by increasing the number of people involved. However, it should be stated that the cost of increasing personnel levels increases exponentially as logistic, supply, equipment, and additional management levels increase. If clear cutting of the impoundment areas or other subsurface disturbing activities take place, the above schedule will have to be adjusted to accommodate the expected timetable of these activities.

In summary, it is anticipated that reconnaissance testing needed to complete the inventory will take two (2) field seasons; systematic testing needed to determine significance and eligibility to the National Register of Historic Places two (2) field seasons; and mitigation five (5) to nine (9) field seasons, all of which could run concurrently. All estimates depend on the number of additional sites found in the untested portions of the project area.

(c) Cost

Based on available information, the preliminary cost estimates for the cultural resource program previously discussed are presented below. It should be mentioned that original estimates (1981) for completing the cultural resource inventory and the necessary systematic testing were four (4) years and five (5) years, respectively. The following cost estimate is based on rearranging these programs into a two-year format in order to complete the work during the license application review period and a modification of the systematic testing program based on more recent data concerning impact of the hydroelectric project on cultural resources.

It is estimated that continued reconnaissance aimed at completing the cultural resource inventory and systematic testing aimed at determining significance and eligibility to the National Register will cost $ The systematic testing portion of this amount is basea on the 53 sites presently requiring testing and an estimated 25 "new" sites that would likely result from continued survey. This estimate is exclusive of air logistics, food, and camp faciities for archeological personnel. It is anticipated that for the two years of continued reconnaissance and systematic testing 38 field and office personnel will be required. The determination of actual costs of any mitigation program for the project must await completion of the cultural resources inventory systematic testing to determine which sites are in direct impact areas and eligible for the National Register of Historic Places and the recommendations of the State Historic Preservation Officer, which will indicate how many sites will actually require investigation or preservation.

However, a preliminary estimate based on number of sites documented to date (167), the known sites which fall within present direct impact areas (38), the number of sites which appear to qualify for inclusion on the national register based on systematic testing to date (20 of the 21 sites tested), an estimated 26 additional sites that could be located as a result of continuing surveys and assuming it will be possible to group the sites is 8 million dollars. This figure can be adjusted accordingly when the above-mentioned information becomes available.

(d) Statement of Sources and Extent of Financing

Funding for cultural resource studies is the responsibility of the Alaska Power Authority. The Archeological Conservation Act of 1974 (Public Law 93-291) authorizes that up to one per centum of the total amount of a dam project may be spent on cultural resource studies, including analysis and publication.

4.3 - Agency Consultation

(a) Consultation Methods

For all federally funded or licensed projects, or projects on federal lands, the latter two which apply to the Susitna Hydroelectric Project, it is necessary to obtain a federal antiquities permit. Formal application, including vitas of individuals in general and direct charge, was made to the National Park Service and the necessary permits obtained for 1980, 1981 and 1982. In addition to federal permits, state antiquity permits were obtained for state selected land within the study area.

The State Historic Preservation Office, the State Archeologist and archeologists with the National Park Service (Alaska) have been consulted concerning the research design and the mitigation plan. Consultation was both written and oral. Copies of the report on the 1980 and 1981 field seasons were reviewed by the Alaska SHPO and the National Park Service.

(b) Summary of Comments

Comments concerning the federal antiquities permit applications were in the form of stipulations to the permits by the National Park Service, Bureau of Land Management, and the U.S. Fish and Wildlife Service. These comments specified the conditions of the permit.

(i) Research Design - The research design and strategy were reviewed by the Alaska SHPO, the State Archeologist and the National Park Service and found to meet project needs and professional standards. It is their opinion that the research conducted to date is thorough and well documented and constitutes an excellent preliminary cultural resource program, but that continued reconnaissance testing of areas not covered during 1980, 1981 and 1982 must be undertaken to locate as many sites as possible given present technology and that systematic testing should continue to further evaluate sites and provide data on which to base significance, determine eligibility to the National Register, assess effect and determine the appropriate mitigation measures. In addition, they recommended that archeological clearance continue for any activities that may impact cultural resources in the study area throughout the project. Letters addressing the research design are included at the end of this section of the application.

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TABLE E.4.1

IMPACT ON CULTURAL RESOURCES BY AREA

	Watana Dam and Impoundment	Devil Canyon Dam and Impoundment	Borrow and Geotechnical Areas	Access Route	Access Route Borrow Areas	Transmission Corridors	Other Areas	TOTAL
Direct	TLM 017	TLM 022	TLM 035	TLM 155*	TLM 051		TLM 015	
Impact	TLM 018	TLM 023 (h)		HEA 211*	TLM 098		TLM 016	
	TLM 026	TLM 024			TLM 099			
	TLM 033	TLM 027			TLM 106			
	TLM 039	TLM 029			TLM 107			
	TLM 040	TLM 030			TLM 108			
	TLM 042	TLM 034			TLM 109			
	TLM 043				TLM 110			
	TLM 048				TLM 111			
	TLM 050				TLM 113			
	TLM 058				TLM 153*			
	TLM 059				HEA 181			
	TLM 060				HEA 182			
	TLM 061							
	TLM 062							
	TLM 063							
	TLM 064							
	TLM 065							
	TLM 072							
	TLM 073							
	TLM 075							
	TLM 077							
	TLM 079 (h)							
	TLM 080 (h)							
	TLM 102							
	TLM 104							
	TLM 115*							
	TLM 119*							
	TLM 126*							
	TLM 137*							

TABLE E.4.1 (Continued)

	Watana Dam and Impoundment	Devil Canyon Dam and Impoundment	Borrow and Geotechnical Areas	Access Route	Access Route Borrow Areas	Transmission Corridors	Other Areas	TOTAL
Indirect Impact				TLM 101			TLM 020 (h)	
				TLM 103			TLM 021	
				TLM 114			TLM 038	
							TLM 047	
							TLM 049	
							TLM 074	
							TLM 076	
							TLM 120*	
							TLM 121*	
							TLM 128*	
							TLM 130*	
							TLM 133*	
							TLM 143*	
							TLM 144*	
							TLM 145*	20
Potential Impact			TLM 068	TLM 112		FAI 213*	TLM 025	
			TLM 070			FAI 214*	TLM 028	
						HEA 026+	TLM 031	
						HEA 030+	TLM 032	
						HEA 035+	TLM 036	
						HEA 037+	TLM 037	
						HEA 038+	TLM 041	
						HEA 080+	TLM 044	
						HEA 083+	TLM 045	
						HEA 119+	TLM 046	
						HEA 137+	TLM 052	
						HEA 210*	TLM 053	

TABLE E.4.1 (Continued)

	Watana Dam and Impoundment	Devil Canyon Dam and Impoundment	Borrow and Geotechnical Areas	Access Route	Access Route Borrow Areas	Transmission Corridors	Other Areas	TOTAL
Potential Impact (Continued)							TLM 054	
							TLM 055	
							TLM 056 (h)	
							TLM 057	
							TLM 066	
							TLM 069	
							TLM 071 (h)	
							TLM 078	
							TLM 081	
							TLM 083	
							TLM 084	
							TLM 085	
							TLM 086	
							TLM 087	
							TLM 088	
							TLM 089	
							TLM 090	
							TLM 091	
							TLM 092	
							TLM 093	
							TLM 094	
							TLM 095	
							TLM 096	
							TLM 097	
							TLM 100	
							TLM 105	
							TLM 116	
							TLM 117	
							TLM 118*	

TABLE E.4.1 (Continued)

	Watana Dam and Impoundment	Devil Canyon Dam and Impoundment	Borrow and Geotechnical Areas	Access Route	Access Route Borrow Areas	Transmission Corridors	Other Areas	TOTAL
<u>Potential Impact</u> (Continued)							TLM 122*	
							TLM 123*	
							TLM 124*	
							TLM 125*	
							TLM 127*	
							TLM 129*	
							TLM 131*	
							TLM 132*	
							TLM 134*	
							TLM 135*	
							TLM 136*	
							TLM 138*	
							TLM 139*	
							TLM 140*	
							TLM 141*	
							TLM 142*	
							TLM 146*	
							TLM 147*	
							TLM 148*	
							TLM 149*	
							TLM 150*	
							TLM 151*	
							TLM 152*	
							TLM 154*	
							HEA 174	
							HEA 176	
							HEA 180	
							HEA 183	
							HEA 184	
							HEA 185	86

TABLE E.4.1 (Continued)

	Watana Dam and Impoundment	Devil Canyon Dam and Impoundment	Borrow and Geotechnical Areas	Access Route	Access Route Borrow Areas	Transmission Corridors	Other Areas	TOTAL
<u>No Impact</u>			TLM 082 HEA 177 HEA 178 HEA 179				TLM 007+ TLM 067 HEA 175 HEA 186	8
TOTALS	30	7	7	6	13	12	92	167

(h) - Historic Site
* - Site located during 1982 field season
\+ - On record in the Alaska Office of History and Archeology

TABLE E.4.2

SUSITNA HYDROELECTRIC PROJECT - CULTURAL RESOURCES

AHRS #	Location	Testing Level	Appears to be Eligible For Inclusion in the National Register of Historic Places: Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
TLM 007*	O						NI	None Required	PR
TLM 015	O	R					II		SS
TLM 016	O	R					II		SS
TLM 017	W	R			X	1983-1984	DI		SS
TLM 018	W	S	X				DI	I	Kn
TLM 020	O	R	X				II	I	Kn
TLM 021	O	R					II		SP
TLM 022	D	S	X				DI	I	Ty
TLM 023	D	R			X	1983-1984	DI		Ty
TLM 024	D	R			X	1983-1984	DI		Ty
TLM 025	O	R					PI	A	VS
TLM 026	W	R			X	1983-1984	DI		SSS
TLM 027	D	S	X				DI	I	Kn
TLM 028	O	R					PI	A	F
TLM 029	D	R			X	1983-1984	DI		Kn
TLM 030	D	R			X	1983-1984	DI		Kn
TLM 031	O	R					PI	A	VS

TABLE E.4.2 (Continued)

AHRS #	Location	Testing Level	Appears to be Eligible For Inclusion in the National Register of Historic Places: Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
TLM 032	O	R					PI	A	VS
TLM 033	W	S		X			DI	None Required	VS
TLM 034	D	R			X	1983-1984	DI		Kn
TLM 035	B	R			X	1983-1984	DI		VS
TLM 036	O	R					PI	A	SSS
TLM 037	O	R					PI	A	VS
TLM 038	O	S	X				II	I	SS
TLM 039	W	S	X				DI	I	SS
TLM 040	W	S	X				DI	I	VS
TLM 041	O	R					PI	A	VS
TLM 042	W	S	X				DI	I	SSS
TLM 043	W	S	X				DI	I	VS
TLM 044	O	R					PI	A	SSS
TLM 045	O	R					PI	A	SP
TLM 046	O	S	X				PI	A	SP
TLM 047	O	R					II		SSS
TLM 048	W	S	X				DI	I	SS

TABLE E.4.2 (Continued)

AHRS #	Location	Testing Level	Appears to be Eligible For Inclusion in the National Register of Historic Places: Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
TLM 049	O	R					II		SSS
TLM 050	W	S	X				DI	I	VS
TLM 051	B/AR	R			X	1983-1984	DI		SS
TLM 052	O	R					PI	A	SSS
TLM 053	O	R					PI	A	SSS
TLM 054	O	R					PI	A	SS
TLM 055	O	R					PI	A	SS
TLM 056	O	R	X				PI	A	SS
TLM 057	O	R					PI	A	SS
TLM 058	W	R			X	1983-1984	DI		VS
TLM 059	W	S	X				DI	I	SS
TLM 060	W	R			X	1983-1984	DI		SS
TLM 061	W	R			X	1983-1984	DI		SS
TLM 062	W	S	X				DI	I	VS
TLM 063	W	R			X	1983-1984	DI		VS
TLM 064	W	R			X	1983-1984	DI		VS
TLM 065	W	S	X				DI	I	SSS

TABLE E.4.2 (Continued)

AHRS #	Location	Testing Level	Appears to be Eligible For Inclusion in the National Register of Historic Places: Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
TLM 066	O	R					PI	A	SS
TLM 067	O	R					NI	None Required	VS
TLM 068	B	R					PI	A	SS
TLM 069	O	S	X				PI	A	SSS
TLM 070	B	R					PI	A	SS
TLM 071	O	R	X				PI	A	SSS
TLM 072	W	R			X	1983-1984	DI		SSS
TLM 073	W	R			X	1983-1984	DI		SSS
TLM 074	O	R					II		SSS
TLM 075	W	R			X	1983-1984	DI		SSS
TLM 076	O	R					II		SSS
TLM 077	W	R			X	1983-1984	DI		SSS
TLM 078	O	R					PI	A	SP
TLM 079	W	R	X				DI	I	SSS
TLM 080	W	R	X				DI	I	VS
TLM 081	O	R					PI	A	SS
TLM 082	B	R					NI	None Required	SS

TABLE E.4.2 (Continued)

AHRS #	Location	Testing Level	Appears to be Eligible For Inclusion in the National Register of Historic Places: Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
TLM 083	0	R					PI	A	SP
TLM 084	0	R					PI	A	SP
TLM 085	0	R					PI	A	SP
TLM 086	0	R					PI	A	SS
TLM 087	0	R					PI	A	SP
TLM 088	0	R					PI	A	SS
TLM 089	0	R					PI	A	SS
TLM 090	0	R					PI	A	SS
TLM 091	0	R					PI	A	SS
TLM 092	0	R					PI	A	SS
TLM 093	0	R					PI	A	SS or PR
TLM 094	0	R					PI	A	SS
TLM 095	0	R					PI	A	SS
TLM 096	0	R					PI	A	SS
TLM 097	0	S	X				PI	A	SS
TLM 098	ARB	R			X	1983-1984	DI		SP
TLM 099	ARB	R			X	1983-1984	DI		SP

TABLE E.4.2 (Continued)

AHRS #	Location	Testing Level	Appears to be Eligible For Inclusion in the National Register of Historic Places: Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
TLM 100	O	R					PI	A	SSS
TLM 101	AR	R					II		SS
TLM 102	W	R			X	1983-1984	DI		VS
TLM 103	AR	R					II		SS
TLM 104	W	R			X	1983-1984	DI		VS
TLM 105	O	R					PI	A	SS
TLM 106	ARB	R			X	1983-1984	DI		SS
TLM 107	ARB	R			X	1983-1984	DI		SS
TLM 108	ARB	R			X	1983-1984	DI		SS
TLM 109	ARB	R			X	1983-1984	DI		SS
TLM 110	ARB	R			X	1983-1984	DI		SS
TLM 111	ARB	R			X	1983-1984	DI		SS
TLM 112	AR	R					PI	A	SS
TLM 113	ARB	R			X	1983-1984	DI		SS
TLM 114	AR	R					II		SS
TLM 115	W	R			X	1983-1984	DI		SSS
TLM 116	O	R					PI	A	SS

TABLE E.4.2 (Continued)

AHRS #	Location	Testing Level	Appears to be Eligible For Inclusion in the National Register of Historic Places: Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
TLM 117	O	R					PI	A	SP
TLM 118	O	R					PI	A	Ty
TLM 119	W	R			X	1983-1984	DI		VS
TLM 120	O	R					II		VS
TLM 121	O	R					II		VS
TLM 122	O	R					PI	A	VS
TLM 123	O	R					PI	A	VS
TLM 124	O	R					PI	A	VS
TLM 125	O	R					PI	A	VS
TLM 126	W	R			X	1983-1984	DI		VS
TLM 127	O	R					PI	A	VS
TLM 128	O	S	X				II	I	SSS
TLM 129	O	R					PI	A	VS
TLM 130	O	S	X				II	I	VS
TLM 131	O	R					PI	A	VS
TLM 132	O	R					PI	A	VS
TLM 133	O	R					II		VS

TABLE E.4.2 (Continued)

			Appears to be Eligible For Inclusion in the National Register of Historic Places						
AHRS #	Location	Testing Level	Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
TLM 134	0	R					PI	A	SSS
TLM 135	0	R					PI	A	SSS
TLM 136	0	R					PI	A	SSS
TLM 137	W	R			X	1983-1984	DI		SSS
TLM 138	0	R					PI	A	SSS
TLM 139	0	R					PI	A	SSS
TLM 140	0	R					PI	A	SSS
TLM 141	0	R					PI	A	SSS
TLM 142	0	R					PI	A	SSS
TLM 143	0	S	X				II	I	SSS
TLM 144	0	R					II		SSS
TLM 145	0	R					II		SSS
TLM 146	0	R					PI	A	SSS
TLM 147	0	R					PI	A	SSS
TLM 148	0	R					PI	A	SSS
TLM 149	0	R					PI	A	SSS
TLM 150	0	R					PI	A	SSS

TABLE E.4.2 (Continued)

AHRS #	Location	Testing Level	Appears to be Eligible For Inclusion in the National Register of Historic Places: Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
TLM 151	O	R					PI	A	SSS
TLM 152	O	R					PI	A	SSS
TLM 153	ARB				X	1983-1984	DI		SS
TLM 154	O	R					PI	A	SSS
TLM 155	AR				X	1983-1984	DI		SP
HEA 026*	T						PI	A	U
HEA 030*	T						PI	A	U
HEA 035*	T						PI	A	U
HEA 037*	T						PI	A	U
HEA 038*	T						PI	A	U
HEA 080*	T						PI	A	U
HEA 083*	T						PI	A	U
HEA 119*	T						PI	A	U
HEA 137*	T						PI	A	U
HEA 174	O	R					PI	A	F
HEA 175	O	S	X				II (1981) NI (1982)	None Required	F

TABLE E.4.2 (Continued)

AHRS #	Location	Testing Level	Appears to be Eligible For Inclusion in the National Register of Historic Places: Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
HEA 176	O	R					PI	A	F
HEA 177	B	R					NI	None Required	F
HEA 178	B	R					NI	None Required	F
HEA 179	B	R					NI	None Required	F
HEA 180	O	R					PI	A	F
HEA 181	ARB	R			X	1983-1984	DI		F
HEA 182	ARB	R			X	1983-1984	DI		F
HEA 183	O	R					PI	A	F
HEA 184	O	R					PI	A	F
HEA 185	O	R					PI	A	F
HEA 186	O	R					NI	None Required	F
HEA 210	T	R					PI	A	U
HEA 211	AR	R			X	1983-1984	DI		F
FAI 213	T	R					PI	A	U
FAI 214	T	R					PI	A	U

*Reported in the files of the Alaska Office of History and Archeology.

Abbreviations for Table E.4.2

Location:
- AR - Access Route
- ARB - Access Route Borrow
- B - Borrow and geotechnical areas
- D - Devil Canyon Dam and Impoundment
- O - Other area
- T - Transmission Route
- W - Watana Dam and Impoundment

Testing Level:
- R - Reconnaissance
- S - Systematic Testing

Significance:
- X - The site has received testing and determined to be significant and is likely to be eligible for inclusion in the National Register.

Expected Impact:
- DI - Direct Impact
- II - Indirect Impact
- PI - Potential Impact
- NI - No Impact by the project as presently known

Recommended Mitigation:
- A - Avoidance
- I - Investigation
- P - Preservation

Land Status:
- SS - State Selected
- SSS - State Selected Suspended
- SP - State Patented
- VS - Village Selection
  Abbreviations for village selections:
  - Ch - Chickaloon
  - Kn - Knik
  - Ty - Tyonek
- F - Federal
- PR - Private
- U - Unknown

TABLE E.4.3

SUMMARY OF IMPACT BY LOCATION

	W	D	B	AR	ARB	T	O	TOTAL
DI	30	7	1	2	13	0	0	53
II	0	0	0	3	0	0	17	20
PI	0	0	2	1	0	12	71	86
NI	0	0	4	0	0	0	4	8
TOTAL	30	7	7	6	13	12	92	167

Abbreviations:

DI - Direct Impact
II - Indirect Impact
PI - Potential Impact
NI - No Impact by the project as presently known

W - Watana Dam and Impoundment
D - Devil Canyon Dam and Impoundment
B - Borrow and geotechnical areas
AR - Access Route
ARB - Access Route Borrow
T - Transmission Route
O - Other area

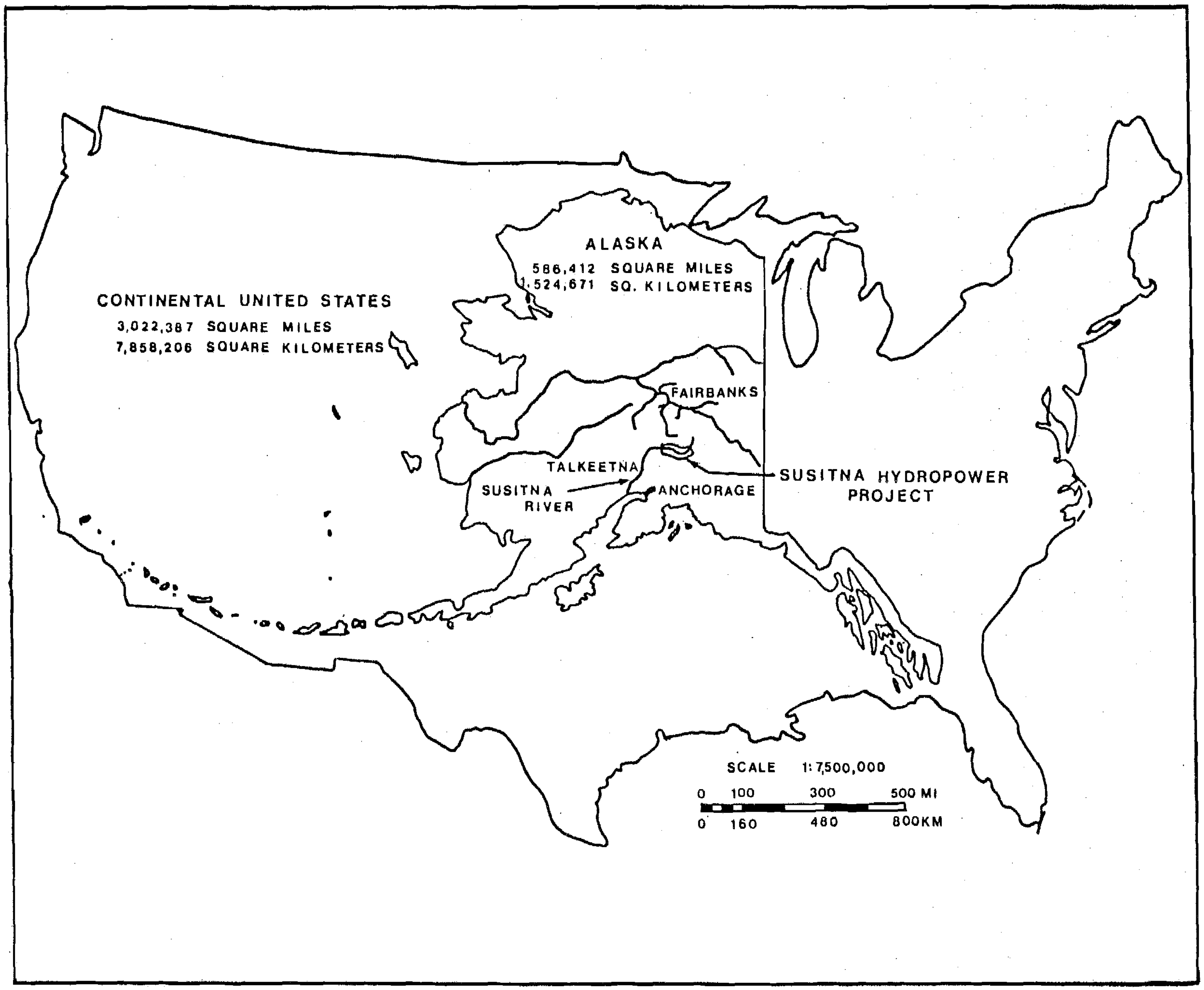

Figure E.4.1. Location of Susitna Hydroelectric Project

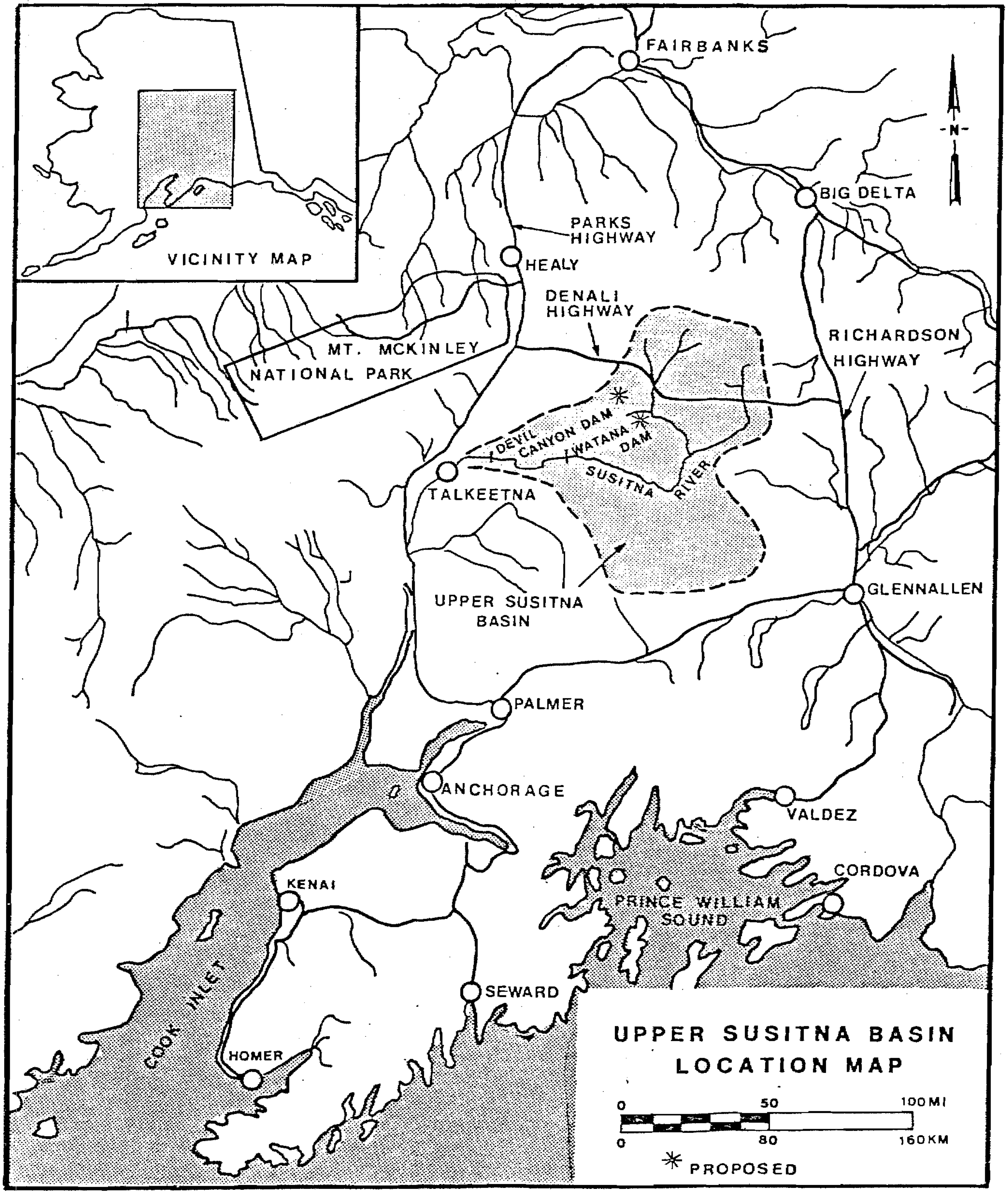

Figure E.4.2. Location of Upper Susitna River Basin

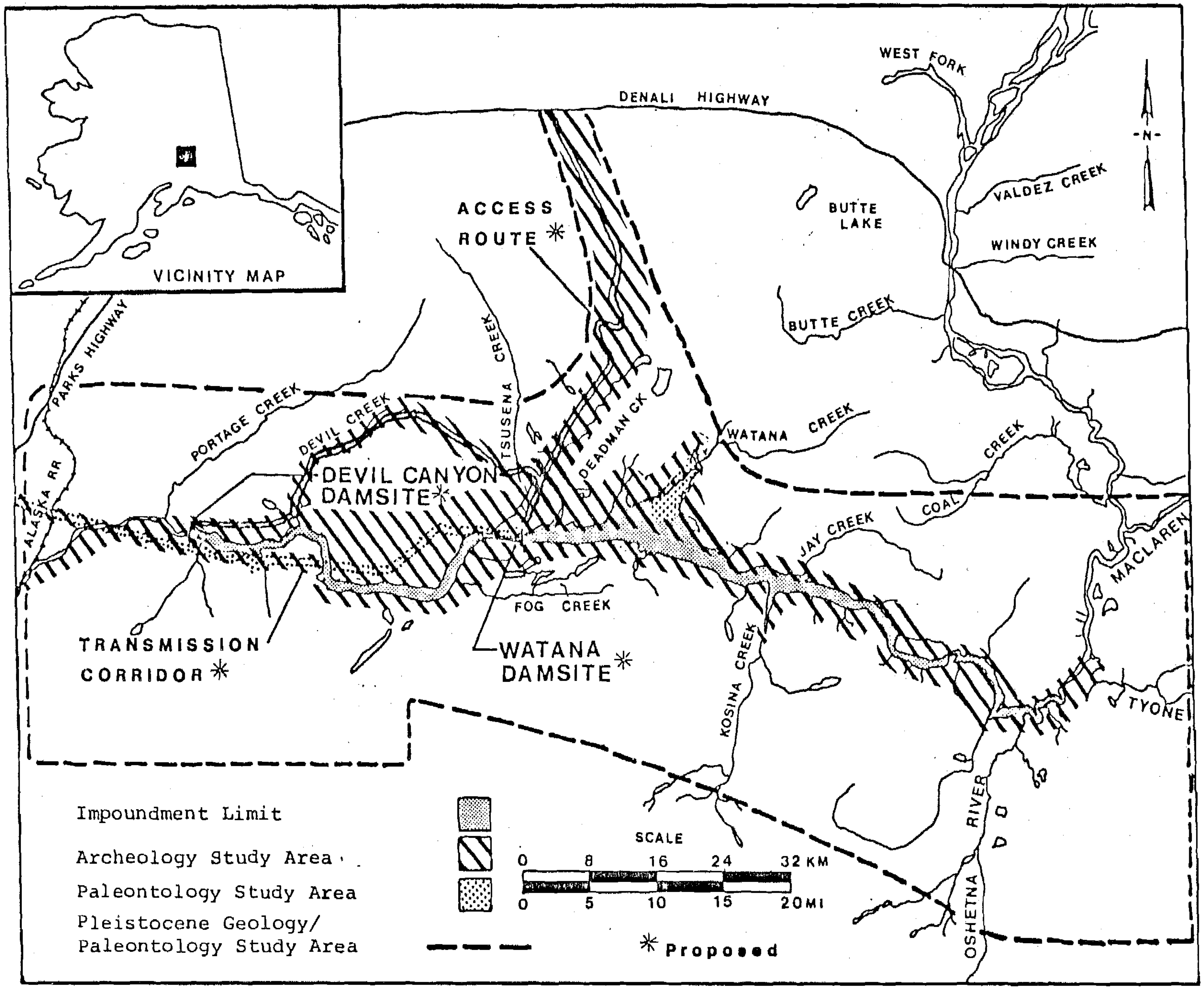

Figure E.4.3. Study Area for Cultural Resources and Associated Activities - Susitna River

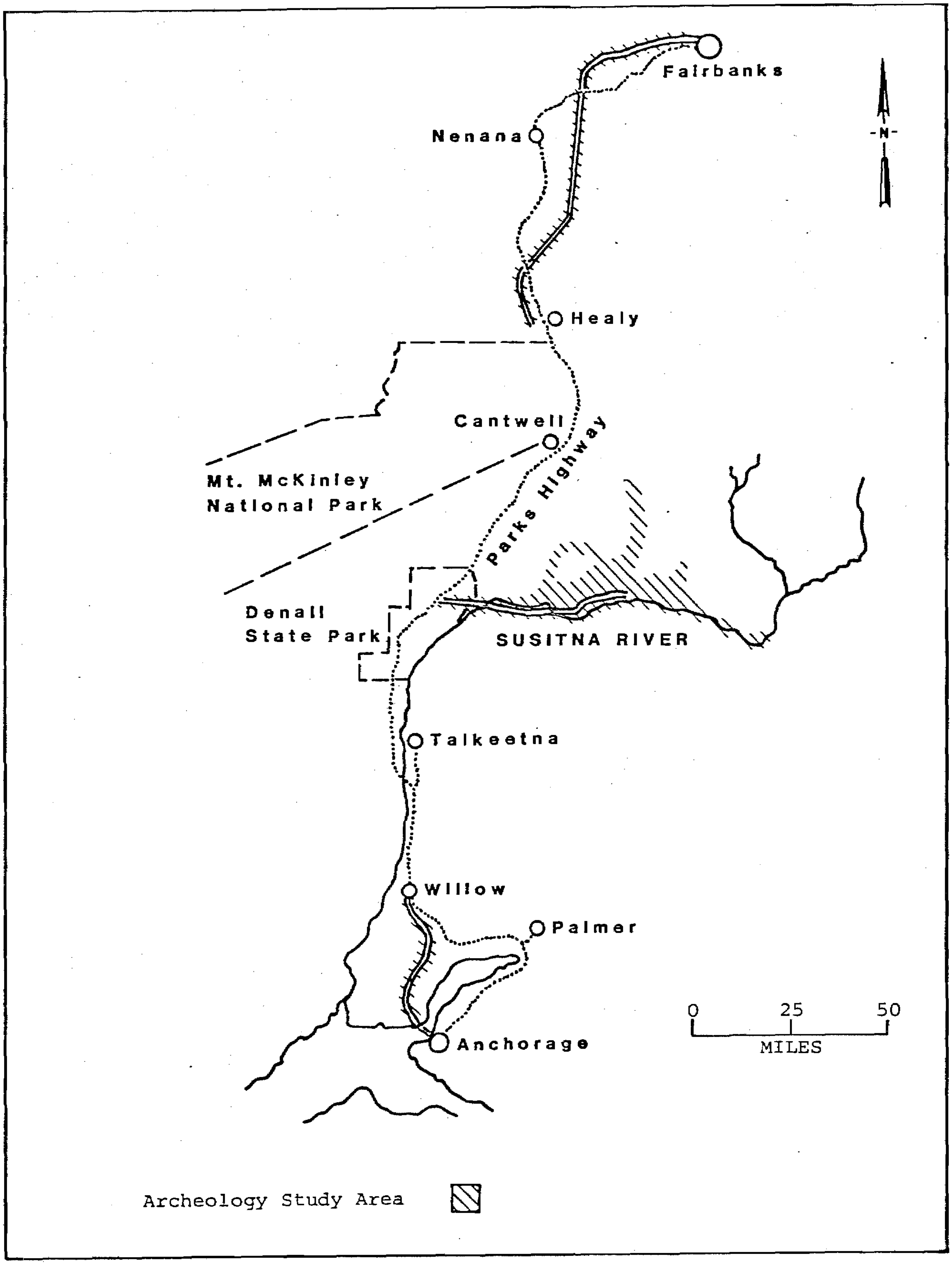

Figure E.4.4. Study Area for Cultural Resources - Transmission Corridors

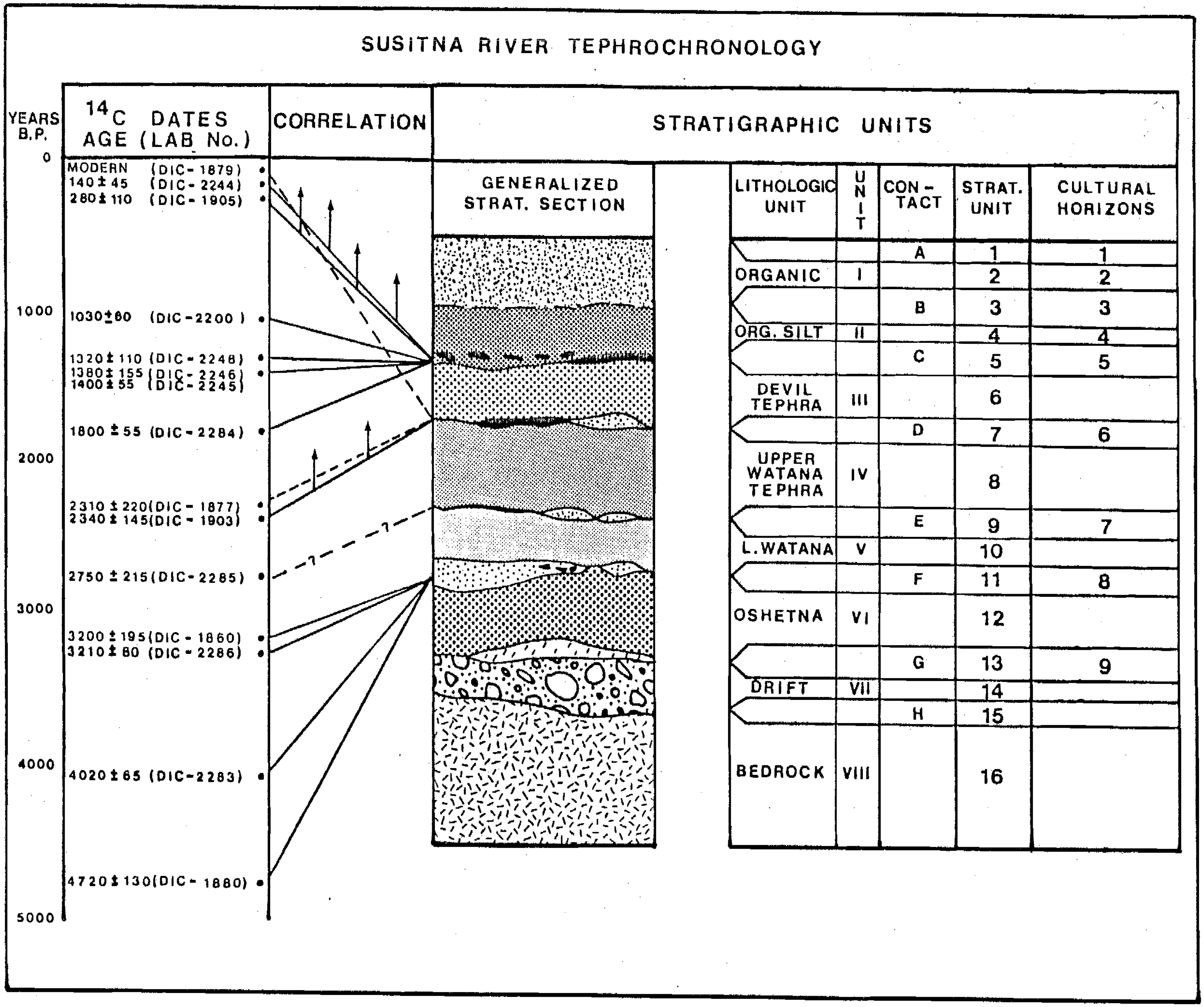

Figure E.4.5. Upper Susitna River Stratigraphic Units and Tephrochronology

STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF PARKS

JAY S. HAMMOND, GOVERNOR

619 WAREHOUSE DR., SUITE 210
ANCHORAGE, ALASKA 99501

PHONE: 274-4676

December 4, 1981

Re: 1130-13

John D. Lawrence
Project Manager
Acres American, Inc.
The Liberty Bank Building, Main at Court
Buffalo, New York 14202

Dear Mr. Lawrence:

We have reviewed the 1980 reports by the University of Alaska Museum dealing with the cultural resources of the Susitna Hydroelectric project area. The report documents the survey activities conducted during 1980 which adequately accomplish the tasks outlined in the proposed work plan. The sampling plan designed on the basis of geomorphic features and known use areas seems to have surpassed our expectations of site incidence in the area. The report shows that the first level inventory was very competently conducted and recorded. The second year activities as outlined in the procedures manual was accomplished in the 1981 field season according to information gained through verbal communication with the principle archaeological investigators. We understand that the field research strategy was changed slightly from that expected due to information gained during 1980. These changes appear to have more directly addressed problems which surfaced during the course of analysis of the 1980 data. A final review of the 1981 results and reports will have to await receipt of that document.

We feel that the steps taken thus far in the cultural resource management of the project have been excellent and one of the few instances of adequate lead time. We would like to make the observation that the work thus far is only preliminary to the work yet needed for the Susitna Hydroelectric project. Reconnaissance and testing of yet to be examined areas should continue. The clearances of specific areas of disturbance provided as additional survey by the Museum should indicate the continued need for clearances of ancillary projects which could affect cultural resources. Also, a formal mitigation plan for those sites to be affected by the project must be formulated. Once definite decisions on the route of access to the project area from existing road systems are made, those access routes and material sites must be examined for conflicts and needs for mitigation. Issuance of a permit by the Federal Energy Regulatory Commission should and probably will include provisions specifying under federal law the need for such protection.

If you have any questions regarding our comments contained here, please call us. We look forward to receiving the report on 1981 field work.

Sincerely,

Chip Dennelein
Director

for Douglas Reger

By: Robert D. Shaw
State Historic Preservation Officer

cc: Dr. E. James Dixon
Curator of Archaeology
University of Alaska Museum
University of Alaska
Fairbanks, Alaska 99701

Eric Yould
Executive Director
Alaska Power Authority
333 W. 4th Avenue
Anchorage, Alaska 99501

DR:clk

United States Department of the Interior

NATIONAL PARK SERVICE
Alaska Regional Office
540 West Fifth Avenue
Anchorage, Alaska 99501

IN REPLY REFER TO:

L7621(ARO-PCR)

OCT 22 1982

Dr. E. James Dixon, Jr.
Curator of Archeology
University of Alaska Museum
University of Alaska
Fairbanks, Alaska 99701

Dear Dr. Dixon:

Our staff has examined the Susitna Hydroelectric Project cultural resources final report, in particular the identification and testing program elements of the research design, and find these and their field application to be very adequate methods and procedures for the discovery and evaluation of archeological and historical resources in the project area. Consultation between our staff archeologists and project personnel from the University of Alaska Museum and Acres American, as you well know, have occurred several times since the project's inception, and we have thus been kept abreast of most developments relating to cultural resources management matters. We hope that the level of identification, testing, and evaluation conducted to date continues as the project proceeds, to assure the highest levels of resource protection and compliance with Federal and State historic preservation law.

We look forward to evaluating your mitigation plan for cultural resources occurring in the project area.

Sincerely,

Regional Director
Alaska Region

cc:
Floyd Sharrock, Alaska Regional Office

STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF PARKS

JAY S. HAMMOND, GOVERNOR

619 WAREHOUSE DR., SUITE 210
ANCHORAGE, ALASKA 99501

PHONE: 274-4676

October 15, 1982

Re: 1130-13

Mr. Eric P. Yould
Executive Director
Alaska Power Authority
334 W. 5th Avenue
Anchorage, Alaska 99501

Dear Mr. Yould:

Thank you for your letter of September 2 soliciting our recommendations on Susitna Hydro Project impacts and mitigation measures with respect to cultural resources.

First of all, we wish to commend archaeologists Dr. E. James Dixon of the University Museum and Mr. Glenn Bacon of the Alaska Heritage Research Group, Inc., for the excellent job they have been doing in locating cultural resources prior to ground disturbing activities.

Preconstruction survey is, of course, the first step in impact mitigation - the location and boundaries of cultural resource sites must be known. While this work is fairly far along, more needs to be done as plans become more concrete.

Secondly, these cultural resource sites must be evaluated in terms of eligibility for inclusion in the National Register of Historic Places. For evaluation, each site within the project area must be sufficiently investigated such that their boundaries, stratigraphy, relative age, cultural affiliation and potential to yield significant scientific information are known. Many of the currently known sites require further, more intensive, investigation for eligibility determinations to be made. Since so little is known about the prehistory of the area, each site discovered takes on added significance. In addition, groups of sites within a river drainage have been classic study areas throughout the history of anthropological archaeology. It would appear that a high percentage of the discovered sites may be eligible for the National Register.

Thirdly, each eligible site must be examined in terms of "Effect." Will the proposed action have "no effect," "no adverse effect," or an "adverse effect"? This would have to be done on a case by case basis. The criteria for determinations of effect may be found under Title 36, Code of Federal Regulations, Part 800.

Please note that every effort must be made to mitigate future "adverse effect" activities to National Register or eligible properties. In the few expected cases where very large, complex sites will be adversely effected, it may be more economical to build a barrier around the sites. In many cases, substantive investigation may be necessary. If so, this will usually mean relatively complete excavation of the site in order to recover as much scientific information as possible.

These recommendations are essentially those suggested by Dixon, et al, in the Cultural Resources Investigation Phase I Report (April 1982).

We are confident that impacts to significant cultural resources will be fully mitigated throughout the course of the Susitna Hydroelectric Project.

Sincerely,

Judith E. Marquez
Director

By: Ty L. Dilliplane
State Historic Preservation Officer

cc: Ms. Leila Wise, DNR, A-95 Coordinator
Dr. Edward Slatter, FERC Archaeologist
Mr. Lou Wall, Advisory Council on Historic Preservation
Dr. E. James Dixon, Lead Archaeologist, Susitna Hydro Project
Mr. Glenn Bacon, Lead Archaeologist, Alaska Heritage Research Group

TS:clk

5 - SOCIOECONOMIC IMPACTS

SUSITNA HYDROELECTRIC PROJECT

EXHIBIT E

VOLUME 3 CHAPTER 5

SOCIOECONOMIC IMPACTS

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1 - INTRODUCTION

The approach of this analysis was to define impact areas, describe and analyze baseline socioeconomic conditions, develop and compare forecasts of socioeconomic conditions with and without development of the dams, and to develop a foundation for an impact management program. Considerable effort was devoted during the baseline analysis to the identification and analysis of factors that will significantly influence the magnitude and geographic distribution of project-induced changes. A socioeconomic impact model was developed and computerized to produce forecasts and analyze the effects of changing key factors.

The key factors include the project and work schedules, the supply of labor within easy traveling distance to the construction sites, and housing and related facilities at the construction sites. The estimated project-induced changes provided in the following sections are based on one of several possible specifications for these key factors. With this specification, it is projected that socioeconomic impacts will be minimal for the Railbelt Region of Alaska. On the whole, the project-induced changes will probably be viewed as positive by most of the parties-at-interest.

There will, however, be project-induced changes in communities located near the construction sites that are not in alignment with these communities' attitudes toward changes. For example, the population of Cantwell is projected to more than double by 1990, the peak year of construction activity, and the population of Trapper Creek is projected to about double by 1990. The potential changes associated with these rapid population increases are not generally desired in Cantwell nor Trapper Creek.

Some of these project-induced changes could be brought into better alignment by altering three of the key factors, but these factors have limited flexiblity. Several mitigation alternatives could be used to reduce the cost or disruption of project-induced changes to the communities.

An impact management program is recommended as a vehicle to help optimize the project-induced changes for the small communities or other bodies located near the construction sites. It involves using the results of an impact assessment, in combination with a monitoring program and with the input of parties-at-interest, to develop, implement and evaluate the results of an anticipatory mitigation program.

This report 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. At the direction of the Alaska Power Authority, supplementary information not required by these rules and regulations was developed. Some of this supplementary information is provided in several sections of this report to provide for a better understanding of the socioeconomic impacts. Additional information is provided in Frank Orth & Associates, Inc., 1982 (1).

2 - BASELINE DESCRIPTION

2.1 - Identification of Socioeconomic Impact Areas

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

(a) Local

After considering the above factors, it was tentatively concluded that most of the significant permanent and temporary project-induced population changes and associated impacts would occur in the Matanuska-Susitna (Mat-Su) Borough and nearby communities such as Cantwell and Paxson. Accordingly, the Mat-Su Borough, including the lands in and around the project site, and nearby communities are designated as the Local Impact Area for the purposes of this analysis.

The Mat-Su Borough is the smallest statistical area for which relevant time-series economic and socioeconomic data are available and which is large enough for the organization of social life for the pursuit of one or several common interests and to provide for necessary infrastructure. Hence, the most reliable quantitative estimates of impacts are for the borough rather than communities in or near the borough.

Project-induced population changes could be large relative to future population levels without the project in several communities in and near the Mat-Su Borough. These significant changes are addressed quantitatively to the extent allowed by available data. A strong effort was made to provide as much geographical detail for impacts as possible because it is the small communities and clusters of population that will be affected most by the project.

(b) Regional

The Regional Impact Area, referred to as the Railbelt, was conceived to include most of the impacts that would spill out of the Local Impact Area. It includes the Anchorage, Kenai-Cook Inlet, Seward, Valdez-Chitina-Whittier, Mat-Su Borough, Southeast Fairbanks, and Fairbanks-North Star Census Divisions (see Figure E.5.1). Project-induced population changes could be significant in the six Census Divisions that surround the Mat-Su Borough, particularly Anchorage and Fairbanks. Some of the physical inputs and many of the labor inputs will be drawn from the Anchorage and Fairbanks Census Divisions.

For analytical purposes, the Regional Impact Area is divided into three subareas: Anchorage, Fairbanks and Valdez. The Anchorage, Kenai-Cook Inlet, Seward and Mat-Su Census Divisions comprise the Anchorage subarea; the Fairbanks North Star and Southeast Fairbanks Census Divisions comprise the Fairbanks subarea; and the Valdez-Chitina-Whittier Census Division comprises the Valdez subarea.

(c) State

Socioeconomic changes that could occur outside of the Regional Impact Area and within the State of Alaska, combined with changes that could occur in the Regional Impact Area, provide an approximation of statewide changes. Because there are likely to be few significant statewide impacts, sections of this report pertaining to statewide impacts are intentionally brief.

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

(a) Local

Recent trends in the population, employment, and per capita income of the Mat-Su Borough are displayed in Figure E.5.2. In general, the Local Impact Area can be described as a rural area with limited public facilities and services and a limited role for local government. The southern part of the area is growing rapidly and becoming more suburban as a result of its proximity to Anchorage. The northern part of the Local Impact Area is comprised of very small communities which have also been growing in the past few years, but at a more modest pace.

(i) Employment

Virtually all employment in the Mat-Su Borough, as reflected in Table E.5.1, is in the government, services and support sectors. Total employment by place of employment has risen steadily from 1,145 in 1970 to 3,078 in 1979, an increase of 169 percent. Employment in the first three quarters of 1980 averaged 3,224. The borough has consistently had high unemployment rates (20 percent in 1970 and 13.8 percent in 1979) because employment opportunities have not kept pace with the growth of the labor force. The rate is often the highest in the state; in addition, the borough is more dependent on seasonal employment than are larger population centers, such as Anchorage (2).

Employment opportunities in the communities closest to the dam sites (Talkeetna, Trapper Creek, the railroad communities north of Talkeetna, and Cantwell) are limited. Lack of local jobs force many residents to leave the area for periods of time to work on the North Slope, in Wasilla or Anchorage and Fairbanks. Retail businesses associated with tourists, some government agencies, guiding and arts/crafts businesses provide the majority of available jobs in these communities.

(ii) Population

Population in the Mat-Su Borough has grown rapidly since 1970, largely reflecting construction of the trans-Alaska pipeline and the evolution of borough areas into bedroom communities for the Municipality of Anchorage. From 1970 to 1980 the population of the borough grew by 175 percent. Table E.5.2 shows population in the borough by community as well as the population of some communities just outside of the borough's borders. Palmer and Wasilla stand out as the largest communities, with 1981 populations of approximately 2,567 and 2,168, respectively (3).

Approximately 90 percent of the borough's estimated 1981 population of 22,339 resides within a 20-mile radius of Wasilla. The bulk of the remainder is distributed along the Parks Highway and railroad corridor. Several hundred inhabitants are scattered throughout the borough's wilderness regions accessible primarily by water or air; these inhabitants include a few borough residents of the Upper Susitna basin in the vicinity of the impoundments.

The Mat-Su Borough, like other areas of the state, is expected to experience growth in the mid-1980's. As a result of the tendency of Anchorage employees to move into the Mat-Su area, strong growth is also projected to continue into the 1990's, with the borough population growing at an average annual rate of six percent. In the Base Case (which describes conditions without the Susitna project), population of the borough is expected to reach almost 43,000 in 1990, over 69,000 in the year 2000 and 88,000 by 2005.

The incorporated communities of Palmer, Wasilla and Houston are expected to grow many times over their present levels to populations in 2005 (without the Susitna project) of 7,581, 12,053, and 5,909, respectively. Houston, Big Lake and Wasilla are expected to receive a large increase in population after 1990 as completion of the Knik Arm crossing brings these communities within a half-hour's drive of Anchorage.

Trapper Creek, presently a community of about 225, is projected to double in population size by the year 2000 to approximately 475 people, growing at a four percent average annual rate. In the Base Case, its population is expected to reach 577 by 2005. Growth in Trapper Creek, in absence of the Susitna project, will be constrained by the amount of private land available and, more importantly, by the lack of employment opportunities. The Talkeetna area, currently containing about 640 inhabitants, is expected to grow at an annual rate of five percent a year and reach population levels of around 1,000 in 1990, 1,642 in 2000 and 2,106 in 2005.

The U.S. Census Bureau listed the population of Cantwell at 62 in 1970 and 95 in 1980. However, a recent census conducted by a local group of residents in conjunction with the post office listed the population of Cantwell in 1980 and 1982 as 182 and 183, respectively (4). Residents have indicated that the population of Cantwell grew rapidly after construction of the Parks Highway in the 1970's and has now levelled off. Based upon an assumption of two percent average annual growth, it is expected that Cantwell's population will equal approximately 214 in 1990 and 260 in the year 2000.

(iii) Income

Trends in per capita personal income are shown in Table E.5.3. Personal income rose substantially in the Mat-Su Borough in the 1970's and stabilized as the trans-Alaska pipeline was completed. Personal income rose from \$3,957 per capita in 1970 to \$9,032 per capita in 1977 and declined to \$8,878 in 1979. The increase between 1970 and 1979 was therefore 124 percent. However, using the Anchorage Consumer Price Index - Urban as a measure of inflation, personal income in 1979 was 19 percent higher than that of 1970 in real terms. The mean household income for Matanuska-Susitna Borough in 1980 was \$30,627, despite one of the highest unemployment rates in the state (5).

(iv) Housing

Table E.5.4 shows 1981 housing stock estimates and vacancy rates for major areas of the Mat-Su Borough. A recent survey by the borough showed total housing stock of 8,582 units, of which 79.4 percent (6,814 units) were occupied (3). Most of the units were in the Palmer-Wasilla area. An earlier survey showed that single family houses predominate in the borough, representing 83 percent of the total; mobile homes and multifamily units accounted for 11 percent and five percent, respectively (6). Population per household for selected communities in the borough averaged 3.07 according to 1980 Census data. This is considerably higher than the national and state averages.

Housing vacancy rates fluctuate rapidly, with a five percent rate seen by local authorities to be healthy and growth-promoting. During the summer of 1981, vacancy rates in the incorporated cities ranged from 6.7 percent to 10 percent; more remote communities such as Talkeetna and Trapper Creek experienced very low vacancy rates of between one and two percent (3).

In 1981, there were 78,962 acres of unimproved subdivided land in the Matanuska-Susitna Borough (7). Based upon a rough average of one acre per home, this amount of private land will be more than sufficient to provide for the increased number of households, under the Base Case. Currently, zoning efforts are under way in the incorporated communities in the borough. There are no zoning regulations that would affect settlement in the areas around Talkeetna and Trapper Creek. The project sites lie in a large area termed the Talkeetna Mountain Special Use District, which is affected by borough regulations that restrict settlement to recreational use.

In 1982, there were 96 housing units in the Cantwell area, of which 69 were occupied (4). 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 an extent, settlement in Cantwell has been limited by the availability of land for development. Non-native private land is scarce in Cantwell and the plots that are available are relatively expensive. Approximately 25 plots of subdivided land are currently available for sale. In addition, Ahtna, Inc., the Native Corporation which represents the Indians living in Cantwell, owns almost 54,000 acres of land in and around the community. Of this amount, approximately 10,000 is already patented; the remainder is in interim conveyence (8).

(v) Public Facilities and Services

This section describes existing public services at the community and borough level, to the detail appropriate to the degree 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.5.5 summarizes the facilities available by community.

Most of the communities in the Local Impact Area have little in the way of public services. Almost all public facilities and services within the Mat-Su Borough will need to be expanded considerably to provide current per capita levels of service to a population that will be growing rapidly over the next twenty years, independent of the Susitna project. In several areas, expansion is already being planned to accommodate this anticipated growth.

- Water Supply and Sewage Treatment

  The cities of Palmer and Wasilla have water supply and chlorination treatment systems with peak capabilities of 1,368,000 gallons per day (gpd) and 864,000 gpd, respectively. Other areas are provided with water on an individual basis, by wells, or by a community water system that serves a specific subdivision.

  Palmer has a city-wide sewage facility in the form of a two-cell lagoon. It currently processes 300,000 gallons per day of sewage with an average 30-day detention time. City officials estimate that the present facilities can handle up to 500,000 gallons per day (9). It is estimated that this level will be reached by 1989. At that point, the system's capacity will need to be augmented by adding at least a third cell. In the Base Case, it is expected that growth in Wasilla will result in a requirement for construction of a centralized sewage treatment facility.

Residents of other areas rely on septic tanks. Since in most parts of the Local Impact Area inhabitants live on plots of one acre or more, it is probable that residents will continue to rely on individual septic tanks. Community sewage systems become feasible only in areas of greater population density. Currently, the waste from septic tanks 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.

- Solid Waste

The Mat-Su Borough has non-areawide solid waste management authority (i.e. outside of incorporated communities) and operates nine landfills comprised of 217 acres. In 1981, landfill capacity equalled about 1600 acre-feet. Each of the incorporated communities contracts with the borough for use of the closest landfills .

The borough intends to close most of these sites by 1987 and set up transfer stations. Final disposal will then take place at an 80-acre central site, near Palmer (10).

Residents of the Cantwell area use a landfill site that is not maintained by any public authority and that is on privately owned land.

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

- Transportation

  - Road and Highway

    The Alaska Department of Transportation and Public Facilities is responsible for maintenance of the highways that run through the Local Impact Area. The department currently operates year-round maintenance stations at Cantwell, Chulitna, Talkeetna and Willow. Road equipment works to the north and south of each station, twenty four hours a day (11).

The Parks Highway is the principal surface transport route for the Local Impact Area, linking it to both Fairbanks and Anchorage. The Parks Highway was built with a large amount of excess capacity relative to the traffic levels at the time of construction. Present levels constitute approximately ten percent of capacity, and without the Susitna project the highway should have excess capacity through the year 2000 (12). Two bottlenecks exist to the northbound traffic on the Parks highway at Anchorage and at Wasilla. A five lane expansion of the Parks Highway in the Wasilla area (currently in the design stage with construction scheduled for 1983) by the Alaska Department of Transportation and Public Facilities is expected to relieve congestion there (13).

During the summer months the 160-mile class 2 gravel Denali highway connects the Parks and Richardson Highways. In the winter, snow is not plowed on the Denali Highway and it is therefore closed to traffic. Cantwell is located at the junction of the Denali and Parks highways. Many of the homes in Cantwell are adjacent to the Denali Highway.

Most local roads in the area are not paved. In the Mat-Su Borough, there is currently a high demand for improved road maintenance of existing roads and expansion of maintenance to rural roads not currently maintained by the borough. In Cantwell, which is not part of an incorporated borough, local roads are largely unmaintained.

As the Mat-Su Borough population grows (with or without the Susitna project), the skeletal framework of the transport system will need to be filled in and built up to meet the increased demands. Incrementally, as new subdivisions are created, additional roads will be required. In addition, upgrading of some roads will be necessary and collector roads will be required to allow traffic to go to and from communities without entering Wasilla (14).

- Rail

The Alaska Railroad runs 470 miles from Seward and Anchorage to Fairbanks. It is federally-owned and operated, but transfer of the railroad to State ownership is now being discussed. Many major communities in the impact area are connected by the

Alaska Railroad, which also provides access to a number of small communities which have no road access. Annual freight traffic volume varies between 1.8 and 2.3 million tons and it is estimated that the system is working at only 20 percent capacity (15). Daily Anchorage-Fairbanks and Anchorage-Whittier passenger service is provided during the summer months with service being reduced to twice weekly, during the winter. The passenger train will stop at any location for embarking or disembarking passengers.

· Air

As shown in Table E.5.5, many communities have active airstrips designed for light propeller aircraft. Float planes are also common in areas with lakes. Most public airports in the Mat-Su Borough and Cantwell are expected to be sufficient in their present or planned capacity to accommodate the additional needs of a growing population. There is, however, need for a new air facility to serve Wasilla. The existing facility is not easily expanded due to the terrain and lack of available land.

- Police

Police protection in the Mat-Su Borough and Cantwell is provided by the Alaska State Troopers. There are 17 Troopers stationed in Palmer, three in Trapper Creek, one in Cantwell and two in Paxson. In addition, five other Troopers are responsible for fish and wildlife protection and enforcement. The city of Palmer has police powers and maintains a force of eight officers and several civilian support personnel. There are three detention and correction facilities in the Mat-Su Borough and another prison is currently planned. Borough correction facilities serve the whole Anchorage region.

- Fire

There are nine operating fire service areas in the Mat-Su Borough. Costs of fire protection are funded by special millage rates on assessed valuations within the service areas. With the goal of achieving a rating of eight from the Insurance Service Organization (ISO), the maximum rating for areas without community water systems, the borough's fire chiefs in 1981 prepared a fire protection plan which proposes 12 additional stations and the purchase of new equipment for existing stations. All of the fire service areas within the borough rely on volunteer staffing.

Residents of the Mat-Su Borough not within the boundaries of a fire service area rely on their own resources and neighbor's volunteer assistance for fire protection.

Cantwell has recently formed a fire service area and is in the process of procuring equipment and constructing a fire hall. This station will rely on volunteer firefighters. Financial arrangements pertaining to the fire service area are discussed in Section 2.2 (a) (vi) Fiscal Conditions of Local Governments.

- Health Care

The 23-bed Valley Hospital, built in Palmer in 1954, provides acute and long-term care to residents of the Mat-Su Borough. The hospital is staffed by eight doctors. There is a satellite facility in Wasilla. An expansion of the hospital is currently underway; it will add seven beds and additional space for equipment to the Valley facility and will enable the hospital to serve a borough population of up to 30,000. Another addition of 30 beds could be built at a later date (16). The majority of the funds for this project were obtained directly or indirectly from the state.

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 ones at Trapper Creek and Talkeetna, has an ambulance for emergency service and individuals trained in Emergency Medical Training (EMT).

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

There are two mental health facilities located in the Mat-Su Borough, both located in Wasilla. These facilities provide the following types of care: individual and group therapy; family and marital counselling; and alcohol and drug consultation.

Cantwell has no medical care available in the community, with the exception of an ambulance and several EMT's. The closest medical expertise is a doctor's assistant in Healy; most residents go to Anchorage or Fairbanks for medical care (17). There is a local chapter of Alcoholics Anonymous in Cantwell, as well.

- Education

The Mat-Su Borough operates 17 schools: 12 elementary schools, two junior high schools and three high schools. At the beginning of the 1981-1982 school year, enrollment totalled 4,515 students. Plans call for expansion of existing facilities and construction of three new schools: an elementary school serving 400 pupils in Wasilla, a permanent elementary school in Trapper Creek for up to 150 students and a secondary school initially accommodating 300 in the Houston area.

The communities of Trapper Creek and Talkeetna each have elementary schools. Junior and senior high school students from both communities attend Susitna Valley High School. The capacities and current enrollments of these schools are displayed in Table E.5.6.

The school at Cantwell is part of the Railbelt School District. It provides education for students in kindergarten through 12th grade. Current enrollment is 33 students. The school has capacity for about 60 students.

- Recreational Facilities

Opportunities for outdoor recreation abound in the Matanuska-Susitna Borough and in the Cantwell area. The largest attraction in the region is Mount McKinley National Park and the surrounding Denali National Park and Preserve. Entrance to the Park is off the Parks Highway, 26 miles north of Cantwell.

Denali State Park, located within the Mat-Su Borough, will eventually offer 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 include other popular recreational sites.

There are relatively few local public recreational facilities in the borough, but plans call for future development of playgrounds and neighborhood parks in conjunction with school complexes (18).

(vi) Fiscal Conditions of Local Governments

Information on current levels of revenues and expenditures were derived from examination of the budgets of the Mat-Su Borough and the incorporated communities and conversations with key public officials (19 through 25).

- Mat-Su Borough

The fiscal responsibilities of Mat-Su Borough stem from the borough's area wide and non-area wide (i.e. outside the incorporated communities) powers of taxation. These powers are granted by the Alaska state constitititution and statutes. With these powers come the responsibilities to provide both area wide and non-area wide services. In 1981 the area wide powers and responsibilities included:

Taxation;
Planning and zoning;
Parks and recreation; and
Education.

The non-area wide responsibilities were solid waste disposal and libraries. In addition, there are several service areas established for the purpose of delivering services such as fire service, road service and others.

- Revenues

There are generally four major fund categories in the budget:

The General Fund

The general fund constititutes about 36 percent of total revenues and has several fund sources. Property taxes contribute approximately 37 percent of general fund revenues and are raised by a mill rate of 6.7 per $1,000 assessed evaluation. Another 20 percent of the borough general fund revenues is contributed by municipal assistance funds from the state. Other major sources of general fund revenues are state shared and federal shared revenues.

Service Areas Fund.

According to the 1981-82 annual budget there are six fire service areas, 16 road service areas, and two special service areas. The borough has the power to levy taxes in these areas to raise revenues to provide the services. About 30 percent of the service areas fund comes from property taxes. The balance, or 70 percent, is provided by state shared funds and municipal assistance revenues. In total, the service areas fund accounts for only three percent of total borough revenues.

Land Management Fund

Like the service areas fund, the land management fund contributes only three percent to the borough budget. The sources of these funds include state grants, recording and land management fees and others.

Education Operating Fund

This fund constitutes well over half the borough budget. It is estimated that as much as 58 percent of the total budget is made up of the education fund. The state is the major contributor primariry through the Foundation Program. In 1981/82, the Foundation Program was estimated to provide $14.37 million to the school district.

· Expenditures.

Expenditures for 1981 were estimated at $16.7 million in the general fund area, $4.4 million for the service areas fund and 1.1 million for land management. The biggest expenditure item for the borough is the school district fund. In turn the largest expenditure items for the school district are regular instruction, which accounts for 33 percent, support services (18 percent) and operations and maintainance (19 percent). The balance of expenditures is divided among vocational education, special education and miscellaneous services.

The 1981 budget figures for the borough show unequal revenues and expenditures. According to Vern Roberts, the borough's budget director, deficits have not been a problem, especially in the recent past (Personal communication). Apparently, state grants have been responsible for bridging the gap. Whether or not deficits become a problem in the future may very well depend on whether the state continues to provide this cushion whenever the want or need arises.

- Talkeetna

Talkeetna is currently unincorporated and has no powers to levy taxes. Talkeetna receives services from the borough based on three service areas. These include a fire service area, Talkeetna flood control area, and the greater Talkeetna road service area. Total revenues in 1981 for the three service areas were respectively $26,142, $1,106 and $45,820. The major sources were local taxes except in the case of road service where the entire $45,820 came from state general revenues. Expenditures were $20,176 for fire service, $576 for flood control and $45,820 for road service.

- Trapper Creek.

Trapper Creek, as an unincorporated community, has no direct fiscal responsibilities and depends entirely on the borough for services.

- Cantwell

Cantwell is an unincorporated community in an unorganized borough and as such has no local government. Recently, residents of the community formed a non-profit corporation called Community of Cantwell, Inc. It was set up as an entity suitable for receipt of state grants for the community. Currently, the Community of Cantwell, Inc. has applied for three grants for 1982: a one-time per capita grant of $89,000; a grant for establishment of a fire hall for $87,000 from the Department of Community and Regional Affairs; and a Public Safe Water grant from the Department of Environmental Conservation (17). The only revenue upon which the community can depend on an annual basis is state shared revenue; this usually amounts to between $25,000 to $32,000 per community (26). It is expected that about $3,000 to $5,000 will be needed on an annual basis for operations and maintenance of the fire hall, and the community is planning a variety of fundraising measures to raise that revenue.

In addition, there is a Native village council in Cantwell which is part of the regional corporation, Ahtna, Inc. In the past, this council has also served as a vehicle for accepting per capita and other state grants for the community.

Residents of Cantwell belong to the Railbelt School District, which is a Rural Education Attendance Area that has no taxing authority and is responsible directly to the state legislature. The school district budget for the 1982-83 school year was estimated at $3,786,770, of which approximately seven percent is earmarked for operating expenses of the school at Cantwell. Approximately 87 percent of the school district's revenue comes from the state government; four percent from local sources and eight percent from the federal government (27).

(b) Regional

Recent trends in the population, employment and per capita income of the Regional Impact Area are displayed graphically in Figure E.5.3.

(i) Employment

Table E.5.7 presents data on non-agricultural employment for the Railbelt. Employment increased by 39 percent between 1970 and 1975, and by an additional 14 percent between 1975 and 1979. Construction, service and support sectors represent large percentages of employment in the region. Employment in the Anchorage Region accounted for 69 percent of Railbelt employment in 1979.

(ii) Population

Population in the Regional Impact Area rose from 204,523 in 1970 to 284,166 in 1980. The Railbelt 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 within the municipality and in nearby areas. The Kenai and Mat-Su Borough census divisions have grown more rapidly than the city itself, and now account for 10.3 and 8.2 percent of the Anchorage region, respectively.

Population in the Railbelt is expected to rise from 284,166 in 1980 to 483,686 in 2000. The population growth rate is projected to be greater during the 1980's than the 1990's. This growth is expected to result from natural resource development projects in various parts of the state.

The population in the Fairbanks region is projected to be about 77,600 in 1988. Population growth after 1988 will average about 1.5 percent.

The Anchorage region will experience a pattern similar to the Railbelt as a whole -- relatively rapid growth during the mid 1980's and then an average annual growth rate of about two percent during the 1990's. The Anchorage region population of 375,000 in the year 2000 will account for 75 percent of the Railbelt's population.

(iii) Income

In the Railbelt, personal income on a per capita basis rose from $4,940 in 1970 to $11,243 in 1976 and has remained close to that level since. In 1978, average per capita income in the region equalled $11,522. In real terms, per capita income rose by 36 percent between 1970 and 1978.

(iv) Housing

The Railbelt contained approximately 98,350 households and 119,555 housing units in 1981. Anchorage and Fairbanks represented the largest concentrations of housing in the region.

As shown in Table E.5.8, the Municipality of Anchorage contained 65,771 civilian housing units, of which 46 percent were single family units, 12 percent mobile homes and 42 percent were in multi-family buildings. Between 1975 and 1981, the civilian housing stock in the city increased by 35 percent. Most of this growth occurred during the construction boom associated with the TAPS pipeline. The vacancy rate in Anchorage has in recent years fluctuated from a low of one percent in 1975 to a high of about 11 percent in 1980. In July of 1982, a survey done for the Municipality indicated a census-defined vacancy rate of 5.8 percent.

In the Municipality of Fairbanks, housing stock in 1978 stood at 7,351 (see Table E.5.9). Multifamily units accounted for 43 percent of the total. Vacancy rates have risen in 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.

(c) State

Recent trends in the population, employment and per capita income of the state are displayed graphically in Figure E.5.4.

(i) 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 towards 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 Alaska 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.5.10. Between 1970 and 1975, a pipeline-induced growth spurt caused employment to increase by 75 percent. From 1975 to 1980, however, total employment increased by only 2.9 percent. In 1981, Alaskan employment equalled 194,000; the annual average unemployment rate in that year was 9.2 percent.

(ii) Population

The population of Alaska has risen steadily since the 1940's yet this largest state of the United States is still the least populous with an estimated 1980 population of 400,031. Alaska's population grew by 32 percent between 1970 and 1980, jumping by 50,000 between 1975 and 1976 alone. Most of the population is in the Southcentral - Fairbanks region (the Railbelt), and half of the state's citizens reside in Anchorage.

(iii) Income

The average per capita personal income in the state rose from $4,638 in 1970 to $10,254 in 1976. Since completion of the pipeline, however, the pace of increase has slowed. Per capita income in Alaska averaged $11,150 in 1979. The real increase in per capita personal income during the nine year period was 27 percent.

3 - EVALUATION OF THE IMPACT OF PROJECT

Tables E.5.11 through E.5.18 present an overview of impacts of the project on the Mat-Su Borough as a whole, on particular communities in the Local Impact Area, and on the region. Emphasis is placed on 1990 and 1999, the two peak years of construction on the project. As these tables show, it is anticipated that the impacts of the project on socioeconomic conditions will be greatest in the communities of Trapper Creek, Talkeetna and Cantwell, due to their proximity to the site and their relatively small size.

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

In the sections below, the expected 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 a service industry whose increase in business is related to increased demands for goods and services by construction workers).

In general, the impacts of the project on local facilities and services will be limited, as a result of the provision of worker housing and extensive facilities and services at the work sites. Thus, the impacts on the nearby communities will be limited in the main to the effects related to the direct and secondary workers that choose to relocate their permanent residence, and families, to these communities. In addition, there will be a limited economic contraction on most parts of the Local Impact Area as construction of each phase of the project terminates, due to the buffering effect of the expected continued increase of the population that will occur as result of other projects and continued suburbanization of the Mat-Su Borough.

The projections of population influx associated with the project rely greatly on several important assumptions regarding work force characteristics and policy decisions related to the project. Further explanation of the methodology used can be found in Section 3.3 and Appendix E.5A.

Public facility and service impacts have been estimated using the following approach: (1) Appropriate per capita standards were developed, based upon an extensive literature review and the input of local officials; (2) the adequacy of existing facilities and services were assessed; and (3) estimates of future needs related to natural growth and to project-induced population influx have been compared with present and planned capacity. Details of the methodology used can be found in Appendix E.5B. Important items of methodological literature reviewed in the course of this work are listed in the List of References (28 through 31).

(a) Watana - Construction Phase

(i) Local

- Mat-Su Borough

In most areas of the Mat-Su Borough, the population influx related to the project will only add slightly to the substantial increases in need for public facilities and services that will be resulting from the population growth projected under the Base Case. In contrast, the large proportional increase of population into the borough communities of Trapper Creek and Talkeetna will have larger impacts on the needs for public facilities and services. These impacts are discussed in detail in the sections that follow.

· Magnitude of Population Influx

As a result of construction of the project, the population of the Mat-Su Borough is expected to increase by a cumulative total of up to 4,700 in 1990, including both new on-site and off-site residents. It is forecast that about 1,110 will resettle in communities in the borough (off-site). Of this off-site inmigrant population, approximately 835 people (75 percent) will be direct workers and their families and about 275 (25 percent) will be support workers and their dependents. The new off-site population would represent an increase of 2.6 percent over Base Case projection of population in 1990, and would result in a total borough population of 44,076 in that year (excluding the work camp/work village). Over 90 percent of the project-induced population influx will occur between 1986 and 1990, and over 40 percent in 1987, alone.

The Susitna project will be only one of several factors contributing to the borough's projected rapid rate of growth between 1985 and 1990. With construction of the project, population in the borough will increase by about 12,770 between 1985 and 1990, of which approximately 11,760 will be related to baseline growth and 1,110 will be project-related. Spillover growth from Anchorage is expected to be one of the most important factors behind this growth.

The population influx into the incorporated communities is expected to be small; between 1985 and 1990, the project will result in an increase of approximately 40 people in Palmer and Houston, each, and about 50 in Wasilla. Over 50 percent of the inmigrant population in the borough is expected to settle in the Trapper Creek-Talkeetna area, and the remainder will probably establish homes in the area around Willow and Montana creeks and the suburban area surrounding Palmer and Wasilla.

Between 1990 and 1993, the population in the borough related to the project will decline along with the decline in work force at the Watana site. Overall, however, the population of the borough is expected to continue to increase during this period.

- Water Supply

The water supply and sewage treatment needs of the project and of the work force and families living at the Watana site will be provided for by the project contractors. There will be no impact on public facilities in Mat-Su Borough.

The population influx associated with in-migrant workers who establish residences in the borough will have only a slight impact on the public water and sewage systems. In Palmer, water consumption at the peak of construction at the Watana site (1990) would rise by one percent over the Base Case projection of 608,000 gallons per day. Water usage requirements were projected using an average daily water consumption of 120 gallons per day per capita in 1981, rising to 150 gallons per day in 2000.

Population influx into Palmer will result in an average increase in sewage treatment requirements of 5,000 gallons per day (0.9 percent) above the 1990 baseline projection level. The population influx during 1985-1990 will occur at a time when existing facilities are already reaching their limits, and a third sewage treatment cell will be required (with or without the project). These projections were based upon a standard of 120 gallons per day per capita.

- Solid Waste

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

It is estimated that the population influx into the borough communities associated with the project will increase the annual landfill needs of the borough by a cumulative amount of .5 acres between 1985 and 1990. This represents a 2.5 percent increase over the baseline projection for that period. This population increase may contribute to a slight advance in requirements for additional landfill acreage, which is expected to be needed under Base Case conditions around 1994-1995.

- Law Enforcement

The project construction contractors will provide for police protection around the dam sites, but it is possible that the State Trooper force in Trapper Creek may be enlarged somewhat to reflect the growing population in the northern part of the borough. The population at the work camps plus the population influx into Mat-Su Borough communities associated with the project will increase the requirements of State Troopers by about four officers over the projected baseline need of 38 in 1990, the year of peak construction activity at Watana. An average rural standard of one officer per thousand population was used to project law enforcement requirements.

- Fire Protection

The project facilities and work camp/family village will be protected by firefighting equipment and personnel at the work sites; there will be little impact on existing service areas.

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

- Health Care

The work camp/family village at the construction site will provide facilities for health care, including a 20-bed hospital. It is expected that there will be little impact by the construction-site population on the Mat-Su Borough's health facilities, with the exception of cases of major illness or accidents which cannot adequately be handled by the site hospital.

The population influx into Mat-Su Borough communities associated with the project is expected to raise the number of hospital beds needed in 1990 by about one bed. This population influx may contribute to a slightly accelerated need for a new hospital, a development which is projected, under the Base Case, to be required around 1990. Appendix E.5B contains a full explanation of the formula used to project hospital requirements in rural areas of Alaska.

There has been some social impact research conducted which suggests that rapid growth in a community and the stress associated with rapid change can result in increases in the incidence of many "people problems" such as divorce, alcoholism, child abuse, and suicide. In most parts of the borough, growth related to the Susitna project will only represent a fraction of the growth and change that are expected to take change. 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 may become more pronounced.

- Education

School-age children at the construction site will be educated at project facilities and hence will not have an effect on the Mat-Su Borough School District.

There will be an approximate increase of 159 primary school children and 133 secondary school children accompanying inmigrants into communities in the Mat-Su Borough between 1985 and 1990. It is estimated that there will be a need for seven additional primary school classrooms and teachers and seven secondary classrooms and teachers, in addition to the 216 primary school and 230 secondary school classrooms which will be needed to accommodate growth between now and 1990, under the Base Case. Projections of enrollment used an estimated ratio of school children to population of 22.8 percent through 1987, rising to 25 percent of population in 2000. These ratios are based upon the Mat-Su Borough's short-term and long-term planning standards.

- Public Recreation Facilities

Recreational facilities will be provided at the construction site for use by project employees and their families. Thus, residents of the work camp are not expected to have much of an impact on public recreational facilities, although some increase in visits to the national and state parks near Mt. McKinley and to other parks can be expected. Residents can also be expected to engage in outdoor recreation activities in portions of the Upper Susitna basin where no public facilities now exist.

The project-induced population influx into borough communities will represent 2.6 percent of borough population in 1990. This additional population will have a slight impact on the requirements for public recreational facilities.

- Transportation

The Susitna hydroelectric project includes the construction of a road into an area that currently has no auto access. If a policy decision is made to allow public access to this road upon completion of the project, the result will be a major addition to the local transportation system. The ultimate status of the road is unsettled at this point.

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

An increase in vehicular traffic on the Parks Highway, the Denali Highway and nearby roads will result to the extent that workers commuting to and from the site drive to pick-up points. In general, the Parks Highway is currently only 10 percent utilized, and this increase in traffic is not expected to have any adverse impacts. The current congested portion of the highway near Wasilla should be relieved by expansion of the highway in that area. The project could add to congestion on weekends during the summer, unless the scheduling of commuting workers is conducted so as to avoid those periods.

Projected increases in vehicular traffic on the Parks Highway and Denali Highway will entail additional maintenance requirements by the Maintenance and Operations Division of the Alaska State Department of Transportation, especially during the months of heavy snowfall. Additionally, if and when the state assumes responsibility for maintenance of the project access road, the Division will be required to service it as well.

- Trapper Creek

The small, remote and unincorporated nature of the community contributes to a low current level of available public facilities and services. A major impact of the increase in population in Trapper Creek may be an increased need for services that are currently not available, such as fire protection and closer proximity to medical care.

- Magnitude of Population Influx

Trapper Creek will experience the largest relative population impacts of all the communities in the Local Impact Area.

Between 1985 and 1990, it is projected that under the Base Case the population of this small community will increase by about 75 people, bringing the 1990 population to 320. With construction of the Watana portion of the project, Trapper Creek's population is expected to reach 660 by 1990, more than doubling the community's projected population in that year. Direct workers and their families will account for about 60 percent of the in-migrant population related to the project.

Trapper Creek will experience a lull period between 1991 and 1993, during which time some project-related families are expected to leave. Growth expected under the baseline projections will only partially compensate for this decline.

- Water, Sewage and Solid Waste

In Trapper Creek, water and sewage needs are met by individual wells and septic tanks, and solid waste is disposed at a nearby landfill run by the borough. To the extent that new housing is built on plots with suitable soil, few impacts from the increased population are expected. It is possible that the added population will exacerbate present problems of insufficient groundwater during dry spells.

Rapid growth can have the potential for hastily built housing developments that do not meet health standards for wells, septic tanks and/or solid waste disposal. It is anticipated that borough and state oversight of growth in the Trapper Creek area could prevent such problems from occurring.

- Transportation

  Increased vehicle traffic on the Parks Highway is expected. The addition of housing units may result in the need for additional roads to serve them; in the Mat-Su Borough, this is the responsibility of subdivision developers.

- Police Protection

  The Susitna project and the accompanying increase in the population of the northern part of the borough may induce an enlargement of the State Trooper substation at Trapper Creek, thus resulting in increased police presence in the community.

- Fire Protection

  Trapper Creek currently has no active fire protection facilities. The present small size of the community has limited its ability to support a fire service area. There is an existing building that could be used if a new service area were developed.

  The population influx into Trapper Creek will exacerbate the need for active fire facilities in the community. It is possible that the additional population added to the natural growth over the 1983-1990 period could result in additional ability of the residents to support a fire service area.

- Health Care

  With the exception of an ambulance, no formal health care facilities are currently available in Trapper Creek. Residents of the area with medical training help out on an informal basis (without pay) when needed, and health care facilities in Wasilla and Palmer are utilized.

  Growth of the community, due to both baseline forecast growth and to project-related in-migration, is expected to put a strain on this informal system of medical care. The community may want to request the establishment of a Public Health Service office in the future.

  In addition, the stress associated with rapid change may result in increased need for provision of some social services in Trapper Creek and surrounding areas.

· Education

The six-classroom elementary school currently under construction in Trapper Creek will have an initial capacity of 100 students, and could be expanded to accommodate up to 200 students.

The project-related population increase will include an increase in student enrollment at the elementary school of about 60 students by 1990, over the Base Case projection of about 80 in that year. The result will be a need for expansion of the school in the late 1980's and addition of two or three teachers.

In addition, about 35 junior and senior high school students living with project related families in Trapper Creek are expected to be added to the enrollment of Susitna Valley High School by 1990.

- Talkeetna

· Magnitude of population influx

Between 1983 and 1990, an estimated population influx into Talkeetna of 263 people is expected to occur as a result of the project. This will represent a 26 percent increase over the baseline forecast level of 1,000. Of these 263 new residents, 80 percent are projected to be comprised of direct construction workers and their families, and 20 percent will be secondary workers and their dependents.

· Water and Sewage

Talkeetna is served by independent wells and septic tanks; there is a potential for problems in the "downtown" area due to the small size of the lots on which houses are built and the proximity of wells to septic tanks. This would not be a problem in the outlying areas around Talkeetna due to the larger sizes of plots of land.

It is not possible to predict with certainty where new residents in Talkeetna will settle. To the extent that project-related in-migrant population settles in the town itself, this group of people will contribute to the need for central water and sewage systems.

As in Trapper Creek, there are no community water or sewage systems in Talkeetna, and thus no direct impact on water and sewage are expected. It is possible that quickly constructed housing will need to be closely supervised to ensure compliance with health standards regarding wells and septic tanks.

- Solid Waste

The peak population influx into Talkeetna associated with the project will occur just around the time that the borough's landfill near Talkeetna is scheduled to be closed (1987-1989). A new landfill or a transfer station will be needed at that time. The additional population is not expected to have any adverse impacts.

- Transportation

A large amount of the supplies and equipment for construction of the dams will be transported by railroad. This is not expected to have any adverse effects on rail service for Talkeetna residents.

As the population increases and new housing is constructed, there will be increased need for construction and maintenance of roads in Talkeetna and the surrounding area. However, baseline forecast growth is expected to cause a large part of this increased need. Construction of new roads to service subdivisions will be the responsibility of individual developers, and maintenance of local roads will be administered by the borough through the Talkeetna Road Service Area.

- Police Protection

As Talkeetna grows, there may be a community desire for a police presence closer than the Trapper Creek station. The additional 26 percent population influx associated with the project between 1985 and 1990 and the proximity of the work camp to the community may further reinforce this tendency. Incorporation of the community would be a prerequisite to the establishment of a local police force.

- Fire Protection

Increased population is not expected to affect the firefighting facilities in the area; these are planned on the basis of distance between the station and population centers, and on the availability of pumped water. The planned addition of equipment to the Talkeetna fire station should be sufficient to serve the community until such time as a community water system is put in place.

- Health Care

  Residents of Talkeetna currently use the health care facilities in Anchorage and the southern part of the borough. The population influx related to the project, along with Base Case projected growth, may result in sufficient demand to warrant some provision of medical care in the community by a private doctor.

  In addition, the stress associated with rapid change may result in increased need for provision of some social services in and around Talkeetna.

- Education

  The population influx associated with the project will include approximately 38 primary school-age children by 1990, just as the enrollment in the elementary school in Talkeetna is projected to exceed its capacity of 120. Additional classroom space and approximately one to two teachers will be required.

  There will be an additional 30 secondary students from Talkeetna attending Susitna Valley High School by 1990 as a result of the project. Together with the additional enrollment at that school of students of Trapper Creek families, this may contribute to a need for expansion by 1988 or 1989.

- Cantwell

  - Magnitude of Population Influx

    The size of the population influx into Cantwell will be heavily influenced by the development of housing in the community by private individuals and by mitigation measures that could be developed and implemented. To the extent that housing and land for housing is not sufficient, it is probable that many of these people will settle in other areas. This is an especially important consideration in the Cantwell area, due to the limited amount of non-native private land and the question surrounding future plans for native-owned land (see Section 3.4). Due to this uncertainty, two scenarios of impacts have been projected.

    The moderate impact scenario projections of population influx were based upon a housing supply constraint model, in which it was assumed that the influx of population would be limited to the number that could be accommodated by existing vacant housing and land that will most probably be available for use by housing, mobile homes or trailers. The high impact scenario projections assume that entrepreneurial activity will produce housing for all in-migrant workers that desire to settle in Cantwell. It is thus a demand-side model which uses assumptions on worker activity based upon the experience of communities near other large projects in remote areas.

Under both scenarios, it is expected that there will be a large influx of population into Cantwell during 1985 and 1986. Under the high impact scenario, the population of the community would triple; under the moderate impact scenario, the population of Cantwell would be double the population level expected without the project.

Under the high impact scenario, approximately 395 people are expected to desire to settle into the community during this period . Of this total, about 240 (61 percent) will be related in the main to the direct construction work force working at the railhead and to a small number of workers at the Watana site who choose to settle their families at Cantwell. The remainder will be comprised of secondary workers and their families. The influx would represent an increase of almost 200 percent over the size of population that was projected for Cantwell in 1986 under the Base Case (200).

After 1986, there will be a sharp decline in the number of workers needed at the railhead. However, as the work force at the Watana site increases, there will be an influx of families of a portion of those workers that will partially offset the decline related to the railhead. It is projected that there will be between 250 and 330 project-related people remaining in Cantwell in 1987 and that this figure will rise to a peak level of between 255 (low case) and 485 (high case) in 1990. Approximately 75 percent of this cumulative in-migrant population will be related to the direct work force in the high case. Under the high case projections, population in Cantwell in 1990 (640) will be approximately three times as large as would be the case without the project.

The population projections upon which the impacts of the project are based assume that the community will obtain some form of power supply by 1985 (residents of the community currently rely on individual generators) and that the lack of power will thus not be a deterrent to future in-migrant settlement. Power may be provided by purchase of a community generator, or possibly by provision of a substation related to the planned Anchorage-Fairbanks transmission intertie.

- Water Supply, Sewage Treatment and Solid Waste Disposal

The residents of Cantwell rely upon individual wells and septic tanks for their water supply and sewage treatment needs. The population influx related to the project will therefore not affect water and sewage in Cantwell. The additional population in Cantwell can be expected to intensify the need for a new community landfill.

- Transportation

The traffic on the Parks Highway and Denali Highway will increase substantially as a result of the commuting of project workers and the transport of supplies from the railhead to the Watana site. This will require an increase in maintenance and maintenance staff by the state to continue current levels of service. In addition, local roads will need to be built to serve any additional subdivisions. This will be the responsibility of individual developers.

The Denali Highway will need to be upgraded to handle the increased traffic from an estimated 30-35 trucks a day, and possible use by commuting workers. The additional traffic will exacerbate the dust problems that nearby residents experience in the summer, unless that portion of the highway is paved.

Additional snow clearing equipment and manpower will be required to service the Denali Highway and project access road during this period of the year. Also, Highway Maintenance Division equipment will be maintaining these two road surfaces during the spring and summer months. The access road gravel surface will require near constant grading due to heavy truck traffic. The extent of maintenance impacts of servicing the Denali Highway section of the route will depend on the nature of road surface ultimately determined for this portion.

A substantial increase in traffic due to the Susitna project is expected at the Cantwell intersection of the Parks and Denali Highways. Anticipated traffic patterns in this area will need to be studied to determine necessary navigational and traffic control aids.

• Police Protection

There are currently one State Trooper and one Fish and Game officer stationed at the Cantwell station. The increased population at the community and the increase in traffic going through the area will result in an increased need for police protection by at least one officer (based upon rural standards of about one officer per thousand population and the remote character area of the community).

• Fire Protection

Increased population is not expected to affect the firefighting facilities in Cantwell; these are planned on the basis of distance between the station and population centers, and on the availability of pumped water. The planned fire hall and equipment should be sufficient to serve the community until such time as a community water system is put in place.

• Health Care

With the exception of an ambulance, no formal health care facilities or social service organizations are currently available in or near Cantwell. Growth of the community may result in an increased need for emergency medical care.

In addition, the stress associated with rapid change may result in increased need for provision of some types of social services within the community.

• Education

It is estimated that between 50 and 70 schoolchildren would be added to the enrollment of the school in Cantwell as result of the project between 1985 and 1986. By the peak of construction at the Watana site in 1990, the project-related number of schoolchildren in Cantwell is expected to equal between 70 and 95, depending upon the number of workers at the camp site who have their families settle at Cantwell. Of this peak total, approximately 70 children will be part of direct work force families and about 25 will be related to the secondary in-migrating work force.

Total enrollment at the Cantwell school (including both enrollment expected under the Base Case and the addition induced by the project) will thus equal about 105 in 1986 and between 110 and 135 in 1990. This would be beyond the capabilities of the existing school and an addition to the school would need to be constructed 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 approximately seven to nine additional teachers, based upon an average teacher-to-student ratio of 15:1.

(ii) Regional

The population of the Railbelt is expected to increase to approximately 400,320 by 1990, of which only 2,325 people (or 0.6 percent) will be related to the project. This represents such a small percent of current and projected population in the region, that impacts on facilities and services outside of the Local Impact Area are expected to be negligible.

(b) Watana - Operation Phase and Devil Canyon - Construction Phase

(i) Local

- Mat-Su Borough

• Magnitude of Population Influx

Project-induced population is not expected to increase significantly in the late 1990's as the construction activity at Devil Canyon intensifies. It is probable that the available work force in the Railbelt, including those who worked on the construction of the Watana dam, will be able to fill the new direct jobs. Some secondary population influx will occur as income from this portion of the project is spent.

Since the population of the borough will continue to grow as a result of natural growth factors implicit in the Base Case population projections, the relative impact of the project-induced off-site population will be smaller. In 1999, the project-induced population (including many people who moved into the area during the earlier Watana period and stayed) of 866 people will account for only one percent of total borough population.

• Water Supply and Sewage Treatment

No further impacts on the water or sewage systems in the Mat-Su Borough are expected.

- Solid Waste Disposal

  The cumulative landfill acreage need of the borough will increase by about 1.4 acres during the 1994-2002 period, or 1.2 percent as a result of the project-related population living off-site in borough communities. The borough may need to provide additional acreage for its central landfill around 1994-1995, with or without the Susitna project.

- Police Protection

  The need for police protection has been calculated by using a rural standard of one officer per thousand population. The need for State Troopers in the Mat-Su Borough is expected to continue to increase in the 1990's under the Base Case, as the population continues to grow. At the peak of Devil Canyon construction in 1999, it is expected that there will be need for about 62 officers, compared to a projected need for 60 Troopers under the Base Case.

- Fire Protection

  The project facilities and work camp/work village will be protected by firefighting equipment and services at the work site; there will be little impact on existing fire service areas during this period.

- Health Care

  No adverse impact on the borough's health care facilities are expected during this period as result of the project.

- Education

  There will be limited additions in enrollment in the Mat-Su Borough School District as result of the Devil Canyon portion of the project. Between 1993 and 1999, enrollment in the school district is expected to increase from about 12,065 to 16,685. Of this total enrollment in 1999, project-related in-migrant households are expected to account for 233 students, or just 1.4 percent.

- Transportation

  The Devil Canyon phase of the project will include construction of a rail spur from Gold Creek to the dam site. No additional impacts on the transportation systems in the borough are expected during this period.

- Trapper Creek

  - Magnitude of Population Influx

    In Trapper Creek, it is expected that as activity at Devil Canyon begins, population will increase from about 590 in 1994 to 710 in 1999. This represents an average annual growth rate of four percent. Project-related population will represent about 40 percent of total population in Trapper Creek in 1999.

  - Impacts on Public Facilities and Services

    No further important impacts on public facilities and services in the community are expected. Any increases in infrastructure which occur during the Watana period as a result of the population influx related to the project are expected to be sufficient to accommodate the community's population during the Devil Canyon phase.

- Talkeetna

  - Magnitude of Population Influx

    Project-related population in Talkeetna will rise gradually from about 190 in 1995 to 210 in 1999. Most of the population growth in Talkeetna during this period will be unrelated to the Susitna project. At the peak of construction at Devil Canyon it is expected that project-related population will account for 12 percent of population in the community.

  - Impact on Public Facilities and Services

    While it is likely that infrastructure needs in Talkeetna will continue to increase in the 1990's, these requirements will be related to the continued increase in population unrelated to the project.

- Cantwell

  - Magnitude of Population Influx

    Upon completion of the Watana portion of the Susitna project, between 90 (low impact scenario) and 140 (high impact scenario) people are expected to move out of the Cantwell area. No further in-migration of project-related population is expected during the Devil Canyon construction phase.

- Impact on Public Facilities and Services

  The decline in population in Cantwell associated with the completion of Watana construction will have most relevance to capacity utilization of the school. It is expected that the number of project-related students enrolled in the school will decline by about 30 upon completion of the Watana portion of the project. To the extent that the school was enlarged to accommodate the peak number of students, there may be some overcapacity. It is expected that potential problems can be avoided through careful planning and communication about the project (see Section 4 on mitigation measures).

(ii) Regional

Due to the limited population influx into the Railbelt and the large projected Base Case population base, no measurable impacts on public facilities and services in the Region outside of the Local Impact Area are expected during the Devil Canyon phase.

(c) Watana and Devil Canyon - Operation Phase

There will be some expected departure of population from the Local Impact Area as construction of the second dam is completed. However, the effects of this decline in population on public facilities are expected to be minimal, with the possible exception of schools in Trapper Creek and Cantwell. Planning, communication with local authorities and other mitigation measures are expected to prevent overcapacity problems. Due to the limited public facilities currently in place in the communities closest to the project and the small size of these communities even with the projected peak amount of project-related population influx, it is not expected that excess capacity will have been built.

During the operation phase of the project, all project workers and their families will be living at the on-site village, where housing and other community facilities will 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 Manpower Requirements and Payroll, by Year

(a) Manpower Requirements

Tables E.5.19 - E.5.21 show the projected total number and origin of on-site construction and operations manpower for the Watana and Devil Canyon dams from 1985 - 2005. These estimates include all construction manpower required for access camps, power facilities, and transmission facilities work, and management and camp manpower. Manpower for off-site activities such as engineering, procurement, manufacturing, and shipping to Cantwell are not included in these estimates.

For the construction work force, manpower is divided into laborers, semi-skilled/skilled, and engineering/administrative. As shown in Table E.5.19, the peak demand for labor occurs in 1990 with an estimated construction work force of 3,498.

The Watana dam will be constructed in two phases with an ultimate generating capacity of 1,020 MW. The first installment of 680 MW's will be completed by January, 1994, at which time operations manpower will total 70 persons. The additional generating capacity will be available in July, 1994 and will result in a total operations work force of 145 workers. Analysis of construction manpower requirements for the 600 MW Devil Canyon dam is based on main access construction beginning in 1992 and site facilities construction beginning in 1994. This dam would come on-line in 2002. The total on-site operations work force for both dams will equal 170 during 2002 and thereafter. During part of 1992 and all of 1993, construction activities related to both dams would be occurring.

It is apparent from Figure E.5.5 that the first phase of the Watana dam requires a significantly greater number of workers than both the second phase of Watana and Devil Canyon combined. This difference can be attributed to the additional labor requirements in the initial years for the 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). Significant decreases in work force requirements (relative to the preceding years) will occur between 1991 and 1996.

(b) Seasonality of Manpower Requirements

The demand for manpower will vary during any given year. As Figure E.5.6 shows, at least 80 percent of the peak demand for labor in a given year will be required during mid-March to mid-September. Labor requirements rise from about 30 percent of the peak to 80 percent of the peak during February to mid-March, and fall from 80 percent of the peak to about 30 percent of the peak during mid-September to the beginning of December. Labor requirements are about 30 percent of the peak during December and January.

The seasonal manpower requirements of the project are consistent with the seasonal pattern of demand for labor in Alaska. During January and February, the total number of jobs available in Alaska is less than during the summer months. The construction sector has historically been particularly seasonal.

The influence of this project on the number of jobs available in any given month is predictable. However, this information would have little value because 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.

Each summer, thousands of job seekers have come to Alaska looking for work in construction, professional and technical, and other occupations. While one would expect the unemployment rate to decline considerably during the summer months as more jobs become available, the decline has been limited to 2.5 - 4.0 percent compared to the maximum unemployment rates during the winter months. In addition, economic expansion has recently tended to exacerbate unemployment. During recent periods when more jobs have been available, unemployment rates have been higher than previous similar periods of job expansion, and the total number of unemployed persons has increased rather than decreased.

It is clear that the number of persons looking for work in Alaska is capable of growing faster than the rate of job growth. This condition is probably more prevalent when the economy in the lower-48 states is in a downturn.

The influence of the timing of manpower demand for this project is uncertain, but it is probable that the project will tend to exacerbate rather than ameliorate the seasonal differences between unemployment rates and the seasonal differences between the number of persons unemployed in Alaska. This phenomenon should be monitored and considered in the Impact Management Program (see Section 4).

(c) Payroll

Payroll is important because it is the source of impacts resulting from direct on-site construction and operations work force expenditures. Based on the on-site construction and operations requirements outlined above, the total yearly project payroll from 1983 - 2005 were derived and are shown in Table E.5.22. These totals were derived by matching wages to the respective trades, assuming that for construction workers there are 1,825 worker hours per year (54 hours per week and an average of 29 weeks per year) and for the operations work force there are 2,496 working hours per year (48 hours per week and 52 weeks per year). The payroll in 1990, the peak year of construction, totals $97.8 million (in 1981 dollars).

3.3 - Residency and Movement of Project Construction Personnel

The magnitude and geographic distribution of project-induced changes in communities are related to the size of the in-migrant work force. This work force creates the extra demand for housing and public facilities and services, and sometimes incremental local tax revenues obtained from this work force are insufficient to cover incremental expenditures.

The size of the in-migrant work force depends on the extent of the primary local labor supply, that is, the availability of craft and professional labor currently residing in the area from which the labor force would be drawn (for this project, this would be the Local and Regional Impact Areas, i.e. the region). Some of these in-migrating workers will choose to maintain their residences outside of the Region and others will choose to relocate their residences to the region. The number of workers that choose to relocate their residences to the region will depend in large part upon the types and quality of housing and related facilities provided at the construction sites, and the work schedule.

For this project, it is assumed that: a single status camp is provided for the laborers and most of the semi-skilled/skilled workers; a village with family housing facilities is provided for some of the semi-skilled/skilled workers and all of the engineering/ administrative workers that desire it; the workers work for four weeks and then have one week off; there are recreational and other facilities at the work camp and village that will help provide for a pleasant environment for the workers during their four-week periods at the construction site; and that most of the work force travels to the construction sites by a combination of private and organized ground transportation and some of the work force travels to the construction sites by organized air service from Anchorage and, possibly, Fairbanks. During construction of the Devil Canyon dam, it is assumed that some workers will travel to the Devil Canyon site by rail.

Given these assumptions, estimations for three elements of the work force are made: (i) number of workers that would reside in the region at the beginning of construction at Watana; (ii) number of workers that would relocate their residences to the region; and (iii) number of workers that will maintain their residences outside of the region. Estimates of population influxes are also included.

Estimates of numbers of workers and population influx are also provided separately for Cantwell because different estimation procedures were used. Different procedures were used because a railhead will be constructed and operated at Cantwell. Estimates for Cantwell follow those for the region.

Assumptions and methods are discussed to a limited extent in sections (a) - (d). Important communications with knowledgeable persons are referenced where appropriate in these sections.

Literature that was reviewed and that contributed substantially to the development of assumptions and methods is listed in the List of References at the end of this chapter (45 through 50). Further elaboration of methods and assumptions, particularly those about the relationship between housing facilities at the construction sites and work schedules, and the proportion of in-migrating workers that will choose to settle in the region, is available in Appendix E.5A.

(a) Region

(i) Regional Work Force

Labor supply is highly idiosyncratic, and the amount of labor available from a labor pool at a point in time depends upon the projected size and craft mix of the labor force, job opportunities available to this force from other projects, and the match of craft labor available to craft labor required by the Susitna Project, and the differing policies and geographic spheres of each craft. In addition, the supply and demand conditions will vary from craft to craft. All of these variables make it difficult to project the number of available construction trade workers in the Local and Regional Impact Areas (the region), and other workers who will become employed on the project.

As noted earlier, peak manpower requirements will occur during the construction of the Watana dam in 1990. Requirements for operations and maintenance manpower will start in 1993 at Watana (70 workers) and will increase to 170 workers in 2002 when the Devil Canyon dam comes on-line.

The regional availability of construction labor was analyzed according to total manpower requirements, which have been divided into the categories of laborers, semi-skilled/skilled, and engineering/administrative. The percentage of jobs that could be filled by the regionally available work force varies with each classification. In general, a greater portion of laborers than engineers and administrators will be supplied from the region.

The basic assumptions for the on-site construction work force shown in Table 5.20 are: for laborers, 85 percent will be supplied from the region, five percent from other areas of the state, and 10 percent will originate from out-of-state; 80 percent of semi-skilled/ skilled workers will be supplied from the region, five percent from other areas of the state, and 15 percent from outof-state; and for the engineering/administrative category, 65 percent will come from the region, 5 percent will come from other areas of the state, and 30 percent will be from out-of-state. Insights obtained from discussions with persons referenced in the List of References (32 through 44) contributed to the development of these assumptions.

These assumptions were applied to the total manpower requirements for the project. The results of this application are shown in the first row of Table E.5.23. Here it can be seen that by 1990, the peak year, about 2842 residents of the region will be employed as on-site construction workers.

The projected distribution of this construction work force's residences among the various Census Divisions of the Regional Impact Area and communities of the Local Impact Area is shown in the remaining rows of Table E.5.23. These figures represent the cumulative number of residents of a particular Census Division or city/community prior to the start of construction who will become on-site construction workers.

Several of the figures in Table E.5.23 are relatively small, particularly for the smaller cities and communities. This is a result of some of the assumptions that were made regarding the labor pool. In particular, it is considered likely that the large number of construction workers in Anchorage and Fairbanks and the presence of the union hiring halls in those cities will result in a majority of workers on the Susitna project being residents of the large cities. This could result in limited employment of people from the smaller communities closer to the project, in the absence of mitigation measures. It is possible that more persons in the small communities than indicated will obtain on-site construction jobs, especially if there is an effective local hire program.

(ii) Relocating Workers

Labor not available from the region will come from other areas in Alaska or from out-of state. Using the assumptions outlined above, Table E.5.24 shows the cumulative number of construction workers, by labor category, year and, implicitly, project phase, that would come from areas outside of the region to work on the project and relocate their residences in the region. Table E.5.24 also includes relocations of workers who resided in the Regional Impact Area at the start of the project and relocated their residences to the Local Impact Area during the project.

It is assumed in Table E.5.24 that workers who resided in the region at the start of the project and relocated their residences to the Local Impact Area during the project will remain at their new residences once their employment on the project is terminated. Further, it is assumed that one-half of the workers that come from outside of the region and settle in the region will leave after their employment on the project is terminated. It is implicitly assumed that the workers that remain will be able to obtain adequate employment.

(iii) Non-Relocating Workers

Table E.5.25 shows the cumulative number of construction workers, by project phase, that would not relocate to the region. These workers would live at the work camp or village and travel to and from their residences, located outside of the region, during their time off of work.

(iv) Relocating Workers and Associated Population Influx

Table E.5.26 shows similar information to that illustrated in Table E.5.23, but added to direct on-site construction employment are indirect and induced (secondary) workers by place of residence in the region. Estimates for secondary employment were made by applying location-specific employment multipliers to the inmigrating (relocating) direct on-site construction work force. These percentages were estimated by analyzing labor availability in each of the Census Divisions.

Table E.5.27 shows total in-migration (and outmigration) and place of relocation for the direct and secondary work forces. For the indirect and induced manpower requirements, it is assumed that the percentage of jobs that will be filled by in-migrants to the region ranges from zero percent in the Seward Census Division to 45 percent in the Mat-Su Borough. Thus, the number of in-migrants required to fill the available secondary jobs is less than the total number of secondary jobs available.

In-migration into the region at the peak of construction activity in 1990 will represent about 13 percent of the total direct construction and secondary work force of 6,365 (this includes all direct and secondary jobs created by the project). When considering only the direct on-site construction work force of about 3500 in 1990, the percentage of in-migrants to this total is even lower, representing about five percent. This low percentage of in-migration of on-site construction work ers is attributable to the large indigenous labor force in the region , the provision of work camps and a village at the project sites, and the work schedule of four weeks on and one week off, among other things.

During the peak of construction activities, 1990, 828 in-migrant direct and secondary workers will reside in the region. Of this total, 170 will be direct on-site construction workers and the remainder, 658, will be secondary workers. As manpower requirements fall during 1991 - 1995, it is assumed about one-half of these in-migrants will remain in the area. Some of these persons will become employed during the construction of the Devil Canyon dam.

During 1996 -1999, workers will again in-migrate to the region. This is shown in Table E.5.27. This in--migration will halt in 1999 and after 1999 there will be some out-migration.

As construction activity is completed in 2002, the percentage of in-migrant workers that remain after construction ends in 2002 is 12 percent. This is because most of the in-migrant workers originate from outside of the region and it is assumed that most of these workers will not choose to remain in the region after their employment on the project ends.about 12 percent of the workers that in-migrated to the region are expected to remain. For the Mat-Su Borough, this figure is much higher: 60 percent. This is because the majority of the in-migration to the borough consists of workers originating from the Anchorage, Fairbanks, and KenaiCook Inlet Census Divisions; it is assumed that 100 percent of these workers that move to the borough from these Census Divisions will view their moves as permanent and will remain in the borough after their employment on the project has ended.

Within the Mat-Su Borough, the settlement of in-migrants is expected to be different than the population distribution of the existing population. It is expected that more than one-half of the in-migrants will establish their residences in the area around the communities of Talkeetna and Trapper Creek. A significant amount of settlement will also occur in "other" areas of the borough; this corresponds to areas outside of incorporated cities, such as Montana Creek, Caswell and Willow. By the peak of construction activity, it is expected that about 90 on-site construction and secondary workers will have settled in Talkeetna, 117 in Trapper Creek, and 128 in the incorporated cities and other areas of the borough. Migration estimates for all years are shown in Table E.5.27.

Table E.5.28 shows estimates of the total population influx into the region, by Census Division and for selected Mat-Su Borough communities. These projections are based on the assumptions that, for the direct construction work force, 95 percent of the in-migrants that relocate in the region will be accompanied by dependents and that an average of 2.11 dependents will come with each in-migrant worker that is accompanied (see Table E.5.29 for estimates of population influx associated solely with the in-migrant onsite construction work force). For estimating the population influx associated with the secondary work force, the Alaska State average number of persons per household figure was used. Total population influx into the region during the two peak periods equals 2,324 and 1228, respectively. Of the total population influx associated with the direct onsite construction and secondary work forces in 1990, 2,214 or 95 percent, will relocate to the Anchorage subarea of the region (the Mat-Su Borough, and the Anchorage, Kenai-Cook Inlet, and Seward Census Divisions). The remainder will relocate to other parts of the region, particularly the City of Fairbanks.

It is expected that the Kenai-Cook Inlet, Anchorage, and Fairbanks Census Divisions will experience slight out-migrations of population during various stages of construction activity as out-migration to the Mat-Su Borough exceeds in-migration from other areas. The totals increase as the construction activities end because a portion of the in-migrant families workers and their families are expected to return to areas outside of the region.

During the peak construction year at Watana, the total project-induced population increase to the Mat-Su Borough totals 1,112. This accounts for 48 percent of the total to the region. Of this total, 694 are expected to remain in the borough after 2002.

In 1990, Talkeetna, Trapper Creek and "other" areas of the borough will experience 89 percent of the total population influx to the borough: Trapper Creek 31 percent; Talkeetna 24 percent; and "other" areas 34 percent. These projections represent considerable population increases relative to the baseline forecasts for each of these areas. Conversely, Palmer, Wasilla and Houston will experience only moderate increases in population. At the end of construction, total population increases to Trapper Creek, Talkeetna and "other" areas are 175, 173 and 257, respectively.

Numbers and categories of school-age children accompanying in-migrant workers were also projected. The implications of these projections were discussed above in Section 3.1.

(b) Cantwell

Project-induced employment and population effects in Cantwell were estimated for two cases, the high and moderate impact cases. In the high case it is assumed that in-migrating construction workers who work on the railhead and or the dams, as well as in-migrating indirect and induced workers are able to successfully settle in Cantwell. In the moderate case it is assumed that lack of land and/or housing limits the number of workers at the dam sites and secondary workers who can settle in Cantwell.

The following sections provide estimates of employment and population effects for selected elements of the work force. A discussion of assumptions and methods used in developing these estimates is provided in Appendix E.5A.

(i) Resident Employment On The Project

The first column of Table E.5.30 shows the estimated total number of residents who now live in Cantwell that will become employed on the project. These figures represent about 11 percent of Cantwell's current population.

(ii) Relocating Workers

The second column of Table E.5.30 shows the estimated total number of construction workers that will relocate to Cantwell during 1985 - 2005, for the high and moderate cases (these figures are cumulative). In the first two years most of the in-migrating workers will be employed at the railhead and in later years most will be employed at the dam sites.

(iii) Population Influx Associated With In-migrant Construction Workers

The total cumulative population influx that is estimated to be caused by in-migrating construction workers is shown in the third column of Table E.5.30. The total influx starts at 240 persons and reaches 336 persons after a dip to 241 persons in 1987. From 1990 onward, the number of people related to the project generally declines and reaches a low of 237 persons in 2003. From 2003 onward the project-related population in Cantwell is estimated to remain at 237 persons. During most years between 1985 - 2002 the total population influx is projected to more than double the Base Case population.

It is apparent from the third column of Table E.5.30 that the total population influx in the moderate case follows the same pattern as the high case. The influx values in the moderate case are generally about one-half to two-thirds those of the high case. The moderate case population influxes represent a little more than a doubling of the Base Case population in the first two years, a little less than the Base Case population during 1987 - 1993 and about half or a little less than half of the Base Case population during 1994 - 2005. The total population influx (which includes secondary in-migrant population as well as direct population) into Cantwell is shown in the last column of Table E.5.30.

Numbers and categories of school-age children accompanying in-migrant workers were also projected. The implications of these projections were discussed above in Section 3.1.

3.4 - ADEQUACY OF AVAILABLE HOUSING IN IMPACT AREAS

(a) Watana - Construction Phase

(i) Local

In the sections below, 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 will be provided at the work camps and family villages for all workers desiring housing and for the families of administrative/engineering personnel (workers will not be allowed to bring in their own housing, in the form of trailers or mobile homes, to the work site). In addition, there will 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 will be limited to direct and support workers who choose to move their permanent 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. For Cantwell and most areas of the borough, housing stock was assumed to increase in direct proportion to growth in the number of households. The exception was the area in the Mat-Su Borough outside of the incorporated communities, for which it was assumed that the vacancy rate (a very high 25 percent in 1981) would fall over time and therefore that the housing stock would increase at a slower rate than the number of households.

- Matanuska-Susitna Borough

As indicated above, housing will be provided at the project site for all construction workers and for the families of administrative/ engineering personnel. The majority of construction workers on the project are expected to use the on-site housing facilities. These workers will not be in-migrating into established communities and therefore will have no impact on the housing market in the Mat-Su Borough.

There will be an impact on the availability of housing in the borough to the extent that workers decide to establish permanent residence in any of the nearby communities. The impact of the in-migrating workers (including support workers as well as direct employees) on the housing market in the borough is displayed in Table E.5.31. The Watana construction period will be characterized by an influx of workers and their families between 1983 and 1990, and a gradual emigration of people from the area after 1990.

A total of approximately 374 project-induced households are expected to settle in the Mat-Su Borough between 1983 and 1990, the height of construction activity at the Watana site. Of this number, it is estimated that 285 will be households of direct workers on the project and that 89 will be indirectly related to the project. There will be a projected 2,336 vacant housing units in the borough in 1990, or about six times as many units as in-migrant households. Thus the in-migration is not likely to cause any dislocations in the borough's housing market as a whole. The number of in-migrating workers and their families may be larger than the above figures indicate if a substantial number of construction workers from outside the state in-migrate in the hope of obtaining employment soon after they arrive.

The period between 1990 and 1993 will see an estimated 11 percent decline in the overall demand for housing by project-related households, as the number of workers needed at the Watana site declines and some leave the area. However, due to baseline forecast growth (i.e. growth unrelated to the project) the overall number of households will continue to increase during this period. The decline in Susitna projectrelated households could be somewhat larger during this period if it appears that the Devil Canyon dam is going to be postponed.

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. The majority of housing demand by project-related in-migrants will be concentrated in the northern part of the borough. Vacancy rates in that area have historically been very low and demand is expected to exceed supply, causing rapid construction and some inflation in land and housing prices. This will be discussed in greater detail in the sections below.

- Trapper Creek

The availability of vacant housing in Trapper Creek has been extremely limited. For instance, in 1981, Trapper Creek contained roughly 68 households and 69 housing units. Very low vacancy rates are expected to be the norm in the future, as well, as additional housing is built only to satisfy definite needs. As Table E.5.31 shows, it is projected that the number of households and housing units in Trapper Creek will reach about 107 and 108, respectively,in 1990 (without the Susitna project).

In contrast, it is expected that an additional 114 workers related to the project (71 direct and 43 support) would be desirous of settling their households in Trapper Creek, if the housing were available. This figure could be somewhat higher if a large number of unemployed workers come into the area in the hope of obtaining employment on the project.

It is possible that speculative activity prior to the construction peak period will 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 needs may be met quickly by purchase of mobile homes and trailers to be used on individual lots or in trailer parks. While there is not a large quantity of private land in the Trapper Creek area, there is a sufficient amount to support the expected population influx. It is probable that this large increase in demand for housing will lead to increases in land and housing prices.

(iii) - Talkeetna

As in Trapper Creek, the availability of vacant housing in the area of Talkeetna has been extremely limited. In 1981, the housing stock consisted of 196 units, of which only two were vacant. It is expected that this trend of low vacancy rates will continue.

The population influx related to the Watana construction phase will result in additional demand for housing by about 71 direct and 16 support households (more if there is a large influx of job-seekers) coming into the area between 1983 and 1990. Under baseline forecast conditions, only about six vacant housing units are expected to be available to accommodate these new families.

The expected shortfall in housing supply may be made up by speculative advance construction, temporary residence in local lodges/hotels, the use of mobile homes and trailers, and rapid construction. There appears to be sufficient private land to accommodate this influx. To the extent that the housing supply cannot meet demand, it is likely that some in-migrant families will find housing elsewhere in the northern part of the borough.

- Cantwell

In 1982, there were 27 vacant housing units in Cantwell. Many of these were somewhat remote or could be considered marginal as year-round housing. The number of vacant housing units is not expected to increase under the Base Case.

Housing will be provided for workers at the railhead, but not for families of those workers. The demand for housing is expected to increase by approximately 115 households between 1984 and 1986, as result of the project. Under the High Impact scenario, it is expected that housing for all of these households will be available, due to entrepreneurial activity. Under the moderate impact scenario, it is projected that housing will be available for less than half of these households (55). The high case scenario will be comprised of approximately 53 households of railhead construction workers, seven other direct households and an estimated 55 families of secondary workers.

Upon completion of the railhead, the number of construction workers living in Cantwell will decline, but this decline will be partially offset by the incoming families of additional workers stationed at the Watana site. By 1990, approximately 125 project-related households are expected to be living in Cantwell under the High Impact scenario (95 direct households and 30 remaining secondary households).

Housing shortages in the first few months of 1985 are likely. It is possible that speculative activity prior to the construction peak period will result in additional housing units being available to meet a portion of the increase in 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 will be more likely to seek rental housing or mobile homes/trailers due to their shorter stay in the area.

Entrepreneurial capabilities and attitudes toward risk will be important factors influencing the amount and rate at which housing becomes available. Some families may reside temporarily in rooms owned by the lodges in the area though in the summer these families will be competing for room with the tourists to whom these lodges currently cater. It is likely that this large increase in demand for housing will lead to increases in land and housing prices.

Land availability could be a significant 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 will be subject to Ahtna, Inc.'s appraisal of the economic feasibility of this development (51).

(ii) Regional

No significant impacts are expected on housing conditions in the Railbelt, outside of the Matanuska-Susitna Borough. At the peak of construction of the Watana portion of the project (1990), the cumulative number of in-migrant households into the region is expected to total approximately 855, of which 170 will be households of direct workers on the project and 685 will be secondary households. This represents only 0.6 percent of the projected number of households in the Railbelt in 1990. Based upon the assumptions that (1) the housing stock keeps pace with baseline forecast housing demand and (2) vacancy rates average around 5 percent, the estimated number of vacant housing units in the Railbelt in 1990 of 8,600 will be far more than sufficient to accommodate the in-migrants.

(b) Watana - Operation Phase and Devil Canyon - Construction Phase

(i) Local

Table E.5.32 displays the impact of the project on housing demand in the Local Impact Area during the Devil Canyon construction phase.

- Mat-Su Borough

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

As construction activity on the Devil Canyon portion of the project begins, another 50 project-related households are expected to move into the Mat-Su Borough between 1995 and 1999. Most of these households will be related to in-migrant support workers, as it is probable that there will be enough direct workers for the project among local residents and the workers who had stayed after construction on the Watana facility was completed. Existing housing is expected to be more than adequate to accommodate these workers.

- Trapper Creek

During the Devil Canyon construction phase, approximately 13 additional families are expected to move into Trapper Creek between 1995 and 1999, reaching a cumulative number of 92 households in 1999 (about 33 percent of all households in the community in that year). As this will be below the earlier Watana peak number of households, adequate housing is expected to be available. After 1999, project-related households are again expected to move out of the area. Approximately 63 of these families will remain in the community at the completion of construction.

- Talkeetna

Between 1995 and 1999, approximately 10 households related to the project are expected to move into Talkeetna, bringing the cumulative number of families living in the community (related to the project) in 1999 to 77, and the total number of households to 658. Adequate housing is expected to be available. At the end of construction of the project, about 64 project-related households are expected to remain in Talkeetna.

- Cantwell

Upon completion of the Watana portion of the project, it is expected that approximately 40 project-related households will gradually move out of the area, and this could result in an oversupply of housing in the community, along with a decline in the value of homes and real estate. The projected decline in housing demand would equal 20 percent of total households in the community. No additional households are expected to move into Cantwell during the Devil Canyon phase of the project. By 1999, approximately 85 project-related households will be living in the community, representing an increase of 91 percent over the number of households projected to be in the community under the Base Case.

(ii) Regional

No measurable impacts on housing in the Railbelt are expected during this phase of construction. In 1999, the peak year of Devil Canyon construction, a cumulative total of 489 project-related households will have moved into the region, representing 0.3 percent of the total number of households in the area. Adequate housing is expected to be available.

(c) Watana and Devil Canyon Operation Phases

As construction of the Devil Canyon facilities is completed, it is expected that some households of project-related workers will leave the area. Trapper Creek and Cantwell will be most affected by this decline in housing demand. In both communities, approximately 30 households are expected to leave the area between 1999 and 2003. An oversupply of housing could result.

The combined operation phase of the project will require a direct work force of about 170. All of these workers and their families will have housing at the site. There will be no impacts on housing conditions in communities in the area.

About 254 of the original 374 households which moved into communities in the Mat-Su Borough are expected to remain in the region. The decline in number of households is not expected to have any impact, as the population of the borough is growing rapidly anyway and the modest decline will occur over a 13 year period (1990-2003).

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 will be very small, due to the rural nature of the impact area and the planning involved in the routing of the project. Other influences on business activity as result of the project will be far more important.

(a) Residences

Although some cabins used intermittently by hunters, trappers and recreationists will be displaced by the project, no permanent residences are expected to be inundated or otherwise displaced. Some residents of the upper basin may voluntarily leave the area for other wilderness 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. The status of these lands and potential improvements on them will be updated by ongoing studies. If there were any displaced residences, displacement would occur during the construction phase of Watana.

(b) Businesses

There are no known businesses that will be displaced by the reservoirs, the transmission lines or other project-related structures or activities. However, there are businesses that will be indirectly influenced by the project.

Most business in the upper basin are dependent upon abundance of fish, big game and furbearer species. These activities include guiding, lodging, trapping, river and lake fishing and other recreation. Partial short term displacement of such enterprises by construction activity may occur, but as each dam becomes operational, increased access to the area will probably increase business opportunities.

During the construction phase of each dam, guides are expected to adjust to changes in abundance and location of fish and game species. When both dams are in operation, guides may benefit from increased access to wilderness areas.

Lodges catering to hunters and fishermen will be affected by the same factors as the guides, and could find new opportunities to offer access to activities such as cross country skiing or to provide facilities for business conferences.

Trappers will be affected by loss of habitat for furbearers. The amount and location of harvestable salmon could change, but long term impacts on the activities of Cook Inlet commercial fishermen, recreational fishermen, and other user groups are expected to be small relative to recent activity levels of these groups. Some estimations of economic and related impacts on commercial, recreational, and subsistence users of fish, big game and furbearer species are being conducted in an ongoing study. Some preliminary results from this ongoing study are reported in Section 3.7. This ongoing work may be included as part of later studies if the projected impacts on harvestable stocks suggest that the user groups could be significantly impacted.

Impacts on other types of recreation will include the loss of sections of the Susitna River to white-water kayaking, but general recreational use is expected to increase as a result of improved access when both dams are in operation.

One active mining site, #1 Moose Creek, will be totally inundated. The project may be beneficial to other mining activities by improving access, hence allowing existing claims to be worked more profitably and facilitating discovery of new deposits. Most of these benefits would begin to accrue when both dams are in operation and if miners are permitted to use access routes created by construction and operation activities.

Business activity will increase along the Parks Highway between Anchorage and Fairbanks during the mid to late 1980's as a result of railhead construction and operation at Cantwell, construction of the access road and camp, and construction of the dam and related facilities at Watana. In general, it is expected that the construction, transportation, wholesale and retail trade, real estate and services sectors will benefit. Businesses that are contracted to provide specific goods or services such as fuel, communications, housekeeping, trucking, helicopter or airplane support will benefit. Existing support sector businesses such as restaurants, service stations, lodging establishments, retail food stores, etc., will expand and new businesses will be started. Table E.5.33 shows the estimated number of secondary (support) jobs that will be created by the project in the region (along the Parks Highway between and including Anchorage and Fairbanks).

The project is expected to have a significant impact on business activity in Cantwell, a significant but lesser impact on Trapper Creek, and still less of an impact on Talkeetna, Houston, Wasilla, Fairbanks, Anchorage, and Palmer. Cantwell's businesses will have increased sales because a relatively large population will relocate there and because it is the community along the access route located nearest to the construction site. The new residents will have spending patterns similar to those residents now living in Cantwell and the workers who pass through Cantwell are expected to concentrate their expenditures on food, beverages, lodging and related items. Each of the other cities or communities mentioned above, except for Palmer, will experience the same types of impacts as Cantwell but the impacts will be less pronounced. Because Palmer is not on the Parks Highway and, therefore, not subject to pass-through workers, it will not receive business stimulus from this source.

During 1985 - 1990, there could be temporary shortages of goods and services in some of the smaller communities where workers pass-through and/or settle. For example, the community of Cantwell will experience significant pass-through and settlement in 1985 - 1986. Currently, most residents get their food and household items in Anchorage. Unless businesspersons plan and prepare for providing considerably more products in their stores in Cantwell, there could be frequent temporary shortages of these products.

Another possibility is that the smaller communities could have excess retail capacity in the early to mid-1990s and from 2000 onward. This would be the case if these communities make permanent rather than temporary business adjustments to the demands of the peak work force and associated relocating workers.

The estimated number of secondary jobs created by the project in the Mat-Su Borough is shown in Table E.5.33. Most of these jobs will be created in Talkeetna, Trapper Creek and unincorporated areas of the borough. It is estimated that about 55 percent of these jobs will be filled by current residents of the borough. These jobs will have a significant impact on the unincorporated communities and areas because employment is seasonal or sporadic and the unemployment rate at any time of the year is probably quite high. Because most of these jobs will be filled by second job holders (spouses and young people) in the base population and dependents of in-migrating workers, they will create very beneficial economic impacts because they will add to family income without adding significantly to the population.

The Susitna project will create a significant number of jobs for the region and the Mat-Su Borough . These are shown in Table E.5.34 along with forecasts of jobs in the Base Case for the region and the Mat-Su Borough. It is apparent from this table that during the construction phases, the number of jobs created in the region by the project is small yet significant when compared to the Base Case forecast of jobs for the region. During construction, the project will increase the total number of jobs available in the region by two to three percent.

It is also apparent from Table E.5.34 that during the construction phases, the number of jobs created in the Mat-Su Borough by the project is large and significant when compared to the

Base Case forecast of jobs for the borough. The ratio of jobs created to jobs forecast ranges from 57 percent in the peak construction year, 1990, to seven percent in the lull between the end of construction at Watana and the start of construction at Devil Canyon.

Competition for labor in the region will increase as construction workers are recruited for the project. Not only will construction workers leave their existing jobs, but some secondary workers will also leave their jobs. This will create more competition for labor and will result in higher wages and salaries for several types of labor in the region. This will tend to increase the prices of locally produced goods and services.

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

(a) Watana - Construction Phase

(i) Local

- Mat-Su Borough

The expenditures by the Mat-Su Borough with and without the project have been projected on a per capita basis, in 1981 real 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 will be real growth in property values, (2) future increases will be realized in the mill rates, and that (3) certain per capita receipts of state shared funds, federal shared funds and municipal assistance funds will be forthcoming.

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

In the following discussion, analysis of projected revenues and expenditures is made. Comparisons between the future with the project and a future without the project (Base Case) are highlighted as are comparisons between expenditures and revenues. Four different funds are discussed. It must be pointed out that discussing individual funds is used here as a means of identifying the impact items only. General fund revenues contain some funds that are collected as non-area wide taxes and which therefore contribute to the service areas fund. Likewise, some property taxes are collected into the general fund for education. Thus, an attempt to aggregate over the four funds discussed below would lead to some double counting of revenues and is, therefore, avoided.

The figures used in in the following discussion may be found in or can be derived from Table E.5.35. All the impacts mentioned are based on total population influx estimates including the population associated with both the direct construction workers and secondary workers. Direct impacts are proportional to the direct con struction workers and associated populations. In 1985 and 1990, the direct population influx will account for 78 percent of total population influx. This proportion will increase to 93 percent in 1994 as some of the secondary workers leave after completion of Watana. At the height of Devil Canyon construction, this proportion is expected to drop again to 86 percent as some indirect and induced populations are attracted by the new level of activity. Direct impacts can therefore be inferred from Table E.5.35 by applying these percentages.

Projected impacts on revenues and expenditures as a result of the project will be small. Most of the growth in the borough budget will be related to Base Case population growth. The service areas fund will experience higher relative impacts than any other fund. This impact will be felt mainly in the revenues. According to Tables E.5.35 and E.5.36, service areas fund revenues will be increased by the project by more than 20 percent during each of the key years. The highest impacts relative to the baseline will occur in 1990 at 30.7 percent. Although the absolute magnitudes involved are small, the service areas revenues are important since they represent the ability to provide services in those communities like Talkeetna and Trapper Creek where project impacts will be most apparent.

· Revenues

According to the projections, all the four major revenue funds of the borough, including general funds, service areas funds, land management, and school district funds will grow between now and the end of the Watana dam construction period. All the four funds will approximately double from current levels by the year 1990 and will have more than doubled by 1994. This growth will occur with or without the project.

During this period, the greatest project impact in terms of deviation from the baseline projections will occur in the service areas fund. It is projected that the 1990 service areas revenues ($3.3 million) will exceed the baseline revenue projections ($2.6 million) by about 30 percent as result of the population influx during construction at Watana. Even as early as 1985, the service areas fund will have an incremental impact over the Base Case of 21 percent, while the other funds will be relatively unaffected by construction activity.

The education fund, which in absolute magnitude is greater than the other three funds combined, will experience incremental impacts of the project amounting to less than one percentage point in the years 1985 and 1990. In 1994 the education fund revenues with the project exceed the education fund Base Case by 1.3 percent (approximately $800,000). The general fund revenues and land management fund revenues will receive relatively little impact.

- Expenditures

In percentage terms, expenditures are expected to rise less than revenues, as result of the project. In absolute terms, however, revenues and expenditures will rise by approximately the same amount for two of the funds (the general fund and the land management fund).

The education fund and the service areas funds experience revenue impacts that are of different magnitude from expenditure impacts. In 1990 the education revenues impacts are $1.2 million while the corresponding expenditure incremental impact is expected to be $1.7 million. On the other hand, service areas funds experience more project related incremental growth in revenues than in expenditures.

It must be pointed out, however, that in all four major fund categories, expenditures are expected to be higher than revenues. With the exception of the education fund, the incremental expenditures due to the project generally do not exceed $200,000 in 1985 or 1990 for any fund. Expenditures of the education fund in 1990 are projected to increase by $1.7 million, for a 2.8 percent increase over a Base Case estimate of $59.4 million. This is the highest absolute impact on any fund expenditure or revenue item that year.

- Comparing Expenditures to Revenues

With or without the project, expenditures are projected to exceed revenues in the Mat-Su Borough budget. Thus, there will be deficits with or without the project. In 1990 the deficit situation will not be affected by the project in the general nor the land management funds, but will worsen by $0.5 million in the education fund and improve by $0.6 million in the service areas funds.

It is expected that the borough will have to increase service substantially in the service areas such as Talkeetna and Trapper Creek due to the project activities. A substantial portion of the service area revenues comes from the state shared funds and municipal assistance funds. Consequently, there are likely to be time lags between the time these services are initially required and the arrival of funds. A portion of the borough general fund comes from the state in form of school debt service reimbusement. Recent legislation has increased this funding level to cover 90 percent of the school bond debt service and has reduced the reimbursement lag so that state funds can be available within the same fiscal year as the expenditures. This should provide some relief.

Implicit in the projections is the assumption that the property taxes will grow both due to an expanding tax base and also from increased mill rates and may constitute more than the current 30 percent share of the service areas fund revenues. If this were to happen, the problem of time lags could become even more acute. There is usually a time lag between the time property is assessed and put on tax rolls and the receipt of tax dollars. In the mean time, new services may be required but face a funds shortfall. Although this has not been a big problem according to the borough budget director, it could be in the future when the spending levels get larger with increased populations. (52)

- Talkeetna

Talkeetna is not incorporated and therefore cannot collect taxes. As a result, the fiscal pressures and benefits of the project will be felt in the borough budget. In 1981 the borough collected $71,000 on behalf of the community of Talkeetna. It is projected that in 1985 this collection will have grown to $98,000 without the project. With the project, an additional $900 is expected. In 1990, revenue collections without the project could amount to $164,200. With the project, the corresponding figure would be $178,900, or $14,700 more.

- Cantwell

Cantwell has no local government and is located in an unorganized borough. Thus, the only local entities that will experience fiscal impacts from the project will include the non-profit group, Community of Cantwell, Inc. and the Railbelt School District.

The only revenue source upon which the Community of Cantwell, Inc. can depend on an annual basis is state revenue sharing; this usually averages between $25,000-32,000 per year for unincorporated communities, and is not based upon the size of population. Thus, it is not expected that the increase in population in Cantwell will be reflected in an increase in revenues.

Due to the unincorporated nature of the community, expenditures will not necessarily need to increase either. The population influx is not expected to have a large impact on the planned fire station, with the exception of an increased need for volunteer firefighters. However, if the community felt that additional expenditures were needed for community facilities (such as a new solid waste disposal area) due to 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 in order to widen its revenue base and provide more facilities and services for the residents there.

The Railbelt school district will be faced with an increase in both expenditures and revenues as a result of the population influx associated with the project.

It is estimated that expansion of the Cantwell school will be needed, and the financing for this expansion would need to be requested from the state legislature. The school district expects there would be a one year lag between a request for revenue for a capital project of this type and the receipt of authorization. Another two years would be required for planning and construction. Present construction costs average around $140-$240 per square foot.

Operating expenses at the school would also increase to reflect the 250 percent increase in enrollment. The addition of between seven and nine teachers would result in an increase in expenditures for teachers salaries, alone, of $245,000 to $315,000 in real dollars. Other operating expenses could also be expected to increase proportionately. Total expenses could be expected to reach approximately $875,000 by 1990.

The increase in enrollment will also result in additional revenues for the school district. Based upon the present average revenue of $8,683 per school child, 1990 revenues for the school district could be expected to rise by approximately $825,000 under the high impact scenario.

(ii) Regional

The project is not expected to have significant regional impacts during this or subsequent phases of developement. For further discussion of this refer to Frank Orth & Associates, Inc., April 1982 (1).

(b) Watana - Operation Phase Devil Canyon - Construction Phase

(i) Local

- Mat-Su

Overall the borough revenues and expenditures will continue to grow during this period, which is expected to last from 1994 to 2002. The following is an analysis of at revenues and expenditures at selected intervals during this period.

• Revenues

General Fund

By 1994 general fund revenues will have grown from a 1981 level of $15.3 million to a baseline projection of $32.2 million. These revenues could, however, reach a higher level at $32.9 million in the presence of Susitna project activities. The incremental impact is an approximate 2.2 percent increase over the baseline forecast. In 1999 the corresponding forecast for the general fund revenues are $39.9 million and $40.7 million and show an incremental impact over the Base Case of 2 percent. This trend of diminishing relative impacts continues and is reflected in the projections for the year 2002 when the project impact over and beyond the Base Case forecast will be 1.8 percent. The dollar amount is estimated at $0.8 million.

Service Area Fund

At the start of the Watana operation phase and the early stages of Devil Canyon construction (1994), the service areas fund revenues will have grown to $3.8 million compared to a baseline forecast of $3.0 million. The incremental impact relative to the Base Case will equal about 26.6 percent (compared to the 1990 impact of close to 30 percent). The absolute magnitude of the impact itself would be $0.8 million. By 1999 the absolute magnitude of the impact is projected to equal one million dollars. Relative to the baseline forecast for that year, this translates to a

27.8 percent increment. At the completion of the Devil Canyon construction phase in 2002, the incremental impact of the project would be 24.4 percent based on a Base Case forecast of $4.1 million in revenues and a project scenario revenue level of $5.1 million.

Land Management Fund

Land management fund revenues are the smallest of the four funds considered. During this phase of development, the greatest impact on land management revenues is projected to occur in 2002. This will be a 3 percent impact but will be negligible ($0.1 million) in absolute magnitude.

School District Fund

The baseline forecast for this phase shows that school funds grow from $60.4 million in 1994 to $78.7 million in 1999 and $90.8 million in 2002. The corresponding incremental impacts of the project are estimated at respectively 1.3 percent, 1.4 percent, and 0.9 percent. In no case does the absolute increment exceed a million dollars.

- Expenditures

General Fund

Incremental impacts in the general fund expenditures are projected to be no higher than 1.5 percent of the Base Case in 1994. The baseline expenditure for that year is $39 million. In 1999, expenditures will have grown to $49.8 million in the Base Case and $50.4 million, assuming the project scenario thus resulting in an incremental impact of 1.2 percent. The reduction in relative incremental impacts is also shown in the 2002 projections where the impacts amount to 0.8 percent.

Service Areas Fund

With the project, the service areas fund expenditures are projected to experience somewhat higher percentage incremental impacts than will the general fund expenditures. Service areas expenditures will be increased by $0.2 million in each of the years 1994, 1999, and 2002 leading to corresponding percentage impacts of 1.8 percent, 1.3 percent, and 1.1 percent. These estimates are based on baseline projections of $11.4 million, $15.5 million, and $18.7 million, respectively.

Land management fund

Actual changes in the Base Case expenditures due to the project are forecast to be small.

School District Expenditures

Relative to the Base Case and also in absolute terms, the incremental impacts in the school district expenditures are forecast to be greater than those of the other borough funds. In 1994, impacts on expenditures are projected to be 1.8 percent of the $74.0 million baseline. The corresponding impact levels for the years 1999 and 2002 are respectively 1.4 percent and 1.9 percent. Of the three years considered, 1999 will experience the largest absolute impact at $1.4 million.

- Comparing expenditures to revenues

As in the Watana construction phase, revenues and expenditures will grow during the second phase of development. This growth is depicted in the projections that assume construction and operation of the project as well as in the Base Case. Over time, a widening gap between expenditures and revenues is forecast and will occur with or without the project. In general, the growing deficit situation is not forecast to be worsened nor alleviated by development of the project. However, examination of individual funds reveals that school district deficits get slightly worse while general funds and service areas funds tend to experience some improvement with the project. The amount of relief or additional burden, however, is dwarfed by the overall size of the deficits involved.

- Talkeetna

Revenue collections on behalf of Talkeetna are projected to grow in the Base Case from $164,200 in 1990 to $226,600 in 1994 and to $355,100 in 1999. The corresponding growth with the project is forecast to be from $178,900 in 1990 to $237,600 in 1994 and again to $368,600 by the year 1999. The incremental project impacts in 1994 and 1999 are therefore $11,000 and $13,500 compared to $14,700 in 1990. These increments will contribute to growth of the service areas fund.

- Cantwell

As the Watana construction phase is completed, it is expected that between 100 and 125 project-related residents will leave Cantwell (though the population and school enrollment in Cantwell are expected to remain almost twice as large as would be the case under the Base Case). This would be reflected in a decline in any per capita state revenues that the community receives. The school district will also be faced with a decline in both revenues and expenditures as the enrollment in the school declines by about 30 children. Over-capacity in the school, and any resulting financial burden, may be avoided by careful planning.

(c) Watana and Devil Canyon - Operation Phases

(i) Local

- Mat-Su Borough

In 2002 the construction of Devil Canyon is expected to be complete. The fiscal impacts on the borough for the period after 2002 are discussed below.

· Revenues

To the general funds the project presence will add \$0.8 million to a Base Case revenue of \$45.2 million or 1.8 percent in 2002. The same dollar amount will be added in 2005 to a baseline projection of \$51.4 million thus causing an impact of 1.6 percent. One million dollars will be added by the project to the service areas fund in 2002 for an impact of 24 percent. In 2005 \$1.2 million will be added to a Base Case revenue of \$4.6 million to produce an impact of 26.1 percent in the service areas revenues.

The land management fund will, both in 2002 and 2005, experience a project impact of \$0.1 million. In relative terms the percentage impact on the Base Case will be 3 percent and 2 percent. School district funds will be increased by \$0.8 million in 2002 and by \$0.7 million in 2005 because of the project. Since the Base Case revenues for these years are respectively \$90.8 and \$104.5 million, the percentage increments due to the project are 0.9 percent and 0.7 percent.

· Expenditures

In terms of individual funds, the least likely to be influenced by the project is the land management fund. The impact on the general fund will be \$0.5 million in both 2002 and 2005. Compared to the Base

Case expenditures these impacts are respectively 0.9 percent and 0.8 percent. The service areas fund is expected to increase by $0.2 million in 2002 and $0.1 million in 2005 due to the project. Land management funds will be unaffected in both years while the education funds will experience a project impact of $1.1 million as incremental expenditures in each of the two years considered. School district expenditures in the Base Case will grow from $113.2 million in 2002 to $130.6 million in 2005 while the project scenario shows growth from $114.3 to $131.7 million during this period. Thus the impacts of the project are estimated at 0.9 percent and 0.8 percent, identical to the general fund expenditures.

- Talkeetna

In the Base Case the borough is projected to collect $355,100 on behalf of Talkeetna in 2002 and this will grow to $549,600 by 2005. With the project the corresponding collections are expected to be $466,600 and $560,500. The incremental impacts due to the project in each of these years will therefore be lower both in absolute magnitude and also relative to the baseline than the 1990 forecasts.

3.7 - LOCAL AND REGIONAL IMPACTS ON FISH AND WILDLIFE USER GROUPS

(a) Fish

(i) Methodology

The impacts to Alaska's fishery resources which would result from construction of the Susitna dams depends upon loss of habitat rather than specific loss of fish. The river habitat is viewed as a production ground capable of producing a number of fish each year. The exact numbers produced depend upon many aquatic and environmental conditions which vary over time.

The data available to evaluate the potential impact of the proposed dams, particularly for the salmon resource, consist of point estimates of the river system's production capability. These data are for the 1981 salmon runs. Since the research necessary to evaluate potential impacts on the river habitat has not been completed, the point estimates for the 1981 level of resource production is used in this section. This methodology requires the qualification that potential impacts may or may not be accurate, depending on whether 1981 was a representative year.

Specific impacts on fishery resources are discussed, to the extent possible in the section immediately following. In later sections, users of the resources are discussed by the categories of commercial, sport and subsistence use.

(ii) The Commercial Fishery

A basic assumption has been made that the commercial fishery for salmon produced in the Susitna system occurs only in Upper Cook Inlet. The Upper Cook Inlet is divided into two management divisions; the Central District and the Northern District. The most important distinction between the two is that both set and drift gillnets are allowed in the Central District whereas set gillnets only are allowed in the Northern District.

Table E.5.37 shows the average annual commercial catch and value from the fishery in the Upper Cook Inlet. The most important species, from the standpoint of economic value, is sockeye salmon. The average annual sockeye ex-vessel value for the ten-year period from 1972 to

1981 was $8,499,102. The average annual catch was 8,854,263 pounds. The second most important species in terms of value is chum salmon. The average annual chum catch was 4,900,471 pounds, giving an average annual exvessel value of $2,619,546. The other species in descending order of economic importance in the Upper Cook Inlet are coho, pinks and chinooks. The actual catch and value fluctuates for each species from year to year, but the ten-year average provides a reasonable indication of recent trends (53 and 54).

The number of participants in the commercial salmon fishery are limited to the number of permits issued. The numbers of drift gillnet and set gillnet permits for Cook Inlet for the years 1975 to 1981 are shown in Table E.5.38. It should be noted that a small number of the set net permits, perhaps 10 percent, are from outside the Upper Cook Inlet. The total number of permits used in 1981 was 1,161 (55). With an average of two people per boat for the drift gillnet boats and an average of 2.5 people per set net site, the total number of fishermen in Upper Cook Inlet would be approximately 2,468 people (data on the average number of persons fishing are from ADF&G, February 1982 (56)). The catch distribution between the different gear types varies by species due to the different areas fished. Chinooks are taken mostly in the set net fishery whereas chum salmon are taken mostly in the drift net fishery. The other species are taken on a more even basis. In general the set net fishery takes more of the coho and pink catch while the drift net fishery takes more of the sockeye catch.

- Specific Impacts

  The specific impacts which would result from construction of the Susitna dams have not been determined in a manner which allows accurate quantification. For the salmon resources, for example, there are point estimates for the 1981 and 1982 escapements of fish passing upriver from Talkeetna. This upstream stretch of the river, from Talkeetna to Devil Canyon, is where many of the impacts would occur. It would be erroneous to assume that two point estimates provide an accurate representation of the actual productive capacity of the river. Similarly, it could be misleading to assign values to potential losses to the fishery resource based only on these estimates since the biological impacts of construction of the Susitna dams have not been resolved.

Given these qualifications, the following discussion may be useful as an example of order of magnitude of potential project impacts on the commercial fisheries. The largest potential impact above Talkeetna would be to chum salmon since this species utilize sloughs in addition to the mainstream Susitna River for spawning. In 1981, an estimated 20,835 chums passed upriver past the Talkeetna Station. Using this figure of 20,835 fish and assuming a worst case that the dams would result in a 100 percent loss, a loss to the total Cook Inlet chum run of 45,837 fish would be indicated. This assumes a catch:escapement ratio of 2.2:1. By these assumptions, then, a potential ex-vessel value of $214,517 could have been lost to the commercial fishery in 1981.

This estimate should not be interpreted as a precise figure since it is based upon incomplete biological data. It does, however, provide a point estimate for the potential post-project loss to the Upper Cook Inlet commercial fishery for chum salmon based on a number of assumptions. Table E-5-39 shows a similar set of calculations for sockeye, pink, chum and coho losses which could have occurred during 1981 and 1982, assuming as a worst case there would be a post-project loss of 100 percent above Talkeetna (54 and 58). There is insufficient biological impact data to ascertain whether or not this is a reasonable assumption.

The potential losses estimated for chum salmon are the highest of the four species included, being $214,517 for 1981 and $428,604 for 1982. Similar estimates for coho, pink and sockeye can be seen in Table E-5-39. Chinook salmon were not included in estimates of potential losses since Susitna chinook are not caught in significant quantities by the commercial fishery.

It should also be carefully noted that the calculations are based upon a catch:escapement ratio of 2.2:1 for coho, chum and sockeye; and a catch:escapement ratio of 3.8:1 for pink. These ratios are statewide averages used by ADF&G and may or may not be accurate in this application. They are, however, the best data available for use at the time of this writing.

(iii) The Sport Fishery

Discussions with sport fish biologists have indicated that potential impacts to the sport fishery which would occur if the Susitna dams were constructed would be in three main areas. One area would be the impoundment area of the proposed dams and the areas downstream. A second area of potential impact would be upstream of the impoundment areas in the main stream Susitna and possibly into some of the tributaries such as the Lake Louise - Lake Susitna - Tyone Lake areas. The third would consist of areas which could be reached from the access route, between the Denali Highway and the Watana site.

The area and level of impact to resident and migratory fishery resources which would result from the Susitna dams construction has not been determined. This makes the task of evaluating the potential impact of the dam construction difficult. Data on specific angler use of the Susitna and tributaries above the Talkeetna confluence are virtually nonexistent. There are data describing use patterns on the lower Susitna and main tributaries which will be presented in summary.

The East Susitna Drainage - West Cook Inlet - West Susitna Drainage areas consist of some of the major sport fishing areas of the state, such as: the Deshka River, Alexander Creek, Talachulitna River, Willow Creek, Montana Creek, Clear Creek, Sheep Creek and others. In these two areas, there was over 97 thousand angler days fished in 1981 (57).

A summary of the sport fish catch by major species and total number of angler days expended in the lower Susitna Drainage is shown in Table E.5.40. Many of the areas included in this table may be out of the area of impact from the Susitna dams, but they do indicate levels of angler activity. Research is currently underway to more fully define the level of impacts to the sport fishery and place a value to sport fishermen of the fishery resources which would potentially be lost as a result of construction of the Susitna dams. These necessary data and analyses will be available in the future.

(iv) Subsistence Fishing

The subsistence catch of fish produced by the Susitna system discussed in this section refers only to the catch from Cook Inlet. Subsistence fishing does occur in the Susitna system, but there are no data available with which to evaluate the magnitude of the catch of that fishery.

The subsistence catch of salmon by species and year for the period 1969 to 1981 is shown in Table E.5.41. During that period, the number of permits increased from 330 to 1178, with most of the increase occurring from 1979 to 1981. The catch of salmon has followed the same pattern as the number of permits, increasing rapidly after 1978 to the largest catch in 1980 of 16,973. Overall, sockeye and coho contribute most to the total catch. In the last two years shown, however, 1980 and 1981, the chinook catch was very significant with over 2,000 fish taken each year, representing 13 to 14 percent of the total catch (58).

The value of the subsistence catch should be determined using a shadow price. The ex-vessel price of the salmon is not an appropriate measure since it can be assumed that subsistence fish are food rather than production input to a processing plant. A more appropriate measure of value would be the retail cost of salmon delivered to the point of subsistence capture, or the price of an equally desirable alternative food source. These valuation estimates (shadow prices) have not yet been made, but will be made as part of an ongoing project on fishery resource valuation by user category.

(b) Game

(i) Commercial

Strictly speaking there is no commercial use of big game. Most game animals are hunted for recreation and not for commercial purposes. In the following discussion, a description of indirect commercial use by various secondary industries that to some degree depend on big game resources is presented.

- Guides and Guide Services

Guiding is a common part of hunting in Alaska. Nonresidents have been required to hire guides if they are hunting certain species. Recent legislation makes it mandatory for nonresidents to use guides for all species in the future. Since the services offered by some guides cover the whole spectrum of the hunter support activities, this section describes the support industry as a whole.

Guides who make at least part of their annual income from big game hunting activity may be divided into three groups - assistant guides, registered guides, and master guides. Assistant guides cannot execute contracts with clients, but must work for a registered guide.

Registered guides are fully licensed operators and may own exclusive guide areas or operate in joint areas where they can guide clients and fulfill their contractual obligations. Exclusive guide areas are recognized as assets and may be transferred for a fee from one guide to another as long as the transfer is recorded at the Game Licensing and Control Board.

A master guide is a registered guide who has been in business for a long time and is nominated by two of his contemporaries.

Services offered by guides vary from person to person and so do the service charges. In some cases a full range of services may include, but not be limited to:

- Transportation;
- Lodging;
- Guides, including assistant guides of which each registered guide is by law limited to three;
- Cooks;
- Boat transportation;
- Equipment for camping.

To provide this range of services requires considerable investment.

Impacts on the guiding industry are expected to be of an indirect nature. Were the project to reduce the number of available harvestable animals, it is conceivable that this would reduce hunting opportunities. This would in turn reduce the number of hunters that can hunt each year. Reduced numbers of hunters translate into reduced business for the guiding industry. Further analysis of this impact possibility is pending.

- Lodge Operators.

The land use study report of April, 1982 (59) identified three different lodges in the project area. They include the Stephan Lake lodge, the High Lake lodge, and the Tsusena Lake lodge. All are currently well maintained and are used either year-round or on a seasonal basis. Current use ranges from private fishing and hunting to guided fishing and hunting to commercial lease.

The lodge on Tsusena Lake is now used for private hunting, fishing and recreation. The High Lake lodge is leased to Acres American Incorporated for work on the Susitna Hydro project studies. In the past this has been a seasonal rather than a year-round operation.

The Stephan Lake lodge which is operated on a commercial basis as a base for guided hunting and fishing, is re- ported to have 10 structures. The current operator also maintains seven cabins which are used as outreach bases for hunting and fishing in the more remote areas. The Lodge offers full services, including guided hunting and fishing, and handles six to eight hunters and about 30 fishing recreationists each year (60).

The services for the most part are package deals. These include:

- Air transportation to and from the lodge and hunting grounds,

- Lodging during the hunt. The lodge itself is used and so are the cabins. When necessary, tent camps are set up if hunting is to be done in areas too far away from the lodge and the cabin locations.

- Guided hunting and fishing. For hunting, available species include bear, moose, and sheep. This particular operation does not provide guided hunting for caribou or goat.

Charges for the hunts vary with species hunted. A bear hunt will cost $5,000, a moose hunt $4,000, a combination hunt for moose and bear $7,500.

The impact of the proposed project on the lodge operators would be indirect and of the same nature as that on the guiding industry. Data collection is now in progress and interviews are planned to more definitively address this question.

(ii) Recreational

- The Hunter

Big game hunters in Alaska may be classified into three groups: Alaska residents who hunt for recreation; nonresidents, both U.S. citizens from other states and foreigners from other countries; researchers who for experimental purposes may from time to time remove limited numbers of game animals from the area. This group of users is neither recreational in nature nor commercial and for the most part represent rela- tively small removals. The following discussion therefore focuses on the first two groups.

Resident hunters hunt for trophy and meat; nonresidents and foreigners primarily for trophies.

- Resources

The big game resources which have been identified as having the potential to be impacted by the proposed project include caribou, moose, bears, sheep, wolf, and wolverine. The following section is devoted to describing the use patterns relating to these resources. At the present time some detailed information regarding caribou and moose is available and presented below. In depth analysis of the other species will be provided at a later date when more detailed statistics are received from other contractors to the Alaska Power Authority.

· Caribou

The Nelchina herd is highly migratory. It is known to have utilized the Nelchina Basin ranging from the Wrangell and Mentasta Mountains in the east through the Lake Louise flats to Talkeetna Mountains and Chunilna hills in the west. For purposes of discussing posible impacts of the Susitna Hydro project, available data on this herd as a whole will be treated as being relevant. However, special attention will be given at a later date to game management subunits 13A, 13B, 13E, 14A, 14B, 16A and 16B. Subunit 13E contains most of the proposed impoundment area while 13A and 13B are immediately neighboring to the area. Areas 14A, 14B, 16A and 16B are to the southwest, but nevertheless constitute areas which, in the past, have been used by the herd.

Resource Status

Population estimates over the past 20 years show that the herd numbers were greatest in the early 1960's. The 1962 population estimate was recorded at some 71,000 animals. The herd declined to a recorded low of 7,693 animals in 1972; since that time, the herd has partially recovered, although not to the resource status depicted in the early 1960's. Preliminary estimates showed a 1981 preharvest population of 20,730 caribou.

The Experience Sought by Hunters

Hunting for caribou provides both recreation and also food meat. The Nelchina herd is conveniently located near the largest population concentration in the state and has attracted proportionately greater participants from Anchorage, Fairbanks and the other population centers in the Southcentral region. Anchorage residents usually account for 50 percent or more of resident participants.

Transportation To and From Hunting Grounds

Access to the hunting areas is by various means. However, the three most frequently reported transport means are off-the-road vehicles (ORVs), a combination of highway and foot access, and air transportation. Available statistics for the period 1972-73 to 1980 show an evolution of access means preference. In the very early 1970's highway vehicles were the most frequently reported means of access closely followed by ORV transport with air transportation being a close third. Later, ORVs took over the lead and air transport followed. More recently, air transport has been most frequently reported while ORVs and highway vehicles follow.

Hunting Pressure

Hunting pressure on the Nelchina herd has historically been greater than that of recent years. By 1980 hunting pressure as measured by number of hunters had dropped to under 30 percent of the 1970-71 level. In 1980 an estimated 982, hunters compared to 3,710 in 1970-71, were involved in hunting for Nelchina caribou. The reduction is even greater because in many areas of game management unit 13 the bag limit is currently one caribou whereas in the early 1970's and before, some hunters took as many as three animals during each regulatory year.

Supply and Demand For Hunting Opportunity

There has been a widening gap between the supply of drawing permits issued and the total number of applicants for this hunting opportunity. As shown below the number of applicants for these permits doubled between 1978 and 1979 and and continued to grow during the following year while the number of available permits grew from 1,000 to 1,300 over the same period. Demand for hunting opportunity outstripped the supply by a factor of 3 to 1 in 1978 and 5 to 1 in 1980.

Caribou Permit Hunt In G.M.U.s 13 & 14

Year	No. Permits	Applicants	Harvest
1978	1,000	2,775	529
1979	1,300	5,600	630
1980	1,300	6,841	621

Controlled hunting pressure in the form of a limited number of hunters each year and a bag limit, have apparently helped the recovery of the resource while at the same time ensuring a steady success rate for individual hunters.

Success Rate

Success rate as measured by reported number of animals taken per participating hunter fluctuated rather widely during the period 1970-71 to 1980. In the 1970-71 season, when a total of some 3,710 hunters took 3,790 animals, the success rate was 1.02 animals per hunter. Yet as many as 1,415 hunters were unsuccessful that year. This apparent contradiction is explained by the fact that some hunters took as many as three animals each. In 1973, the rate dropped to 32 percent indicating one kill for every 3 hunters. Success, however, has improved and stayed above 60 percent since the institution of permit hunts in 1977 and was approximately 63 percent in 1980. The institution of permit hunts through limits on the number of hunters is at, least in part, responsible for stabilization of the success rates.

- Moose

For purposes of impact analysis, moose populations in the Susitna River Basin have been divided into two groups and studied as upstream and downstream moose. Big game studies conducted by ADF&G revealed that upstream moose are made up of some 13 subpopulations that conduct a significant amount of their year-round activities in and around the proposed impoundment area. They are associated with the numerous creeks and rivers that are tributaries and subtributaries of the Susitna River (61).

Downstream moose include those subpopulations that have their home ranges to the south of the proposed Devil Canyon dam site. They traverse areas to the north and south of Talkeetna utilizing both sides (east and west) of the Susitna. These areas constitute one of the most important wintering habitats for moose in the state (62).

Resource Status

A history of moose population estimates in the study area does not exist. During the fall of 1980, ADF&G sampled portions of the study area in game unit 13 and made a gross estimate of 4,027 animals as the population of upstream moose in parts of subunits 13A, 13B and 13E. There appears to be no population information for the whole of game unit 13, nor for 14 and 16. It is therefore difficult to state what the resource condition is now compared to what it may have been in the past.

Experience Sought

Moose are hunted for recreation and trophies as well as for meat. Most nonresidents take moose for antler trophies while residents take moose for meat in addition to the recreation activity involved.

Resident hunters who seek moose in game unit 13 are most frequently residents of Anchorage, Fairbanks, Palmer and Whittier. The rank order of participation in game unit 14 is Anchorage, Palmer, Wasilla, Whittier and others. Anchorage, Whittier, Fairbanks and Eagle River residents are prominent in moose hunting in game unit 16. In each case, Anchorage residents account for 50 percent or more of total participation.

Transportation To and From Hunting Grounds

The most frequently used transport means for moose hunters in game unit 13 are: highway vehicle, off-the-road vehicles, air transport and boat. The data, however, is derived from harvest ticket reports which allow for reporting of a combination of travel means. Frequently, these methods are used in combination with one another and with others such as snow machines. These statistics, however, can be viewed as indicators of the most popular transport means.

Hunting Pressure

Hunting pressure in terms of number of hunters participating in game unit 13 has varied over the past 12 years and so has the success rate. In 1971, 4,881 hunters participated to take a total of 1,814 moose for a success rate of 37 percent. The corresponding activity for 1981 was 2,859 hunters who experienced a success rate of 25.6 percent. Table E-5-42 contains hunting pressure and total harvest of moose in GMU 13 since 1970.

Success Rate

The reported success rate of hunters has fluctuated between 19 percent and 36 percent since 1972. The average success rate from 1972 through 1981 was 26.8 percent and ranged from a low of 19 percent in 1980 to a high of 36 percent in 1979. The 1981 success rate was, therefore, about average for the past 10 years. It is, however, in contrast to the rates depicted during the late 1960's, when success was generally above 30 percent. In 1960, the success rate approached 50 percent.

- Other species

  The other big game species found in the project area include black and brown bear, Dall sheep, wolf and wolverine. Currently efforts are being made to obtain detailed data for all big game species on total harvest, location, method of access, and residence of the hunters. Once acquired, these data will be used together with estimated impacts on individual species to assess the economic impacts on the recreational user.

- Importance of Regulations

  Current regulations and changes in these prompted by the Susitna project will determine the level of impact on the opportunity to hunt in the area. For some species, the regulations are already very strict compared to years past. In such cases, the project would cause little or no additional reduction in hunting oppotunity. In other cases, current regulations may have to be tightened further, thus leading to impacts on the hunter.

  Some idea of the current supply of hunting opportunity in the project area may be gained by examining the hunting regulations pertaining to GMU's 13, 14, and 16. For example, there are more opportunities to hunt for black bear than brown bear. This is reflected in the bag limit of three black bears each year compared to one brown bear every four years per hunter. Similarly, whereas there is no bag limit for wolf in GMU 13 nor for wolverine in GMU's 13 and 14, there are rather stringent rules on the hunting of caribou, moose, and Dall sheep for the 1982-83 hunting season. This pattern reflects both the condition of the resource and the regulatory philosophy. Thus the impacts of the project on the hunter will depend in part, on the changes in hunting regulations of individual species.

- Impacts on the hunter

  There are several factors that influence the number of hunters who will visit any given site. One of the most important is the quality of hunting to be expected at the site. As stated above, the regulatory regime governing the taking of game is also important. Both of these factors could be affected by changes in animal populations. Changes in animal populations directly affect the quality of hunting recreation while creating a need to alter hunting regulations to protect the resource. The impacts of the Susitna project on the hunter are therefore expected to stem from both regulatory limitations on participation and alterations in the quality of available sites. Work is continuing to develop methodology and obtain data that will facilitate quantification of economic effects of the project on the recreationist.

(iii) Subsistence Hunting

Subsistence users have the main goal of bringing home food meat. In the majority of cases, subsistence users are Alaska residents that qualify under certain criteria. In some cases and for some species and hunting areas, a nonresident who has an Alaska resident as a relative may qualify to hunt as a subsistence user. Qualifying as a resident subsistence user is based on specific standards such as:

- Long-term, consistent pattern of use
- Recurring seasonal use
- A use pattern involving methods related to local conditions.
- Accessibility and nearness of the resource

In addition, however, an application must be submitted stating that the applicant is at least 12 years of age, is of Alaska rural residence and lives in a household which obtains more than (usually) 50 percent of its fish and meat from other than commercial sources. Currently (October, 1982) subsistence use has priority over other uses with the provision that it shall not interfere with resource conservation efforts. For the 1982-83 season no nonresident will be allowed to qualify as a subsistence hunter for caribou in game units 13 and 14. It may be pointed out here that the question of subsistence use priority has been and will continue to be under review.

The extent of subsistence utilization of the resources in the project area will be investigated in the future as a first step in determining the likely impacts on the subsistence user.

(c) Furbearers

The major furbearer species in the impact area include lynx, beaver, mink, muskrat, pine marten, red fox, river otters, short-tail weasels (ermine) and least weasels. Wolves and wolverine are also often trapped for their fur, but for purposes of this study these species have been classified as game.

(i) Commercial Users

Trapping, and some hunting, of furbearers for the purpose of the sale of pelts is the major human use of these species. The commercial trapping of specific species increases and decreases in cycles, in accordance with the abundance of the species and, to some extent, the price of pelts.

Available data on the activity of trappers operating in the impact area and the size of harvests is of limited usefulness, due to several factors which are explained below. Thus, this section will focus on a general description of the trappers operating in the vicinity of the project and the economic value of the species they harvest.

- Data limitations

The impact area of the project as it relates to game and furbearers (see Chapter 3 - Fish, Wildlife, and Botanical Wildlife) crosses the boundaries of several Game Management Units, as defined by the Alaska Department of Fish and Game. Thus, it is difficult to relate estimates of harvests in particular game units with harvests in the impact area. Furthermore, it is difficult to determine harvests of furbearers within a particular game management unit from available statistics, due to the types of data collected and the difficulty of obtaining data by the origin of the fur.

Records are kept by the state on 1) trapper exports of furs, 2) dealer purchases of furs and 3) dealer exports. In addition, sealing reports, which include all pelts obtained from a particular locale, are compiled for three furbearer species: lynx, river otter and beaver. The basis for the first three types of records is the residence of individual trapper or dealer reporting, not the actual origin of the furs. In the case of Game Unit 13, many of the trappers who actually operate there are residents of other areas, such as Anchorage and the surrounding suburbs. In addition, export data is likely to underestimate actual harvests significantly, since a certain percentage of pelts are used in-state or sold to tourists in the form of garments and thus are not included in the statistics. Finally, it is believed that compliance of trappers to reporting procedures is not high.

Another severe data limitation which acts as a constraint to an analysis of the impacts of the project on trappers operating in the area is the lack of information on the population of furbearer species. Without information on population size, it is difficult to estimate the various interrelationships between species population, amount of habitat, harvest effort and harvest success.

- Trapping Activity

In general, it appears that there are not currently a large number of trappers operating in the areas in which furbearer populations are expected to be affected. This seems to be due to the relative inaccessibility of the area.

The 1980-1981 trapper questionnaire prepared by the Alaska Department of Fish and Game estimated that five individuals trapped in the Cantwell-Denali area and six trappers operated around Talkeetna-Petersville (this includes an area far larger than the impact area). Approximately 35 percent of the trappers responding to the overall survey (which included all game management units in the Southcentral Region) indicated that they had not trapped during the 1980-81 season and many of these indicated they had not done so because of the mild winter and lack of snow (63). Oral interviews with residents of the Local Impact Area as part of the land use portion of this study indicated that early trappers were also few in number but covered far more extensive areas in their trapping. In the 1940's and 1950's, many long-time trappers switched over to the more lucrative activity of guiding big game hunts (64).

Winter trapping currently is focused in areas near Stephan Lake, Tsusena Creek, and Clarence Lake. Trap lines average 25 miles in length, and are usually travelled by snowmobile. There are also some traps set by trappers working out of aircraft in the eastern portions of the Susitna valley. These have become economically feasible as result of the value of lynx, wolves, wolverine and other high-priced pelts.

- Aquatic Species

  - Baseline

  Beaver and muskrat are present in some lakes in the project area, with beaver being increasingly more abundant downstream from Devil Canyon. There is also a relatively large quantity of beaver along Deadman Creek, which is located near the proposed access road from the Denali highway to the Watana site.

The value of beaver pelts in 1982 were in the range of $10-$55. Muskrat pelts were valued at between $1.00 and $4.50 for pelts of animals that were trapped (65), and between $.50 and $2.00 for slight shot pelts (at breakup, muskrats are harvested by hunters shooting from boats). Historically, beaver and muskrat in alpine areas, such as the project sites, are seldom pursued by trappers due to the relative cost of obtaining the furs versus their market value. Exports of beaver pelts are not currently high, reflecting the relatively low price. It is believed that trapping of beavers downstream of Devil Canyon has not declined as much as exports. Often, trappers continue to operate but delay sale of the pelts until the price rises (66).

The meat of both muskrat and beaver is used as well as the fur. The meat is used for bait, for dog food, and for human consumption.

River otter and mink are common in areas of the upper basin of the Susitna, but trapping effort of these species has not been great. Mink are abundant near some lakes and streams and all major tributary creeks; otters are common in the Upper Susitna River basin. 1982 market prices per pelt ranged from $20.00 to $70.00 dollars for otter, and $10.00 to $50.00 for mink (65).

· Impacts of the Project

It is expected that trappers of aquatic furbearers will, on balance, benefit from the increased access to the Upper Susitna Basin which will result from the construction of the access road and transmission lines. From the perspective of economic impacts to commercial trappers, this increase in access is expected to more than compensate for the declines in furbearer populations that are expected to result from the destruction of habitat by the impoundments and borrow sites. Downstream of Devil Canyon, the improved habitat for beaver resulting from the alteration in stream flows can be expected to result in more profitable trapping by users.

- Pine Marten

  - Baseline

    Pine marten (sable) are abundant in the vicinity of the proposed impoundments and have been historically important to trappers. It is estimated that there are 150 pine marten present in the area to be flooded by the Watana impoundment and 55 in the Devil Canyon area. The value of marten from Southcentral and Interior Alaska in 1982 ranged from $10 to $50 per pelt (65).

  - Impacts

    The impacts of the project on the pine marten are expected to be of the greatest magnitude of all furbearers, due to this species' high dependence upon forested habitats along the Susitna River and its tributaries and the inundation of habitat of that type by the impoundments. In those areas, the harvest of marten by trappers could decline accordingly. It is expected that the increased access to areas supporting marten will be beneficial to trappers, to the extent that this access is allowed.

    The impacts of the project on the pine marten are expected to be of the greatest magnitude of all furbearers, due to this species' high dependence upon forested habitats along the Susitna River and its tributaries and the inundation of habitat of that type by the impoundments. It is expected that the harvest of marten by trappers would decline accordingly.

- Lynx

  Lynx have been scarce in Southcentral Alaska in recent years but there are indications that the population of this species will be increasing over the next couple of years. The population of lynx generally is prone to large fluctuations which are related to the size of the snowshoe hare population, a major food source. Lynx are very uncommon in the Upper Susitna Basin.

  The wholesale value of a lynx pelt in the spring of 1982 ranged from $100 to $500, depending upon the size and quality of the fur (65). It is believed this high value has induced additional trapping pressure of lynx in the region, and has increased the economic feasibility of running trap lines with aircraft (67).

Until 1980, there were prohibitions against the export of lynx pelts that were part of an international effort to preserve this species. No such controls currently exist. The present scarcity and high value of lynx in Southcentral Alaska may be resulting in an underreporting of the harvest of this species by trappers due both to concerns about future reinstatement of controls and to sensitivity regarding their current income.

- Fox

The fox population in the impact area has been low since the 1970's. Project research indicated that only one trapper operated in the Tyone-Susitna and Devil Canyon areas in 1979-1980, and that in 1980-1981 and 1981-1982 there were two and three trappers, respectively, seeking fox pelts. Very few fox were actually taken in each of these years. Thus, impacts of the project on trappers of fox will be minimal.

- Secondary Industries

There are several categories of businesses that are directly or indirectly affected by the fortunes of the trapping industry in Alaska. These include enterprises which sell equipment, clothing and food to trappers, individuals who build and/or lease cabins, tanning establishments, fur dealers, and garment manufacturers, among others Due to the relatively small percentage of Alaskan trappers who operate in the impact area, impacts of the project on these secondary industries are not expected to be significant.

(ii) Recreational

It is estimated that there are a large number of residents of the Local Impact Area who do some trapping on a part-time basis and keep the pelts for their own use or sell a few to supplement their income in the winter months. There are no data available on the size of this user group. Land use investigations of the project area showed that several recreational trappers work out of cabins along Clarence Lake, Deadman Lake, Portage Creek, Indian River and some other large lakes in the Upper Susitna basin (64).

4 - MITIGATION

This section uses a broad definition of mitigation that includes both the objectives of (1) decreasing the rate, magnitude and/or geographic distribution of a project-induced change, or avoiding a project-induced change that is perceived by a party(s)-at-interest to be costly, disruptive or both (negative change); and (2) enhancing a project-induced change that is perceived to be beneficial (positive change). Mitigation measures are to be developed and implemented only when the private sector (market mechanism), existing local and state government mechanisms, and social assimilation mechanisms (social service organizations, churches, etc.) do not have the capacity nor capability to adequately perform (1) and (2) above.

In addition, it is important to acknowledge that the labeling of a change as costly and/or disruptive, or beneficial, is a normative action and is typically done by recipients of change. Each individual within a community or other body will have his own opinion of the effect of a change, and the individual might change this opinion with the passage of time. Likewise, the community or other body could develop a label (an opinion regarding the positive or negative character of a change) by consensus or other means, and this label is also subject to change with time.

The approach utilized here is to examine recent attitudes toward changes in potentially impacted communities (parties-at-interest), and identify tools to decrease the rate, magnitude and/or geographic distribution of the negative project-induced changes, or avoid the negative project-induced changes. Opportunities to use selected tools to enhance positive project-induced changes are also identified.

This project has been designed with several major mitigation measures already in place, most notably housing and community facilities at the site, the scheduling of work and a flexible transportation program. However, no attempts are made to prescribe a complete set of specific mitigation measures.

During the next two years, several things will or could occur to make currently prescribed mitigation measures inappropriate. These are: (1) Attitudes toward changes might not be the same. Current residents' perceptions might change or new residents could move in and significantly influence the community consensus. With the rapid growth recently experienced by many of the potentially impacted communities, and the high probability of this trend continuing for several years, the need to base mitigation measures on future rather than current attitudes toward change is even greater; (2) Some information about project-induced changes has been made available to potentially impacted communities. Little of this information has b-een fully absorbed and reflected upon. Therefore, few citizens are really prepared to label the project-induced changes as negative or positive; and (3) Information about project-induced changes will improve as construction draws nearer. Residents need to make their judgements based on the best information available. Erroneous or incomplete information could lead residents to label project-induced changes improperly and this could lead to inappropriate mitigation measures.

The last element of the approach is to recommend the development and implementation of an impact management program. An impact management program includes impact assessment, monitoring and mitigation. It takes account of the time element and serves as a vehicle to help ensure that the most appropriate and cost-effective mitigation measures are implemented. It evaluates the performance of mitigation measures and makes adjustments to, or additions or deletions of measures where indicated.

This section is divided into three parts. The first part presents recent attitudes toward changes in potentially impacted communities; the second part presents alternative tools that could help bring project-induced changes into alignment with attitudes towards changes; and the third part is a discussion of an impact management program for this project. Selected reports and papers on mitigation measures that were reviewed are listed in the List of References at the end of this chapter (68 through 72).

4.1 - Attitudes Toward Changes

The public's recent responses to potential project-induced changes were mixed. Persons in Palmer, Wasilla, Houston, and Cantwell were generally in favor of the project-induced changes discussed in Sections 3.1 and 3.5. These cities and communities want more economic development (particularly jobs) and a more diversified and stable economic base. However, these indications should be taken as tentative because these persons probably had not fully absorbed the information made available to them when they expressed their views.

Persons in Cantwell were more guarded than the other communities in their general support for the potential project-induced changes. Several of these persons wanted more jobs for residents of Cantwell and more sales for local businesses, but were concerned about project-induced traffic, price increases for goods, services, housing and land, needs for additional education facilities and services, and impacts on the environment. Ahtna, Inc. (a Regional Native corporation) has indicated that it is willing to lease or sell land in and near Cantwell if it is in its economic interest.

Residents of Trapper Creek and Talkeetna have indicated that rapid and uncontrolled change is not desired. Some of the residents of each community would like no changes and others in each community would like to have controlled economic development. Those in favor of controlled development want to proceed with caution and learn more about what could happen to their communities as a result of the project before committing to a growth plan. Additional information regarding small communities' attitudes toward changes is provided in Stephen R. Braund & Associates, 1982.

Project-induced changes in Anchorage and Fairbanks are expected to be slight. Residents of these cities attitudes toward change are, therefore, not relevant here.

4.2 - Mitigation Alternatives

The goal of mitigation is to bring project-induced changes into alignment with attitudes toward change, subject to cost constraints and after the existing capacities and capabilities of the private sector, local and government mechanisms, and social assimilation mechanisms have been evaluated.

Two categories of mitigation tools will be considered. The first category contains mitigation tools that significantly influence the magnitude and geographic distribution of project-induced changes. The second category contains tools that help communities or other bodies cope with residual disruptions and budget deficits. Only if the private sector, local and state government mechanisms, and social assimilation mechanisms cannot adequately reduce project--induced disruptions and costs should the second category of mitigation tools be considered. Each of these categories is discussed below.

(a) Tools That Influence the Magnitude and Geographic Distribution of Project-Induced Changes

Project schedule, work schedule, housing and related facilities at construction and other sites, and a transportation program for workers can be specified to produce different magnitudes and geographic distributions of project-induced changes. Each specification will produce unique magnitudes and geographic distributions. Associated with each specification will be a set of costs that will be borne by the Alaska Power Authority through the Contractor (for example, costs of constructing and operating housing and related facilities at the construction sites), and a set of costs that could be borne by the Alaska Power Authority. This latter set of costs includes the cost of reducing disruptions and budget deficits in communities where the private sector, local and state government mechanisms and social organizations would not have the capacity nor the capability to reduce disruptions or budget deficits to acceptable levels. It will be desirable to select a specification that minimizes the sum of the first and second sets of costs.

It is difficult to identify and quantify all of these costs, especially some of the implicit costs in the second set. Some costs, such as disrupting or permanently changing individuals' ways of life, are not readily quantified. Because of this inherent problem, the following discussion and partial specification of mitigation tools is to be regarded as an approximation for minimizing the sum of the first and second sets of costs. One task of the Impact Management Program discussed below will be to refine this specification.

The project schedule can be used as a tool to smooth out work force peaks and to lengthen the construction period of the project. Both of these actions have tended to reduce magnitudes and rates of project-induced changes in nearby communities impacted by other large projects. Although the schedule for this project is rather inflexible, it will be considered as a mitigation tool where possible .

The work schedule can be used to influence the frequency of workers commuting or traveling to and from the construction site. A schedule that includes frequent periods of one or more days off encourages workers to relocate temporarily or permanently near the construction site. This will be avoided for this project. The four week on, one week off schedule that is planned for this project appears to be appropriate (that is, it will help bring project-induced changes in nearby communities into alignment with these communities attitudes' toward change).

The availability, type and quality of housing and related facilities has a tremendous influence on where workers' residences are located. It has been observed in other projects that if adequate housing and related facilities are available at the construction site of a rurally/remotely located project, and that if the work schedule is appropriate, workers will tend to maintain their existing residences. This has the effect of minimizing settlement by workers in communities near the construction sites.

This project plans to provide single status accommodations for most workers and family accommodations and related facilties for some workers at the construction sites. These arrangements, together with the planned work schedule, will serve to minimize settlement of workers in nearby communities. This will help bring project-induced changes in nearby communities into alignment with these communities attitudes toward change.

A transportation program for workers can influence both the geographic distribution and magnitude of project-induced changes. In general, the project schedule, work schedule, and housing and related facilities generally tend to have a much larger influence than does the transportation program. This would not be true, however, if most workers traveled by organized air transportation.

For this project, there will be no daily commuting due to the distances involved and workers will not have the opportunity to drive personal vehicles to the camp/village or construction site. For these and other reasons, a multi-mode and flexible transportation program will best serve the interests of the communities and the workers. A program that includes a combination of private and organized ground (bus and, possibly, van) transportation will allow those workers living in communities along the Parks Highway, including the cities of Fairbanks and Anchorage, to more easily access the construction sites. Workers could be encouraged through incentives to use organized transportation; it has been observed on other projects that more local workers are hired and that workers are less tired, more alert and punctual, and miss fewer work hours and days if organized transportation is used. This will be particularly true for this project because buses can cope better with the weather than most private (personal) vehicles and reduced traffic will result in fewer accidents.

The ground transportation can be structured to influence the geographic distribution of project-induced changes. The configuration and location of park-and-ride lots as well as bus stops are key variables. These will be considered in the mitigation plan.

Organized air service will also influence the geographic distribution and magnitude of project-induced changes. Air transportation from Anchorage and Fairbanks will encourage workers who want to relocate to settle near or in these cities. These cities are the most able cities in Alaska to absorb population influxes. Anchorage is currently experiencing an influx of about 1000 persons per month. It is projected that a total of approximately about 1000 persons will relocate to Anchorage during 1985 -1990 as result of this project.

Research to date indicates that air service should be limited to a portion of the work force. Some level of air service (to be determined) will help bring project-induced changes into alignment with communities' attitudes toward changes. Air service levels should be flexible because it might be desirable to change the limitations if projectinduced changes do not occur as anticipated. For example, during the peak construction years, it might be appropriate to consider changing the air service limitations if the projectinduced changes become inconsistent with the communities' attitudes towards changes. This could occur if traffic and, perhaps, settlement becomes too great during the peak periods. The air service will route workers, particularly workers that arrive from out of the region and do not want to settle temporarily or permanently in the region, away from the smaller communities.

Further research must be done before organized air and/or ground transportation programs are decided upon. Key areas for research include issues such as: recruitment and competition for workers; state or other regulations; union and worker demands; and potential employee problems. These areas of research will be included in later studies.

In summary, the Alaska Power Authority, through the current work schedule, housing and related facilities plans at the construction sites, and flexible transportation program, a number of potentially negative projectinduced changes in the local communities have already been avoided or partially reduced. Specifications for these mitigation tools will be further refined in the Impact Management Program (see Section c).

(b) Tools That Help Communities and Other Bodies Cope With Disruptions and Budget Deficits

Given that the mitigation tools discussed above have been considered and designed for implementation, as appropriate, it is then time to: (1) evaluate whether the private sector, local and state government mechanisms, and social assimilation mechanisms can adequately reduce any remaining disruptions and budget deficits; (2) consider mitigation tools that can be used to further reduce project-induced changes that are not adequately reduced: and (3) consider mitigation tools that will enhance positive project-induced changes.

The approach to considering mitigation tools and designing and implementing mitigation measures will be systematic. Once it is determined that the private sector, local and state government mechanisms and social assimilation mechanisms are not likely to have the capacity nor capability of providing for sufficient reduction of disruptions and costs, mitigation tools will be identified and mitigation measures will be developed. These tools and measures will be site-specific and the probable effects of each measure will be estimated. The cost of implementing each measure will be estimated and each measure will be evaluated for cost-effectiveness. This process will allow the Authority to select from a "menu" of mitigation measures, with knowledge of the probable effects and costs of the selected measures.

There are several means by which the private sector, local and state governments, social service organizations and, if appropriate, the Contractor/Alaska Power Authority can reduce disruptions and budget deficits. These include: subdivision development; temporary off-site housing; house financing; provision of additional community facilities and/or services; community planning; and project-community communication. Within each of these categories, technical and/or financial assistance can be provided. Each category is discussed briefly below.

- Subdivision developments can be located in or near a community that is likely to receive unwanted project-induced changes. The development can accommodate a few or many families and include few or many facilities and services. The extent of the Power Authority's/Contractor's involvement could be a direct payment, a subsidized or unsubsidized loan, front end financing, lot clearing and/or development, development planning assistance, etc. This tool should not be considered by the Contractor/Power Authority unless other entities do not come forth or unless other tools are inadequate.

- Temporary housing can be located in or near a community that is likely to receive unwanted project-induced changes. This type of development is less substantial than a subdivision development: it typically has pads or hookups for recreational vehicles or trailers, and sewer, water, laundry, shower, or recreational facilities might be available. Since this type of development is not suitable for families, and because it would work at cross purposes to the work camp, it will not be considered by the Power Authority/Contractor as a mitigation tool.

- House financing assistance could be provided to stimulate developers or to assist relocating employees. It is recommended that the Authority/Contractor not use this tool because it will tend to encourage rather than discourage relocation by workers. One exception to this might be at Cantwell. If the Contractor does not provide family housing to senior railhead construction workers and there is a shortage of housing in Cantwell, this tool could be considered.

- Additional community facilities and/or services could be provided or financed by the local or state government, or the Power Authority/Contractor in areas where there are temporary or permanent shortages or budget deficits caused by in--migrating construction workers and their dependents. This assistance could be relevant for Cantwell and to a lesser extent the smaller communities of the Mat-Su Borough, if support is not sufficient through existing government mechanisms. It should be noted that the majority of revenues used for community facilities and services in communities in the Local Impact Area currently are derived directly or indirectly from the state.

- At the request of communities, limited community planning assistance could be provided by government agencies and/or the Authority/Contractor to communities lacking planning bodies and those with small or newly created planning bodies. This assistance could include mitigation planning as well as helping to coordinate mitigation planning and overall planning.

- Communication among the Alaska Power Authority/Contractor, local and state agencies, and impacted communities through a public participation program and other means is a necessity. Information about anticipated project-induced changes must be communicated to communities in a timely manner and community attitudes toward these changes must be communicated back to the Contractor in a timely manner. Timing is important because the goal of the mitigation program will be to anticipate and pre scribe mitigation measures in advance of the predicted impacts rather than to react to impacts. Communication between entities is discussed further in the presentation of the Impact Management Program below.

- Social impacts of the project will be monitored closely. If it appears that the rapid growth of the communities most affected by the project is resulting in an increase in social problems and that existing social assimilation mechanisms such as community groups and human service organizations are not adequate, the Alaska Power Authority/Contractor will consider providing assistance. Forms that this assistance could take are partial funding of a counselling clinic or community school coordinator position in communities like Cantwell and Trapper Creek. These communities do not have human service organizations available at present and it might be desirable to provide for more community development through the efforts of a coomunity schoool coordinator.

- To influence the geographic distribution of worker settlement, incentives could be provided to influence workers' settlement decisions. These include various types of land acquisition and housing subsidies. Some examples are: preparing lots for or providing recreational vehicle, trailer or mobile home pads; guaranteeing occupancy rates for local motel, lodge, or mobile home/trailer park owners; and helping to finance housing developments. To be effective at altering the geographic distribution of project-induced changes, careful consideration must be given to where and under what conditions these subsidies would be available. These types of incentives will be considered at a later time if other mitigation tools do not result in a desirable geographic distribution of project-induced changes.

- A tool for enhancing positive project-induced changes is to actively encourage through incentives the hire of residents in locally impacted communities and, more generally, Alaska. Ways to increase employment of local labor will be investigated.

There are at least a couple of reasons to believe that local labor might have a difficult time obtaining construction jobs. One reason is that Alaska law currently states that 95% of the work force must be Alaska residents. Eligibilitiy requirements for residency are such that newcomers to Alaska do not have difficulty meeting the resident requirement. If this continues, it will tend to make it more difficult for local labor to obtain employment on the project.

A second deterrent to the hire of labor from the communities most impacted by the project is related to the fact that a substantial amount of union labor will be used for the project. Local workers who do not belong to unions will have a more dif ficult time trying to obtain employment on the project, and in many of the small communities near the dam sites, fewer potential workers belong to unions than in the larger metropolitan areas.

4.3 - Impact Management Program

The goal of the impact management progam is to ensure that impacted communities or other bodies adequately handle project-induced changes. The challenge in meeting this goal lies in (1) creating and maintaining a balance between the capacity of the community or other body to handle project-induced changes, and the combined capabilities of the market mechanism (private sector), local and state government mechanisms, and social assimilation mechanisms to handle these changes; (2) identifying appropriate mitigation tools and designing and implementing cost-effective mitigation measures to achieve the balance if the balance is not obtained in (1); and (3) anticipating and responding to project-induced imbalances in a positive and timely manner.

For example, it is probable that there will be an imbalance will be created in Cantwell in 1985. There could be a shortage of education services and housing. One of the first tasks of this Program will be to address such potential imbalances and to consider and select ways to avoid or ameliorate them.

To help create the balance through existing mechanisms the Authority/Contractor will have to work closely with the communities, the private sector, government institutions such as the Alaska Department of Community and Regional Affairs, and human service organizations. Where an appropriate balance cannot be created and/or maintained through existing mechanisms, the Authority/Contractor will systematically develop and implement the most cost-effective mitigation measures possible.

For this project, the socioeconomic impact management program will be composed of the following elements:

1. A continued update and a possible expansion of the socioeconomic forecasts to ensure that the Base Case is adequately defined so that projectinduced changes can be more accurately predicted prior to the start of the construction. This will include monitoring of state and local economic and social indicators. If substantial uncertainty exists in key assumptions or perameters, a multiple scenario model will be considered.

2. A continued monitoring and surveying of the construction work force to enable the contractor to identify, assess and handle problems that may arise. This monitoring program will also assist in separating project-induced changes from other changes.

3. A program will be created to develop, implement and evaluate mitigation strategies, plans, and measures. The mitigation tools discussed above would be considered in the mitigation strategizing and planning processes. It is anticipated that representatives from impacted communities, the Power Authority and the Contractor should participate in the creation and implementation of this program.

4. The Power Authority should develop, with the assistance of the Contractor, a public participation program. The purpose of this program would be to communicate forecasted project-induced changes to parties-at-interest (communities and other bodies) and to communicate communities' attitudes towards these changes back to the Contractor. It would also be used to assist with the developement and evaluation of mitigation strategies, plans, and measures.

In summary, the impact management program includes impact assessment, public participation, and impact mitigation and monitoring. It is anticipatory rather than reactionary and provides the best available means for aligning project-induced changes with the community's or other body's attitudes toward change. This is accomplished by creating and maintaining a balance between the capacity of the community or other body to handle project-induced changes, and the combined capabilities of the market mechanism, local and state government mechanisms, and social assimilation mechanisms to handle these changes. The Authority/Contractor will first work through existing mechanisms to mitigate project-induced changes. Where this effort is considered to be inadequate, the Authority/Contractor will review and select cost-effective mitigation measures.

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TABLE E.5.1

MATANUSKA-SUSITNA BOROUGH ANNUAL NONAGRICULTURAL EMPLOYMENT BY SECTOR

<table>
<tr><th></th><th colspan="6"></th><th colspan="3">PERCENT OF REGIONAL IMPACT AREA</th></tr>
<tr><th></th><th colspan="2">1970</th><th colspan="2">1975</th><th colspan="2">1979</th><th>1970</th><th>1975</th><th>1979</th></tr>
<tr><th></th><th>Total</th><th>%</th><th>Total</th><th>%</th><th>Total</th><th>%</th><th>%</th><th>%</th><th>%</th></tr>
<tr><td>TOTAL[(a)] - Nonagricultural Industries</td><td>1,145</td><td>100.0</td><td>2,020</td><td>100.0</td><td>3,078</td><td>100.0</td><td>1.8</td><td>1.8</td><td>2.7</td></tr>
<tr><td>Mining</td><td>*</td><td>-</td><td>*</td><td>-</td><td>11</td><td>.3</td><td>*</td><td>*</td><td>.0</td></tr>
<tr><td>Construction</td><td>120</td><td>10.5</td><td>188</td><td>9.3</td><td>184</td><td>6.0</td><td>2.3</td><td>1.1</td><td>2.2</td></tr>
<tr><td>Manufacturing</td><td>*</td><td>-</td><td>30</td><td>1.5</td><td>40</td><td>1.3</td><td>*</td><td>1.2</td><td>1.1</td></tr>
<tr><td>Transportation - Communication & Utilities</td><td>114</td><td>9.6</td><td>218</td><td>10.8</td><td>316</td><td>10.2</td><td>1.9</td><td>1.8</td><td>2.6</td></tr>
<tr><td>Wholesale Trade</td><td rowspan="2">174</td><td rowspan="2">15.2</td><td>44</td><td>2.2</td><td>49</td><td>1.6</td><td rowspan="2">1.4</td><td>.8</td><td>1.0</td></tr>
<tr><td>Retail Trade</td><td>271</td><td>13.4</td><td>696</td><td>22.6</td><td>1.7</td><td>3.8</td></tr>
<tr><td>Finance-Insurance and Real Estate</td><td>22</td><td>1.9</td><td>62</td><td>3.1</td><td>129</td><td>4.2</td><td>.8</td><td>1.3</td><td>2.1</td></tr>
<tr><td>Services</td><td>179</td><td>15.6</td><td>288</td><td>14.3</td><td>447</td><td>14.5</td><td>2.0</td><td>1.4</td><td>2.3</td></tr>
<tr><td>Federal Government</td><td>106</td><td>9.3</td><td>124</td><td>6.1</td><td>97</td><td>3.1</td><td>.9</td><td>1.0</td><td>.8</td></tr>
<tr><td>State and Local Government</td><td>376</td><td>32.8</td><td>758</td><td>37.5</td><td>1,101</td><td>35.8</td><td>3.2</td><td>4.3</td><td>5.2</td></tr>
<tr><td>Miscellaneous</td><td>*</td><td>-</td><td>*</td><td>-</td><td>21</td><td>.7</td><td>*</td><td>*</td><td>1.8</td></tr>
</table>

* Data unavailable due to disclosure policy.

(a)Figures may not total correctly because of averaging and disclosure limitations on data.

Source: Alaska Department of Labor. Statistical Quarterly. Juneau, AK. (various issues)

TABLE E.5.2 - COMMUNITY POPULATION: MATANUSKA-SUSITNA BOROUGH, 1939, 1950, 1960, 1970, 1976, 1980, 1981

Community	1939	1950	1960	1970	1976[a]	1980[b]	1981[a]
Talkeetna	136	106	76	182	328	265	640
Willow	N.A.[c]	N.A.	78	38	(323)	134	N.A.
Wasilla	96	97	112	300	1566	1548	2168
Palmer	150	890	1181	1140	1643	2143	2567
Montana	N.A.	N.A.	39	33	76	40	N.A.
Big Lake	N.A.	N.A.	74	36	721	412	2408
Chickaloon	N.A.	N.A.	43	22	62	20	N.A.
Eska Sutton	14	54	215	89	496	N.A	N.A.
Houston	N.A.	N.A.	N.A.	69	375	325	600

COMMUNITY POPULATION: OTHER COMMUNITIES NOT IN MATANUSKA-SUSITNA BOROUGH

Community	1950	1960	1970	1976	1980[b]	1982[d]
Nenana	242	286	382	493	471	N.A.
Healy	N.A.	N.A.	79	503	333	N.A.
Cantwell	N.A.	85	62	N.A.	182	183
Paxson	N.A.	N.A.	20	N.A.	30	N.A.
Glennallen	142	169	363	N.A.	488	N.A.
Copper Center	90	151	206	N.A.	213	N.A.
Gakona	50	33	88	N.A.	85	N.A.
Gulkana	65	51	53	N.A.	111	N.A.

(a) Mat-Su Borough Survey. The methodology for these surveys differs from U.S. Census data and hence the 1976 and 1981 figures are not comparable to Census data.

(b) Alaska Department of Labor, Administrative Services Division. January 1, 1981. Alaska 1980 Population: A Preliminary Overview. Juneau, AK.

(c) N.A. = Not Available.

(d) Community Census, September 1982.

Source: For all other data, U.S. Department of Commerce, Bureau of the Census.

TABLE E.5.3 - PER CAPITA PERSONAL INCOME IN THE MAT-SU BOROUGH IN CURRENT AND 1970 DOLLARS

Year	Per Capita Personal Income: Current Dollars	Per Capita Personal Income: In 1970 Dollars[(a)]
1970	3,957	3,957
1971	4,279	4,150
1972	4,539	4,286
1973	4,970	4,526
1974	6,068	5,011
1975	8,092	5,855
1976	8,542	5,718
1977	9,032	5,666
1978	8,939	5,231
1979	8,878	4,704

(a) Discounted using the Anchorage Consumer Price Index - Urban (CPI-U) as a measure of inflation.

Source: U.S. Department of Commerce, Bureau of Economic Analysis.

TABLE E.5.4 - HOUSING STOCK ESTIMATES AND VACANCY RATES IN THE LOCAL IMPACT AREA

Area	Number of Units	Percent of Total	Vacancy Rate
Talkeetna	196	2.3	1.0%
Houston	229	2.7	9.6
Big Lake Special Area	1,750	20.4	49.9
Wasilla	718	8.4	6.7
Suburban[a]	3,801	44.3	6.8
Palmer	872	10.2	10.2
Other Areas in Mat-Su[b]	1,016	11.8	52.8
Cantwell	96	1.1	28.1
Total Local Impact Area	8,678	100.0	20.7

(a) Includes an area that is outside of Palmer and Wasilla's city limits and extends west to Houston and east to Sutton.

(b) Includes an estimated 69 housing units in Trapper Creek.

Sources: Matanuska-Susitna Borough Planning Department, Population and Housing Survey, October 1981; and Cantwell Population and Housing Census, September, 1982.

TABLE E.5.5

COMMUNITY FACILITIES SUMMARY

	Schools			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	Government				
	Elementary	Secondary	Higher																							Home Rule	First Class	Second Class	Unincorporated	Unified Home Rule
Nenana	*	*		*	*	*	*			*	*				*	*		*		*	*	*	*	*	*		*			
Cantwell	*	*				*	*								*	*		*		*	*			*	*				*	
Trapper Creek	*					*	*								*						*		*	*	*				*	
Talkeetna	*					*				*					*	*		*	*	*	*	*	*	*	*				*	
Willow	*					*									*	*		*	*	*	*		*	*	*				*	
Houston						*				*					*	*							*	*	*			*		
Palmer	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*				
Wasilla	*	*	*	*		*				*	*		*		*	*		*	*	*	*	*	*	*	*			*		
Paxson						*									*			*					*	*	*				*	
Glennallen	*	*				*	*		*	*	*	*		*	*			*	*	*	*		*	*	*				*	
Copper Center	*		*			*				*	*				*			*		*	*		*	*	*				*	
Gakona						*									*			*		*	*		*	*	*				*	
Healy	*	*		*	*	*	*				*				*	*		*			*		*	*	*				*	
Gulkana				*	*	*					*				*					*			*	*	*				*	
Valdez	*	*		*	*	*	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*	*				
Anchorage	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*					*
Fairbanks	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				

TABLE E.5.6

CHARACTERISTICS OF PUBLIC SCHOOLS:
MATANUSKA-SUSITNA SCHOOL DISTRICT
1981

School	School Type	School Grade	Capacity	Enrollment	Condition/ Plans for Expansion
Big Lake	E	1-6	350	177	No plans.
Butte	E	1-6	500	300	No plans.
Glacier View	E/J	1-8	60	50	Currently consists of portables. Plan to build two classrooms.
Iditarod	E	Pre-6	550	460	Recently burned down. Plan to have back in operation by 1/82.
Sherrod	E	Pre, 3-6	450	454	No plans.
Skwentna	E/J/S	4-12	15	16	No plans.
Snowshoe	E	1-6	500	409	New facility.
Swanson	E	1,2	350	231	No plans.
Talkeetna	E	1-6	120	65	No plans.
Trappers Creek	E	1-6	30	40	Presently four portable facilities Have submitted a grant proposal for facility consisting of 4 class rooms and a gym/multipurpose room.

TABLE E.5.6
(cont.)

School	School Type	School Grade	Capacity	Enrollment	Condition/ Plans for Expansion
Wasilla Elem.	E	1	120	90	Very old facility with half of building condemned. Have plans for a new facility in 1984.
Willow Elem.	E	1-6	91	96	Expansion considered in the five year building plan.
Palmer	J	7-8	500	332	No plans.
Wasilla	J	7-8	600	353	Recently completed addition to facility.
Palmer	S	9-12	900	619	No plans.
Susitna Valley	J/S	7-12	180	122	Plans for additions for the band and vocational studies.
Wasilla	S	9-12	1,200	715	Recently completed addition to the facility.
Matanuska-Susitan Community College	CC	N/A	N/A	1,500	N/A

E = Elementary; J = Junior; S = Senior; CC = Community College

Source: Matamuska-Susitna Borough School District.

TABLE E.5.7 - REGIONAL NONAGRICULTURAL EMPLOYMENT

	1970 Total	1970 %	1975 Total	1975 %	1979 Total	1979 %	PERCENT OF STATE 1970 %	PERCENT OF STATE 1975 %	PERCENT OF STATE 1979 %
TOTAL[1] - Nonagricultural Industries	62,690	100.0	113,818	100.0	113,204	100.0	67.8	70.4	68.0
Mining	1,610	2.6	2,243	2.0	2,822	2.5	53.7	59.2	48.9
Construction	5,264	8.4	16,359	14.4	8,257	7.3	76.3	63.6	81.8
Manufacturing	1,850	3.0	2,596	2.3	3,705	3.3	23.7	26.9	28.9
Transportation - Communication & Utilities	6,021	9.6	12,094	10.6	12,062	10.7	66.2	73.4	72.2
Wholesale Trade	12,111	19.3	5,366	4.7	5,083	4.5	79.2	90.8	92.2
Retail Trade			15,965	14.0	18,309	16.2		78.6	76.7
Finance-Insurance and Real Estate	2,520	4.0	4,696	4.1	6,139	5.4	81.3	77.9	76.4
Services	8,868	14.1	20,995	18.4	19,674	17.4	77.8	83.5	69.4
Federal Government	12,372	19.7	13,022	11.4	12,728	11.2	72.4	71.2	71.0
State and Local Government	11,585	18.5	17,799	15.6	21,130	18.7	62.6	60.9	57.7
Miscellaneous	52	.1	217	.2	712	.6	26	19.0	98.9

[1] Sums of individual entries may not equal totals due to averaging and disclosure limitations on data.

Source: Alaska Department of Labor. Statistical Quarterly. Juneau, AK. (various issues)

TABLE E.5.8

1981 CIVILIAN HOUSING STOCK IN THE MUNICIPALITY OF ANCHORAGE, BY TYPE

Type of Unit	Number of Units	Percent of Total
Single Family	30,097	45.8
Duplex	6,040	9.2
3-4 Units	6,211	9.4
5-19 Units	9,356	14.2
20+ Units	6,036	9.2
Mobile Homes	8,031	12.2
In Parks	6,146	9.3
On Lots	1,885	2.9
Total	65,771	100.0

Source: Municipality of Anchorage Planning Department.

TABLE E.5.9

HOUSING STOCK IN FAIRBANKS
AND THE FAIRBANKS-NORTH STAR BOROUGH, BY TYPE,
OCTOBER 1978

	Fairbanks-North Star Borough	Municipality of Fairbanks
Single Family	6,849	3,312
Duplex	960	714
Multifamily	3,832	3,187
Mobile Homes	2,097	138
Total	13,738	7,351

Source: Fairbanks North Star Borough Community Information Center. Community Information Quarterly: Summer 1980. Volume III, Number 2. p. 70.

TABLE E.5.10

STATE ANNUAL NONAGRICULTURAL EMPLOYMENT BY SECTOR

	1970		1975		1979	
	Total	%	Total	%	Total	%
TOTAL[1] - Nonagricultural Industries	92,400	100.0	161,689	100.0	166,406	100.0
Mining	3,000	3.2	3,790	2.3	5,773	3.5
Construction	6,900	7.5	25,735	15.9	10,092	6.1
Manufacturing	7,800	8.4	9,639	6.0	12,818	7.7
Transportation - Communication & Utilities	9,100	9.8	16,473	10.2	16,704	10.0
Wholesale Trade	3,200	3.5	5,908	3.7	5,511	3.3
Retail Trade	12,100	13.1	20,300	12.6	23,877	14.3
Finance-Insurance and Real Estate	3,100	3.3	6,030	3.7	8,035	4.8
Services	11,400	12.3	25,136	15.5	28,345	17.0
Federal Government	17,100	18.5	18,288	11.3	17,915	10.8
State and Local Government	18,500	20.0	29,247	18.1	36,617	22.0
Miscellaneous	200	.2	1,143	.7	720	.4

[1] Figures may not total correctly because of averaging.

Source: Alaska Department of Labor. Statistical Quarterly. Juneau, AK. (various issues)

TABLE E.5.11: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON MATANUSKA-SUSITNA BOROUGH

	Present Conditions		Watana Construction Peak				Devil Canyon Peak			
Socioeconomic Variable	1981 Capacity	1981 Amount/ Usage	1990 Baseline Forecast	1990 Forecast with Project	Impact of Project	Percent Increase Over Baseline Forecast	1999 Baseline Forecast	1999 Forecast With Project	Impact of Project	Percent Increase Over Baseline Forecast
Population	N.A.	22,285	42,964	44,076[a]	1,112[a]	2.6[a]	66,338	67,204[a]	866[a]	1.3[a]
Employment[b]	N.A.	4,002	6,914	10,842	3,928	56.8	9,505	11,554	2,049	21.6
Housing Demand (no. of units)	8,582	6,810	14,417	14,791	374	2.6	24,670	24,992	322	1.3
Water (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Solid Waste Disposal (acres per year)	617	2.5	6.7	6.9	0.2	2.5	13.6	13.8	0.2	1.3
Sewage Treatment (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Police	20	20	38	42	4	10.5	60	62	2	3.3
Education (primary students)	3,136	2,388	5,406	5,565	159	2.9	8,884	9,011	127	1.4
(secondary students)	3,380	2,141	4,605	4,738	133	2.9	7,568	7,674	106	1.4
Hospital Beds	23	20	60	61	1	1.7	109	110	1	0.9
Community[c] Parks (acres)	0	-	80	82	2	2.4	133	135	2	1.5

N.A. - Not Applicable

(a) Population increase refers to population influx in Mat-Su Borough communities, and does not include population residing only at work camp/village.
(b) By place of employment.
(c) Community parks generally contain facilities such as tennis courts, ball diamonds, play apparatus, basketball courts, nature walks, and swimming pools.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.12: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON THE CITY OF PALMER

Socioeconomic Variable	Present Conditions: 1981 Capacity	Present Conditions: 1981 Amount/Usage	Watana Construction Peak: 1990 Baseline Forecast	Watana Construction Peak: 1990 Forecast with Project	Watana Construction Peak: Impact of Project	Watana Construction Peak: Percent Increase Over Baseline Forecast	Devil Canyon Peak: 1999 Baseline Forecast	Devil Canyon Peak: 1999 Forecast With Project	Devil Canyon Peak: Impact of Project	Devil Canyon Peak: Percent Increase Over Baseline Forecast
Population	N.A.	2,567	4,525	4,567	42	0.9	6,167	6,200	33	0.5
Employment[a]	N.A.	-[b]	-[b]	-[b]	27	-[b]	-[b]	-[b]	13	-[b]
Housing Demand (no. of units)	872	783	1,551	1,563	12	0.8	2,299	2,311	12	0.5
Water (gallons per day)	1,368,000	300,000	608,000	614,000	6,000	1.0	918,000	923,000	5,000	0.5
Sewage Treatment (gallons per day)	500,000	300,000	543,000	548,000	5,000	0.9	740,000	744,000	4,000	0.5
Police	8	8	8	8	0	0	9	9	0	0.0
Education (primary students)	800[c]	685[c]	569	580	11	1.9	826	830	4	0.5
(secondary students)	1,400[c]	951[c]	485	490	5	1.0	704	708	4	0.6
Hospital Beds	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

N.A. - Not Applicable
(a) By place of employment
(b) Data not available
(c) School service areas do not correspond exactly to city limits. 1981 enrollment may include a service area that extends beyond city boundaries, whereas projections for 1990 and 1999 refer only to school children living in Palmer

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.13: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON WASILLA

Socioeconomic Variable	Present Conditions: 1981 Capacity	Present Conditions: 1981 Amount/ Usage	Watana Construction Peak: 1990 Baseline Forecast	Watana Construction Peak: 1990 Forecast with Project	Watana Construction Peak: Impact of Project	Watana Construction Peak: Percent Increase Over Baseline Forecast	Devil Canyon Peak: 1999 Baseline Forecast	Devil Canyon Peak: 1999 Forecast With Project	Devil Canyon Peak: Impact of Project	Devil Canyon Peak: Percent Increase Over Baseline Forecast
Population	N.A.	2,168	4,157	4,207	50	1.2	7,969	8,010	41	0.5
Employment[(a)]	N.A.	-[(b)]	-[(b)]	-[(b)]	-[(b)]	-[(b)]	-[(b)]	-[(b)]	13	-[(b)]
Housing Demand (no. of units)	718	670	1,404	1,421	17	1.2	2,965	2,980	15	0.5
Water (gallons per day)	864,000	-[(b)]	559,000	565,000	6,000	1.1	1,186,000	1,192,000	6,000	0.5
Sewage Treatment (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Police	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Education (primary st	1,170	959[(c)]	523	530	7	1.3	1,067	1,073	6	0.6
(secondary students)	1,800-[(c)]	1,068-[(c)]	446	452	6	1.3	909	914	5	0.6
Hospital Beds	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

N.A. - Not Applicable
(a) By place of employment
(b) Data not available
(c) School service areas do not correspond exactly to city limits. 1981 enrollment may include a service area that extends beyond city boundaries, whereas projections for 1990 and 1999 refer only to school children living in Wasilla.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.14: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON HOUSTON

	Present Conditions		Watana Construction Peak				Devil Canyon Peak			
Socioeconomic Variable	1981 Capacity	1981 Amount/ Usage	1990 Baseline Forecast	1990 Forecast with Project	Impact of Project	Percent Increase Over Baseline Forecast	1999 Baseline Forecast	1999 Forecast With Project	Impact of Project	Percent Increase Over Baseline Forecast
Population	N.A.	600	1,415	1,453	38	2.7	3,335	3,367	32	1.0
Employment[a]	N.A.	-[b]	-[b]	-[b]	15	-[b]	-[b]	-[b]	7	-[b]
Housing Demand (no. of units)	229	207	508	522	14	2.8	1,249	1,261	12	1.0
Water (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Sewage Treatment (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Police	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Education (primary students)	0[c]	0[c]	178	184	6	3.4	447	451	4	0.9
(secondary students)	0[c]	0[c]	152	156	4	2.6	380	384	4	1.1
Hospital Beds	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

N.A. - Not Applicable
(a) By place of employment
(b) Data not available
(c) School service areas do not correspond to city limits. Children in Houston currently attend schools outside of the city. A secondary school initially accommodating 300 students is planned.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.15: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON TRAPPER CREEK

	Present Conditions		Watana Construction Peak				Devil Canyon Peak			
Socioeconomic Variable	1981 Capacity	1981 Amount/ Usage	1990 Baseline Forecast	1990 Forecast with Project	Impact of Project	Percent Increase Over Baseline Forecast	1999 Baseline Forecast	1999 Forecast With Project	Impact of Project	Percent Increase Over Baseline Forecast
Population	N.A.	225	320	661	341	106.6	456	701	245	49.8
Employment[a]	N.A.	-[b]	-[b]	-[b]	66	-[b]	-[b]	-[b]	31	-[b]
Housing Demand (no. of units)	69	68	107	221	114	106.5	169	261	92	54.4
Water (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Sewage Treatment (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Police	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Education (primary students)	30[c]	40[d]	78	128-148	50-70	64.1	116	151-171	35-55	30.1
(secondary students)	0[d]	0[d]	34	74	40	117.6	52	82	30	57.7
Hospital Beds	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

N.A. - Not Applicable
(a) By place of employment
(b) Data not available
(c) Planned capacity of 100, with room for expansion to 200.
(d) School service areas do not correspond exactly to community delineations. The Trapper Creek elementary school serves a wide area outside of the community. Secondary school-age children from Trapper Creek attend Susitna Valley High School.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.16: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON TALKEETNA

Socioeconomic Variable	Present Conditions: 1981 Capacity	Present Conditions: 1981 Amount/Usage	Watana Construction Peak: 1990 Baseline Forecast	Watana Construction Peak: 1990 Forecast with Project	Watana Construction Peak: Impact of Project	Watana Construction Peak: Percent Increase Over Baseline Forecast	Devil Canyon Peak: 1999 Baseline Forecast	Devil Canyon Peak: 1999 Forecast With Project	Devil Canyon Peak: Impact of Project	Devil Canyon Peak: Percent Increase Over Baseline Forecast
Population	N.A.	640	1,000	1,263	263	26.3	1,563	1,773	210	13.4
Employment[a]	N.A.	-[b]	-[b]	-[b]	71	-[b]	-[b]	-[b]	34	-[b]
Housing Demand (no. of units)	196	194	334	421	87	26.0	581	658	77	13.3
Water (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Sewage Treatment (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Police	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Education (primary students)	120[d]	73[d]	126	164	38	30.2	209	240	31	14.8
(secondary students)	0[d]	0[d]	107	138	31	29.0	178	204	26	14.6
Hospital Beds	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

N.A. - Not Applicable
(a) By place of employment
(b) Data not available
(c) School service areas do not correspond exactly to community delineations. Secondary school-age children attend Susitna Valley High School.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.17 - SUMMARIZED IMPACT OF THE SUSITNA PROJECT ON CANTWELL (HIGH CASE IMPACTS)

	Present Conditions		Watana Construction Peak				Devil Canyon Construction Peak			
Socioeconomic Variable	1982 Capacity	1982 Amount/ Usage	1990 Baseline Forecast	1990 Forecast With Project	Impact of Project	Percent Increase Over Baseline Forecast	1999 Baseline Forecast	1999 Forecast With Project	Impact of Project	Percent Increase Over Baseline Forecast
Population	N.A.	183	214	641	427	199.5	256	543	287	112.1
Housing Demand (no. of units)	96	69	78	205	127	162.8	93	178	85	91.4
Water (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Sewage Treatment (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Police	N.A.	1	1	2	1	100.0	1	2	1	100.0
Education	60	33	39	135	96	246.2	46	108	62	134.8

N.A. - Not Applicable

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.18: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON THE REGION[a]

		Watana Construction Peak				Devil Canyon Peak			
Socioeconomic Variable	1980 Amount	1990 Baseline Forecast	1990 Forecast with Project	Impact of Project	Percent Increase Over Baseline Forecast	1999 Baseline Forecast	1999 Forecast With Project	Impact of Project	Percent Increase Over Baseline Forecast
Population	284,166	397,999	400,323	2,324	0.6	473,191	474,419	1,228	0.3
Employment	114,112[b]	200,112	206,477	6,365	3.2	232,311	235,668	3,357	1.4
Households	96,899	138,938	139,794	856	0.6	171,895	172,384	489	0.3

(a) Includes the following census divisions: Anchorage, Kenai Peninsula, Mat-Su Borough, Fairbanks-North Star Borough, S.E. Fairbanks and Valdez-Chitina-Whittier.

(b) Average employment during the first nine months of 1980.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.19 - ON-SITE CONSTRUCTION AND OPERATIONS MANPOWER REQUIREMENTS, 1985-2005(A)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
CONSTRUCTION																					
LABORERS	562	843	1279	1693	1897	2369	2202	1723	894	549	338	539	844	1076	1144	1002	507	105			
SEMI-SKILLED/SKILLED	148	323	355	448	502	627	583	422	220	136	92	148	230	295	312	308	234	24			
ADMINISTRATIVE/ENGINEER.	390	184	268	359	402	502	467	355	185	115	71	115	176	229	243	187	159	22			
SUB-TOTAL CONSTRUCTION	1100	1350	1902	2500	2801	3498	3252	2500	1299	800	501	802	1250	1600	1699	1497	900	151			
OPERATIONS AND MAINTENANCE																					
ALL LABOR CATEGORIES									70	145	145	145	145	145	145	145	145	170	170	170	170
TOTAL	1100	1350	1902	2500	2801	3498	3252	2500	1369	945	646	947	1395	1745	1844	1642	1045	321	170	170	170

(A) SUPPLIED BY ACRES AMERICAN, INC.

TABLE E.5.20 - SOURCE OF ON-SITE CONSTRUCTION WORK FORCE: REGIONAL, ALASKA NON-REGIONAL, AND OUT-OF-STATE, 1985-2002

REGIONAL	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
LABORERS (85%)	478	717	1087	1439	1612	2014	1872	1465	760	467	287	458	717	915	972	852	431	89
SEMI-SKILLED/ SKILLED (80%)	118	258	284	359	402	502	466	337	176	109	74	118	184	236	250	246	187	19
ADMINISTRATIVE/ ENGINEERING (65%)	254	120	174	233	261	326	304	231	120	75	46	75	114	149	158	122	103	14
SUBTOTAL REGIONAL	850	1094	1545	2031	2276	2842	2642	2033	1056	650	407	651	1016	1299	1380	1220	722	122
NON-REGIONAL																		
ALASKA NON-REGIONAL																		
LABORERS (5%)	28	42	64	85	95	118	110	86	45	27	17	27	42	54	57	50	25	5
SEMI-SKILLED/ SKILLED (5%)	7	16	18	22	25	31	29	21	11	7	5	7	11	15	16	15	12	1
ADMINISTRATIVE/ ENGINEERING (5%)	20	9	13	18	20	25	23	18	9	6	4	6	9	11	12	9	8	1
SUB-TOTAL ALASKA NON-REGIONAL	55	67	95	125	140	175	163	125	65	40	25	40	62	80	85	75	45	7
OUT-OF-STATE																		
LABORERS (10%)	56	84	128	169	190	237	220	172	89	55	34	54	84	108	114	100	51	11
SEMI-SKILLED/ SKILLED (15%)	22	48	53	67	75	94	87	63	33	20	14	22	34	44	47	46	35	4
ADMINISTRATIVE/ ENGINEERING (30%)	117	55	80	108	121	151	140	107	56	35	21	35	53	69	73	56	48	7
SUB-TOTAL OUT-OF-STATE	195	188	262	344	386	482	448	342	178	110	69	111	172	221	234	202	134	21
TOTAL NON-REGIONAL	250	255	357	469	526	656	610	467	243	150	94	151	234	301	319	277	179	28
TOTAL	1100	1350	1902	2500	2601	3498	3252	2500	1299	800	501	802	1250	1600	1699	1497	900	151

TABLE E.5.21: OPERATIONS WORK FORCE: 1993-2005

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Activity													
Watana (680 MW)	30	60	60	60	60	60	60	60	60	60	60	60	60
Watana (340 MW)		45	45	45	45	45	45	45	45	45	45	45	45
Devil Canyon (600 MW)										25	25	25	25
Dispatch Control	40	40	40	40	40	40	40	40	40	40	40	40	40
Total	70	145	145	145	145	145	145	145	145	170	170	170	170

Source: Acres American, Inc.

TABLE E.5.22 - TOTAL PAYROLL FOR ON-SITE CONSTRUCTION AND OPERATIONS MANPOWER, 1985-2005 IN THOUSANDS OF 1981 DOLLARS

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
CONSTRUCTION (A)																					
LABORERS	16847	25323	38319	50739	56863	70984	65985	51529	26806	16543	10186	16141	25433	32211	34255	29892	14950	3114			
SEMI-SKILLED/ SKILLED	3671	9162	9441	11750	13169	16440	15282	10643	5475	3389	2383	3871	5952	7725	8189	8182	6438	574			
ADMINISTRATIVE/ ENGINEER	8159	3810	5555	7436	8334	10404	9671	7362	3842	2378	1465	2374	3655	4737	5038	3946	3289	492			
SUBTOTAL CONSTRUCTION	28677	38295	53315	69925	78366	97828	90938	69534	36123	22310	14034	22386	35040	44673	47482	42020	24677	4180			
OPERATIONS (B)																					
ALL LABOR CATEGORIES									2684	5559	5559	5559	5559	5559	5559	5559	5559	6517	6517	6517	6517
TOTAL PAYROLL	28677	38295	53315	69925	78366	97828	90938	69534	38807	27869	19593	27945	40599	50232	53041	47579	30236	10697	6517	6517	6517

(A) BASED ON 1,825 WORKING HOURS IN THE YEAR.

(B) BASED ON 2,496 WORKING HOURS IN THE YEAR.

TABLE E.5.23 - ON-SITE CONSTRUCTION WORK FORCE: CUMULATIVE PROJECT EMPLOYMENT AND RESIDENCE OF INDIVIDUALS CURRENTLY RESIDING IN THE REGION

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
REGION	850	1094	1545	2031	2276	2842	2642	2033	1056	650	407	651	1016	1299	1380	1220	722	122
ANCHORAGE SUBAREA	627	808	1141	1499	1679	2097	1949	1500	779	480	300	480	750	959	1019	900	532	90
ANCHORAGE	475	612	864	1135	1272	1588	1477	1136	590	363	228	364	568	726	772	682	403	68
MAT-SU	58	74	104	137	153	191	178	137	71	44	27	44	68	87	93	82	49	8
KENAI-COOK INLET	94	121	172	225	253	315	293	226	117	72	45	72	113	144	153	135	80	14
SEWARD	2	2	3	4	5	6	5	4	2	1	1	1	2	3	3	2	1	0
FAIRBANKS	202	260	368	483	542	676	629	484	251	155	97	155	242	309	329	290	172	29
SE FAIRBANKS	2	2	3	4	5	6	5	4	2	1	1	1	2	3	3	2	1	0
VALDEZ-CHITINA-WHITTIER	18	23	32	43	48	60	55	43	22	14	9	14	21	27	29	26	15	3
MAT-SU COMMUNITIES																		
PALMER	6	7	10	14	15	19	18	14	7	4	3	4	7	9	9	8	5	1
WASILLA	5	6	8	11	12	15	14	11	6	4	2	4	5	7	7	7	4	1
HOUSTON	2	2	3	4	5	6	5	4	2	1	1	1	2	3	3	2	1	0
TRAPPER CREEK	1	1	1	1	2	2	2	1	1	0	0	0	1	1	1	1	1	0
TALKEETNA	2	3	4	5	6	8	7	5	3	2	1	2	3	4	4	3	2	0
OTHER	42	54	77	101	113	141	131	101	52	32	20	32	50	65	69	61	36	6

TABLE E.5.24 - ON-SITE CONSTRUCTION WORK FORCE: CUMULATIVE INMIGRATION AND PLACE OF RELOCATION IN THE REGION

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TOTAL REGION	54	67	93	122	137	170	158	140	111	98	91	91	91	100	102	98	84	65
ANCHORAGE SUBAREA	41	51	99	131	147	184	175	160	137	128	122	122	122	129	131	127	116	101
ANCHORAGE	17	20	-37	-51	-57	-73	-76	-80	-86	-89	-91	-91	-91	-89	-88	-89	-92	-97
MAT-SU	23	29	152	202	227	285	279	269	253	247	243	243	243	248	249	246	239	229
KENAI COOK INLET	1	2	-14	-18	-20	-25	-26	-26	-27	-28	-28	-28	-28	-28	-28	-28	-28	-29
SEWARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FAIRBANKS	13	16	-8	-11	-12	-16	-19	-23	-29	-31	-33	-33	-33	-31	-30	-32	-34	-39
SE FAIRBANKS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALDEZ-CHITINA-WHITTIER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAT-SU COMMUNITIES																		
PALMER	1	1	6	8	9	11	11	11	10	10	10	10	10	10	10	10	10	9
WASILLA	1	1	8	10	11	14	14	13	13	12	12	12	12	12	12	12	12	11
HOUSTON	1	1	6	8	9	11	11	11	10	10	10	10	10	10	10	10	10	9
TRAPPER CREEK	6	7	38	50	57	71	70	67	63	62	61	61	61	62	62	62	60	57
TALKEETNA	6	7	38	50	57	71	70	67	63	62	61	61	61	62	62	62	60	57
OTHER	9	11	56	75	84	105	103	99	94	91	90	90	90	92	92	91	88	85

TABLE E.5.25 - CUMULATIVE NON-RELOCATING ON-SITE CONSTRUCTION WORKERS

Year	Number of Workers(a)	
1985	61	
1986	52	
1987	151	
1988	218	Watana Construction
1989	253	
1990	338	
1991	305	
1992	182	
1993	negligible	
1994	negligible	
1995	negligible	
1996	negligible	
1997	37	Devil Canyon Construction
1998	90	
1999	106	
2000	68	
2001	negligible	
2002	negligible	

(a) Residents of Cantwell who obtain construction employment on the project and construction workers that settle in Cantwell were considered in these estimates. The Cantwell "High Impact Scenario" was used in deriving these estimates. Further, it is assumed that if workers do not settle in Cantwell, they will settle elsewhere in the region.

TABLE E.5.26 - TOTAL REGIONAL EMPLOYMENT: ON-SITE CONSTRUCTION, INDIRECT AND INDUCED

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
REGION	1475	1897	2664	3609	4043	5049	4768	3669	1907	1175	736	1176	1875	2399	2548	2288	1356	232
ANCHORAGE SUBAREA	1156	1487	2099	2866	3212	4010	3751	2886	1499	923	579	925	1483	1897	2016	1792	1061	181
ANCHORAGE	917	1180	1608	2193	2456	3066	2851	2194	1142	705	444	706	1140	1457	1547	1368	812	142
MAT-SU	111	142	264	375	421	526	489	375	193	117	72	117	185	239	254	224	131	18
KENAI-COOK INLET	127	163	225	296	332	414	408	314	163	100	63	100	157	200	213	199	117	20
SEWARD	2	3	4	5	6	7	7	5	3	2	1	2	3	3	4	3	2	0
FAIRBANKS	294	378	521	684	766	957	942	725	377	233	146	233	363	464	493	460	273	47
SE FAIRBANKS	2	3	4	5	5	7	6	5	2	2	1	2	2	3	3	3	2	0
VALDEZ-CHITINA-WHITTIER	22	28	39	52	58	72	67	52	27	17	10	17	26	33	35	33	19	3
MAT-SU COMMUNITIES																		
PALMER	10	13	22	31	35	44	41	31	16	10	6	10	15	20	21	19	11	2
WASILLA	9	11	20	28	31	39	37	28	14	9	5	9	14	18	19	17	10	1
HOUSTON	4	5	10	14	16	20	18	14	7	4	3	4	7	9	9	8	5	1
TRAPPER CREEK	2	3	10	15	17	22	20	15	8	5	3	5	7	10	10	9	5	0
TALKEETNA	7	9	29	43	49	61	57	43	22	13	8	13	21	27	29	26	15	2
OTHER	79	101	172	243	272	341	317	243	125	76	47	77	120	155	165	145	85	13

TABLE E.5.27 - TOTAL INMIGRATION AND OUTMIGRATION IN THE REGION: ON-SITE CONSTRUCTION, INDIRECT AND INDUCED

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
REGION	236	300	425	592	664	828	783	621	361	252	188	245	345	425	448	409	269	96
ANCHORAGE SUBAREA	205	261	401	562	630	787	739	594	363	267	209	261	353	424	444	406	281	129
ANCHORAGE	164	210	211	302	337	419	382	273	98	25	-19	24	100	155	170	139	44	-72
MAT-SU	34	42	196	268	301	378	365	335	287	267	255	263	275	289	293	285	262	231
KENAI-COOK INLET	7	9	-5	-6	-6	-8	-6	-11	-19	-23	-25	-23	-20	-18	-17	-17	-22	-28
SEWARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FAIRBANKS	30	37	19	25	27	33	37	20	-7	-18	-24	-19	-11	-4	-2	-2	-17	-35
SE FAIRBANKS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALDEZ-CHITINA-WHITTIER	2	2	3	4	4	5	5	4	2	1	1	1	2	2	3	3	2	0
MAT-SU COMMUNITIES																		
PALMER	1	2	7	10	11	14	14	13	11	10	10	10	11	11	11	11	10	9
WASILLA	2	2	9	12	13	17	16	15	14	13	13	13	13	14	14	13	13	12
HOUSTON	1	1	7	9	10	13	13	12	11	10	10	10	10	11	11	11	10	9
TRAPPER CREEK	9	12	60	83	93	117	112	100	80	71	67	71	77	82	84	81	71	58
TALKEETNA	7	9	46	63	71	89	86	80	70	65	63	65	67	70	71	69	64	58
OTHER	13	16	67	90	102	128	124	115	102	96	93	95	98	102	103	101	94	85

TABLE E.5.28: TOTAL POPULATION INFLUX INTO THE REGION: DIRECT, INDIRECT AND INDUCED

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
REGION	672	852	1203	1671	1867	2324	2191	1735	1014	714	535	690	957	1170	1228	1122	743	278	179	179	179
ANCHORAGE SUBAREA	583	739	1139	1589	1777	2214	2075	1669	1027	761	602	742	986	1177	1229	1122	788	378	297	297	297
ANCHORAGE	463	590	578	826	919	1137	1030	725	242	42	-77	35	240	385	425	339	84	-225	-292	-292	-292
MAT-SU	99	123	580	789	886	1112	1074	988	852	796	763	784	817	856	866	844	778	694	676	676	676
KENAI COOK INLET	21	26	-16	-20	-23	-28	-22	-37	-60	-70	-76	-71	-64	-57	-55	-54	-68	-85	-87	-87	-87
SEWARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FAIRBANKS	85	107	52	66	72	88	96	49	-26	-57	-75	-62	-41	-20	-14	-15	-56	-107	-117	-117	-117
SE FAIRBANKS	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALDEZ-CHITINA-WHITTIER	5	6	8	11	12	15	14	11	5	3	2	3	5	7	7	8	5	1	0	0	0
MAT-SU COMMUNITIES																					
PALMER	4	5	22	30	33	42	40	38	33	31	30	31	32	33	33	33	31	28	27	27	27
WASILLA	5	6	26	36	40	50	49	46	41	39	37	38	39	40	41	40	38	35	34	34	34
HOUSTON	3	4	20	27	31	38	37	35	32	31	30	30	31	32	32	31	30	28	27	27	27
TRAPPER CREEK	27	34	175	242	272	341	327	291	235	212	198	209	225	241	245	236	209	175	169	169	169
TALKEETNA	22	27	138	186	209	263	254	236	208	196	189	193	199	207	210	205	191	173	169	169	169
OTHER	37	46	199	268	301	378	366	342	304	288	278	284	291	302	305	299	280	257	250	250	250

TABLE E.5.29 - TOTAL POPULATION INFLUX INTO THE REGION ASSOCIATED WITH THE DIRECT CONSTRUCTION WORK FORCE

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
TOTAL REGION	163	201	279	366	410	511	476	420	333	296	274	274	274	301	308	293	251	194	179	179	179
ANCHORAGE SUBAREA	124	152	299	394	442	553	525	481	413	384	367	367	367	388	393	382	348	303	297	297	297
ANCHORAGE	50	60	-112	-152	-172	-219	-227	-240	-259	-267	-272	-272	-272	-266	-265	-268	-277	-290	-292	-292	-292
MAT-SU	70	86	457	606	681	856	837	807	761	742	731	731	731	744	748	740	718	688	676	676	676
KENAI COOK INLET	4	6	-42	-55	-61	-76	-77	-79	-82	-84	-85	-85	-85	-84	-83	-84	-85	-87	-87	-87	-87
SEWARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FAIRBANKS	40	49	-23	-33	-37	-48	-56	-68	-86	-94	-99	-99	-99	-93	-92	-95	-104	-116	-117	-117	-117
SE FAIRBANKS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALDEZ-CHITINA-WHITTIER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAT-SU COMMUNITIES																					
PALMER	3	3	18	24	27	34	33	32	30	30	29	29	29	30	30	30	29	28	0	27	27
WASILLA	3	4	23	30	34	43	42	40	38	37	37	37	37	37	37	37	36	34	34	34	34
HOUSTON	3	3	18	24	27	34	33	32	30	30	29	29	29	30	30	30	29	28	27	27	27
TRAPPER CREEK	17	22	114	152	170	214	209	202	190	185	183	183	183	186	187	185	180	172	169	169	169
TALKEETNA	17	22	114	152	170	214	209	202	190	185	183	183	183	186	187	185	180	172	169	169	169
OTHER	26	32	169	224	252	317	310	299	282	274	270	270	270	275	277	274	266	255	250	250	250

NOTE: THIS TABLE ASSUMES THAT 95% OF IMMIGRANTS ARE ACOMPANIED BY DEPENDENTS.

TABLE E.5.30 - EMPLOYMENT AND POPULATION EFFECTS IN CANTWELL

Year	Resident Employment on Project		Cumulative In-migrant Construction Workers		Cumulative Population Influx Associated with In-migrant Construction Workers		Cumulative Total Population Influx (a)	
	High	Moderate	High	Moderate	High	Moderate	High	Moderate
1985	19	19	116	113	240	230	394	230
1986	19	19	118	113	245	230	399	230
1987	20	20	93	75	241	165	328	255
1988	20	20	109	79	279	178	366	255
1989	20	20	115	80	297	184	384	255
1990	20	20	128	85	341	198	427	255
1991	20	20	127	84	336	197	422	255
1992	20	20	125	83	329	194	415	255
1993	20	20	121	82	317	190	403	255
1994	20	20	91	53	253	130	286	163
1995	20	20	90	53	251	129	284	162
1996	20	20	90	53	251	129	284	162
1997	20	20	90	53	251	129	284	162
1998	20	20	91	53	254	130	287	162
1999	20	20	91	53	255	130	287	162
2000	20	20	91	53	253	130	285	162
2001	20	20	89	52	248	128	280	160
2002	20	20	87	51	240	125	272	157
2003	0	0	64	42	171	99	176	63
2004	0	0	64	42	171	99	176	63
2005	0	0	64	42	171	99	176	63

(a) Includes the population influx associated with both in-migrant project workers and in-migrant secondary workers (indirect and induced workers).

TABLE E.5.31 - IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON HOUSING DEMAND IN THE LOCAL IMPACT AREA DURING THE WATANA CONSTRUCTION PHASE

(Forecasts by Frank Orth & Associates, Inc.)

	Projected Housing Stock	Baseline Projection of Households	Cumulative Project-Induced Influx of Households	Total Housing Demand
Total Mat-Su Borough				
1985	11,730	9,927	32	9,959
1986	12,868	10,916	40	10,956
1987	14,095	11,986	189	12,175
1988	15,121	12,910	259	13,169
1989	16,092	13,788	294	14,082
1990	16,754	14,417	374	14,791
1991	17,728	15,354	364	15,718
1992	18,574	16,156	339	16,495
1993	19,761	17,245	295	17,540
Trapper Creek				
1985	84	83	9	92
1986	88	87	11	98
1987	93	92	56	148
1988	98	97	79	176
1989	103	102	89	191
1990	108	107	114	221
1991	114	112	111	223
1992	119	118	100	218
1993	126	124	82	205
Talkeetna				
1985	251	246	7	253
1986	267	262	9	271
1987	284	278	45	323
1988	302	296	61	357
1989	320	314	69	383
1990	340	334	87	421
1991	362	355	86	441
1992	385	377	81	458
1993	409	401	72	473
Cantwell				
1985	97	71	123	194
1986	99	72	125	197
1987	100	73	107	180
1988	102	75	118	193
1989	103	76	124	200
1990	105	78	137	215
1991	107	80	136	216
1992	108	81	134	215
1993	110	83	130	213

TABLE E.5.32 - IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON HOUSING DEMAND IN THE LOCAL IMPACT AREA DURING THE WATANA OPERATION AND DEVIL CANYON CONSTRUCTION PHASE

(Forecasts by Frank Orth & Associates, Inc.)

	Projected Housing Stock	Baseline Projection of Households	Cumulative Project-Induced Influx of Households	Total Housing Demand
Total Mat-Su Borough				
1994	20,821	18,235	279	18,514
1995	22,043	19,371	271	19,642
1996	23,278	20,528	282	20,810
1997	24,719	21,885	297	22,182
1998	26,048	23,145	314	23,459
1999	27,672	24,670	322	24,992
2000	29,207	26,095	317	26,412
2001	30,626	27,373	271	27,644
2002	32,115	28,715	259	28,974
Trapper Creek				
1994	132	131	74	206
1995	139	138	70	208
1996	147	145	75	220
1997	155	153	82	235
1998	163	161	89	250
1999	171	169	92	261
2000	180	178	89	267
2001	187	186	78	264
2002	195	193	66	259
Talkeetna				
1994	435	426	68	494
1995	462	453	67	520
1996	492	482	69	551
1997	523	513	72	585
1998	557	546	76	622
1999	592	581	77	658
2000	630	618	77	695
2001	662	650	71	721
2002	696	683	65	748
Cantwell				
1994	112	84	100	184
1995	114	86	100	186
1996	116	88	100	188
1997	118	89	100	189
1998	120	91	100	191
1999	122	93	100	193
2000	124	95	100	195
2001	126	97	98	195
2002	128	99	96	195

TABLE E.5.33 - SECONDARY JOBS CREATED IN THE REGION AND MAT-SU BOROUGH BY THE PROJECT, 1985 - 2002

Year	Secondary Jobs: Region		Secondary Jobs: Mat-Su Borough
1985	806		64
1986	1035		82
1987	1451		205
1988	2048	Watana Construction	304
1989	2295		342
1990	2865		428
1991	2752		398
1992	2117		304
1993	1101		155
1994	678		93
1995	426		56
1996	679		93
1997	1114	Devil Canyon Construction	149
1998	1424		193
1999	1513		205
2000	1381		180
2001	819		105
2002	141		13

E.5.34 - EMPLOYMENT IMPACTS IN THE REGION AND MAT-SU BOROUGH, 1985 - 2005

Year	Total Jobs Created in the Region(a)	Forecast of Jobs for the Region: Base Case	Regional Jobs Created as a Percent of Total Base Case Regional Jobs	Total Jobs Created in the the Mat-Su Borough (a)	Forecast of Jobs in the Mat-Su Borough: Base Case	Borough Jobs Created as a Percent of Total Base Case Borough Jobs
1985	1906	179,636	1 %	1164	5,442	21 %
1986	2385	194,212	1 %	1432	5,975	23 %
1987	3353	200,610	2 %	2107	6,373	33 %
1988	4548	200,912	2 %	2804	6,641	42 %
1989	5096	202,596	3 %	3143	6,858	46 %
1990	6363	200,111	3 %	3926	6,914	57 %
1991	6004	202,128	3 %	3650	7,135	51 %
1992	4617	202,846	2 %	2804	7,296	38 %
1993	2470	205,872	1 %	1454	7,550	19 %
1994	1623	208,791	1 %	893	7,806	11 %
1995	1072	212,050	1 %	557	8,076	7 %
1996	1626	216,576	1 %	895	8,403	11 %
1997	2509	221,561	1 %	1399	8,755	16 %
1998	3169	226,547	1 %	1793	9,107	20 %
1999	3357	232,311	1 %	1904	9,505	20 %
2000	3023	237,812	1 %	1677	9,897	17 %
2001	1864	243,344	1 %	1005	10,308	10 %
2002	462	249,007	Negligible	164	10,733	2 %
2003	170	254,808	Negligible	170	11,176	2 %
2004	170	260,749	Negligible	170	11,636	1 %
2005	170	266,835	Negligible	170	12,116	1 %

(a) Created as a direct or indirect result of the Susitna project.

TABLE E.5.35 - MAT-SU BOROUGH BUDGET FORECASTS
(In millions of 1981 dollars)

	GENERAL FUNDS			SERVICE AREAS FUNDS			LAND MANAGEMENT FUNDS			SCHOOL DISTRICT FUNDS		
	Without the Project	With the Project	% Impact	Without the Project	With the Project	% Impact	Without the Project	With the Project	% Impact	Without the Project	With the Project	% Impact
REVENUES:												
1981	15.2	15.2	--	1.2	1.2	--	0.9	0.9	--	23.9	23.9	--
1985	19.0	19.2	1.0	1.4	1.7	21.4	1.3	1.3	--	34.5	34.6	0.3
1990	27.2	28.1	3.3	2.6	3.3	30.7	1.8	1.9	5.0	48.9	50.1	0.4
1994	32.2	32.9	2.2	3.0	3.8	26.6	2.2	2.2	--	60.4	61.2	1.3
1999	39.9	40.7	2.0	3.6	4.6	27.8	2.8	2.8	--	78.7	79.6	1.4
2002	45.2	46.0	1.8	4.1	5.1	24.4	3.2	3.3	3.0	90.8	91.6	0.9
2005	51.4	52.2	1.6	4.6	5.8	26.1	3.7	3.8	2.0	104.5	105.2	0.7
EXPENDITURES:												
1981	16.7	16.7	--	4.4	4.4	--	1.1	1.1	--	26.4	26.4	--
1985	23.4	23.5	0.4	6.2	6.2	--	1.6	1.6	--	40.2	40.3	0.2
1990	32.2	33.1	2.8	9.1	9.2	1.0	2.1	2.2	4.8	59.4	61.1	2.8
1994	39.0	39.6	1.5	11.4	11.6	1.8	2.6	2.6	--	74.0	75.3	1.8
1999	49.8	50.4	1.2	15.5	15.7	1.3	3.3	3.4	3.0	97.6	99.0	1.4
2002	57.2	57.7	0.9	18.7	18.9	1.1	3.8	3.8	--	113.2	114.3	0.9
2005	66.1	66.6	0.8	22.6	22.7	0.4	4.4	4.4	--	130.6	131.7	0.8

Source: Frank Orth & Associates, Inc. 1982

TABLE E.5.36 - MAT-SU BOROUGH SERVICE AREAS REVENUE FORECASTS

($ million)

Year	Without the Project	With the Project	% Impact
1981	1.2	1.2	--
1985	1.4	1.7	21.4
1990	2.6	3.3	30.7
1994	3.0	3.8	26.6
1999	3.6	4.6	27.8
2002	4.1	5.1	24.4
2005	4.6	5.8	26.1

Source: Frank Orth & Associates, Inc. 1982

TABLE E.5.37 - UPPER COOK INLET ANNUAL COMMERCIAL CATCH AND VALUE[1]

Ten Year Annual Average 1972-1981	Species Chinook	Sockeye	Coho	Pink	Chum
Average Annual Catch (no. of fish)	11,339	1,302,097	227,164	734,610	680,621
Average Annual Catch (no. of pounds)	365,119	8,854,263	1,408,418	2,791,520	4,900,471
Average Annual Ex-vessel Value (in dollars)	391,128	8,499,102	1,017,241	957,412	2,619,546

[1]Upper Cook Inlet includes catch from the Northern and Central Districts.

Source: Calculated by Frank Orth & Associates, Inc., October 1982. ADF&G provided catch statistics from their current (October 1982) IBM files and also average size per fish data. Cook Inlet ex-vessel price data was obtained from the Commercial Fisheries Entry Commission.

TABLE E.5.38 - COOK INLET COMMERCIAL SALMON PERMIT USE

	DRIFT GILLNET		SET GILLNET	
	Permits Used	Permanent Permits in Effect	Permits Used	Permanent[1] Permits in Effect
1975	438	453	530	657
1976	472	514	521	712
1977	501	539	524	737
1978	537	549	581	742
1979	556	554	581	744
1980	513	554	571	744
1981	576	554	585	744

Source: Commercial Fisheries Entry Commission

1 Permanent permits in effect include both revenued and non-revenued permits. Discrepancies reflect interim use permits utilized in the fishery. Data for 1980 and 1981 is preliminary. There are cases pending which may alter permit numbers in the future.

TABLE E-5-39 - ESTIMATED POTENTIAL LOSSES TO THE UPPER COOK INLET COMMERCIAL FISHING FROM SUSITNA DAMS CONSTRUCTION

	Estimated Escapement Above Talkeetna (Numbers of Fish)1		Estimated Potential Loss (In Dollars)2	
	1981	1982	1981	1982
Sockeye	4,809	3,126	86,331	51,441
Pink	2,335	73,057	12,813	210,989
Chum	20,835	49,197	214,517	428,604
Coho	3,306	5,143	37,428	52,613

Source: Calculated by FO&A, Inc. November, 1982.

1 Potential losses are estimated using the 1981 and 1982 escapement levels above Talkeetna.

2 Potential losses are estimated under a number of assumptions, described in the text, which may or may not be valid. One important assumption is a worst case post project loss of 100 percent above Talkeetna.

TABLE E.5.40 - SPORT FISH CATCH FOR MAJOR SPECIES IN THE EAST SUSITNA DRAINAGE - WEST COOK INLET - WEST SUSITNA DRAINAGE

Species	1981 Catch	1980 Catch	1979 Catch
Chinook	7,136	7,552	7,164
Coho	13,386	23,137	10,671
Sockeye	2,289	1,984	2,577
Pinks	8,793	57,284	13,107
Chums	4,466	5,043	4,945
Rainbow	21,843	20,060	23,081
Dolly Vardin/Arctic Char	5,835	5,771	9,136
Arctic Grayling	17,110	20,206	19,578
Total Angler Days	97,189	139,429	128,596

Source: Michael J. Mills, Statewide Harvest Survey, ADF&G, various years.

TABLE E.5.41 - UPPER COOK INLET SUBSISTENCE SALMON CATCH(a)
(Catch in Number of Fish)

	Chinook	Sockeye	Coho	Pink	Chum	Total	No. of Permits
1969	0	1,509	1,259	30	94	5,892	330
1970	3	1,206	2,192	295	139	3,832	335
1971(b)	0	7	148	0	0	155	37
1972	0	4	55	27	15	101	30
1973	0	35	332	12	37	416	123
1974	1	14	291	17	2	325	109
1975	1	4	659	8	92	764	114
1976	0	21	567	113	13	714	111
1977	2	13	327	3	14	359	83
1978	5	42	3,529	128	31	3,735	323
1979	158	5,564	3,570	359	272	9,923	1,161
1980(c)	2,268	5,459	3,912	4,842	492	16,973	1,396 (d)
1981(e)	2,072	587	11,752	93	237	14,741	1,178 (f)

(a) Includes the Central District and Northern District.

(b) Knik Arm closed to subsistence fishing.

(c) Household permits were issued starting in 1980, whereas individual permits were issued prior to 1980.

(d) Includes 85 permits issued for special openings of the Central District and 65 permits issued for the special king salmon fishery at Tyonek.

(e) Preliminary data.

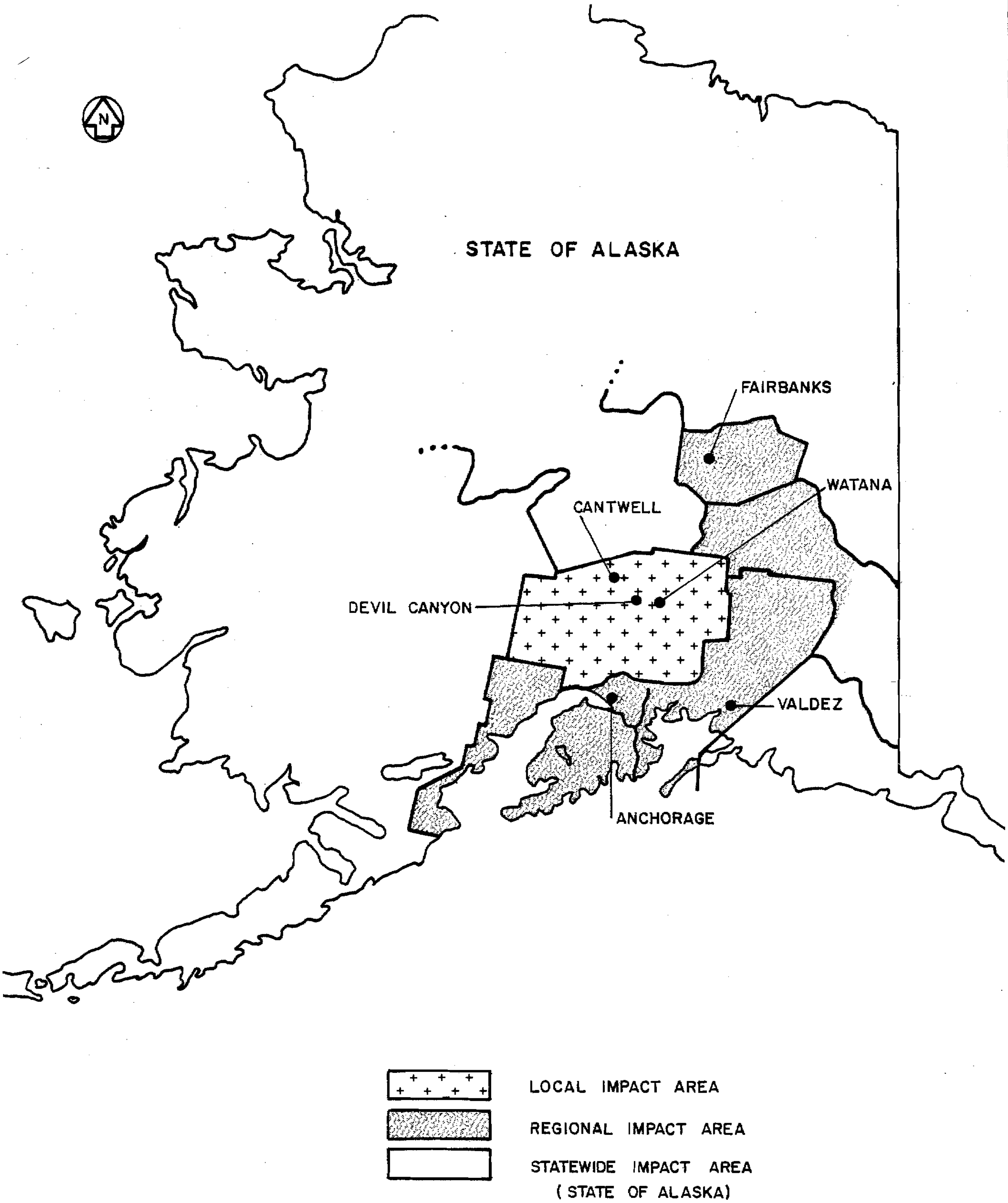
(f) There were 1,108 non-commercial set net permits issued in the Central District. The Tyonek fishery, with 70 permits, was the only subsistence fishery allowed in the Northern District in 1981.

Source: Alaska Department of Fish and Game, Soldotna Regional Office, May 1982.

TABLE E-5-42 - MOOSE HARVEST AND HUNTING PRESSURE IN G.M.U. 13

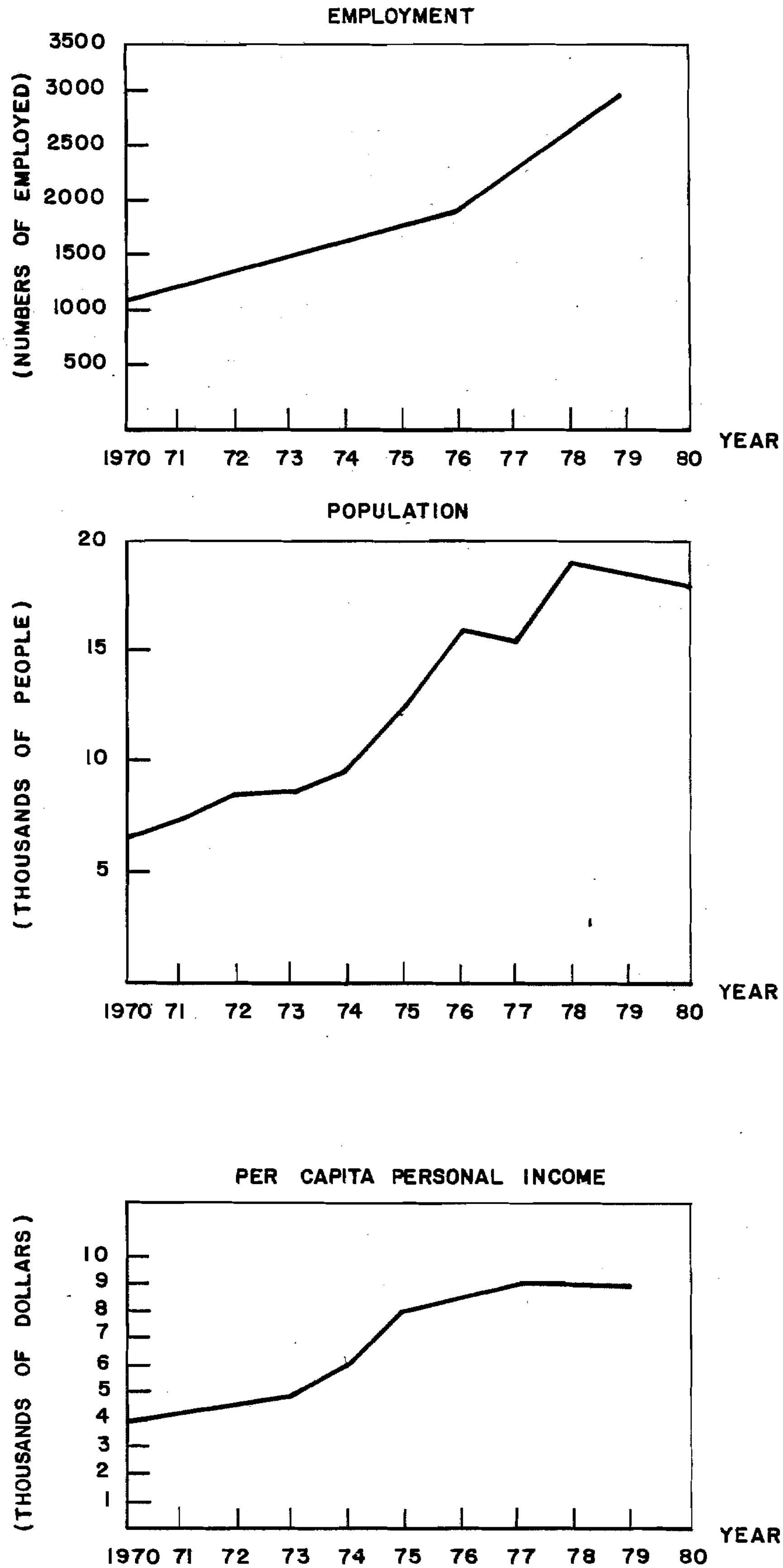
Year	Hunters	Harvest
1970	3,535	1,391
1971	4,881	1,814
1972	3,199	712
1973	2,513	618
1974	2,770	794
1975	2,978	715
1976	3,122	732
1977	2,299	698
1978	3,034	863
1979	2,377	848
1980	2,859	557
1981	3,105	794

Source: Alaska Department of Fish and Game, Division of Game. March 1980. Annual Report of Survey Inventory Activities, Part II and other ADF&G files.



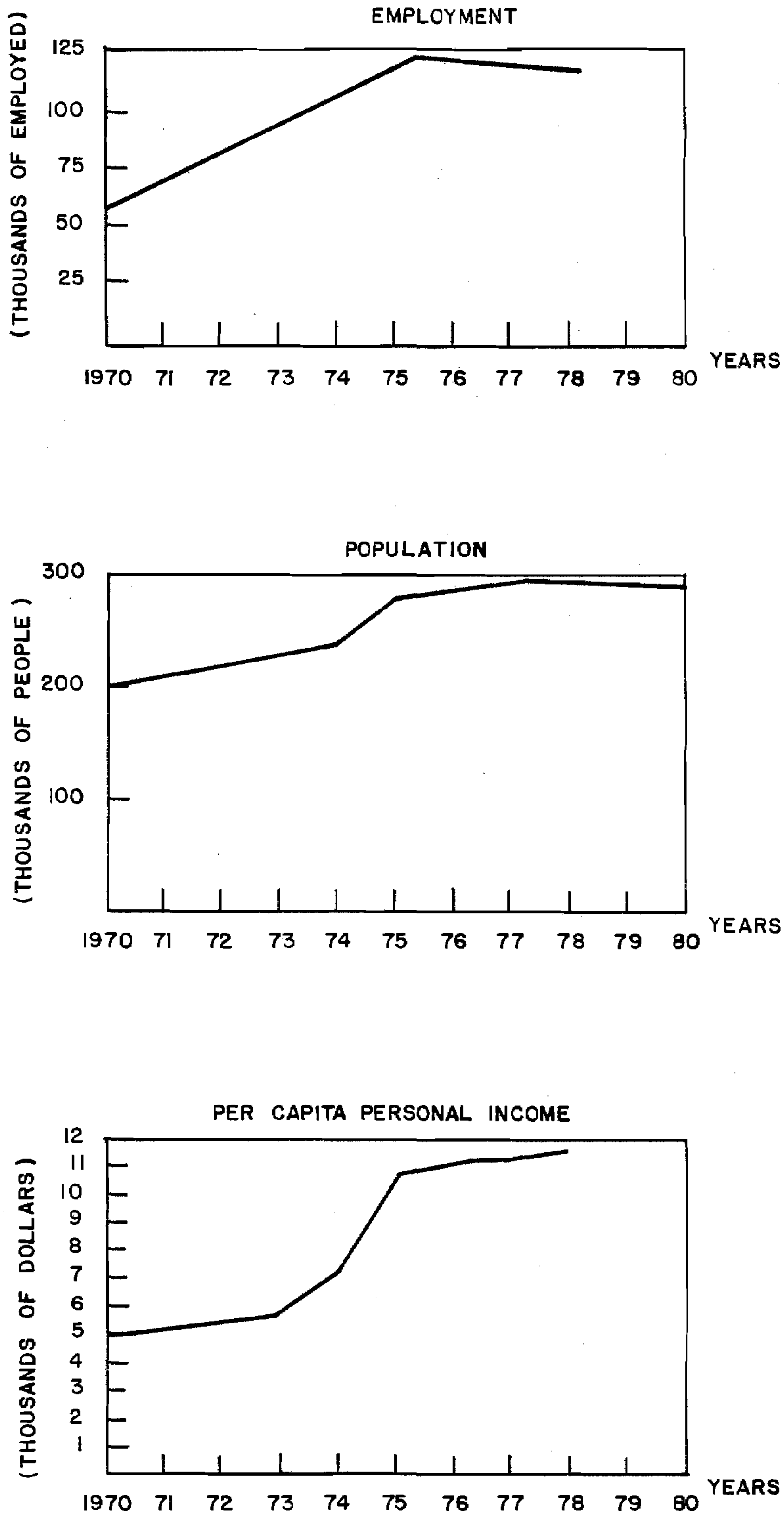
SOCIOECONOMIC IMPACT AREAS

FIGURE E.5.1



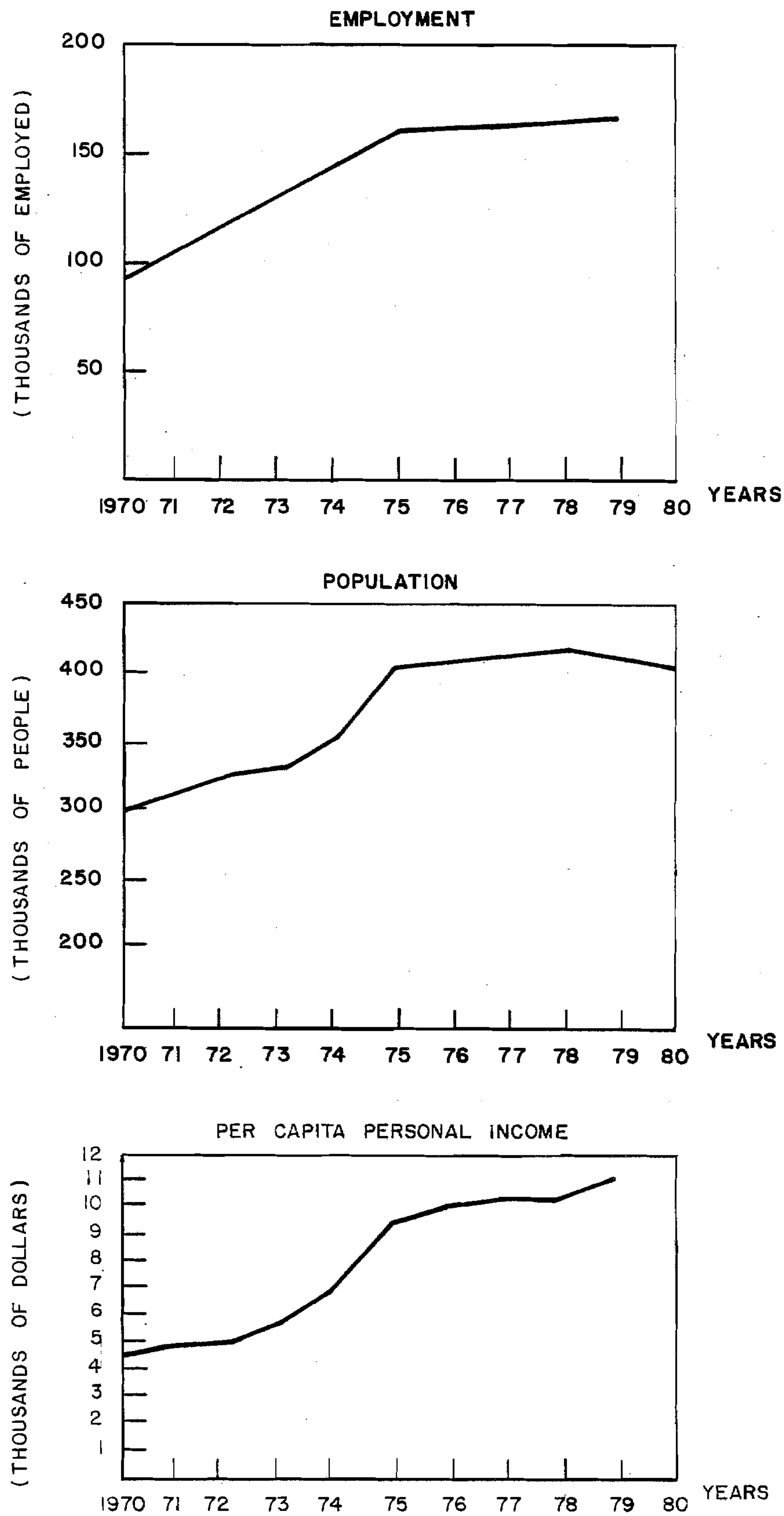
EMPLOYMENT, POPULATION AND PER CAPITA PERSONAL INCOME IN THE MATANUSKA-SUSITNA BOROUGH, 1970-1980

FIGURE E.5.2



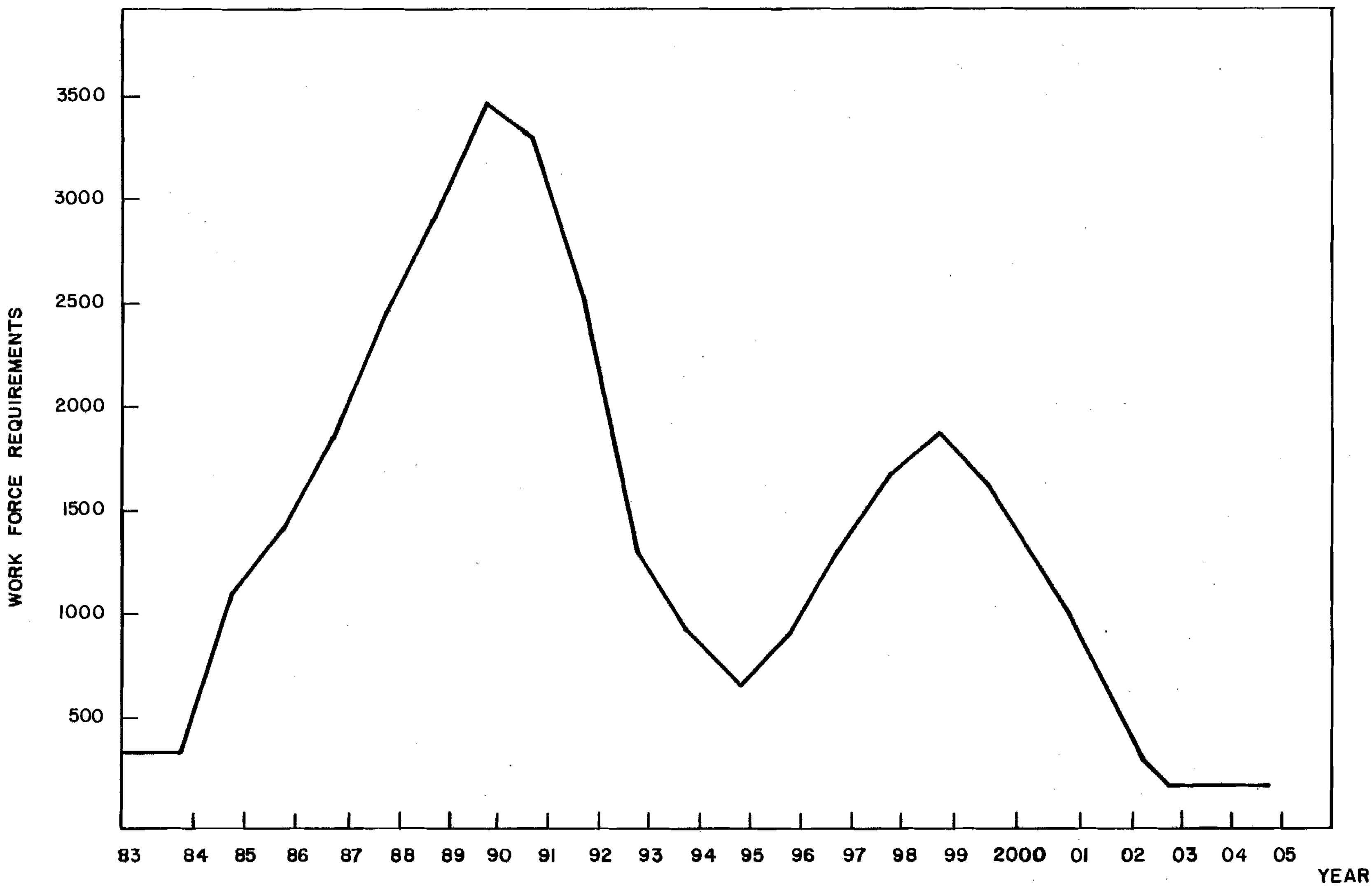
EMPLOYMENT, POPULATION AND PER CAPITA PERSONAL INCOME IN THE RAILBELT REGION

FIGURE E.5.3



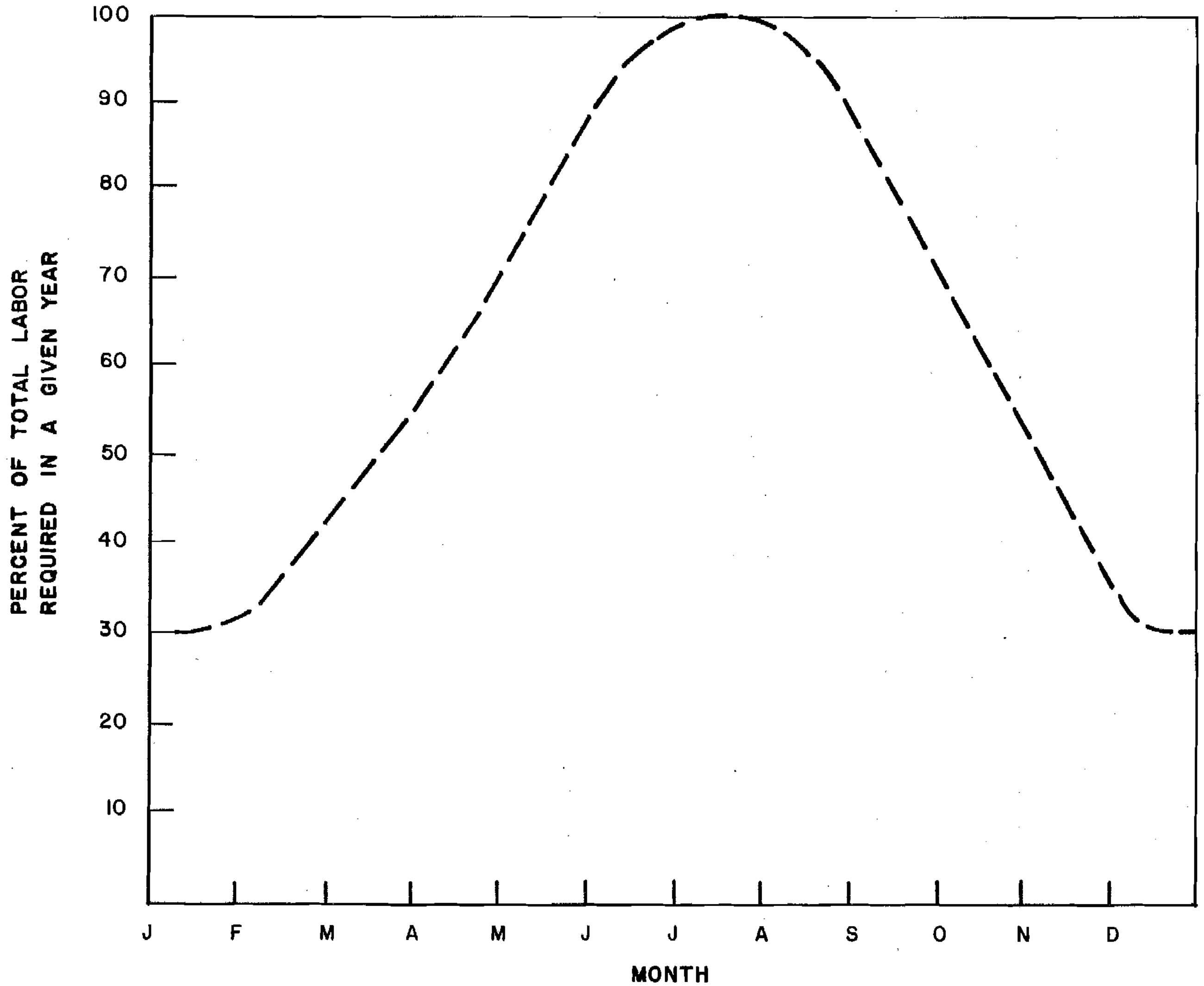
EMPLOYMENT, POPULATION AND PER CAPITA PERSONAL INCOME IN THE STATE OF ALASKA, 1970-1980

FIGURE E.5.4



ON-SITE CONSTRUCTION AND OPERATION WORK FORCE REQUIREMENTS

FIGURE E.5.5



SEASONAL LABOR CURVE

FIGURE E.5.6

APPENDIX E.5A - ELABORATION ON APPROACH, ASSUMPTIONS AND METHODS

This appendix is intended to provide (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 made in Section 3.3. Further information can be found in 5, 10, and other sections of reference (1).

(a) Approach

After the impact areas were defined, and as a precursor to making base case forecasts, recent and current socioeconomic conditions were analyzed. These included employment, population, income, housing, public facilities and services, local governments' budgets, land use, and other socioeconomic elements. Base case forecasts were then made for selected socioeconomic elements. A brief description of the forecasting techniques used is provided in Table E.5A.1. Forecasts were made for the years 1983 - 2005.

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 are shown in Table E.5A.2. Forecasts were made for 1983 - 2005.

Base case and impact forecasts were compared and contrasted to identify project-induced changes in the base case. Next, the significance of these changes was analyzed and discussed.

(b) Impact Model

A model was developed that could take into account settlement and traveling/commuting patterns of construction workers. It was specified to allow for in-migration and out-migration of workers and their dependents. 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. There are likely to be some changes before construction begins in 1985 and it will be helpful to be able to quickly and efficiently determine the socioeconomic implications of these changes.

(c) Elaboration of Assumptions

Several assumptions in Section 3.3 require more explanation. These assumptions are elaborated upon below.

(i) Sources of Labor

The percent of the workforce originating from various areas is discussed on page E-5-40. These percentages are constant throughout the project. At present there is no way to predict how these percentages are likely to change with time. As more information about the manpower requirements becomes available, it might be possible to make this prediction.

(ii) Relocating Versus Non-Relocating Workers

It was assumed that about 30 percent of the workers that initially resided outside of the region would relocate to the region, and that the remaining 70 percent would maintain their permanent residences outside of the region. This assumption is implicit in the figures presented in Table E.5.24.

(iii) Aggregate Multipliers

Total indirect and induced employment that will accrue to the region and its Census Divisions was estimated by applying aggregate multipliers to the direct construction and operations workforces residing in the region. The value of each location-specific multiplier was assumed to increase with time due to import substitution, time lags in expenditures made by the workforce and other factors that reflect a maturing economy. These multipliers are shown on page 10-34 through 10-35 of reference (1).

(iv) Settlement Patterns

Compared to other large resource development projects in the United States, there will be a relatively large number of workers that will choose to settle in smaller communities rather than larger communities or cities. For this project, there are two reasons for this anticipated phenomenon: (1) the smaller communities are located closer to the construction sites; and (2) Alaskans, and others that move to Alaska, tend to be attracted to rural/remote areas more readily than persons who live in other parts of the country.

TABLE E.5A.1

BASELINE FORECASTING TECHNIQUES

ELEMENT	FORECASTING TECHNIQUE
EMPLOYMENT	
State and Regional	Time-series econometric[a]
Census Division	Linear regression
POPULATION	
State and Regional	Time-series econometric[a]
Census Division	Linear regression
Community	Population Share (judgmental)
INCOME	
State, Regional and Census Division	Trend analysis and judgment
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

(a) Includes Results from Institute of Social and Economic Research's Man-in-the-Arctic Model, October, 1981.

TABLE E.5A.2

IMPACT FORECASTING TECHNIQUES

ELEMENT	FORECASTING TECHNIQUE
EMPLOYMENT	
State, Regional and Census Division	Accounting model
State and Regional	Time-series econometric (for comparison purposes only)[a]
POPULATION	
State, Regional and Census Division	Accounting model
State and Regional	Time-series econometric (for comparison purposes only)[a]
INCOME	
State, Regional and Census Division	Accounting Model
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

(a) Includes Results from Institute of Social and Economic Research's Man-in-the-Arctic Model, Octomber, 1981.

APPENDIX E.5B - PUBLIC FACILITIES AND SERVICES

This appendix provides additional explanation of the methodology used to project impacts of the project on public facilities and services. The general approach to forecasting public facility and service requirements during 1985-2005 was (1) to develop appropriate standards, for each service category and for each relevant community, that relate service and facility requirements to the size of population. (2) to assess the adequacy of existing facilities and services and to quantify any over- or under-capacity using these standards and (3) to estimate future needs based on the application of these standards to the population growth forecasts with and without the Susitna project.

(a) Types of Standards

Standards can be divided into two categories--average and prescriptive. Average standards are based on recent data on existing service levels on a per capita basis for a given area. Average standards may be based on national, regional, state or local averages, or on averages for a given type or size of community; their distinguishing feature is that they are based on an average of what currently exists. For some service types, there exist prescriptive standards that are set by relevant agencies or associations. These standards often vary by size, type and community, and may be of a voluntary or mandatory nature. For instance, a state government may require certain standards for health care and education; standards for fire protection based on insurance tables may be used widely.

A mix of average and prescriptive standards have been used in this analysis. The objective has been to provide detailed measures of adequate service levels, for those services which the local governments now provide, while keeping under consideration the resource constraints that communities face. Local preferences, based upon conversations with local, state and borough officials, have been taken into account.

For some facilities and services, the required level of service varies among communities, depending on factors such as the size of the community and the type of community (urban, rural or suburban).

In some cases, relevant standards may be based on variables other than population per se--for example, the number of dwellings or the number of school-age children. These variables are related to population levels, but the actual ratios may change over time. Service categories such as education and health care are especially sensitive to demographic changes. Where possible, forecasts of demographic changes have been incorporated into the analysis.

Due to the many factors that influence the needs for public facilities and services, the uniqueness of each community, and the subjectivity in deciding adequate service levels, the standards listed below should not be considered absolutes but rather as general indicators. A summary of the standards used is displayed in Table E.5B.1. In the sections below, specific considerations relating to the choice of standards are discussed.

(b) Water Supply

Water systems are comprised of three components -- the supply source, the treatment facility and the pipe distribution network. The most widely used standards for water service are the average and peak water consumption per capita, in terms of gallons per day (gpd). Facility standards sometimes include pipe length per thousand dwellings, and treatment capacity.

The standards are relevant only for communities that have or are expected to develop water systems. Only two communities in the Local Impact Area, Palmer and Wasilla, have city-wide water supply systems. Other residents, including inhabitants of the communities that will be most affected by the project, rely on individual wells or "community" systems that serve a particular subdivision, trailer park or other small area.

An average per capita water consumption standard of 120 gallons per day in 1981 rising to 150 gpd by the year 2000 was used. The city of Palmer currently has an average per capita wtater usage rate of 120 gpd, and this relatively low usage may be attributed to the small amount of industry in the area. It is expected that future growth will include an increase in business activity and hence a rise in per capita water consumption.

(c) Sewage Treatment

The amount of sewage generated is a function of the amount of water that is used daily. It has been estimated that an average of 65 percent of total water supplied becomes sewage, or 100 gpd per capita, with the remainder used for miscellaneous purposes such as watering lawns and gardens, firefighting and generating steam (Stenehjem & Metzger, 1980). This standard may not be as appropriate for application to rural communities. Sewage treatment in Palmer is currently equal to 100 percent of average water usage, or 120 gallons per day per capita. For the purposes of projections of impacts, a con stant standard of 120 gpd has been used for Palmer, the only community with a sewage treatment system in the Mat-Su Borough.

(d) Solid Waste Disposal

Solid waste can be disposed through incineration or sanitary landfill disposal; sanitary landfill has become the prevalent mode. Facility requirements for solid waste disposal can be measured in terms of the amount of land needed per capita on an annual basis. Published standards range from 0.2 to 0.3 acres per thousand people, depending on assumptions of pounds of waste per capita, depth of the site and the rate of compression of the waste.

A lower standard of .11 acres per thousand population has been assumed initially for the Mat-Su Borough, based on the premises that waste production per capita is much lower and the fill depth of the central landfills is twice as high as national averages. This standard is calculated to rise to 0.21 acres by 2000 and held constant at this level between 2001 and 2005.

(e) Education

The major determinant of the requirement for educational facilities and services is the number of school-age children per capita, modified to take into account private school attendance. Two different methodologies were used to estimate the amount of school-age children associated with the (1) Base Case population and (2) in-migrant population associated with the Susitna project.

Under the Base Case, for the Mat-Su Borough, the standards that the school district uses for planning were used in this study as well. Short-term planning through 1987 uses an estimate of 22.8 percent. For long-range planning purposes, an estimate of 25 percent is used. For the purposes of this study, the ratio is assumed to rise gradually from 22.8 percent in 1987 to 25 percent in 2000 and then held constant at that level through 2005. In Cantwell, the present 18 percent level was assumed to remain constant over time in the Base Case.

The number of school-age children acoompanying workers on the project has been estimated using a ratio that was calculated through surveys of other large projects of .89 schoolchildren per in-migrant worker accompanied by dependents. The number of school-age children associated with the in-migrant secondary population was calculated on the same basis as Base Case school-age children.

A major service standard for education relates the number of school-age children to the number of classes and teachers. Local preferences have been used as standards in this case. In the Mat-Su Borough school district, planning standards iinclude an optimum of 25 students per class for primary schools and 20-22 for secondary schools. In addition, Mat-Su Borough statistics show that teachers comprise about 50 per cent of total school district personnel requirements. In Cantwell, the Railbelt School District's planning standard teacher-student ratio of 15:1 was used.

Requirements for classroom space can be measured in terms of number of classrooms or alternatively, the number of square feet per pupil (90 square feet for primary school students and 150 square feet for secondary school students). For the purposes of this study, space required has been projected in numbers of classrooms.

It is assumed that the present ratios of primary school students (54 percent of total) and secondary school students (46 percent of total) will remain constant. It is beyond the scope of this analysis to forecast changes in distribution by school and by grade.

(f) Health Care

Standards for acute public health care focus on the capability of hospital facilities and staff accommodate the expected number of patients without building overcapacity that will then add to hospital costs. While rule-of-thumb bed multipliers of between 2.1 and 5.8 beds per 1000 population are often used, it has become appropriate to base the number of beds on a measure of the long-term daily average daily census of patients using the hospital divided by the desirable occupancy rate. In Alaska, the recommended occupancy rates are 80 percent for urban hospitals and 55 percent for rural hospitals. The formulas used are:

Acute care Patient Days at Valley Hospital plus Days at Alaska and Providence for Borough Residents		/	Borough Population	= Hospital Use Rate for Borough Residents

Hospital Use Rate for Borough Residents	X	Estimated Borough Population	/	365 days in year	=	Projected Average Daily Census (PADC)

Projected Average Daily Census	X	Proportion of Bed Need Met at Valley Hospital	/	Minimum Occupancy for Rural Hospital (55%)	=	Valley Hospital Acute Care Bed Need

A significant aspect of the hospital system in Alaska deserves note. The Municipality of Anchorage has developed a comprehensive acute and long-term health care system that provides the main medical care for the residents of Southcentral Alaska, as well as other areas of the state. A large percentage of people living in areas such as the Mat-Su Borough, as well as Cantwell, presently elect to use hospitals in Anchorage over the local hospital due to the larger number of doctors (especially specialists) and the more modern facilities. However, the percentage of patients that use the Valley Hospital in Palmer has been rising rapidly in recent years, and this trend is expected to be accelerated by the planned addition to and renovation of this hospital, as well as the possible addition of certain medical specialists to the staff. It is assumed that the usage of Valley Hospital as a percentage of total Alaskan hospital use by Mat-Su Borough residents will rise from 38 percent in 1980 to 75 percent in 2000 and remain constant at that level through 2005.

Age and sex distributions of the population are important determinants of hospital use. For the purposes of this study, demographic factors have been assumed to remain constant.

(g) Law Enforcement

Police service standards range from one officer per thousand population in unincorporated rural areas to 1.5 officers per thousand population in small communities and 2 officers per thousand in moderately large cities. For the Local Impact Area, a rural standard of 1.0 officers per thousand was applied to the population projections for the area outside Palmer, which has its own police force.

Alaska State Troopers judge the relative adequacy of their staffs in terms of the average case load (i.e. number of crimes) that each officer is charged with investigating. Six cases per Trooper is considered average, and eight is considered the level at which additional staff is needed.

(h) Fire Protection

The major variables that are used to judge the fire protection are (1) the available flow of water. (2) the frequency of response, and (3) the manpower needed.

There are several standards that relate these variables to population size in the literature. Water flow, response time or service radii, and the equipment capacity are of particular use. It is common in communitites of less than 7,000 to rely on volunteer firefighters, and thus standards for manpower are not applicable to the communities under study.

Fire protection planning in Alaska, as in many other states, often takes the form of trying to achieve a certain fire rating as measured by the Insurance Service Organization (ISO). The ISO is a national organization that rates fire protection on a scale from one (best) to ten (worst); fire insurance rates closely reflect these ratings.

Communities without a community water system can at best achieve an ISO rating of 8 (which is the objective that the Mat-Su Borough presently hopes to achieve for its most populous fire districts). The requirements, to achieve a rating of 8 are: that dwelling class property be within five road miles of a fire station (on roads that are in good condition) and that the fire department has demonstrated its ability to deliver 200 gallons per minute (gpm) for a period of twenty minutes without interruption. The latter requirement implies a need for a capacity of 4,000 gallons of water "on wheels."

(i) Recreation

Projected requirements for recreation facilities, in terms of acreage for playgrounds, neighborhood parks and community parks, were calculated by applying national standards for rural areas (Stenehjem & Metzger, 1980). Standards for playgrounds and neighborhood parks are most applicable to the cities of Palmer, Wasilla, and Houston, whereas community parks are planned for larger areas, and the standard pertaining to this category is most relevant to Mat-Su Borough as a whole.

TABLE E.5B.1 - SUMMARY OF PUBLIC FACILITY AND SERVICE STANDARDS FOR SELECTED COMMUNITIES IN THE LOCAL IMPACT AREA

	Palmer	Wasilla	Houston	Trapper Creek	Talkeetna	Total Mat-Su Borough	Cantwell
Water Supply							
Average Water Supply & Treatment (gpd per capita)	120-150	120-150	-	-	-	-	-
Sewage Treatment							
Sewage Treatment (average gpd per capita)	150	-	-	-	-	-	-
Solid Waste Disposal							
Landfill Requirements (acres per 1,000 population)	.11-.21	.11-.21	.11-.21	.11-.21	.11-.21	.11-.21	.11-.21
Education							
Maximum Primary School-Age Children To Teacher Ratio	31	31	-	31	31	31	15
Maximum Secondary School-Age Children To Teacher Ratio	35	35	-	-	-	35	15
Teacher to Support Staff Ratio	8:1	8:1	8:1	8:1	8:1		
Health Care							
Desired Hospital Bed Occupancy Rate	-	-	-	-	-	55%	
Law Enforcement							
Police Officers (officers per thousand population)	1.5	-	-	-	-	1.0	1.0
Parks and Recreation							
Playgrounds (acres per 1000 dwelling units)	3.9	3.9	3.9	-	-	-	-
Neighborhood Parks (acres per thousand dwelling units)	3.3	3.3	3.3	-	-	-	-
Community Park (acres per thousand dwelling units)	-	-	-	-	-	4.8	

6 - GEOLOGICAL AND SOIL RESOURCES

SUSITNA HYDROELECTRIC PROJECT

EXHIBIT E

VOLUME 3 CHAPTER 6

GEOLOGICAL AND SOIL RESOURCES

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6 - 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 an 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" (1) and the "Final Report on Seismic Studies for the Susitna Hydroelectric Project," Woodward-Clyde Consultants (2).

2 - BASELINE DESCRIPTION

2.1 - Regional Geology

(a) Stratigraphy

The oldest rocks which outcrop in the region are a metamorphosed upper Paleozoic (Table E.6.1) rock sequence which trends northeastward along the eastern portion of the Susitna River Basin (Figure E6.1). 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 expressed in the project area around Watana and Portage Creeks. The Paleozoic and lower Mesozoic rocks are intruded by Jurassic plutonic rocks composed chiefly or granodiorite and quartz diorite. The Jurass ic age instrusive rocks form a batholithic complex of the Talkeetna Mountains.

Thick turbidite sequence of argillite and graywackes deposit during the cretaceous 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 in compostion and includes 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. Mafic volcanics, composed of andesite porphyry lie downstream from the Watana site.

(b) 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 in 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 orogency. 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 is postulated as representing an old suture zone, involving the thrusting of Paleozoic, Triassic and Jurassic rocks over the Cretaceous sedimentary rocks (2). Other compressional structures related to this orogency 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 Cenozoic time. 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.

(c) Glacial History

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 from both the Alaska Range and the Talkeetna Mountains that 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 Wisconsinian), glaciers filled the adjoining lowland basins and spread onto the continental shelf. 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 tills and lacustrine deposits.

2.2 - Quarternary Geology

Quaternary geology involved the study of geological processes in recent geologic time (i.e., the past 1.8 million years). In the site region these processes are primarily of glacial origin.

Within the site region, the late Quaternary surfaces are of greatest interest to the seismic geology study. These surfaces include those of Holocene and Pleistocene age (including the Wisconsinian and Illinoian stages). These surfaces are present throughout the site region, and their age ranges from a few years to approximately 120,000 years before present.

The Talkeetna Mountain region existed as an extensive mountainous to rolling upland at the beginning of the Quaternary Epoch, approximately 1.8 years ago. Subsequent to that time a series of climatic fluctuations, apparently began to affect the region. The fluctuating climate, lead to several periods of extensive glaciation during polar conditions. At its Quaternary maximum, glacier ice formed an ice cap over the Talkeetna Mountains. These periods of glaciation were separated by interglacial periods with relatively temperate climatic conditions generally similar to those now found in the region.

Amoung the more recent glaciations that occurred in the Talkeetna Mountains, four were recognized during this investigation in the Quarternary study region (Figure E6.2). The glaciations and their respective ages are: pre-Wisconsin, Early Wisconsin, Late Wisconsin, which included four stades, each of which was less extensive than the preceding one; and Holocene.

The ages for the four glaciations were assigned on the basis of radiocarbon age dates obtained for this study and generally accepted age assignment for similar glacial sequences elsewhere in Alaska (2).

There are ten types of Quaternary glaciogenic features that were used in part to interpret the age and extent of Quarternary surfaces. These features include: till, lacustrine deposits, outwash deposits, ice disintegration deposits, kame terrace deposits, fluvial deposits, fluting, trimlines, side glacial channels, and an assortment of glacially sculptured bedrock forms including whalebacks, stoss and lee, and grooves. Additional data including maps of the Quaternary surfaces are contained in the Final Report on Seismic Studies (2).

2.3 - Seismic Geology

(a) Introduction

A detailed seismologic study for the Susitna project was undertaken by Woodward-Clyde Consultants. The study, performed over a two year period, included:

- Detailed literature research;
- Interpretation of remote sensing data;
- Geologic mapping of faults and linears;
- Microseismic monitoring;
- Ground motion studies; and
- Analysis of dam stability.

Details of Woodward-Clyde's study are presented in Reference 2. A summary of their study is presented below.

(b) Conceptual Approach

According to present understanding of plate tectonics, the earth's lithosphere, which contains the brittle 12 to 19 miles (20 to 30 KM) or so of more 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 the 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. Criteria further study are that faults that have been subject to surface displacement within approximately the past 100,000 years are classified as having recent displacement.

Inherent with this concept of "fault with recent displacement" is the basic premise that faults without recent displacement will not have surface rupture nor be a source of earthquakes. Faults without recent displacement (as determined during this investigation) are considered to be of no additional importance to Project feasibility and dam design.

(c) 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 volcaes to the west, and the Benioff zone at depth (Figure E6.3). 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. None of the faults and lineaments observed 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.

(d) 1980 Approach

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 setforth in Woodward-Clyde's report (2). 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 microearthquake 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.

(e) Significant Features

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.

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; an estimation of the preliminary 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 dam site, 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 E6.4).

Of these 13 features, four are in the vicinity of the Watana site including the Talkeetna thrust fault (KC4-1), Susitna feature (KD3-3), 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.c., KC4-1) has been assigned to each fault and lineament.

These significant features were delineated for study during the 1981 program.

(f) 1981 Approach

The 1981 study of the 13 significant features identified during 1980 involved the following objection.

- Assessing the likelihood that each of the 13 features is a fault;
- Assessing the age of the sediments overlying each of the 13 features;
- Selecting an excavating trenches across topographic features that resembled topographic expression of faults in the young geologic deposits;
- 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;
- 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;
- 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;
- 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);
- 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;
- Estimating the potential for surface rupture on any faults with recent displacement within 6 miles (10 km) of the dam sites; and

- Estimating the values of ground-motion parameters for the seismic sources identified in objective (_) above that are appropriate for seismic design.

(g) Results of Study

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 (10 km) 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.6.3). 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.

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 (100 kM) 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.

Interpretations 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 surace 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.

As discussed previously, earthquakes up to a given magnitude could occur on faults with recent displacement that might not be detectable by our 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.

(h) 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.

Sources of moderate earthquake appear to exist within the Talkeetna Terrain, although no faults with recent displacement were detected by the 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			
	MCE	Devil Canyon		Watana	
Source	(M_S)	miles/(km)		miles/(km)	
Castle Mountain fault	7-1/2	71	(115)	65	(105)
Denali fault	8	40	(64)	43	(70)
Benioff zone (interplate)	8-1/2	57	(91)	40	(64)
Benioff zone (intraplate)	7-1/2	38	(61)	31	(50)
Detection level earthquake	6	<6	(<10)	<6	(<10)

Estimated mean peak horizontal ground accelerations and duration of strong shaking (significant duration) at the sites due to the governing maximum credible earthquake are the following.

		Mean Peak Acceleration		
Earthquake Source	Maximum Magnitude	Watana Site	Devil Canyon Site	Significant Duration (sec)
Benioff Zone	8-1/2	8.35g	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.

(i) Reservoir-Induced Seismicity (RIS)

The studies concluded that there would be a high 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".

2.5 - Watana Site

(a) 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 E6.5.

(i) Overburden

Overburden thickness in the damsite area ranges from 0 up to 80 feet in localized areas. On the lower slopes, the overburden consists primarily of talus. The upper areas of the abutments near the top of the slope are deposits of glacial tills, alluvium, and talus. Subsurface investigations show the contact between the overburden and bedrock to be relatively unweathered.

The depth of the river alluvium beneath the proposed dam averages about 80 feet and consists of sand, silt, coarse gravels and boulders.

(ii) 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 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 from the damsite is an andesite porphyry. This rock is medium to dark gray to green and contains quartz diorite inclusions. The contact zone of the andesite with the diorite is generally weathered and fractured up to 10 to 15 feet above the contact.

(iii) Bedrock Structures

- Joints

There are two major and two minor joint sets at the site. Set 1, 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 1 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 develope 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 shear zones parallel this orientation. Set IV appears to have developed from stress relief from glacial unloading and/or valley erosion.

Table E6.2 details the joint characteristics.

- Shears and Fracture Zones

Several shears, fracture zones, and alteration zones are present at the site (Figure E6.5). 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 E6.5).

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 shear zones have high RQDs and the rock is fresh and hard. The second type is common to all rock types and consists of unhealed brecca and/or gouge. These shear zones are soft, friable, and often have secondary mineralization of carbonate and chlorite showing slickenslides. These zones are generally less than 1 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 or carbonate coated. Where exposed, the zones trend to form topographic lows.

Alteration zones are areas where hydrothermal solution 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 zones may range to 20 feet thick although are usually less than 5 feet.

(b) Structural Features

The Watana site has several significant geologic features consisting of shears, fractures and alteration zones described previously (Figure E6.5).

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. It is an area approximately 400-feet wide, characterized by three major northwest trending zones of shearing and alteration that have eroded into steep gullies. These alteration zones are separated by intack rock bands (ribs) 5 to 50 feet wide. The 20-foot-wide upstream zone of the series coincides with the diorite/andesite porphyry contact. The other two zones, approximately 55 and 30 feet wide, are filled with severely altered rock. This zone trends 310° with a near vertical dip. The extension of the zone has been extrapolated to extend northwestward outcropping in Tsusena Creek.

The "Fingerbuster" is located downstream from the damsite and is exposed in a 40-foot-wide deep talus-filled gully along the andesite porphyry/diorite contact (Figure E6.5). The rock is severely weathered with closely spaced joints trending parallel to Set I (330°) and Set III (0°). Slickenslides indicate vertical displacement. The extension of this zone to the south is based on a strong north-south topographic lineament. Because of the lack of exposure, its location and extent have been approximated.

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.

(c) Ground Water Conditions

The ground water regime in the bedrock is confined to movement along fractures and joints. The water table is a subdued replica of the surface topography. Water levels on the right abutment are deep, ranging from about 110 to 280 feet. Ground water conditions on the south abutment are complicated because of the apparent continuous thick permafrost resulting in a perched water table near surface and a deep table below the frost.

(d) Permafrost Conditions

Permafrost conditions exist on the north-facing slopes (left bank) of the damsite area. Measurements indicate that permafrost exists to a depth of 200 to 300 feet. Temperature measurements show the permafrost to be "warm" (within 1°C of freezing). No permafrost was found on the north abutment but sporadic areas of frost can be expected.

(e) Permeability

The rock permeability does not vary significantly within the site area; generally ranging between 1 x 10-4 cm/sec to 1 10-6 cm/sec. The permeability is controlled by a degree of fractures within the rock, with the higher permeability occurring in the more sheared and fractured zone. Permeabilities tend to decrease with depth (Figure E6.7).

(f) Relict Channels

(i) Watana Relict Channel

A relict channel exists north of the Watana damsite. The location of this preglacial feature is shown in Figure E6.8. The maximum depth of overburden in the thalweg channel, as shown in Figure E6.8, is approximately 450 feet.

The stratigraphy in the channel has been described by a number of stratigraphy units as shown in Figure E6.9 as A through K.

Taking these in order these units are described as follows:

Units A and B are the near surface deposits consisting of organic tundra material and a silty sand matrix. Unit C is glacial outwash. Unit D occurs locally as well sorted alluvial sands, silts and gravels while Units E and F are glacial outwash similar to Unit C. Unit G contains greater amounts of fine material with clay and lacustrine deposits with ice rafted cobbles and boulders. Unit H is a series of alluvial and outwash deposits. Unit I is a fill as is the underlying Unit J. Overlying the dense till of J is J' which is a localized clean sand and gravel deposit. The deepest deposit overlying bedrock is Unit K which is composed of boulders, cobbles and gravels.

(ii) 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.

(g) Borrow Areas

Several borrow areas have been identified in the Watana site area and are shown in Figure E6.10. The gradation of the materials from each of these sites as shown in Figures E6.11 through E6.16.

In addition to the granular and finer grained borrow sites, Quarry Site A, which is a large diorite and andesite exposure on the left abutment may be used for rockfill.

2.6 - Devil Canyon Damsite

A detailed description of the site investigations and the geologic and geotechnical conclusions at the Devil Canyon site is provided in the 1980-81 Geotechnical Report (1). The following is a brief summary and interpretation of the findings presented in the Geotechnical Report.

(a) Geologic Conditions

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 E6.17 in this section.

(i) Overburden

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. 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.

(ii) Bedrock Lithology

The bedrock at the Devil Canyon site is a low-grade metamorphosed sedimentary rock consisting predominantly of argillite with interbeds of graywacke. A geologic map of the site is shown in Figure E6.17. 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 non-existent foliation. The graywacke is interbedded with the argillite in beds generally less than 6 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 1 foot wide and unfractured with tight contacts. Sulphide mineralization is common with pyrite occurring in as much as 5 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 (Figures E6.17) 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.

(iii) Bedrock Structures

- Bedding

The argillite/graywacke has been completely 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 E6.17). 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.

- Joints

Four joint sets have been delineated at Devil Canyon. Set I (strike 320° to 355° and dips 60° to 70° NE) and Set II (strike 040° to 065° and dips 40° to 60°S) are the most significant. 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 6 inches. Set III 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 lesss than 1 foot to more than 10 feet. The spacing and tightness of the joints increase with depth.

Tables E6.3 and E6.4 characterize the joints at Devil Canyon.

- Shears and Fracture Zones

Shears and fracture zones were encountered in localized areas of the site in both outcrops and boreholes (Figure E6.17). Shears are defined as areas containing breccia, gouge, and/or slikenslides indicating relative movement. These zones 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 1 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.

(b) Structural Features

Several structural features at the Devil Canyon site were investigated during the 1980-1981 program.

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 investigaitons (2). 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 several-hundred-foot drop-off in the bedrock surface under the alluvial fan was detected by seismic refraction surveys. Land access restrictions imposed during the study prohibited any further investigation of this area. Possible explanation for this apparent anamalous drop-off could be attributed to misinterpretation of the seismic data or else the lower velocity material could be either a highly fractures rock in lieu of soil or an offset of the rock surface caused by faulting. The latter interpretation in unlikely in that work performed in this area concluded that there was no compelling evidence for a fault. Future work remains to be done in this area to more clearly define this feature.

Detailed examination of rock core and mapping in the river valley bottom showed no evidence for through going faulting in the riverbed.

(c) Ground Water Conditions

Ground water migration within the rock is restricted to joints and fractures. It is inferred that the ground water 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.

(d) Permafrost

No permafrost was found in either the bedrock or surficial material at or around the damsite.

(e) Permeability

Rock permeability ranges from approximately 1×10^{-4} cm/sec to 1×10^{-6} cm/sec with tower permeabilities generally at depth. Higher permeability occur in the more weathered fractured rock zones (see Table E6.28).

(f) Geology Along Proposed Long Tailrace Tunnel

(i) Introduction

This section discusses the lithology and structure along the proposed long 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.

(ii) Lithology

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 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 grandodiorite 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.

(iii) Structures

Joints sets and shear/fracture zones similar to those mapped at the damsite are likely to occur along the tailrace tunnel (see Figure E6.19).

The four joint sets identified at the damsite continue downstream; however, variations in orientation and dip occur. Table E6.4 contains a list of joint characteristics for joints along the tailrace tunnel.

Joint Set I is northwest trending with a moderate to high angle dips to the northeast and southwest. The average strike and dip of this set in the tailrace area is 325° and 70° northeast, respectively, which differs 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 rth 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. Tailrace geology is shown in Figure E6.19.

(g) Borrow Areas

Borrow site G has been identified as a source of granular material for concrete aggregate. The range of grain sizes in borrow area G area shown in Figure E6.21.

A rock quarry area designated as borrow site K has been identified approximately 5,300 feet south of the saddle dam. This area contains a granodiorite similar to rock found at the Watana damsite.

2.7 - Reservoir Geology

(a) Watana

(i) 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 photo-analysis are contained in the 1980-81 Geotechnical Report (1).

(ii) Surficial Deposits

Generally, the lower section of the Watana Reservoir and adjacent slopes are covered by a vaneer 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 less 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 exhibits a crude stratification.

On the south side of the Susitna River, the Fog Lake 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 comprised of 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.

(iii) Bedrock Geology

The Watana damsite is underlain by a diorite pluton. Approximately three miles upstream of the Watana damsite, a non-conformable 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 of the confluence of Watana Creek and the Susitna River, the bedrock consists of semi-consolidated, Tertiary sediments and volcanics of Triassic age. These Triassic volcanics consist of metavolcaniclastic rocks and marble. From just upstream of Watana Creek to Jay Creek, the rock consists of a metavolcanogenic sequence dominantly composed of metamorphosed flows and tuffs of basaltic to andesitic composition. From Jay Creek to just downstream of 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.

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 of the Watana damsite. The southwest end of the fault is overlain by unfaulted Tertiary volcanics.

(b) Devil Canyon

(i) 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 grandodiorite crosses the Susitna River just upstream of the Devil Canyon damsite. It is non-conformable 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)

(a) 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 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 (2) 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 an 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 Deveil Canyon-Watana reservoir will be approximately 87 miles (140 km) 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	Ingenous	Ingenous

The combined hydrologic body of water, as proposed, would constitute a very deep, very large reservoir within a primarily ignenous bedrock terrain that is undergoing compressional tectonic stress.

(b) Evaluation of Potential Occurrence

(i) Likelihood of Occurrence

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 conductive to RIS occurrence.

Models have been developed by Baecher and Keeney in Packer and others (2) 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 calcualted 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.

(ii) Location and Maximum Magnitude

Woodward-Clyde Consultants (2) among other, have 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 reserovir 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 (2) 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 prosed reservoir has been described as an envelope with a 19-mile (30 km) radius that encompasses the reservoir area, as discussed in Woodward-Clyde Consultants (2).

Previous studies (2) present evidence that strongly suggests that moderate to large RIS events are expected only to occur 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 eigth of these ten reservoirs (2).

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.

3.2 - Seepage

Due to construction of the Watana and Devil Canyon dams and the impoundment of the reservoirs, one of the main impacts will be the creation of a gradient through which induces seepage.

Specifically, as in any dam, there will be the tendency for seepage through the foundation rock. Permeabilities in the foundation of both dams are not high and are amenable to grouting.

Buried channels which bypass the dam present the only other seepage path of concern at either of the two dam sites. 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 there are two channels which will be impacted by increased seepage gradients. The channel to the south of the river in the Fog Lakes area is not expected to pose seepage problems due to the low gradient and long travel distance (approximately 4-5 miles) from the reservoir to Fog Creek. However, additional work will be required in this area to accurately determine subsurface conditions.

The relict channel north of the Watana site poses the greatest potential for seepage, particularly through the deepest deposits on a path from the reservoir to Tsusena Creek.

In addition to loss of water from the reservoir the main impact of seepage through the buried channel area could result in piping and erosion of materials at the exist point on Tsusena Creek.

A further potential impact is saturation of the various zones in the buried channel combined with the thawing of permafrost in this area which could lead to a condition which could culminate in liquefaction of one of the horizons. This could, most likely, occur during a strong earthquake, but could be triggered due to surface loading. The stratigraphy of the relict channel was defined during 1980-81 exploration work (1) and subsequently summer of 1982. The preliminary results of that work show 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 may have resulted in overconsolidating the majority of the unconsolidated sediments within the relict channel thereby minimizing their potential for liquefaction.

3.3 - Reservoir Slope Failures

(a) General

Shoreline erosion will occur as a result of two geologic processes: (1) beaching, and (2) mass movement. The types of mass movement expected to occur within the reservoirs will be:

- Bimodal Flow;
- Block Slide;
- Flows;
- Multiple Regressive Flow;
- Multiple Retrogressive Flow/Slide;
- Rotational Slides;
- Skin Flows;
- Slides; and
- Solifluction Flow.

Aside from the formation of beaches due to erosion, instability along the reservoir slopes can result from two principal causes: a change in the ground water 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.

- Changes in Ground Water Regime

  As a reservoir fills, the ground water table in the adjacent slope also rises. This may result in a previously stable slope above the ground water table to become unstable due to increased pore pressures and seepage acting on the slope.

  Rapid drawdown of a reservoir may also result in increased instability of susceptible slopes.

- Thawing of Permafrost

  Solifluction slopes, skin flows and the lobes of bimodul flows are caused by instability on low angle slopes resulting from thawing of permafrost. Mobility is often substantial and rapid as the movements are generally distributed throughout the mass.

- Stability During Earthquakes

  Submerged slopes in granular materials, particularly 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 have the reservoir rim in which the ground water table has re-established itself could have a greater potential for sliding during an earthquake due to the increased pore water pressures.

  Thawing permafrost could generate excess pore pressures in som 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 is not extensive in the reservoir areas. Therefore, it is considered that the extent of failures due to liquefaction during earthquakes will be small and primarily limited to areas of permafrost thaw. Some slides could occur above the reservoir level in previously unfrozen soils due to the earthquake shaking.

(b) 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 E6.22 and E6.24 and consist of several types of beaching, flows and slides that could occur in the reservoir during and after impoundment. 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 E6.24 through E6.48. As stated above, these maps have been constructed using 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 (1).

(c) 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 a narrow and deep with minimal seasonal drawdown. From Devil Canyon Creek downstream to the damsite, the slopes of the reservoir and its shoreline consist primarily of bedrock with localized areas of thin vaneer of colluvium or till. Upstream of 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 possibility of sporadic permafrost existing within the delineated areas. Upstream of this are the basal till is nearly continuously frozen as evidenced by field information in Borrow Area H.

Downstream of 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 heaving 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 stability. In Devil Creek, a potential small block slide may occur after the reservoir is filled.

Above Devil Creek up to about river mile 180, beaching will be the most common erosive agent. Present slope instability above reservoir normal pool level will continue to occur, with primary beaching occurring at the shoreline. At approximate river mile 175, there is and old landslide on the south abutment. This large rotational slide is composed of basal till which, for the most part, is frozen. A large bimodal flow exists within this block headed by a large block of ground ice. Yearly ablation of the ice results in flowage of saturated material downslope. The landslide has an arcuate back scarp which has become completely vegetated since its last movement. However, this landslide, which has an estimated volume of 3.4 mcy, could possibly be reactivated due to continued thawing or change in the ground water regime brought about with reservoir filling.

Since the maximum pool elevation 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 is indicative of stable slope conditions after reservoir impounding.

- An old large 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.

(d) 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 sporatic to continuous in the lacustrine deposits. The distribution of permafrost has been delineated primarily on the flatter slopes below elevation 2300 feet. Inclined slopes may be underlain by permafrost, but based on photogrametric characteristics, 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), indicate 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.

Three major factors which will contribute significantly to slope instability in the Watana Reservoir are changes in the ground water regime, large seasonal fluctuation of the reservoir level (estimated at 100 feet), and thawing of permafrost.

It is estimated that filling of the reservoir to normal pool level will take approximately three years. Due to 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 ground water regime has reestablished tself in the frozen soils.

Near the damsite, assuming that the present contours will remain unchanged, the north abutment will primarily be subject to beaching except for some small flows and slides, which may occur adjacent to Deadman Creek. On the south abutment, thawing of the frozen basal tills will result in numerous skin and bimodal flows. There is also a potential for small rotational sliding to occur primarily opposite Deadman Creek.

On the south abutment between the Watana damsite and Vee Canyon, the shoreline of the reservoir has a high potential for flows and shallow rotational slides. In contrast to the north abutment, 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 abutment below Vee Canyon and on both abutments upstream of 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 abutment, in contrast with the south abutment, 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 is high due to: (a) the wide seasonal drawdown zone that will be in contact with a thin vaneer 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 be come thermal niche erosion resulting in small rotational slides.

The potential for a large block slide occuring, and generating a wave which could overtop the dam is very remote. For this to occur, a very high, steep slope with a potentially unstable block of large volume would need to exist adjacent to the reservoir. This condition was not observed within the limits of the reservoir. In approximately the first 16 miles upstream of the dam, the shoreline will be in contact with the low slopes of the broad U-shaped valley. Between 16 and 30 miles upstream of 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 which might generate a wave that could overtop the dam is remote; and

- The period in which restabilization of the slopes adjacent to the reservoir will occur is largely unknown.

In general, most of the reservoir slopes will be toally submerged. Areas where the filling is above the break in slope will exhibit less stability problems than those in which the 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 has already been discussed in relation to reservoir slope failures and liquefaction potential above the relict channel at the Watana site.

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 as well as cause increased seepage through the south abutment of the Watana dam.

With regard to settlement it is anticipated that the freeboard dike, 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 will occur due to thawing of the permafrost.

Since fractures in the rock below the south abutment of the Watana dam are ice-filled to approximately 200 feet, thawing of this permafrost may cause additional seepage even though thawing will be induced prior to grouting of the cutoff below the core. This thawing will be generated due to the thermal effect of the large reservoir which will remain several degrees above freezing throughout the year. It is anticipated that thawing in the cutoff zone can be effectively accomplished prior to grouting and that grouting the foundation below the core in this zone is feasible.

3.5 - Seismically Induced Failure

Details of seismic induced failures in the reservoir are addressed in Section 3.3.

Seismically-induced failure in the relict channel area has been addressed and although it is possible there are mitigation measures which can be undertaken.

The access route and transmission lines in the immediate site area, that is 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 landslides 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.

4 - MITIGATION

4.1 - Impacts and Hazards

Section 3 identified four major impacts which area either generates due to construction of the project as it affects the geologic environment and one major impact of the seismic environment on the project. These impacts 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 mentioned impacts the avoidance of geologic hazards is also addressed.

4.2 - Reservoir-Induced Seismicity

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 carefully 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. A manual for operation of the system has been prepared and is included as Reference 3. Consideration 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.

4.2 - 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. The effect is to reduce the amount of seepage as well as control 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 in the design for the construction of underground grouting gallaries which will provide access for remedial grouting. In addition, extensive instrumentation of the dam and abutments will be implaced during post construction for long-term monitoring of seepage.

Seepage through the relict channel at the Watana site will be handled by a two-step process. Initially a more detailed drilling program will be initiated at the beginning of 1983 to investigate the materials at depth in the channel. This will provide data on grain size, permeability, continuity of horizons and hence the potential for seepage.

Secondly, the design provides for a downstream filter to control piping should it occur. Materials would be stockpiled and used for construction of filters to control exit gradients at locations where seepage is observed.

4.3 - Reservoir Slope Failures

It is anticipated that, although instability of reservoir slopes will occur and to some extent be an ongoing occurrence in the Watana reservoir their impact on the project will be minimal. The magnitude of wave generated in the reservoir due to 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 tential for larger slides in the Watana reservoir.

4.4 - Permafrost Thaw

Two possible impacts will be felt due to permafrost thaw, both at the Watana site. Settlement of facilities in areas of deep overburden and increased seepage through the dam foundation.

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 has been provided which will evenly distribute the load and insulate the subsoil, hence retarding thaw.

Regrading of the airstrip and monitoring of settlements at the freeboard dike will be necessary as a maintenance program to offset the affects of differential settlement in these areas.

The permanent camp is located in an area relatively permafrost on good soils to prevent long term problems.

4.5 - Seismically-Induced Failure

If subsequent studies show the potential for liquefaction in the buried channel area, it is feasible to excavate through this horizon and rebuild the freeboard dike foundation to a point below this layer.

Seismically-induced failure of reservoir slopes, although possible will not be hazardous to the project.

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.

4.6 - Geologic Hazards

There are only three main geologic features which can have an affect on the construction an. d operation of the power facilities at the two sites. These are the short shear zone south of the parallel to the river at Devil Canyon, the "Fins" feature upstream of the Watana site and the "Fingerbuster" zone downstream of 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 are posed. Tunnelling through such a feature could pose problems with large tunnels. However, only the small drainage gallery is planned to pass beneath the saddle dam.

TABLE E6.1 GEOLOGIC TIME SCALE

ERA	PERIOD	EPOCH	GLACIATION	MILLION OF YEARS AGO
Cenozoic	Quaternary	Holocene Pleistocene	Wisconsinian 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 E6.2 : 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'			
	SE		090°		25°S			Planar to irregular, smooth to rough, discontinuous	--	Probably stress relief, near surface
			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 E6.3: DEVIL CANYON JOINT CHARACTERISTICS*

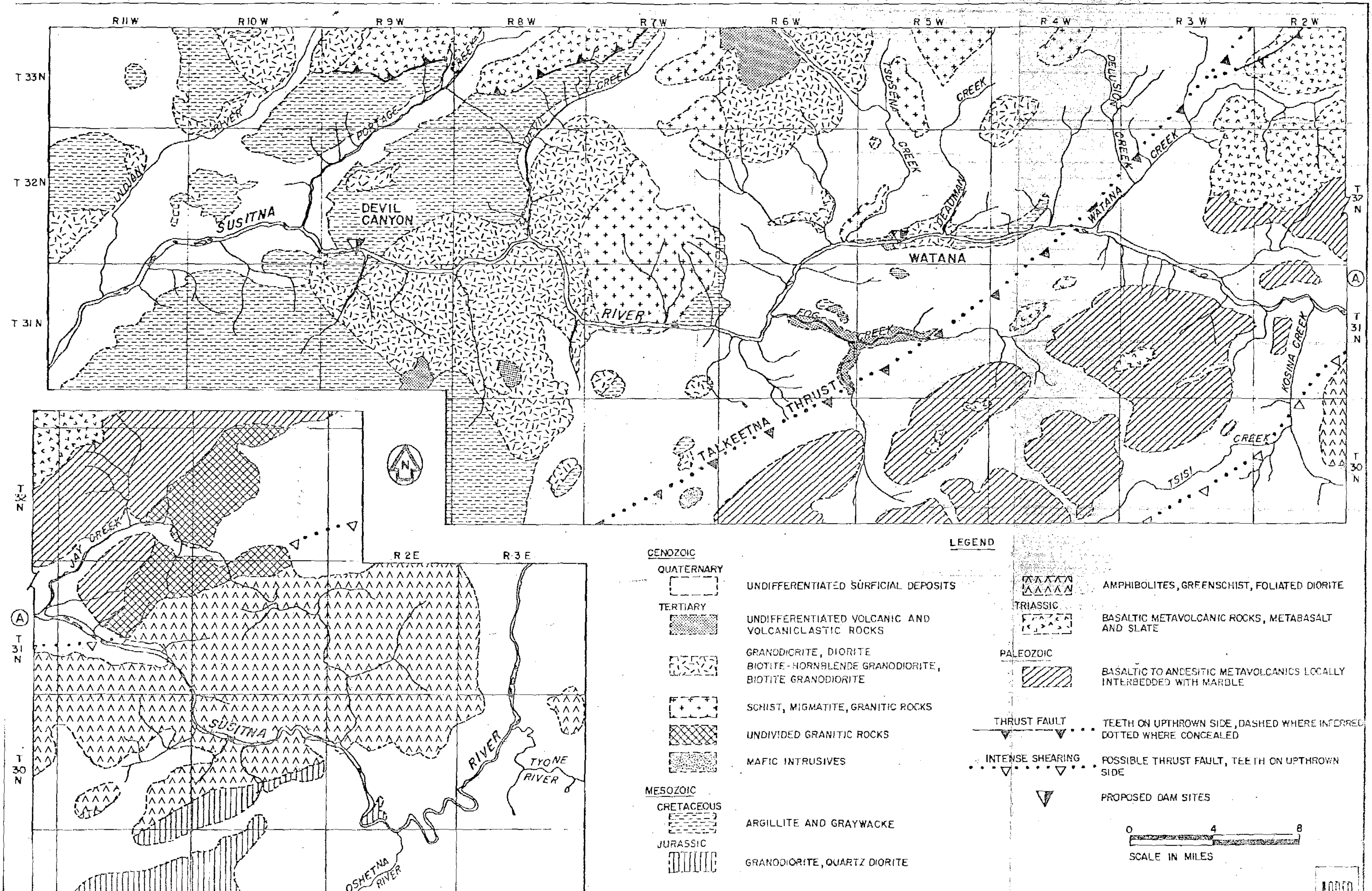
Joint Set	Location	Strike (Range)	Strike (Avg.)	Dip (Range)	Dip (Avg.)	Spacing** (Range)	Spacing** (Avg.)	Surface Conditions: Texture	Surface Conditions: Coating	Remarks
I	North Bank	320°-0°	345°	60°NE-70°SW	80°NE	0.5"-10'	1.5'	Planar, smooth, occasional rough, continuous	Occasional iron oxide and carbonate	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 E6.4 DEVIL CANYON TAILRACE TUNNEL - JOINT CHARACTERISTICS*

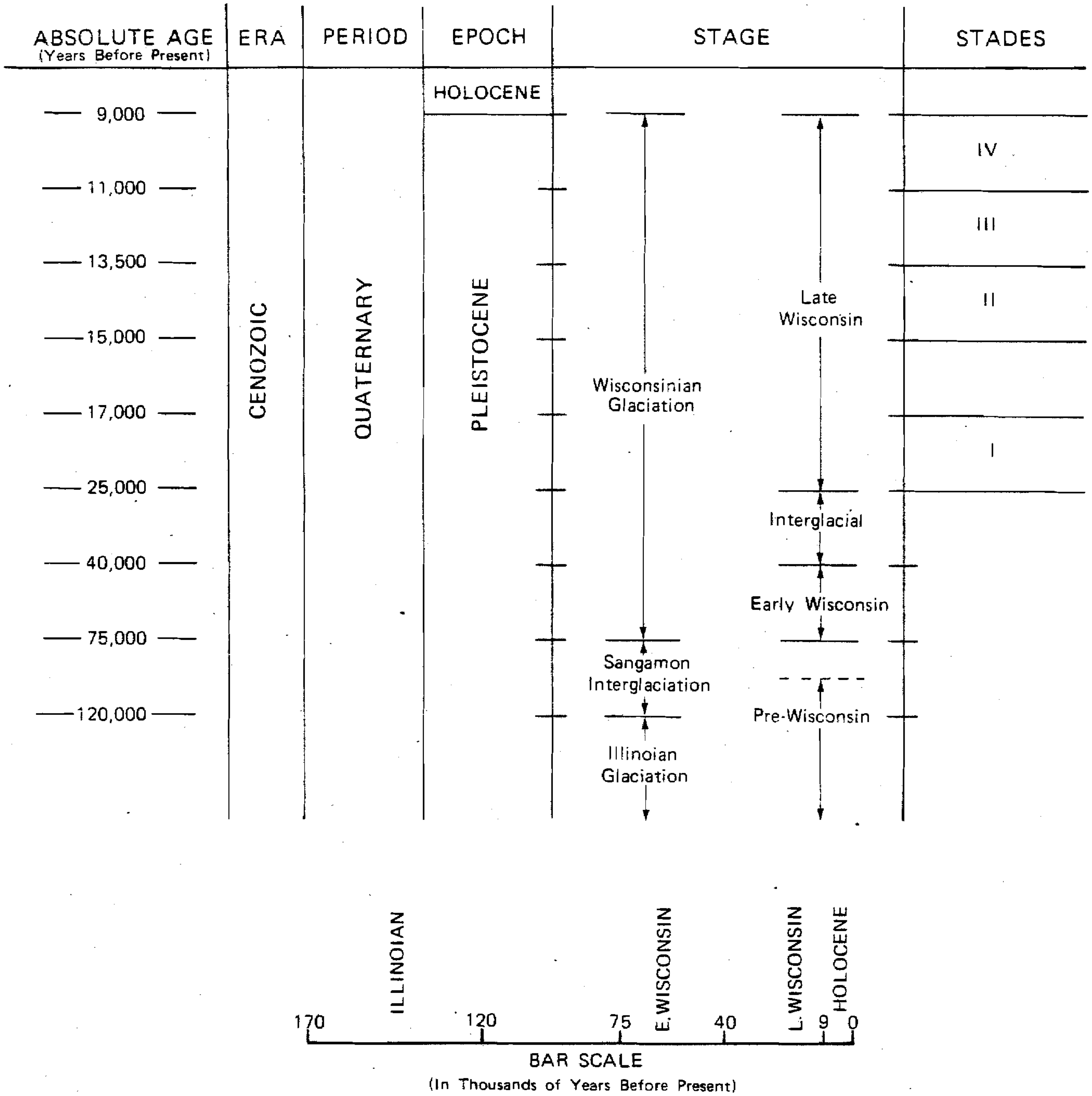
Joint Set	Strike (Range)	Strike (Avg.)	Dip (Range)	Dip (Avg.)	Spacing** (Range)	Spacing** (Avg.)	Surface Conditions: Texture	Surface Conditions: Coating	Remarks
I	284°-355°	325°	50°NE-55°SW	70°NE	0.5"-10'	1.5'	Planar, smooth, occasional rough, continuous	Occasional iron oxide and carbonate	Parallel to 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



REGIONAL GEOLOGY

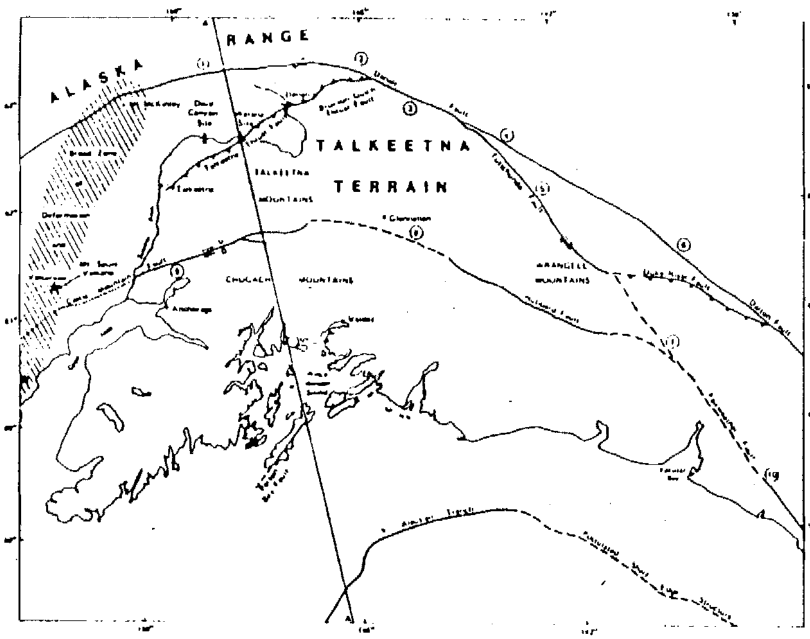
FIGURE E6.1



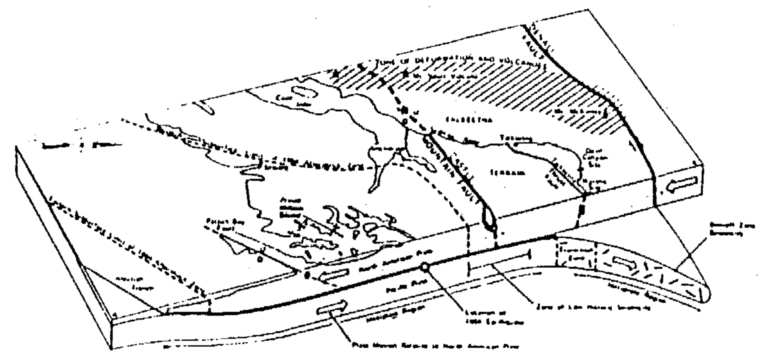
NOTES

1. Era through Epoch terminology and absolute ages are after Van Eysinga (1978).
2. Stage terminology and ages are after Pewe' (1975).
3. Stade ages are modified after Ten Brink and Waythomas (in press).

QUATERNARY STUDY REGION
TIME SCALE



A. TALKEETNA TERRAIN MODEL



B. SCHEMATIC TALKEETNA TERRAIN SECTION

LEGEND

Mapped strike-slip fault, arrows show sense of horizontal displacement

U
D
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

NOTES

1. 0.9 – 2.0 cm/yr Hickman and Campbell (1973); and Page (1972).
2. 0.5 – 0.6 cm/yr Stout and others (1973).
3. 3.6 cm/yr Richter and Matson (1971).
4. 1.1 cm/yr, no Holocene activity farther east, Richter and Matson (1971).
5. 0.9 – 3.3 cm/yr Richter and Matson (1971).
6. Inferred connection with Dalton fault; Plafker and others (1978).
7. Inferred connection with Fairweather fault; Lahr and Plafker (1980).
8. Connection inferred for this report.
9. 0.1 – 1.1 cm/yr Detterman and others (1974); Bruhn (1979).
10. 5.8 cm/yr Lahr and Plafker (1980).
11. Aleutian Trench and Postulated Shelf Edge Structure after Guptill and others (1981).
12. Slip rates cited in notes 1 through 10 are Holocene slip rates.
13. All fault locations and sense of movement obtained from Beikman (1978; 1980).

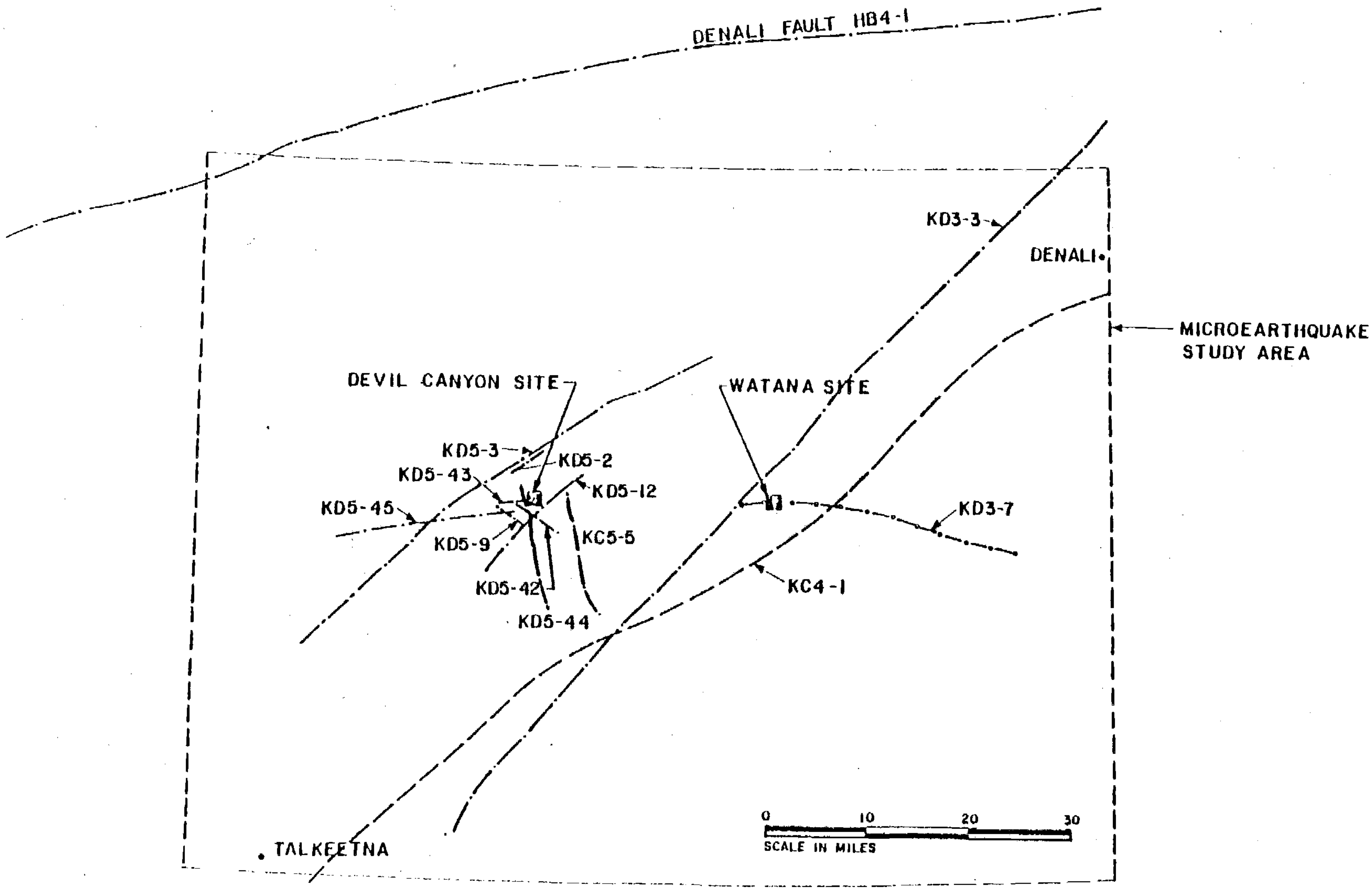
0 100 200 Miles
0 100 200 Kilometers

TALKEETNA TERRAIN MODEL
AND SECTION

FIGURE E6.3

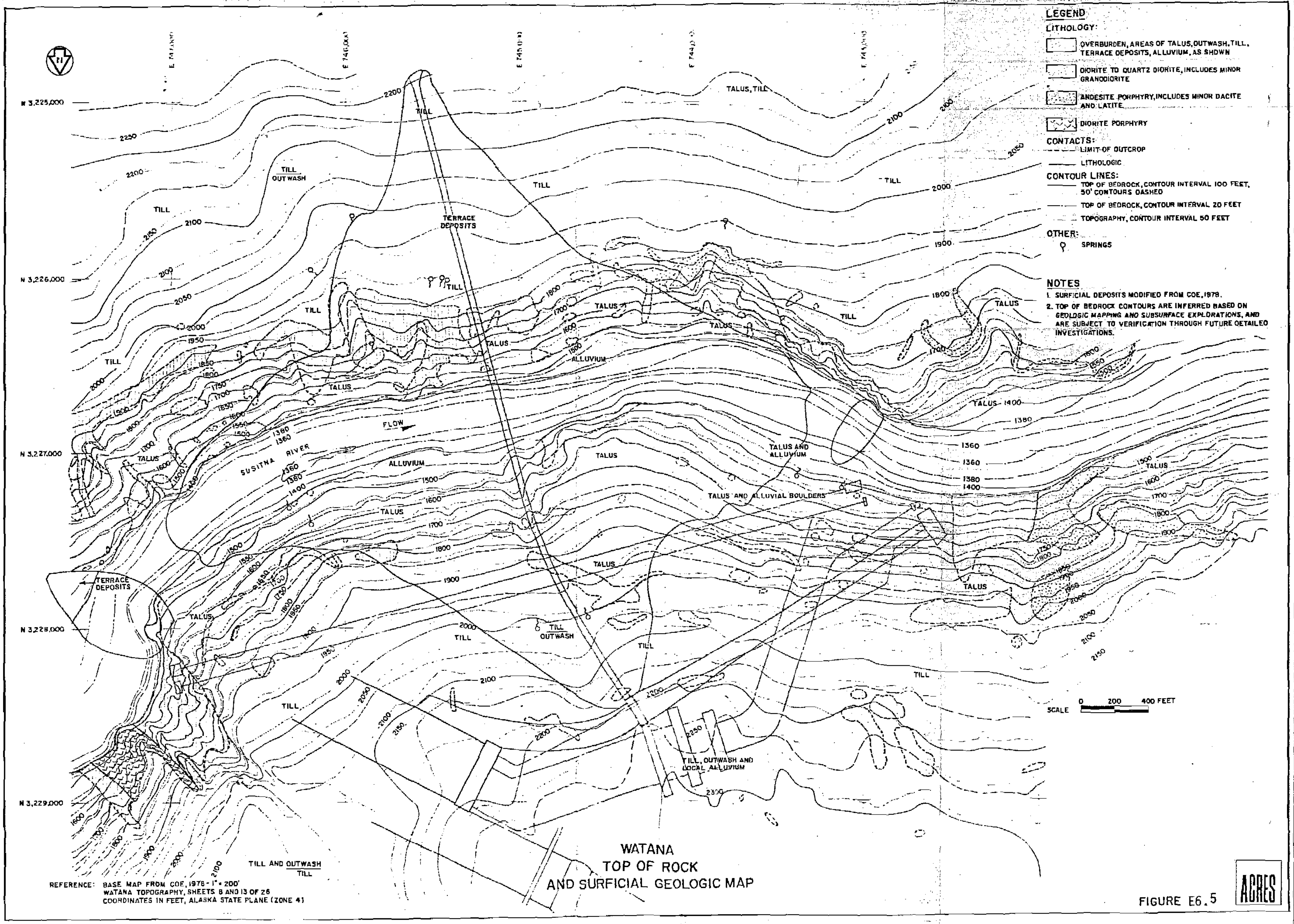
ACRES

WOODWARD-CLYDE CONSULTANTS 41410A February 1982



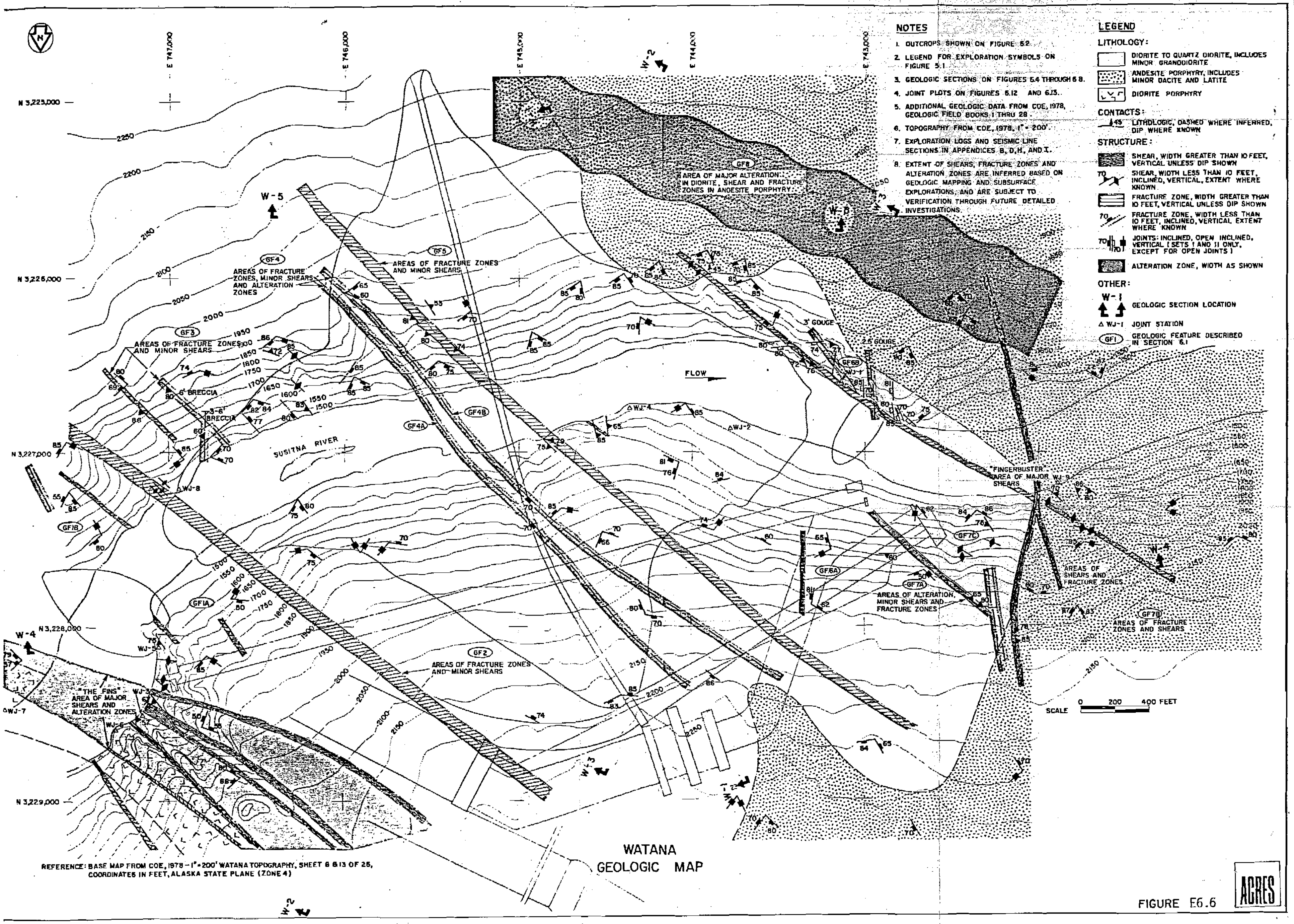
FEATURES SELECTED FOR 1981 STUDIES

Figure E6.4



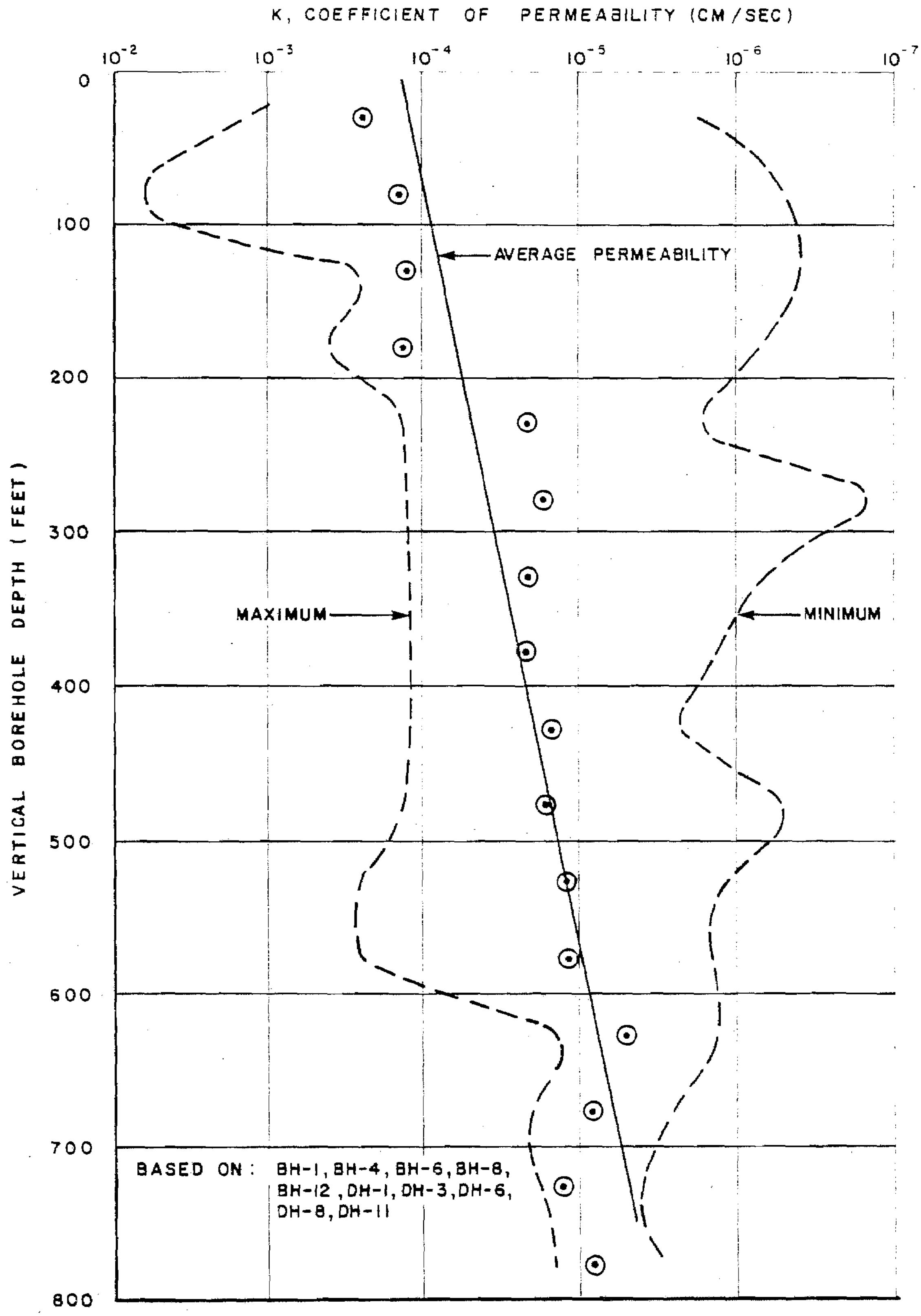
WATANA
TOP OF ROCK
AND SURFICIAL GEOLOGIC MAP

FIGURE E6.5



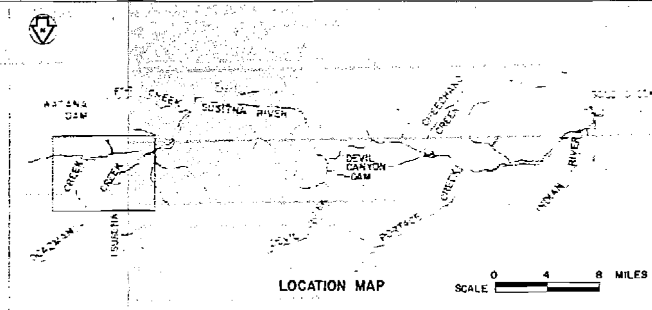
WATANA
GEOLOGIC MAP

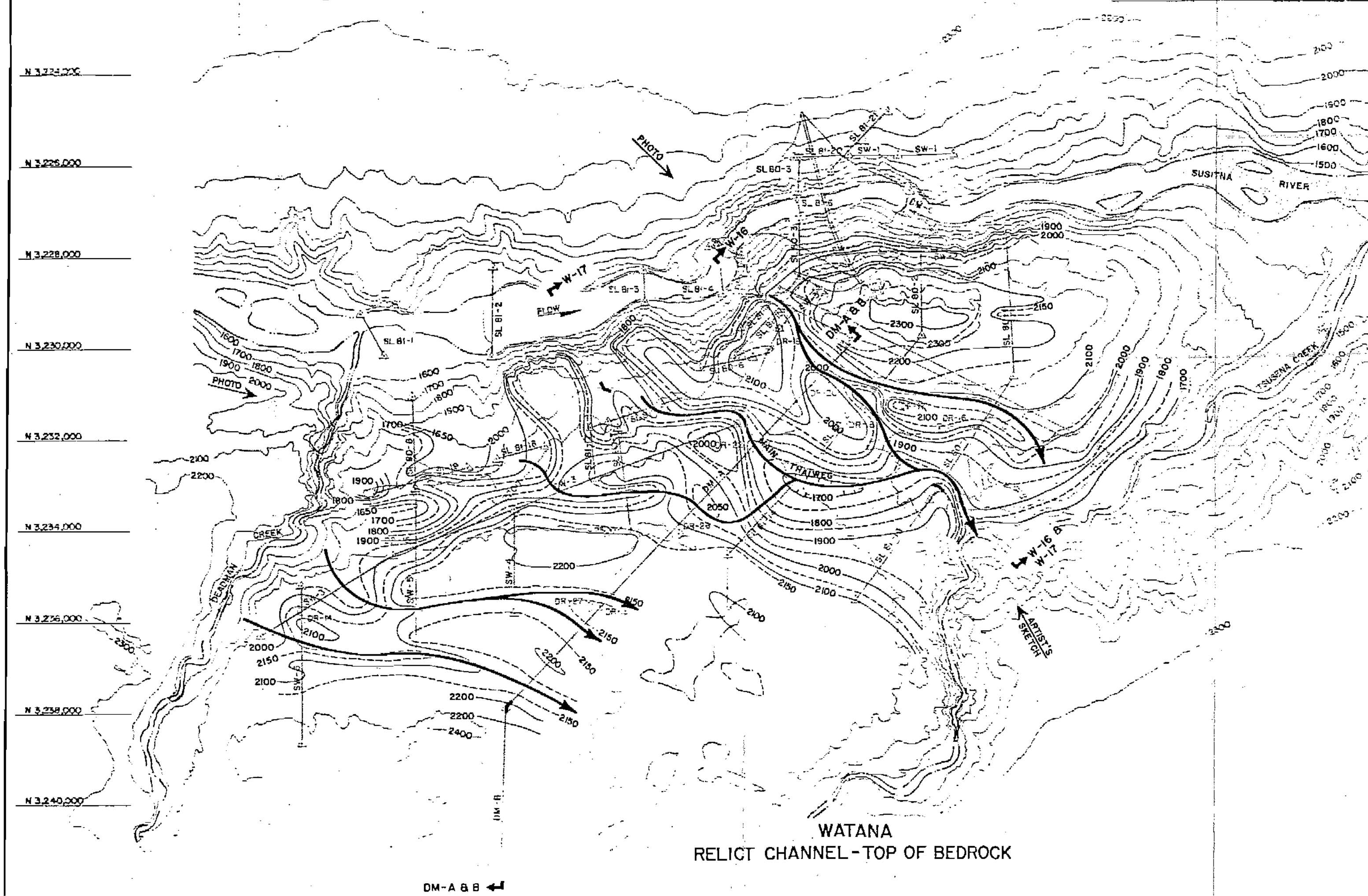
FIGURE E6.6



WATANA ROCK PERMEABILITY

FIGURE E6.7





LEGEND

- TOP OF BEDROCK, CONTOUR INTERVAL 50 FEET, 50 FOOT CONTOURS DASHED.
- TOPOGRAPHY, CONTOUR INTERVAL 100 FEET.
- POTENTIAL CHANNEL THALWEGS
- W-16 W-16 PROFILE OR CROSS-SECTION LOCATION (SEE NOTES 1 AND 2)

NOTES

1. SECTION DM-A AND B SHOWN ON FIGURE 6.31.
2. PROFILES W-16 AND W-17 SHOWN ON FIGURE 6.34.
3. DETAILED STRATIGRAPHIC FENCE DIAGRAM SHOWN ON FIGURE 6.32.
4. DETAILED SEISMIC LINE SECTIONS SHOWN IN APPENOICES H AND I.
5. RELICT CHANNEL PHOTOS SHOWN ON FIGURE 6.30.

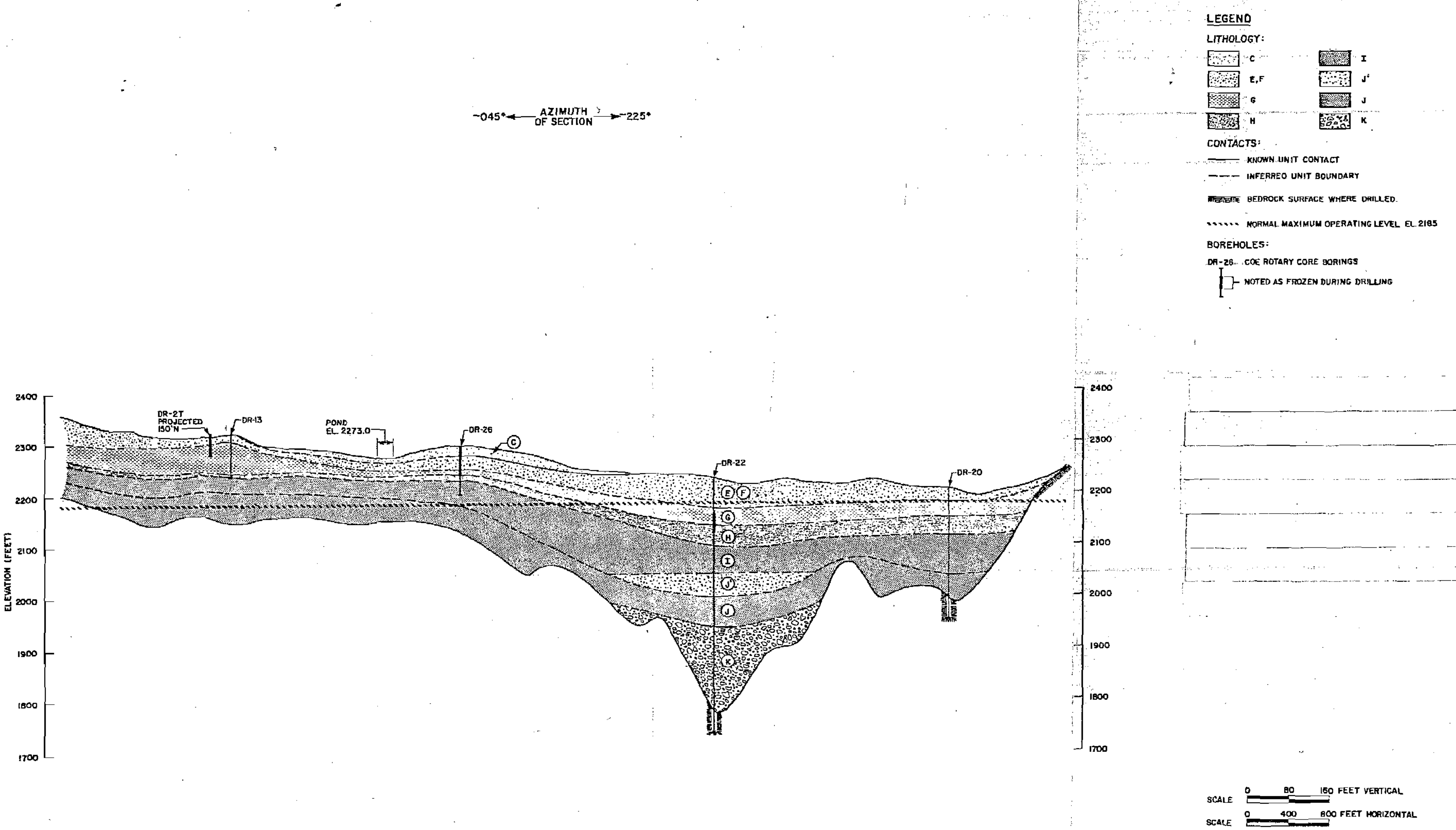
SCALE 0 1000 2000 FEET

DM-A & B

WATANA
RELICT CHANNEL - TOP OF BEDROCK

FIGURE E6.8

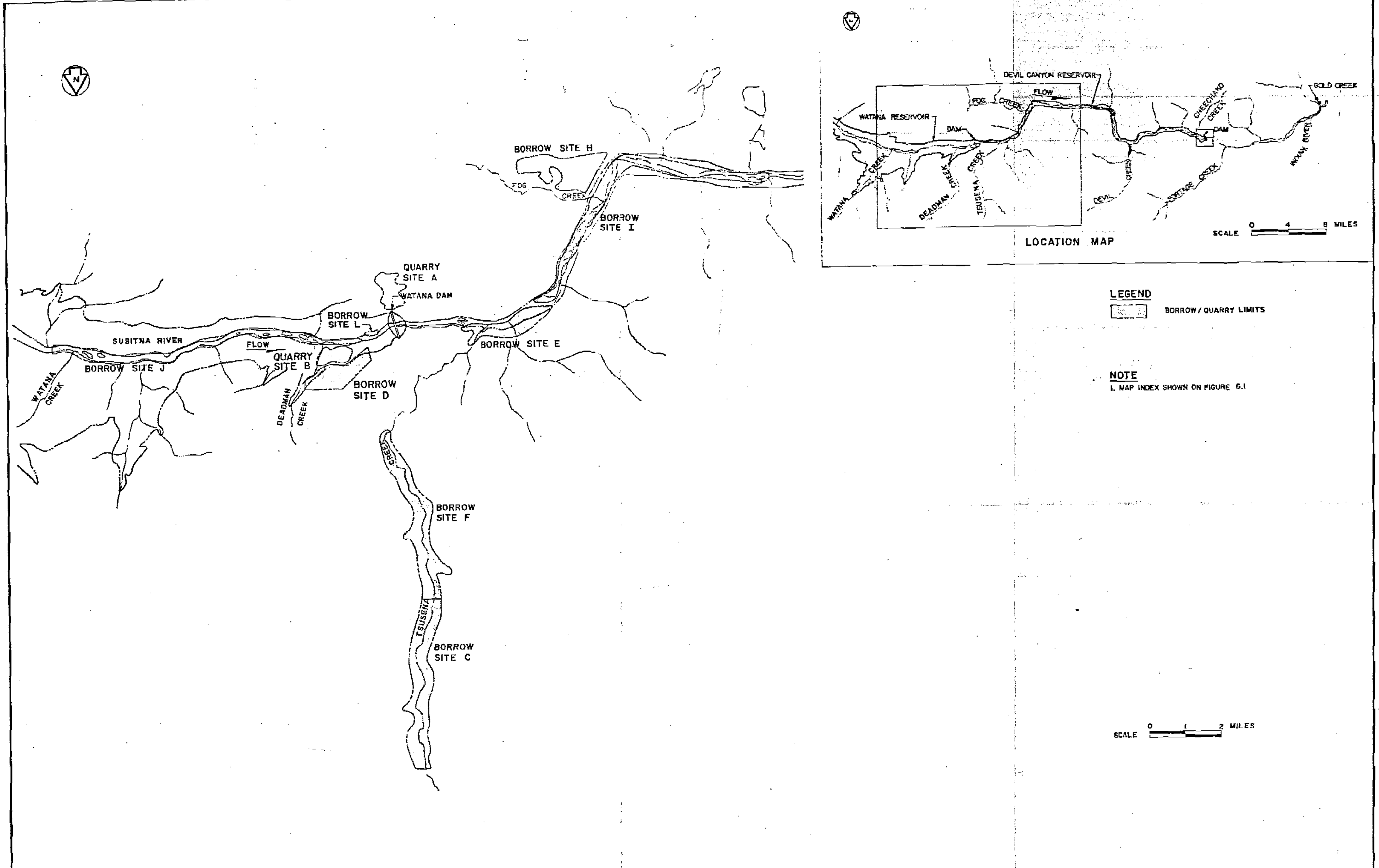
ACRES



WATANA
RELICT CHANNEL-EXPANDED THALWEG SECTION

ACRES

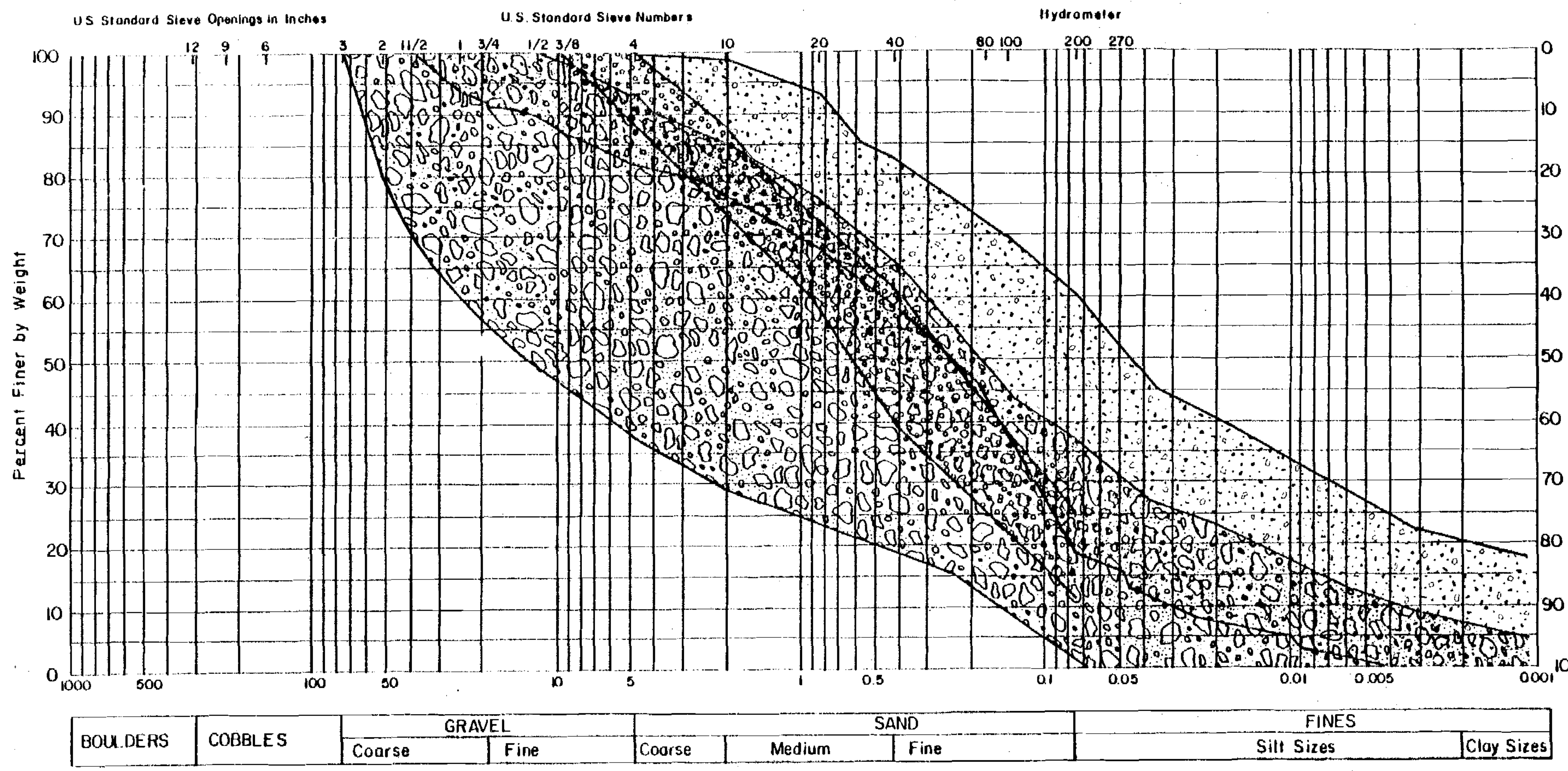
FIGURE E6.9



WATANA
BORROW SITE MAP

FIGURE E6.10

ACRES

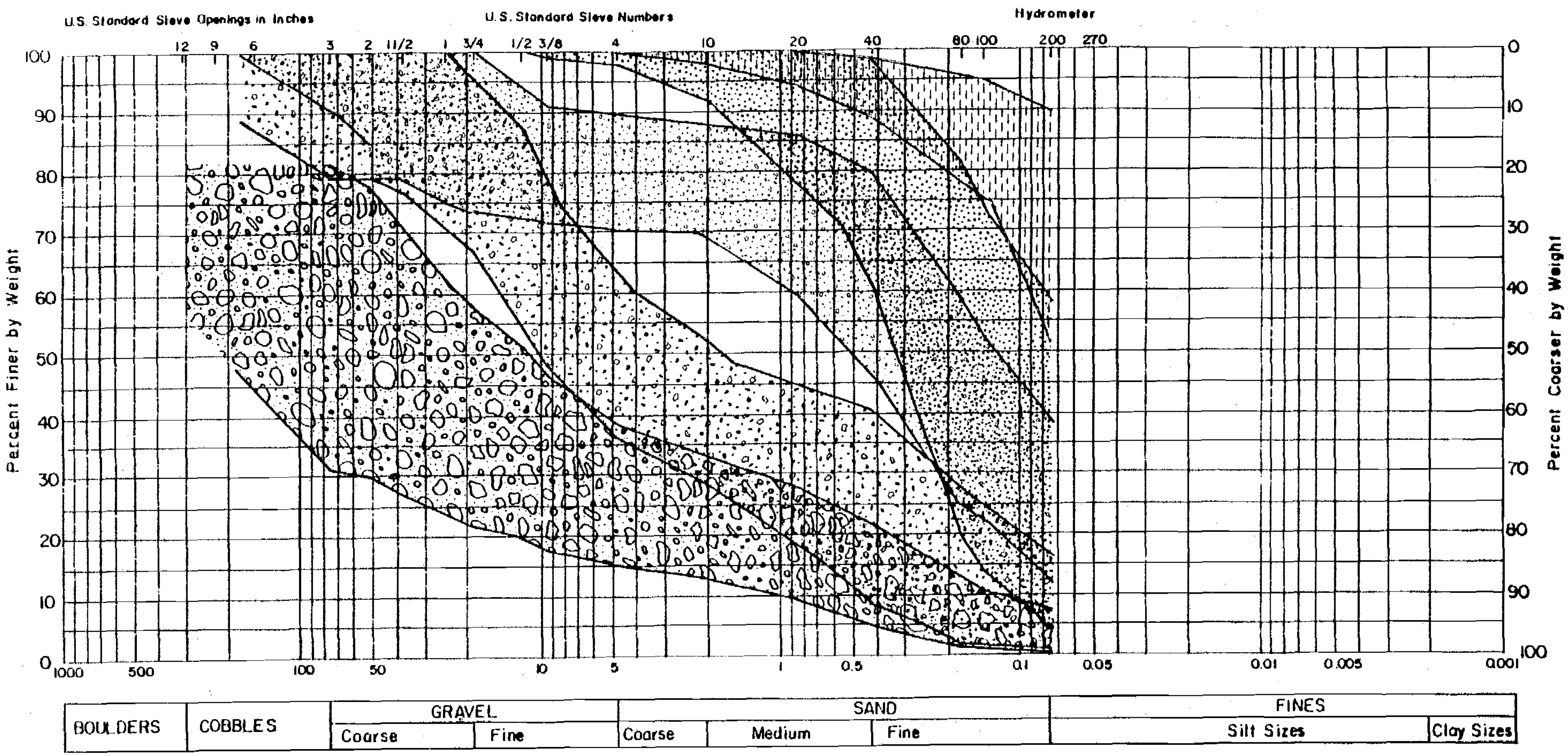


GRADATION TYPE	MATERIAL	NO. OF SAMPLES
4	SILTY SAND WITH CLAY AND GRAVEL	41
5	SILTY SAND WITH GRAVEL	8
6	GRAVELLY SAND, SANDY GRAVEL	50

WATANA
BORROW SITE D
MATERIAL GRADATION TYPES
SHEET 2 OF 2

FIGURE E6.12

ACRES



UNIT	MATERIAL	NO. OF SAMPLES	UNIT	MATERIAL	NO. OF SAMPLES
A	SANDY SILT WITH TRACE CLAY	4	D	SANDY GRAVEL, GRAVELLY SAND	11
B	SILTY SAND	10	E	SANDY GRAVEL WITH SILT, COBBLES, BOULDERS	19
C	SILTY SAND WITH CLAY, GRAVEL, COBBLES	6			

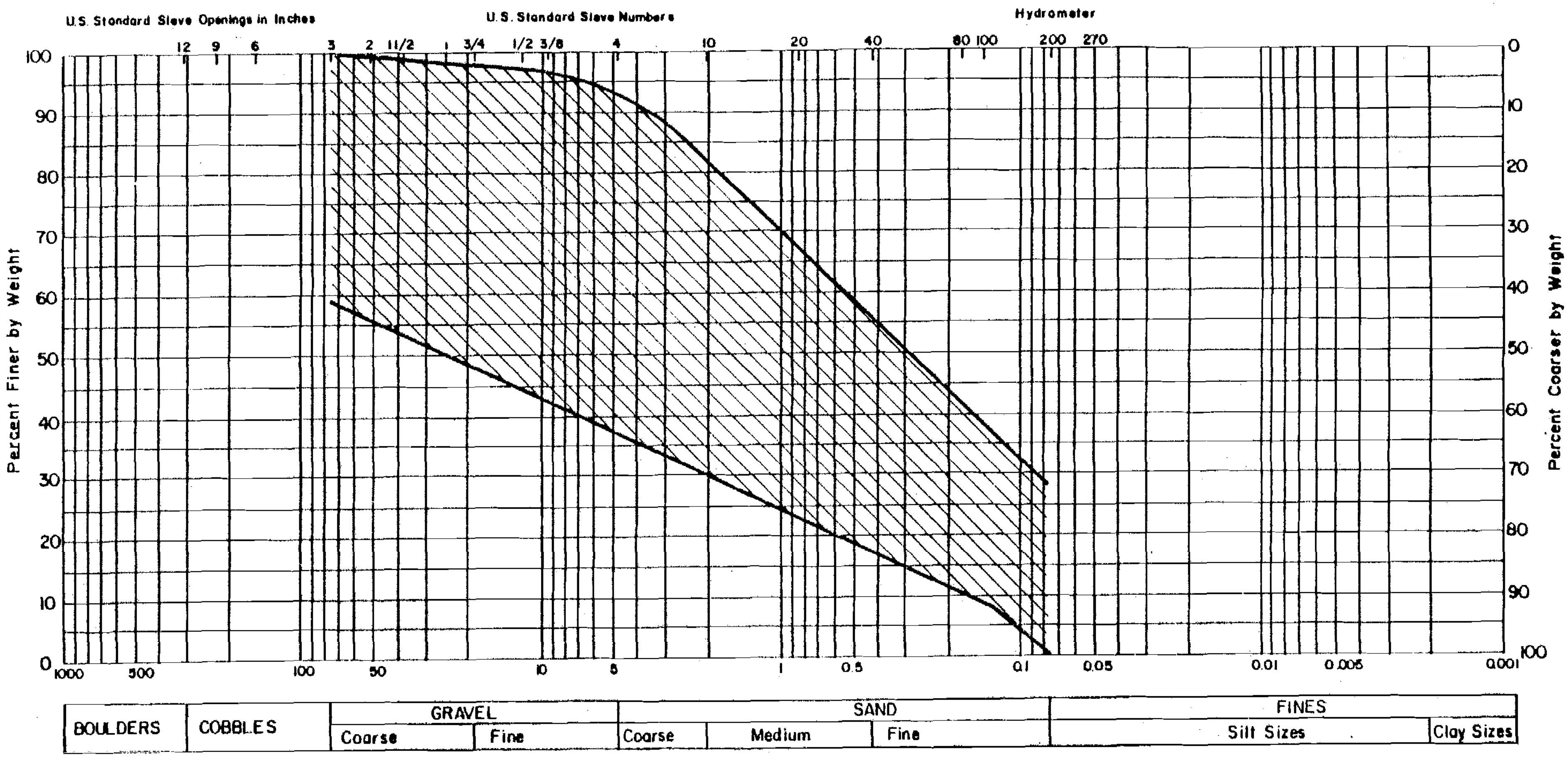
WATANA

BORROW SITE E

STRATIGRAPHIC UNIT GRADATIONS

FIGURE E6.13

ACRES

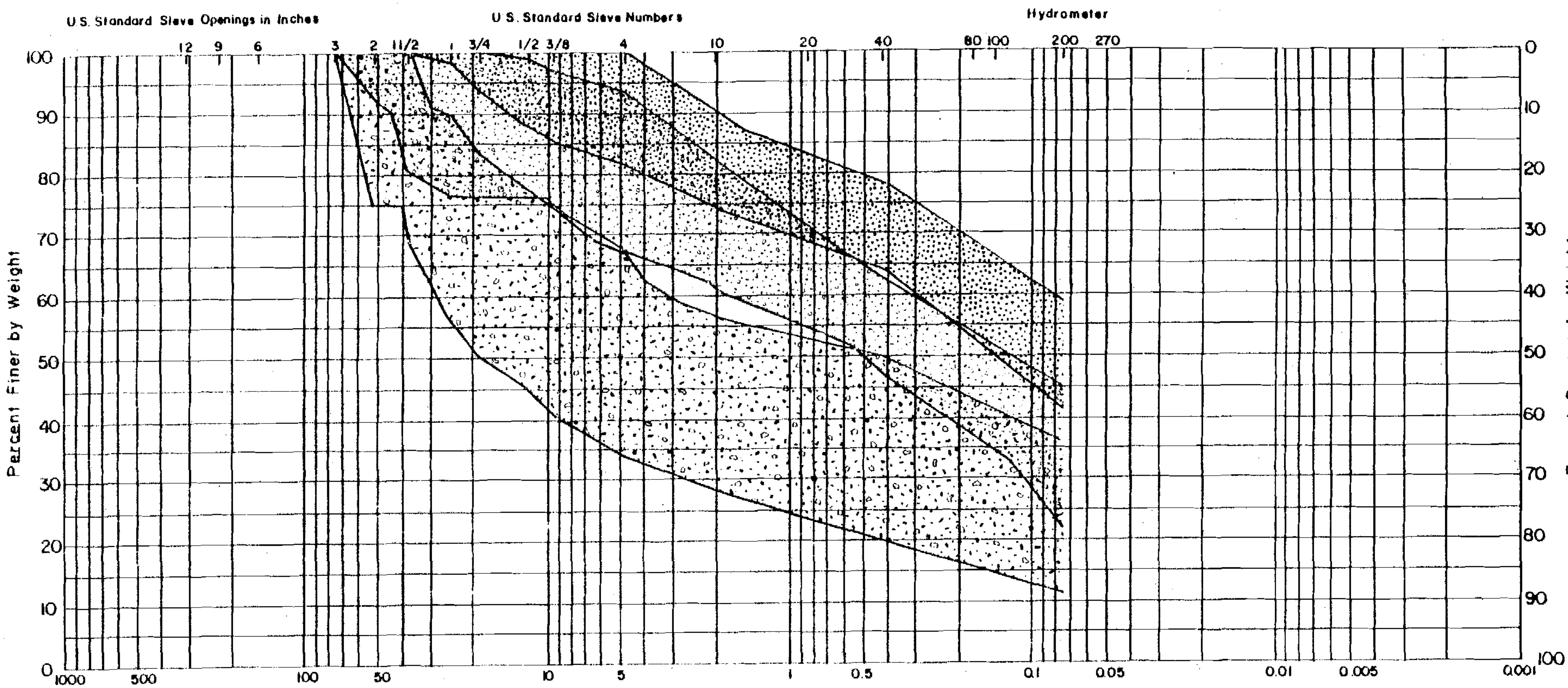


TOTAL NUMBER OF SAMPLES: 10

WATANA
BORROW SITES C & F
RANGE OF GRADATIONS

FIGURE E6.14

ACRES



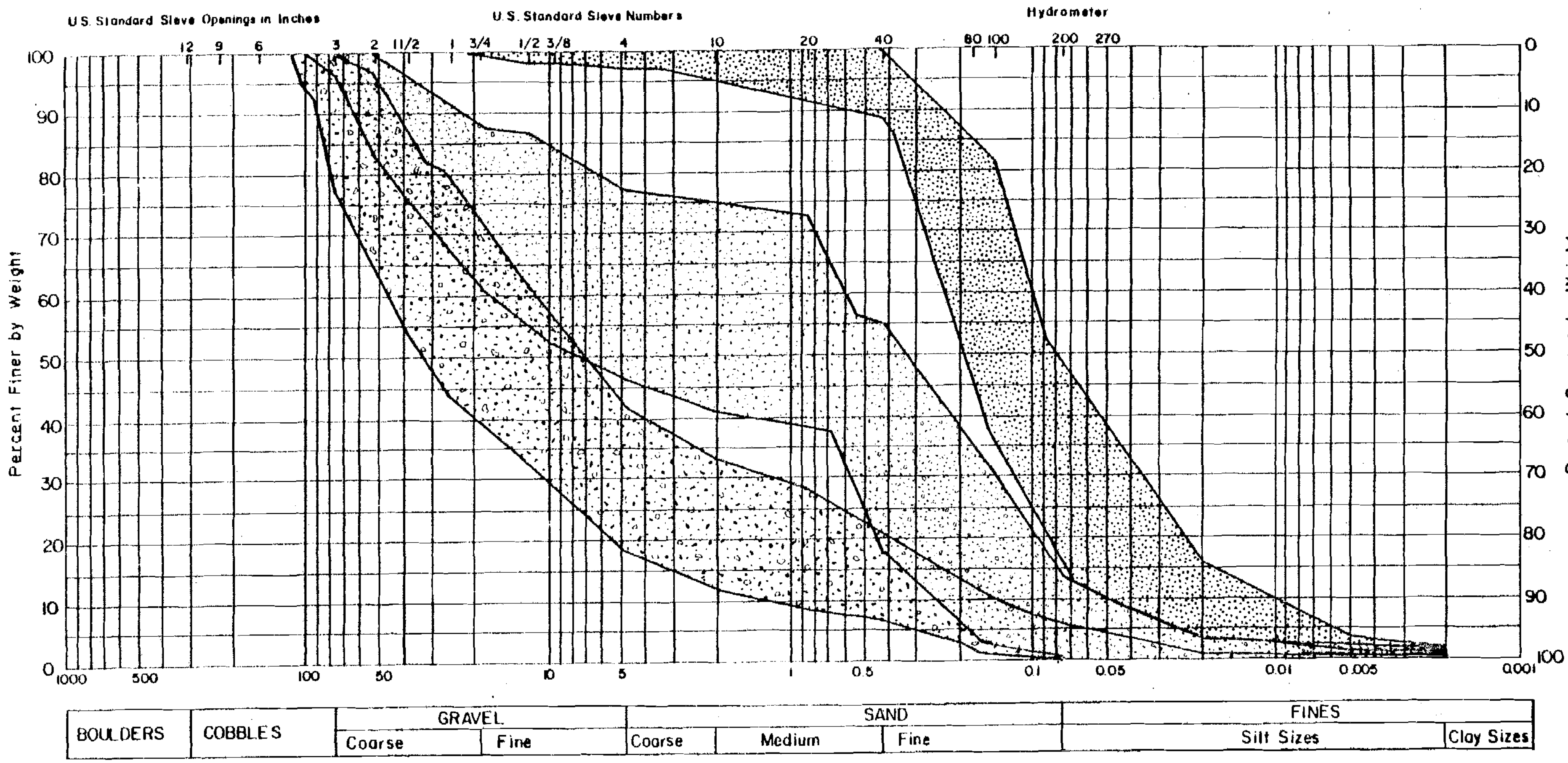
BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		Coarse	Fine	Coarse	Medium	Fine	Silt Sizes	Clay Sizes

UNIT	MATERIAL	NO. OF SAMPLES
A	SANDY SILT WITH GRAVEL, CLAY	9
B	SILTY SAND WITH GRAVEL	30
C	SANDY GRAVEL	10

WATANA
BORROW SITE H
STRATIGRAPHIC UNIT GRADATIONS

FIGURE E6.15

ACRES

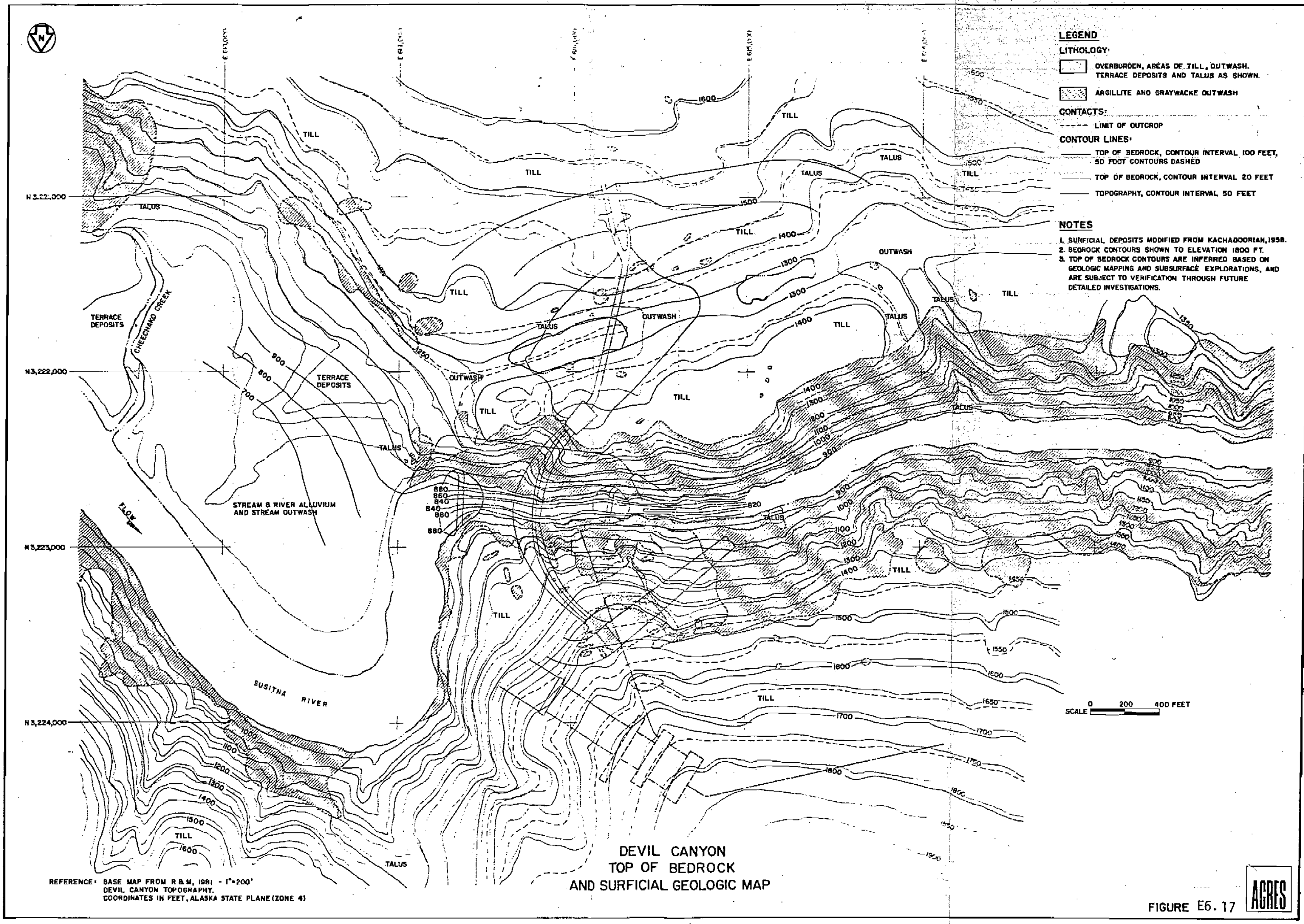


UNIT	MATERIAL	NO. OF SAMPLES
A	SILTY SAND	6
B	SAND	4
C	GRAVEL	25

WATANA
BORROW SITES I & J
STRATIGRAPHIC UNIT GRADATIONS

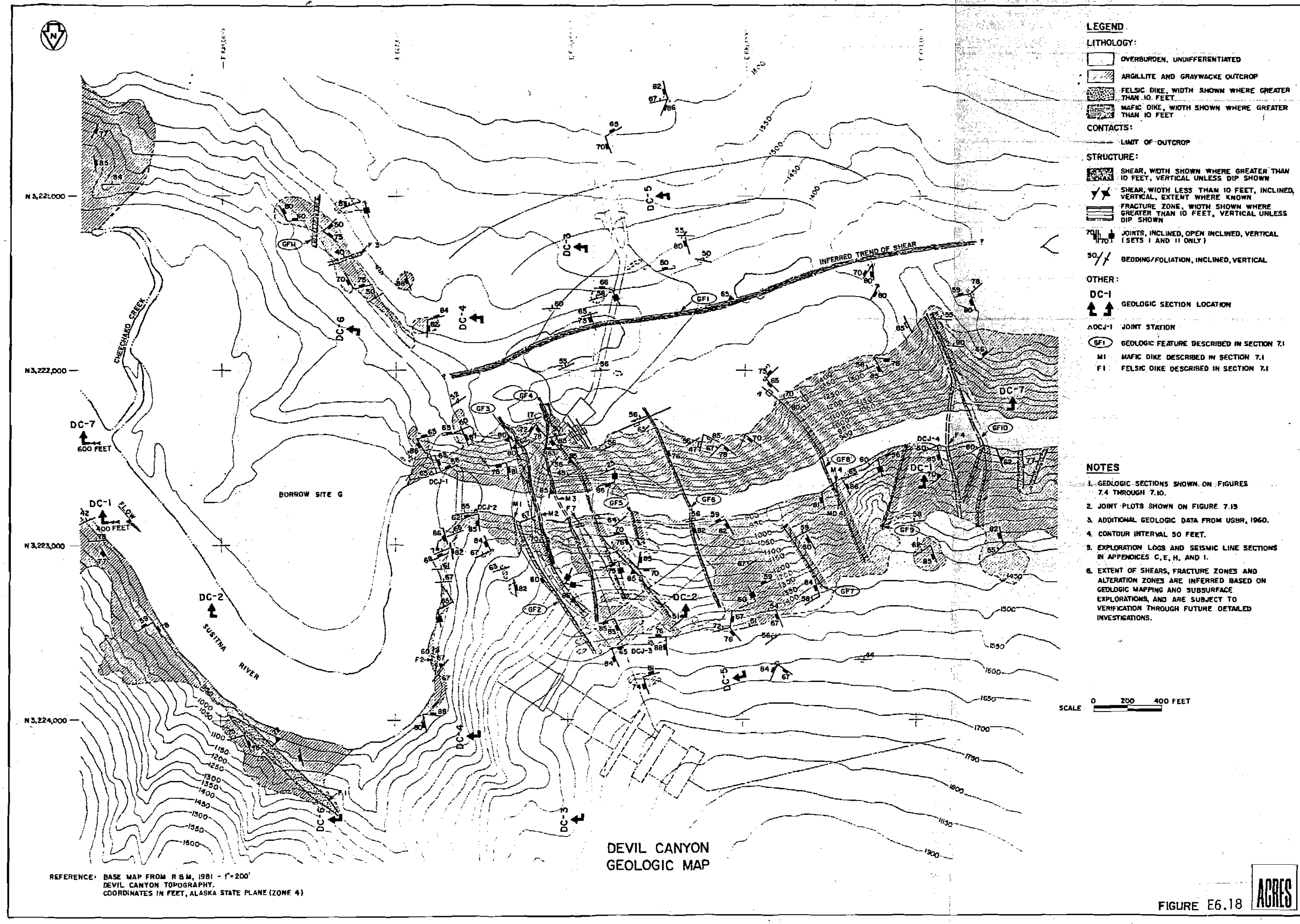
FIGURE E6.16

ACRES



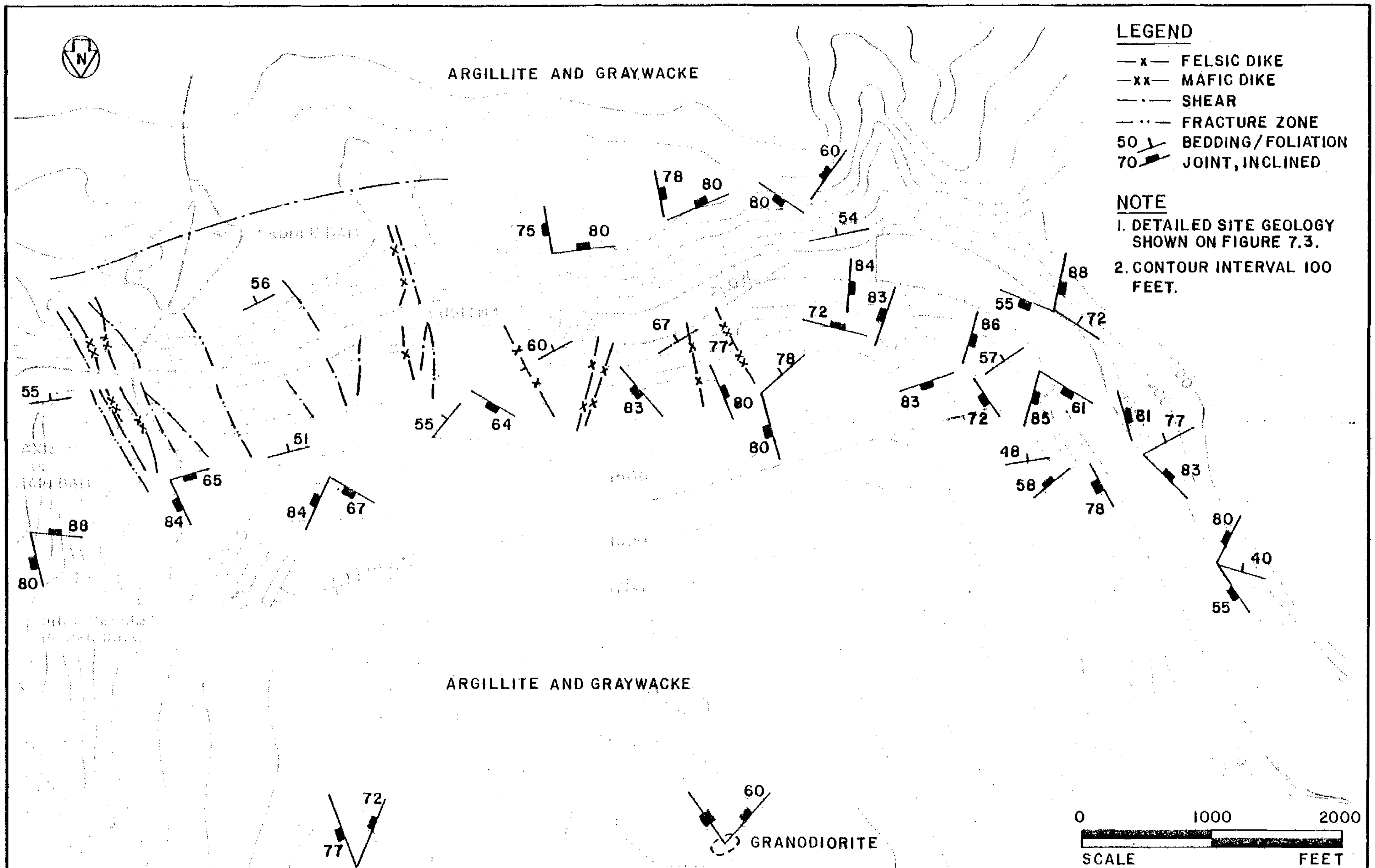
DEVIL CANYON
TOP OF BEDROCK
AND SURFICIAL GEOLOGIC MAP

FIGURE E6.17



DEVIL CANYON
GEOLOGIC MAP

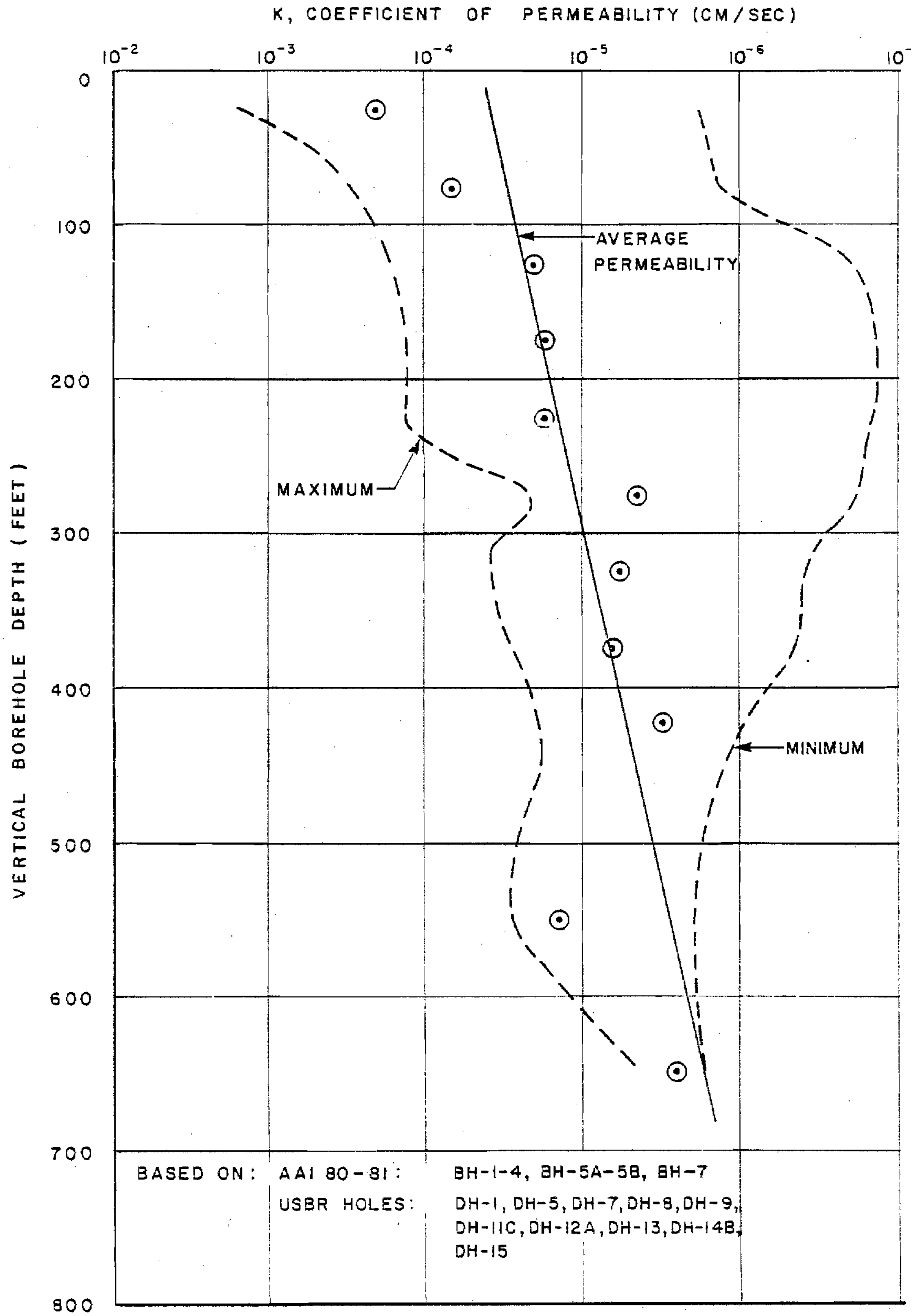
FIGURE E6.18



DEVIL CANYON
TAILRACE GEOLOGIC MAP

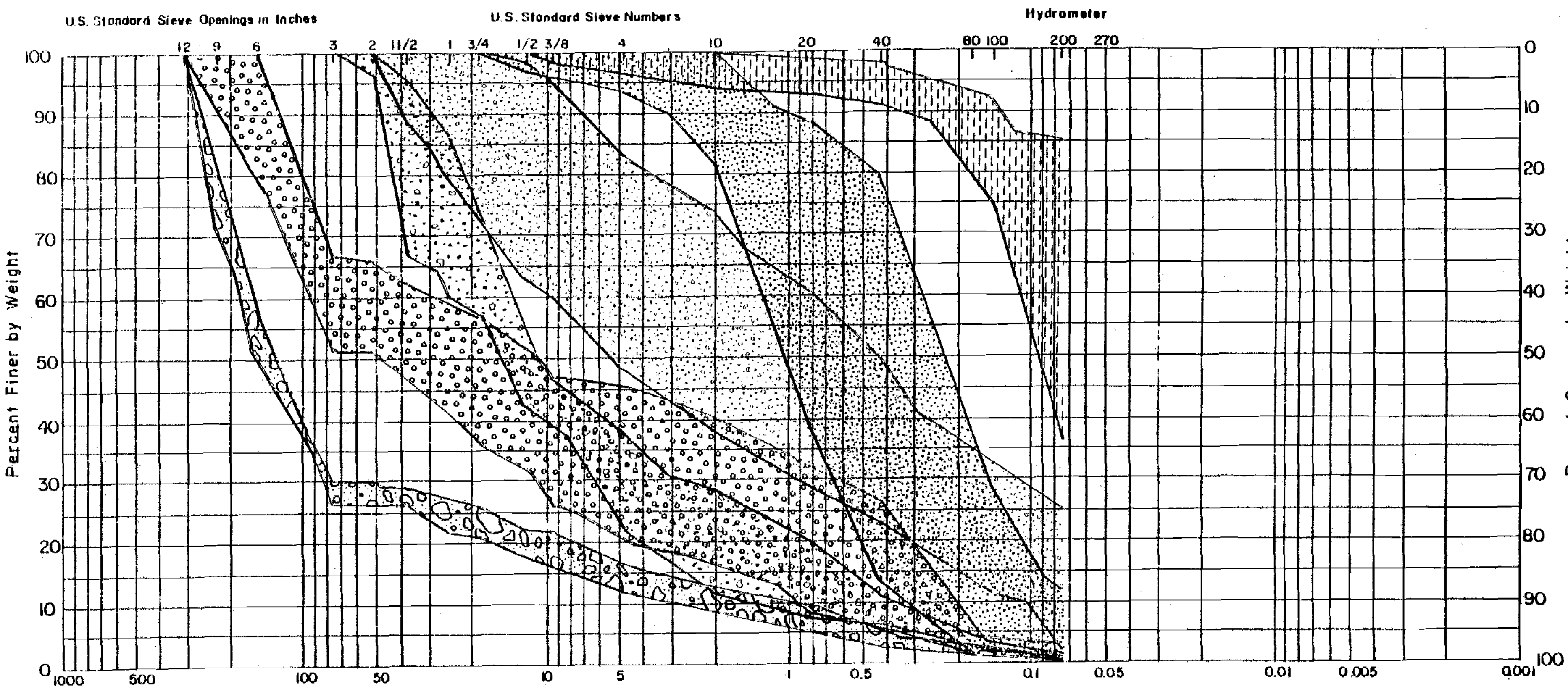
FIGURE E6.19

ACRES



DEVIL CANYON ROCK PERMEABILITY

FIGURE E6.20



BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		Coarse	Fine	Coarse	Medium	Fine	Silt Sizes	Clay Sizes

UNIT*	MATERIAL	NO. OF SAMPLES
C	SILT WITH SAND, GRAVEL	4
D	SAND WITH TRACE SILT	9
N	SANDY GRAVEL	3
O	SANDY GRAVEL	4
P	GRAVELLY SAND, SANDY GRAVEL	3
Z	SANDY GRAVEL WITH SILT, COBBLES	24

* SEE EXPLORATORY TRENCH GEOLOGIC SECTIONS, APPENDIX G

DEVIL CANYON
BORROW SITE G
STRATIGRAPHIC UNIT GRADATIONS

FIGURE E6.21

ACRES

INITIALLY | AFTER SEVERAL YEARS | ASSUMPTIONS:

BEACHING (I)

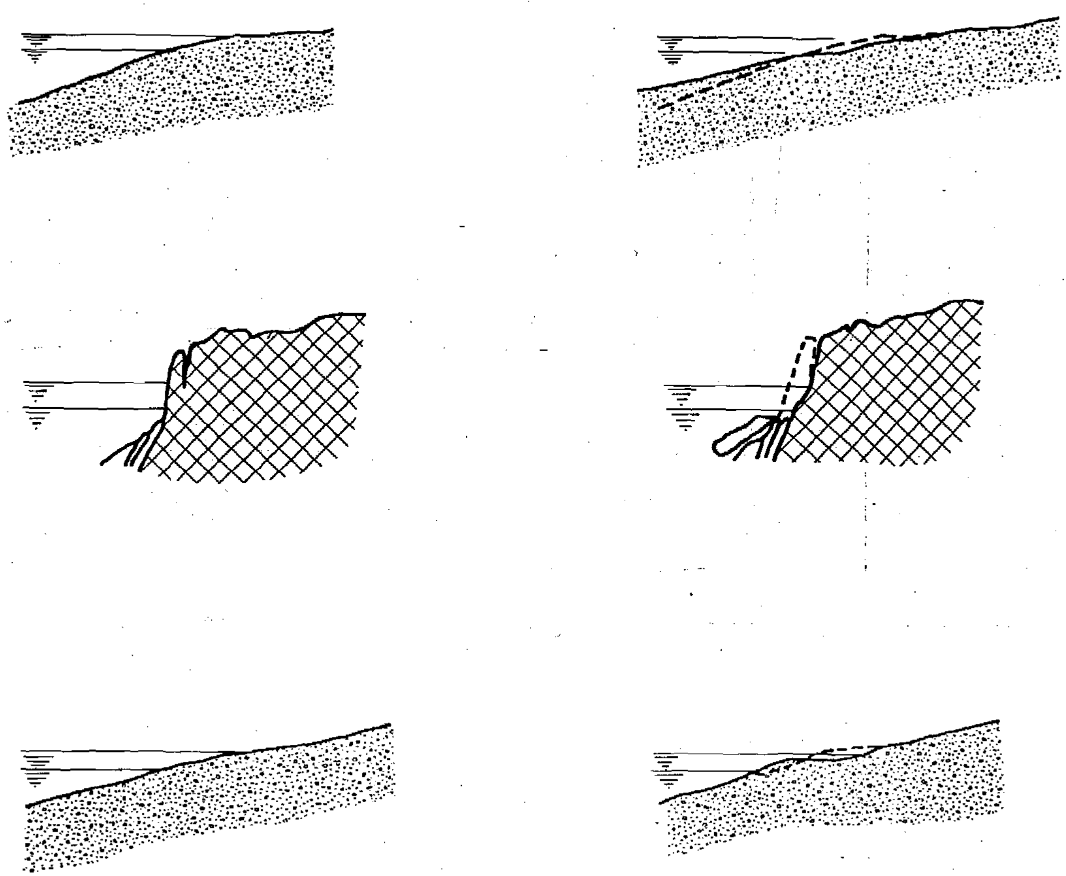
FLAT SLOPES.
COARSE GRAINED DEPOSITS OR UNFROZEN TILL AND LACUSTRINE DEPOSITS.

BEACHING (I) MINOR

STEEP BEDROCK SLOPES.
FLUCTUATION OF RESERVOIR AND GROUNDWATER TABLE CAUSES FROST WEDGING TO OCCUR CAUSING ROCKFALL.

FLOWS (II)

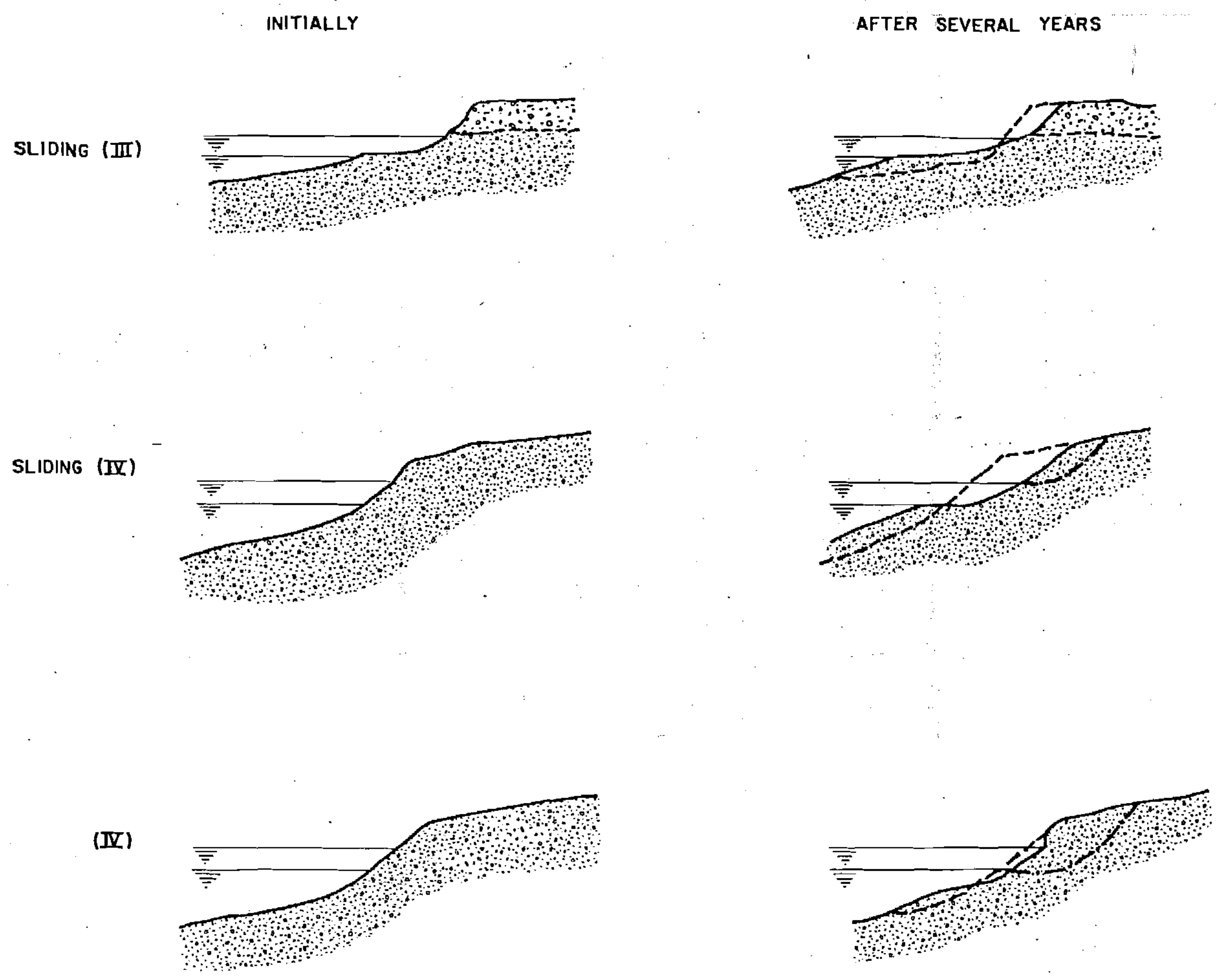
FLAT SLOPES.
GENERALLY FINE GRAINED DEPOSITS, FROZEN.



SLOPE MODELS FOR THE WATANA AND DEVIL CANYON RESERVOIRS

FIGURE E6.22

ACRES



ASSUMPTIONS:

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

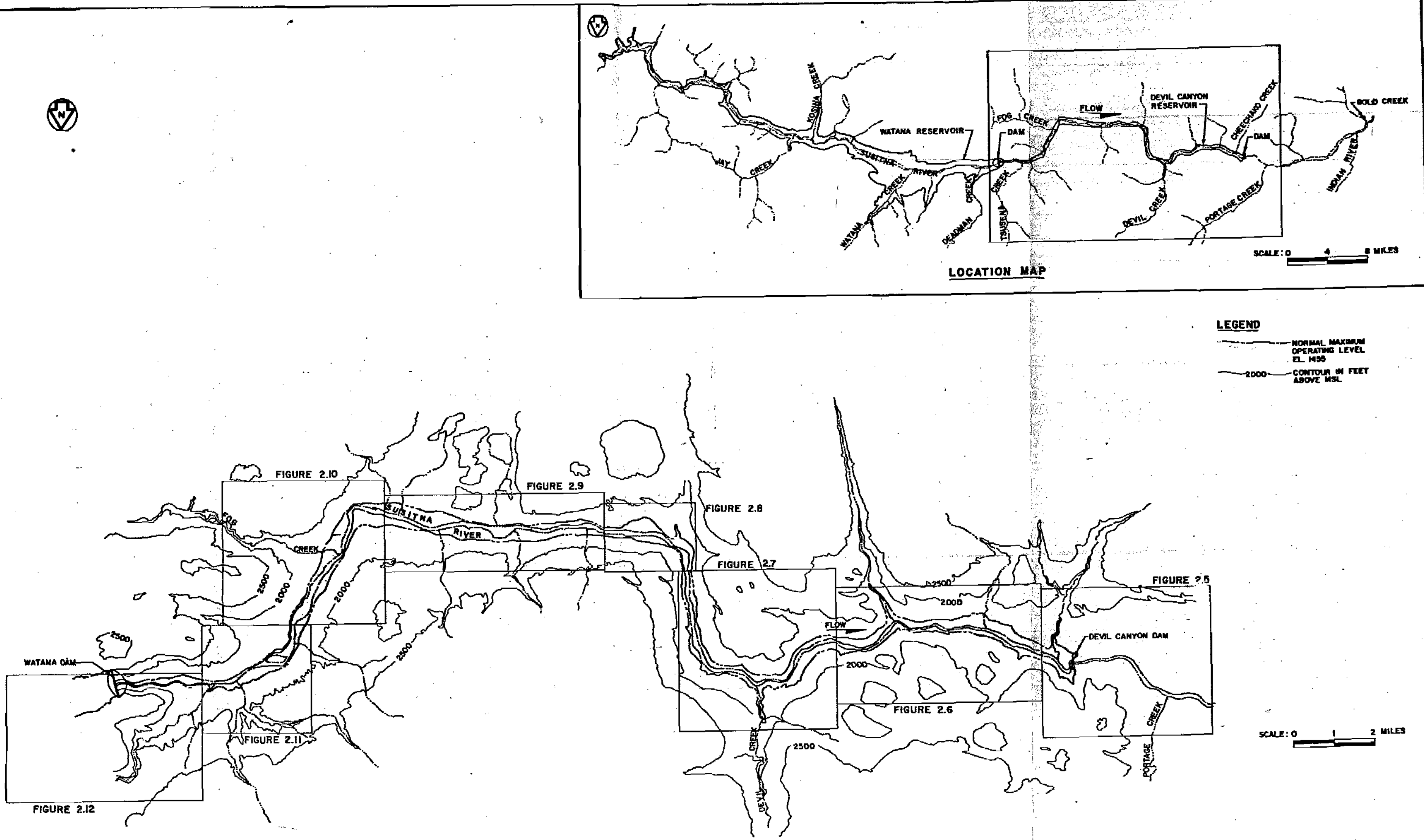
STEEP SLOPES.
FINE GRAINED AND UNFROZEN.

STEEP SLOPES.
FINE GRAINED AND UNFROZEN.
NOTE: POSSIBLE FURTHER SLIDING IF THAW BULB EXTENDS INTO SLOPE WITH TIME.

SLOPE MODELS FOR THE WATANA
AND DEVIL CANYON RESERVOIRS

FIGURE E6.23

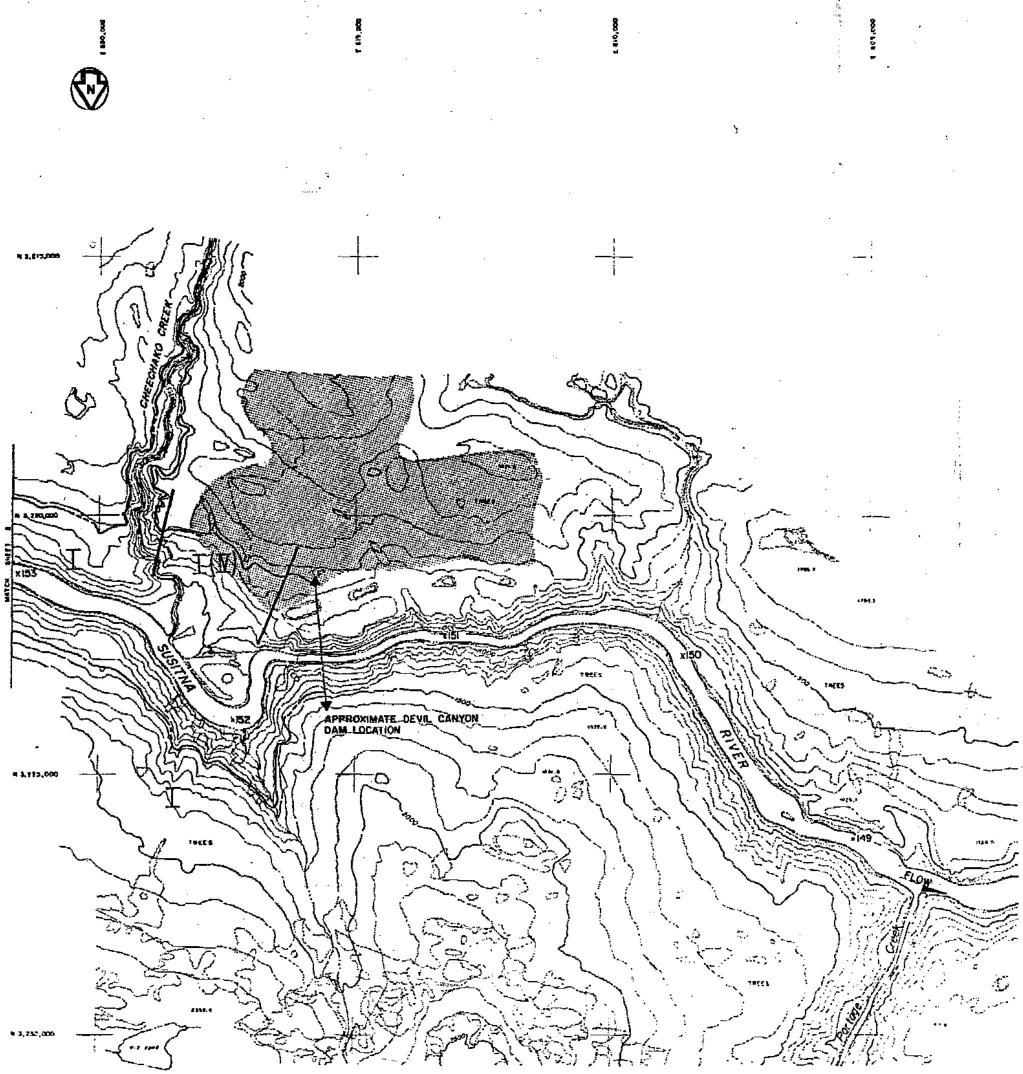
ACRES



DEVIL CANYON RESERVOIR
INDEX MAP

ACRES

FIGURE E6.24



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
A A SECTION LOCATION
AREA OF POTENTIAL PERMAFROST

NOTES

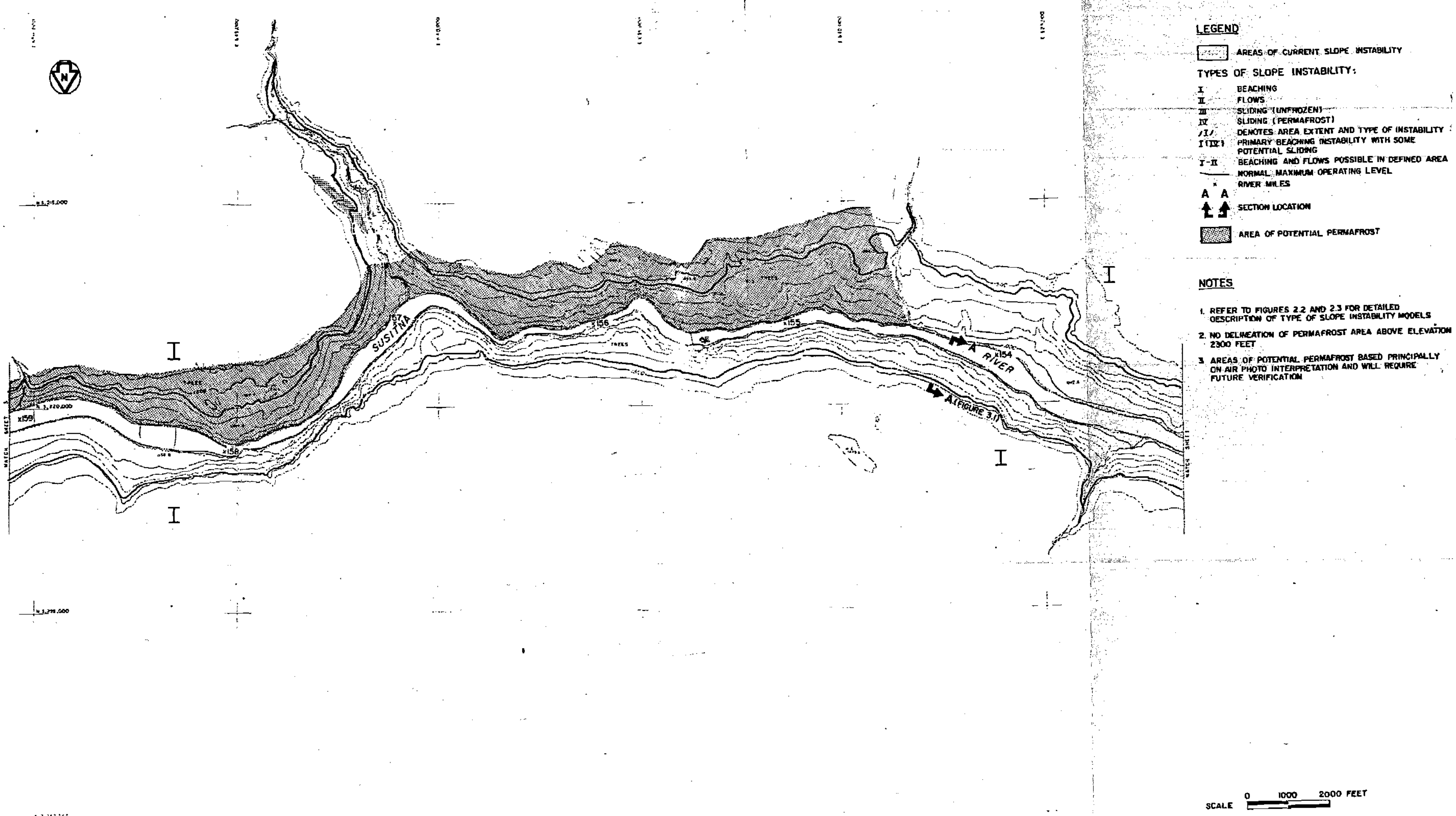
1. REFER TO FIGURES 2.2 AND 2.3 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION.

SCALE 0 1000 2000 FEET

DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E6.25

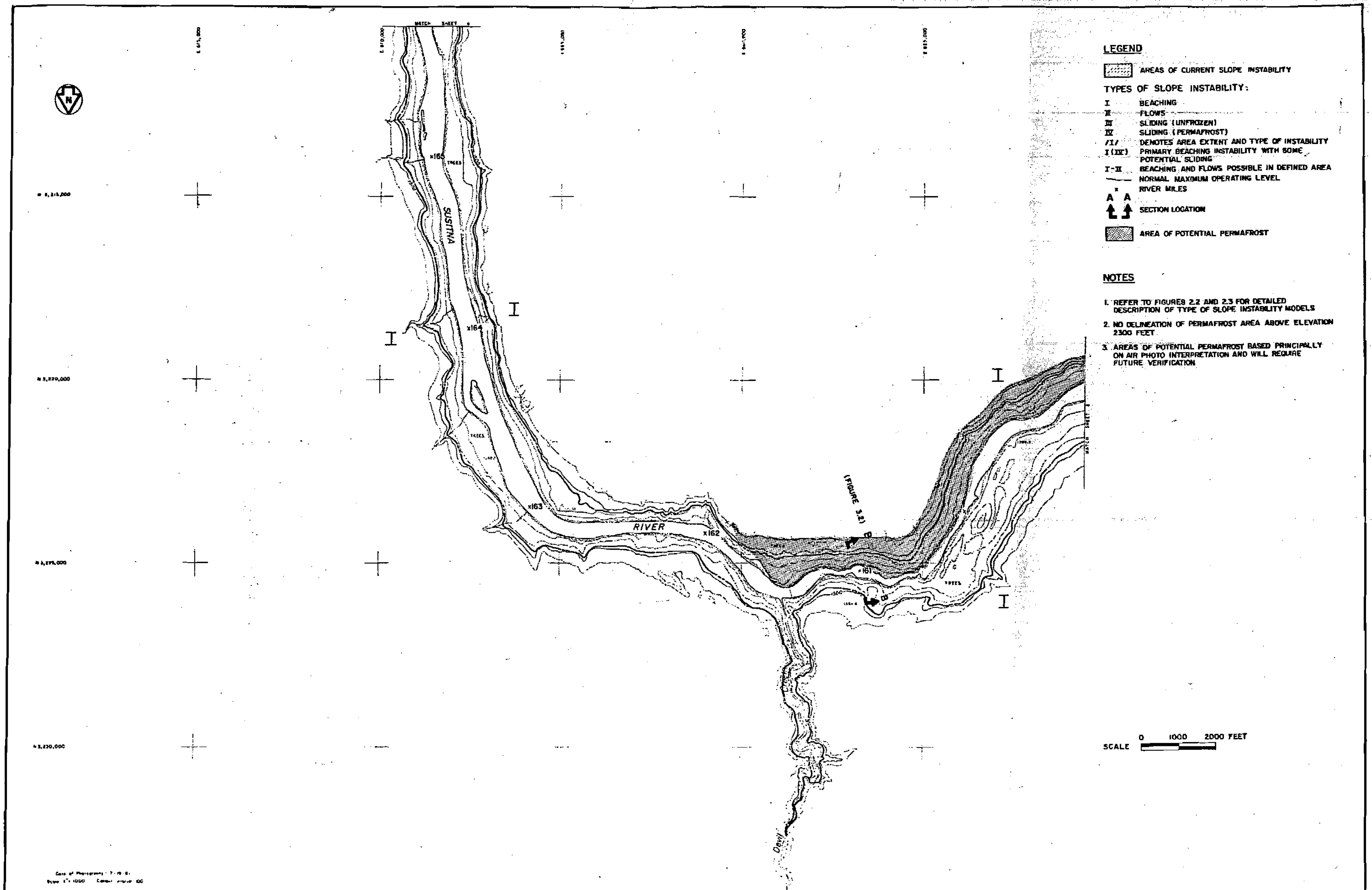
ACRES



DEVIL CANYON
SLOPE STABILITY MAP

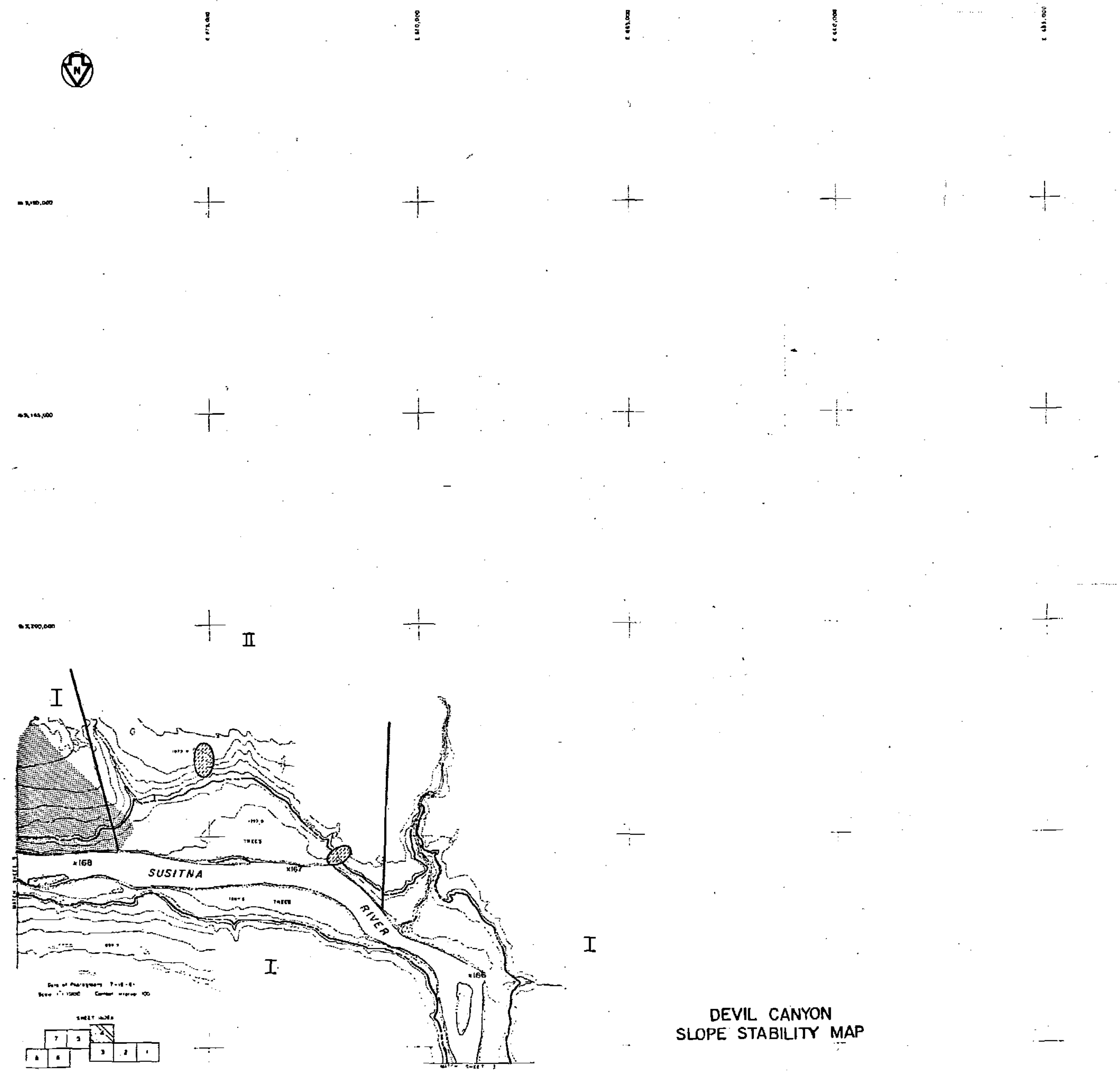
FIGURE E6.26

ACRES



DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E6.27



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
- x — RIVER MILES
- A A — SECTION LOCATION

AREA OF POTENTIAL PERMAFROST

NOTES

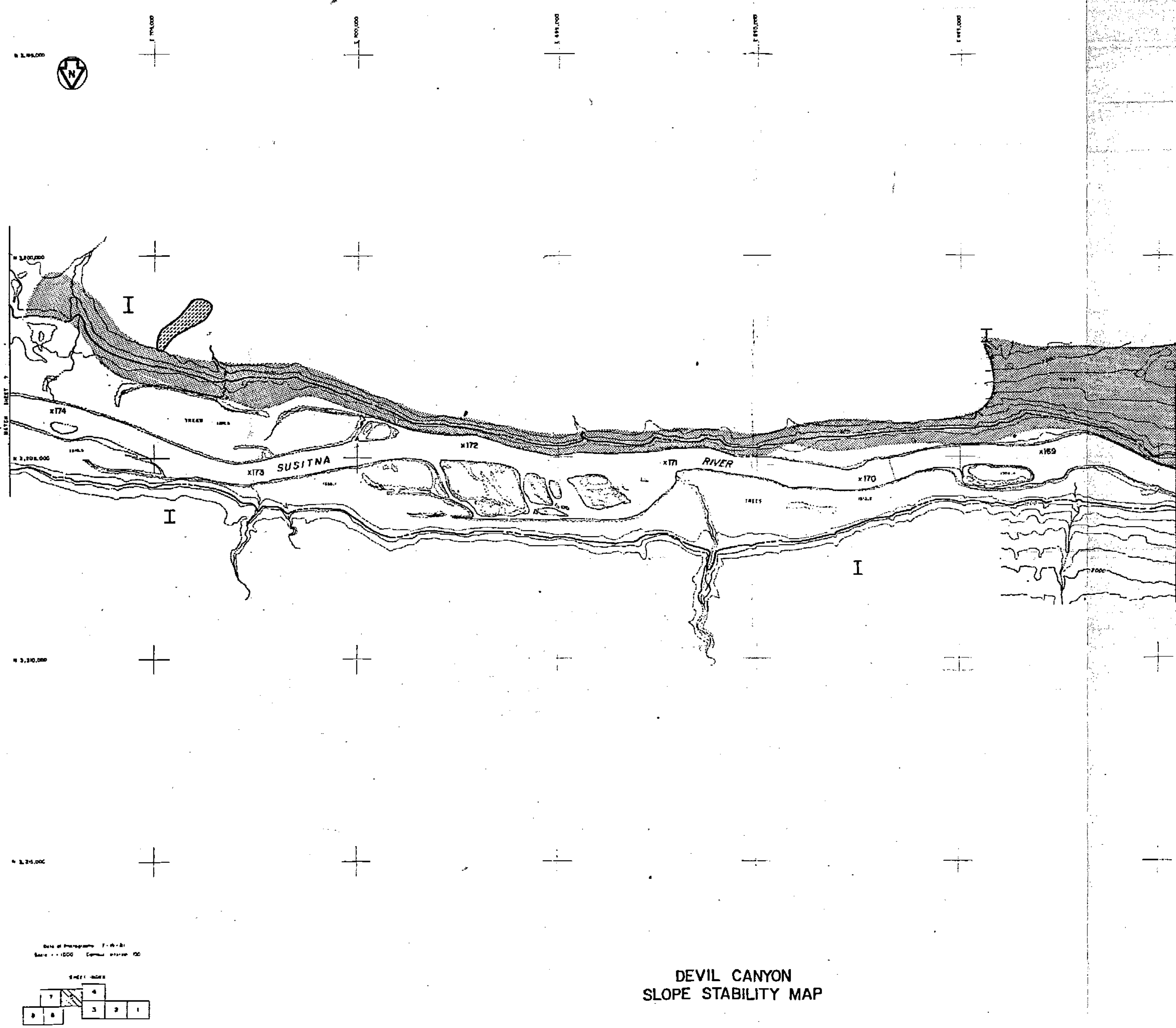
1. REFER TO FIGURES 2.2 AND 2.3 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E6.28

ACRES



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
- x RIVER MILES
- A A SECTION LOCATION
- AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES 2.2 AND 2.3 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 E6.29

ACRES

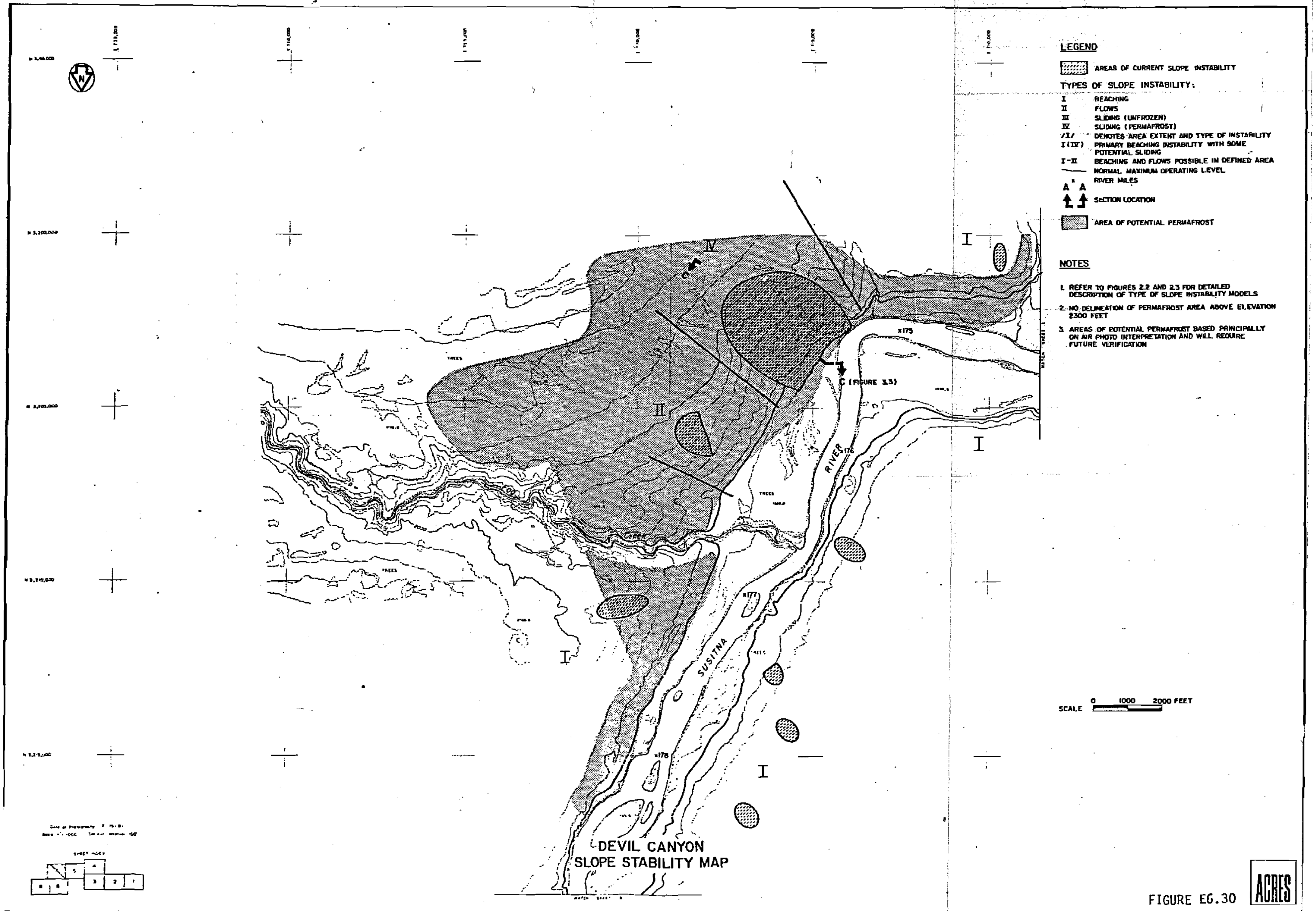
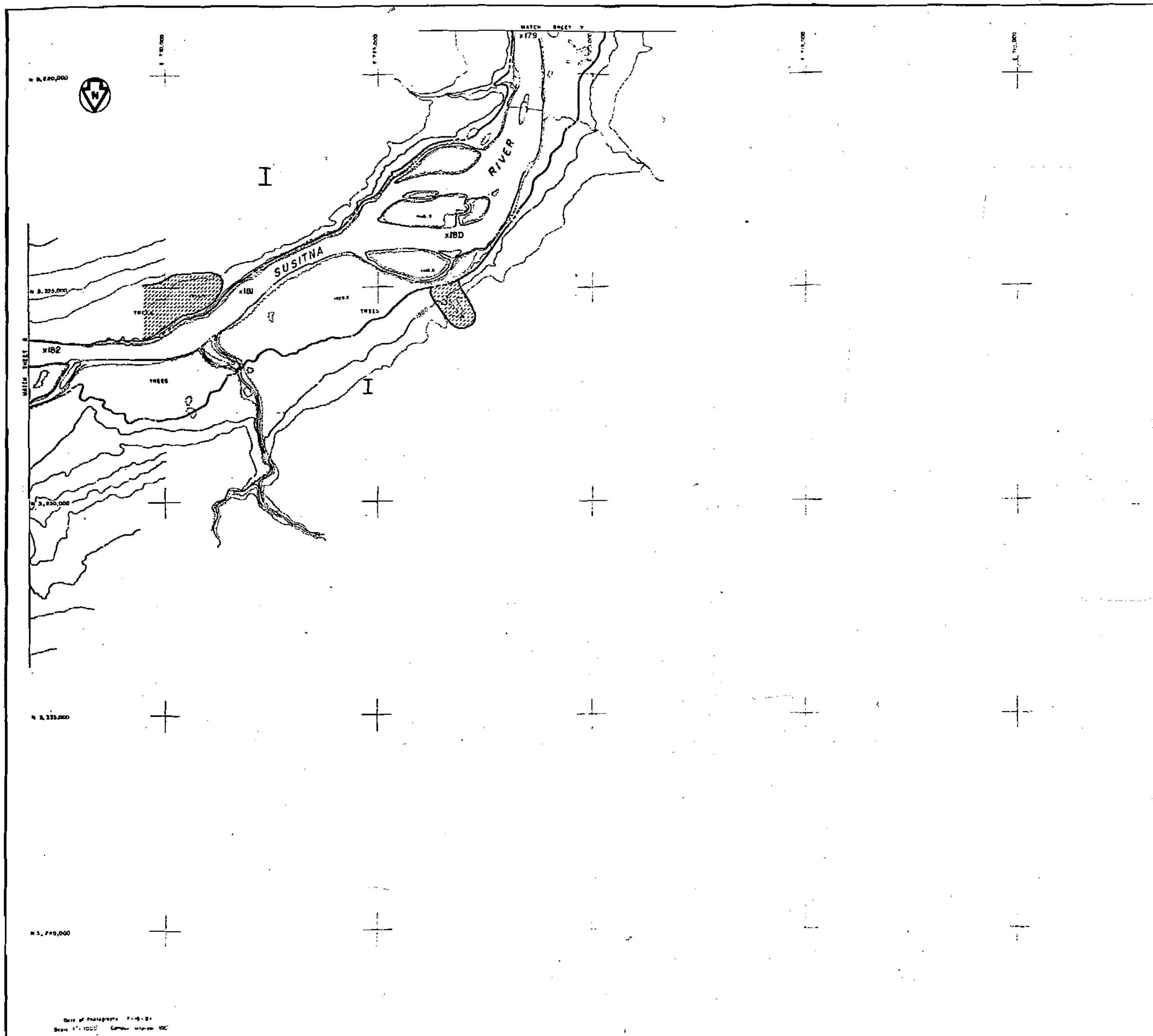

LEGEND
AREAS OF CURRENT SLOPE INSTABILITY
TYPES OF SLOPE INSTABILITY:
I BEACHING
II FLOWS
III SLIDING (UNFROZEN)
IV SLIDING (PERMAFROST)
/I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
NORMAL MAXIMUM OPERATING LEVEL
RIVER MILES
A A
SECTION LOCATION
AREA OF POTENTIAL PERMAFROST
NOTES
1. REFER TO FIGURES 2.2 AND 2.3 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
C (FIGURE 3.3)
SUSITNA
RIVER
DEVIL CANYON
SLOPE STABILITY MAP
ACRES

FIGURE EG.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
- x RIVER MILES
- A A SECTION LOCATION

NOTES

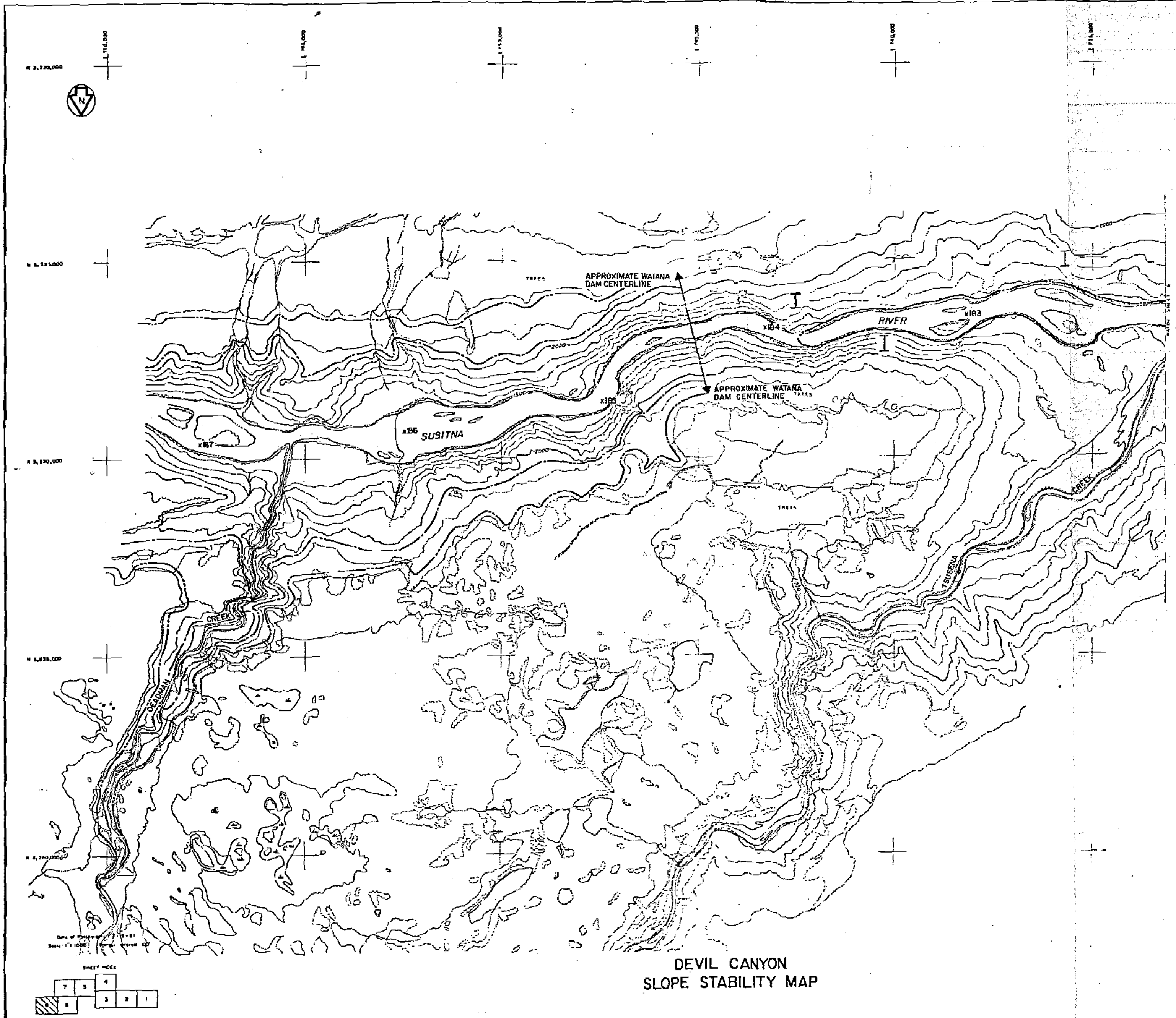
1. REFER TO FIGURES 2.2 AND 2.3 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

DEVIL CANYON
SLOPE STABILITY MAP

ACRES

FIGURE E6.31



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
- NORMAL MINIMUM OPERATING LEVEL
- x — RIVER MILES
- A A — SECTION LOCATION

NOTES

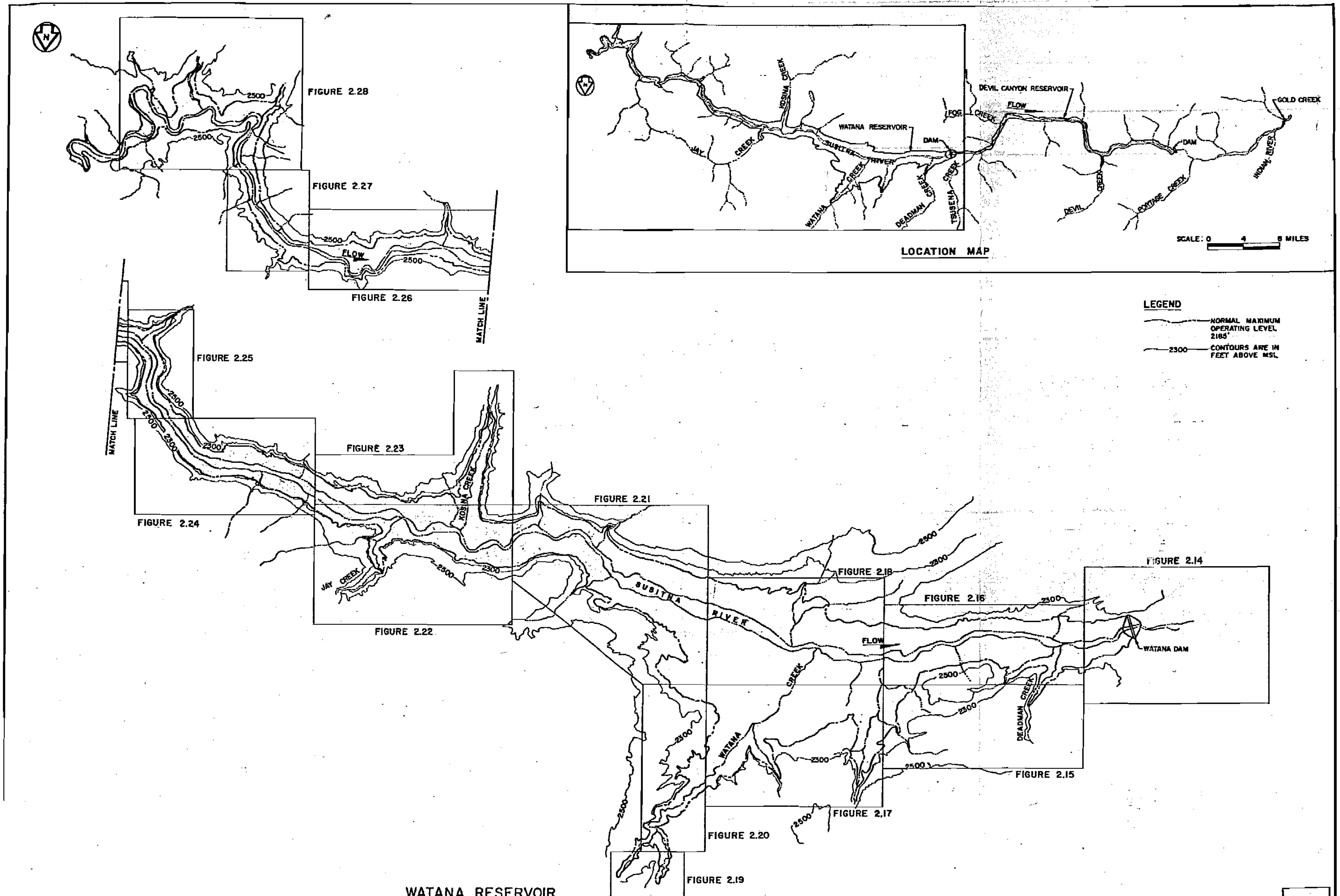
1. REFER TO FIGURES 2.2 AND 2.3 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

DEVIL CANYON
SLOPE STABILITY MAP

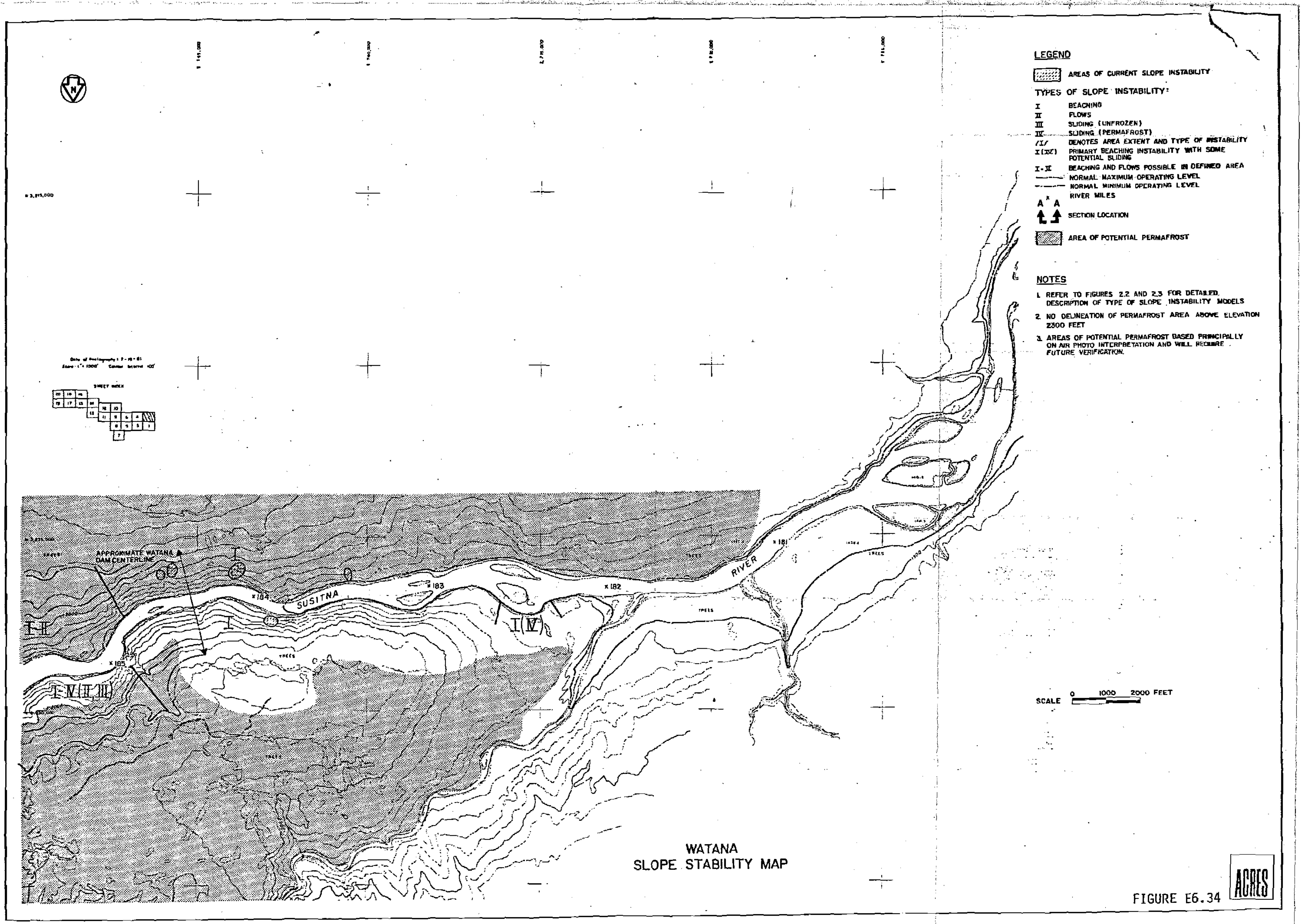
FIGURE E6.32

ACRES



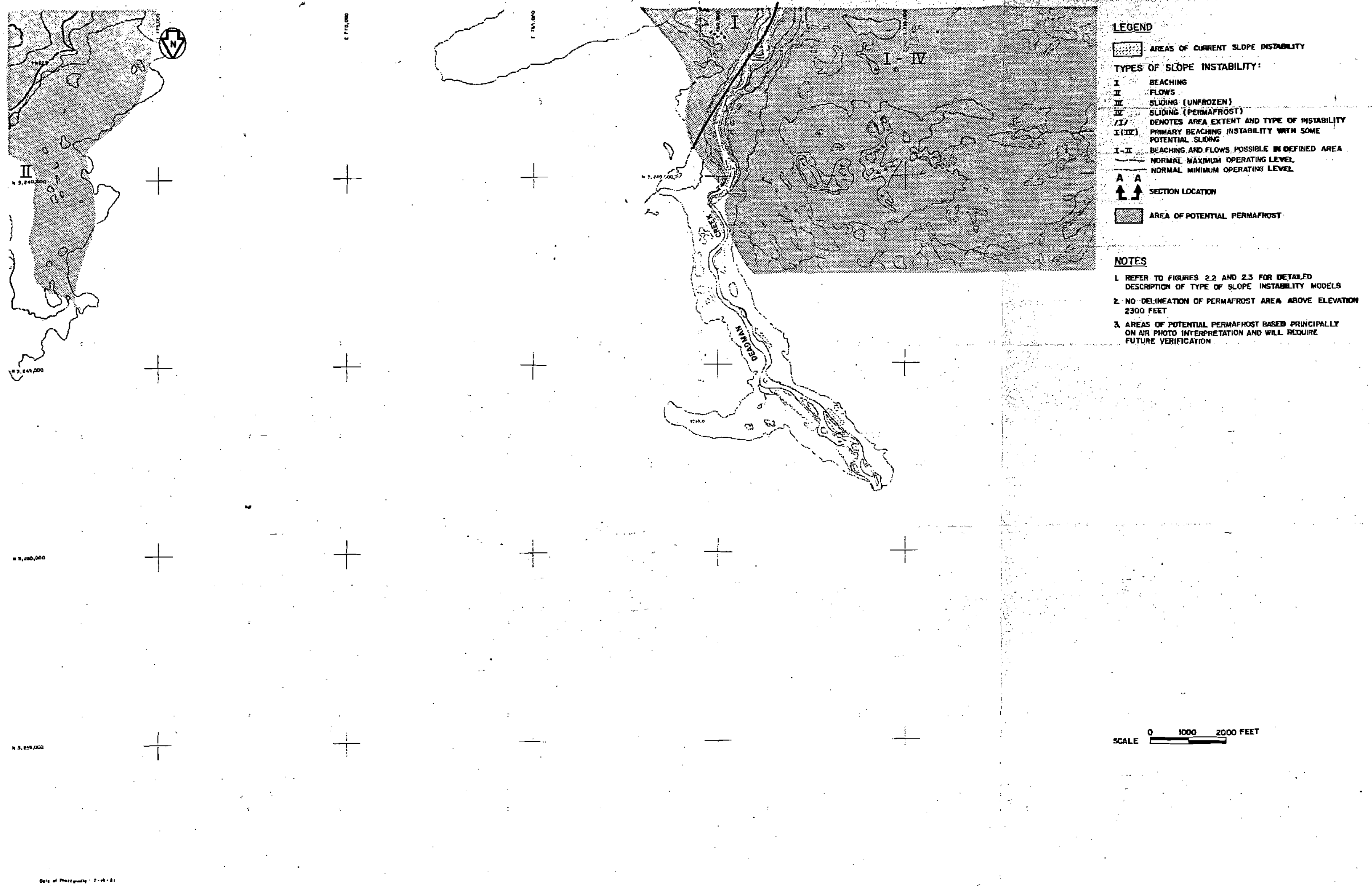
WATANA RESERVOIR
INDEX MAP

FIGURE E6.33



WATANA
SLOPE STABILITY MAP

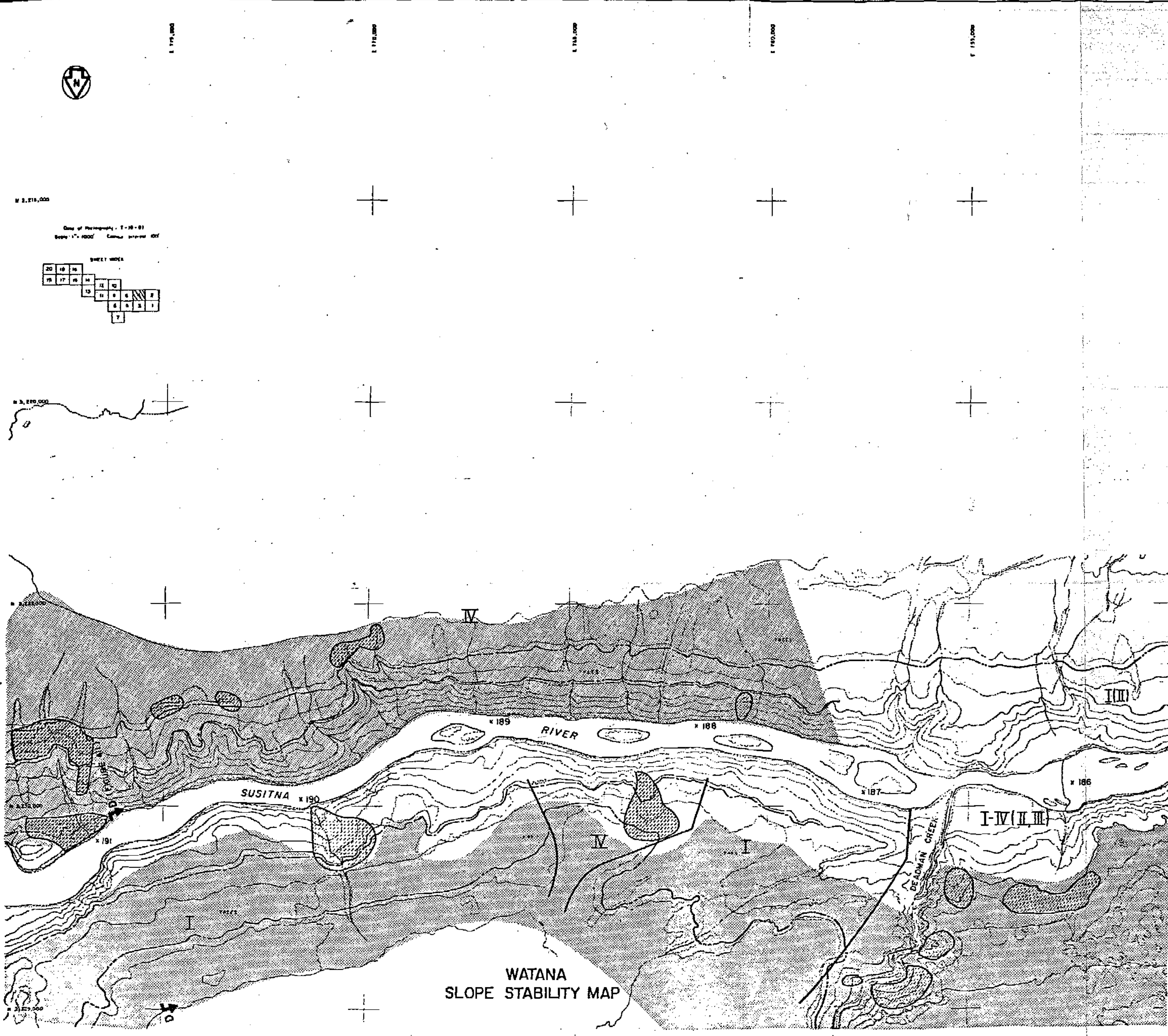
FIGURE E6.34



WATANA
SLOPE STABILITY MAP

ACRES

FIGURE E6.35



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
NORMAL MINIMUM OPERATING LEVEL
x RIVER MILES
A A SECTION LOCATION
AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES 2.2 AND 2.3 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 E6.36

ACRES

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(III) — PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I–II — BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- NORMAL MINIMUM OPERATING LEVEL
- RIVER MILES
- A A — SECTION LOCATION
- AREA OF POTENTIAL PERMAFROST

NOTES

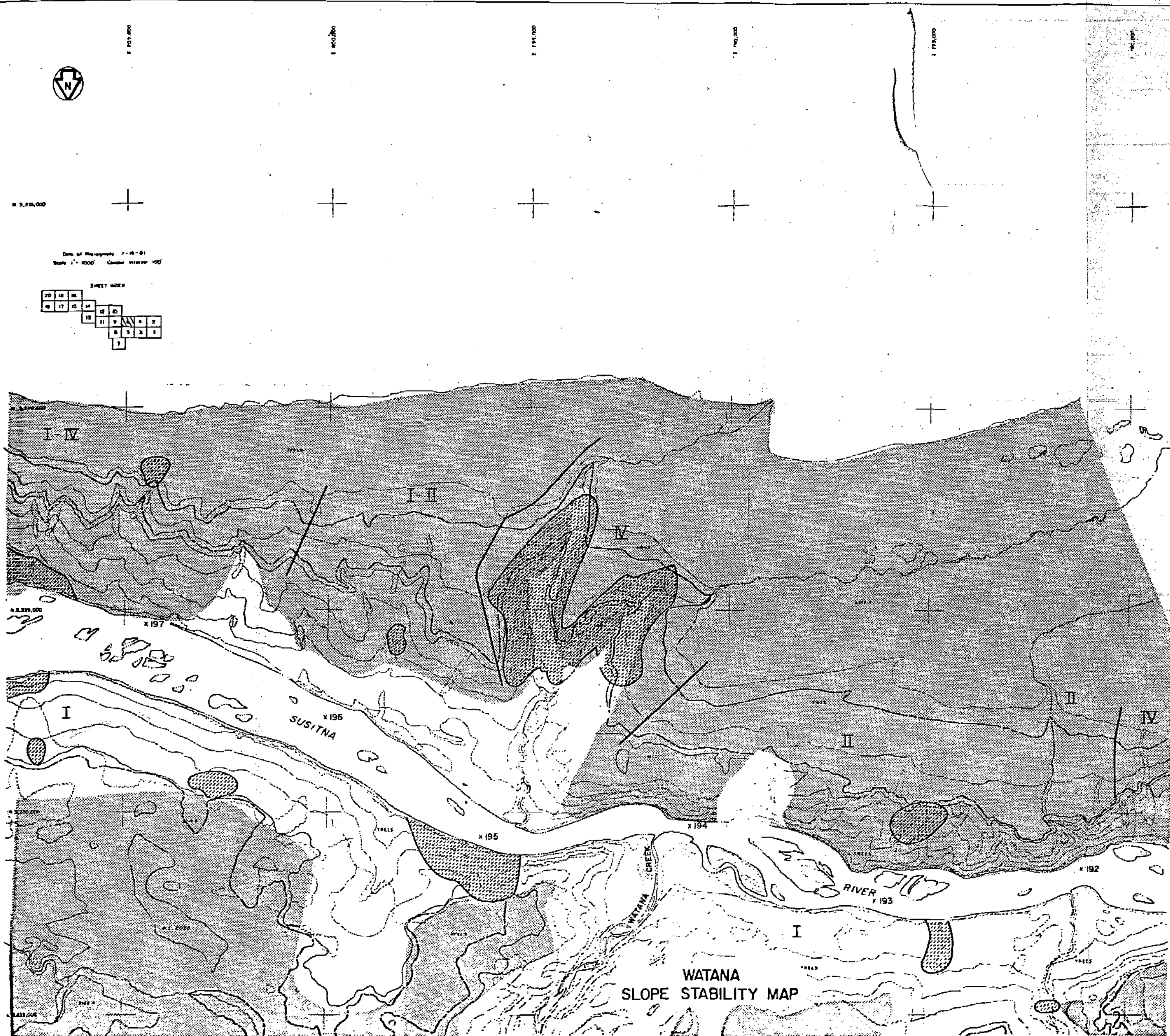
1. REFER TO FIGURES 2.2 AND 2.3 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION.

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E6.37

ACRES



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

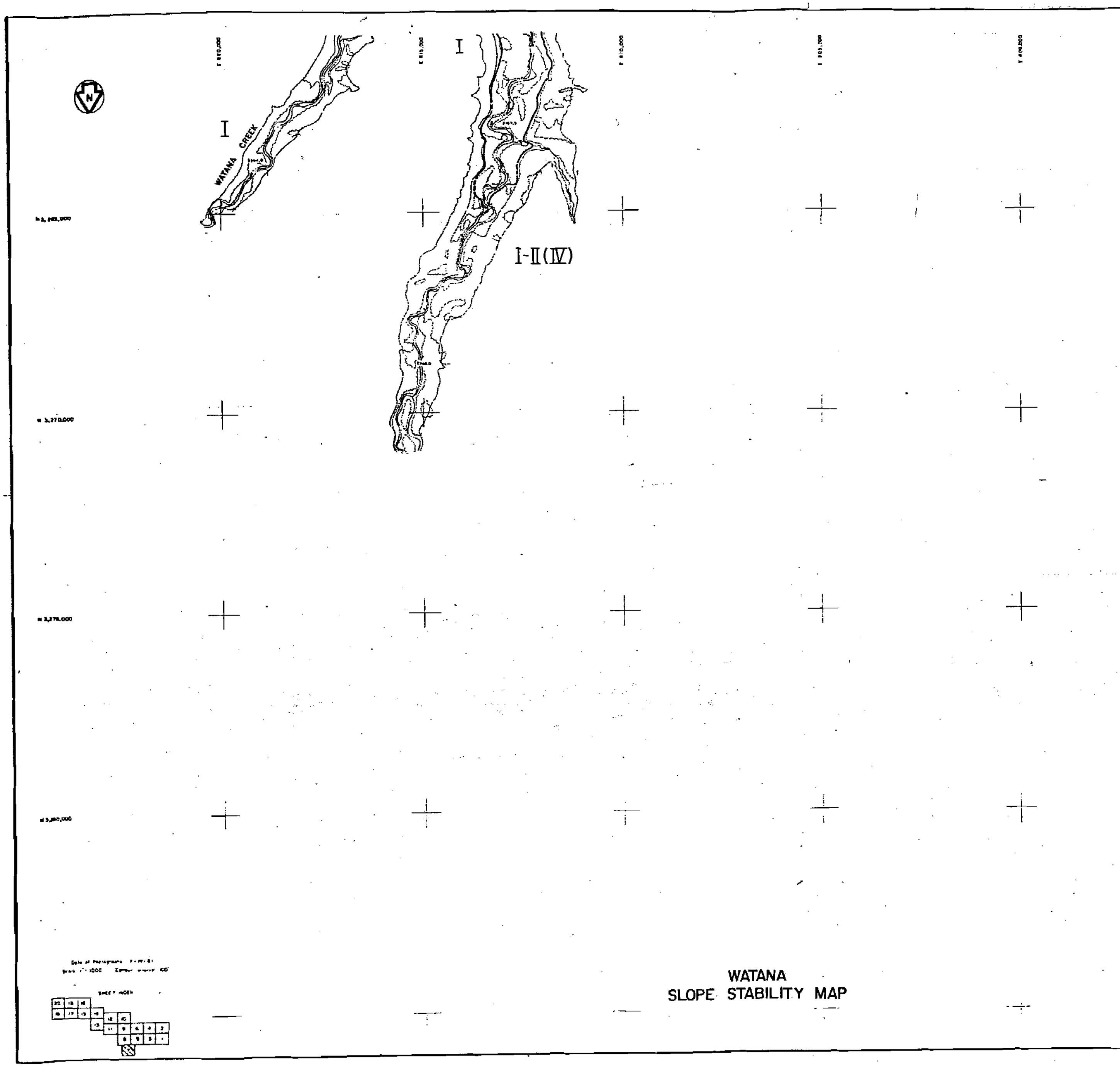
I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I(IV)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
	NORMAL MAXIMUM OPERATING LEVEL
	NORMAL MINIMUM OPERATING LEVEL
X	RIVER MILES
A A	SECTION LOCATION
	AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES 2.2 AND 2.3 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

WATANA
SLOPE STABILITY MAP

FIGURE E6.38



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
- NORMAL MINIMUM OPERATING LEVEL
- RIVER MILES
- A A SECTION LOCATION

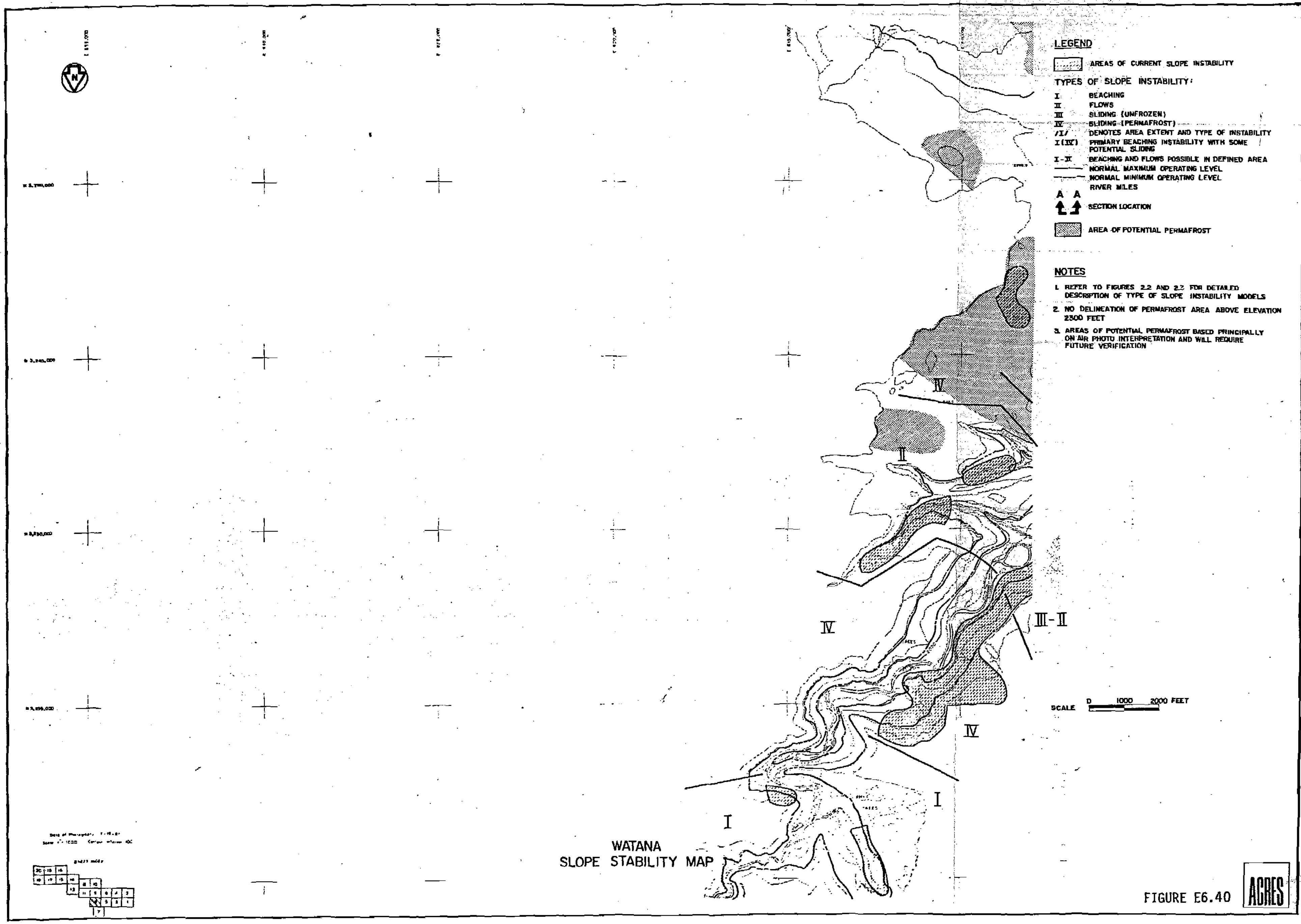
NOTES

1. REFER TO FIGURES 2.2 AND 2.3 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

WATANA
SLOPE STABILITY MAP

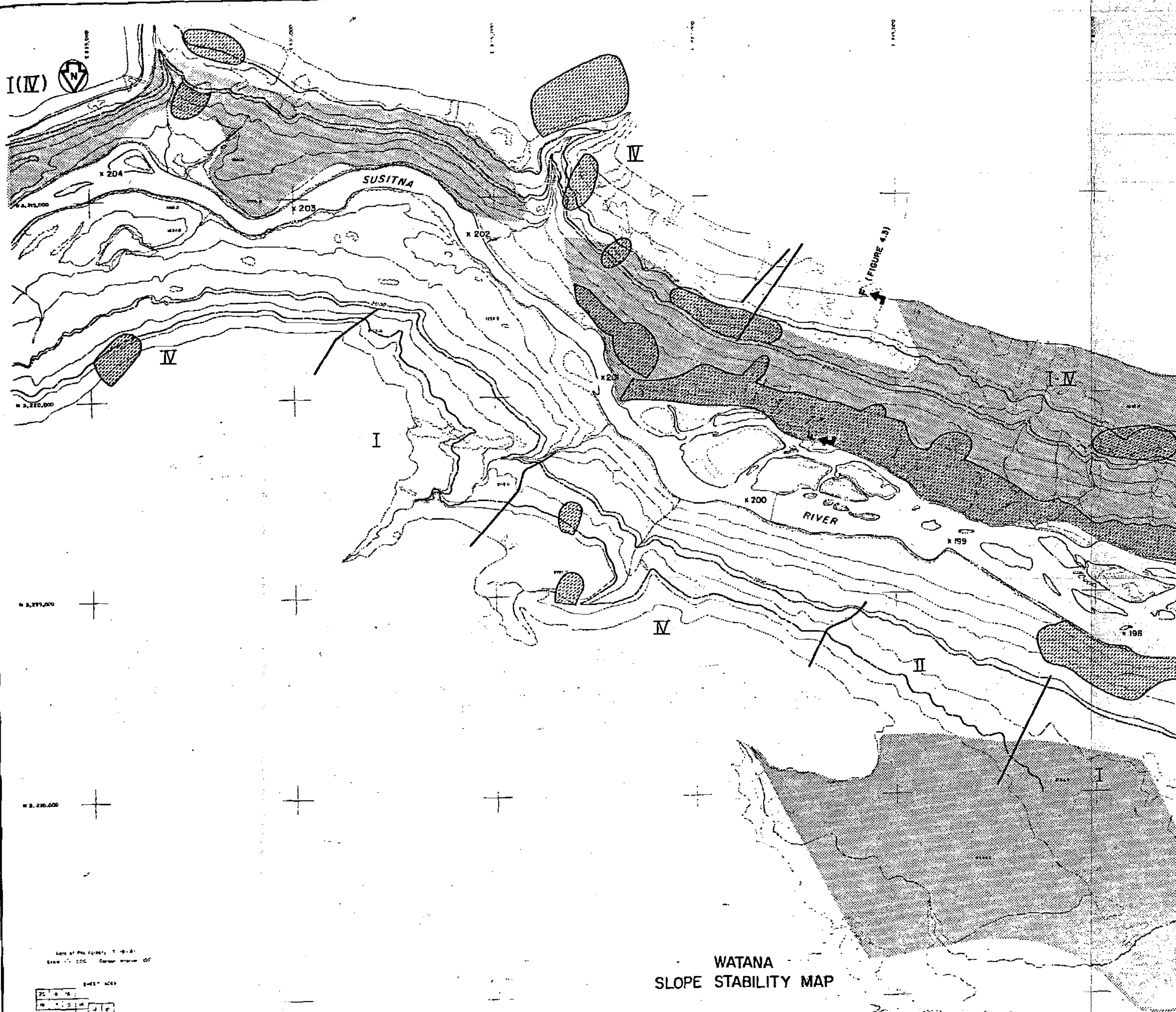
FIGURE E6.39

ACRES



WATANA
SLOPE STABILITY MAP

FIGURE E6.40



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
- NORMAL MINIMUM OPERATING LEVEL
- X — RIVER MILES
- A A — SECTION LOCATION
- AREA OF POTENTIAL PERMAFROST

NOTES

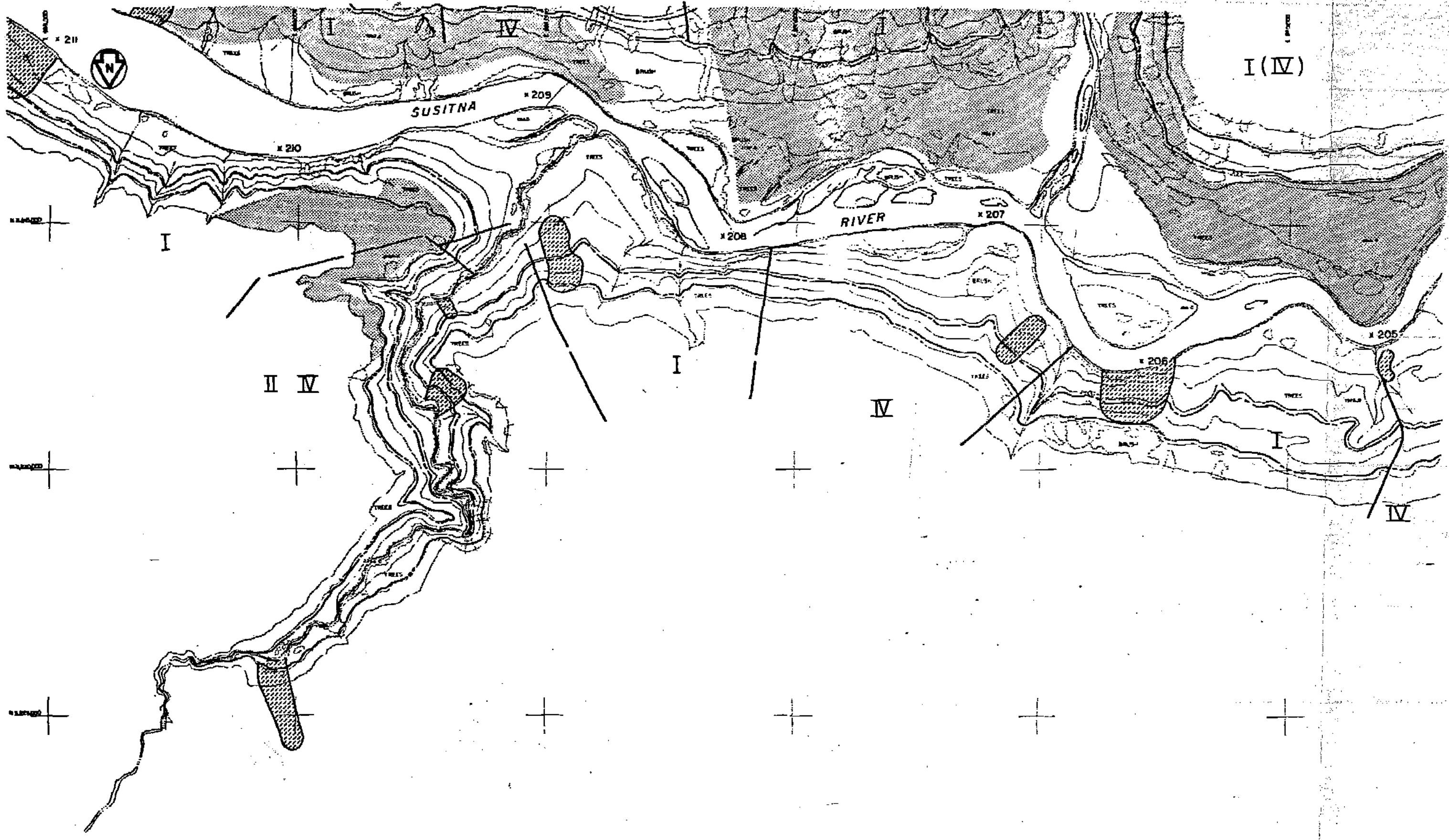
1. REFER TO FIGURES 2.2 AND 2.3 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E6.41

ACRES



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
A A	SECTION LOCATION
	AREA OF POTENTIAL PERMAFROST

NOTES

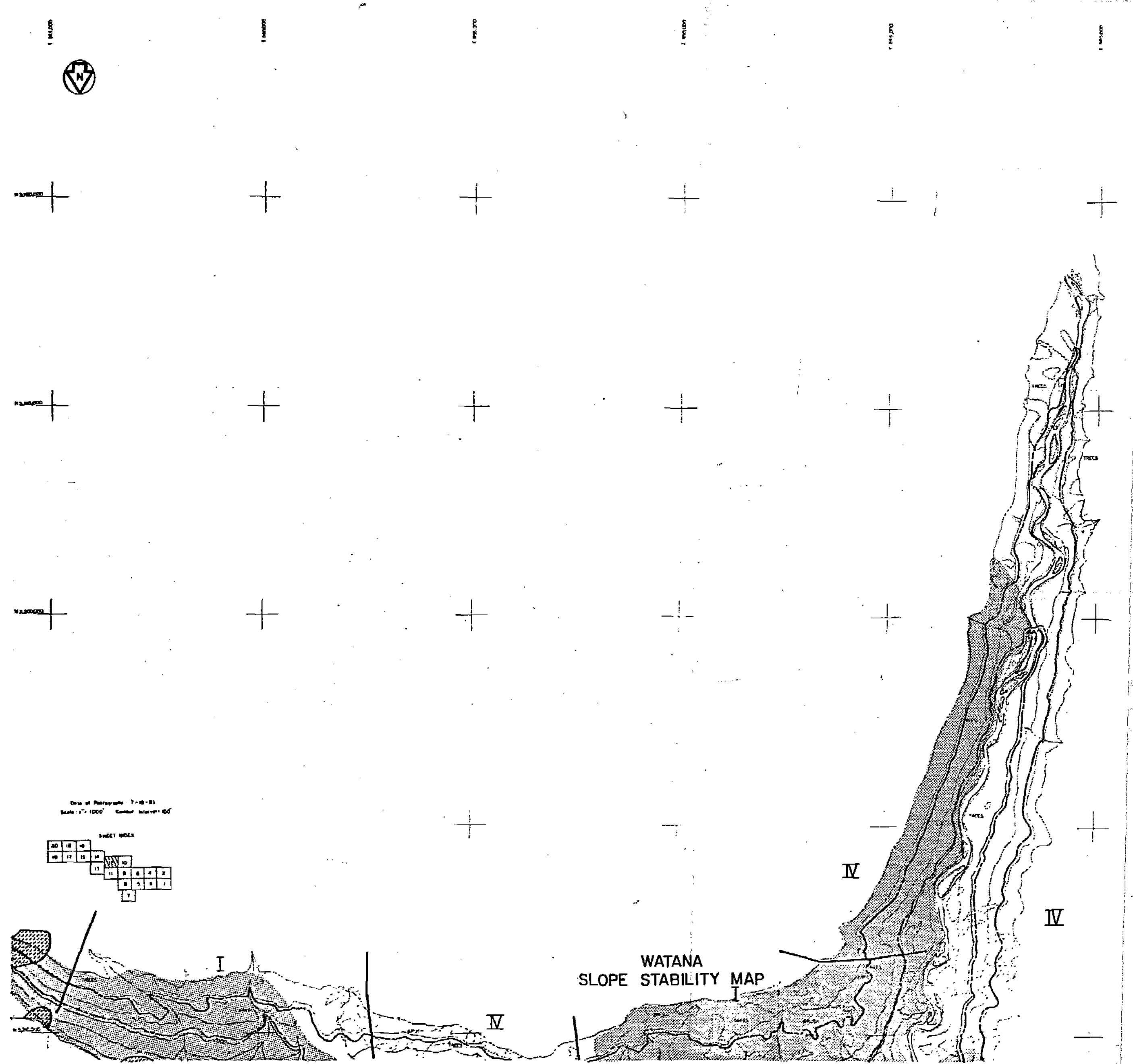
1. REFER TO FIGURES 2.2 AND 2.3 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E6.42

ACRES



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
	RIVER MILES
A A	SECTION LOCATION
	AREA OF POTENTIAL PERMAFROST

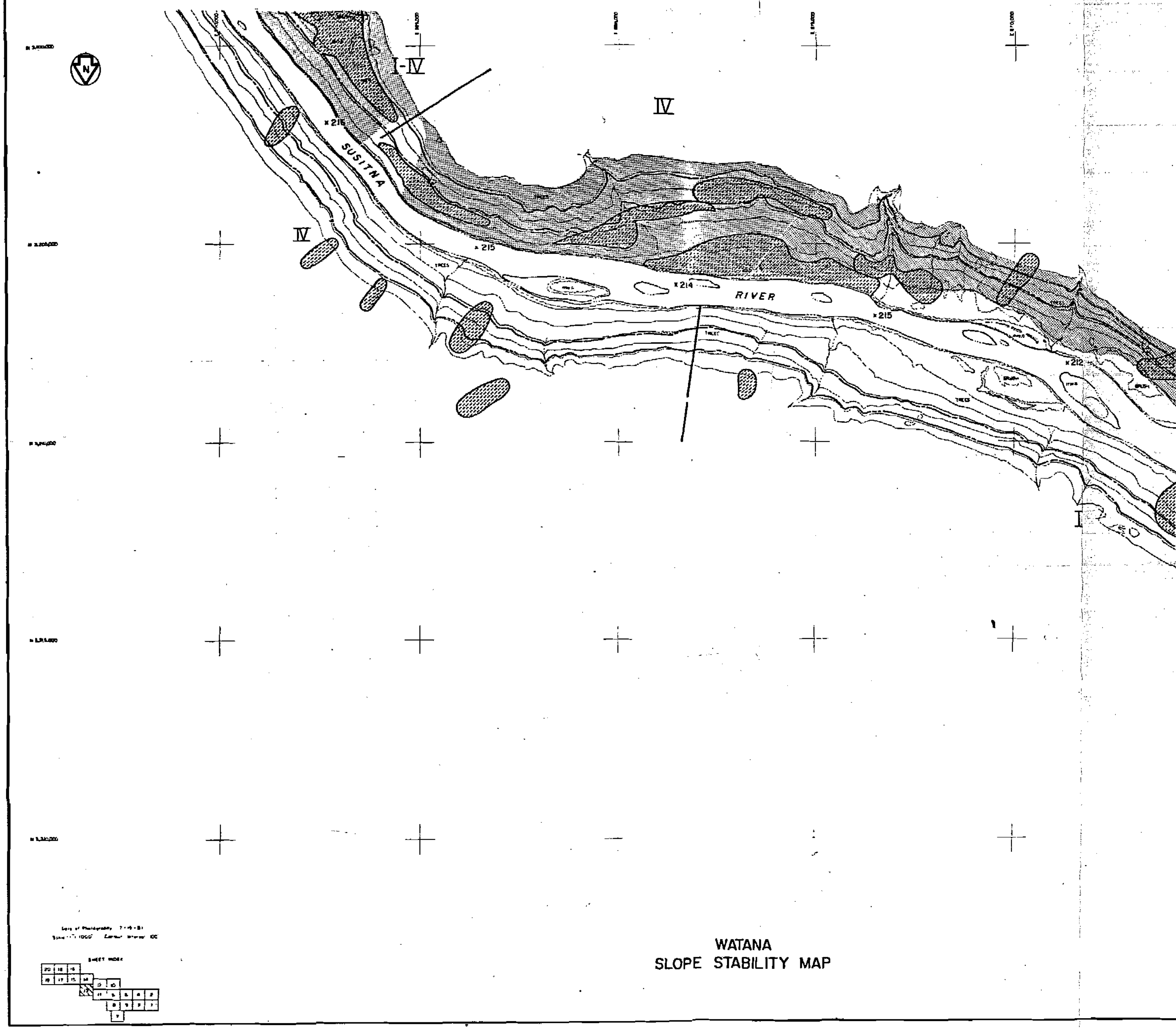
NOTES

1. REFER TO FIGURES 2.2 AND 2.3 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 E6.43



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
NORMAL MINIMUM OPERATING LEVEL
X RIVER MILES
A A SECTION LOCATION

AREA OF POTENTIAL PERMAFROST

NOTES

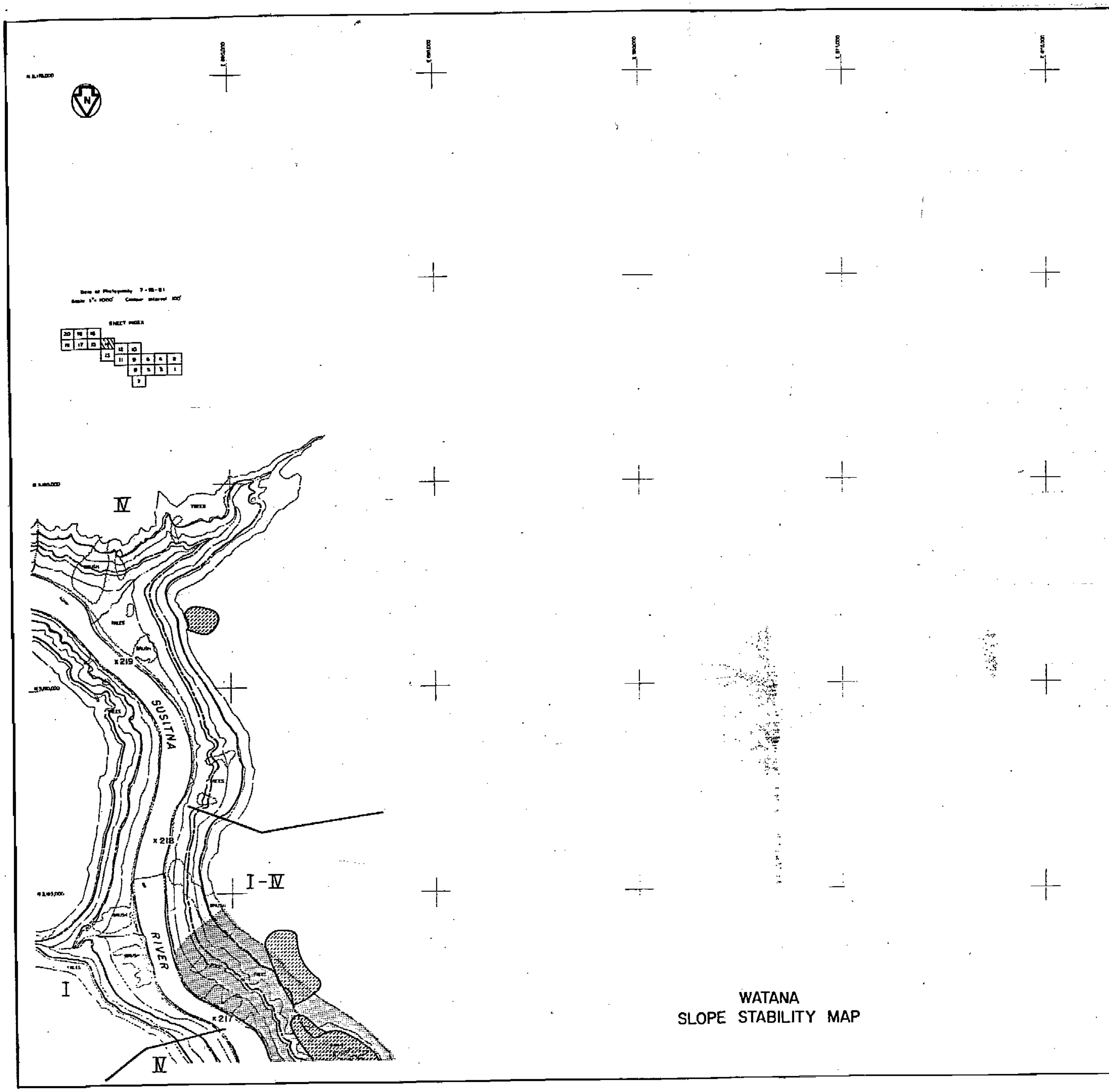
1. REFER TO FIGURES 2.2 AND 2.3 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E6.44

ACRES



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
A A SECTION LOCATION
AREA OF POTENTIAL PERMAFROST

NOTES

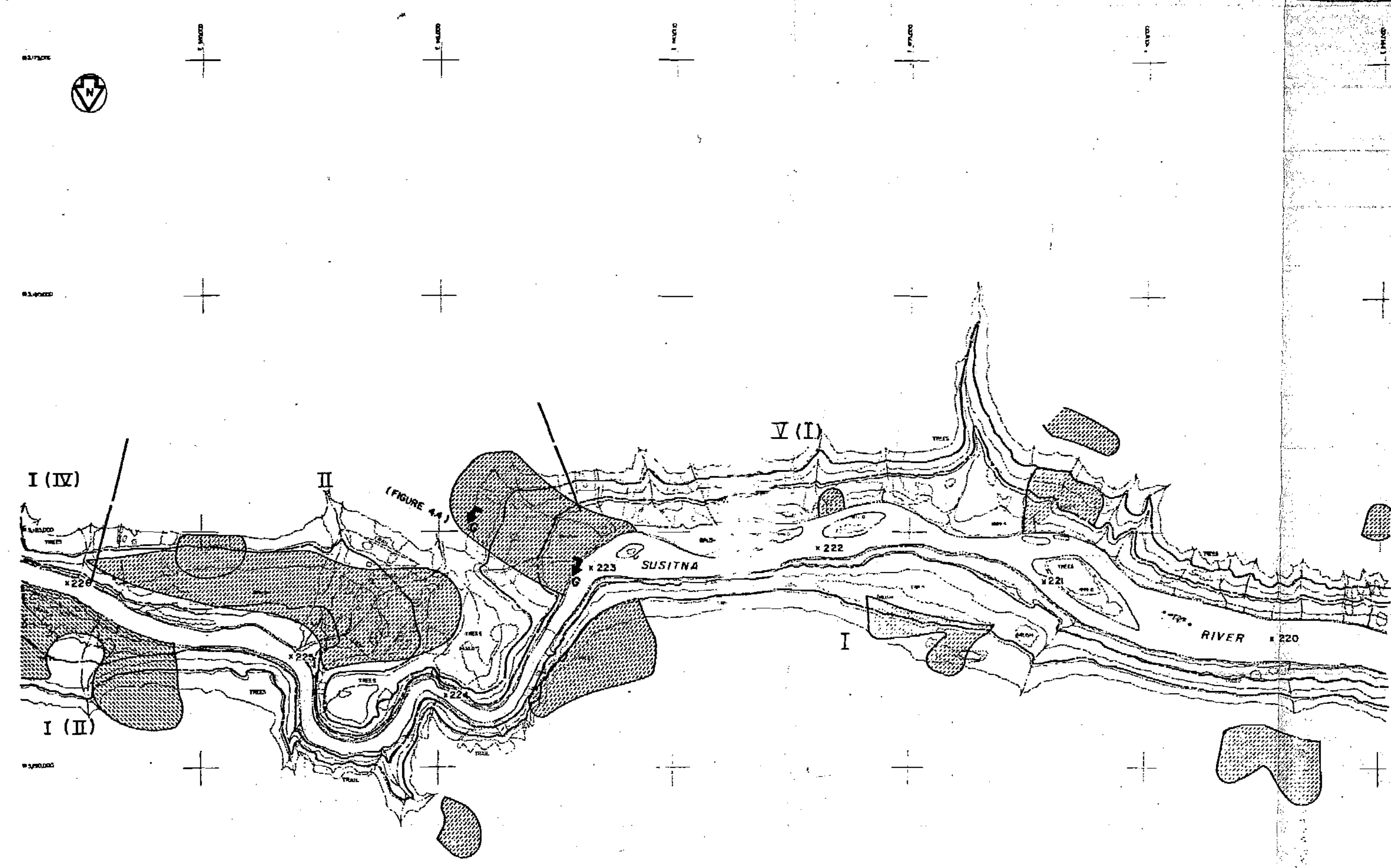
1. REFER TO FIGURES 2.2 AND 2.3 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E6.45

ACRES



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
- A A — SECTION LOCATION

NOTES

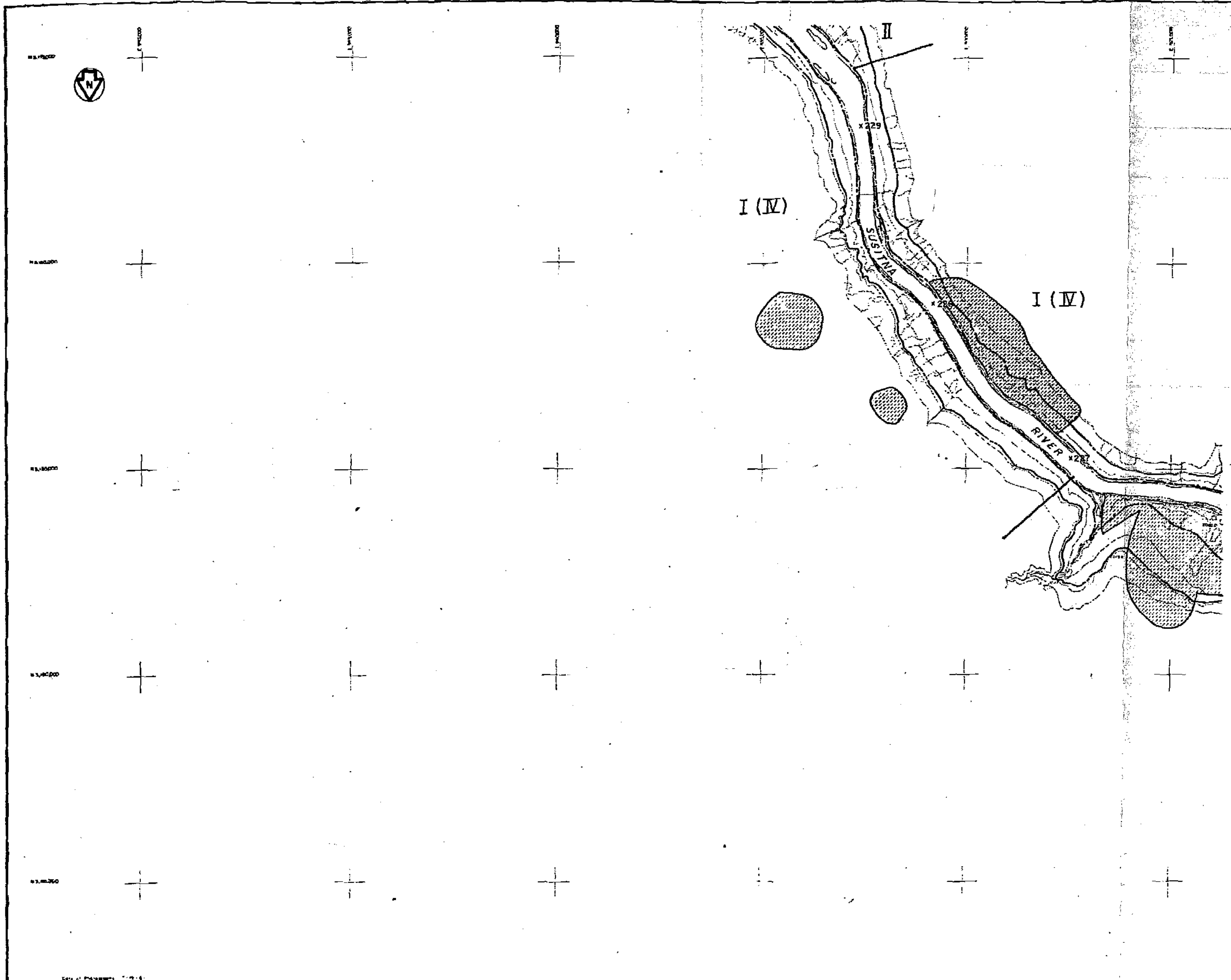
1. REFER TO FIGURES 2.2 AND 2.3 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E6.46

ACRES



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
A A	SECTION LOCATION

NOTES

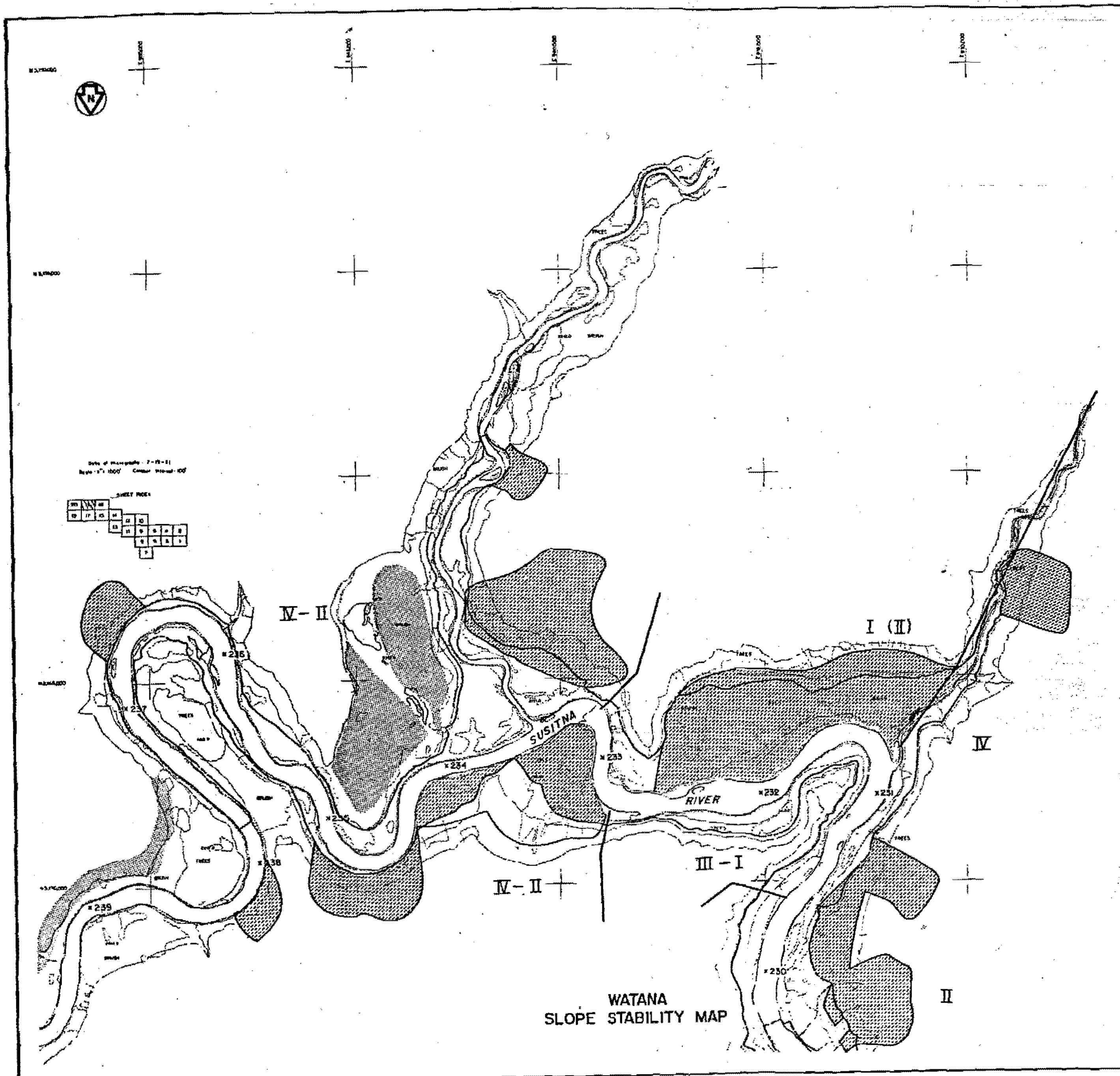
1. REFER TO FIGURES 2.2 AND 2.3 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E6.47

ACRES



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
- NORMAL MINIMUM OPERATING LEVEL
- x RIVER MILES
- A A SECTION LOCATION
- AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES 2.2 AND 2.3 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 E6.48

ACRES