ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

VOLUME I

REVISED DRAFT - PLAN OF STUDY

JANUARY 1980

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February 4, 1980

AN OPEN LETTER TO THE PUBLIC AT LARGE AND TO ALL INTERESTED AGENCIES AND ORGANIZATIONS

I am particularly pleased to provide for your review and comment the detailed Plan of Study for the Susitna Hydroelectric Project. The document itself is both comprehensive and complex, since it deals with a program which, if completed, will have far-reaching implications for the State of Alaska as well as for the Nation as a whole.

A series of steps has been taken during the past year to identify all and select one of those public agencies and private consulting firms with experience in the development of major hydroelectric projects. Your assistance, particularly in the selection process, has been invaluable; and I extend to you the sincere appreciation of the Board of Directors of the Alaska Power Authority and my own personal gratitude.

Governor Jay Hammond approved the recommendations of the Board of Directors and an agreement was signed with Acres American Incorporated on December 23, 1979, to undertake a major feasibility study leading to the preparation of a license application to the Federal Energy Regulatory Commission. Acres has had extensive experience in successful hydroelectric developments in northern regions and has assembled a team which draws heavily upon the contributions of Alaskan firms and which includes strong representation by Alaskan Natives whose selected lands lie within the proposed project area.

As you review the attached plan, I hope you will keep in mind two important thoughts:

1. The fact that a feasibility study is to be undertaken does not necessarily mean that a hydroelectric project of any kind will ever be constructed on the Susitna River. It will provide the basis, however, upon which an informed decision can be made as to whether the State could or should proceed in the matter.

2. The publication of this plan does not permanently fix the manner in which the proposed work is to be accomplished. On the contrary, I regard it as a dynamic document which will, I hope, be steadily improved with your assistance. It has already undergone an important metamorphosis as a result of testimony and correspondence received during the past four months, and I have no doubt that further editions will be responsive to your suggestions and comments.

I have scheduled public meetings on March 4, 5, and 6, 1980, in Anchorage, Fairbanks, and Talkeetna respectively. I hope you will plan to attend one of those sessions because I believe you will find it informative. More important, though, it will offer a real opportunity to influence the course of the work early in its conduct. If you are unable to attend, your ideas are still needed; I hope you will address them to Nancy Blunck, Public Participation Officer for the Alaska Power Authority, as soon as possible. I have set no deadline for comments, since the State will benefit much from a continuing interactive process.

As you will note in reviewing the plan, additional public meetings and workshops are scheduled. I will keep you informed as to dates and times; and I will also make it a point to provide you with progress reports and descriptions of various work elements from time to time.

In short, I am enthusiastic about having embarked on this important venture; and I am especially proud to note that the State of Alaska has dared to take the lead. If we are going to be successful, though, we need your help. May I count on you to become involved?

Sincerely,

Eric Yould
Executive Director
Alaska Power Authority

ACKNOWLEDGEMENT

This Plan of Study could not have been produced without major contributions from each corporate member of the Acres team. Frequent cross country journeys, long hours devoted to preparation of inputs, and an unusual degree of effort from various administrative support staffs have together been instrumental in completing the assigned task--and much of the work has been an out-of-pocket expense for each corporate member. In addition to this enthusiastic support, however, a number of other individuals and organizations have cooperated fully and advised sagely.

The Alaska District, U.S. Army Corps of Engineers, has made available for our perusal all of the materials which have been collected to date in support of their own feasibility study and subsequent field exploration program. The genuine interest displayed by the District in providing this information and in offering many hours of explanation from already busy staff members is deeply appreciated.

A group of concerned citizens and representatives of environmental groups was kind enough to offer their time to express issues which they regard as important. The session spent with them was most helpful as we prepared plans for environmental studies in particular and for other tasks in general.

The Alaska Department of Fish and Game has met with us on a number of occasions. The thoughtful efforts of that organization in developing a program necessary to achieve project objectives and in discussing ways and means to achieve it without compromising ADF&G's own requirement for maintaining objectivity have been necessary and important.

The Federal Energy Regulatory Commission has been kind enough to provide us with advance information regarding possible regulatory changes soon to be promulgated.

Individual consultants who would serve as principal investigators for environmental studies and others who have agreed to become candidates for external review boards have been extremely helpful in laying out this plan.

The University of Alaska, through its various institutes and individual faculty members, has made its extensive capabilities known to us and has offered advice and assistance in planning for their use.

The Alaska Department of Natural Resources has provided a program to us for the conduct of certain in-stream studies for our consideration.

Discussions with various utilities during prior visits in November 1978, and subsequently have been helpful to our understanding of the power market.

The Alaska Power Administration has provided valuable information about power surveys, transmission line planning, and unique operational experiences at existing hydroelectric projects under their control in Alaska.

The Bureau of Land Management has offered coordination and explanations which will be useful in satisfying certain important permit requirements.

Staff members of other Alaska agencies such as the Department of Economic Development, Department of Commerce, and the Department of Environmental Conservation have kindly furnished us with statistical data and with vital information regarding plans for the future in Alaska.

The Fish and Wildlife Service and the National Marine Fisheries Service have offered advice to our environmental planners as the basis for understanding their roles in our satisfaction of FERC regulations.

We have been impressed with the professionalism displayed by the Alaska Power Authority in devising the program for possible selection of a private engineering firm and especially in their impartiality as they scrupulously provided assistance and advice to the various competitors in this exciting endeavor.

Once the original version of this Plan of Study had been submitted to the Alaska Power Authority, it was reviewed with care by organizations and individuals noted above and by numerous others. Many individuals took the time to testify to the Board of the Power Authority, and offers of asistance have come from most of them. This revised version of the Plan includes a new Section A4 which describes the manner in which such inputs have been handled to date. We gratefully acknowledge the help so generously given by all those mentioned in Section A4.

Other individuals and groups too numerous to mention have contributed as well. To all who have supported the Acres effort, sincere appreciation is extended. We are delighted to know that such a high degree of cooperation exists throughout the State of Alaska and within the organizations of others having interests there. Our confidence in our ability to successfully implement this POS has been enhanced immeasurably as a result.

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A.1.1 - Introduction

This Plan of Study was originally prepared by Acres American Incorporated on September 11, 1979 in response to the Request for Proposal issued on June 25, 1979, by Mr. Eric Yould, Executive Director of the Alaska Power Authority. A series of presentations by competing consulting engineering firms on September 27, 1979, and public testimony accepted by the Board of Directors of the Alaska Power Authority (APA) on September 28, 1979, preceded the selection of Acres American Incorporated as the recommended Consultant to the State of Alaska in the event the State should later choose to proceed on the Susitna Hydroelectric Project without federal involvement. By unanimous resolution on November 2, 1979, the Board recommended to Governor Jay Hammond that the State enter into a contract with Acres American Incorporated to conduct a feasibility study and prepare a license application to the Federal Energy Regulatory Commission (FERC).

In response to suggestions from interested citizens as well as public and private organizations and agencies, a number of revisions have been made to the original Plan of Study (POS). This version has been prepared for the purpose of providing an opportunity for further public review and comment prior to proceeding with major portions of the work. Subject to the approval of APA, further revisions will be made subsequent to public meetings to be conducted in February 1980 and from time to time thereafter in response to the legitimate concerns of interested individuals and organizations. Certain major changes from the original POS are detailed in subsequent sections. Briefly stated, these include:

(i) The preparation of demand forecasts is a sensitive and crucial task. Issues such as when--or even if--a Susitna Project is needed cannot be resolved without such efforts. To ensure total objectivity in forecasting and to avoid any question of conflict of interest, the State of Alaska has entered into a separate contract with the Institute of Social and Economic Research (ISER) to develop independent forecasts.

(ii) Significant increases in the amount of effort devoted to environmental matters and particularly to fishery studies have been introduced in response to comments from the Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service.

(iii) To ensure objectivity in the conduct of the public participation program, the public information officer and his or her assistants will be employees of the Alaska Power Authority rather than of Acres American Incorporated.

(iv) The level of effort associated with marketing and finance has been reduced in the first phase of the study, thereby deferring certain financing subtasks until initial questions as to project viability and concept have been more thoroughly addressed.

(v) Some changes have been made in logistical and administrative support efforts both to accommodate the increased level of environmental

activity and to ensure efficiency and responsiveness as the study progresses.

(vi) Tabulations have been added for the purpose of providing more explicit details regarding man-hours and expenses to be associated with each subtask.

(vii) Additional effort has been prescribed for in-stream flow studies downstream of Talkeetna in response to concerns expressed by the Alaska Department of Natural Resources.

Because of the magnitude of the proposed effort and the diversity of skills required to accomplish it, Acres American Incorporated has assembled a group of subcontractors who will contribute to satisfaction of the overall program objectives. Major participants in the Acres team include R&M Consultants, Inc.; Woodward Clyde Consultants; Terrestrial Environmental Specialists, Incorporated; Cook Inlet Region Incorporated/ Holmes and Narver, Incorporated; Salomon Brothers; and Frank Moolin Associates.

The gestation period for giant projects tends to be long. Wild bursts of enthusiastic effort followed by periods of genuine apathy (or total despair, depending upon whose vantage point is selected) are common. Development of the Susitna River has so far followed that classic pattern.

As early as 1952, the Bureau of Reclamation published a report identifying a large number of potential hydroelectric power sites in Alaska, noting pointedly the strategic advantages enjoyed by the Susitna River because of its proximity to Anchorage and Fairbanks. Even then, Devil Canyon was perceived as the place to install a large dam. It was--and is--a steep, narrow rock walled canyon through which silt laden grayish waters swirl and churn and turn to white froth as they rush for the sea. Updates by the Bureau led to proposed authorization in 1961 of Devil Canyon and Denali--a site far up-river of Devil Canyon, astride extensive wet lands and marshy areas, where the Susitna draws strength from relative placidity before it attempts the inevitable plunge through miles and miles of canyons.

Another giant project was under active contemplation in the early sixties and its mind boggling size, together with the engineering challenges it offered, were especially exciting in a brand new state and during the space technology wars then being waged. The Rampart hydro project would have created a pool larger than the State of Connecticut if it had ever been built.

While the Rampart studies put the Susitna project in limbo for a while, a number of long time Alaskans worried about the risks of such a venture. As fate and thoughtful argument would have it, Rampart is unlikely to be built at any time in this century.

Susitna was delayed long enough, though, to allow for discovery and development of then economical natural gas production. By the time the warnings of energy doomsayers were beginning to be heard and felt in 1973, the Susitna project once again began to appear attractive. The Bureau of Reclamation updated its earlier studies in 1974, recommending a four dam system, and the U. S. Army Corps of Engineers launched a major pre-feasibility study which led to a recommendation in 1976 by the Chief of Engineers that the Susitna Project be authorized. The Corps plan

recommended two high dams, the first of which would be built as a massive earthfill gravity structure 810 feet in height at the Watana site more than 30 miles upstream of Devil Canyon. The second Corps dam was to be a 635-foot-high thin arch concrete structure which would sweep across the canyon from rock abutment to rock abutment--essentially the same as the Bureau's Devil Canyon proposal.

By June 1978, the Corps of Engineers had prepared a plan of study requiring 24 million dollars and offering a program leading to completion of a detailed feasibility study. Further investigations by the Corps confirmed the adequacy of the Watana site, though they did reveal that some changes were required in particular for the spillway arrangement.

Data, analyses and reports collected and prepared by the Corps of Engineers will be used throughout the course of the work to be undertaken by Acres American Incorporated. Even so, it is likely that new load forecasts will differ from those earlier offered by the Corps of Engineers. In addition, expanded alternatives studies, continuing geotechnical and seismic investigations, vigorous public involvement, and thorough environmental inventories and assessments can significantly affect the range of conclusions which might be derived from the work. It follows that the earlier development plan may not necessarily prove to be the optimum. This Plan of Study describes a series of tasks and subtasks, along with reasons for these, and provides information regarding organizational matters and team qualifications. A new concept for development, if development is found appropriate, will begin to emerge by the end of the first year of study.

A.1.2 - Primary Objectives of Study

(i) Establish technical, economic and financial feasibility of the Susitna Project to meet future power needs of the Railbelt Region of the State of Alaska.

(ii) Evaluate the environmental consequences of designing and constructing the Susitna Project.

(iii) File a completed license application with the Federal Energy Regulatory Commission.

A.1.3 - Specific Objectives of the Study

To meet the primary objectives of the study, the following specific objectives are proposed:

(i) Determine the future electric power and energy needs of the Southcentral Railbelt Area, based upon independent analysis by ISER.

(ii) Assess alternative means of meeting the load requirements of the Railbelt Area.

(iii) Prepare an optimal development plan for the Susitna Project wherein power costs and probable impacts are minimized, safety is enhanced, and financing is achievable.

(iv) Establish a definitive estimate of the total cost of bringing power on line, together with a statement of cash flow requirements.

(v) Evalute the physical, economic, and financial risks of the Susitna Project and determine ways and means to avoid or minimize their consequences.

(vi) Evaluate existing environmental and social factors as they now exist in the proposed project area, assess the impacts of the proposed project, enhance environmental values to the extent possible, and recommend mitigating measures.

(vii) Estimate the annual system power costs in the Southcentral Railbelt with and without the project, study the integration of Susitna power into the Railbelt utility systems, and assess power marketability.

(viii) Prepare a complete license application and file this with the Federal Energy Regulatory Commission.

(ix) Ensure that the needs and desires of the public are known, keep interested parties and the public informed, and afford an opportunity for public participation in the study process.

(x) Determine an optimal program for achieving financing, including resolution of issues regarding tax-exempt status of bonds which may later be offered.

(xi) Minimize the costs incurred by the State of Alaska in successfully achieving the above objectives or alternatives in reaching the earliest practicable conclusion that development of the Susitna Project is or is not in the best interests of the State.

(xii) Maximize opportunities for equal employment opportunities for Alaskans and for involving in the work members of those Native Corporations in the region.

A.1.4 - Primary Aspects for Susitna Project Requiring Study

(i) Introduction

As with any major hydroelectric project, the number of investigations and substudies required to achieve the primary objectives noted in paragraph A.1.2 above is significant. Each of these requirements is described in terms of precise tasks and subtasks in Section A5. Even so, a number of primary aspects, particularly insofar as they address major concerns, deserve to be highlighted.

(ii) Power Studies

While this Plan of Study had necessarily to be written on the assumption that project feasibility will in fact be demonstrated, we are well aware of the importance of demonstrating that a need for significant increases in power generating capacity does truly exist

in the Railbelt Area and that this need can best be satisfied by the Susitna Project. Indeed, it is clear that the absence of need or the discovery of a better means of satisfying it if it exists will represent prima facie evidence that development of the project is not in the best interests of the State. Power studies will be undertaken to examine and define a range of load forecasts and to assess possible alternatives or groups of alternatives which together could satisfy the projected demand.

We will avail ourselves of intimate knowledge of Alaska in general and the Railbelt in particular through employment of the Alaskan office of Woodward Clyde Consultants (WCC) to assist in conducting power studies. Load forecasts will be developed independently by ISER and will form the basis upon which demand curves and load duration curves are prepared. The study of non-hydro alternatives by WCC (reviewed by Acres Thermal Power Division) and of hydro alternatives by Acres will be enhanced through use of the General Electric Optimum Generation Program Series (sophisticated computer models designed to permit multiyear analysis of generation system mixes) which we have successfully used in the past for a comprehensive study of alternatives to the Dickey Lincoln School Lakes Project in New England.

(iii) Financing Plan

Successful financing of giant projects is inevitably a complex and time-consuming task. Our own expertise in this area, as evidenced by participation in the successful financing of the Churchill Falls Project where Mr. J. G. Warnock managed the team responsible for bond support documents, will be available to the financial consultants of the Salomon Brothers. This well known investment banking firm has managed or co-managed 655 issues of tax-exempt bonds in the total amount of $48.3 billion since January 1, 1974. Dr. C. P. Chapman will manage risk analysis studies. His unique capabilities in that area have been demonstrated time and again for large projects including some in sub-arctic environments.

(iv) Ice Engineering

The study of ice engineering has necessarily been an important part of Acres' efforts for past projects in recent years. Our successful involvement in hydroelectric projects throughout North America, with a total installed capacity of over 14,000,000 kW, is a matter of record. Assistance in ice engineering studies will be provided as well by R&M whose hydrologic investigations of rivers and streams throughout Alaska has been significant. Our conceptual designs for minimizing the problems associated with frazil ice, ice jams, ice shelving and the like will be subjected to exhaustive modeling after license application has been made and during the preparation of detailed designs. Problems associated with permafrost are also familiar to the Acres organization; our staff has extensive experience in developing unique and effective methods of dealing with such problems in connection with large power projects in subarctic regions.

(v) Earthquake Engineering

Of the many potential risks associated with the Susitna Project, those associated with seismic problems are probably the most significant. Certainly, no single area of concern is likely to have more immediate catastrophic consequences if the engineering work has not been done thoroughly and well. Not only is it important to design all structures to survive unscathed in the event of an earthquake, but it is also essential to determine the extent to which creation of reservoirs on the Susitna River will itself induce earthquakes.

Our approach to this problem is twofold: first, we have engaged the California office of WCC to undertake extensive seismic studies. WCC has operated in Alaska for over ten years and has amassed a considerable data base on geological and geotechnical conditions, faulting, and seismicity of the Anchorage and Railbelt Areas. WCC have also had extensive seismic experience with major dam and power projects elsewhere. Secondly, we have recommended a list of eminent professional engineers whose accomplishments are recognized worldwide as the basis for selection by the Power Authority of one or more external review boards. The engineering board would be provided funds on the order of $1 million with which to undertake confirmatory or additional studies. Acres would offer coordination services and administrative support, where appropriate, to the board(s), but authority to select, remunerate, terminate and to direct their activities would remain with the Power Authority.

(vi) Project Management/Construction Management

In order to provide Alaskan-experienced project and construction management capability in the POS team, Acres will combine with its in-house resources the additional resources of the Frank Moolin and Associates, Inc. organization. This company presently operates out of Fairbanks, Alaska and provides executive project and construction management experience to the energy industry. The Moolin team provides many years of "hands-on" experience on varying sizes and types of projects, including recent responsibility for construction of the Trans-Alaska Pipeline, a $4.2 billion effort. Members of the organization provide an unusual, multi-disciplined, combination of energy, industry and heavy construction experience. In addition, conditions unique to planning, managing and constructing projects on the Alaskan scene are familiar to all of these individuals.

SECTION A2 - STUDY APPROACH

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A.2.1 - Discussion of Problems to be Resolved

(i) Introduction

In formulating a logical approach to study of a major hydroelectric development in a relatively hostile climate and environmentally sensitive region, it is necessary to identify the particular problems which must be addressed and to place these in proper perspective with the more routine elements of technical and economic feasibility assessment. The objective is to arrive at an optimal development which recognizes and allows for all constraints imposed, and addresses such vital issues as environmental acceptability at the proper stage to allow it be considered adequately through public participation and other processes to satisfy licensing procedures. The financial viability of the project is, of course, also a vitally important consideration which lies beyond the strict technical and economic parameters of the proposed development. The approach taken in the overall studies must lead to a confident determination of the financiability (or otherwise) of the project.

We have identified a number of potential problem areas early in our planning efforts as the basis for ensuring that the final Plan of Study will provide adequate measures for dealing with them.

(ii) Optimal Development

Millions of dollars have been spent to date in an effort to determine just which of many concepts will lead to optimal development. Optimization, like beauty, though, is in the eyes of the beholder. The Bureau of Reclamation selected a four-dam system to be established on the Susitna River. The Corps of Engineers has succeeded in obtaining authorization to conduct detailed feasibility studies for a two-dam system which would provide essentially the same amount of power as that for four dams of lesser height. The Corps approach benefitted from the Bureau of Reclamation's work and built upon it. The Acres approach will continue that refinement process. In so doing, though, it must account for certain potential problems:

(a) Load Forecast Accuracy

There has been a nationwide slackening of historically high load-growth rates for electric utility systems since the energy crisis of 1973. It can no more be assumed that this trend will continue throughout the next decade or two than it can be assumed that longer term historical patterns will once again assert themselves. The State must, nonetheless, develop load forecasts in whose accuracy a high level of confidence can be placed.

(b) Alternatives to Susitna Development

Implicit in the search for optimal development is the identification of all reasonable alternatives. We must acquire strong and reasonably definitive knowledge of alternatives to the Susitna Project for satisfying projected load forecasts.

(c) Alternatives for Development of the Susitna River

In the event that no alternative to Susitna Development is found to be superior in terms of technical, economic, and environmental considerations, we will need to assure the Power Authority that the Corps of Engineers concept or some other is the most appropriate. The days when a simple economic test led to plan selection have long since passed.

(iii) Data Acquisition

Significant portions of the total cost of the Plan of Study are devoted to the acquisition of additional data. Field studies in the areas of survey, geotechnical, hydrology, environmental, seismicity, and transmission will demand a base of support and proper means of site access and egress in addition to time and equipment for the purpose. Certain important problem areas include:

(a) Seasonal and Weather Constraints

Most data collection will have to be accomplished during relatively short summer seasons, resulting in high peak loads on camp facilities (a major consideration in the Logistical Plan in Section A8) and in particular on demands for certain equipment (including drilling, special survey, gaging, seismic instruments) not necessarily in great abundance in Alaska--at the very time that other projects in the State simultaneously require like items.

(b) Study Period

The relative brevity of the proposed 30 month study period does not allow for training personnel to operate in a relatively harsh sub-arctic environment.

(c) Coordination of the Program

The variety of investigations conducted at the same time in the same general area and subject to severe, albeit important, land use restrictions demands an unusual degree of coordination and management of the data acquisition effort (see also (ix) below).

(iv) Financial Risk

It must be recognized at the outset that several aspects of the Susitna Hydroelectric Project will inevitably imply substantial risk to potential investors. It will be necessary, therefore, to address all real and perceived risks with a high degree of intensity, limiting or disposing of as much of the exposure as possible to build a realistic level of confidence in the project. There will, no doubt, be residual risks for the potential investor to consider but attitudes to these will be significantly affected by the way in which the Alaska Power Authority can demonstrate that all potential problems have been diligently examined and fully addressed.

(a) Superposition of a Large Project on a Small System

In the case of Susitna, a very major, capital-intensive project undertaking is being considered for addition to an existing utility base of relatively limited facilities and fixed assets. The financial approach must therefore be on the basis of Project Financing where funding is raised on the assured revenue and cash flow generated, usually, from a long term sales contract, in this case for purchase of power and energy.

(b) Risk of Meeting Anticipated Power Output

The nature of the financing approach has a bearing on many aspects of the overall study plan for Susitna. It requires, for instance, that hydrological and energy assessments are made with a particularly high level of confidence and that risks of short-fall are carefully examined.

(c) Design Risks

A high level of confidence must be achieved in the adequacy of engineering design and in the construction costs involved in meeting the requirements imposed. The estimates should be at a level allowing for a relatively high likelihood of an "under-run" on total costs including contingency provisions. The most careful judgment must be applied to assessing likely increases in material, labor and equipment costs to allow for confident definition of a provision for escalation.

Construction and contracting practice must be developed which avoids or even eliminates over-run exposure. These and many other aspects of the plan for development must be all the more intently addressed to meet the need of a project of the extent of Susitna.

(v) Design Problems

Our own experience in planning, design, and construction management of large engineering projects in North America and particularly in sub-arctic environments has made us acutely aware of certain design problems which must be addressed early in the process of total project development. These include:

(a) Seismicity

The Susitna River flows in a region of known high seismic activity. Acquiring knowledge of the precise nature and extent of this activity must necessarily be a prelude to designing earthquake resistant project features. In addition, the question of the effect of large reservoirs on the Susitna River in stimulating earthquakes must be studied in some detail. Because of the potential for catastrophe, careful and thoughtful evaluations of seismic efforts by others appears to be necessary.

(b) Ice

It will be necessary to ensure that icing problems do not interfere with operation of the completed hydroelectric project as well as to determine how downstream ice conditions with the project will differ from those without. The effect of ice shelving in the reservoirs or ice jamming must also be addressed.

(c) Slope Stability

The nature of the project area is such that proposed reservoirs tend to be long and narrow. Landslides, avalanches, and side slope failures are especially to be guarded against.

(d) Siltation

It will be necessary to consider the rate at which sediment load fills dead storage space in the upper reservoir of the system, since the risk of losing energy production due to losses in active reservoir storage must be eliminated. Downstream of any dams, the effect of changes in sediment content will require evaluation as well. In the latter evaluation, it will be important to determine the extent to which relatively clearer sediment starved summer flows will pick up additional load from the river bed downstream.

(vi) Environmental Impact

There is no doubt that the level of effort to be applied to environmental studies is necessarily significant, because little is known of the total environmental resources in the project area and the superposition of a giant project on the Railbelt will have social consequences which must be determined. Certain problem areas of note include:

(a) Complete Cycle Studies

Definitive evaluations in the environmental area frequently require successive multi-season data acquisition efforts. In the case of the fishery resource, for example, a five year program is indicated. Yet, license application is scheduled less than three years hence.

(b) Getting up to Speed

The unique nature of the environment in the project area is best studied by those who have earlier gained familiarity with sub-arctic regions in general and Alaska in particular. The proper individuals must be identified lest lengthy training periods consume valuable study time.

(c) Relationships with ADF&G

We recognize the great expertise of ADF&G in certain areas and we believe certain environmental studies can best be accomplished if undertaken directly by ADF&G. Even so, it is

imperative that the necessary review, evaluation and approval function which ADF&G must also perform be objective. Procedures must be worked out to preserve this objectivity.

(d) Information Exchange

As environmental data are collected and impacts are assessed, it will be necessary to ensure that provisions are made for information exchange and for contributions from the many interested individuals and groups whose particular focus will be on environmental issues.

(e) Interpretations of NEPA

A major battleground in the recent past between project proponents and opponents has been the National Environmental Policy Act. Major projects in the past would almost certainly travel a route of court litigation to determine compliance with the Act. The litigation has centered upon the Environmental Impact Statement, FERC application Exhibit W. The recent council on Environmental Quality's Requirements for Environmental Impact Statements should clarify the review process at the Federal level; however, problems still exist in agency interpretation and between the state and federal governments.

(f) Mitigation

The Fish and Wildlife Coordination Act requires that an applicant coordinate with Federal and State fish and game agencies to prepare a fish and wildlife plan. The plan is included in the license application as Exhibit S. Exhibit S will contain essentially a mitigation plan for the adverse impacts which project development will have upon the existing wildlife resources in the project area. Considering the pristine setting of the project area and migratory and habitat patterns of such resources as caribou herds and moose, preparation of and agreement on the mitigation plan will be a major effort in project development. The FERC must resolve disagreements on the adequacy of the mitigation plan prior to issuing a license. A great deal of time can be involved in the series of correspondence, meetings or formal hearings if needed to resolve the conflict.

(g) Conflicting or Overlapping Authorities

Along these same lines are compliances with the Anadromous Fish Act and the Endangered Species Act. As these acts are administered by different agencies (Fish and Wildlife Service and National Marine Fisheries Service, respectively), approval by one does not necessarily ensure approval by the other. For example, method of fish transportation (if required) around the dam may not be acceptable to both agencies. Proposed operation of the reservoirs may also fall into conflict over maintenance of minimum downstream release and fluctuating release volumes.

(h) Historic Preservation Concerns

Exhibit V of the license application requires the applicant to show consultation with the Advisory Council on Historic Preservation and the State Historic Preservation Officer ~~to assure that no historic or cultural sites will be adversely affected. Numerous problems could be associated with this aspect should such sites be uncovered.~~ NEXT page INSERT

(vii) Licensing

Prior to constructing the Susitna Hydropower Project, extensive coordination and consensus agreements must take place between the project developer and numerous Federal government agencies. Several permitting processes will need to executed. However, the focal point of the efforts will most probably be the preparation and action relative to the Federal Energy Regulatory Commission (FERC) license application. The license would allow the applicant to construct and eventually operate the proposed facility for a period of up to 50 years. The licensing process is fairly complex as noted by the fact that the current average major license review time is approximately seven years from time of application to approval.

(a) Complexity of Review Process

The reason for the length of time and complexity of review lies in the fact that the FERC and the reviewing agencies have a number of requirements under existing statutes which must be satisfied prior to taking action upon an application. Additionally, the statutes, under certain circumstances, provide conflicting authorities between review agencies and the FERC.

(b) Intervenors

Compounding the review difficulty is the special status of intervenors in the process. The FERC's authorization laws and administrative practice give enormous powers to the project intervenor to delay the process with a series of hearings on legal questions pertaining to project licensing. Essentially, the burden of proof of compliance with the listed statutes will fall upon the developer.

(c) Land Rights Issues

Even at this stage of project formulation, several pitfalls within the licensing process can be foreseen. Land rights for construction and access to the project could be a problem, particularly with the complexity of the Alaska native land rights, and use of federal lands under the Federal Land Policy and Management Act. At this time, the U. S. Departments of Interior and Agriculture are developing regulations for administering the Act. As the regulations will be relatively new during planning and development of the Susitna project, administrative and legal problems associated in compliance with the Act can be expected.

(d) Water Resource Development Plan

Section 10(a) of the Federal Power Act requires that the project be best adapted to a comprehensive water resource development plan for the project area. In the case of the Susitna project, compliance will mean that the need for the project and all alternatives to the project have been carefully studied to determine that this development is indeed in the best interests of the public.

(e) New Regulations

We have determined that FERC will shortly issue new proposed draft regulations for licensing a major hydroelectric project. It will be necessary to review new procedures and respond to required changes while the planned study is in progress.

(viii) Problems in Public Participation

There is a distinct difference between the concepts of public information and public participation. The former is designed to let the public know what is happening (sometimes, unfortunately, to let the public know only what the planner wants it to think is happening). The latter not only includes public information as a subset, but also provides a means for the public to become involved in and influence the course of work. For an effort as large as the Susitna Hydroelectric Project and with impacts extending effectively into perpetuity, public participation--including accurate public information-- is an imperative. The attendant problems are significant:

(a) Conflicting Interests.

Taken alone, the motivations and objectives of individuals and organizations who have been involved to date on the Susitna Project are generally sincere and relatively easily understood. Considered collectively, however, they represent clear conflicts. It follows that it will be virtually impossible to satisfy every desire. Problems will almost certainly arise in determining what heirarchy of concerns is to be established. How will federal interests in accelerated development of energy resources be reconciled with those of citizens who would preserve the Alaskan quality of life? Of recreational interests in preserving a natural river with those of consumers who seek ways and means to stabilize the cost of electric energy? The following list of special interests is not exhaustive:

-- Utility interests, including concerns about ability to meet energy demands, prospects for recovery of capital investments, profits for investors.

-- Alaskan native groups, particularly those which have selected lands in the Susitna River Basin.

-- Fisheries industries whose concerns about impacts on future catch, particularly of anadromous fish, have not yet been fully addressed.

-- Downstream residents concerned especially about changes the Susitna Project will impose upon their way of life.

-- Consumers of electric power in the Southcentral Railbelt.

-- Marketers of alternative energy resources.

-- Conservationists who perceive the Susitna Project as likely to spur unwanted growth.

-- Industrial and commercial interests who perceive stabilization of energy costs as important to future progress.

-- Workers interested in employment opportunities arising directly or indirectly from construction of dams on the Susitna.

-- Agencies charged with maintenance and preservation of Alaskan wildlife, including in particular the Alaska Department of Fish and Game and the Federal Fish and Wildlife Department.

-- Railbelt residents who seek assurances that a Susitna Project will neither induce earthquakes nor fail catastrophically if one does occur.

-- And others.

(b) Impacts on Schedules

A proper public participation program necessarily requires that provisions be made to permit time for review and comment at various points as the study develops. Accommodating review time requirements, particularly in cases where proceeding on a new task depends upon a favorable decision having been made on results of the previous task, can serve to delay scheduled completions.

(c) Changing to Accommodate the Public Interest

True public participation requires not only that the public be informed and that they be allowed to offer comment, but also that their legitimate inputs be incorporated into the work. Thus, provisions must be made to properly address new issues as they arise and to take action where required. It is almost inevitable that an effective public involvement program will require that the plan of study be dynamic. An increased risk that costs will be incurred and scheduled completion times will be extended as new courses of action are pursued must be regarded as a problem area.

(d) Communications in Alaska

The large area over which power would be distributed, relatively undeveloped road nets, and remoteness of many of the areas to be

affected by the Susitna Project combine to create unusual pressures on effective communications. It follows that any proposed public participation program must be designed to afford reasonable involvement opportunities even for those who have no practical means to attend meetings or make regular visits to information centers in large metropolitan areas.

(ix) Control and Coordination

We have assembled a team whose individual corporate members bring strong special skills to bear upon satisfaction of the various project objectives. The danger associated with such an assemblage is that control and coordination problems increase in complexity as a result. It becomes important then, that early steps be taken and procedures established so that the synergism promised by putting the team together is not lost through failures in management. Two areas in particular are worthy of consideration:

(a) Planning, Control and Management of the Study Itself

Provisions must be made to avoid costly redundant efforts as well as to ensure that each and every task and action is budgeted for and accomplished.

(b) Planning the Eventual Construction Program

The matter of timely and efficient constructibility of a proposed major project can be an extremely costly problem area if it is not attended to throughout the planning and design process.

A.2.2 - Proposed Approach to Solution of Problems

(i) Introduction

Given the size and complexity of the proposed project, it should come as no surprise that the problem areas noted above and others as well demand carefully developed, often innovative, solutions. In general we believe a certain pervasive discipline must be a part of our approach to the project as a whole and to each of the necessary tasks and subtasks individually.

Briefly stated, we recognize a series of steps as virtually universally applicable:

(1) Define the problem
(2) Establish objectives
(3) Describe the work necessary for achieving the objectives at minimum cost
(4) Assign responsibility to the appropriate team or subteam leaders
(5) Ensure each leader has sufficient qualified persons to do the work
(6) Make the necessary physical resources and logistic support available
(7) Schedule the activities to ensure resource commitments and overall project schedule are appropriate
(8) Collect the necessary data
(9) Evaluate the data
(10) Draw conclusions
(11) Provide expert review
(12) Define new problems
(13) Establish flexible procedures to permit rescheduling and new resource commitments as necessary when new problems or scope changes arise.

While these steps will apply in general, certain specific comments as regards problems identified in paragraph A.1.1 above are noted in succeeding subparagraphs.

(ii) Optimal Development

(a) Load Forecast Accuracy

The business of predicting the future inevitably involves varying degrees of uncertainty. We plan to reduce this uncertainty to an acceptable level through the use of proven analytical econometric models developed in the State at the University of Alaska precisely to support the type of predictive efforts required. ISER will lead this work, supported by Professors T. L. Husky and O. S. Goldsmith. ISER will establish a range of forecasts together with assumptions associated with their development. This approach will, of course, allow us to test the implications of various growth scenarios on project viability and timing, as well as permit evaluation of reasonable alternatives.

(b) Alternatives to Susitna Development

Definition of reasonable alternatives demands that a marriage of appropriate technical knowledge of each alternative to intimate knowledge of Alaska be accomplished. Acres has strong hydro-electric experience as well as a large thermal power development group. WCC (Alaska) furnishes capabilities in analysis of non-hydro alternatives as well as an Alaskan presence. Our intention is to study the widest possible range of alternatives and to test various combinations which might satisfy load forecasts. This testing process will be facilitated through the use of sophisticated computer models which we have used in prior alternative studies of major hydroelectric projects.

(c) Alternatives for Development of the Susitna River

While much time, effort and thought has gone into the earlier Corps of Engineers studies, we will nonetheless take a fresh look at possible alternative ways of developing the Susitna Basin. These studies will include, for example, consideration of a long power tunnel extending downstream from the Watana site. Our project team includes a number of personnel who are skilled in the art of hydroelectric planning and we have included a Concept Planning team within our Feasibility Studies task force.

(iii) Data Acquistion

We recognize the requirement for large field investigating teams. It follows that proper field support facilities will be necessary. Our logistics plan at Section A8 provides details in that regard. The matter of equipment demands in Alaska is a serious one. Not only must the proper type of drilling, measuring, instrumenting and sampling devices be available when and as needed, but also they must in many cases be modified to permit use in remote sub-arctic regions. R&M is the only organization of its kind in Alaska. R&M's special surveying and drilling equipment and extensive Alaskan experience contributes much to our confidence in our ability to complete the proposed work on time and on schedule. In addition, most other principal investigators have had extensive experience in sub-arctic environments and all have made preliminary arrangements for equipment needs. Coordination will be facilitated through the establishment of an Alaskan project office headed by a senior Acres engineer who has himself led similar efforts in the past for major projects in Canada.

(iv) Financial Risk

We have chosen the investment banking firm of Salomon Brothers whose strong experience in tax-exempt bonding matters will be extremely important in preparation of plans for successful project financing. Mr. J. G. Warnock's own successful experience as the leader of the bond documentation team on the Churchill Falls project provides an important strength on the Acres team. The study effort for

financial planning will be shared equally by Salomon Brothers and Acres. In addition, we have planned an extensive risk analysis program for ensuring that we identify and minimize various financial and design risks. Certain special considerations pertain:

(a) Multidisciplinary Involvement

It will be clear that to deal adequately with the matter of financial risk it has to be considered from very many viewpoints inevitably involving a multidisciplinary approach.

Traditionally, engineers alone were engaged in the early planning and consideration of hydroelectric power sites with other interests - such as financial, insurance, labor relations, etc. - joining in later when feasibility had all but been established. Such a procedure was quite practicable when hydroelectric sites clearly justified development on their own merit, economics were not in question, and environmental constraint unheard of. Nowadays, despite rapid escalating costs of fuel generated power alternatives, hydroelectric power generation is often marginal in power supply economics and development faces constant uncertainty as to whether any installation could be justified at all in the face of environmental constraint and objections.

Into this aura of uncertainty major projects such as Susitna are being launched. It is clear that only the highest standard of management and dedication to an ultimate belief in proper development of renewable resources will lead such a project to implementation. Methods and approaches are, however, available and well tested which will assist the process markedly. Basic to the successful approach is a broad interdisciplinary involvement from the start. Engineers must be effectively backed up by a team of financial specialists, economic analysts, environmentalists, insurance experts, construction managers, labor relations specialists, etc. No longer is it practical for a single engineering discipline to carry a project from initial concept to commitment to construction in a program of relatively isolated concentration on the physical aspects of the site.

We advocate, therefore, a carefully planned close involvement of the engineering team with all the other disciplines and specialists which, when integrated to a sum of effort over the preliminary phases of a project, can build the basic confidence which overcomes the apparent and growing constraints. Fundamental to the approach we recommend, is a close integration of engineering, financial and insurance speciality input from the start.

(b) Technical/Economic Relationships to Power Contract Negotiations

Fundamental to the success of any plan to develop the Susitna project is the focus of contract for the sale of energy and capacity from the completed plant. In order to provide the

adequate debt service a contractual arrangement is necessary which calls for "take or pay" obligations on the part of the energy purchases. This and other basic elements of the power contract can have a profound effect on the viability of the project.

It might be suggested that this is not an engineering problem but one for the marketing/utility negotiation team alone. But not necessarily so; it is the engineer who can contribute vital knowledge to the assessment of the reliability of energy supply over the years of the contract. He also has to balance the values of various capacity factors for the planned plant. He has to assess, furthermore, the changing role that may be attributed to the facilitation as time passes. It is necessary to view power system planning on a "dynamic basis."

Economists play their succinct role too. Much of the forecasting of likely market conditions falls to their judgment. They have to assess likely future variations in fuel and energy aspects of alternative generation. Cost escalation on construction has a heavy bearing on a hydroelectric project and is amenable to careful judgment by economic specialists.

(c) Risk Assessment and Contingency Planning

In order to protect the project capital structure, allowances have to be made for contingencies, provisions for escalation in costs and for a completion guarantee. The first two of these items are basic elements of the capital cost budget while the third is usually dealt with as a standby financing arrangement. In arriving at prudent allowances for contingencies on very major projects, it is becoming increasingly desirable to determine these as a result of a carefully conducted risk analysis. Modern methods are available, which have been adequately tested on large undertakings, to determine the likely confidence level of estimates both of costs and schedule (which itself has cost implications).

The approach planned for Susitna would employ up-to-date techniques of risk assessment and contingency planning which on the one hand would permit the reduction to a minimum of "real money" over-run allowances and employ to the maximum extent possible measures to mitigate risk.

The study contributes substantially to the determination of the "residual risk," which, in a project of the nature of Susitna, remains to be covered by insurance or by a conscious acceptance by the owner that it will be covered in some other way should adverse circumstances prevail. The capacity of the international insurance market method to assume greater levels of insurance has improved as the size of major projects has increased. The type of approach recommended is intended to lead to the most favorable practicable basis for insurance provisions.

(v) Design Problems

Special design problems demand special attention, for time and effort devoted to their resolution prior to construction pay handsome dividends in terms of correction costs avoided later and in terms, as well, of securing the necessary degree of confidence on the part of investors, environmental interests, State authorities, and the public in general.

(a) Seismicity

We have noted earlier the importance of seismicity studies and of designing earthquake resistant structures. So important do we regard this area that we have planned for exhaustive investigations supported by modern sophisticated instrumentation. Acres has dealt with seismicity issues with great success in the past on a number of major hydroelectric and other power projects. WCC (California) will conduct the seismicity studies for the Susitna Project, with careful review provided by the Acres team. While the WCC expertise in this area is unquestionable, we have been particularly careful to provide the means and the resources to seek confirmation by objective experts whose duties will be conducted quite apart from the Acres team. In accordance with APA's expressed desires for a level of effort of $1 million to be applied to an external seismicity investigation, we have chosen an approach which calls upon a proposed external board (or boards) to invest that sum in those confirmatory or additional studies which they regard as essential to rendering an expert opinion on how well our own designs are responsive to earthquake concerns.

(b) Ice

Ice studies are provided for in the study program to assess the current icing conditions found naturally in the Susitna basin without the project. Field investigations and surveys will also produce vital information, including appropriate in-stream hydrographic surveys and flood plane cross-sections downstream of the proposed dam sites. As design concepts are evaluated, we will draw upon the expertise of members of the Acres team who have countered operational icing problems on past projects. In this regard, for example, our mechanical engineering staff will pay particular attention to the possibility that frazil ice may interfere with generation flows. A separate Ice Studies team has also been included within our Feasibility Studies organization. The nature and extent of the potential for ice jamming and ice shelving in the reservoirs will be detailed and close coordination will be maintained with those involved in environmental studies to ensure that impacts of ice formations on wildlife migration and survival are understood.

(c) Slope Stability

Field investigations by R&M will provide a source of data for

evaluating slope stability. The extent of permafrost in the dam and reservoir areas and the resulting potential for slope instability will be carefully investigated by the Project Team. The combined expertise of R&M and Acres will be directed toward the design of countermeasures as appropriate and risk studies will consider the consequences of unanticipated slope failures and snow slides.

(d) Siltation

Earlier Corps of Engineers studies have indicated that the deposition of sediment in the Watana reservoir will be entirely in the dead storage area throughout the proposed operating period for the project. We will conduct necessary studies to confirm those earlier findings and to better determine the expected rate of siltation. Changes in silt load patterns downstream of the dams will also be examined from both environmental and water quality standpoints.

(vi) Environmental Impact

Our overall approach to a proposed extensive environmental program relies upon the coordination of a series of individual studies conducted by individuals whose entire professional careers have been devoted to particular subject areas. A number of consultants, several with considerable sub-arctic and/or Alaskan experience in pertinent areas of study, will participate in the work. The coordination effort will be accomplished primarily by TES whose own staff will augment the consultants' efforts. Certain specific matters highlighted above as problems will be resolved as follows:

(a) Complete Cycle Studies

The comprehensive program recommended by ADF&G is well conceived and is consistent with our own evaluations of the level of effort needed in important fish and game studies. The fact that the program extends beyond the proposed point for license application need not represent a deterrent, because our discussions with Mr. Ronald Corso of FERC have indicated that, provided the application itself describes what continuing studies will be conducted, it can be filed before they are completed.

(b) Getting up to Speed

Selection of consultants and, in appropriate areas of study, of ADF&G to perform baseline data acquistion work has been accomplished based on the criterion that each of the principal investigators must have experience in sub-arctic environments, preferably in Alaska.

(c) Relationships with ADF&G

Our approach to the issue of ensuring the ADF&G maintains its proper status as an objective reviewing and approving authority

while concurrently undertaking investigatory tasks involves a unique concept. Each of the field studies and reports to be produced by ADF&G will be produced for and funded directly by the Power Authority. None of our organization charts or concepts includes ADF&G as a subsidiary or subcontractor to Acres. ADF&G's involvement is assumed to occur in accordance with the following scenario:

(1) Baseline studies will be performed by ADF&G ~~where appropriate, the data being supplied to TES and its consultants.~~ For big game and fisheries including data collection, analysis and interpretations.

(2) TES and its consultants develop the environmental assessment.

(3) ADF&G reviews and comments upon TES work ~~which is reviewed and appropriate modified.~~ and modifications are recommended

(4) Mitigatory~~ry~~ion measures are proposed by TES (in some cases relying on data furnished to APA by ADF&G).

(5) ADF&G reviews proposed mitigation plans and offers comments.

(6) TES updates earlier submission.

(7) ADF&G approves.

This procedure will be followed as necessary throughout the period prior to FERC license approval.

(d) Information Exchange

Our approach to involvement of environmental interests external to the Acres team includes a series of eight workshops, each one of which will be partially or fully devoted to environmental matters. Six of the workshops are scheduled in advance and two are funded but not scheduled, to permit flexibility in response to issues of opportunity.

(e) Interpretations of NEPA

We will maintain our close review of recent CEQ actions as well as our monitorship of FERC license processing. We intend as well, through our Alaska Project Office, to maintain continuous close liaison with appropriate State agencies. State agencies will be invited to participate as well in workshop sessions.

(f) Mitigation

The scenario for seeking State approval for mitigation measures has been summarized in subparagraph (c) above. ~~It is our intention to resolve as many of the mitigation issues as possible prior to license application.~~

Continued next page

(g) Conflicting or Overlapping Authorities

By seeking the involvement of Federal and State agencies throughout the study period and especially in workshop sessions, we seek to minimize conflicts.

(h) Historic Preservation Concerns

We will schedule necessary consultations on historic preservation matters with appropriate federal and state agencies. Our plans to ensure archeological reconnaissance prior to site disturbance will also contribute to our satisfaction of problems in this area.

(vii) Licensing

Paragraph A.2.1 identified numerous difficulties which can occur in obtaining an FERC license. Although the list touches upon the problems which appear applicable to Susitna, others can arise during the lengthy process.

Our approach to the licensing issue calls for the establishment of a small team whose entire efforts will be devoted to coordinating the preparation of the total application as well as to maintaining frequent contact with FERC. Whereas individual exhibits will be generally prepared as outputs of other tasks, this focal point for licensing work will provide the means to minimize later interventions by anticipating sensitive issues in advance. Of particular importance will be the impact of new draft regulations when they are published. The early indications are that some cost savings may accrue as a result of simplifications in procedures. Even so, the Plan of Study is necessarily based on satisfaction of current regulations. We will propose changes at a later date if appropriate.

Particularly important in the licensing of a large project such as Susitna is the effective scheduling of preparatory activities. Plate A.2.1 indicates our proposed scheduling of all activities which we propose to undertake prior to submission of the license application, and afterwards. The essential philosophy of our proposed approach is to involve the FERC as soon as possible and to initiate contacts with all concerned local, state and Federal agencies and individuals well in advance of the submission. Yet the submission must respond adequately to the requirements laid down by the FERC. We confidently project a 30 month period to fully complete the data acquisition requirements for submission of a compliant license application to the FERC. We base these projections on our experience and discussions with FERC staff. License activities are discussed in detail in Task 10, Section A5 of this POS.

(viii) Public Participation

The overall objectives of the public participation program are twofold: to keep the public fully informed and to provide a means whereby the public can influence the work. These objectives will be

satisfied in general by conducting a thorough and enthusiastic public information program which includes multi-media exposure, scheduled events, resources set aside to capitalize on unforeseen information opportunities, and a total commitment to establishment of a continuously available and accessible information office; and the provision for dynamic planning. It is this latter facet of the public participation program which distinguishes it from more conventional approaches. Simply stated, we have built into the study process a provision for incorporating newly identified actions as well as independent review procedures. Our plan of study is an excellent blueprint for licensing. Public input and the sage advice of independent panels of experts cannot help but improve the plan--and thus, the study--as the work proceeds. Our specific approach to resolution of previously identified problems is as follows:

(a) Conflicting Interests

A series of milestones, including all public meetings and workshops, will become the trigger for preparation of action lists. Each substantive comment or concern will be translated into a specific action or will be recommended for rejection by the project manager. Proposed actions with significant impacts on time, schedule, or concept will be referred to APA for specific approval. Other actions of lesser apparent consequences will be routinely processed and undertaken, with APA kept fully informed. Those comments and concerns which are recommended for rejection will be referred for consideration (along with reasons for recommending rejection) to APA and to the appropriate external review board. (Note that both engineering and environmental review boards have been proposed.) The proposed actions as well as recommended rejections will represent the study team's best efforts to resolve conflicting interests and concerns. Even so, there is no reasonable way to ensure that all publicly expressed desires will be satisfied. Creation of an action list will provide the vehicle so that every concern is at least explicitly considered and deliberations of external review boards will provide further recourse for those who disagree with the position taken by the project manager.

(b) Impacts on Schedule

The extensive public participation program described in detail in Task 12 (Section A5) and illustrated at plates in that section has been designed to permit maximum public review and comment activities without disrupting the progress of the study. By publishing monthly progress reports, by conducting frequent workshops open to the public, and by allowing ample review periods for important reports prior to public meetings, we believe that it will be possible to maintain the agreed schedule and ensure maximum public participation.

(3) Changing to Accommodate the Public Interest

Whereas it is both possible and proper to plan for review periods under the assumption that the proposed plan of study

will proceed as originally prepared, there is no way to predict with certainty the extent to which actions introduced through the public participation program will influence schedules and costs. To minimize problems which may occur in this area, we have sought to involve the public immediately upon commencement of the study effort and to establish continuous coordination procedures for various interested agencies, with particular attention to those charged by statute with protection of environmental resources and those to be involved in distribution and sale of electric power. Flexibility has been built into the plan of study to allow for accommodating a reasonable number of changes to be introduced through the public involvement program.

(4) Communications in Alaska

In recognition of the extensive area which would be served by the proposed project, provisions have been made in the public participation program to allow for broad information coverage as well as the widest possible involvement. Each regularly scheduled public meeting is actually a set of three meetings to be held in Anchorage, Fairbanks, and Talkeetna. A total of eight workshops, each one of which may involve separate sessions with utilities, regulatory agencies, and environmental interest organizations, are planned. Locations for workshops will be chosen with a view toward maximizing public exposure. Indeed, the public participation plan is founded on the principle of taking aggressive action to seek public involvement rather than passive tolerance of public interests. No matter when or where meetings are scheduled, though, it is inevitable that some interested individuals will simply be unable to attend. We will have broad information coverage and our proposed information office will receive comments and suggestions at any time during the course of the study. Actions developed as a result of these latter inputs will be treated in a fashion similar to those introduced during or incident to formal meetings and workshops.

(5) Role of APA

To ensure total objectivity in the conduct of this program, it will be carried out by employees of the Power Authority. Constant coordination and knowledge of project status will be enhanced by the fact that the APA public participation staff will be colocated with Acres project personnel.

(ix) Control and Coordination

A number of approaches to the development of a successful large-project management plan have been tried in the past. We believe, from this experience, that sponsors of large projects are beginning to recognize the importance of first developing a program planning guide for the management of these projects.

The tendency in the past has been to inundate a project with a relatively large number of planners and managers. There is nothing

wrong with large numbers of managers and planners, when they are needed, but we believe that the larger and more complex a project, the more important it becomes to have a small group generating the plan. Our experience on large projects has revealed that a relatively small number of planners actually prepare the specifications for the plan. That is, during a preliminary planning phase, they should develop in considerable detail the specific elements that the project manager or construction management contractor or the management organization are to prepare during the planning period. Whether a large project is located in an area that lacks local services and therefore depends upon outside support, or in an area with an existing, well-developed service base, an extensive planning effort is required to handle the great number of parallel and similar organization concepts required to effectively manage the project. We are prepared to include such a planning effort as a product of the POS.

(a) Planning, Control and Management of the POS

Clearly, the POS, with funds in excess of $8 million already allocated and an eventual expenditure of over $20 million, qualifies as a large project and dictates the need for a more than casual approach to the planning and control. A business-oriented approach will be required to deliver, cost effectively, the final products of the POS. Effective "front-end" planning and the early involvement of the project management team is a key determinant of the project's success. Cost/schedule/financial control development and the preparation of corporate/administrative policies and procedures must parallel and be a part of front end planning and design. Effective implementation of the controls and procedures and the participation, acceptance and commitment to follow through to project completion must be incorporated into the program. We are committed to provide these services through the assignment of a relatively small group of well-qualified individuals to the POS team. In particular, the extensive Alaskan experience in large project management offered by FMA will be vital elements in our planning, control and management efforts.

The proposed schedule for undertaking this POS is presented in Plate A2.1.

(b) Planning the Eventual Construction Program

Certainly the multi-billion dollar construction phase of the Susitna hydropower project qualifies as a "giant" project and comes complete with the myriad of problems associated with "giant" projects. In this respect, the ability of the POS team to effectively plan this monumental project may prove to be the most important product of the the POS. The Acres/Moolin team provides a unique combination of talent and concepts to support this planning effort.

A.2.3 - Proposed Program

The effective resolution of the problems to be dealt with in meeting the overall study objectives requires the development of a carefully integrated program of study, design and exploration. The study will be undertaken in a series of interrelated and interdependent tasks as follows:

Task 1 - Power Studies
Task 2 - Surveys and Site Facilities
Task 3 - Hydrology
Task 4 - Seismic Studies
Task 5 - Geotechnical Exploration
Task 6 - Design Development
Task 7 - Environmental Studies
Task 8 - Transmission
Task 9 - Cost Estimates and Schedules
Task 10 - Licensing
Task 11 - Marketing and Finance
Task 12 - Public Participation
Task 13 - Administration

Each of these tasks has been broken down into a manageable number of subtasks (See Section A5). The level of effort and timing allows for progressive determination of project feasibility with minimum expenditure of funds.

A.2.4 - Potential Difficulties and Anticipated Methods of Handling

Several of the products that are developed as a part of Task 13--Program Administration are going to be the basic documents that will implement the POS. To stress how important they are would be to belabor the obvious; these products establish the basic course for the project and will be used to enunciate strategy and policy decisions throughout the POS. The key to the effectiveness of these programs is the early implementation and acceptance by all members of the project team.

It is extremely important that the interface and responsibilities of each of the subcontractors be spelled out in excruciating detail. This is best done by listing the numerous functions that have to be performed and then making sure that each of these functions has been assigned to a specific team. This sounds simple, but it requires a considerable effort and an in-depth understanding of the scope of work to tabulate all the required functions.

Working with government agencies requires some special precautions. There is a tendency, when submitting plans of operations, to propose exaggerated plans or solutions to make them sound as good as possible. These plans must be scrutinized, before submission, for reasonableness and cost effectiveness, to ensure that conditions that cannot later be tolerated are not proposed. It is equally important that the government agencies also participate in the preparation and review of such plans so that constraints may be identified and planned for.

The subject of constraints is of particular importance to the planning and estimating phases of the project. Constraints, if adequately understood in the early stages, can be tolerated. Constraints, if they come up after the start of construction, result in breaks in cadence, work stoppages, poor utilization of equipment and manpower and direct impacts to cost and schedule. Constraints can appear in the form of government mandates, environmental/climatic conditions, design changes necessitated by the discovery of new data as construction proceeds and other causes. Regardless of their cause, every effort must be made during the planning stages to identify constraints by working directly with government and other agencies and convincing these agencies to participate in, accept and commit themselves to this effort. In addition, the cost and benefits of constraints must be developed, as the constraints are being identified, to allow APA and government officials to fully assess the impacts involved.

There must also be a close relationship between the planning and the obtaining of permits from government agencies. Included in the Project Planning Guide should be a schedule of submissions that identify what permits are required at what point in time and when each submission will be made. This will go a long way towards easing the acquisition of the myriad of permits required.

The foregoing remarks are necessarily general in nature. Sections A4 through A6 of the POS describe in some detail the potential difficulties foreseen at this time in specific areas of the study and the proposed methods of overcoming them.

TASK	DESCRIPTION	1980	1981	1982	1983	1984	1985
		J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D
1-13	MILESTONES	COMMENCE STUDY; SUSITNA BASIN GO/ NO-GO	DEVELOPMENT SELECTION	DAM SELECTION; FEASIBILITY & LICENSE SUBMISSION		LICENSE (1)	BONDS
1	POWER STUDIES	LOAD FORECAST; ALTERNATIVES					
2	SURVEYS & SITE FACILITIES	CAMPS; SURVEYS; CONTINUOUS CAMP OPERATION	SELECT ACCESS ROUTE	ROAD PERMITS; ROAD CONSTRUCTION		CONTINUED CAMP OPERATION	
3	HYDROLOGY	DATA REVIEW; INSTALLATIONS; CONTINUOUS PROCESSING & STUDIES		DATA PROCESSING	CONTINUED MEASUREMENT / PROCESSING		
4	SEISMIC STUDIES	DATA REVIEW; PRELIMINARY EVALUATION; MONITORING SYSTEM; REFINED EVALUATION		CONSULTING	CONTINUED MEASUREMENT / PROCESSING		
5	GEOTECHNICAL EXPLORATION	DATA REVIEW; PLAN; PROGRAM; REPORT; WINTER PROGRAM; PLAN; SUMMER PROGRAM; REPORT		PLAN	CONTINUED EXPLORATION (3)		
6	DESIGN DEVELOPMENT	DEVELOPMENT SELECTION	DAM SELECTION; FEASIBILITY		PROJECT DESIGNS / SPECIFICATIONS		
7	ENVIRONMENTAL STUDIES	PLANNING; PERFORM FIELD STUDIES		IMPACT ANALYSIS; EXHIBIT E	EXHIBIT E SUPPLEMENT	EXHIBIT E SUPPLEMENT	
8	TRANSMISSION	DATA REVIEW; CORRIDOR SELECTION	ROUTE SELECTION	PRELIMINARY DESIGN	DESIGNS / SPECIFICATIONS		
9	COST ESTIMATES & SCHEDULES	DATA		SCHEDULE & ESTIMATES	UPDATES AS REQUIRED		
10	LICENSING	PRELIMINARY DATA; CONTINUED DATA AQUISITION		EXHIBITS	RESPONSES TO FERC		
11	MARKETING & FINANCING	TAX EXEMPTION & MARKET ISSUES; ALTERNATIVES RISK ANALYSIS; SUSITNA RISK ANALYSIS	DRAFT BOND DOCUMENTATION	INPUT TO LICENSE	BOND OFFERING SUPPORT		
12	PUBLIC PARTICIPATION (4)	PM; WS; WS; WS; PM; BOARD MEETING; WS	WS; WS	PM; FINAL REVIEW	CONTINUED PROGRAM		
13	ADMINISTRATION	DEVELOP PROCEDURES; APPLY PROCEDURES			CONTINUED AS REQUIRED		

LEGEND: REPRESENTS SUBTASK COMPLETION

NOTES: (1) TENTATIVE BASED ON COMPLETION OF ENVIRONMENTAL STUDIES AND PLANS FOR INVESTIGATION

(2) ACCESS TRACK CONSTRUCTION IS ASSUMED TO COMMENCE IN 1982 FOR PURPOSES OF "FAST-TRACK" PROJECT COMPLETION ONLY. COSTS ARE INCLUDED IN ACTIVITIES UNDERTAKEN AFTER SUBMISSION OF LICENSE APPLICATION.

(3) GEOTECHNICAL EXPLORATION IS ASSUMED TO CONTINUE THROUGH 1988 FOR PURPOSES OF "FAST-TRACK" COMPLETION. COSTS ARE INCLUDED IN ACTIVITIES UNDERTAKEN AFTER SUBMISSION OF LICENSE APPLICATION.

(4) PM = PUBLIC MEETING ; WS = WORKSHOP

ACRES

SUSITNA HYDROELECTRIC PROJECT

PLAN OF STUDY

PLATE A2.1: SUMMARY SCHEDULE

SECTION A3 - BUDGET SUMMARY

SECTION A3 - BUDGET SUMMARY

Summaries of estimated study costs and man-hours for periods through submission of the FERC license application (June 30, 1982) and subsequently through receipt of license (tentatively estimated as January 1985) are presented in Tables A.3.1 through A.3.16. These summaries are presented by Task and, in Table A.3.15, quarter. All costs are in 1979 dollars, effective through the first quarter of 1980, with escalation beyond that date assumed at a rate of 8.5 percent per annum.

Two alternatives are possible after a license application has been submitted. One approach would accelerate the "on line" date for a potential project by advancing detailed design and associated activities sufficient to permit starting construction virtually immediately after a license is received. The second approach focuses only on those activities essential to award of license, deferring commencement of construction until some time thereafter. Section A6 describes both alternatives. Table A.3.16 provides cost information for the second, more conservative, alternative.

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TABLE A.3.1 COST ESTIMATE - TASK 1, POWER STUDIES

Consultant	Subtask -	1.01	1.02	1.03	1.04	1.05	1.06	Totals Manhours	Totals Costs
ACRES	Manhours	50	70	540	740	70	280	1,750	
	Manhour Cost	$ 1,700	$ 2,500	$ 19,000	$ 26,000	$ 2,500	$ 10,000		$ 61,700
	Disbursements*	1,300	1,500	3,000	4,000	500	2,000		12,300
	Subtotal	$ 3,000	$ 4,000	$ 22,000	$ 30,000	$ 3,000	$ 12,000		$ 74,000
WCC	Manhours	350	450	790		1,200		2,790	
	Manhour Costs	$ 22,200	$ 28,700	49,300		$ 77,000			$177,200
	Disbursements	10,000	15,000	15,000		13,000			53,000
	Subtotal	$ 32,200	$ 43,700	$ 64,300		$ 90,000			$230,200
TES	Manhours			320		1,430		1,750	
	Manhour Cost			$ 8,900		$ 40,400			$ 49,300
	Disbursements			1,100		4,600			5,700
	Subtotal			$10,000		$45,000			$ 55,000
	TOTAL MANHOURS	400	520	1,650	740	2,700	280	6,290	
	TOTAL COSTS	$35,200	$47,700	$96,300	$30,000	$138,000	$12,000		$359,200

*Including Alaska Office Expense

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TABLE A.3.2 COST ESTIMATE - TASK 2, SURVEY AND SITE FACILITIES

Consultant	Subtask -	2.01	2.02	2.03	2.04	2.05	2.06	2.07	2.08	2.09	2.10	2.11	2.12	2.13	2.14	2.15	2.16	Totals Manhours	Totals Costs
ACRES	Manhours			285	30	15	30	75	630	430	860	25	15	15	200	205	260	3,175	
	Manhour Cost			$10,000	$1,000	$500	$1,000	$2,600	$22,000	$15,000	30,000	$800	$500	$4,000	$7,000	$7,200	$9,000		$110,600
	Disbursements*							400	3,000	5,000	5,000	200		800	500	1,000	1,000		16,900
	Subtotal			$10,000	$1,000	$500	$1,000	$3,000	$25,000	$20,000	$35,000	$1,000	$500	$4,800	$7,500	$8,200	$10,000		$127,500
R&M	Manhours			945				1,430	7,500	6,300	4,570	100	100	40			4,290	25,275	
	Manhour Cost			$33,000				$50,000	$262,000	$220,000	$160,000	$3,600	$4,000	$1,500			$150,000		$884,100
	Disbursements							10,000	238,000	90,000	40,000	400	1,000	400			30,000		409,800
	Subtotal			$33,000				$60,000	$500,000	$310,000	$200,000	$4,000	$5,000	$1,900			$180,000		$1,293,900
CIRI/H&N	Manhours		57,000		370	255	340							230				58,195	
	Manhour Cost		$1,995,200		$13,000	$9,000	$12,000							$8,000					$2,037,200
	Disbursements				2,000	1,000	2,000							1,800					6,800
	- Camp Facilities		1,901,900																
	- Fuel		219,000																
	- Food		256,000																
																			2,376,900
	Subtotal		$4,372,100		$15,000	$10,000	$14,000							$9,800					$4,420,900
DIRECT COSTS	High Lake Lodge		$382,500																
	Airport Construction			$1,123,800															
	Air Transportation		$510,000																
	Subtotal		$892,500	$1,123,800															$2,016,300
	TOTAL MANHOURS		57,000	1,230	400	270	370	1,505	8,130	6,730	5,430	125	115	285	200	205	4,545	86,645	
	TOTAL COSTS		$5,264,600	$1,166,800	$16,000	$10,500	$15,000	$63,000	$525,000	$330,000	$235,000	$5,000	$5,500	$16,500	$7,500	$8,200	$190,000		$7,858,600

*Including Alaska Office Expenses

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TABLE A.3.3 COST ESTIMATE - TASK 3, HYDROLOGY

Consultant	Subtask -	3.01	3.02	3.03	3.04	3.05	3.06	3.07	3.08	3.09	3.10	Totals Manhours	Totals Costs
ACRES	Manhours	60		330	3,270	740	1,800	45	350		180	6,775	
	Manhour Costs	$2,700		$15,000	$87,200	$19,600	$48,100	$2,000	$9,300		$8,000		$191,900
	Disbursements*												
	- Travel	1,200			1,700	1,000	1,500		1,700		1,000		8,100
	- Consultants					7,500	5,000						12,500
	- Computer Services				7,200	2,500	5,500		1,500				16,700
	- Communications	300			1,000	800	1,000		1,000		1,000		5,100
	- Reproduction	200			200	200	200		500		500		1,800
	Subtotal	$4,400	-	$15,000	$97,300	$31,600	$61,300	$2,000	$14,000	-	$10,500		$236,100
R&M	Manhours	135	3,440	13,930	480	850	1,050	830		320	1,710	22,745	
	Manhour Costs	$5,600	$69,700	$468,900	$16,800	$29,600	$37,100	$30,200		$11,800	$60,000		$729,700
	Disbursements												
	- Consultants			5,000				5,000					5,000
	- Computer Services		2,000	16,000	2,500	5,000	5,000	5,000		2,000			37,500
	- Communications	300	500	1,700	1,500	1,000	1,000	500		300			6,800
	- Reproduction	200	3,000	1,000	500	500	500	500		200			6,400
	- Laboratory			125,000							1,000		126,000
	- Equipment			208,000							45,000		253,000
	Subtotal	$6,100	$75,200	$825,600	$21,300	$36,100	$43,600	$36,200	-	$14,300	$106,000		$1,164,400
Direct Costs	Fixed Wing Aircraft			$ 44,000				$			$ 4,000		$ 48,000
	Helicopter			350,000				7,500			20,000		377,500
	Subtotal			$394,000				$7,500			$24,000		$425,500
	TOTAL MANHOURS	195	3,440	14,260	3,750	1,590	2,850	875	350	320	1,890	29,520	
	TOTAL COSTS	$10,500	$75,200	$1,234,600	$118,600	$67,700	$104,900	$45,700	$14,000	$14,300	$140,500		$1,826,000

* Including Alaska Office Expenses

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TABLE A.3.4 COST ESTIMATE - TASK 4, SEISMIC STUDIES

Consultant	Subtask -	4.01	4.02	4.03	4.04	4.05	4.06	4.07	4.08	4.09	4.10	4.11	4.12	4.13	4.14	4.15	Totals Manhours	Totals Costs
ACRES	Manhours	30	110	30	30	80	220	60	110	30	30	140	280	30	-	440	1,620	
	Manhour Cost	$ 900	$3,600	$ 900	$ 900	$2,700	$7,200	$1,800	$3,600	$ 900	$ 900	$4,500	$ 9,000	$ 900		$14,000		$51,800
	Disbursements*	100	400	100	100	300	800	200	400	100	100	500	1,000	100		2,000		6,200
	Subtotal	$1,000	$4,000	$1,000	$1,000	$3,000	$8,000	$2,000	$4,000	$1,000	$1,000	$5,000	$10,000	$1,000		$16,000		$58,000
WCC	Manhours	1,240	2,520	440	880	2,880	3,720	680	920	1,240	240	3,240	3,920	240	160	120	22,440	
	Manhour Cost	$53,000	$158,000	$17,000	$37,000	$115,000	$128,000	$26,000	$36,000	$51,000	$9,000	$127,000	$135,000	$ 9,000	$6,000	$4,500		$ 911,500
	Disbursements	4,000	95,000	-	15,000	5,000	10,000	5,000	4,000	10,000	-	10,000	8,000	2,000	1,000	500		169,500
	Subtotal	$57,000	$253,000	$17,000	$52,000	$120,000	$138,000	$31,000	$40,000	$61,000	$9,000	$137,000	$143,000	$11,000	$7,000	$5,000		$1,081,000
	TOTAL MANHOURS	1,270	2,630	470	910	2,960	3,940	740	1,030	1,270	270	3,380	4,200	270	160	560	24,060	
	TOTAL COSTS	$58,000	$257,000	$18,000	$53,000	$123,000	$146,000	$33,000	$44,000	$62,000	$10,000	$142,000	$153,000	$12,000	$7,000	$21,000		$1,139,000

* Including Alaska Office Expenses

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TABLE A.3.5 COST ESTIMATE - TASK 5, GEOTECHNICAL EXPLORATION

Consultant	Subtask -	5.01	5.02	5.03	5.04	5.05	5.06	5.07	5.08	Totals Manhours	Totals Costs
ACRES	Manhours	315	1,200	420	3,850	875	6,580	1,250	5,250	19,740	
	Manhour Costs	$10,000	$39,500	$ 15,000	$154,000	$35,000	$260,000	$50,000	$191,500		$755,000
	Disbursements*	3,000	500	120,000	17,500		17,500		8,500		167,000
	Subtotal	$13,000	$40,000	$135,000	$171,500	$35,000	$277,500	$50,000	$200,000		$922,000
R&M	Manhours	1,265		85	5,530	600	10,500	640		18,620	
	Manhour Costs	$10,000		$3,000	$189,000	$21,000	$367,850	$22,500			$613,350
	Disbursements										
	- Drilling/ Geophysical				436,000		610,150				
	- Equipment				15,000		25,000				
	- Clearing				50,000		50,000				
	- Laboratory				21,000		80,000				1,287,150
	Subtotal	$10,000		$3,000	$711,000	$21,000	$1,133,000	$22,500	-		$1,900,500
Direct Cost	Helicopter**				$272,000		$526,000				$798,000
	TOTAL MANHOURS	1,580	1,200	505	9,380	1,475	17,080	1,890	5,250	38,360	
	TOTAL COSTS	$23,000	$40,000	$138,000	$1,154,500	$56,000	$1,936,500	$72,500	$200,000		$3,620,500

* Including Alaska Office Expenses
** Includes Task 7 Requirements

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TABLE A.3.6 COST ESTIMATE - TASK 6, DESIGN DEVELOPMENT

Consultant	Subtask -	6.01	6.02	6.03	6.04	6.05	6.06	6.07	6.08	6.09	6.10	6.11	6.12	6.13	6.14	6.15
ACRES	Manhours	1,325	2,055	1,790	425	415	1,785	1,260	910	1,105	1,100	3,515	3,225	940	545	2,085
	Manhour Costs	$45,750	$57,300	$55,450	$12,200	$12,850	$52,250	$37,250	$27,700	$33,050	$32,850	$109,050	$95,550	$30,050	$16,400	$64,550
	Disbursements	4,250	5,700	4,950	1,200	1,150	5,150	3,750	2,700	2,950	2,850	10,950	9,450	2,950	1,600	6,450
	Subtotal	$50,000	$63,000	$60,400	$13,400	$14,000	$57,400	$41,000	$30,400	$36,000	$35,700	$120,000	$105,000	$33,000	$18,000	$71,000
R&M	Manhours	130														
	Manhour Costs	$4,500														
	Disbursements	500														
	Subtotal	$5,000														
	TOTAL MANHOURS	130														
	TOTAL COSTS	$55,000	$63,000	$60,400	$13,400	$34,000	$57,400	$41,000	$30,400	$36,000	$35,700	$120,000	$105,000	$53,000	$18,000	$71,000

Consultant	Subtask -	6.16	6.17	6.18	6.19	6.20	6.21	6.22	6.23	6.24	6.25	6.26	6.27	6.28	6.29	6.30	6.31	Totals Manhours	Totals Costs
ACRES (Cont'd)	Manhours	1,890	2,315	2,590	1,215	1,950	1,800	1,980	2,710	2,655	815	3,005	2,955	550	1,945	1,865	1,290	54,010	
	Manhour Costs	$59,050	$78,200	$74,500	$33,300	$55,450	$50,900	$57,250	$77,400	$75,500	$25,000	$86,500	$84,700	$17,750	$54,650	$52,800	$40,800		$1,606,000
	Disbursements	5,950	7,800	7,500	3,300	5,550	5,100	5,750	7,600	7,500	2,500	8,500	8,300	1,850	5,350	5,200	4,200		158,000
	Subtotal	$65,000	$86,000	$82,000	$36,600	$61,000	$56,000	$63,000	$85,000	$83,000	$27,500	$95,000	$93,000	$19,600	$60,000	$58,000	$45,000		$1,764,000
R&M (Cont'd)																		130	$5,000
	TOTAL MANHOURS																	54,140	
	TOTAL COSTS	$65,000	$86,000	$82,000	$56,600	$61,000	$56,000	$63,000	$85,000	$83,000	$27,500	$95,000	$93,000	$19,600	$60,000	$58,000	$65,000		$1,769,000

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TABLE A, 3.7 COST ESTIMATE - TASK 7, ENVIRONMENTAL STUDIES

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Consultant	Subtask -	7.01 Coordination	7.02 Monitoring	7.03 Hydrometeorology	7.04 Water Quality	7.05 Socioeconomics	7.06 Cultural	7.07 Land Use	7.08 Recreation	7.09 Transmission	7.10 Fish	7.11 Wildlife	7.12 Minerals	7.13 Geology and Soils	7.14 Access	7.15 Exhibit Center	Totals Manhours	Totals Costs
ACRES	Manhours	700	25		35	30	90	20		90	150	170			20	60	1,390	
	Manhour Costs	$27,100	$1,000		$1,500	$1,100	$4,100	$ 700		$4,100	$ ~~7,000~~ 10,400	$ 7,900			$1,000	$2,600		~~$ 58,100~~ 61,500
	Disbursements*	22,400	1,000		2,000	1,700	1,900	300		1,900	208,600 219,000	6,100			1,000	1,900		248,800 310,500
	Subtotal	$49,500	$2,000	-	$3,500	$2,800	$6,000	$1,000	-	$6,000	~~$216,600~~ $229,400	$14,000	-	-	$2,000	$4,500		~~$306,900~~
TES	Manhours	10,820	2,845		200	795	875	1,050	320	1,120	14,680	2,890	2,985		785	1,350	40,715	
	Manhour Cost	$255,100	$126,100		$6,600	$29,000	$33,900	$27,500	$8,400	$31,500	$456,500	$123,100	$91,900		$22,200	$39,000		$1,250,800
	Disbursements	58,300	12,800		1,000	5,900	6,300	6,300	2,100	4,800	87,800	28,200	21,000		6,000	9,300		249,800
	Subtotal	$313,400	$138,900	-	$7,600	$34,900	$40,200	$33,800	$10,500	$36,300	$544,300	$151,300	$112,900	-	$28,200	$48,300		$1,500,600
F.O.A.	Manhours					3,400											3,400	
	Manhour Cost					$102,700												$102,700
	Disbursements					25,700												25,700
	Subtotal					$128,400												$128,400
U of A	Manhours						17,320	1,500	200			17,020	18,800				54,840	
	Manhour Cost						$410,600	$52,300	$6,900			$266,600	$315,300					$1,051,700
	Disbursements						72,900	16,000	4,700			72,900	61,300					227,800
	Subtotal						$483,500	$68,300	$11,600			$339,500	$376,600					$1,279,500
ADF&G**	Subtotal										$1,444,600	$1,312,000						$2,756,600
C.A.& M.B.	Manhours										2,400	1,660					4,060	
	Manhour Cost										$90,000	$80,800						$170,800
	Disbursements										6,000	8,500						14,500
	Subtotal										$96,000	$89,300						$185,300
Direct Cost	Equipment for Subtask 7.10										$409,600							$409,600
	TOTAL MANHOURS	11,500	2,870		235	4,225	18,285	2,570	520	1,210	17,230	21,740	21,785		805	1,410	104,405	~~$570,800~~
	TOTAL COSTS	$362,900	$140,900	-	$11,100	$166,100	$529,700	$103,100	$22,100	$42,300	$2,710,123 2,713,500	$1,906,100	$489,500	-	$30,200	$52,800		~~$6,566,900~~

* Including Alaska Office Expenses
** Manhours and Labor Costs not Available Separately

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TASK A.3.8 COST ESTIMATE - TASK 8, TRANSMISSION

Consultant	Subtask -	8.01	8.02	8.03	8.04	8.05	8.06	8.07	Totals Manhours	Totals Costs
ACRES	Manhours	2,300	3,900	5,600	2,200	2,300	2,100	900	19,300	
	Manhour Cost	$75,700	$130,300	$185,500	$73,000	$76,800	$68,500	$28,000		$637,800
	Disbursements*	7,500	20,500	19,500	4,500	4,500	10,500	2,500		69,500
	External Consultants			$1,000	$1,000		$20,000			$22,000
	TOTAL MANHOURS	2,300	3,900	5,600	2,200	2,300	2,100	900	19,300	
	TOTAL COSTS	$83,200	$150,800	$206,000	$78,500	$81,300	$99,000	$30,500		$729,300

* Including Alaska Office Expense

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TABLE A.3.9 COST ESTIMATE - TASK 9, COST ESTIMATES & SCHEDULES

Consultant	Subtask -	9.01	9.02	9.03	9.04	9.05	Totals Manhours	Totals Costs
ACRES	Manhours	225	530	1,320	995	355	3,455	
	Manhour Costs	$ 9,100	$18,100	$47,700	$31,800	$11,900		$118,600
	Disbursements*	900	1,900	5,300	3,200	1,100		12,400
	Subtotal	$10,000	$20,000	$53,000	$35,000	$13,000		$131,000
FMA	Manhours	300	60	480	540	170	1,550	
	Manhour Cost	$ 9,400	$1,800	$14,900	$16,900	$5,300		$48,300
	Disbursements	600	200	1,100	3,100	700		5,700
	Subtotal	$10,000	$2,000	$16,000	$20,000	$6,000		$54,000
	TOTAL MANHOURS	525	590	1,800	1,535	525	5,005	
	TOTAL COSTS	$20,000	$22,000	$69,000	$55,000	$19,000		$185,000

* Including Alaska Office Expense

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TASK A.3.10 COST ESTIMATE - TASK 10, LICENSING

Consultant	Subtask -	10.01	10.02	10.03	10.04	10.05	10.06	10.07	10.08	10.09	10.10	Totals Manhours	Totals Costs
ACRES	Manhours	230	630	25	1,430	715	2,430	630	130	885	115	7,220	
	Manhour Cost	$8,000	$22,000	$ 900	$50,000	$25,000	$85,000	$22,000	$4,500	$31,000	$4,000		$252,400
	Disbursements*	1,000	3,000	100	6,000	2,500	10,000	3,000	500	4,000	1,000		31,100
	Legal Review	-	10,000	-	-								10,000
	Subtotal	$9,000	$35,000	$1,000	$56,000	$27,500	$95,000	$25,000	$5,000	$35,000	$5,000		$293,500
	TOTAL MANHOURS	230	630	25	1,430	715	2,430	630	130	885	115	7,220	
	TOTAL COSTS	$9,000	$35,000	$1,000	$56,000	$27,500	$95,000	$25,000	$5,000	$35,000	$5,000		$293,500

* Including Alaska Office Expense

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TABLE A.3.11 COST ESTIMATE - TASK 11, MARKETING & FINANCING

Consultant	Subtask -	11.01	11.02	11.03	11.04	11.05	11.06	11.07	11.08	11.09	11.10	11.11	Totals Manhours	Totals Costs
ACRES	Manhours	1,600	900	270	370	160	-	80	350	40	-	-	3,770	
	Manhour Cost	$67,300	$38,400	$10,500	$14,500	$6,100	-	$3,800	$14,000	$1,800	-	-		$156,400
	Disbursements	10,800	7,400	4,500	4,500	3,900		1,200	6,000	1,200	-	-		39,500
	Subtotal	$78,100	$45,800	$15,000	$19,000	$10,000	-	$5,000	$20,000	$3,000	-	-		$195,900
WCC	Manhour Cost & Disbursements			$2,500										$2,500
FMA	Manhour Cost & Disbursements				$5,500									$5,500
SALOMON BROTHERS	Fee	$21,400	$45,800					$71,300	$5,000	$35,700				$179,200
	TOTAL MANHOURS												3,770	
	TOTAL COSTS	$99,500	$91,600	$17,500	$24,500	$10,000	-	$76,300	$25,000	$38,700	-	-		$383,100

SUSITNA HYDROELECTRIC POWER PROJECT - ALASKA POWER AUTHORITY

TABLE A.3.12 COST ESTIMATE - TASK 12, PUBLIC PARTICIPATION

Addendum to POS
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Consultant/ Authority	Subtask -	12.01	12.02	12.03	12.04	Totals Manhours	Totals Costs
ACRES	Manhours	-	1,285	1,140	285	2,710	
	Manhour Cost	$ -	$45,000	$40,000	$10,000		$ 95,000
	Disbursements*	121,500	14,800	6,100	64,500		206,900
	Subtotal	$121,500	$59,800	$46,100	$74,500		$301,900
CIRI/H&N	Manhours		170	150		320	
	Manhour Cost		$6,000	$5,000			$11,000
	Disbursements		1,000	800			1,000
	Subtotal		$7,000	$5,800			$12,800
WCC	Manhours		170	300		470	
	Manhour Cost		$6,000	$10,000			$16,000
	Disbursements		1,000	1,500			2,500
	Subtotal		$7,000	$11,500			$18,500
TES	Manhours		1,270	300		470	
	Manhour Cost		$6,000	$10,000			$16,000
	Disbursements		1,000	1,500			2,500
	Subtotal		$7,000	$11,500			$18,500
FMA	Manhours		170	150		320	
	Manhour Cost		$6,000	$5,000			$11,000
	Disbursements		1,000	800			1,800
	Subtotal		$7,000	$5,800			$12,800
R&M	Manhours		170	300		470	
	Manhour Costs		$6,000	$10,000			$16,000
	Disbursements		1,000	1,500			2,500
	Subtotal		$7,000	$11,500			$18,500
	TOTAL MANHOURS					4,660	
	TOTAL COST	$121,500	$94,800	$92,200	$74,500		$383,000

* Including Alaska Office Expense

SUSITNA HYDROELECTRIC PROJECT - ALASKA POWER AUTHORITY

TASK A.3.13 COST ESTIMATE - TASK 13, ADMINISTRATION

Addendum to POS
December 18, 1979

Consultant	Subtask -	13.01	13.02	13.03	13.04	13.05	13.06	13.07	13.08	13.09	Totals Manhours	Totals Costs
ACRES	Manhours	35	50	40	840	1,940	15	740	15	1,150	4,825	
	Manhour Costs	$1,300	$1,800	$1,500	$29,500	$68,000	$500	$26,000	$500	$45,100		$174,200
	Disbursements *	200	400	200	3,500	8,000	-	3,000	-	20,700		36,000
	Subtotal	$1,500	$2,200	$1,700	$33,000	$76,000	$500	$29,000	$500	$65,800		$210,200
FMA	Manhours	50	60	45	930	2,130	15	1,125	30	40	4,425	
	Manhour Costs	$1,600	$2,000	$1,500	$29,700	$68,400	$500	$36,000	$1,000	$1,300		$142,000
	Disbursements	200	200	200	3,500	8,000	-	4,000	200	200		16,500
	Subtotal	$1,800	$2,200	$1,700	$33,200	$76,400	$500	$40,000	$1,200	$1,500		$158,500
R&M	Manhours									220	220	
	Manhour Costs									$10,000		$10,000
	Disbursements									700		700
	Subtotal									$10,700		$10,700
TES	Manhours									1,880	1,880	
	Manhour Costs									$50,300		$50,300
	Disbursements									15,800		15,800
	Subtotal									$66,100		$66,100
CIRI/H&N	Manhours									300	300	
	Manhour Costs									$15,000		$15,000
	Disbursements									5,000		5,000
	Subtotal									$20,000		$20,000
WCC	Manhours									40	40	
	Manhour Costs									$2,000		$2,000
	Disbursements									200		200
	Subtotal									$2,200		$2,200
	TOTAL MANHOURS										11,690	
	TOTAL COSTS	$3,300	$4,400	$3,400	$66,200	$152,400	$1,000	$69,000	$1,700	$166,300		$467,700

* Including Alaska Office Expense

ALASKA POWER AUTHORITY - SUSITNA HYDROELECTRIC PROJECT

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Table A.3.14 - ESTIMATE SUMMARY

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9	Task 10	Task 11	Task 12	Task 13	Total
Acres American, Inc.														
Manhour Costs	$ 61,700	$110,600	$191,900	$ 51,800	$755,000	$1,606,000	$ 61,500	$637,800	$118,600	$252,400	$156,400	$ 95,000	$174,200	$4,272,900
Disbursements	12,300	16,900	44,200	6,200	167,000	158,000	248,800	91,500	12,400	41,100	39,500	206,900	36,000	1,080,800
Subtotals	$ 74,000	$127,500	$236,100	$ 58,000	$922,000	$1,764,000	$310,300	$729,300	$131,000	$293,500	$195,900	$301,900	$210,200	$5,353,700
Direct Costs														
ADF&G Equipment		$	$		$		$409,600							$ 409,600
High Lake Lodge		382,500												382,500
Airfield		1,123,800												1,123,800
Air Transportation		510,000	425,500		796,000									1,733,500
Subtotals		$2,016,300	$425,500		$798,000		$409,600							$3,649,400
Subcontractors														
CIRI/H&N	$	$4,420,900	$	$	$	$	$		$		$	$12,800	$20,000	$ 4,453,700
WCC	230,200			1,081,000							2,500	18,500	2,200	1,334,400
TES (Incl. Subs)	55,000						3,093,800					18,500	66,100	3,233,400
FMA									54,000		5,500	12,800	158,500	230,800
R&M		1,293,900	1,164,400		1,900,500	5,000						18,500	10,700	4,393,000
Salomon Brothers											179,200			179,200
ADF&G							2,756,600							2,756,600
Subtotals	$285,200	$5,714,800	$1,164,400	$1,081,000	$1,900,500	$5,000	$5,850,400	-	$54,000	-	$187,200	$81,100	$257,500	$16,581,100
Non-Discretionary														
APA Administration*	$						$					$	$287,500	$287,500
APA Public Participation												220,000		220,000
ISER	30,000													30,000
Land Use*													90,000	90,000
ADF&G Coordinator							187,500							187,500
Native Inspector*													120,000	120,000
External Review*													1,000,000	1,000,000
Subtotals	$30,000	-	-	-	-	-	$187,500	-	-	-	-	$220,000	$1,497,500	$1,935,000
GRAND TOTALS	$389,200	$7,858,600	$1,826,000	$1,139,000	$3,620,500	$1,769,000	$6,757,800	$729,300	$185,000	$293,500	$383,100	$603,000	$1,965,200	$27,519,200

*Assumed to be allocated under "general administration", Task 13.

SUSITNA HYDROELECTRIC PROJECT - ALASKA POWER AUTHORITY

Table A.3.15 ESTIMATED STUDY COSTS BY QUARTER

Addendum to POS
December 18, 1979

Task No.	Task Description	1980 1	1980 2	1980 3	1980 4	1981 5	1981 6	1981 7	1981 8	1982 9	1982 10	TOTALS
1	Power Studies	$ 41,400	$ 95,800	$ 155,000	$ 67,000	$	$	$	$	$	$	$ 359,200
2	Surveys & Site Facilities	2,697,350	1,304,550	1,348,350	339,950	420,350	467,050	505,300	287,450	244,150	244,100	7,858,600
3	Hydrology	204,350	65,650	131,200	162,800	250,800	208,800	224,350	206,650	204,350	167,050	1,826,000
4	Seismic Studies	42,800	189,700	290,200	168,100	28,100	117,500	146,400	94,100	32,800	29,300	1,139,000
5	Geotechnical Exploration	54,500	570,000	654,500	177,500	491,200	712,400	693,400	152,500	67,500	47,000	3,620,500
6	Design Development	-	7,900	72,300	78,600	111,400	166,900	258,900	486,800	483,300	102,900	1,769,000
7	Environmental Studies	670,700	968,900	726,700	727,300	674,500	675,200	666,400	650,400	443,300	366,900	6,570,300
8	Transmission	12,100	45,700	47,700	47,600	36,400	109,350	129,650	135,550	135,550	29,700	729,300
9	Construction Cost Estimate & Schedule	-	-	-	-	-	48,600	13,200	13,200	46,600	63,400	185,000
10	Licensing	62,600	27,900	15,100	15,100	15,100	15,100	15,100	28,000	26,900	72,600	293,500
11	Marketing & Financing	-	-	-	-	39,400	39,400	46,400	111,900	94,700	51,300	383,100
12	Public Participation	38,300	38,300	38,300	38,300	38,300	38,300	38,300	38,300	38,300	38,300	383,000
13	Administration	228,300	26,600	26,600	26,600	26,600	26,600	26,600	26,600	26,600	26,600	467,700
	Subtotal	4,052,400	3,341,000	3,505,950	1,848,850	2,132,150	2,625,200	2,764,000	2,231,450	1,844,050	1,239,150	25,584,200
	Non-Discretionary Amounts											
	APA Administration	28,700	28,800	28,700	28,800	28,700	28,800	28,700	28,800	28,700	28,800	287,500
	APA Public Participation	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	220,000
	ISER	15,000	15,000	-	-	-	-	-	-	-	-	30,000
	Land Use	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	90,000
	ADF & G Coordinator	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	16,500	187,500
	Native Inspector	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	120,000
	External Review	-	-	-	-	20,000	180,000	200,000	200,000	200,000	200,000	1,000,000
	Subtotal	105,700	105,800	90,700	90,800	110,700	270,800	290,700	290,800	290,700	288,300	1,935,000
	Escalation 8-1/2% on Tasks 1 - 13	0	70,996	149,003	117,864	181,233	283,522	362,084	343,643	326,397	250,308	2,085,050
	Subtotal	4,158,100	3,517,796	3,745,653	2,057,514	2,424,083	3,179,522	3,416,784	2,865,893	2,461,147	1,777,758	29,604,250
	Cumulative Cash Flow	4,158,100	7,675,896	11,421,549	13,479,063	15,903,146	19,082,668	22,499,452	25,365,345	27,826,492	29,604,250	

Revisions

January 7, 1980

TABLE A3.16 - BUDGET SUMMARY POST LICENSE APPLICATION STUDIES (1979)

(Cost data contained within this table applies to work necessary to support successful award of a license from FERC. Activities such as detailed design, construction contract packages, and work on an access road discussed as part of a "Fast Track" system in Section A6 would require additional expenditures.)

Task No.	Task Name	Cost
1	Power Studies	-
2	Surveys & Site Facilities	$3,025,000
3	Hydrology	300,000
4	Seismic Studies	100,000
5	Geotechnical Exploration	-
6	Design Development	-
7	Environmental Studies	4,810,500
8	Transmission	-
9	Construction Estimates & Schedules	-
10	Licensing	430,000
11	Marketing and Financing	200,000
12	Public Participation	250,000
13	Administration	$ 100,000
	Subtotal	$9,215,500
	Non-discretionary amounts (Include private land use payments, Native Inspector, APA coordination, and ADF&G environmental coordinator)	617,500
	Grand Total	$9,833,000

SECTION A4 - RESPONSE TO PUBLIC COMMENT

SECTION A4 - RESPONSE TO PUBLIC COMMENT

A.4.1 - Introduction

The original version of this Plan of Study (POS) was submitted to the Alaska Power Authority on September 11, 1979. Concurrently with that submission, more than 50 copies were distributed to certain State and Federal Agencies as well as to public interest groups. Two opportunities for public testimony were provided at Alaska Power Authority Board Meetings on September 28 and November 11, 1979. In addition, written comments have been received that resulted from a series of face-to-face discussions with interested individuals. Finally, Plans of Study submitted by other qualified engineering firms have been reviewed with a view toward identifying ideas which could improve the original proposed approach.

The introduction to Section A1 highlighted certain major changes which have been incorporated in this edition of the Plan of Study. The purpose of this section is to provide a more detailed summary of comments, responses, and actions taken since September 11, 1979. Because a strong participation program has been planned from the start, it is certain that further changes to the POS will be made from time to time to ensure that the work to be performed is responsive to the needs and desires of the public. It follows that this plan is--and must be--a dynamic document.

Annex A to this Section, which appears on the following pages, is a memorandum prepared by the Project Manager to document the manner in which public response has been handled to date.

ANNEX A

TABLE OF CONTENTS

1 - INTRODUCTION

Since the submission on September 11, 1979, of Acres' proposed Plan of Study (POS) for the Susitna Hydroelectric Project, concerns and constructive criticisms have been voiced by numerous individuals, groups, and agencies (see Tables 1.1 and 1.2). It is the purpose of this Annex to address these concerns and to describe possible changes to the POS where considered warranted. Also, as requested by the Alaska Power Authority (APA) the POS's proposed by Harza and IECO have been evaulated with the intention of extracting useful components which could improve the Acres POS.

TABLE 1.1: LIST OF SOURCES OF WRITTEN POS COMMENTS

1. Thomas Trent, Department of Game & Fish
2. Dave Sturdevant, Department of Environmental Conservation
3. Don McKay, Fish and Wildlife Service
4. Paul Lowe, Alaska Centre For Environment
5. John Adams, Fairbanks Environmental Center
6. Suzanne Weller, Trustees For Alaska
7. Pat Wennekens, Alaska Conservation Society
8. Lawrence Kimbau, Dept. of Community and Regional Affairs
9. Clarissa Quinlan, Division of Energy and Power Development
10. Gary Hickman, U.S. Fish and Wildlife Service
11. Al Carson, Dept. of Natural Resources
12. David Kickok, University of Alaska
13. Robert Cross, Alaska Power Administration
14. Robert Mohn, Alaska Power Authority

TABLE 1.2: LIST OF SOURCES OF VERBAL POS COMMENTS

1. Robert Cross, Alaska Power Administration
2. Thomas Stahr, Anchorage Municipal Light and Power
3. Paul Lowe, Alaska Center for Environment
4. Patricia Anderson, Private Citizen
5. Brian Rogers, Alaska State Legislator
6. Al Carson, Department of Natural Resources
7. Dave Sturdevant, Department of Environmental Conservation
8. John Adams, Fairbanks Environmental Center
9. Suzanne Weller, Trustees For Alaska
10. Pat Wennakins, Alaska conservation Society
11. Troy Sullivan, Highlake Lodge
12. Don McKay, U.S. Fish and Wildlife Service
13. Dale Rusnell, Department of Commerce
14. Christopher Estes, Alaska Department of Fish and Game
15. Thomas Trent, Alaska Department of Fish and Game

2 - COMMENTS ON ACRES' POS

2.1 - Written Comments

Numerous groups and agencies have reviewed Acres' POS and have directed written comments to the APA (see Table 1.1). Acres responses to these comments are listed below.

Task 1 - Power Studies

T1.1 Comment: The load forecasting and the feasibility study should be separated.

Response: This is a good suggestion, and would result in better credibility by the public should the study show a definite early need for the Susitna Project. To this end, the APA will contract the University of Alaska's Institute of Social and Economic Research (ISER), to provide the load forecast. However, Acres and Woodward-Clyde Consultants (WCC) will review the techniques proposed by ISER and will agree on the approach to be used before the study begins.

T1.2 Comment: There is a need for a comprehensive conservation study.

Response: Conservation has been addressed adequately in Tasks 1.01, 1.02 and 1.03. It will be considered sufficiently by ISER in their load forecasting study.

T1.3 Comment: The study of alternatives to the Susitna Project and the feasibility study of the project itself should be separated.

Response: Acres does not recommend that this be done because:

(a) Acres is highly skilled in carrying out such evaluations of power system expansion, and would produce the comprehensive and complete study results which are necessary for optimal development of a river basin of this size and potential.

(b) Once the load forecast is fixed, the alternatives, their composition and cost will be subjected to public scrutiny and will be publicly agreed upon before the sequence of development is analyzed on a system-cost basis.

(c) The cost to APA of the overall study program will be minimized by avoiding the coordination, liaison and duplication of effort inherent in a split of alternatives and project feasbility studies.

T1.4 Comment: The POS needs consideration of locally oriented and decentralized power systems with emphasis on renewable resources.

Response: This need has been addressed adequately in Acres' POS under Subtask 1.03, Selection of Alternatives.

T1.5 Comment: An overall energy budget should be considered for all alternatives to the Susitna Project.

Response: It is assumed that this "energy budgeting" means the consideration of the total energy consumed in the development of each alternative power source. This is not normally done in feasibility studies, nor is it required for FERC license application. Consideration of such a study will be included in activities to be undertaken after submission of the FERC license application.

T1.6 Comment: The POS does not give sufficient attention to system-wide costs with and without the Susitna Project.

Response: This concern is already adequately addressed under Subtask 1.04, Selection of Viable Expansion Sequences.

Task 2 - Surveys and Site Facilities

T2.1 Comment: There is inadequate attention to the logistics of getting study teams into the field.

Reponse: Logistical problems are fully recognized: further clarification of the Acres proposals has been included in the revised POS.

T2.2 Comment: The POS is weak in evaluation of existing data and lacks specific justification for undertaking new data programs. (This comment also applies to Tasks 3, 4 and 5).

Response: With respect to Site Surveys, the proposed program has been formulated by Acres after assessment of all the existing survey information which is available to Acres. The proposed program is considered the minimum necessary for FERC license application.

The data collection programs described in Task 3, 4 and 5 will be tailored to provide the data not already available from previous investigators or other resources. Subtasks 3.01 (Review of Available Material), 4.01 (Review of Available Data) and 5.01, (Data Collection and Review) have been specifically included in the POS to provide a basis for development of cost-effective data collection programs.

Task 3 - Hydrology

T3.1 Comment: The POS requires more emphasis on hydrological and climatological data collection programs.

Response: These programs have been adequately covered under Subtasks 3.01, 3.02 and 3.03.

T3.2 See T2.2

Task 4 - Seismic Studies

T4.1 Comment: The POS requires as thorough a seismic study as possible.

Response: Acres agrees fully that the seismic problem must be thoroughly studied. The program described under Task 4 is to be adequate to evaluate seismicity and its effect on the project. In addition to this, a sum of $1,000,000 has been allowed to include independent review and evaluation by a separate panel of seismic experts.

T4.2 Comment: The POS should include the delineation of areas subject to flooding due to seismically induced dam failures.

Response: The study is included under post-FERC license application studies.

T4.3 See T2.2

Task 5 - Geotechnical Exploration

T5.1 See T2.2

Task 6 - Design Development

T6.1 Comment: Task 6 is very ambitious and may not be attainable within the proposed time frame.

Response: Acres agrees that considerable work in Task 6 must be completed in a fairly short span of time. However, it is Acres' opinion that it can be accomplished to the degree of detail necessary for FERC license application, provided the requisite field programs are accomplished. It must be remembered that the effort will not be aimed at producing

detailed designs but rather to investigate various alternative project arrangements to ensure that the optimal plans are selected. The level of detail necessary at this stage is reflected in the man-time and cost estimates for this task.

Task 7 - Environmental Studies

T7.1 Comments received by various environmental agencies have been discussed at length with those agencies, notably ADF&G and F&WS. The POS has been appropriately modified to reflect these discussions.

Task 8 - Transmission

T8.1 Comment: Insufficient attention has been focused on the transmission system and its environmental impacts.

Response: It is considered that the POS as currently proposed is adequate to cover transmission aspects prior to FERC license submission. Consideration will be given to any additional environmental studies warranted during the period following submission of the FERC license application. APA has also initiated other studies in connection with the intertie.

Task 10 - Licensing

No comments.

Task 11 - Financing

No comments.

Task 12 - Public Participation

T12.1 Comment: There is a need for public involvement before the POS is finalized.

Response: This first reprint of the POS is being made available for public scrutiny and comment. Furthermore, the proposed POS includes a public meeting early in the program (February 1980) wherein public response to the POS can be assessed. The second reprint of the POS will be appropriately modified and issued subsequent to that meeting.

T12.2 Comment: There is a need for an independent public involvement program.

Response: The public participation program proposed by APA and Acres is substantial and sufficiently visible. An independent public program is not considered necessary. The proposed POS provides for three public meetings and eight workshops over the 30-month study period. The public and all interested state agencies will have ample opportunity to scrutinize the study activities. Acres considers that adequate public participation can be generated by such frequent exchanges between the study team and the public, and additional independent action is not necessary.

T12.3 Comment: There is a need to demonstrate how public input is affecting the plan of study as well as future decisions.

Response: Subtask 12.05 (Prepare and Maintain Action List) has been devised to implement this requirement. Maintenance of the Action List will provide a positive system for ensuring all issues are addressed, to permit up-to-date status reports on progress and procedures for addressing issues; and to ensure that all necessary actions arising from the public participation program are assigned by name to team members. Acres consider that this "action list" scheme will provide an efficient vehicle for demonstrating to the public how their input is affecting the study outcome.

T12.4 Comment: The POS does not consider an adequate degree of coordination with the Matanuska-Susitna Borough.

Response: Acres intends to coordinate the POS with Mr. L. H. Kimball, Director of the Division of Community Planning, and with the Matanuska-Susitna Borough.

T12.5 Comment: The time-frame of the study is too short for public discussion and input on alternatives to the Susitna project.

Response: As stated above, the proposed POS includes three public meetings and eight workshops over the 30-month study period. Acres considers that there is ample opportunity for public comment on the study.

With regard to public comment on the alternatives to the Susitna Project, either Workshops 2 or 3 in May and August 1980 would be appropriate times for public opinions to be voiced.

Task 13 - Administration

T13.1 Comment: There are considerable management problems inherent in coordinating as many study participants as are included in Acres POS.

Response: Acres acknowledges that considerable effort must be directed towards coordination of the many participants involved in the study. However, Acres has had much experience in management of such efforts and is fully confident of its capability to successfully complete the study objectives. Perhaps a convincing demonstration of Acres strength in this coordinating function is the development of the study proposal for the Susitna Project, wherein the inputs of seven different firms were combined into a single comprehensive plan of action.

General Comments on the POS

G.1 Comment: The 30-month time frame of the study is too short and should provide a mechanism for the review, redirection and continuation of selected projects post-FERC license application.

Reponse: As requested by APA, Acres has prepared a plan of study leading up to the FERC license application, and has outlined the work that would be involved subsequent to that application. If the project is determined to be feasible, it is assumed that the appropriate studies would be continued and supported by APA beyond the proposed initial 30-month program.

G.2 Comment: Interagency coordinating mechanisms need to be refined with clear delineation of how information from the various disciplines will be synthesized.

Response: The POS will be amplified to reflect the many interagency coordination mechanisms which will utilized during the studies.

G.3 Comment: There is a need for a formal interagency review committee.

Response: The various agencies involved will be consulted on this matter during the initial stages of the study. It is believed that the communication mechanisms currently envisaged will be adequate to satisfy this comment.

G.4 Comment: It is advisable to separate the planning and design responsibilities.

Response: Although there is no current commitment not to separate these activities, to do so will not be cost effective. There is ample opportunity within the proposed POS for public scrutiny of the objectivity and cost-effectiveness of the study.

B.5 Comment: There is a need to tailor the POS to the needs of the decision maker.

Response: All information developed in the study will be documented in the form of summary and comprehensive reports which will be in the most appropriate form for efficient use by decision makers.

G.6 Comment: There must be an acknowledgement of the state liability program.

Reponse: This will be appropriately dealt with during the study.

G.7 Comment: The overall program is very ambitious and may not be completed in the proposed time frame.

Response: It is Acres' opinion that while the study will require a great deal of hard work, provided unforeseen circumstances do not arise, the program can be accomplished in the proposed time frame.

2.2 - Verbal Comments

Acres has been provided the transcripts of the hearing on September 28, 1979, on the Susitna Feasibility Study, so that all criticisms of Acres' proposal may be considered in arriving at a final version of the POS (see Table 1.2). Several of these comments have been already addressed in Section 2.1 above. The remainder are summarized and discussed below. It should be noted that the dialogue of many of the contributors at the hearing has been incompletely documented due to background noise, poor voice recording, etc. There may, therefore, be some omissions or misunderstandings.

Task 1 - Power Studies

T1.7 Comment: A very detailed, comprehensive study of alternatives is necessary.

Reponse: The level of effort proposed by Acres for the study of alternatives is considered adequate to confirm that the Susitna development is indeed the most desirable option.

T1.8 Comment: Acres' POS is inadequate in terms of assessing alternatives to the Susitna development.

Reponse: The level of effort for the study of alternatives is considered adequate to confirm conclusively whether or not the Susitna development should be pursued to supply the future growth in demand for electricity in Alaska.

Task 2 - Surveys and Site Facilities

T2.3 Comment: The availability of the "Highlander Lodge" located some five miles from the Devil Canyon site should be considered in providing camps for the field programs.

Reponse: Use of existing camp facilities will be considered. All such facilities which are available and shown to be a cost effective alternative will be utilized to the fullest extent possible.

Task 3 - Hydrology

T3.3 Comment: Full advantage should be taken of the University of Alaska's knowledge of river ice conditions.

Response: Acres intends to retain experts from the University of Alaska in assessing the river ice problems on the Susitna.

Task 5 - Geotechnical Exploration

T5.2 Comment: There is a concern on the competence of R & M Consultants Inc. for a job of this magnitude.

Reponse: This comment is apparently based on Anchorage Municipal Light and Power's experience with R & M on a recent job. It is Acres' understanding that the cost overrun on this job was due to circumstances beyond R & M's control.

Task 6 - Design Development

T6.2 Comment: There is a concern that the tunnel scheme proposed by Acres is not feasible.

Reponse: This may be true. At this point in time, the tunnel concept is an unproven scheme which must be studied in more detail to determine its economic and technical feasibility.

Task 7 - Environmental Studies

T7.2 Comment: There should be a study of the possible change in climate due to the formation of reservoirs on the Susitna River.

Reponse: Although not specifically highlighted in Acres' POS, this impact on the region's climate will be addressed in Subtask 7.03, Evaluation of Alternatives.

T7.3 Comment: There is a concern on the objectivity of the Alaska Department of Fish and Game in their participation in the study.

Reponse: ADF&G in their role as a state agency for monitoring and controlling environmental disturbances are obviously the best qualified and equipped agency for gathering of baseline data for the areas affected by the project. APA has, therefore, contracted with ADF&G to undertake this work. Any other involvement by ADF&G will be restricted to their customary role of review and approval of environmental assessments, proposals for mitigating measures, and permit applications.

Task 8 - Transmission

T8.2 Comment: There is a need for a study on the risk of transmission line outage.

Reponse: This will be adequately addressed in Subtasks 8.02, Electric System Studies, and 8.04, Tower, Hardware and Conductor Studies.

General Comments

G.8 Comment: The time frame for the study is too short.

Reponse: If the Susitna project is proven to be economically feasible, the field data collection program will continue after the 30-month period presently planned.

G.9 Comment: The POS's submitted by all three consultants should be combined into a single comprehensive plan.

Response: The more desirable aspects of the HARZA and IECO proposals, where appropriate, have been reviewed and taken into account in the revised POS (see Sections 3 and 4).

G.10 Comment: A comprehensive field program is needed.

Reponse: The data collection programs outlined in Tasks 2, 3, 5 and 7 are considered sufficiently comprehensive at this stage of the project evaluation.

G.11 Comment: There should be an external review of the basic assumptions, methodologies and final results of the Susitna Study.

Reponse: Acres agrees that external review of the study is necessary. To this end, three external mechanisms are planned:

(i) The proposed external review panel of world-renowned experts will provide a necessary check on the basic assumptions, methodologies and study results.

(ii) The public participation program will give the public the opportunity to comment on and influence the study.

(iii) The study of the projected load growth of Alaska will be given to the Institute of Social and Economic Research as an external consultant.

G.12 Comment: The feasibility study should be postponed until the alternatives to Susitna are fully assessed.

Reponse: Indications to date are that the Susitna development is economically attractive and will be needed at an early date to satisfy the electrical load growth of Alaska. To postpone the feasibility study may result in the ultimate delay of the project at the cost of having to develop more expensive alternatives in the interim, or even of incurring short-term power shortages relative to the small potential savings involved. If the feasibility of the Project can be established, then it is desirable to obtain the FERC license with the minimum of delay. Even so, the proposed program has been devised to minimize expenditures prior to completion of alternatives studies while still accomplishing licensing of the project at the earliest possible date.

3 - ASSESSMENT OF HARZA PROPOSAL

The proposal submitted by Harza Consultants to APA has been assessed with the intention of extracting those portions which could be used to improve the Acres plan.

In general, the Harza plan of study is similar to that of Acres. Many of the apparent differences are a result of different emphasis in the presentation of the plans of study. It is Acres' opinion that all major tasks proposed by Harza are already included in the Acres POS, where they are organized and scheduled in a comparable or more comprehensive manner. Specific differences in the proposals are discussed below.

3.2 - Specific Differences in the Proposals

(a) Harza proposed to engage an Alaskan resident with a thorough background of Alaskan attitudes, customs, etc. as the manager of their "Public Information and Participation Program".

Acres agrees with this approach, and intends to do the same, although it was not specifically stated in the original proposal.

(b) Harza recommends the formation of a "Technical Advisory Committee" composed of representatives of interested groups and agencies for a "two-way communication between the project planners and interested state and federal agencies". The Acres POS is considered to provide for these communications through the proposed review panels and public participation program.

(c) Harza's proposed mapping of the Susitna River appears to be more comprehensive and detailed than that of Acres.

Acres research has shown that a considerable amount of survey data is already available. Aerial photography and subsequent mapping is very expensive, and will consequently be kept to the minimum required for evaluating project alternatives. Acres considers that their mapping program is adequate to augment the existing data envisaged. If specific development schemes prove to be attractive in this feasibility study, more detailed mapping in the post-FERC license period may be necessary.

(d) Harza proposes to make a comprehensive inventory of existing generating facilities and transmission lines.

Although this is not listed as a specific item in Acres POS, it was intended to form part of the groundwork of Subtask 1.04, Selection of Viable Expansion Sequences, and has been included in the cost estimate of that item.

(e) In their proposal, Harza emphasizes their intention of developing a concept of staged development of the Susitna River. They describe six major schemes which will be investigated thoroughly.

The basis of the Acres POS is essentially that the substantial amount of competent work which has already been done by USBR and the Corps of Engineers should at this point be assumed to be correct and that the Corps' most recently proposed scheme is near-optimal. Acres' detailed proposals were, therefore, developed on the basis of this previous work and the POS will refine and build upon it rather than start afresh. However, in the event that the Acres study of alternatives (Subtask 6.03) indicates that other development schemes are more desirable, Acres' POS will have to be modified to include a more thorough search and refinement of the optimal plan.

(f) Harza's POS includes the use of the "WQRRS" computer model developed by the Corps of Engineers to analyze the water quality in the reservoir(s) and the Susitna River.

It is Acres' opinion that use of this model will not produce meaningful results without extensive field data for its calibration. Therefore, although some analytical modeling of the thermal stratification in the reservoir is planned in the pre-FERC license application period, refined modeling of the water quality has been reserved for the post-FERC license application period when adequate basic data will begin to become available.

(g) Harza proposes to study "Riparian Habitats". The objective of this will be to characterize the interrelationships between the maintenance of willow/moose habitat in the downstream flood plain and seasonal flooding characteristics.

The current revisions to the POS have been developed in combination with ADF&G and are, therefore, considered to be adequately responsive to these aspects.

(h) Harza proposes a "Recreation Resources Study" to inventory and evaluate the recreation resources within the Susitna River Basin for the purpose of assessing the impacts that the project might have on them.

Although it is not specifically discussed in the Acres proposal, it is intended that such a study would form the necessary groundwork for Subtask 7.08, Analysis of Recreation Development. The estimated cost of this Subtask has been included for this work.

(i) Harza proposes to assess the potential impact of project alternatives on the aesthetic and visual resources, and to identify measures to ensure that project works blend with the surrounding environment. Two computer programs developed by HARZA for this purpose will be used to evaluate the visual impacts.

The environmental impact assessments of the proposed development, including aesthetic and visual resources, will be achieved by competent experts in a conventional manner under the Acres POS.

(j) Harza proposes to develop a "Resources Inventory" and a "Project Data Management Program".

Although this approach to tabulation of project data has not been proposed specifically in Acres' POS, it is intended that a comparable, methodical cataloging of such data will be carried out as necessary for the complete documentation of study results.

(k) Harza proposes a Project Sponsor who would maintain periodic liaison with APA and provide a communications channel to Harza management for evaluation of the performance of the project team as a whole.

Although not originally proposed by Acres as a formal part of the project team structure, such a communications channel will be made available for APA to the senior management of Acres.

4 - ASSESSMENT OF IECO PROPOSAL

4.1 - General

IECO's proposed POS has been reviewed in detail. Each task outlined by IECO has been critically and objectively assessed and compared with those previously formulated by Acres. In general, the two POS's are quite similar, although in many areas Acres' plan appears to be more comprehensive and complete. Several Tasks apparently considered necessary by IECO have not been detailed specifically in Acres' proposal. These Tasks are discussed below.

4.2 - Task C-4-9 - Aquatic Resources-Upper Cook Inlet Estuary

In this task, IECO proposed to develop a mathematical model of the Cook Inlet and to use it to assess the potential impact from upstream development. Although Acres intends to assess the impact on the estuary, it will be done not by mathematical model but by more reliable and proven empirical methods. It is Acres' opinion that at this early stage of the project, without adequate basic data, the use of such a sophisticated tool would not provide meaningful results.

4.3 - Task C-4-17 - Air Quality and Noise

As part of this Task, IECO proposes to evaluate measures to minimize potential impacts to air quality and noise that could occur during the construction of a Susitna project.

Although Acres' POS includes an evaluation of the impact of alternative power sources (thermal plants in particular) on air quality, this has not been specifically addressed with respect to construction of hydroelectric projects on the Susitna. Such impacts, considered minimal at this time, will be assessed in Task 7, Environmental Studies.

4.4 - Task C-4-21 - Public Safety

The purpose of this task will be to describe any impacts resulting from accidents and natural catastrophes which might occur, and provide an analysis of the capability of the area to absorb predicted impacts.

Although such a work item has not been specifically included in Acres' POS, it is expected that such impacts would have to be described for public meetings and workshops, and it is considered that sufficient funds are included in Task 12, Public Particiption, to cover this.

4/5 - C-4-22 - Visual Resources

IECO proposes a separate task at a considerable cost ($70,000) to:

- Determine the significant visual effects of the Watana and Devil Canyon structures.

- Simulate the appearance of the structures and suggest mitigation measures for undersirable visual impacts.

- Establish criteria for scenic quality which provides a basis for comparative evaluation of proposed project features and alternative energy sources.

Although such an item has not been specifically included in Acres' POS it is intended that visual impacts of the projects will be satisfactorily evaluated in Task 7, Environmental Studies.

4.6 - D-4-1 - Develop Comprehensive Watershed Model

Acres does not consider that development of such a model will be necessary during pre-license application studies. Acres proposes to refine the work already conducted by the U.S. Army Corps of Engineers with the SSARR watershed model, and thus avoid the heavy cost of developing and calibrating a new model.

4.7 - D-4-2 - Develop Specific Models for Arctic Conditions,
D-4-3 - Calibrate and Verify Models

Acres does not consider that this will be necessary. Acres will draw primarily from "off-the-shelf" models which have already been developed on Acres' previous jobs where Arctic conditions have been a problem. Some work may be necessary, however, to calibrate these models to the specific conditions encountered in the Susitna Basin.

4.8 - D-5-4 - Glacial Water Balance,
E-5-3 - Mass Balance and Dynamic Behavior of Glaciers

IECO proposes to launch a detailed assessment (at a cost of $158,000) of the glaciers in the Susitna Basin.

Although Acres considers that some evaulation of the glaciers is necessary (as included in Subtask 3.04 (vi)), it would be more appropriate to have a moderate investigative effort at this early stage. If more comprehensive study appears warranted, it can be planned and implemented after submission of the FERC license application.

4.9 - E-3-2 - Shear Wave Hammer Testing of the Watana and Devil Canyon Sites

This is not considered necessary during pre-licensing submission activities. The proposed Acres program for seismic and geotechnical exploration is adequate.

4.10 - E-8-4 - Conduct Mass Concrete Tests

IECO proposes to expend some $40,000 on conducting laboratory tests to develop a mass concrete design mix and to check the suitability of avialable materials to obtain the desired concrete mix.

Acres considers that such effort should be reserved only for the later design stage of the project. For the feasibility study, Acres will draw on their extensive experience with concrete mixes for northern construction to evaluate the appropriate composition.

4.11 - D-6-6 - Downstream Hazards from Dam Failure

In this task, IECO plans to evaluate downstream hazards of dam failure because of a catastrophic event.

Evaluation of downstream hazards is an important activity, but is best undertaken after submission of the license application, when definitive schemes of the Susitna project have been developed.

4.12 - Hydrology

IECO has included $1.8 million for hydrologic studies, compared to $1.6 million for Acres. This difference is mostly due to IECO's estimate of $340,000 for developing sophisticated mathematical models which Acres believes to be unnecessary at this time.

SECTION A5 - DETAILED ACTIVITY DESCRIPTIONS

SECTION A5 - DETAILED ACTIVITY DESCRIPTIONS

A.5.1 - Introduction

As discussed in Section A2 it is proposed to achieve the objectives of the Susitna Plan of Study by undertaking a program of work divided into the following 13 tasks:

Task 1 - Power Studies
Task 2 - Surveys and Site Facilities
Task 3 - Hydrology
Task 4 - Seismic Studies
Task 5 - Geotechnical Exploration
Task 6 - Design Development
Task 7 - Environmental Studies
Task 8 - Transmission
Task 9 - Construction Cost Estimates and Schedules
Task 10 - Licensing
Task 11 - Marketing and Financing
Task 12 - Public Participation
Task 13 - Administration

Within each of these tasks, a series of subtasks has been identified as shown on the Master Schedules, Plates A7.1 and A7.2. Plate A2.1 is an overall summary schedule for the entire Plan of Study. More detailed schedules and logic diagrams for some specific areas of the study appear under individual subtask description in this section of the POS. In the following subsections the Scope Statements for Tasks and Subtasks are presented and discussed. A complete listing of all subtasks with associated costs is presented in Section A3 - Budget Summaries.

Throughout this section of the proposal, reference will be found to "Design Transmittals". This term is used by Acres to describe a formalized document prepared to present the engineer's or designer's response in definitive terms as to how he interprets a statement of work and how he intends to proceed with the detailed engineering. The "Level of Effort" shown for each subtask relates to the completion of that task as part of the combined effort of all participants.

A.5.2 - TASK 1: POWER STUDIES

(i) Task Objectives

To determine the need for power in the Alaska Railbelt Region, to develop forecasts for electric load growth in the area, to consider viable alternatives for meeting such load growth, to develop and rank a series of feasible, optimum expansion scenarios and finally to determine the environmental impacts of the selected optimum scenarios.

(ii) Task Output

The primary output of Task 1 will be a report dealing with the selection and ranking of optimum system expansion scenarios for the Alaska Railbelt Region. The final version of this report will be submitted for review and approval by Alaska Power Authority on or about Week 48 of the Study. Preliminary findings of the study will be discussed with Alaska Power Authority on or about Week 30 of the Study. Such a discussion will center on whether or not work on the Susitna Development should continue or whether another, possibly more viable alternative should be examined. Design transmittals outlining intermediate stages of the power studies will also be issued as indicated on the logic diagram, Plate T1.1.

(iii) List of Subtasks

Subtask 1.01 - Review of the ISER Work Plan and Methodologies
Subtask 1.02 - Forecasting Peak Load Demand
Subtask 1.03 - Identification of Alternatives
Subtask 1.04 - Selection of Viable Expansion Sequences
Subtask 1.05 - Expansion Sequence Impact Assessments
Subtask 1.06 - Power Alternatives Study Report

(iv) Subtask Scope Statements

The primary purpose of Task 1 as discussed in Section (ii) above is the establishment and documentation of appropriate load forecasts for the Alaska Railbelt area and the development of optimum system expansion sequence scenarios to meet this forecast. The evaluation of these factors for the Railbelt Region and the relationship and scheduling of Task 1 to the remaining twelve tasks of the overall Plan of Study are illustrated in the master schedule, Plate A7.1. This portion of the study will be undertaken in essentially three parts. The initial phase will include evaluation of the various projected energy consumption scenarios developed by independent study teams. From these forecasts, the Acres team will develop kilowatt load forecasts appropriate for the low, medium, and high growth rate scenarios. The second portion of Task 1 will deal with the development of optimum mixes and sequences of feasible alternative sources for meeting future power demands. These mixes will be developed with and without the Susitna Project, which at this stage will be assumed for study purposes to be that developed

by the Corps of Engineers. The third section of the study will deal with the preliminary comparative environmental and socioeconomic impacts of the developed optimum mixes on the Railbelt Region.

In order to meet the overall objectives of the Plan of Study as stated in Section A2 above, other activities of the program will proceed in parallel with Task 1. These will essentially involve Task 2 - Surveys and Site Facilities, Task 3 - Hydrology, Task 4 - Seismic Studies and Task 5 - Geotechnical Exploration. For logistical reasons, these activities will have been initiated on the assumption that the Susitna Project will be that which proves to be the optimum development for Alaska Power Authority. However, the Task 1 power studies may determine otherwise. Under such circumstances, the ongoing studies would be halted pending discussions with Alaska Power Authority to determine the future course of action most appropriate. On the other hand, should Task 1 studies confirm the earlier studies undertaken by the Corps of Engineers and others that the Susitna Project, with dams at Watana and Devil Canyon is the appropriate means of meeting future load growth in the Railbelt area, the study will continue as planned.

(v) Concurrent Studies by Others

Concurrent with work undertaken by the Institute of Social and Economic Research (ISER) and by the Acres team, a number of studies bearing on Task 1 efforts will be accomplished by others. A full-time power system study representative from the Acres team will be stationed in Alaska during the first year of the work and he will closely monitor these concurrent activities as a portion of his total duties. Some particular efforts which should enhance the quality of Task 1 work include:

(1) A Power Alternative Study coordinated by the Alaska House Power Alternatives Committee is now in progress. Specific Study contracts include:

(a) Power Market Demand Projections--by the University of Alaska Institute for Social and Economic Research.

The section of the study is being done in cooperation with the Power Authority. They have shared in the design of the contract, and will participate in the funding. This portion of the study will also serve as the power market demand projection for the Susitna Phase I of Study (see Subtask 1.01).

The particulars of the scope of work include methodological review, data collection and updating, economic projections, assessment of interfuel substitution possibilities, electricity use projections, and an assessment of possibilities, electricity use projections, and an assessment of the probabilities of the various scenarios and projections.

The institute will hold a workshop in December to review the assumptions behind the economic projections, and will cooperate with a variety of other committee consultants.

(b) Review of the ISER Demand Work

Dr. Bradford Tuck, an economist with the University of Alaska School of Business, and Energy Probe, of Toronto, will separately analyze and criticize past demand projections as well as the work ISER is undertaking for the committee.

(c) Potential of Conservation and Renewable Energy

The Alaska Center for Policy Studies will manage the various portions of this section of the study. The work will include an analysis of the end uses of energy in the Railbelt area, a determination of the potential for energy conservation and the use of renewable energy sources, a discussion of the social, economic and political measures necessary to achieve the conservation and renewable energy potential, and work on conservation legislation for the 1980 session (HB 364). A variety of subcontractors will carry out the specific tasks.

(d) Natural Gas

This portion of the study will address institutional limitations on the future use of natural gas for power generation, the future price and availability of gas, the efficiency of gas-fired generation facilities, and the potential for the use of natural gas in direct consumer applications. A proposal by economist Greg Erickson is pending.

(e) Overview

This section would address the historical background of the supply of electric power in the railbelt, survey the basic policy questions at stake in the Susitna decision, delineate financing questions and address the decision-making structure for Susitna and other power alternatives. A proposal by economist Arlon Tussig is pending.

(f) Sociocultural Impacts

This section would investigate the effect of the construction of the Susitna dam on both the local area and Alaska, and relate those effects to both a historical and a normative context. A proposal by the Arctic Environmental and Data Center of the University of Alaska is pending.

(g) Other Sections of the Study

Additional work is contemplated in the areas of coal-fired generation. A review of the adequacy of Phase I study of environmental impacts is also contemplated.

(2) Assessments of hydroelectric and other electric generation potential throughout the State and particularly in or near the Railbelt Area, to be undertaken by others from time to time under contract to APA.

(3) Ongoing work by the Alaska District, U.S. Army Corps of Engineers, on the Bradley Lake Project and other hydroelectric studies.

(4) Studies undertaken for the Alaska Power Administration, including in particular a study of wind generation potential in the Cook Inlet Region.

Subtask 1.01 - Review of the ISER Work Plan and Methodologies

(a) Objective

Critically review the work plan and the methodologies developed by the University of Alaska's Institute of Social and Economic Research (ISER) for forecasting energy demands.

Review and comment upon those written documents prepared by ISER as a part of its study. These documents will include, but will not be limited to, those documents listed under section (b) of this Subtask.

Reach a thorough understanding of the assumptions used by ISER in its work.

Exchange information with ISER regarding data needed by the Acres team in its subsequent work.

Ensure adequate data output by the ISER through coordination efforts.

(b) Approach

ISER is under contract with the State of Alaska's Legislative Affairs Agency to develop projections of the possible future energy consumption trends for the Railbelt Region. As a part of this work, it is responsible for developing the methodologies used for the projection; for the collection of data used in its models; for producing projections detailing the energy consumption trends for six categories of consumers in three distinctly different areas of the Railbelt. The six categories of consumers for which individual growth projections will be made are:

a. Residential
b. Commercial
c. Non self-supplied industrial
d. Self-supplied industrial
e. Potential industrial
f. Users who cannot be supplied by the urban power grids.

The three geographical areas which will be studied individually are:

a. The Anchorage-Cook Inlet area which forms the southwestern section of the Railbelt Region. This area will include the Kenai Peninsula.

b. The Fairbanks-Tanana Valley area, lying to the north.

c. The Glenallen-Valdez area which is the southeastern area under study.

These three study regions are relatively distinct areas of load concentration.

The approach taken by the ISER, as broadly described in its contract with the Alaska Legislative Affairs Agency, and as further defined in its "Detailed Work Plan" dated November 14, 1979, consists of four major areas of effort:

1. A review of available econometric forcasting methods and models. The most apparently suitable model will be selected for further use in ISER work. A written report will be produced describing the advantages and disadvantages of the methods which were studied.

2. A review of the available electrical energy consumption forecasting methods. The most apparently suitable method will be selected for further use in ISER work. A written report will document the advantages and disadvantages of the methods which were studied.

3. Data needed for implementation of the forecasts of 1 and 2 above will be collected and analyzed to determine its limitations and potential uses. A written report will describe the data collection and the uses to which it will be put in future work.

4. Incorporation of all appropriate data into the econometric and electric energy use forecasting models. These models will then be used to predict electrical energy consumption through the year 2005. Inputs to the models will be varied to produce values of energy consumption growth at the most likely level, the highest probable level, and the lowest probable level.

As a general rule, the scenario method implies a consistent description of a system's evolution by fixing, through exogenous assumptions, the evolution of the scenario components: those variables characteristic of the system. The components selected by the ISER as well as the assumptions upon which the decisions to select those components lie will be critically reviewed.

Finally, the electricity use projection methodology developed by ISER and the steps involved in its use, namely model design, regression equation, and forecasting, will be examined.

Model design involves the selection of the independent variables which affect model output and the formulation of the mathematical relations between those variables.

Estimation of the form taken by the regression equation involves the use of historical data. Limitations in the data may, in some cases, preclude the use of otherwise relevant variables. Availability of data will be studied.

A statistical analysis of the model's accuracy and validity will be undertaken.

The responsibility for incorporation of the WCC recommendations, as well as the validity of the model and the accuracy of its projections, will be that of ISER.

(c) Discussion

It is the responsibility of the Acres team to carefully evaluate the steps undertaken by the ISER in developing its energy consumption

projections. Undoubtedly, to successfully accomplish subsequent Task 1 work, it is imperative that the Acres team have a thorough understanding of, and a high degree of confidence, in the work of ISER. This can come only by close cooperation between members of ACRES team and those involved in the ISER work.

ISER submitted a detailed work plan to the Alaska Power Authority (APA) dated November 14, 1979. This work plan will be reviewed and modifications will be suggested to ISER if it is deemed appropriate. The energy and econometric modeling methodologies and the development scenarios proposed by ISER will be reviewed for the validity of their assumptions.

(d) Schedule

Weeks 1 through 12

Subtask 1.02 - Forecasting Peak Load Demand

(a) Objective

Derive scenarios describing a reasonable range of load (kW) and load duration curve forecasts for the system through the year 2010. Prepare data in a form adequate for incorporation in the power system model to be developed in Subtask 1.04.

(b) Approach

Based on projections of energy (kWh) consumption as developed by ISER (see Subtask 1.01), annual power (kW) demands for each of the three defined Railbelt Regions will be forecast through year 2010. The forecasts will include both peak load levels and the shape of the load demand over time in the form of load duration curves. To ensure that the maximum accuracy of the system model is realized, load duration curves will be developed for both typical weekend and midweek days. These data will be produced separately for each of the three geographic areas of the study region and for each of the six consumer groups within each of those regions.

(c) Discussion

As noted in Subtask 1.01, ISER will prepare projections of future energy consumption in the Railbelt area. ISER will not predict peak power demands (kW) or load duration curves.

It shall be the responsibility of WCC, under the supervision of Acres, to produce these data in a manner which is consistent with the economic, social, political and technical assumptions made by the ISER when developing their energy consumption forecasts.

It is intended that the forecasts to be developed by WCC satisfy the dual purpose of filling out ISER data into a total picture of electrical demand for the study period and of providing detailed data to Subtask 1.04 for direct utilization in the generation planning model. This required data will include consideration of load shapes on a monthly basis as well as typical daily load shapes for week-day and weekend occurrences.

Load duration curves describe the percentage of time that a power system operates at any fraction of its full power level. Load duration curves can be developed on an annual, seasonal, monthly or even a daily basis. A load duration curve can be interpreted to yield the average power level for the time period described by the curve. The average-to-peak ratio is known as the load factor of the system.

Several methods can be used to produce peak load (kW) forecasts once energy (kWh) consumption predictions have been made. The basic procedure is to divide the energy consumption (kWh) of a given time period by the product of that period's length (in hours) and its load factor, to obtain power (kW).

For the above discussion, it is evident that a crucial point in producing credible load forecasts is the development of the load duration curves. The available methods and the degree to which they will be applied to the system under study, will be reviewed to determine their suitability to the problem at hand.

(d) Output

Since the subsequent Task 1 work is dependent upon the efforts of this Subtask, it is imperative that the data produced by this work is accurate, complete and in a readily usable form. Discussions of all methods used and assumptions made must be produced in report form to support the power and load duration data.

For use in the system modeling work of Subtask 1.04, the following data are required:

a. Month-to-annual peak load ratios for full 12 month period.

b. For typical weekend and midweek days, hourly-to-monthly load ratios, arranged in descending order, month to month.

c. Per unit peak load ratios associated with the 0, 20, 40 and 100 percent points on the monthly load duration curve month by month.

d. Peak power level, annual.

e. The year-to-year variations of the quantities a - d, above.

To remain consistent with earlier work, data outputs will be broken down along the same geographical and consumer lines as the energy predictions of the ISER.

(e) Schedule

Weeks 8 through 26

Subtask 1.03 - Identification of Power Alternatives

(a) Objective

Identify and select for evaluation purposes alternative power sources appropriate for inclusion in future Alaska Railbelt Region load-growth scenarios.

(b) Approach

This subtask will be subdivided into two further work packages:

- Non-hydro alternatives
- Hydro and tidal alternatives

These packages will be undertaken concurrently, non-hydro alternatives being developed by Woodward-Clyde Consultants, Anchorage and hydro and tidal alternatives by Acres American. Each package will include appropriate analyses to identify which (if any) energy sources would be viable alternatives to the Susitna Project. The evaluation will include an initial review of the March 1978 "Analysis of Future Requirements and Supply Alternatives for the Railbelt Region" published by Battelle Laboratories.

In deciding if a particular system or group of systems could be a viable alternative, five basic factors must be considered:

- Anticipated demand (location and amount) that the Susitna Project must supply,
- The maximum amount of power (or reduction in demand for power) that could be supplied to the Alaska Railbelt Region by each alternative,
- The cost per unit of electricity supplied by each alternative,
- Construction and licensing schedule of each alternative,
- The non-cost impact of implementing each alternative.

The intent will be to examine the widest possible range of alternatives while relying, as much as possible, on published data.

(c) Non-hydro Alternatives

The non-hydro alternatives to be examined include "traditional" energy sources such as coal or gas-fired steam turbines, combustion turbines (including combined cycle design), diesel electric systems and nuclear power plants (however, it is most unlikely that the nuclear alternative will receive serious consideration in Alaska). Studies undertaken to date for the Railbelt Region suggest that development of the Beluga and Nenana coal fields are likely to prove to be the largest viable alternative resources. Published data already developed by Woodward-Clyde Consultants on behalf of the Golden Valley Electric Association will be used in the proposed study. "Non-traditional" alternatives will

include solar generation, wind biomass, geothermal, and energy from wood and municipal waste. The Alaska Power Administration is presently pursuing a study of the potential offered by wind generation in the Cook Inlet Region. The results of this study will be utilized in the evaluation of non-hydro alternatives. In addition, "non-structural" alternatives will be considered including time of day pricing, demand controls or more efficient use of existing system resources.

Consideration will also be given to the impact of possible changes in government policy with regard to uses of Alaskan natural gas, the possible "non-action" alternative and the construction of an Anchorage-Fairbanks transmission intertie alone, in lieu of the project.

(d) Hydro and Tidal Alternatives

The hydro alternative will not necessarily involve a single conventional hydro project and may consist of a group of smaller hydro projects with, for instance, a gas-turbine installation to provide firm capacity backup or some similar combination meeting the screening criteria--along with conservation measures which could serve to limit projected growth.

Within the Southcentral Railbelt of Alaska, the Susitna and Copper River drainage basins and other small rivers, including Crescent, Chakachatna, Beluga, Yentna, Skiventna Chulitna, Talkeetna, Bradley (Creek) and Love were identified in the 1976 Alaska Power Survey by the Federal Power Commission as having significant conventional hydropower potentials. This study identified 23 projects, including Devil Canyon, Watana and Vee on the Susitna, with a potential installed capacity for all 23 sites of 8,419 megawatts. There are currently indications that the 70 MW Bradley Lake Project in the Kenai Peninsula may be developed in the foreseeable future. Current studies are also being undertaken with the Alaska Power Administration to identify "small hydro" potential.

The above references, in addition to other earlier work by the Bureau of Reclamation and Corps of Engineers and the most recent national Hydropower Study inventory by the Corps of Engineers, will be used to develop an overall scope of available hydro potential in the region. The sources will also be used to develop a specific alternative which could satisfy projected load demands at least as well as the Susitna Project. Published reports on the potential for development of the tidal power resources of the Cook Inlet Region will be reviewed for consideration of this alternative.

(e) Discussion

The analysis of energy supply alternatives for the Railbelt Region requires input from Subtask 1.02 as well as the forecasting work performed by the ISER as described in Subtask 1.01. These efforts describe the anticipated need for the power and energy which will be consumed in the Railbelt Region, regardless of its ultimate source.

The load duration curves, the distribution of power demand over a given period of time, are also an important part of the alternatives study. Depending upon the general shape of the load duration curves, various alternatives may be recognized as being particularly attractive to meet the future needs of the Railbelt Region.

Concurrent with the demand estimation phase (Subtask 1.02), an evaluation will be made of the amount of energy that can be supplied by each of the technologies considered. This will involve a preliminary review of the estimated amount of each energy resource available in Alaska, including such items as coal and oil reserves, solar, wind and tidal patterns and geothermal as well as other hydroelectric resources. The estimates for developing technologies will also include the availability date for commercial use. Preliminary cost estimates will be developed for each technology (cost/unit energy) based on the many existing studies (for example see "California Electricity Generation Methods Assessment Project", 1976). These cost estimates may vary with the amount of energy delivered, reflecting the necessity to use scarcer resources.

The supply estimates for each alternative will be compared to the projected demand to determine what percentage of the demand each alternative can meet. It may be that some alternatives cannot supply any of the demand at reasonable cost. These can be immediately eliminated from consideration. Or, it may be that a technology is cost effective but cannot meet the total expected demand. In this case, several technologies will be combined to make a single alternative system to compare with the Susitna project.

The most viable technologies (or groups of technologies) will then be reduced to a set of well-defined power generation alternatives for more detailed analysis. The analysis will include a detailed cost analysis of each alternative (still based primarily on published studies). This cost analysis will include capital costs (including transmission system), operation, maintenance and fuel cost, capacity factor estimation and potential for concurrent operations such as waste heat distribution. The emphasis will be on consolidating and correlating information from various sources to allow a consistent comparison of alternatives.

A scheduling analysis will be conducted to determine when the technology(s) for the alternative will be available and what lead times are necessary for construction. Finally, a comprehensive evaluation will be made to identify the non-cost impacts of each alternative. These impacts are likely to include environmental impacts (air quality, water quality and ecology); public health and safety impacts; socioeconomic impacts (such as a "boom-bust" cycle of population during plant construction); and the licenseability of specific alternatives to the extent that no insurmountable legal or environmental barriers are evident.

Non-cost concerns will be organized into a set of attributes for measuring the overall desirability of each alternative and combined with cost and scheduling concerns to evaluate each alternative.

These attributes will be designed to cover the range of identified concerns while not overlapping with one another. Each attribute will have an associated scale (or measure) to identify the level of achievement of each alternative with respect to attribute.

Scales will be designed to be meaningful to decision makers and to be measurable using existing data as much as possible. If no natural scale (such as dollars for the cost attribute) exists, constructed (judgmental) scales will be used. The results of this analysis can be presented in a matrix showing the level achieved on each attribute for each alternative.

(f) Schedule

Weeks 20 through 35

Subtask 1.04 - Selection of Viable Expansion Sequences

(a) Objective

To determine the total system costs of selected future Railbelt Region expansion sequences, both with and without incorporation of the Susitna Hydroelectric Project, and rank the perferred generation expansion scenarios.

(b) Approach

The most straightforward method of evaluating the potential economic benefit of a hydroelectric project in a given system expansion scenario is to compare capital investment and system operating costs on an annual basis, throughout the term of the study, for two scenarios: one without the benefit of the proposed hydro project; the other with it.

A number of mathematical models are available to facilitate the vast number of calculations involved in this type of study. In simplified terms, the user of such a model provides the program with data which includes the characteristics of the forecasted loads and the characteristics, availability and costs of generation sources which will be available throughout the period of the study. The model then selects the generation sources available to it to satifisy the projected load in the most economical manner.

To evaluate the economics of a given project, a comparison may be made of total annual costs of the two system scenarios on a year-by-year basis throughout the study period. If the system with the hydro project available is less costly throughout the planning period, the project is obviously attractive (though not necessarily selected, because impacts must also be accounted for). Conversely, if this system is more expensive in all years, then the project is unattractive.

It is possible, indeed likely, that the outcome of an economic evaluation would prove not to be so clear cut. It may be that the system incorporating the hydro plant would be more expensive in some years of the study, and less expensive in others, than the system without that project. In this situation, it would be necessary to perform comparisons between present worth values of operating cost for systems represented by the two scenarios.

Although such a strategy may provide a valid economic comparison, the results may be inconclusive. This is most likely to occur in the case of a hydro project having a capacity which is relatively small when compared to its connected system. The economic comparison then may be relatively small when compared to its connected system. The economic comparisons may produce a relatively small difference in two large numbers.

(c) Selection of Model

In the search for a usable generation planning computer model, three characteristics of the model are paramount:

- Flexibility -- does the model allow for a varied combination of alternatives?

- Accessibility -- is the model presently available and can it be used with a minimum of learning time?

- Reliability -- is the model actively maintained by its supplier and has it been used by other utility planners?

A preliminary survey of the market has revealed one model which satisfies all three criteria. Other models may be available, but these are generally developed either by or for specific utilities to solve their particular problems or they are so intricate so as to require special training for their use.

The computer model selected by Acres for this study is the General Electric Opimized Generation Program, Version Five (OGP-V). Several of Acres' staff have become familiar with the use of this program on other studies similar to the Susitna alternatives evaluations. The model is currently being used by Acres for the evaluation of small hydro sites in the eastern U.S. Earlier versions of the model, OGP-III and OGP-IV were used in studies performed for the U.S. Army Corps of Engineers in evaluating alternatives for New England Power Supply scenarios through the year 2000. This study was part of the Environmental Impact Statement for the proposed 944 MW Dickey-Linclon School Lakes Project in Maine.

(d) OGP-V

The OGP-V program combines three main factors of the generation expansion planning decision process: system reliability evaluation, operations cost estimation, and investment cost estimation. The program begins by evaluation of the power system reliability in the first study year by means of one of two methods -- either a percentage-of-reserves calculation or the computation of the loss of load probability (LOLP).

When the system demand level rises to the point at which either the user-specified reserve level or the LOLP criteria is violated, the program "installs" new generating capacity. The program will add generation capacity from a user-provided list of available sources. As each possible choice is evaluated, the program carries out a production cost calculation and an investment cost calculation, and eliminates those units or combinations of units whose addition to the system results in higher annual cost than other units or combinations. The program continues in this manner until the least-cost system addition combination is determined for that year. In cases where operating cost inflation is present, or where outage rates vary with time, OGP-V has a look-ahead feature which develops levelized fuel and O&M costs and mature outage rates out to ten years ahead of the "present" time. Once the apparent least-cost additions to the system necessary to satisfy reserve or LOLP criteria have been selected, the optimum system is described.

(e) Discussion

Load forecasting and daily load variation data generated in Subtask 1.02 will be used as input to the computer model together with the following technical and economic planning criteria:

- generation capacity and energy reserve requirements
- retirements of older units
- cost of money
- economic discount rate
- insurance and tax rates
- economic lifetime of equipment
- effects of cost escalation
- period of analysis

This data will be established in consultation with Alaska Power Authority, other utilities in the Railbelt Region and other pertinent agencies. The analysis will be carried out at the base rate with sensitivity testing over the possible range for selected alternatives.

One of the benchmarks against which the economics of a power generating facility may be measured is the economics of its alternatives. In many cases, it is possible to identify specific alternatives against which a given project may be directly compared. Most generating projects are intended for a specific operating regime within the power system, such as base-, intermediate-, or peak-load operation. For such sources, it is a relatively straightforward task to evaluate the cost of operating a specific alternative.

Hydroelectric projects, due to their hydrologic characteristics, must be evaluated in a somewhat different manner. A hydro project can be subject to significant seasonal variations in its generation capacity. Factors such as rainfall patterns and springtime snowpack runoff can work to make baseload and peaking benefits available from the same hydroelectric project. Also, although intitial studies of the Devil Canyon-Watana installations were based upon fifty percent annual capacity factor (1,394 MW, 6,100,000 MWh/yr), some based-load (greater than 80 percent capacity factor) and some peak-load (less than 10 percent capacity factor) energy can be expected to be available. The way in which such additional capacities become available complicates the evaluation of a hydroelectric project.

Conventional base-load plants such as coal-fired or nuclear steam plants are commonly built to take advantage of the economies of scale available to large plants of this type. Conversely, peaking plants are

usually relatively small (less than 100 MW). The base-load energy produced by even a large hydro plant may be available only at such a small capacity as to make comparison with the conventional alternatives meaningless. For example, if the Susitna project, with its 1,394 MW output at 50 percent can produce only 125 MW at capacity factors greater than 80 percent, it is difficult to make comparisons with base-load nuclear or coal plants with capacities on the order of 500 MW or larger. In the same sense, hydrologic conditions may make a great deal of capacity available at a given site for very short periods of time as peaking energy. Such large amounts of surplus energy may make meaningful comparisons between the hydro project and its conventional alternatives (combustion turbines) difficult.

Thus, the Susitna Project will be evaluated in the light of its effect upon the mix of alternatives in the power system and any possible deferment of capital expenditures for other facilities. To properly take into account the capacity variations of the projects, its operation within a power system will be analyzed on a monthly, or at least a seasonal, basis. More detailed analyses could be performed to define exact operating procedures, but such detail is not justified in a long-term planning study.

(f) Schedule

Weeks 26 through 40

Subtask 1.05 - Expansion Sequence Impact Assessments

(a) Objective

To compare, from an environmental standpoint, the consequences of developing the selected alternative expansion scenarios in the Alaska Railbelt Region, including historical, socioeconomic and other factors.

(b) Approach

The approach to review and assessement of alternatives will be to primarily utilize existing data, and available aerial photography of the selected or potential source sites whenever and wherever sufficient information is already available. However, it may be necessary to gather limited site-specific data for the assessment, since the environmental resources of many of the more remote portions of the study corridor have not been inventoried. The key to this approach is the use of staff who have an in-depth knowledge of both fish and wildlife habitat requirements and a short-term and long-term effects of impact-producing actions of construction and operation of various facilities in Alaska.

The environmental consequences of developing alternative energy sources are highly dependent upon numerous factors including energy resource, collection method, site location characteristics, site fish and wildlife characteristics, land-use patterns, and facility construction and operation designs. A thorough assessment of the impacts of optimum generation expansion mixes is also dependent upon an understanding of the habitat requirements of local fish and wildlife during their life history; a knowledge of limiting habitat factors; and sensitivities such as fish overwintering areas, and nesting and feeding habitats of endangered or threatened fauna.

The significant impact-producing actions will vary with the alternative being assessed. At times, the selected site location will be the prime factor, while for other alternatives, the short-term or long-term air quality or water quality perturbations, or wildlife habitat degradation may be the overriding factor. Some of the more significant potential concerns are discussed below.

The environmental evaluation of the selected hydroelectric and tidal power development alternatives (if any) will identify the associated potential impact issues, and their relative magnitudes. Such issues will involve the relative sizes of reservoirs and impacts on water quality and fish and wildlife habitats in particular. The environmental analysis will be performed on the basis of available data, which will be compiled for this purpose. For the Task 1 studies, the comparative impact issues associated with the Susitna Project already identified in the current Corps of Engineers EIS, will be used as the yardstick against which all other alternatives will be measured. Transmission facilities associated with the hydro alternative sites will be included in this environmental analysis.

The intensity of analysis required for comparison of the hydroelectric alternatives will be less than that required for the primary alternative (unless, of course, preliminary analysis demonstrates an apparent preference for a particular alternative set). Field investigations will not be undertaken to confirm the potential magnitude of impacts of the alternatives.

With coal-fired power plants, such as those associated with the Beluga and Nenana field, the collection of large quantities of coal through surface mining would create environmental concerns. These concerns are related primarily to large-scale, long-term habitat alterations affecting fish and wildlife. The operation of coal-fired plants would also create problems relating to air quality, cooling water discharges, and run-off from fly ash ponds. However, plants can be designed to successfully mitigate (though not eliminate) these concerns.

New gas or oil-fired power plants require construction of pipelines that at least lead to short-term concerns associated with river crossings, wetlands disturbance, and habitat alterations. On-site facilities can cover large acreages, and operation can create air quality problems related to nitrogen emissions and winter steam plumes.

Wood-produced energy would also cause air quality problems such as those currently found in the Fairbanks area. Such plants would furthermore require clear-cutting of vast acreages of timber. This may not be environmentally wise due to the slow regeneration times required for timber production and hence would lead to long-term wildlife habitat alterations. Potentially severe impacts to stream habitats and local fish populations would also result.

(c) Land and Water Use

Land ownership in the vicinity of the alternatives will be identified as federal (including agency jurisdiction), state, borough, private and Native Corporation. Land ownership status may be in transition due to the Alaska-Native Claims Settlement Act and State Selection under the Statehood Act. Land management plans and regulations affecting alternatives will be evaluated. The various federal, state and local agencies, and some Native Corporations will have land classification and management systems governing activities that are allowed on those lands and waters being managed. Stipulations concerning allowable activities could affect the feasibility of alternatives to Susitna. Land and water use patterns (historical, current and proposed) will be documented in order to evaluate impacts and potential use conflicts posed by Susitna alternatives.

Unique features in the vicinity of alternative projects, such as recreation areas and aesthetic/visual resources, also will be identified. The presence of popular recreation areas and unusual aesthetic quality may present impact and feasibility problems, particularly when on public lands.

(d) Socioeconomic Characteristics

Demographic data, historic, current and projected, will be evaluated to estimate the impact created by the influx of construction and operations work forces. Employment characteristics of the work force in the vicinity of alternative projects will also help to evaluate positive and negative impacts created by project implementation. This information would include employment and unemployment by region and skill classification, and wage rates (also regional and skill specific).

Financial characteristics of any borough or municipal governments in alternative project areas will be considered. Tax revenue, mill rates, and tax base data will help estimate potential impacts. Housing characteristics, such as available stock (including rental units) and vacancy rates, will be utilized for impact evaluation. Community infrastructure could be impacted by implementing alternatives to the Susitna project. Current loads on infrastructural systems (i.e., electricity, water, sewage) service areas, and system capacity will therefore be considered.

Transportation systems potentially affected by project alternatives will be identified. Data will include current traffic estimates, capacity, area of service, and intermodal connections.

Sociocultural characteristics could be an issue in several project areas. Life style, ethnic traditions and subsistence use patterns of biological resources will be documented.

(e) Archaeological and Historical Resources

Existing archaeological and historical sites will be inventoried in alternative project areas, as available data allow. The State Historical Preservation Office maintains a statewide file of known sites and will be utilized in this effort.

(f) Schedule

Weeks 30 through 45

Subtask 1.06 - Power Alternatives Study Report

(a) Objective

Prepare power alternatives study report for Susitna Hydroelectric Project.

(b) Approach

The power alternatives study report will address:

- Load forecasting for the Railbelt Region
- Selection of alternative energy and/or power generation scenarios
- Evaluation of viable expansion sequence scenarios
- Recommended expansion sequence

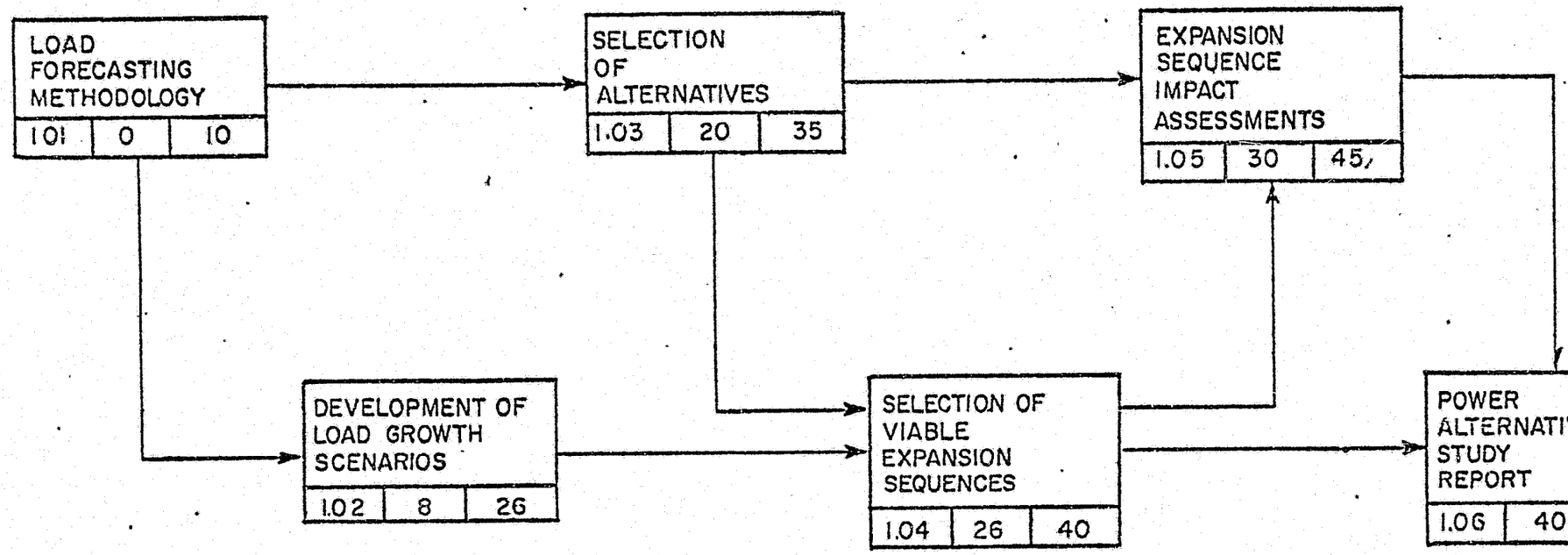
The report will document the findings of Subtasks 1.01 through 1.05 and incorporate the transmittal prepared under Subtask 1.02.

(c) Discussion

This report will seek to address the fundamental issues of the "need for power" and selection of the optimum future Railbelt Region electrical power supply scenario through the year 2010. If the Susitna Project is to be justified as a viable and licensable development, this report has to provide the fundamental basis for such justification. Alternatively, if the Susitna Project should not proceed, this report must provide the rationale for a decision to cease further investigations. The report will initially be prepared in draft form for submission to Alaska Power Authority for review, and subsequently made available to all concerned parties for comment and discussion under the task 12 Public Participating Program.

(d) Schedule

Weeks 40 through 48



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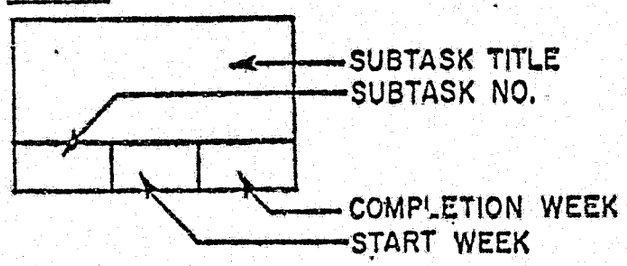


ACRES

SUSITNA HYDROELECTRIC PROJECT
PLAN OF STUDY
PLATE TI.1: TASK 1 LOGIC

A.5.3 - TASK 2: SURVEYS AND SITE FACILITIES

(i) Task Objectives

To provide for safe, cost effective, and environmentally acceptable logistical support of all project field activities; to conduct those surveys necessary to furnish data for use in other subtasks which must be performed prior to licensing; to resolve real estate issues associated with the proposed project in sufficient detail to permit preparation of Exhibit F of the FERC license application; and to undertake initial studies of proposed reservoir areas and access roads.

(ii) Task Output

The primary outputs of this task will be major portions of certain exhibits required for FERC license application and data which will be necessary inputs for many of the remaining exhibits. Specifically, this task will contribute to Exhibit D (demonstrating evidence of compliance with State water and land use laws), Exhibit E (providing water rights data and plans for perfecting rights to use water for project operation), Exhibit F (statement of land ownership). In addition, surveys and mapping will be essential portions of Exhibit J (general project map) and Exhibit K (detailed project map showing boundaries, survey data, land ownership, and feature locations). In addition to the data collection and exhibit preparation, a number of tangible products will be acquired or constructed and will generally be suitable for use during the post- application phase and beyond. In this latter category are included camp facilities, airfield, and similar semi-permanent items.

(iii) List of Subtasks

Subtask 2.01 - Provision for Land Use Payments and Directed Inspection Services

Subtask 2.02 - Provision of Field Camps and Associated Logistic Support

Subtask 2.03 - Resupply and Emergency Service

Subtask 2.04 - Land Status Research

Subtask 2.05 - Land Acquisition Analysis

Subtask 2.06 - Right-of-Entry

Subtask 2.07 - Site Specific Surveys

Subtask 2.08 - Aerial Photography and Photogrammetric Mapping

Subtask 2.09 - Control Network Surveys

Subtask 2.10 - Access Roads

Subtask 2.11 - Map and Photo Search

Subtask 2.12 - Field Reconnaissance of Reservoir Areas

Subtask 2.13 - Marketability and Disposal Study for Reservoir Area

Subtask 2.14 - Cost Estimates for Reservoir Clearing

Subtask 2.15 - Slope Stability and Erosion Studies

Subtask 2.16 - Hydrographic Surveys

(iv) Subtask Scope of Statements

Section A.8 of this plan of study provides a logistical plan describing measures, procedures, considerations, and responsibilities incident to the conduct of effective logistic operations. Subtasks 2.01 through 2.03 are generally concerned with implementation of field operations under that plan in a safe, economical, and environmentally acceptable manner. Task 13, Administration, provides for an in-state project office as the essential link between field operations and concurrent efforts to be undertaken in Alaska and elsewhere. This project office will not only facilitate essential procurement, communication, and coordination of logistical support, but also it will ensure that data generated in the field is properly and expeditiously routed to various points where it will be processed, interpreted, and evaluated.

Subtasks 2.04 through 2.06 deal with real estate aspects. It is by no means clear at the time of preparation of this plan of study just which of several land interest will predominate at any given stage in the study process. Thus, it is all the more essential that careful attention to real estate details be paid early and continuously.

Land survey activities are generally provided for in Subtask 2.07 through 2.09 and hydrographic survey in Subtask 2.16. Only such mapping and control as is necessary for license application will be accomplished in the initial 30 months after notice to proceed is given. It follows, then, that some survey activity may be expected to occur in succeeding months prior to granting of the license.

Subtasks 2.10 through 2.15 deal in general with lands whose current conditions will be permanently changed in the event that the proposed project is ultimately constructed. Technical implications of actual conditions discerned along alternative access roads and within potential reservoir areas are assessed in this group of subtasks. Surveys and route selection studies associated with transmission lines are separately provided for under Task 8.

It is clear that a certain risk is associated with incurring the relatively large expenditures in accomplishing this task.

It is entirely possible that concurrent efforts dealing, for example, with possible alternatives under Task 1 or environmental impacts under Task 7 may lead to a decision at the end of the twelfth month to abandon the Susitna Hydroelectric Project in favor of some other choice or combination of choices for satisfaction (or, indeed, if appropriate, consciously forcing growth limits through nonsatisfaction) of forecasted load requirements. We will minimize the risk insofar as practicable by delaying those field subtasks which can reasonably be delayed as long as possible without jeopardizing plans for filing the FERC license application by mid-1982.

Subtask 2.01 - Provision for Non-Discretionary Payments

(a) Objective

Make explicit provision for certain budget items not subject to discretion of the engineer.

(b) Approach

Several budget items are included in this plan of study to account for APA's directions in that regard. Specifically, the costs noted in subparagraph (d) below account for land use payments to affected Native Corporations in the amount of $36,000 per year, full time inspection services to protect native interests in the amount of $3,000 per month, and funds for study coordination and review by APA in the amount of $100,000 per year.

(c) Discussion

The APA Request for Proposal, dated June 25, 1979, directed that the above items be included. The requirement to fund a full time Susitna Coordinator in the Alaska Department of Fish and Game and to set aside $1 million for an independent cost estimate and seismic risk analysis is accounted for elsewhere in this plan of study.

(d) Schedule

Throughout entire period.

Subtask 2.02 - Provision of Field Camps and Associated Logistic Support

(a) Objectives

Provide acceptable living accommodations for assigned field personnel and necessary visitors and provide a base for field operations in the most economic and efficient manner.

(b) Approach

There will be a permanent base camp at Watana. To the extent that accommodations are required at Devil Canyon, an existing lodge will be used or austere tent facilities will be temporarily operated. All the design work and the procurement of modular units and attendant life support system (power plants, water plant, sewage treatment plant and communications system) will be done immediately after contract award. The Watana camp will be sized to accommodate a maximum of 42 people and its layout will be based on previous camps designed for Alaskan conditions. This "off the shelf" approach will help reduce costs. The modular units and equipment will then be transported overland from Denali Highway. The Watana camp will be erected in late February, 1980, and operations will begin by March, 1980. This camp will be the main base of field operations as well as the point of in-depth study of the Watana site and the surrounding area.

The Watana camp will be operated and maintained on a continual basis from March, 1980 through June, 1982. The Devil Canyon facilities will be occupied as required by the field support schedule (June through September, 1980 and 1981).

The Watana camp will be constructed from modular units and will have complete water and sewer treatment systems. It will have warehouse, shop, recreational, office, food service, laundry, and fuel storage facilities. It will also have sheltered electrical generators and an incinerator. The dormitory, food service, and recreation buildings will be interconnected with Arctic walkways.

A variety of cost comparison alternatives will be evaluated prior to start of field operations. Should any of these alternatives be found to be cost effective, they will be included in the field plan. The alternatives to be evaluated include:

(1) Utilization of Arctic type sewage treatment plant, with chlorinated effluent, in lieu of a sewer treatment plant with a lagoon system for waste water effluent. This approach will depend upon obtaining the necessary permit for the Arctic type plant.

(2) Utilizing a lake as the water supply in place of drilling a water well.

(3) The elimination of some or all the Arctic walkways and reconfiguring the camp to minimize exposure to the most severe ambient conditions.

(4) Burying solid waste instead of incineration if the proper permit can be obtained.

A potential way to reduce program cost is through a consolidated logistics effort. Consolidated logistics management would ensure the minimal utilization of supply aircraft and vehicles, consistent with the field schedule and quantity of materials to be transported. We will continuously monitor and adjust the overall logistics operation to minimize costs and environmental disruption. The principal Acres representative (Chief Engineer for Alaskan Operations--CEAO) will have responsibility and authority for such efforts and may, if economics can be effected thereby, designate a single logistics manager from within the Acres team.

(c) Discussion

It will be noted that meeting the planned FERC application target at 30 months after notice to proceed requires the earliest possible commencement of field operations. Certain key assumptions implicit in our plan for establishment of a permanent camp near the Watana damsite prior to break-up include the following:

(1) Funds will be made available immediately after contract award to permit expedited procurement of "long lead" items.

(2) The important requirement for archeological reconnaissance and associated clearances prior to disturbing natural conditions generally cannot be satisified until snow cover is gone from the proposed camp area. We assume that the first stage camp construction and initial operation will be conducted in areas previously checked out for earlier Corps of Engineers activities. Only so much of the semi-permanent camp near Watana as can be erected on archeologically cleared land will be installed initially. Remaining modules and supplies to be brought in while the ground is frozen will be stored until after break-up. Archeological reconnaissance to permit expansion will be undertaken as a matter of priority as soon as conditions are favorable for that work.

(3) Ownership for project lands will be transferred to Cook Inlet Region Incorporated prior to commencement of field activities.

(4) The cooperation of various permitting agencies and organizations in expediting necessary early permits will be secured.

The camp accommmodation requirements in a remote Alaskan environment cannot be underestimated. The size of camp proposed has been determined as the minimum size necessary to undertake the required field work (surveys, geotechnical exploration, hydrologic and seismic monitoring, and environmental studies) in the proposed time frame.

The capital cost of erecting a semi-permanent camp capable of accommodating peak loads of 40 people or so and average loads of 20 to 30 is significant. Whereas the initial contract will cover a period of only 30 months, it may be anticipated that field activities will be required on a continuous basis for some years after license application is made. Thus, the camp is expected to remain in place to support post-application studies and investigations.

(d) Schedule

Throughout project period.

Subtask 2.03 - Resupply and Emergency Service

(a) Objective

Provide responsive and reliable resupply and emergency service capability with minimum environmental degradation.

(b) Approach

As soon as possible after the camp has been put in place, a helicopter pad will be constructed nearby. During the initial year of camp operation, helicopters will be employed to transport personnel, perishables, certain consumables, equipment, and miscellaneous items to and from the camp site. Helicopter support will be furnished both from Anchorage and from Talkeetna, with the bulk of the effort from the Talkeetna terminus. An average of one large helicopter flight daily (such as by Bell 205A-1) will be required for this purpose. By the end of the first year of work, an evaluation of the need for construction of an airfield at the camp site will be made and an assessment of the environmental consequences of its construction will be accomplished. In the event that a decision is then made not to construct an airstrip, camp resupply and emergency service will continue to be accomplished by helicopters.

Development of a properly sized and designed airstrip could serve to expedite subsequent operations at the project site. Site selection can best be obtained through a repetitive process of evaluation, beginning with several alternatives and eliminating those that do not meet the necessary requirements.

The scope of work during the initial airstrip design activity would be Airphoto study, aided by evaluation of existing boring logs and topographic maps. If an airstrip is found to be justified, a field check of this initial study will be made prior to making the final selection of the airstrip site. The design phase is envisioned as being completed in three stages. The initial stage will consist of providing tentative drawings for the airstrip and related facilities, such as access roads to material sources needed in its construction. The subsequent phase will provide drawings suitable for construction purposes as well as a cost estimate for the construction of the facility.

Time dependent requirements such as permits, wind direction information, archeological studies, and the stockpiling of initial construction supplies will be started as soon as possible.

The airstrip will continue to function after FERC license application has been made. Indeed, assuming that the project is shown to be viable, the airstrip will continue to serve throughout the period during which the proposed dam is constructed (and beyond that, perhaps during operation of the project some years hence). It follows that design, arrangement, and construction will be accomplished in such a way that later expansion or permanent surfacing will be possible.

(c) Discussion

The first version of the POS (September 11, 1979) envisioned construction of an airfield during the first year of the project. A careful re-evaluation of this approach became necessary, however, when it was determined that overland transportation during the summer months--even by Rolligon--may be counter indicated because of the fragility of the vegetation over which all-terrain vehicles would pass. The inability to remove heavy construction equipment until the following winter (when Rolligons or cat trains could negotiate the terrain) resulted in extremely high costs associated with rental of idle equipment. In addition, the fact that a Go-No-Go decision is scheduled for the end of the first year suggests that capital investments should be minimized to the extent possible until it becomes clear that a project is in fact warranted. Thus was it determined that the alternative of helicopter support is preferable during 1980.

If after the first year it is clear that hydroelectric development of the Susitna River is in the best interests of the State of Alaska, the question of airfield construction must once again be evaluated. While feasibility study effort can proceed using helicopter support continuously and using overland heavy resupply in the winter, it is nonetheless true that an airfield will eventually be required for support of activities during later construction stages. Once the high initial cost of an airfield is incurred, subsequent resupply by fixed wing aircraft becomes less costly than exclusive helicopter usage. Through the public participation program (Task 12), the views of the public at large and of all interested agencies will be solicited prior to reaching a decision on airfield construction.

The level of effort provided in cost tabulations in Section A3 will be assigned to helicopter costs until an affirmative decision is made to build an airfield. Remaining portions of budgeted costs for this subtask will then be assigned to airfield construction work. In the event that no airfield is built during the first 30 months of effort, air transportation costs included under Subtask 2.02 for fixed wing air resupply will ultimately be diverted as well to helicopter support.

(d) Schedule

Weeks 9 through 130

Subtask 2.04 - Land Status Research

(a) Objectives

Identify ownership and other interests in and adjoining the project area and associated transmission corridors and provide information needed for power project planning, land acquisition analysis, and for obtaining rights-of-entry to conduct field studies.

(b) Approach

Ownership information will be gathered from the tax assessor and land recorder, BLM, the State Division of Lands, and Native Corporations. Lands will be categorized by general ownership category (private land, State land, U. S. land, and Native land) and status maps at an appropriate scale will be prepared. Other factors affecting land status, such as third party rights, State or Federal agency designations, or limited interest rights will be indicated.

(c) Discussion

Cook Inlet Region, Inc. has already collected a substantial portion of the information required. The cost of completing this task will be reduced substantially because this information and the corporation's land status research capability will be utilized.

(d) Schedule

Weeks 0 through 15

Subtask 2.05 - Land Acquisition Analysis

(a) Objectives

Identify lands which must be acquired or for which right-of-way permits or easements must be obtained and estimate land acquisition costs and right-of-way permitting requirements.

(b) Approach

Once plans for the siting of all elements of the power project have been developed, a detailed inventory of private and public lands on which facilities are to be built will be prepared. Each private land owner will be identified and the amount and market value of land to be acquired by either easement or purchase will be estimated. The amount of public land required will be broken down by agency land holder and an estimate of the cost of right-of-way permits will be made. Evidence of title will be secured as needed. All third party rights will be identified and evaluated in terms of impact on acquisition costs.

(c) Discussion

Cook Inlet Region, Inc. has already collected a substantial portion of the information required. The cost of completing this task will therefore be minimized.

(d) Schedule

Weeks 61 through 73

Subtask 2.06 - Right-of-Entry

(a) Objectives

Provide the information needed to obtain right-of-entry to private lands as required for reconnaissance, surveying, and other field investigations; acquire necessary rights-of-entry.

(b) Approach

On the basis of the overall field plan, the private lands to be entered will be determined and the appropriate land owners will be identified.

Permits required for entry and use of public lands will normally be obtained by CIRI/H&N in response to requirements of individual investigating teams.

(c) Discussion

Obtaining rights-of-entry will more efficiently be accomplished when done by one project associate rather than by each individual team member. This will also assure that the needed rights-of-entry have been obtained and that no trespass occurs. And beyond that, of course, it provides a positive means to ensure that redundant applications are not filed--an important consideration to permittor and permittee alike.

(d) Schedule

Throughout project period with most emphasis during initial six months.

Subtask 2.07 - Site Specific Surveys

(a) Objective

Provide "on the ground" surveys of specific areas which require a higher level of accuracy than can otherwise be obtained through photogrammetric mapping.

(b) Approach

Two field surveyed cross sections will be obtained at each dam site consisting, essentially, of an accurate profile perpendicular to the river on a predefined axis.

The site survey of the airstrip, if found necessary after the first year, will be conducted using conventional survey techniques to establish topography of such accuracy as to allow construction plans to be prepared. This activity includes the construction lay-out surveys for building of the airstrip and it is covered under Subtask 2.03.

The site survey will be required of the temporary camp to facilitate design of the camp, sewage disposal system and water supply. This activity is covered under Subtask 2.02.

A site survey at each dam site will be conducted "on the ground" at a location contemplated for switchyards-transformer pads to facilitate the design of those facilities but will not require construction staking during this study phase.

(c) Discussion

These site specific survey efforts will augment photogrammetric mapping. They must be conducted reasonably early in the study process since the results will be required for subsequent design studies and field construction of certain temporary facilities. Crews involved in the work will be furnished lodging and air transportation, the costs for which are separately included under Subtask 2.02. The long experience of R&M Consultants, Inc., in similar work throughout the State has resulted in R&M's acquisition of equipment tailored for use in remote, harsh environments as well as in the develop of field procedures well suited to the instant requirement.

(d) Schedule

Weeks 9 through 12, and 22 through 26

Subtask 2.08 - Aerial Photography and Photogrammetric Mapping

(a) Objective

Provide contour mapping of both Devil Canyon and Watana Dam and Reservoir sites, photography and contour mapping of access corridors, photography of transmission corridor, photography to be used by geologists in terrain unit mapping, photography to be used in the environmental studies of the project area and photography of the Susitna River downstream to Talkeetna for use by hydrologists.

Approach

Partial mapping of the Watana Dam Site has previously been accomplished through efforts of the Army Corps of Engineers. Photography exists on the Devil Canyon Dam Site but no contour mapping has been accomplished.

The Corps of Engineers' effort, as stated above, will be evaluated and augmented, as required, by additional mapping of the dam sites at a scale of 1" = 200' with a contour interval of 2 feet.

The reservoir sites, camp and airport sites, switchyard sites, access corridors, transmission corridor and lower Susitna River downstream to Talkeetna will be paneled (targeted), survey tied to horizontal and vertical control and aerial photographed. Contour mapping by photogrammetrical methods will be performed at a mapping scale of:

Watana and Devil Canyon Reservoir Sites---1" = 400' with 10' contours
Watana and Devil Canyon Dam Sites---------1" = 200' with 2' contours
Alternative Access Routes-----------------1" = 400' with 10' contours
Field Camp and Airstrip-------------------1" = 400' with 10' contours

Certain activities essential to eventual detailed design will be deferred until after license application has been filed. These include contour mapping by photogrammetrical methods at mapping scales of:

Switchyards-------------------------------1" = 200' with 5' contours
Selected Access Route---------------------1" = 200' with 5' contours
Selected Transmission Route---------------1" = 200' with 5' contours

The lower Susitna River and transmission corridor will be photographed and ortho photos prepared prior to license application but no contour mapping is anticipated until later in the program.

All aerial photography that is to be used for contour mapping of 1" = 200' must be taken during the spring or fall of the year when snow is not present on the ground and when deciduous vegetation is without leaves. Fortunately, the pre-application requirements in this area are relatively modest.

Existing contour mapping previously performed by the Corps of Engineers must be correlated to accurate vertical datum as current datum used was determined from V.A.B.M. (Vertical Angle Bench Mark) and is only accurate to plus or minus 15 feet.

(c) Discussion

The aerial photography and mapping program described herein is considered the minimum necessary to satisfactorily prepare necessary exhibits for FERC license application. Even so, the costs of such efforts are not insignificant. Thus, any additional measures which may serve to further reduce costs are important. In this regard, we will make a detailed and comprehensive assessment of all photography flown to date by the Corps of Engineers and others to ensure that duplication of previous efforts does not occur.

We are aware that some unprocessed aerial photographic data has been collected in the past two years by the Corps. Its usefulness for partial satisfaction of the subtask objective has yet to be evaluated.

The output of this subtask will produce much of the base map and other data required for FERC Exhibits J and K, general and detailed project maps respectively. The requirement for 10' contours is explicit under FERC regulations for Exhibit K. Should new regulations relax that rule, effort will be adjusted accordingly.

(d) Schedule

Weeks 3 through 39

Subtask 2.09 - Control Network Surveys

(a) Objective

Provide a more frequent interval of horizontal and vertical survey control than currently exists in the project area.

(b) Approach

Both U.S.C. & G.S. and recently conducted private control network schemes will be expanded for use on site specific surveys, photo control surveys and cadastral surveys of otherwise protracted township and section surveys. The control network will also be used to expand State Plane and Universal Transverse Mercator grid values to all project surveys.

The frequency of high order survey monuments of known precise horizontal values are all but non-existent in the project area.

Utilizing "one second" theodolites, medium to long range electronic distance measuring devices and helicopter supported ground crews, a chain of high accuracy control monuments will be established on each side of the river basin from the upper reaches of Watana Reservoir site to the lower end of Devil Canyon. This network will serve as the "spine" of all subsequent survey activity and mapping effort.

A precise level circuit will be run extending from the existing U.S.C. & G.S. circuit up to the Parks Highway-railroad, up river through both the Devils Canyon Dam site and the Watana Dam site and tying to the existing U.S.C. & G.S. circuit along the Denali Highway.

This level circuit will be the first precise level circuit ever run in the area and will be the basis for all vertical elevations used on the project.

Helicopter support for this subtask is included within Subtask 3.03.

(c) Discussion

The effort required in establishing control network surveys is significant. In less remote regions in the lower 48 states, such activity will normally have been conducted by others well in advance of hydroelectric project planning. Thus, it is unusual that a feasibility study must bear the cost of such an undertaking. Even so, the work is imperative, for the uncertainty associated with current locations and elevations as found on existing topographic maps is simply too great to support precise planning incident to determination of project viability. Whether or not a project is ever constructed on the Susitna River, though, the establishment of a control network will provide significant residual value for the State of Alaska.

(d) Schedule

Weeks 5 through 30

Subtask 2.10 - Access Roads

(a) Objectives

Define alternative access routes; evaluate technical, economic, and environmental factors for each; and recommend best alternative.

(b) Approach

Access roads will be required during construction to dam sites, quarries and borrow pits. Effort will be made to minimize grades, number and size of borrow pits, unwanted access, and limit environmental constraints at the smallest cost and time to the project.

Geological studies and surveys are discussed under other task headings.

For this portion of the work it is anticipated that three separate routes will be considered in detail. Two of these routes will originate from the Park's Highway and extend to the east to the dam site. One route will follow the north bank of the Susitna River to the dam site. The other route will follow the south bank of the Susitna River. The third route to be considered will come from the northeast from the Denali Highway. It is further anticipated that one of these routes will be selected to be considered as a possible railroad access route. In addition, a sub-alternative to be considered in the Parks Highway routings will be one which envisions the establishment of a railhead (near Gold Creek, for example) as the western terminus of the access road.

The preliminary study portion of this phase of the work will entail reviewing photos and existing maps of the possible access routes as well as the complete review of all work already completed by the U.S. Army Corps of Engineers. Once this work is completed, it is anticipated that all three corridors selected for possible access routes will have low level aerial photography flown. Once this photography is available, detailed analyses of the photos coupled with existing data will result in initial route selection. During this process those problem areas identified by the low level aerial photography will be investigated in the field to determine solutions. Following this work cross comparisons of preliminary design will be accomplished so as to finalize selection of the best access to the project. Environmental data collection and impacts analysis of alternative routes--and, in more detail, of the selected route--will be accomplished as a part of Task 8 - Environmental Studies. Sufficient detail will be developed to permit preparation of a preliminary cost estimate. Selection of a best route will consider all aspects and will draw heavily as well on inputs from the public participation program outlined in Task 12.

Subsequent to license application, full control will be established along the access route that has been selected and once again low level aerial photos will be flown and mapping will be accomplished to a five foot interval at a scale of 1-inch = 200-feet. Once this information has been obtained, the detailed design of an alignment within the route

corridor will be accomplished. In conjunction with this detailed alignment study, possible material sites will also be investigated. Once the final alignment has been established, the drilling program to establish geotechnical and geological criteria will be initiated. Upon the completion of that phase, further investigations will be necessary to remedy any problems discovered by the geotechnical information. After this phase is completed the final costing for the selected alignment with the proposed plan and profile sheets and a written report will be presented.

(c) Discussion

The selection of access roads involves consideration of diverse factors and neither technical ease of development nor economic considerations alone will necessarily be the deciding factor. Indeed, fundamental questions regarding eventual plans for controlling access to the project and the fragility of the environment itself will be extremely important. In this regard, an access road which connects only with a railhead (to be established, for example, near Gold Creek) would better facilitate controlling visitor access than would a connection with any of the highways. There is little doubt that conflicting interests will need to be addressed. It is certain that Native villages and the Cook Inlet Region, who will eventually acquire surface and subsurface rights in the project area, will have to be heeded. It is certain, too, that the impacts on local fish and game populations will have to be weighed and assessed. In short, this subtask will provide for the collection of engineering data, the preparation of preliminary economic data, the evaluation of environmental data collected on other tasks, and the selection of the apparent best choice when all factors are considered in their proper perspectives.

(d) Schedule

Weeks 52 through 100

Subtask 2.11 - Map and Photo Search

(a) Objective

Conduct a preliminary assessment of the reservoir areas as the basis for identifying proper locations for pursuing an optimum field reconnaissance program.

(b) Approach

All aerial photography, satellite photography, existing topographic maps, geologic maps, and other available field information will be reviewed by selected members of the project team. This review will concentrate on the identification of particular areas which require verification or evaluation in the field during a site inspection. Based upon this review, a program for conduct of subsequent field reconnaissance efforts will be planned in detail.

(c) Discussion

Depending upon ultimately selected dam height and sites, reservoirs can be upwards to 100 miles in length. It is neither necessary nor practical in the pre-licensing phase to conduct detailed extensive investigations of every square foot in this extensive area. Even so, a proper assessment of the implications of inundation in the project area will be necessary. Based upon this assessment, cost estimates involved in preparing lands for eventual inundation can be derived. In addition, there may be ways and means to reduce environmental impact if judicious use of materials recovered from reservoir areas is planned in the project construction.

(d) Schedule

Weeks 16 through 26

Subtask 2.12 - Field Reconnaissance of Reservoir Area

(a) Objectives

Make on-the-ground checks to verify adequacy of information obtained during the map and photo search; more precisely delineate dimensions of those portions of the reservoir area which are likely to require special attention during the ultimate construction of the project.

(b) Approach

The field reconnaissance team will be furnished with marked-up maps produced during Subtask 2.11. By making on-the-ground inspections, the team will be able to ascertain the extent of clearing required as well as estimate size, nature and density of various trees to be removed. In addition, some initial estimates will be made of soil types, particularly as they would affect slope stability. To the extent that surficial inspection will reveal it, the field team will seek borrow areas in reservoirs in order to minimize eventual environmental impact outside reservoir areas.

(c) Discussion

A portion of the field reconnaissance effort can actually be accomplished by helicopter, as the reconnaissance team overflies reservoir areas and checks the general shape and location of vegetative growth to be removed, verifying that it has been accurately reflected in the initial subtask.

Some on-the-ground verifications will be required. The whole effort, insofar as field reconnaissance is concerned, is primarily geared toward producing a reasonable estimate of the effort required in preparing various areas for eventual inundation. In this regard, for example, it becomes important to verify the size, nature, diameter of trees because marketability will be studied. The question of slope stability and protection is naturally pertinent since the reservoir level particularly behind Watana Dam is expected to fluctuate on an annual basis by as much as 150 feet. This latter question is separately addressed in Subtask 2.15.

(d) Schedule

Weeks 26 through 34

Subtask 2.13 - Marketability and Disposal Study for Reservoir Area

(a) Objectives

Study alternative means for disposing of vegetative material to be removed from the reservoir area.

(b) Approach

Enquiries will be made of various companies dealing in timber in Alaska with a view toward determining the extent to which timber harvested from the proposed reservoir areas may be marketable. In the event that the costs of recovery exceed market values, an assessment will be made of intangible benefits which may still suggest that attempting to sell cut timber is the appropriate option. Other alternatives for disposing of materials to be removed will be considered, to include burial as well as burning. Native villages whose lands border or actually overlap with proposed reservoir areas will be consulted during the course of the study with a view toward seeking their desires on timber disposal.

(c) Discussion

It is important to note that economics will not be the only determinant in the evaluation of alternative means for disposing of vegetative materials. Indeed, ultimate disposition may be directed far more by other factors than by apparent least cost alone. Even so, for purposes of estimating costs for licensing, it will be sufficient to represent the probable least cost method of undertaking the work. Native villages owning surface rights to the affected areas will be directly affected by this work. CIRI will coordinate the input of the villages.

Data gathered during the previous subtask regarding sizes, types and quantities of trees as well as slope conditions and general accessibility will be used. Alternatives such as helicopter logging, construction of logging roads and use of hovercraft will be considered. There is a distinct and important interface between this study and environmental studies conducted in the same area. Summary impacts will be described to indicate the most serious consequences of burial, burning, and removing. While data collection during previous subtasks will have been accomplished during the summer period, the marketability and disposal study itself can be conducted at any time thereafter.

(d) Schedule

Weeks 34 to 48

Subtask 2.14 - Cost Estimates for Reservoir Clearing

(a) Objective

Determine reservoir clearing costs.

(b) Approach

This subtask is not independent of the marketability study which precedes it in this Plan of Study. For each marketing alternative, there could be a different clearing approach. Thus, a series of successive iterations of cost estimates will be necessary until the proper combination of marketing approach and its related clearing technique has been found. An estimate will then be made of the costs of doing the clearing so that the net profit or loss on timber marketing can be determined.

(c) Discussion

It will be necessary during this task to separate clearing costs for reservoirs associated with each of the proposed dams. This will permit subsequent evaluations of a range of alternative phasing for separate dams in the system.

(d) Schedule

Weeks 34 to 48

Subtask 2.15 - Slope Stability and Erosion Studies

(a) Objectives

Estimate the extent to which cleared slopes will maintain stability; estimate the risk that continued reservoir operation will cause one or more slopes to fail; and estimate costs of minimizing slope failure risks.

(b) Approach

Field data collected during the reconnaissance under Subtask 2.12 will be used as the basis for analyzing the potential for slope stability problems. To the extent that such problems appear to exist, alternative means of slope protection will be considered. It will be assumed that slope protection will be required if there is a danger of failure during continued operation.

(c) Discussion

Risk estimates developed during this study will be used ultimately in the risk analysis to ensure that all potential difficulties have been accounted for. The costs of providing appropriate slope protection necessarily become a part of the total project cost estimate to be considered ultimately in determining project financibility and viability.

Subsequent to submission of the license application, much more detailed and vigorous erosion control studies will be required to minimize damage caused by a concentrated flow of water over newly constructed slopes or in areas where the natural vegetative cover has been removed. The objective of this post-application task will be to issue recommendations and delineate problem areas where an added degree of caution should be exercised. A two part study is contemplated to fulfill these needs. This task will be limited to the general site earthwork and is not intended to address erosion of the downstream channel of the dam site.

Input from the first phase of the detailed erosion study will come from an evaluation of soil types obtained from project test borings and laboratory test data. Air photo studies will also be used. It is presently anticipated that a sufficient number of test borings will have been drilled in other project tasks to accomplish this study without additional test borings. Nevertheless, samples of surficial soil may be collected for identification and classification purposes, and laboratory tests may be performed.

A report describing areas of varying degrees of erosion susceptibility will be prepared. Some of the factors that will be considered in this evaluation will be the soil type and its consistency. Included in this report will be a discussion of erosion control for general site grading.

(d) Schedule

Weeks 47 to 54

Subtask 2.16 - Hydrographic Surveys

(a) Objective

Provide field and aerial survey data relating to the river gradient and cross sectional configuration of the active flood plain.

(b) Approach

Through the use of deferential level circuits, 60 miles of river will be profiled from the lower portion of Devil Canyon, downstream, to the confluence of the Susitna, Talkeetna and Chulitna Rivers near the town of Talkeetna.

Pre-set picture panels for aerial photogrammetry will be tied to the profile level circuit for later use in river cross sections.

Cross sections of the river's active flood plain will be measured at selected intervals and based on elevations established during river profiling.

The true interval and relationship of river cross sections to the river and other cross sections will be determined photogrammetrically and geometrically from pre-set picture panels (crosses) that can be identified in the aerial photos.

(c) Discussion

Careful study of downstream hydrographic conditions is a vital part of the total data collection effort, particularly because project operation will produce changes in the flow regime. Subsequent environmental studies will rely on the data produced here for use in the study of potential impacts on fisheries as well as on moose browse now growing in certain low areas subject to regular inundation when the project operates. In addition, as design studies progress, determinations will be made as to the need for re-regulation structures.

(d) Schedule

Weeks 5 through 17 and 36 through 48

A.5.4 - TASK 3: HYDROLOGY

(i) Task Objectives

To undertake and report on all hydrologic, hydraulic, ice,and climatic studies necessary to complete the feasibility design of the Susitna project and to provide sufficient documentation for the FERC license application.

(ii) Task Output

- Data Index System

A data index system listing all the available hydrologic and climatologic data will be compiled and circulated. Hard copy of the more relevant data items will be stored in the project office in Anchorage and copies made available to those requesting it.

All the additional hydrologic and climatologic field data collected as part of this study will be documented on either computer printout sheets or typewritten tables.

- Written Sections and Drawings for Inclusion in the FERC License Application

Exhibit H - proposed reservoir operating rules, predicted reservoir behavior, and downstream water quality and flow conditions.

Exhibit I - dependable power flow, critical design low flow period, flow duration curves and tailwater rating curves.

Exhibit K - reservoir shorelines for maximum and minimum reservoir water levels and reservoir water level area and capacity curves.

Exhibit L - spillway design flood and capacity and freeboard allowance.

- Hydrologic Appendices to Engineering Report

The detailed technical appendices will contain sections on the following types of studies: hydrology (resource and floods), reservoir operation, hydraulic, sediment yield, river morphology, ice engineering, climatic studies for transmission line design, and hydrologic and hydraulic studies for the access road.

- A Series of Design Transmittals

These will summarize the pertinent design parameters obtained from the studies outlined above.

(iii) List of Subtasks

3.01 - Review of Available Material
3.02 - Field Data Index and Distribution System
3.03 - Field Data Collection and Processing
3.04 - Water Resources Studies
3.05 - Flood Studies
3.06 - Hydraulic and Ice Studies
3.07 - Sediment Yield and River Morphology Studies
3.08 - Climatic Studies for Transmission Line
3.09 - Access Road Studies
3.10 - Lower Susitna Studies

(iv) Subtask Scope Statements

The scheduling of the above subtasks is presented in Section A7, Plate A7.1. The activities have been specifically scheduled to make maximum use of the field data as it becomes available and to provide the necessary input to the other components of the studies.

Arrangements have been made to enlist the services of Dr. R. Carlson to act as consultant to Subtask 3.05 (Flood Studies). We propose to make similar arrangements with Dr. T.E. Osterkamp of the Geophysical Institute, University of Alaska to act on the ice engineering related aspects of Subtasks 3.06 (Hydraulic and Ice Studies) and 3.03 (Field Data Collection and Processing). Contact will also be made with the U.S.G.S. office in Anchorage to determine what assistance they can provide both in terms of expert advice on field equipment selection and operation (Subtask 3.03) as well as reactivation and generation of some of their discontinued gauging stations (Subtask 3.10).

A detailed discussion of the objectives, the approaches and the costs and schedules associated with the subtasks follows.

Subtask 3.01 - Review of Available Material

(a) Task Objectives

Assembly and review of all available reports, maps and studies relating to hydrologic aspects of the Susitna and neighboring basins, and abstraction of hydrologic design parameters required for the planning studies concerned with alternative hydro sites, including small hydro development.

(b) Approach

All available reports, maps and other pertinent documents will be obtained and reviewed. Detailed discussions will be held with individuals and agencies who have been engaged in the past and who are currently engaged in studies in the Susitna basin and surrounding areas, (e.g., staff at the University of Alaska, APA, the Hydrology Section of the U.S. Corps and the USGS office staff in Anchorage).

All information on mean annual flows, seasonal distribution of flow, reservoir drawdown and firm and installed capacity will be abstracted. If necessary, manual adjustments will be made to these parameters to ensure that standardized parameters are available for each site and that similar approaches are applied to defining firm power and installed capacity.

This task will be performed jointly by R&M and Acres.

(c) Schedule

Weeks 1 through 26

Subtask 3.02 - Field Data Index and Distribution System

(a) Objectives

Establish a formal data indexing and distribution system to keep the study team and all other parties concerned with the project fully updated on the status of available hydrological and climatologic data.

(b) Approach

The field data acquisition requirements for the proposed study are substantial. A data index describing all the currently available hydrologic and climatologic data will therefore be compiled. All new data collected by other organizations within the basin and by the study team will be added to the index. It is proposed to update the index every six months.

Hard copy of the available data will be obtained and stored. Copies of selected items of data will be dispatched to project team members and other concerned parties on request. All new field data collected by the project team will be stored on computer facilities and/or in tabulated form. Copies of the information will be issued to those requesting it.

(c) Discussion

It will not be possible to obtain and store hard copy of some of the detailed climatic data collected at the existing complete meteorologic stations or from the proposed automatc climate stations. However, provision will be made to access these data files and abstract from them data in summarized form as required by the project staff.

This work will be done by R&M.

(d) Schedule

Setup: Weeks 5 through 13
Operation: Weeks 14 through 130

Subtask 3.03 - Field Data Collection and Processing

(a) Objective

To supplement the available streamflow and climatologic data within the Susitna River Basin and along the proposed transmission corridors.

(b) Approach

The data collection program outlined in this section has been specifically tailored to provide adequate input to the design of the project and to meet the requirements of the FERC licensing procedure.

- Field Data Specifications

It is proposed to produce formal specifications for all the hydrologic and climatologic field data to be collected. This will facilitate the detailed planning of the field program and will allow the various technical disciplines associated with the study to derive maximum benefit from the data collection program.

During the early stages of the study, data specifications will be drawn up by a multidisciplinary team responsible for environmental, hydrologic, hydraulic and ice engineering aspects of the study during the initial field trips in the area. These specifications would be submitted to Federal and state agencies for comment to ensure that maximum benefit is derived from the field program.

The specifications will describe items to be collected, list the type of equipment to be used, the accuracy to be achieved, the frequency of the observations and the rate at which the information is to be processed and published.

Discussions will be held with the consultants to the study based in the University of Alaska to explore the possibility of applying satellite or high-level aircraft photography to improve accuracy of estimating the spatial distribution of the snow cover. It should be noted that no budget has been provided for undertaking this type of work should it prove feasible.

- Field Data Collection

To ensure that adequate data is available for the feasibility design and license application and subsequent preliminary engineering, an early start must be made with field data collection. A tentative program has been developed and is summarized in Table A.5.1. Provisional locations of data collection points are shown in Plates T.5.1. and T.5.2.

A permanent field crew of two people will be assigned to install and operate the equipment and to retrieve the data. Extensive use will be made of helicopter transport to access the remote stations. A fixed-wing aircraft will be used in the aerial ice cover surveys and to service some of the remote snow course and climatic stations.

During the first half of 1981, the field data specifications will be reviewed and amended in the light of one year's experience in the field. It is anticipated that the location of the transmission line corridor will have been selected and that some of the automatic climatic, in-cloud icing, and freezing rain stations may have to be relocated. The additional three automatic climatic stations, as well as the additional in-cloud icing, freezing rain and snow creep stations will be installed.

- Field Data Processing

Field data processing will be concerned with the following:

-- abstracting and storing information on the charts obtained from the automatic climatic stations and water level recorders
-- calculating water and sediment discharges from field observations
-- laboratory analyses of water quality and sediment samples
-- documentation of the ice cover observation program
-- documentation of the snow course data, transmission line icing, freezing rain, snow creep and glacial measurements.

Some of this data processing will be carried out on a computer; the remainder will be dealt with manually.

A technician will be responsible on a full-time basis for all the data processing. Additional technical assistance will be available as and when required.

(c) Discussion

This task will be undertaken by R&M with review by Acres. Important aspects associated with Table A.5.1 are as follows:

- The program has been based on the assumption that the Devils Canyon and Watana Dam site will be the selected project sites.

- The initial location of the climatic stations is based in the assumption that the transmission route will be located along the railway linking Fairbanks and Anchorage. Should an alternative transmission corridor be selected during 1980, the climatic stations installed along the rail route will be relocated during 1981. This is not anticipated to cause any delays in the study as the data obtained during the first year could be used to obtain preliminary design criteria for the alternative route. Provision has been made in the cost estimates to cope with relocation of the stations.

- An additional five automatic climatic stations will be held in reserve during the first year. It is intended to utilize two of these as spares. The three others will be installed during 1981 along the selected transmission line to improve estimation of the spatial variation in design parameters.

- Discussions have been held with the staff responsible for the snow course surveys at the Soil Conservation Service in Anchorage. As a result the locations of the additional four snow course stations depicted in Plate A.5.2 were selected. These discussions also indicated that snow pillows have been operated very successfully and should function well at the proposed locations. Only a minimum amount of measurement using conventional snow survey equipment will be necessary.

- The proposed sediment station at the Vee site (see Plate A5.2) will not be operated on a continuous basis. A limited number of observations will be taken and used to assess whether the sediment discharges at Vee and Gold Creek are correlated. If these analyses indicate no correlation, then the sediment observations at Vee will be increased during Phase 2.

- We do not propose to use bed load samplers during this phase of the work. Although the Heli-Smith type sampler has been successfully used by the USGS on the Tanana River, it is doubtful whether it would operate in the coarse sediments of the Susitna. However, this aspect will be reviewed once more detailed information on the bed material is available. If deemed practical and useful, a bedload sampler could be employed during Phase 2 to firm up estimates of bedload.

(d) Schedule

Field Data Specifications and Review - Weeks 14 through 22
Weeks 70 through 74

Equipment Installation - Weeks 23 through 35
Weeks 75 through 82

Field Data Collection - Weeks 31 through 130

Field Data Processing - Weeks 36 through 130

Subtask 3.04 - Water Resources Studies

(a) Objectives

To develop all the necessary water resource parameters such as monthly flow data, design low-flow characteristics, etc., at the reservoir sites and to study long-term reservoir operation.

(b) Approach

(i) Streamflow Extension

Multiple regression analyses will be used to develop monthly streamflow sequences at the Watana, Devil Canyon and other sites being considered within the Susitna basin. The aim is to improve on the correlations previously achieved in the U.S. Corps of Engineers studies. The gauging station at Gold Creek (2920) will be used as the master station. However, attempts will be made to see whether meaningful correlations can be achieved by using longer-term stations outside the study area (e.g., Matanuska River at Palmer, 2840). Both monthly and annual flows will be correlated and climatic parameters such as monthly/annual temperature and preciptation will be introduced to determine whether they improve the correlations. Extrapolation of mean annual flow and the seasonal variation of flow to ungauged locations will be done using factors developed from drainage basin area and other physiograpic and climatic parameters (e.g., area covered by glaciers, lakes and swamps, mean annual precipitation, and mean annual temperature).

Acres will undertake these analyses.

(ii) Low-Flow Frequency: Duration Analysis

Utilizing the above information, analyses will be carried out to produce curves relating volume of runoff in low-flow periods of different durations ranging up to several years to the frequency of occurrence. These curves will be used to determine firm power and energy from the proposed developments during specified critical low flow periods.

Acres will undertake these analyses.

(iii) Reservoir Filling and Operation Studies

It is proposed to set up the Acres' multireservoir water balance computer model for the Susitna basin. This is a particularly versatile model, and allows easy application to different reservoir systems. Reservoir operation rules are specified as input data, thus allowing considerable flexibility in studying alternative rules and priorities. The model can operate with time periods varying from a week to several months, and can incorporate power generation and load stacking.

This model will be used to undertake reservoir operation and energy generation studies, and the analyses required to determine filling schedules. The basic input data to the model will be derived from the studies discussed in (i) and (ii) above.

Acres will undertake the work.

(iv) Statistical Analysis of Pre- and Post-Project Streamflow

Flow duration curves are required for the FERC license application and the determination of annual sediment yields at various locations within the basin. Seasonal and annual duration curves will be evaluated using the natural monthly streamflow data derived in (i) above and for the post-project flows simulated using output from the multi-reservoir model discussed in (iii) above.

Recorded natural daily streamflow data at a limited number of gauging stations within the basin will be utilized to describe typical flow variations within the calendar months.

Once the project layouts have been finalized, the flow duration curves described above will be redeveloped for post-project flow conditions downstream from the damsites. Based on a knowledge of the daily plant operating characteristics, the effects of discharge fluctuations within typical months will be described.

Acres will undertake the studies.

(v) Evaporation Studies

Desk studies will be undertaken to refine the estimate of net evaporative loss from the reservoir surface area. Based on available climatic and evaporation data within the Susitna basin and the vicinity regional estimates of gross evaporation from an open water surface will be made and extrapolated to the damsites. Available streamflow and precipitation data will be used (again on a regional basis) to estimate the pre-project evapotranspiration rate from the reservoir area and subtracted from the open water evaporation to yield the net effect of the reservoir. R&M will undertake these studies.

(vi) Glacial Studies

The results of field surveys for detecting glacial movement and the aerial inspections and information obtained from aerial photographs will be evaluated to determine whether the glacier was noticably moving and if there was potential for a lake dump. The USGS studies on the Black Rapids Glacier will be reviewed and general information abstracted and used to assist in this evaluation.

Should these studies indicate that changes in the glaciers water and sediment yield could occur, or that a lake dump could develop, a more comprehensive long-term glacial observation and study program would be planned for implementation during Phase 2.

R&M and Acres would jointly undertake this study.

(c) Discussion

The streamflow extension (Section (i)) analyses will be based on available streamflow data up to the end of the 1978-1979 year, i.e., October 1979. The data obtained during the first 12 months of the field program will be utilized to check on the validity of the extrapolation factors used to derive streamflow data for ungauged sites. If deemed necessary, these factors will be revised and the appropriate adjustments made to the streamflow data.

(d) Schedule

Weeks 21 through 120

Subtask 3.05 - Flood Studies

(a) Objectives

To provide design flood peaks and hydrographs for design of the project and for assessing pre- and post-project flood conditions in the Susitna River reaches located down and upstream of the Watana and Devil Canyon damsites.

(b) Approach

(i) Regional Flood Peak and Volume Frequency Analysis

A localized regional flood peak and flood volume analysis will be undertaken for the Matanuska, Susitna (including the Yentna) and Chakachatna River basin; i.e., the entire Cook Inlet basin. All gauging stations with periods of records longer than 7 to 8 years and with drainage basin areas larger than approximately 250 square miles will be incorporated in the analysis.

Annual maximum and seasonal maximum flood peaks will be abstracted from the records. It is proposed to use two seasons: the season during which significant ice cover is present and the ice-free season. The flood peak data will be subjected to frequency analysis using the Log Pearson Type III distribution (or alternatively the three-parameter Lognormal distribution which has been found to work well in northern climates). These individual frequency curves will be utilized to develop regional frequency curves as well as regression equations for predicting design flood peaks at ungauged locations within specified homogeneous flood regions. The definition of homogeneous flood regions will be based both on statistical tests (e.g., Langbein) as well as visual plots of single station frequency curves.

In developing regression equations, use will be made of physiographic parameters such as drainage basin area, area covered by glaciers and lakes or swamps, mean late winter snow cover, mean spring temperatures, etc. The results obtained will be compared to those presented in the broad-based regional study recently completed by Lanke (USGS, Water Resources Investigations 78-129).

A flood-volume frequency analysis will be undertaken for the streamflow records on the Susitna at Gold Creek (2920) and at Cantwell (2915). A screening process will be undertaken to determine which of the flood types are the most critical:

- spring floods
- high mountain snow melt - rainfall events (June/July)
- summer rainfall events.

The annual maximum flood volumes associated with the critical type will be abstracted from the streamflow data files and subjected to a frequency analysis. Analyses will also be conducted to determine whether a relationship exists between the ratio of the flood peak to the flood volume and to develop typical flood hydrograph shapes. The results of these calculations will be used to develop design flood hydrographs for the proposed reservoir sites on the Susitna. Extrapolation to the ungauged sites will be accomplished by using drainage area ratios or factors involving other physiographic and climatic parameters.

R&M would undertake this work and Acres would act in a review capacity.

(ii) Probable Maximum Flood Determination

The approach adopted by the Corps of Engineers in their feasibility studies in developing the Probable Maximum Flood (PMF) is appropriate for this stage of the study. The SSARR watershed model used was reasonably well calibrated considering the paucity of available data. Recalibration would not be warranted until the proposed new climatic stations (Subtask 3.03) have been installed and operated for at least two years. It is therefore proposed to undertake a detailed review and revision of the input parameters to the Corps of Engineers model. Several runs will then be undertaken with the model to test for sensitivity of output to changes in input data and to revise the estimate of the PMF if necessary. The key input parameters that would be reviewed include:

- probable maximum precipitation
- initial snow cover
- temperature sequence
- loss rates or loss functions.

It is assumed that the consultants would have access to the Corps of Engineers model in rerunning the SSARR model.

Acres will undertake this work.

(iii) Reservoir Flood Routing

In-house computer programs will be used to route design floods through the proposed reservoir system. These studies will be used to size the required service and emergency spillways and to produce the downstream post-project flood hydrographs required for the downstream water level and ice studies (Subtask 3.06).

Acres will undertake this work.

(c) Discussion

During Phase 2, more extensive analyses will be undertaken to firm up the design flood estimations (see Section A.7). This will include

recalibration of the SSARR model or, if deemed more appropriate, the application of an alternative computer model such as the more sophisticated Hydrologic Simulation Package (HSP) developed by Hydrocomp or the National Weather Service model.

(d) Schedule

Weeks 21 through 120

Subtask 3.06 - Hydraulic and Ice Studies

(a) Objective

The determination of water levels and ice cover conditions upstream and downstream from the project sites under flood and low-flow conditions corresponding to pre- and post-project conditions.

(b) Approach

Computer model simulations will be carried out to compute the pre-project to predicted post-project conditions and to provide input to the civil layout and system operation studies. This will ensure that potential problems such as the maintenance of a stable ice cover, ice jamming and flooding, etc. can be dealt with during the project planning and design process. The results of the studies will also be utilized in the environmental studies (Task 7) to assess potential environmental impacts.

(i) River Channel Water Levels and Flows

We propose to utilize the following three basic computer programs to study the water level and ice regime in the Susitna River from just upstream of the Watana site to Talkeetna.

- HEC-2 - (Acres modified version, incorporating an ice cover)

- Ice Cover Process Model - This is a computer program which has been developed in-house by Acres specifically for hydropower generation studies in northern climates. It simulates the growth and decay of a stable ice cover on a channel containing flowing water.

- One-Dimensional Dynamic Flow Model - Acres has several in-house versions of this program which is capable of simulating the dynamic response of a channel to a time varying flow input.

All of the above models are one-dimensional flow models. Table A5.2 indicates which of the Susitna River reaches these models will be applied to and the purpose of the simulations to be carried out.

The ice cover observations and the ice cover thickness and strength measurements undertaken by the Geophysical Institute and made during the course of this study will be utilized for:

- calibrating the ice cover process model
- determining typical ice cover conditions to be simulated with the backwater program (HEC-2)
- assessing where potential ice jams could occur.

The studies outlined in Table A5.2 deal with the Susitna River only as far downstream as Talkeetna. It is proposed to use a less rigorous approach to assess the effects of the proposed project on flow in the river channel downstream from Talkeetna (see Subtask 3.10). Should these analyses indicate that more detailed studies are required, they will be done during Phase 2.

As soon as the topographic survey information of the Susitna reaches concerned becomes available and sufficient water level observations are obtained (Subtask 3.03), the flow models will be set up and calibrated. The simulation exercise will then follow and continue on through the project design studies (Task 6).

Acres and R&M will jointly undertake the foregoing studies. R&M will concentrate on the river reach downstream from the Devil Canyon damsite as this aspect could be usefully combined with flood-plain mapping work they may be undertaking in the area.

Acres will direct the work undertaken by R&M.

(ii) Reservoir Freeboard

The required reservoir freeboard for wind conditions will be evaluated. The wind data collected in the basin during the first 18 months will be utilized to extrapolate design wind conditions to the reservoir sites.

Acres will undertake this work.

(iii) Slide Induced Reservoir Surge

It is proposed to undertake a literature review of previous work done in this area. Of particular interest will be the mathematical and physical modeling work done by B.C. Hydro on the Downie slide and Revelstoke dam and their work on the Mica slide. Information obtained from this review plus the results of the reservoir seismic studies (Task 4) will be used to assess the nature and magnitude of the potential problems and to establish some preliminary design criteria. Should further detailed study be necessary, a suitable methodology and scope of work would be developed for application in Phase 2.

Acres will undertake this work.

(iv) Reservoir Temperature Regime

An in-house computer model will be utilized to simulate the vertical temperature stratification within the proposed reservoirs for a typical year. This model will be calibrated according to our experience with such models, other studies on similar projects, and utilizing the results of similar work being conducted at the University of Alaska.

Output from this model will be utilized to assist in the selection of the levels of the offtakes for the discharge structures and to predict changes in the downstream water temperatures.

Acres will undertake the work.

(d) Discussion

The foregoing approach, particularly the application of the backwater program incorporating an ice cover and the ice-cover process model, has been developed based on our extensive experience with design of hydroelectric facilities in northern climates, particularly on the Nelson River in Manitoba. The type of problems we anticipate with ice in the Susitna project and the methods that could be adopted to deal with them are discussed in Section A2.

(e) Schedule

Weeks 40 through 120

Subtask 3.07 - Sediment Yield and River Morphology Studies

(a) Objective

Determination of the rate of sediment accumulation in the proposed reservoirs and prediction of the effects on the downstream river channel morphology.

(b) Approach

(i) Sediment Yield and Deposition

The U.S. Corps of Engineers total sediment yield studies described in the 1975 feasibility report will be updated by incorporating all new data on sediment discharge that have since become available. A literature review will be undertaken to confirm the reservoir trap efficiency figures used and to develop an appreciation of the spatial distribution of the deposited sediment in the reservoir. State-of-the-art settlement theory will be used to determine average sediment concentration in the reservoir at various times of the year. This latter information will be required to determine the quality of the water released from the reservoir.

(ii) River Morphology

A thorough review of previous work done in the Susitna Basin and other Alaskan rivers and available field data for the Susitna River will be undertaken. An air photo mosaic will be prepared for the reach between Devil Canyon and Talkeetna. Historical photographs will be studied to assess past regime changes both in the main river channel and the tributaries.

Studies will be undertaken to determine a suitable regime-type equation. With the aid of this formula and input from the reservoir simulation studies (Subtasks 3.04 and 3.05) expected morphologic changes will be assessed. The more pronounced changes will be illustrated on the air photo mosaic.

(c) Discussion

The reservoir sediment calculations will be revised during Phase 2, once several seasons of additional field data have become available.

The state of the art in modelling the distribution of deposited sediment is not yet sufficiently advanced to produce reliable estimates of the spatial distribution of sediment within a reservoir, unless extensive calibration studies are undertaken and a large amount of field data is available. During Phase 2 of the study an assessment will be made as to the adequacy of the available data to calibrate such a model, and a decision will be made whether or not to undertake such modelling.

R&M will undertake the work described in this subtask and Acres will act in a review function.

(d) Schedule

Weeks 40 through 120

Subtask 3.08 - Climatic Studies for Transmission Line

(a) Objective

To provide climatologic design criteria for the design of transmission lines. These include ice-cover thickness and wind speed.

(b) Approach

Preliminary design criteria will be evaluated during the early stages of the study. Utilizing available climatic information and experience obtained in other northern transmission line projects, design parameters will be established; i.e., wind speeds, icing conditions (frequency and thickness of accumulation) and temperature conditions.

Input will be obtained from an experienced staff meteorologist to assist in developing these parameters. An attempt will be made to develop a general perception of the spatial variation in these parameters for input to the transmission-line route-selection studies.

During the second year of the study, as the climatic field data becomes available, a more detailed approach will be adopted to confirm the design criteria. An in-cloud icing model is available in the Acres computer library and has been used to calculate ice loads for the design of a transmission line from Ocean Falls to Kemano in northern British Columbia.

We will use this model to predict ice cover thickness for specified design climatic conditions. A check on model accuracies will be made by comparing model results with measured ice accumulations from the Field Data Collection Program (Subtask 3.03) and using data from other sources such as the in-cloud ice accumulation data which is available (4 years, 42 events) for McLean Mountain, British Columbia. Determination of freezing rain accumulation will be based on the data collected in the field and obtained from other sources such as the first order meteorological stations in Alaska, the Yukon and northern British Columbia.

Acres will undertake this subtask.

(c) Discussion

To estimate risks of combined wind and ice loads for various return periods, two meteorological events must be considered. On the routing sections which would carry the line to high elevations, in-cloud ice accumulation is likely to represent the most severe condition. Where the line would follow valley floors, freezing rain or drizzle would result in maximum loads. In-cloud icing produces rime accumulation having a density of about 0.6 g/cm^3, as does the occurrence of freezing drizzle. Freezing rain results in glaze icing with a density of about 0.9 g/cm^3.

(d) Schedule

Preliminary Design Parameters - Weeks 14 through 25
Detailed Studies - Weeks 70 through 82

Subtask 3.09 - Access Road Studies

(a) Objective

To provide the necessary design flood peaks and to evaluate the capacity of the required hydraulic structures such as bridges and culverts.

(b) Approach

For design floods associated with larger basins, the results of the regional flood studies (Subtask 3.05) will be used. For the smaller catchments measured flood flows from small catchments will be utilized to develop regional flood peak relationships. Summer rainfall statistics will be evaluated and utilized with a rational type formula to calculate design summer flood peaks.

(c) Discussion

Hydraulic calculations, using standard techniques and design curves will be employed to evaluate the necessary size of the hydraulic structures. Bridge size and abutment shapes and alignments will be determined so as to minimize the effect on the drainage of water and general and local scour.

R&M would perform this subtask.

(d) Schedule

Weeks 52 through 100

Subtask 3.10 - Lower Susitna Studies

(a) Objective

To estimate the flow regime, sediment regime and morphological characteristics of the lower Susitna River under natural conditions, and a preliminary determination of morphological impacts which could result from flow regulation and sediment trapping at the Susitna project.

(b) Approach

This task will comprise the three following components:

(i) Flow and Sediment Measurements

Assessment of impacts on the Susitna River below Talkeetna requires basic information on the proportion of flow and sediment which is contributed from the area above the proposed dams. Although this can be estimated approximately by analytical methods based on the sparse records available, it will be confirmed by direct field measurements. In addition to the existing U.S.G.S. gauging station on the Susitna River below the confluence with the Yentna River, it is proposed to select three additional gauging sites on consultation with the Department of Natural Resources sites in consultation with the Department of Natural Resources (DNR). It is tentatively envisaged that these will be located on the following sites:

(1) Chulitna River near Talkeetna (see Plate T3.1)
(2) Susitna River between the Parks Highway Bridge and the Delta Islands
(3) Yentna River near the Susitna confluence.

Measurement of river discharge, water levels, water temperatures, and suspended sediment concentration will be conducted for a period of at least one year. This will provide information for estimating the natural contribution of flow and sediment from the basins upstream of the project sites to the lower Susitna reaches on a seasonal basis.

(ii) River Observations and Aerial Photographs

A potential impact of flow regulation on the highly graded lower Susitna River is the dewatering of side channels and sloughs which may be good fish habitats. To be able to assess this potential impact, the following additional information will be collected:

- aerial photography of the river from the mouth to Talkeetna
- aerial observations and oblique photographs of the river under various conditions:
  - before and during spring breakup
  - at various flow magnitudes during the summer
  - before and during the ice formation period.

(iii) Interpretation of Data

The data collected on the lower Susitna River will be analyzed in conjunction with the flow regulation and sediment studies described in Subtask 3.04, Water Resources Studies, and 3.07, Sediment Yield and River Morphology Studies.

A preliminary evaulation of the potential morphological changes, and impact on the river characteristics due to flow regulation will be made during the early part of 1981. If considered necessary at this stage, an expanded field data collection and study program aimed at evaluating impacts in more detail will be developed in conjunction with the DNR and presented for consideration to APA. Should an expanded program not be necessary the program outlined here will be continued and the preliminary assessments completed by the end of the study period.

R&M will undertake the work and Acres will act in a review capacity.

(c) Discussion

The lower Susitna River is an important multi-purpose resource which must be considered in planning the Susitna project. However, at this point in the study, it is considered prudent to minimize the level of investigation until

(1) The power studies confirm that the Susitna project is indeed the best alternative for Railbelt power requirements.

(2) Project studies have progressed to the point where definite regulatory patterns and effects on sediment transport can be identified.

(3) Preferred areas of fish habitat in the lower Susitna River have been identified (see Subtask 7.10, Fish Ecological Baseline Studies and Analysis).

(4) Better knowledge on the morphological effects of the project on the upper Susitna River is obtained.

This subtask has been developed after extensive discussions with DNR.

(d) Schedule

Weeks 31 through 126.

TABLE A5.1 - PROPOSED HYDROLOGIC FIELD DATA COLLECTION PROGRAM

Station Type	Measured Parameters: Parameter	Measured Parameters: Type of Equipment	Time Between Observations	Time Between Station Visits	Number of Stations Installed: 1980	Number of Stations Installed: 1981	Type (and Quantity) of Major Equipment to be Purchased
Gaging	Water level	Chart or tape recorder	Continuous	Summer: 2-4 weeks	3 (2 new at project sites, reactivate USGS Station 2915 on the Susitna River)	None	Water level recorders (3 + 1 spare) Current meters (2) Boats (2) Cable ways (2) Ice augers (2)
	Water discharge	Cable way or boat and current meter	Summer: 2-4 weeks Winter: 2-3 months	Winter: 1 month			
Water level	Water level	Staff gauge and peak level indicator	Summer: 2-8 weeks Winter: 2 months	As in previous column	8	None	Staff gauges Peak level indicators
Sediment discharge[5]	Suspended sediment concentration Bed material size	Suspended sediment sampler	As for water discharge	As in previous column	4 (3 involve supplementary measurements at USGS stations 2910, 2912, 2920).	None	Suspended sediment samplers (3) Bed material samplers (2)
Snow course	Snow pack depth and water equivalent	Conventional snow survey equipment and/or snow pillows	2-4 weeks during winter months	As in previous column	4	None	Conventional snow survey equipment (1 set). Snow pillows (4 + 1 spare)
Water quality	Temperature, turbidity, conductivity, dissolved oxygen, pH	Field measuring equipment	Summer: 1 month Winter: 2-3 months	Summer: 1 month Winter: 2-3 months	3	1	Meters (1 set)
	Alkalinity CO_2	Grab samples and laboratory analysis in field camp	As above	As above			Titration kit
	Total and ortho phosphorus Total and kjeldahl nitrogen Total dissolved and suspended solids Trace metals	Grab samples and laboratory analysis in Anchorage	As above	As above			Freezing equipment in field camp (1)
Climatic (automatic)	Wind speed and direction Relative humidity Temperature Rain/snow (unheated gauge)	Automatic weather station	Continuous	Monthly	6	3	Automatic weather stations (9 + 2 spare)

TABLE A5.1 - PROPOSED HYDROLOGIC FIELD DATA COLLECTION PROGRAM (Cont'd)

Station Type	Measured Parameters: Parameter	Measured Parameters: Type of Equipment	Time Between Observations	Time Between Station Visits	Number of Stations Installed: 1980	Number of Stations Installed: 1981	Type (and Quantity) of Major Equipment to be Purchased
1 Climatic (automatic with heated gauge plus some observer information)	As above, plus solar radiation Evaporation pan Visibility (heated gauge)	Automatic weather station plus some observer information	Continuous	Daily	1	None	
In cloud icing	Ice buildup on a transmission line	Short section of transmission line, 6 feet long mounted 5 feet above ground	Only during or immediately after icing conditions	Sporadic	3	2	Short section of transmission line
Freezing rain	Ice buildup during a precipitation event	Horizontal steel plate,	Only during or immediately after freezing rain	Sporadic	3	2	Steel plates
Snow creep	Snow creep	Snow markers and survey equipment	2-4 weeks during winter months	Monthly during winter months	3	5	Snow markers
2 Ice cover (Ground survey)	Ice thickness	2-5 auger holes for measurement	Summer: none Winter: 1 month	Summer: none Winter: 1 month	8-12	0-4	Ice penetrometer
	Ice competence	Visual inspection and/or penetrometer device					
3 Ice cover (Aerial survey)	Extent of ice cover	Visual and photographic records	During break-up period - one to several days	--	--	--	Camera equipment
	Location of ice jams		During freeze-up period - weekly	--	--	--	--
Glacial	Ice surging/ recession & glacial surface features	Survey, visual & photographic records	Two months	Two months	--	--	Survey markers

Footnotes:

(1) Located at the permanent Watana field camp.
(2) Locations to be firmed up after initial field trips and review of field data collected by Geophysical Institute, University of Alaska. Anticipate 6-8 stations on the Susitna River and 2-4 on important tributaries.
(3) As for Note 2. Anticipate to cover entire reach from MacLaren - Susitna River junction to confluence of Chulitna River.
(4) It is assumed that the existing cable at Vee can be upgraded for use.
(5) It is porposed to undertake only sporadic units to the station at VEE (i.e. at gage 2915).

TABLE A5.2

PROPOSED APPLICATION OF
ONE-DIMENSIONAL FLOW MODELS
TO THE SUSITNA RIVER

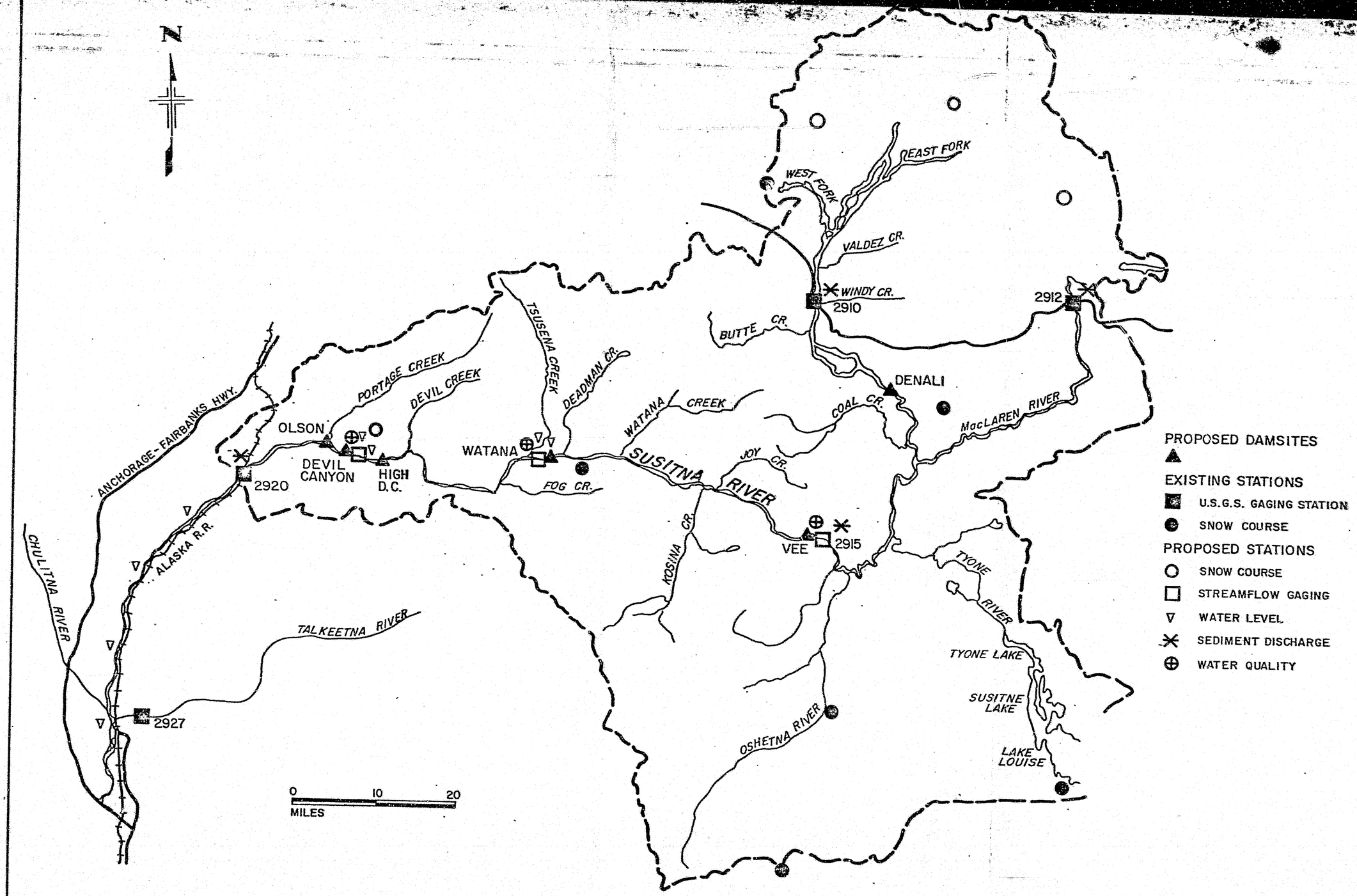
Study No.	River Reach	Model	Purpose of Simulations
1	Upstream of Watana	HEC-2, Ice Cover Process Model	To study the establishment of the stable ice cover on the Watana Reservoir
2	Watana Dam site to Talkeetna	HEC-2, Ice Cover Process Model	To study the ice cover and water level regime downstream of Watana prior to construction of Devil Canyon Dam and to calculate tailwater rating curves
3	Watana Dam Site to Devil Canyon site	HEC-2, Ice Cover Process Model	To study the ice cover regime at the Devil Canyon Reservoir
4	Devils Canyon site to Talkeetna	HEC-2, Ice Cover Process Model, Dynamic Flow Model	To study the ice cover and water level regime in the reach below Devil Canyon and to calculate tailwater rating curves
5	Watana and Devil Canyon site during the diversion stage of construction	HEC-2, Ice Cover Model Process	To design an adequate diversion system

NOTES:

The word "regime" implies the following:

- ice cover - nature and timing of growth
  - stability
  - decay and jamming

- water level - low flow conditions
  - flood flow conditions



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SUSITNA HYDROELECTRIC PROJECT

PLATE T3.1: PROPOSED DATA COLLECTION STATIONS IN THE SUSITNA BASIN-1980

A.5.5 - TASK 4: SEISMIC STUDIES

(i) Task Objectives

To determine the earthquake ground motions which will provide the seismic design criteria for the major structures associated with the Susitna Hydroelectric Project, to undertake preliminary evaluations of the seismic stability of proposed earth-rockfill and concrete dams, to assess the potential for reservoir induced seismicity and landslides, and to identify soils which are susceptible to seismically-induced failure along the proposed transmission line and access road routes.

(ii) Task Output

The data collection programs and studies outlined in this task will be sufficiently comprehensive for FERC license applications.

Thorough presentations of conclusions, evaluations and data are also desirable for projects that are being carefully reviewed by permitting agencies. Complete reporting of the seismic geology and seismology investigations will be made with this philosophy as a guide. This task will be conducted primarily by Woodward Clyde Consultants with review by Acres and field support by R&M Consultants. The ground motion study data will be utilized in Task 6 for design studies. Identification of seisimically susceptible soils for the road and transmission routes will be inputs to Task 2 and 8 studies. Field activities will be coordinated with the Task 5 activities.

The primary products of this task will include:

- Technical reports containing thorough documentation of all work done during the first year.
- Final technical reports containing thorough documentation for all studies during the first two years.
- Monthly management reports during the course of the investigation.

The technical reports will be accompanied by geologic maps showing locations of all controlling features, fault lines, etc.

Management reports will deal with technical and financial progress with respect to plan.

(iii) List of Subtasks

Subtask 4.01 - Review of Available Data
Subtask 4.02 - Short-term Seismologic Monitoring Program
Subtask 4.03 - Preliminary Reservoir Induced Seismicity
Subtask 4.04 - Remote Sensing Image Analysis
Subtask 4.05 - Seismic Geology Reconnaissance
Subtask 4.06 - Evaluation and Reporting
Subtask 4.07 - Preliminary Ground Motion Studies
Subtask 4.08 - Preliminary Analysis of Dam Stability
Subtask 4.09 - Long-term Seismologic Monitoring Program
Subtask 4.10 - Reservoir Induced Seismicity
Subtask 4.11 - Seismic Geology Field Studies
Subtask 4.12 - Evaluation and Reporting
Subtask 4.13 - Ground Motion Studies
Subtask 4.14 - Dam Stability
Subtask 4.15 - Soil Susceptibility to Seismically-Induced Failure

(iv) Subtask Scope Statements

Task 4 activities will be crucial in establishing the safety of dams and other structures under potential earthquake or induced seismicity conditions. The FERC license application for the selected Susitna project components must demonstrate convincingly that the maximum credible earthquake has been identified and the major structures have been properly designed to safely cope with such conditions.

Task 4 activites will be initiated immediately upon commencement of studies and will be designed to provide an effective basis for design of dams and other structures prior to submission of the FERC license application.

Task 4 activities have been subdivided into a total of fifteen packages arranged to include a program of field and office studies and installation of a monitoring system to adequately satisfy the most stringent requirements of dam safety. These activities will be appropriately coordinated with parallel geotechnical exploration and dam design efforts.

Subtask 4.01 - Review of Available Data

(a) Objective

To acquire, compile and review existing data and identify the earthquake setting of the Susitna River basin area.

(b) Approach

Data obtained under this subtask will be used to plan the details of the seismologic investigations (Subtasks 4.02, 4.03, 4.09 and 4.10) and the seismic geology field reconnaissance (Subtask 4.05). Available geological, seismological, and geophysical data for the region will be gathered from sources such as Woodward-Clyde files, the Department of Geologic and the Geophysical Institute of the University of Alaska, the Alaska Geological Survey, the U.S. Geological Survey and the major colleges and universities involved in research pertinent to the project. In addition, researchers with on-going programs of study will be contacted and the current status of their research will be obtained by discussions and written correspondence.

The acquisition of geological data will be concentrated on structural features of the earth that may represent major active faults. The geomorphic expressions of these features will also be identified from the available data.

Geophysical data regarding the structure of the earth will be acquired and reviewed. Regional gravity and magnetic data are particularly useful in identifying major discontinuities in the crust of the earth. These discontinuities may be along faults that could produce large earthquakes and surface fault ruptures. If available, other types of geophysical data such as seismic refraction, seismic reflection and electrical resistivity may also be of use in identifying major active faults.

Seismological data will be acquired for the project area. This data includes historical information on past earthquakes, instrumental data from the Geophysical Institute of the University of Alaska, and regional instrumental data from the U.S. Geological Survey.

The geological, seismological and geophysical data will be compiled in order to obtain a thorough current knowledge of the tectonics of the Susitna River area. The end product will consist of maps that identify faults, lineaments, and epicenter clusters or alignments identified by others. These maps will provide a basis for the proposed geological and seismological studies.

In addition to the data acquired for the project area, data relating to reservoir-induced seismicity will also be compiled. The world-wide data on reservoir-induced seismicity will provide a partial basis for evaluating whether or not induced earthquakes may be generated in the Susitna River area. Woodward-Clyde Consultants has an extensive file on world-wide data on reservoir-induced earthquakes, and is currently being retained for further research in reservoir-induced seismicity by the U.S. Geological Survey.

The specific products of this subtask include:

- Historical earthquake map and catalog

  A catalog of reported earthquakes with magnitude 4.0 and larger from 1899 to the present will be prepared for the region within 200 miles of the site. For the larger earthquakes in the period, the geologic and engineering effects will be discussed. Data quality as a function of time will be evaluated to estimate the completeness level of the catalog with respect to magnitude, focal depth and spatial location.

- Summary of recent regional monitoring

  Microearthquake monitoring by the University of Alaska Geophysical Institute and the U.S. Geological Survey will be reviewed and summary plots of seismicity data will be prepared. Results and interpretations based on these data will be reviewed with appropriate personnel in governmental and academic organizations. Of particular importance is evaluation of the accuracy of focal depth determinations based on these network studies.

- Tectonic model

  Based on available seismologic and geologic data, a preliminary kinematic tectonic model will be developed for the region within approximately 200 miles of the site. This model will be modified as needed by studies in later subtasks and will provide the basis for understanding the interrelated geologic source areas for future earthquake activity in the Alaskan interior. Applications and implications of seismic gap theory will be considered.

(c) Discussion

The seismicity and seismic sources of the Alaskan interior have only recently begun to be studied in significant detail. Interest in the seismicity of continental Alaska was stimulated by the major 1964 earthquake and involved the initiation of regional microearthquake monitoring and the augmentation of geological investigations to improve understanding of the tectonics of Alaska.

The seismological environment of the Susitna Project is characterized by two major earthquake sources:

- shallow earthquake activity occurring along crustal faults such as the Denali fault, with depth of focus less than approximately 12 miles; and

- earthquake activity in a Benioff zone which has a depth range of 30 to 90 miles and is associated with the subduction of the Pacific plate beneath Alaska.

Geological studies are used, along with seismological data, to investigate the shallow earthquake sources. The deeper-focus earthquake sources are not directly expressed at the earth's surface and must be investigated using seismological data combined with a kinematic understanding of the present-day tectonic activity of the Alaskan interior. The occurrence of past large earthquakes within the region, such as the 1904 and 1912 magnitude 7 to 8 earthquakes, indicates that both the shallow and deeper seismic zones may have the potential for generating earthquakes with ground motions significant to the project.

The Susitna River area is within a zone of active seismicity that extends from the Aleutian trough on the south into central and northern interior Alaska. Woodward-Clyde Consultants has previously conducted regional studies of seismic geology and seismicity over broad regions of Alaska. The past regional evaluations have been for the Trans-Alaska Pipeline System, the proposed Offshore Continental Shelf regions surrounding Alaska, and for the proposed Alcan Gas Pipeline. These past regional studies provide data regarding the earthquake sources in Alaska, and they also provide up-to-date knowledge of the current status of research in the area.

(d) Schedule

Weeks 0 through 22

Subtask 4.02 - Short-term Seismologic Monitoring Program

(a) Objective

Establish initial monitoring system, obtain and analyze basic seismologic data on potential earthquake sources within the Susitna River area and supply information required to implement a more thorough long-term monitoring program (Subtask 4.09).

(b) Approach

This subtask involves two major packages of work:

(1) Analysis of Existing Data

Further limited analysis of existing regional earthquake data will be undertaken to enable sufficiently accurate and appropriate selection of maximum earthquake sources and associated attenuation relationships. Source studies will be carried out on several of the largest historical earthquakes, including the 1904 and 1912 events, in order to constrain their location, local depth and causative geological structure. The maximum earthquake potential of the subduction zone beneath the Susitna site is poorly understood, and it will be of significant value to use the historical data to properly characterize this source. These studies will also be directed to the evaluation of the seismic attenuation characteristics of deeper earthquakes to enable the proper utilization of the results of the Alaskan OASES study by Woodward-Clyde Consultants (1978) and other studies in selecting appropriate attenuation relationships required for Subtask 4.07 and 4.13.

(2) Establishment of a Monitoring Network

Since the study area is in a remote but seismically active area additional detailed earthquake source data will be collected by installing and operating a localized microearthquake recording network.

The network will be established and operated during the summer of 1980. The area covered will include the region within approximately 30 miles of the dam sites. Eight to ten recorders with station spacing of 5 to 10 miles will be installed to record microearthquake activity down to magnitude of 1.0 or less. Low-power radio telemetery will be used to make the field operation as efficient as possible. Helicopter support will be used for installation and maintenance.

Initial station deployment will be guided by the information obtained during the data review (Subtask 4.01). It will be required to monitor known significant geologic features, such as the Susitna fault.

During the course of the study, some of the stations may be moved to study specific areas of activity. Data analysis will be carried out to locate active seismic sources and evaluate their spatial extent and focal depth. These analyses will also be used to establish causative stress orientations based on focal mechanism studies, to evaluate seismic attenuation, and to evaluate the statistical features of the microearthquake activity.

Specific results to be obtained relative to source and wave propagation assessment include the association of larger earthquakes (such as the 1904 and 1912 events) with probable source structures, depth determination of the Benioff Zone of deeper seismic activity and attenuation characteristics of subduction zone earthquakes. Seismic source location in terms of maximum earthquake potential in the Benioff Zone will be performed. Comparisons will be made with seismic activity in other comparable tectonic areas to assess attenuation and maximum earthquake potential. The scope of these studies will be modified as necessary on the basis of the results obtained as the work progresses.

Liaison will be maintained with data collection by the University of Alaska Geophysical Institute and the U.S. Geological Survey. The recording period is initially planned as three months; however, if this should need to be modified, appropriate recommendations will be made during the course of the study.

(c) Discussion

The present location and focal mechanism level using the Geophysical Institute network is approximately magnitude 2-1/2 or larger. The data obtained from the proposed monitoring program will supplement the existing regional network operations and will provide needed accuracy and detection threshold. In addition, the results obtained will provide the information needed to accurately site the long-term network stations (Subtask 4.09) and to select appropriate instrumentation. They will also aid in planning the seismic geology reconnaissance (Subtask 4.05).

(d) Schedule

Weeks 21 through 52

Subtask 4.03 - Preliminary Reservoir Induced Seismicity

(a) Objective

Evaluate the potential for the possible future occurrence of reservoir-induced seismicity (RIS) in the Susitna Project area.

(b) Approach

The results of this evaluation will be used to establish scenarios of possible outcomes of the occurrence reservoir induced seismicity. Woodward-Clyde Consultants has recently completed a major analysis of geologic, seismologic and hydrologic factors associated with past cases of reservoir-induced seismicity. The results of this study also will be applied to the known factors for the Susitna project in order to statistically relate the Susitna Project to the potential for RIS. The resulting potential will be evaluated in terms of possible scenarios for the occurrence of induced activity, and the possible outcome of such occurrences will be discussed.

This analysis will result in a quantitative assessment of the potential for the occurrence of reservoir-induced seismicity as a result of the damming of the Susitna River. A comparison will be made of depth, volume, regional stress, geologic setting and faulting at the Susitna dam sites with the same parameters as the world's deep and/or very large reservoirs. Based on this comparison, the probability of reservoir-induced seismicity at the Susitna dam sites will be assessed.

A description of known cases of RIS emphasizing the relationship between filling of the reservoir and the length of time to the first and largest earthquakes and the relevance of these data to the Susitna dam sites will be discussed.

Scenarios will be presented that discuss possible courses of action that can be taken if RIS is anticipated or detected during filling of the reservoir.

(c) Discussion

The activities associated with this task will be closely coordinated with the hydraulic studies aimed at assessing the potential impact on the reservoir water level of a reservoir-induced slide. (See Subtask 3.06).

(d) Schedule

Weeks 23 through 50

Subtask 4.04 - Remote Sensing Image Analysis

(a) Objective

Select and interpret available remote sensing imagery to identify topographic features that may be associated with active faulting.

(b) Approach

Data obtained under this subtask will be used during the Seismic Geology Reconnaissance (Subtask 4.05) and the Seismic Geology Field Studies (Subtask 4.11) to identify youthful faults that may produce future earthquakes and future surface fault ruptures. Remote sensing imagery and aerial photography relevant to approximately 100 km radius about the dam site will be selected for a lineament analysis. This remote sensing data includes available Landsat, SLAR (side-landing airborne radar), Skylab photography; high altitude U-2, or RB-57 color infrared photographs, and black-and-white aerial photographs. The remote sensing and high altitude imagery and aerial photographs will be interpreted in terms of the geology, geomorphology and structure of the study region.

Interpretation will help to identify lineaments and other features that may be related to active faults. Seismicity clusters and alignments identified during the seismicity evaluation in Subtask 4.02 will be compared with the lineaments identified by the imagery interpretation and the known faults on existing maps to assess the possible relationship of the epicentral locations, surficial lineaments and mapped faults. The imagery interpretation will be conducted by geologists experienced in lineament evaluation and in the recognition of features associated with active faults. It will be important to distinguish these lineaments from similar features that result from non-tectonic geologic processes.

(c) Discussion

The activities in this task will be closely coordinated with the photo interpretation studies being conducted for the dam site, reservoir and constructed material areas (Subtask 5.02) to ensure that information requests and analyses are not duplicated. Following an initial aerial and ground reconnaissance it may be decided that low-sun-angle aerial photography should be acquired for specific geomorphic features that may be fault-related. For this purpose, low-sun-angle color infrared and black-and-white photography at a scale of approximately 1:24,000 is proposed. This has proven exceedingly valuable in delineating subtle topographic features that may be fault-related. The long shadows cast by the low-sun-angle highlight subtle topographic features related to faults, such as scarps or offsets, that would be undetectable with conventional vertical aerial photographs.

Color infrared photography has also proven extremely useful in delineating subtle features in the terrain such as a contrast in vegetation or in surface moisture. Such features are often associated with faults where ground water is either closest along the fault zone or on only one side of the fault.

A map of lineaments within 100 km of the project area will be produced as a guide for Subtasks 4.05 and 4.11. The lineament map will be supplemented by mapped faults from Subtask 4.01, in order to compare known faults with lineaments of various origins.

(d) Schedule

Aerial photographs will be ordered during the first month. The analysis will be performed during weeks 10 through 26.

Subtask 4.05 - Seismic Geology Reconnaissance

(a) Objective

Perform a reconnaissance investigation of known faults in the Susitna River area, and of lineaments that may be faults, identify active faults and establish priorities for more detailed field investigations.

(b) Approach

This task will utilize the data obtained from Subtask 4.01 and the aerial photographic interpretations outlined in Subtask 4.04 as a basis for planning aerial and ground reconnaissance.

The aerial reconnaissance will systematically cover all lineaments and faults identified in previous subtasks. A field analysis will be made in order to identify whether or not each feature may be an active fault capable of impacting the project area due to its being aassociated with a large earthquake or capable of producing a future surface fault rupture. Features within 60 miles of the project area will be studied during the reconnaissance, with each lineament and fault being identified by number. In addition, regional reconnaissance of major features such as the Denali fault and the Castle Mountain fault which may extend as far as 200 miles from the project area will be investigated. Interpretations regarding the origin of each feature will be made by expert seismic geologists with past experience on similar projects. Those features that are interpreted to originate from youthful faulting, or features of unknown origin that may be due to youthful faulting, will be studied further in the field and subjected to reconnaissance-level geologic mapping.

The reconnaissance-level geologic mapping will be oriented toward identifying whether or not the bedrock units near the feature suggest the presence or absence of a fault. In addition, the Quaternary geomorphic surfaces and stratigraphic units in proximity to each feature will be studied to aid in identifying whether or not faulting has occurred in young units. The reconnaissance-level mapping, at a scale of 1:63,360, will aid in identifying those features that will require detailed study during the field season of 1981.

These activities will be coordinated with the geologic mapping tasks associated in Subtask 5.04.

(c) Discussion

The Susitna River area is in a complex tectonic area that is poorly known geologically. Previous work by Kachadoorian and Moore emphasized the structural complexity of this area, and the large number of linear features at the surface that may be due to faulting or to other origins. These surface features require field investigation to identify their origins. In order to identify the origins of some features, it may require detailed mapping, trending, borings, or

geophysical data. Despite thorough investigations, however, it may not be possible to obtain definitive information regarding the origins of all the lineaments.

Woodward-Clyde Consultants has conducted seismic geology reconnaissance investigations over large regions of Alaska and in many other seismically active areas of the world. Based upon that experience, we estimate that reconnaissance-level investigations as proposed in this subtask will define the origins of about 90 percent of the lineaments identified on remote sensing images. If these features are considered to be controlling faults for the design of dams and other important facilities, further detailed investigations will be undertaken in the Seismic Geology Field Studies, Subtask 4.11.

The products of this subtask will consist of a map that identifies recently active faults and features of unknown origins that may be faults significant to one or more dam sites and other critical facilities. In addition, all field observations will be tabulated for each lineament studied, and preliminary estimates of the maximum credible earthquake and faulting, along with the recurrences of faulting, will be made for each active fault and other features that may be faults.

(d) Schedule

Weeks 24 through 39

This task can begin after Subtask 4.04 is complete. Subtask 4.02 should either proceed concurrently with this subtask or it should precede this subtask.

Subtask 4.06 - Evaluation and Reporting

(a) Objectives

Complete a preliminary evaluation of the seismic environment of the project, define the earthquake source parameters required for earthquake engineering input in design and document the studies in reports suitable for use in design studies (Task 6).

(b) Approach

The approach of this subtask will be to provide a probabilistic analysis of earthquakes concerning control of active faulting, and to estimate maximum credible earthquakes for each active fault. These analyses will be completed by an interdisciplinary team utilizing the reconnaissance-level information obtained from Subtask 4.01 to 4.05. Reporting will be in a format suitable for use in selecting the design basis earthquakes, and will include thorough documentation that will be suitable for FERC and peer group review.

(c) Discussion

A panel of leading experts in seismology investigation and seismic design of major structures will be convened during this activity to review and comment on all study work undertaken and the findings thereof.

Overall management and coordination of Subtasks 4.01 to 4.05 is also incorporated in this subtask.

(d) Schedule

Weeks 18 through 52

Subtask 4.07 - Preliminary Ground Motion Studies

(a) Objective

Undertake a preliminary estimate of the ground motions (ground shaking) to which proposed project facilities may be subjected during earthquakes.

(b) Approach

The ground motion characteristics to be estimated include peak parameters (peak accelerations, velocities, and displacements), response spectra (describing the frequency content of ground shaking) and significant duration (describing the time duration of strong ground shaking). This initial assessment of ground motions will be made using information from the seismic geology (Subtask 4.05) and seismology (Subtask 4.02) studies. The ground motion estimates will be refined if necessary on the basis of additional information gathered during the second year. (See Subtask 4.13).

In consideration of ground motions, the terms "seismic exposure" and "seismic risk" are sometimes used interchangeably. However, for the purposes of this proposal they have two distinctly different meanings:

- "Seismic Exposure" is used to define the nature of the earthquake-induced ground motion characteristics at a specific site;

- "Seismic Risk" is used to define the risk as the probability of structural damage or destruction by an earthquake at the project site. It reflects the degree to which the structure has been designed to cope with earthquakes.

Ground motions will be estimated using a probabilistic approach, usually called a seismic exposure analysis. In this approach, the probability of exceeding various amplitudes of ground motion is estimated, taking into account the frequency of occurrence of earthquakes from all significant seismic sources and the attenuation of ground motion from each source to the locations of project facilities. Earthquakes of various magnitudes, up to the magnitudes of maximum credible events, will be considered. Attenuation relationships will be derived from examination and analyses of earthquake recordings made in similar tectonic environments and in similar subsurface geologic conditions, including available recordings from Alaska. WCC has recently conducted a comprehensive state-of-the-art analysis of seismic exposure in Alaskan offshore areas (OASES, 1978). The results and data of this previous study, which included assessment of activity for major onshore faults (e.g., Denali Fault, Castle Mountain fault) as well as offshore faults (e.g., Benioff zone), will be extremely valuable to the progress study.

The end products of this subtask will consist of estimates of the probability of exceedence during selected time periods (e.g., 100 years) of various levels of ground motions at the locations of each proposed major dam and other major facilities. For the long transmission lines and major access roads, the probability estimates will be given for appropriate segments of the systems. Probability levels and corresponding amplitudes of ground motions that may be considered in selecting project seismic design criteria will be discussed. For the dams, ground motion criteria will be consistent with ground motions associated with maximum credible earthquakes. For less critical project components, ground motion characteristics having a higher probability of exceedence would be used as design criteria.

(c) Discussion

It is widely recognized that neither the occurrence of future earthquakes nor the resulting ground motions at a site can be predicted with great accuracy even when the best available data and technology are employed. The fact is recognized in the above approach and considerable attention will be devoted to determining the reliability of the estimated design criteria.

The key interrelationships of this subtask and others are the following:

Projections of earthquake recurrence and identification of maximum credible earthquakes is an essential input to this subtask and will be accomplished in Subtask 4.06. The results of this subtask constitute essential input to Subtask 4.08 (Preliminary Analysis of Dam Stability) and Subtask 4.15 (Identification of Soils Susceptible to Seismically Induced Failure Along the Transmission Line and Access Road Routes).

The products of this task include the following:

- Estimates of the probability of exceedence during selected time periods (e.g., 100 years) of various degrees of ground motion at the location of each proposed major dam and other major project components.

- A discussion of and recommendations for project ground motion design criteria.

(d) Schedule

Weeks 24 through 52

Subtask 4.08 - Preliminary Analysis of Dam Stability

(a) Objective

Make preliminary evaluations of the seismic stability of proposed earth, rockfill and/or concrete dams during maximum credible earthquakes.

(b) Approach

These evaluations will be of a conceptual nature and will be undertaken as input to Task 6 design studies and determinations of the impact of seismicity on dam costs; i.e., on the requirements for design and/or treatment of foundations, design of dams, construction materials and placement requirements.

The preliminary evaluation of the adequacy of designs of earth and rockfill dams to resist seismic ground shaking will involve the following steps:

- Evaluation of strength characteristics under seismic loading conditions of in situ soils left in place in earth or rockfill dam foundations.

- Evaluation of key static and dynamic properties of embankment materials. Particularly important properties are the static and cyclic strength characteristics and permeability.

- Assessment of the potential for landsliding and large deformations through embankment or concrete dams and foundation during or following seismic ground shaking.

The cyclic strength characteristics of foundation soils will be assessed on the basis of field boring data and laboratory index and classification test data. For unfrozen sands in the foundation, blow counts from standard penetration tests (SPT's) in borings will be used to evaluate the resistance of the soils to liquefaction. Properties of embankment materials will be estimated on the basis of general description, grain size distributions and compaction requirements of proposed borrow materials. This information will be supplemented by the experience of the project staff and information obtained from published data. In addition, approximately six dynamic cyclic tests of proposed embankment or foundation materials are planned. The results of these tests will be compared with data for similar materials available in published literature and in the files of WCC.

The potential for landsliding in the embankments and their foundations will be analyzed using simplified analytical approaches and experience in similar studies. The key evaluations that are needed for the assessment of dam behavior are:

- the potential for generation and dissipation of excess pore water pressures in the materials during and following an earthquake (strongly dependent on permeability).

- the potential for sliding using conventional stability analysis approaches and taking into account the effect of seismically-induced pore pressures on soil and rockfill strengths.

(c) Discussion

The execution of this subtask will involve an iterative approach. For the initial designs, the experience of the project team will be used to establish broad guidelines for material selection and design. These designs will be evaluated for seismic stability. These results will then be used to modify, if necessary, the designs which in turn may be checked by a second evaluation.

The interrelationships of this subtask to others are the following:

- input is required from Subtasks 4.07 - Preliminary Ground Motion Studies, Task 5 - Geotechnical Exploration and Task 6 - Design Development. Task 6 input will be particularly required from the subtasks dealing with preliminary designs of dams and descriptions of construction materials and placement requirements.

- outputs of this subtask will be used as input to Task 6 - Design Development, particularly for preliminary dam design.

The products of this subtask are:

- Preliminary evaluation of the seismic stability of embankment cross sections subject to maximum credible earthquake loading.

- Recommendations for changes in preliminary embankment cross sections, material compaction requirements, and foundation treatment if required for increasing seismic stability.

- Preliminary evaluations of requirements for design of concrete dams (arch or gravity, as required).

The required dynamic analyses of the embankments will be undertaken under Task 6 activities. Woodward-Clyde Consultants will provide ongoing consulting services for these analyses, under Subtask 4.14.

(d) Schedule

Weeks 50 through 85

Subtask 4.09 - Long-term Seismologic Monitoring Program

(a) Objective

Develop a long-term seismologic monitoring program to provide a continuing source of seismological data for refinement of the seismic design aspects of the project during the detailed design phase.

(b) Approach

Based on the experience gained with the short-term seismologic monitoring program (Subtask 4.02) a detailed program of long-term monitoring and data analysis will be designed for implementation prior to the license award. This program will be designed to determine the background level of seismic activity on shallow crustal faults pertinent to the evaluation of possible reservoir-induced seismicity. Emphasis will therefore be placed on providing an inexpensive, reliable data collection facility and flexibility analysis procedures.

(c) Discussion

The long-term seismologic monitoring program will be developed on the understanding that arrangements will be made by APA for continued operation of the system and evaluation of data through construction of the Susitna Project and beyond. Appropriate documentation and operating manuals will be prepared for this purpose.

(d) Schedule

Weeks 100 through 130

Subtask 4.10 - Reservoir-Induced Seismicity

(a) Objective

To refine the estimate for the potential for reservoir induced seismicity made in Subtask 4.03.

(b) Approach

The additional field data collected in Subtask 4.11 will be incorporated in a reassessment of the work done in Subtask 4.03.

(c) Schedule

Weeks 83 through 91

Subtask 4.11 - Seismic Geology Field Studies

(a) Objectives

Perform seismic geology field studies to identify faults that may be active and in the vicinity of the selected dam sites.

(b) Approach

These data will be used in the final evaluation to identify the maximum credible earthquakes on each fault, and the recurrence of faulting and earthquakes along each fault. The results of this subtask will be used as input to Subtask 4.12 - Evaluation and Reporting. Planning of the field studies will be based on the results of Subtask 4.05 - Seismic Geology Reconnaissance and of Subtask 4.04 - Remote Sensing Image Analyses. We will also ensure that field studies be pursued at features that may affect project design at selected dam sites.

The subtask will include the following investigations which will be specifically designed for each feature to be studied:

- geologic mapping at a scale of 1:24,000.
- trenching of selected features
- borings
- test pits
- geophysical investigations
- age dating.

Compared to the work done in Subtask 4.05, the geologic mapping will include more detailed Quaternary data, and bedrock mapping at selected places along specific lineaments and geologic features (e.g. the Susitna fault and other features that may be fault-related). Age-dating studies will be undertaken to aid in the identification and correlation of geologic units. Trenches excavated across features that may be fault-related, or borings on either side of these features, will be used to aid evaluation of these features. The trenching (or boring) sites will be selected during the geologic mapping phase and will be located in areas considered suitable for assessing the nature of the faults and the degree of fault activity.

It is currently anticipated that approximately three trenching sites will be identified, with two trenches at each site. One site will be located along the Susitna fault, and an additional three sites along other features that are preliminarily identified as controlling features. During the course of the study, geophysical investigations (including seismic refraction lines and gravity or magnetic surveys) will also be undertaken to aid in locating and evaluating the faults and the nature of the faulting.

(c) Discussion

All of the field exploratory work outlined above is incorporated in Subtask 5.06.

The data derived from these geologic studies on controlling features will be evaluated to assess the potential of these features as seismic sources. This process will include refining the estimate of the maximum magnitude of an earthquake that may occur along the feature, the frequency of occurrence of seismic events along the feature, the focal mechanism of the event, the distances from the dam sites at which the event may occur and the type of faulting and the amount of fault displacement that may occur on these features. This data will form the basis for design values derived in Subtask 4.12.

Products derived from this Subtask will include:

- Documentation, tabulation, and an assessment of lineaments, mapped faults, and epicenter locations identified as potential controlling features,

- A map (scale 1:24,000) of the selected controlling features in the vicinity of the dam site,

- A geologic map (scale 1:24,000) and selected areas along the controlling features,

- Trench logs or core data of excavations or borings undertaken to evaluate the controlling features,

- The interpretation of geophysical data collected along the controlling features,

- Estimates of the maximum earthquake, the type of faulting and the amount of displacement that may occur during that event, the distance of the earthquake from the damsites and the frequency of occurrence of earthquakes of that magnitude along each controlling feature,

- An evaluation of significant, related seismic effects that may occur in the dam site and reservoir area.

(c) Schedule

Weeks 64 through 95

Subtask 4.12 - Evaluation and Reporting

(a) Objectives

To refine the evaluation of the seismic environment and the earthquake source parameters derived in Subtask 4.06, complete the reporting of all the fieldwork and studies undertaken in Subtasks 4.01, 4.05 and 4.09 to 4.11, and provide coordination and management to Subtasks 4.09 to 4.11.

(b) Approach

All the additional field data collected for the Long-Term Monitoring Program - Subtask 4.09, Reservoir-Induced Seismicity - Subtask 4.10 and Sesimic Geology Field Studies - Subtask 4.11 will be utilized to refine the preliminary evaluations undertaken in Subtask 4.06. The same basic methodologies as employed in Subtask 4.06 will be used.

The seismic review panel will again be convened during this subtask.

(c) Schedule

Weeks 70 through 104

Subtask 4.13 - Ground Motion Studies

(a) Objectives

Refine the estimate of ground motion characteristics made in Subtask 4.07.

(b) Approach

Based on the additional information gathered during the second year of the study, the work done in Subtask 4.07 will be reviewed, and, if necessary, appropriate adjustments will be made.

(c) Schedule

Weeks 75 through 104

Subtask 4.14 - Dam Stability Consulting Services

(a) Objective

To provide consulting assistance to the Acres design group engaged in the feasibility design of the dams.

(b) Approach

During the feasibility design stage Acres will undertake all the necessary dynamic analyses required to complete the design of the dams under Task 6 - Design Development Activities. WCC will act in a general consultancy role and respond to specific questions raised by the Acres' team. The seismic review panel will also be consulted under this subtask.

(c) Schedule

Weeks ~~80~~ 85 through 120

Subtask 4.15 - Soil Susceptibility to Seismically-Induced Failure

(a) Objective

Identify those areas along the transmission line and major access road routes that appear to be underlain by soils particularly susceptible to seismically-induced ground failure such as liquefaction or landsliding.

(b) Approach

The intent of this subtask is not to provide detailed design-level evaluations of soil failure potential. Rather it is to identify those areas having conditions that could significantly affect costs of transmission lines or access roads by requiring rerouting, special designs or contingency measures.

This subtask will be accomplished by a review of the geologic mapping, soils data, topographic data and estimated seismic ground motions (Subtask 4.07) along the routes. The identification of failure-susceptible soils will be accomplished mainly on the basis of experience in performance of soil deposits during earthquakes. Simplified analytical approaches and empirical correlations will be used to aid in assessing the potential for liquefaction of unfrozen, saturated, cohesionless sands. Possible remedial measures for areas of high failure potential will be briefly described. These include rerouting, special foundations, soil excavation and/or filling.

(c) Discussion

The results of this subtask will enable estimates to be made of additional costs required for design and construction of facilities due to seismicially-induced soil failure potential. However, if the consequences of failure are not too severe, and/or if the probability of damaging earthquake ground motions is low, it may be appropriate to utilize conventional designs but to provide contingency plans and budgets for repairs. For example, considerable lateral spreading and settlements of access roads might be acceptable consequences during an earthquake but would generate additional repair cost to the project.

Inputs to this subtask will be obtained from Subtask 4.07 - Ground Motion Studies, Subtask 5.04 - Field Program 80, and Subtask 5.06 - Field Program 81. Outputs from this task will be utilized in the design and costing of these facilities.

The products of this subtask are:

- Delineation on maps and/or in tabular form of areas having high potential for seismically induced ground failure.
- Brief descriptions of possible remedial measures for facilities in areas of high failure potential.

(d) Schedule

Weeks ~~53~~ 83 through ~~74~~ 104

	TASK DESCRIPTION	1980 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1981 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
SEISMIC GEOLOGY & SEISMOLOGY	4.01 DATA REVIEW																								
	4.02 SHORT-TERM MONITORING PROGRAM																								
	4.03, RESERVOIR-INDUCED 4.10 SEISMICITY																								
	4.04 REMOTE SENSING IMAGE ANALYSIS																								
	4.05 SEISMIC GEOLOGY RECONNAISSANCE																								
	4.06, EVALUATION & 4.12 REPORTING																								
	4.09 LONG-TERM MONITORING PROGRAM																								
	4.11 SEISMIC GEOLOGY FIELD STUDIES																								
	REVIEW MEETINGS																								
EARTHQUAKE ENGINEERING	4.07, GROUND MOTION 4.13 STUDIES																								
	4.08, 4.14 DAM STABILITY																								
	4.15 SOILS SUSCEPTIBLE TO SEISMICALLY-INDUCED FAILURE																								

ACRES

SUSITNA HYDROELECTRIC PROJECT
PLAN OF STUDY
PLATE T4.1 : TASK 4 SCHEDULE

A.5.6 - TASK 5: GEOTECHNICAL EXPLORATION

(i) Task Objectives

To determine the surface and subsurface geology and geotechnical conditions for the feasibility studies of the proposed Susitna Hydroelectric Project, including the access roads and the transmission lines.

(ii) Task Output

The Task 5 studies will be designed to provide input to the Task 6 design studies and will provide support to the Task 4 studies.

The primary outputs of Task 5 will consist of comprehensive documentation of geotechnical exploration undertaken at the Devil Canyon and Watana sites, reservoirs, and access roads and transmission line routes. This documentation will include the following:

- geologic maps
- geologic sections
- descriptive and graphic borehole logs
- descriptive test trench logs
- field inspection borehole and test trench logs
- photogeologic maps
- borehole rock core photographs
- low level air photointerpretation
- seismic and resistivity bedrock profiles
- radar imagery interpretation maps
- geotechnical exploration program summaries (1980, 1981, 1982)
- data summaries for
  - -- in-hole seismic testing
  - -- borehole camera studies
  - -- laboratory testing.
- geotechnical exploration summary reports (1980, 1981)

(iii) List of Subtasks

Subtask 5.01 - Data Collection and Review
Subtask 5.02 - Photointerpretation
Subtask 5.03 - Exploratory Program Design (1980)
Subtask 5.04 - Exploratory Program (1980)
Subtask 5.05 - Exploratory Program Design (1981)
Subtask 5.06 - Exploratory Program (1981)
Subtask 5.07 - Exploratory Program Design (1982)
Subtask 5.08 - Data Compilation

(iv) Subtask Scope Statements

For the purposes of this Plan of Study, the geotechnical exploratory programs are essentially divided into first-, second- and third-year stages (1980, 1981 and 1982). Exploratory work to be undertaken in 1982 and beyond is not included in Task 5 activities. Preparation of the program for 1982 is nevertheless included on the understanding that the 1982 program will be initiated prior to submission of the FERC license application, but is not an essential prerequisite

to that submission. The 1980 geotechnical exploration program will be designed to identify and investigate in limited detail those geological and geotechnical conditions which will significantly affect the feasibility of the proposed dam projects. Limited preplanning opportunities and climatic constraints are such that investigations in 1980 will be somewhat limited in scope, and the data limited in detail. Emphasis will therefore be placed on identifying and investigating to the maximum extent the most adverse geotechnical conditions encountered.

The objectives of the 1981 geotechncial exploration program will be to investigate in more detail those geological and geotechnical conditions, both general and adverse, which will significantly affect the design and construction of the proposed dam projects. Exploration along the routes selected for the access roads and transmission lines will also be undertaken in 1981. Although the scope of the exploratory work and the data produced in 1981 will still be somewhat limited, the exploratory program will be designed to establish with reasonable confidence the feasibility and total cost of the project, access roads and transmission lines. The exploratory program in 1982 will be yet more detailed. This and subsequent programs will be aimed at providing greater certainty in the design of major dams and structures with a view towards further ensuring the safety of structures while minimizing potential project cost overruns due to unforeseen geotechnical design conditions. The geotechncal exploration programs will be specifically designed to be complementary to the work already completed.

The geotechnical exploration programs in the field will also be severely constrained by difficulties of access and maneuverability of equipment imposed by weather conditions and the requirements for environmental preservation. Full account has been taken of these constraints in developing this Plan of Study.

A detailed discussion of the individual subtasks follows. It should be stressed that the exploration program design is based on the assumption that Watana and Devil Canyon are the selected sites.

Subtask 5.01 - Data Collection and Review

(a) Objective

Collect and review all existing geological and geotechnical data pertaining to the Susitna Project area, including the access road and transmission line corridors and the Susitna River basin.

(b) Approach

Data to be collected at this stage include, but are not limited to the following:

- previous regional and site geological mapping and studies
- published or unpublished geological and geotechnical data and reports from federal, state, academic or private sources
- air photos and high level ERTS photos of the project area, including the proposed access road and transmission line
- geophysical survey, remote sensing and seismicity studies and data pertaining or relevant to the project

A short field visit will be made to the proposed damsites for preliminary geologic interpretation. This will assist in making the preliminary damsite and dam alignment selections in Task 6. This in turn will determine the design of the exploratory investigation program. The data and results of review will be assembled into a brief report with appropriate appendices. These documents will be made available for subsequent use by all project design and study groups.

Borehole rock cores from previous investigations will also be examined in Anchorage. Contacts will be made with the University of Alaska to gather geologic and geotechnical data. A check will be made for mining interests in the project areas. Data pertaining to geological and geotechnical problems associated with the construction of large embankments, access roads and transmission lines will be collected. Discussions will be held with the U.S Corps of Engineers concerning details of the past field studies.

This task will be undertaken by Acres' Anchorage staff with appropriate support from R&M Consultants.

(c) Schedule

Week 0 through 9

Subtask 5.02 - Photointerpretation

(a) Objective

Perform air photointerpretation and terrain analysis of the Watana and Devil Canyon damsite areas, reservoir areas, construction material borrow areas and access road and transmission line corridors, and identify adverse geological features and geotechnical conditions that would signficantly affect the design and construction of the project features.

(b) Approach

Photointerpretation will be based on available air photography obtained under Subtask 5.01, and new aerial photos of a larger scale obtained under Task 2 for the damsites, reservoirs, and construction materials borrow areas, access road and transmission line corridors.

The initial photoanalysis will utilize existing air photos obtained either from private or government sources. These photos are believed to be high level and consequently small scale. They will, however, serve to establish preliminary surface geology, including geomorphology, geologic history, glacial geology, lithology and stratigraphy, structural geology, permafrost characteristics and geohydrology and engineering geology. Land forms will be identified. Alluvial or glaciofluvial deposits of previous sand and gravel; glacial deposits of impervious till and floodplain deposits of poorly drained, compressible silty materials will be located. The distribution, quality and stratigraphic relationships of rock types will be identified.

Photo analysis will also be used to generally delineate or infer permafrost areas and buried channels. Groundwater regimes will also be studied and unstable and/or erodible slopes identified.

A short field study will be required to verify the photointerpretation analysis. This will be performed early in the first field season (1980).

(c) Discussion

New air photos produced under Task 2 will be available at the end of the first field season. These low level, high resolution, large scale photos will have two purposes:

- preparation of second year exploratory investigation program
- production of accurate topographic maps on which to base subsequent geological mapping and design studies.

Photointerpretation under this subtask will be undertaken by Acres' Anchorage staff and closely coordinated with the photointerpretation work done by WCC (Subtask 4.05) in order to eliminate unnecessary duplication of work.

The results of photointerpretation will be documented in the form of brief summary reports and appended photographs and maps to highlight the principal findings.

(c) Schedule

Weeks 5 through 41

Subtask 5.03 - Exploratory Program Design (1980)

(a) Objective

Design the geotechnical exploratory investigation programs for 1980 for Watana and Devil Canyon damsites, dam construction materials, and reservoir areas, and along the access road route.

(b) Approach

The design of the various exploratory investigations will be based on the results of the data collection and review study (Subtask 5.01) and the air-photo interpretation study (Subtask 5.02). Input from the preliminary access road studies under Task 2 will also be required.

Generally, these exploratory investigations will consist of geologic mapping, auger drilling and sampling, test trenching, seismic and resistivity studies, airborne radar imagery techniques and laboratory testing. In cases where environmental damage is a problem or accessibility is poor, test trenches will be replaced by shallow auger drilling by helicopter. The design will specify the following details:

- area to be geologically mapped
- position and extent of seismic and resistivity lines
- areas to be investigated by airborne radar imagery techniques
- types and numbers of laboratory tests.

Investigations for access roads will be confined to geologic mapping and radar imagery. Table A5.3 and A5.5 detail the type and extent of investigations and laboratory testing that are currently proposed elsewhere. The design of the exploratory investigations will be flexible enough to permit changes during the execution of the work. These changes will become evident as the field studies proceed.

(d) Discussion

Work under this subtask will be performed by Acres' Anchorage staff with support in logistical planning provided by R&M and close liaison with WCC.

In the design of the exploratory investigations, full advantage will be taken of the extensive investigations previously undertaken. These include drilling, test pitting, geologic mapping and seismic surveys by the US Corps of Engineers at Watana damsite, and the drilling investigations and seismic studies at Devil Canyon by the US Corps of Engineers and the US Bureau of Reclamation.

- Watana Site

At the Watana damsite area, 17 boreholes have been drilled for a total of 3,340 feet and 11 boreholes have been drilled, totalling 1,815 feet in the right bank spillway and buried channel area. Reconnaissance reservoir mapping and fault mapping has been performed by Kachadoorian. A total of 19 auger and diamond drill

holes and 26 test pits have been made in the construction material areas. A total of 69,600 feet of seismic surveys has also been completed.

These investigations have tentatively shown the Watana site to be suitable for an earth and rock-fill dam. The dam foundation contains small shear zones but no major shear zones have been found. Construction materials appear to be available and suitable. Although the important Susitna fault traverses the reservoir, no active faults have as yet been proven in the reservoir. There has been a suggestion that the Tsusena Creek alignment downstream of the dam may represent discontinuity of some kind. Discontinuous permafrost exists locally. Overburden depth in the riverbed at the site appears to be less than 80 feet. A deep buried and potentially leaky channel exists in the right abutment.

Further studies at Watana are required to prove the absence of major faults in the riverbed and in the abutments, to delineate permafrost zones and identify its characteristics, prove the availability and suitability of the construction materials, confirm good quality rock in the spillway and powerhouse area and define the buried channel and identify its geohydrologic properties.

- Devil Canyon Site

At the Devil Canyon damsite, 13 boreholes totalling 1,350 feet have been drilled in the dam area and another eight boreholes totalling 735 feet have been drilled in the left abutment buried channel area. Nineteen test trenches have been excavated in potential borrow areas. A total of 3,300 feet of seismic surveys have been performed. Although there has been little geologic mapping of the abutments at Devil Canyon, the investigations have shown this site to be suitable for a concrete gravity structure.

Major shear zones have not been found in the dam foundation area but minor shear zones are present. Although no active faults have been found in the reservoir, a deep buried channel exists in the left abutment. Some potential construction material areas have been identified.

Further studies at Devil Canyon are required to prove the absence of major faulting in the riverbed and abutments or active faults in the reservoir. Studies are also needed to determine the site geology in more detail, to delineate and evaluate the left abutment buried channel and to prove the availability and suitability of construction materials.

(c) Schedule

Weeks 12 through 20

TABLE A5.3

PROPOSED GEOTECHNICAL EXPLORATORY PROGRAM - 1980

Area	Exploration	PROJECT STRUCTURES/FACILITIES Devil Canyon Dam & Reservoir	Watana Dam & Reservoir
Damsite	Geologic Mapping	yes	yes
	Geophysical (seismic and resistivity)	3 - 900 ft. lines at buried channel site 3 - Oblique 450 ft. lines across river channel 2 - 1,000 ft. lines on right abutment	1 - 5,000 ft. line at proposed spillway site 2 - Oblique 1,500 ft. lines across river within upstream portion of dam
	Diamond Drilling	1000 ft.	600 ft.
	Airborne radar imagery	± 3,500 ft. at right and left abutment and saddle dam site	± 4,000 ft. at right and left abutments
Dam Construction Materials		One established and two new borrow areas	Four established and two new borrow areas
	Geologic Mapping	yes	yes
	Portable Auger Drilling	20 - 10 ft. deep holes in the two proposed borrow areas	20 - 10 ft. deep holes in the two proposed borrow areas
	Geophysical (seismic and resistivity)	2 - 1,000 ft. lines in the two proposed borrow areas	2 - 1,000 ft. lines in the two proposed borrow areas
	Test Trenches	30 trenches in the three borrow areas	30 trenches in threen of borrow areas
	Airborne Radar Imagery	6 - 1,000 ft. lines in the three borrow areas	8 - 1,000 ft. lines in four of the borrow areas
Reservoir Basin	Geologic Mapping	yes	yes
	Portable Auger Drilling	10 - 10 ft. deep ho	10 - 10 ft. deep holes
	Geophysical (seismic)	2,000 ft.	6,000 ft. at site of right bank relict channel
	Diamond Drilling	100 ft.	100 ft.
	Airborne Radar Imagery	10,000 ft.	20,000 ft.

Subtask 5.04 - Exploratory Program (1980)

(a) Objective

Perform initial surface and subsurface investigations at Watana and Devil Canyon sites and reservoir areas and access road routes to establish general and specific geological and foundation conditions.

(b) Approach

The program will essentially be designed to

- obtain more details on the surface and subsurface geology and foundation conditions at the Watana and Devil Canyon damsites.
- complete the preliminary evaluation of the availability and suitability of the various construction materials required, i.e. fine and coarse aggregate, fine and coarse rockfill, impervious earth fill, pervious and semipervious granular fill and riprap.
- determine the surface geology and geotechnical conditions in limited detail to the Watana and Devil Canyon reservoir areas.
- provide preliminary geologic assessments of the proposed access road routes.

Field work programs will generally be designed by Acres' Anchorage office personnel with input from the Buffalo design group as needed. Seismologic input will be provided by WCC and logistical support by R&M. All field operations will be performed by R&M with appropriate technical inspection and supervision by Acres and to a lesser extent the WCC staff.

(c) Damsites

The proposed exploratory investigations will supplement previous work in establishing general and specific surface and subsurface geologic and foundation conditions at the Devil Canyon and Watana damsite areas.

The investigations will comprise geologic mapping, diamond drilling, geophysical, seismic and resistivity studies and airborne radar imagery, to substantiate and augment the available information on

- depth, distribution, type, stratigraphy and properties of overburden
- distribution, type, quality, degree of weathering and permeability of bedrock
- location, orientation, width, continuity, filling characteristics and capability of major discontinuities in bedrock such as faults

- orientation, frequency, opening, continuity and filling of joints in bedrock

- permafrost characteristics including location, temperature profile and soil type

- groundwater regime

Emphasis will be placed on locating and studying adverse geological features. Such features will include faults, excessive depths of overburden in riverbeds and buried channels which will signficantly effect the design and cost of a dam project at a given site.

The geologic mapping at Watana and Devil Canyon damsites will be undertaken to supplement and verify the previous geological mapping carried out by the U.S. Corps of Engineers and the U.S. Geological Survey (Kachadoorian).

The photointerpretation (Subtask 5.02) will be checked in the field, and adverse geologic features and conditions suggested in the photointerpretation will be investigated on the ground. The geologic mapping will utilize the most recent topographic maps. Aerial photos and survey lines normal to the river will be used as reference in the field. The geologic mapping will be performed primarily by Acres' Anchorage office personnel with assistance from R&M.

Geophysical seismic refraction and resistivity studies will be carried out primarily to determine bedrock depth in deep overburden areas such as buried relict channels and the riverbed area. This work will be done at both damsites. Seismic work can be misleading in permafrost regimes and resistivity provides a reasonable alternative.

Bedrock depth profiles will be prepared from these studies. Airborne radar imagery will be used to delineate the areas of permafrost. The geophysical work, including the interpretation, will be undertaken by R&M, with review and liaison by Acres' Anchorage office personnel.

(d) Construction Materials

The exploratory investigations for construction materials will comprise geological mapping, portable auger drilling, geophysical seismic and resistivity studies, test trenching and laboratory testing.

The geologic mapping, drilling, trenching and geophysical work will generally be used to establish the limits, depth, stratigraphy, type and properties of the borrow materials. The limits, type and properties of potential quarry rock will be similarly determined. The explorations will also serve to verify the photointerpretation and previous studies by the Corps of Engineers. Groundwater and permafrost conditions will be investigated and extensive soil sampling undertaken. Rock outcrops will be mapped and test trenches excavated by small track-mounted backhoes to a depth of about 13 feet.

Geophysical techniques such as seismic refraction and resistivity will be used to prove the depth of the potential borrow materials and the groundwater depth. Airborne radar imagery or low sun angle air photos will be used to assist in identifying the permafrost areas.

A moderate amount of laboratory testing of the borrow material will be conducted at this stage. The testing will comprise routine soil identification tests including unit weight, moisture content, consistency, Atterberg limits and gradation.

Standard Proctor compaction tests will also be performed on pervious and impervious material and permeability of compacted impervious materials assessed. Some dynamic shear strength tests under high confining pressures will also be performed on impervious and pervious materials. Potential concrete aggregate samples will be tested for sodium sulfate soundness, acidity and Los Angeles abrasion characteristics.

All field exploration work under this subtask will be undertaken by R&M. Laboratory testing on borrow material will be performed by R&M with some assistance from WCC .

Design liaison, supervision and review will be provided by Acres' Anchorage office personnel.

(e) Reservoir Areas

The exploratory investigations to be carried out for the reservoir areas will include geologic mapping, portable auger drilling and geophysical seismic refraction surveys.

The primary aim will be to map those geological features and geotechnical conditions in the reservoir area which may seriously affect the reservoir performance. Such features may include previous buried channels or faults in the reservoir rim which may jeopardize the reservoir watertightness, faults which may be activated under reservoir impounding and natural slopes which may become unstable or erodible with reservoir impounding or reservoir drawdown.

The geologic mapping will be on a reconnaissance scale. The airphoto interpretation (Subtask 5.02) will be checked on the ground and specific adverse features suggested in the photointerpretation will be investigated. The distribution, type and properties of overburden and bedrock materials will be checked against the photointerpretation. Portable auger drills will be used to drill shallow holes to assist in establishing the subsurface geology and geologic history. Low sun angle air photos or airborne radar imagery techniques will be utilized to help delineate general permafrost areas which may cause unstable slopes once the reservoir is impounded. Specific test areas will be identified in which auger borings utilizing a modified CRREL core barrel will be used to sample permafrost. Thermal probes will be installed in the holes to determine temperature profiles.

No buried channels have been found to date in the reservoir rim. If such channels are suggested in the photointerpretation, geophysical seismic studies will be initiated to determine the depth and nature of the overburden and channel widths.

A relatively minor amount of laboratory testing will also be undertaken in this phase. This will comprise routine soils identification tests on those samples taken in the reservoir studies.

All field and laboratory work undertaken under this subtask will be performed by R&M. Design liaison, supervision and review will be provided by Acres' Anchorage office personnel.

(f) Schedule

Weeks 20 through 40

Subtask 5.05 - Exploratory Program Design (1981)

(a) Objective

Design the geotechnical exploratory investigation programs for 1981 for Watana and Devil Canyon damsites, dam construction materials and reservoir areas, and for the selected access road and the transmission line routes.

(b) Approach

The design of the 1981 program will be determined to a large extent by the results of the 1980 investigations and other preliminary design activities in progress.

The 1981 investigations will be by means of a confirmation of the 1980 program of geologic mapping, auger drilling and sampling, test trenching, seismic and resistivity studies, airborne radar imagery techniques and laboratory testing. In addition, diamond drilling and in-hole seismic, borehole camera and instrumentation studies will be performed. The program will be designed to obtain more detailed information on the subsurface geology in general, on rock mass deformation properties, rock mass jointing characteristics and slope movement. Locations, depths and inclinations of the boreholes and methods and priorities of drilling will be defined, together with identification of which holes will be tested by in-hole seismic methods or studied by borehole camera.

The design of the exploratory investigations for the access road and transmission line will also be performed in this subtask. The access road and transmission line corridors will traverse terrain varying from flat, wet marshland and soft overburden to dry, sloping rock hillsides. No field investigations have been performed to date on the access road or transmission line.

Explorations along the selected transmission and access road routes will include drilling and sampling. To comply with environmental constraints, it is anticipated that this exploration will be undertaken using track-mounted hollow-stem auger drill rigs during the winter months of February and/or March. In wooded areas, helicopter supported auger rigs will be used to permit access. Exploratory investigations for the road will include delineation of areas of permafrost, unstable slopes, soft foundations and availability and suitability of construction materials. Investigations for the transmission line will be similar but will also be planned to determine probable tower foundation conditions.

Tables A5.4 and A5.5 outline the details of the proposed 1981 investigation and testing program as currently anticipated.

Design of the 1981 field program will take full account of the constraints necessary to comply with federal and state permit requirements.

(c) Discussion

The program envisaged at this time has been based on selection of the Watana and Devil Canyon sites for development. Preparation of the program design will be closely coordinated with activities of Tasks 2, 4, 6 and 8. This will ensure that the data obtained will provide cost effective input to the selected locations and designs of major structures, particularly the dams.

The field exploration data will be used to confirm or appropriately modify the adopted design criteria for embankment construction materials and foundations. Emphasis will be placed on ensuring the safety of structures and the minimization of potential construction cost overruns.

Work under this subtask will be performed by Acres' Anchorage staff with support in logistical planning provided by R&M and close liaison with WCC seismic investigations.

(d) Schedule

Weeks ~~59~~ through ~~70~~

AI 9V

TABLE A5.4

PROPOSED GEOTECHNICAL EXPLORATORY PROGRAM - 1981

Area	Type of Exploration	POWER STRUCTURES/FACILITIES		
		Devil Canyon Dam & Reservoir	Watana Dam & Reservoir	Other
Damsite	Geologic Mapping	yes	yes	
	Diamond Drilling	4 holes in right abutment (powerhouse and dam) 4 holes in left abutment (saddle dam and diversion tunnel) 3 holes in riverbed*	2 holes in relict channel, right abutment 2 holes in right abutment spillway and dam) 2 holes in left abutment (powerhouse and dam)**	
	In-hole Seismic	1500 ft.	1000 ft.	
	Borehole Camera	1500 ft.	1200 ft.	
	Test Trenching	15 trenches	15 trenches	
Dam Construction Materials		Three borrow areas from 1980 program plus two new areas	Six borrow areas from 1980 program plus two new areas	
	Auger Drilling	10 - 30 ft. deep holes	12 - 30 ft. deep holes	
	Diamond Drilling	10 - 50 ft. deep holes in five borrow areas	12 - 50 ft. deep holes in six borrow areas	
	Test Trenching	30 trenches in two new areas	30 trenches in two new areas	
Reservoir Basin	Geologic Mapping	yes	yes	
	Portable Auger Drilling	10 - 10 ft. deep holes	10 - 10 ft. deep holes	
	Diamond Drilling	3 - 100 ft. deep holes, 1 - 200 ft.	3 - 100 ft. deep holes, 1 - 200 ft.	
	Geophysical/Seismic	1000 ft.	1000 ft.	
	Reservoir Slope Monitoring	1 - 200 ft. slope indicators	1 - 200 ft. slope indicator	
Access Road Route (Approx. 50 miles)	Geologic Mapping Airborne Radar Imagery Portable Auger Drilling Hollow Stem Auger Diamond Drilling			ACCESS ROAD yes 10 miles (20% of total length) 25 - 10 ft. deep holes 15 - 50 ft. deep holes
Transmission Line Route (Approx. 360 miles)	Geologic Mapping Portable Auger Drilling Hollow Stem Auger Diamond Drilling			TRANSMISSION LINE yes 35 - 10 ft. deep holes (one per 10 miles) 35 - 50 ft. deep holes (one per 10 miles)
Major Fault Lines	Test Trenching Geophysical (seismic) Gravity Survey			FOR SEISMIC STUDY 12 test trenches at six sites

NOTES:

*Average depth of holes is expected to be 275 feet and total drilling length approximately 3,025 feet, of which 1000 feet will be completed in the 1980 program. This would increase total at site to 5,025 feet.

**Average depth of holes is expected to be 350 feet and total drilling length approximately 2,000 feet, of which 600 feet will be completed in the 1980 program. This would increase total at site to 5,450 feet.

Subtask 5.06 - Exploration Program (1981)

(a) Objective

Complete surface and subsurface investigations at Watana and Devil Canyon sites, reservoir areas, access roads and transmission line routes to the extent necessary to provide adequate data to confirm project feasibility and for submission of the FERC license application.

(b) Discussion

This program will essentially be designed to

- complete the investigation of the surface and subsurface geology and foundation conditions at the Watana and Devil Canyon dam site to a level sufficient to ensure safety of design of major structures and foundations and reliable project construction cost estimates.

- establish detailed geological conditions and geotechnical properties of potential construction material sources to ensure the adequate availability of embankment fill.

- undertake a detailed evaluation of the geological features and geotechnical conditions in the Watana and Devil Canyon reservoir areas to ensure the safety and integrity of the impoundments.

- to determine the surface and near surface geology and foundation conditions along the selected access road and transmission line routes to ensure technical and economic feasibility for submission of the FERC license application.

Field work programs will generally be designed by Acres' Anchorage Office personnel with input from the Buffalo design group as needed. Seismologic input will be provided by WCC and logistical support by R&M. All field operations will be performed by R&M with appropriate technical inspection and supervision by Acres and WCC staff as necessary.

(c) Damsites

The proposed exploratory investigations at the dam sites will comprise geologic mapping, diamond drilling, geophysical in-hole seismic testing, borehole camera studies, test trenches and laboratory testing.

The exploratory methods used in this program will be involved in collecting detailed information to augment and complement that obtained in 1980. The surface geological mapping will be completed. Outcrops will be located by survey and mapped in detail. Adverse geological features will be further investigated on the surface. Exploratory drilling will be performed at both sites in the various structure areas on both abutments and in the riverbed to determine foundation conditions. Diamond drills of the Longyear 34 type or

equivalent will be used. Split-spoon and Shelby tube sampling, as well as standard penetration tests will be performed in the overburden. NX-size core will be drilled and double-tube core barrels will be employed for maximum core recovery.

Some boreholes will penetrate to a depth equal to the head to evaluate deep seated conditions. Permeability testing will be performed and piezometers will be installed. Major discontinuities suggested by previous drilling or surface mapping will be further explored by drilling and verified. Potential leakage channels, the depth of weathered rock on the abutments and the depth of overburden in the riverbed will be probed by drilling. Riverbed drilling at each site will be undertaken during the winter months to take advantage of the ice cover. Drills will be moved by helicopter. Drilling operations will be performed by R&M with inspection and review by Acres' Anchorage office personnel.

The evaluation of the foundation rock conditions will be further supplemented by in-hole geophysical testing and borehole camera studies. The in-hole geophysical testing which will be done by R & M will provide a relative measure of the rock quality, and more specifically, the deformation modulus. The borehole camera studies which will be done by Acres will serve to evaluate the in-situ rock jointing characteristics.

Permafrost conditions will be closely studied with the assistance of thermal probes installed in boreholes. Test trenches will be used to assist in the geological mapping process.

Laboratory testing will be carried out for the purpose of describing the overburden characteristics. Samples of foundation overburden material which may be left in place beneath the dam structure will also be tested for static and dynamic shear strength under high confining pressure. Samples of weak, clay-filled seams in the rock will be taken and subjected to direct shear strength testing. Samples of rock core will be subjected to sonic velocity and for unconfined uniaxial compressive strength tests. Laboratory sonic velocities will be compared to the field in-hole geophysical testing. Samples of jointed rock also will be tested for frictional shear strength along discontinuities. Most of the laboratory testing will be performed by R&M with some assistance from WCC and technical supervision by Acres' Anchorage office personnel.

(d) Construction Materials

The exploratory investigations will essentially comprise diamond drilling, test trenching and laboratory testing. Some geologic mapping and geophysical studies will also be undertaken. Emphasis will be placed on firming up the quantity estimates and proving the quality of available borrow materials. New borrow areas may also be explored. Drilling will be carried out in both borrow areas and potential rock quarries. Split-spoon and Shelby tube sampling and standard penetration tests will be performed. Drills will be moved by helicopter. Drilling will be done by R&M, with inspection and review by Acres.

A considerable amount of laboratory testing of the borrow material samples will be undertaken in addition to the routine soil identification tests, Proctor compaction testing, permeability testing and concrete aggregate testing, including static, dynamic and direct shear strength testing. Strength tests will consist of consolidated undrained tests with pore pressure measurements on pervious and impervious materials. The dynamic tests also will be done under high confining pressure and on pervious and impervious material. A limited number of direct shear tests may be made on impervious materials.

Laboratory testing on the borrow materials will be performed mainly by R&M with assistance from WCC and technical inspection by Acres.

(e) Reservoir Areas

To avoid unnecessary duplication of work, this task will be closely coordinated with the WCC Task 4 studies.

The investigations to be carried comprise geologic mapping, auger and diamond drilling, seismic refraction surveys, reservoir slope monitoring and laboratory testing. Adverse features identified in the 1980 program will be further explored.

A minor amount of laboratory soil identification testing will be undertaken for the reservoir studies. These tests will provide data which will assist in establishing the geology.

With the exception of the geologic mapping, all of the reservoir investigations will be done by R&M, with technical supervision by Acres.

(f) Access Road Routes

The exploratory investigations along the selected access road corridors will comprise geologic mapping and airborne radar imagery studies to amplify the 1980 work. In addition, in 1981 portable auger and hollow-stem auger, diamond drilling and laboratory testing work will be undertaken.

Preliminary access route selection studies will be undertaken in Task 2 and detailed designs under Task 6. The field investigations will be designed to achieve a minimum level geological and geotechnical understanding of the conditions along the selected route on a reconnaissance scale. This will permit an assessment of the general conditions as well as those problems likely to affect the design and construction of the access road significantly. Feasibility cost estimates will then be facilitated.

Exploratory investigations will generally concentrate on the surface and near surface soil and rock distribution, types and properties, permafrost limits, groundwater conditions, potential landslide areas and the availability and suitability of construction materials. Potential bridge sites will require more detailed studies of the abutment foundation conditions.

The type of investigation and scope of work for a particular type at a given site will depend on the anticipated foundation conditions, as determined by air-photo interpretation and geological inference, and the foundation requirements.

The general study approach will be first to perform the hollow-stem auger drilling and sampling at designated sites during the winter months. A track-mounted drill can best carry out this work with least cost and environmental damage, except in wooded areas as previously indicated. Later, in the snow-free season, geological mapping, airborne radar imagery, portable auger drilling and sampling will be done. The mapping will establish the general overburden and bedrock geology (surface distribution, types and properties) and will verify the photointerpretation. The airborne radar imagery will be used to delineate areas of permafrost and freedraining granular deposits. Shallow auger holes will probe the near-surface geology. Soil samples from the winter and summer drilling will be selected for routine laboratory identification tests as well as unconfined compressive strength tests and Proctor compaction tests.

The laboratory work and most of the exploratory work will be performed by R&M with geological mapping and technical supervision by Acres' Anchorage office staff.

(g) Transmission Line Routes

The exploratory investigations along the transmission line will comprise geologic mapping, airborne radar imagery studies, portable auger, hollow-stem auger, diamond drilling and laboratory testing.

The most feasible transmission line route will be selected in Task 8. The basic approach adopted to geotechnical explorations will be similar to that for the access road route.

The investigations will be performed with specific tower foundations in mind, i.e., anchored footings in rock, spread or mat footings in granular deposits, piles or caissons in silt and clay. Sections of transmission line on well-drained, granular deposits of rock will require less detailed study. Detailed drilling and sampling, however, will be done in areas of soft, compressible or thaw-unstable foundations. Vane shear strength testing will be required in soft compressible foundations. In these potential problem areas, information will be required on the type, stratigraphy and properties of the soil foundation. Foundations of towers at points of line direction change will require special attention due to the most stringent foundation requirements. Foundations of towers at the ends of long spans or on potentially unstable slopes will also require special attention.

R&M will perform the field explorations and laboratory testing with geologic mapping and technical supervision by Acres.

(h) Schedule

Weeks 56 through 91

Subtask 5.07 - Exploratory Program Design (1982-1984)

(a) Objective

Design of the geotechnical exploratory investigations program for 1982-1984 to obtain basic design data for Watana damsite, dam construction materials and reservoir area, and for the selected access road and transmission line routes.

(b) Approach

A great deal of exploratory information will have been obtained prior to 1982 and a substantial amount of safe, reliable, project component designs undertaken prior to submission of the FERC license application. Although this work will be adequate to ensure project feasibility with a reasonable level of confidence, further exploratory work is essential to minimize the possibility of unforeseen conditions which could potentially impact the safety and cost of major structures. This exploratory work will provide the necessary input to the ongoing detailed design work through commencement of project construction. Based on the Corps studies to date, it is currently anticipated that construction of the Watana diversion scheme will be the first activity to follow award of the FERC license. The adopted diversion scheme will in turn depend to a large extent in the layout of the major project components. It is therefore anticipated that following submission of the FERC license application for the Susitna Project, further exploration investigations will be necessary to fully determine in detail all significant geologic and geotechnical factors affecting the following:

- the diversion tunnels and cofferdams
- the dam and other major structure foundation treatment and designs
- the availability of adequate supplies of cofferdam construction materials
- subsurface design conditions at the proposed locations of underground structures
- the potential for ground instability as a result of erosion adjacent to diversion tunnel spillway and tailrace discharges
- the watertightness and integrity of the reservoir
- design of access roads

(c) Discussion

The extent and scheduling of this additional exploratory work will be influenced to a great extent by the findings of the 1980 and 1981 programs and the development of project designs. This subtask will be undertaken in late 1981 and early 1982 with a view to ensuring continuity of exploratory work in 1982 and beyond. The major portion of this subtask will be undertaken by Acres' Anchorage office staff with appropriate input and support by WCC and R&M.

The scheduling of the 1982-1984 program will be significantly affected by the availability of access facilities. Although certain portions of the program can be accomplished within the same environmental constraints as those undertaken in 1980 and 1981, other portions of the 1982-1984 program will require the access road to be available for use. Thus, for the purpose of this plan of study, it is assumed that the access road will be designed and the necessary permits obtained by commencement of the 1982 construction season.

For purposes of this plan of study, it has been assumed that the selected access road route will commence at a staging area to be constructed at the railroad at Gold Creek and essentially follow the left bank of the Susitna River to the Watana site. Bridges will be required at several ravine and river crossings. Bridge abutment foundations will be somewhat more closely investigated than the general alignment of the road. Slightly modified routes and bridge sites also may be investigated. New borrow areas may be studied. Proposed high rock and soil cuts will be explored for stability. Further drilling may be required to firm up the permafrost characteristics.

The 1982-1984 program of exploratory investigations for transmission lines will comprise further hollow-stem auger drilling and sampling, vane shear testing, laboratory testing and geological mapping, if necessary. These tools will be used to obtain considerably more data on the general and the geotechnical conditions which affect the design of the transmission line.

Pump well testing in the riverbed will be required in areas of deep and pervious riverbed overburden. This testing will be used to estimate representative permeability values for design of riverbed excavation dewatering systems.

The 1982-1984 laboratory testing program will be designed to determine reliable values for the overburden properties. These data, together with standard penetration test data will be essential in defining the extent of removal of materials under the proposed dams.

(d) Construction Materials

More diamond drilling, trenching and laboratory testing will also be required in the construction material areas. This program will be designed to further substantiate the availability and properties of rockfill, impervious, semipervious and pervious earthfill, rockfill and rip-rap materials. Sampling will again be done by split spoon or Shelby tube. Laboratory testing as described in Table A5.5 will be expanded to include several large triaxial shear strength tests in earth and rockfill under high confining loads.

(e) Reservoir Areas

The proposed 1982-1984 investigation program will be designed to amplify the information obtained in 1980 and 1981. Final drilling

and instrumentation will be completed in the reservoir areas. The program will include diamond drilling, reservoir slope monitoring and laboratory testing. These exploratory tools will be used to obtain detailed data on geotechnical conditions in potential problem areas such as pervious buried channels in the reservoir rim or unstable rservoir slopes. Further geological mapping may be required for adverse features identified in the 1981 program. Potentially unstable slopes will continue to be monitored together with piezometric levels.

A relatively small amount of laboratory testing will be undertak for the reservoir area in this phase.

(f) Access Roads and Transmission Lines

The scheduling of the remaining exploration for the access roads is such that this work will have to be completed in early 1982. For transmission lines, on the other hand, the program can be spread over a longer period without affecting overall scheduling of the project. The data requirements for the design of the roads and transmission lines, although fewer than for the dams, are similar in scope. Minimum detailed information on the overburden properties such as compressibility, shear strength, permeability and compaction characteristics, and rock quality and strength (for the bedrock), will be required for the basic design.

Thus, for the access road and transmission line areas, additional foundation drilling, sampling and laboratory testing will be required in this program. Firm quality and quantity estimates of construction materials will be required for the access road. In the transmission line, drilling and sampling will be required for each tower foundation. Foundation drilling for the access roads and transmission lines is best undertaken in the winter months by means of a track-mounted, hollow-stem auger diamond drill.

(g) Schedule

Weeks 95 through 120

Subtask 5.08 - Data Compilation

(a) Objective

Assemble all geotechnical exploratory data into documents suitable for inclusion in relevant project reports and licensing documentation.

(b) Approach

Data to be compiled will include the following:

- air-photo interpretation
- geologic mapping
- seismic and resistivity data
- borehole logs
- auger hole logs
- test trench logs
- airborne radar imagery data
- laboratory test data

The test trench logs will be prepared to describe the overburden in the borrow areas. Laboratory testing data will be incorporated into these logs. Seismic and resistivity profiles will be prepared to show the ground surface and the bedrock topography. This information will be combined and used to prepare preliminary site geology maps and sections which will form the basis for the preliminary geotechnical assessments to be performed in Task 6. The maps and sections will show the overburden and bedrock surface distribution, types and characteristics, faults, jointing, permafrost areas, potentially unstable slope or poor foundation areas and buried channels. Geologic maps will range from reconaissance scale in the reservoir areas to limited detail in the damsite areas.

Borehole and test trench logs for the 1982 program will be used to substantiate and improve the geological maps and sections and to show surface and subsurface geology and geotechnical conditions of importance to the design and construction of the dams, access roads and transmission lines.

(c) Discussion

Although R&M and WCC will provide some input to this subtask, all final compilation of data will be undertaken by Acres in its Anchorage and Buffalo offices.

Compiled data will be attached to the periodic reports issued as the work progresses. Detailed reports summarizing all the exploratory investigations will be prepared at the end of each exploration season.

(d) Schedule

Weeks 5 through 125

A.5.7 - TASK 6: DESIGN DEVELOPMENT

(i) Task Objectives

To undertake planning studies, to evaluate, analyze and review all previous engineering studies related to hydroelectric development of the Upper Susitna River Basin and to develop preliminary engineering design and cost information for Watana and Devil Canyon Dam sites with all associated intake, outlet works, spillways and power facilities to allow preparation of a project feasibility report.

(ii) Task Output

The primary output of Task 6 will be a logical and systematic development of the requisite project features. Alternative sites for dams and power developments will be evaluated. Alternative arrangements at each site will also be considered. One such alternative will involve a 30-mile long power tunnel from Watana to Devil Canyon to eliminate the high dam at that site. A Development Selection Report will be issued on or about Week 65 of the Study for review and approval by Alaska Power Authority. Preliminary findings of the study will be discussed on or about Week 50, in order to establish whether or not work on two dam sites should continue or whether more viable alternatives exist and should be examined. Design transmittals will be at appropriate points in the study. All necessary input from parallel tasks including hydrology, geotechnical, economic, seismic, survey, and environmental studies will be factored into the planning studies and the development of the various features of the project. Engineering evaluation criteria and project definition will be developed. If sites are found to be technically viable, economically feasible and environmentally acceptable, additional studies and investigations will be conducted to establish the feasibility of the project and the optimum scale and sequence of development.

(iii) List of Subtasks

Subtask 6.01 - Review of Previous Studies
Subtask 6.02 - Investigate Tunnel Alternative
Subtask 6.03 - Evaluate Alternative Susitna Developments
Subtask 6.04 - Evaluation of Arch Dam at Devil Canyon Site
Subtask 6.05 - Development Selection Report
Subtask 6.06 - Watana/Devil Canyon Staged Development Alternatives
Subtask 6.07 - Preliminary Watana Dam Alternatives
Subtask 6.08 - Preliminary Devil Canyon Dam Alternatives
Subtask 6.09 - Establish Watana Design Criteria
Subtask 6.10 - Establish Devil Canyon Design Criteria
Subtask 6.11 - Preliminary Design Watana Dam
Subtask 6.12 - Preliminary Design Devil Canyon Dam
Subtask 6.13 - Dam Selection Report
Subtask 6.14 - Spillway Design Criteria
Subtask 6.15 - Watana Spillway Alternatives
Subtask 6.16 - Devil Canyon Spillway Alternatives
Subtask 6.17 - Preliminary Design Watana Spillway
Subtask 6.18 - Preliminary Design Devil Canyon Spillway

Subtask 6.19 - Spillway Selection Report
Subtask 6.20 - Access and Camp Facilities
Subtask 6.21 - Watana Diversion Scheme
Subtask 6.22 - Devil Canyon Diversion Scheme
Subtask 6.23 - Optimize Watana Power Development
Subtask 6.24 - Optimize Devil Canyon Power Development
Subtask 6.25 - Optimize Dam Heights
Subtask 6.26 - Preliminary Design Watana Power Development
Subtask 6.27 - Preliminary Design Devil Canyon Power Development
Subtask 6.28 - Power Development Report
Subtask 6.29 - Watana General Arrangement
Subtask 6.30 - Devil Canyon General Arrangement
Subtask 6.31 - Feasibility Report

(iv) Subtask Scope Statements

Plate T6.1 illustrates the interrelationship of various subtask studies and the logical input of various other tasks. The subtasks have been specifically arranged to make maximum use of input from various other tasks including Tasks 1 through 5 and 7 through 9. A detailed discussion of the objectives, the methodologies and associated costs and scheduling for each subtask follows. Note that for the purpose of this plan of study, it has been assumed that only Watana and Devil Canyon sites will be considered for additional field exploration and analysis. However, in the initial subtasks, all possible sites and modes of development on the Susitna will be examined to confirm that the Watana/Devil Canyon arrangement is the most appropriate.

Subtask 6.01 - Review of Previous Studies and Reports

(a) Objective

Assemble and review all available engineering data, siting and economic studies relating both to the Susitna hydropower development and to alternative potential sites.

(b) Approach

Reports and also field reconnaissance studies generated by various agencies including USBR, the Corps of Engineers, Kaiser and others will be reviewed to assess the design assumptions for the sites. Information obtained from these reports, including reservoir storage and power head, site evaluation, geologic and seismic conditions, topographic features and other special physical and environmental constraints, will be tabulated. Total potential for power development at each site and the associated costs will be assembled in tabular form; costs will be updated to current levels for comparison. Sites studied will include all those identified in the previous reports.

Layouts for all sites and special constraints for each site will be identified. All conceptual design parameters will be developed to update the cost of each site to a uniform level in order to rank the sites. The task will include the indexing of all basic information that could be used in analysis under Subtask 6.03. Indexing will include all basic information on nature, type and extent of geotechnical investigations previously completed, maximum level of development considered for each site, type and size of dam selected, type and size of spillway considered for each site studied, and on-line dates considered in the previous reports. Other data to be indexed will include reservoir storage, average, maximum and minimum flow, regulated flow, power capacity and energy development at each site, equivalent construction costs and other factors, such as special environmental and seismic impact on each site.

(c) Discussion

The level of study previously undertaken for each site varies considerably, not only with respect to geotechnical investigations and preliminary planning, but also in relation to hydrologic and economic assessment. Project ranking techniques and cost updating criteria will necessarily have to include additional cost parameters and analysis. These data will be used at the specified level of development as an input to Task 6.03.

In order to meet the overall objectives of the subtask, a critical review and assessment will be made of all technical information on power capacities; and other constraints for the development of each site will be identified. Previous work has identified six dam sites for which ranges of heights and power installation have been considered. These sites will be analyzed in order to select the projects which are both technically feasible and economically attractive for initial construction and are compatible with the plan

for hydropower development of the entire basin. It is likely that some of the sites will be rejected in initial screening because of poor foundations or because of very high cost of development. Previous studies have demonstrated that the Watana and Devil Canyon sites are probably the most favored; but if the studies under this task indicate otherwise discussions with the Alaska Power Authority will be scheduled immediately.

All cost data from the previous reports will be updated to 1980 cost levels. As project costs are highly dependent not only upon site foundation conditions, size of spillway and outlet works, but also upon whether a low level outlet is provided, costs will be adjusted to a common design.

(d) Schedule

Weeks 25 through 40

Subtask 6.02 - Investigate Tunnel Alternatives

(a) Objective

To investigate the feasibility of a scheme for development of the Susitna River eliminating the Devil Canyon project by the substitution of a tunnel-supplied power plant fed from the Watana dam site.

(b) Approach

A preliminary review of the proposed Watana/Devil Canyon development of the Susitna River suggests that a feasible alternative, which would allow the elimination of the major reservoir formed by the Devil Canyon dam, would comprise the construction of a power tunnel starting at, or near, the currently proposed Watana site and terminating at a power plant near the proposed Devil Canyon site as illustrated in Plate T6.2.

In addition to the reduced environmental impact brought about by the elimination of the Devil Canyon dam and lake, the tunnel alternative would eliminate a major dam, reduce the size of one power plant, and allow a much larger proportion of the construction work to be located underground, shielded from severe Alaskan winters.

Potential disadvantages of the tunnel alternative include loss of power output due both to head losses in the tunnel and to the necessity to maintain flow in the river between Watana and the lower power plant tailrace. The considerable length of the tunnel would require the provision of several construction adits with corresponding environmental impacts during construction.

In order to make an initial assessment as to whether this alternative should be carried forward into more detailed evaluation, the following activities are proposed:

(1) On the basis of the material assembled in Subtask 6.01, a number of tunnel alternative arrangements will be identified. Some preliminary concepts are shown in Plate T6.2. Several others incorporating different tunnel alignments and intake/power plant locations will be identified.

(2) These initial alternatives will be subjected to a gross screening to eliminate those least likely to meet economic, technical or environmental requirements. Preliminary layouts will be developed for those remaining and major dimensional and design characteristics will be established.

(3) Preliminary quantity and cost estimates will be prepared for the selected tunnel alternatives, together with corresponding cash flows.

(4) Estimates of capacity and energy for each of the alternatives will be developed.

(5) The most attractive of the tunnel alternatives will be compared from the technical, economic, and environmental standpoints with other options for the river development identified in Subtask 6.03.

(c) Discussion

The tunnel alternative to the Devil Canyon project would appear, from initial review, to have some rather attractive features which may warrant careful evaluation. From the environmental standpoint, the elimination of the large Devil Canyon reservoir must be a significant step. This may, of course, be offset to some extent by the increased live storage to be provided at Watana and by the possible wider spread of construction activity during tunnel construction. Initial "order of magnitude" cost estimates seem to indicate at least a trade-off level of cost for the tunnel alternative, without assessing the impact on the schedule and power generation capabilities of the long power tunnel.

(d) Schedule

Weeks 30 through 50

Subtask 6.03 - Evaluate Alternative Susitna Developments

(a) Objective

To identify the most appropriate scheme for development of the Susitna River on the initial basis of technical feasibility and cost.

(b) Approach

Primary input for this subtask from the cost and technical standpoints will be derived from the review of previous studies (Subtask 6.01) and from the investigation of the "tunnel alternatives" (Subtask 6.02). Further input will be provided from the hydrological studies undertaken in Task 3 and from the public participation program carried out under Task 12. This subtask will involve the development, comparison and subsequent ranking of all reasonably feasible combinations of sites and power facilities identified either in the previous studies or in the course of Acres studies to this time. Economic parameters for a range of dam heights and power installations will be developed for each site and for the complete river development; these will be analyzed by computer to identify the most promising scheme.

Specific activities will include:

- Evaluation of six previously identified sites including Susitna I and II, Denali, Vee, Watana and Devil Canyon and other sites, for which data will be obtained from the review of literature (Subtask 6.01).

- Data on rated head, regulated flow, yield and power available from previous reports for these sites will be developed and the value and cost of power for each site will be compared. Only previous layouts and engineering information generated will be evaluated.

- Data on foundation conditions, availability of construction materials, limits of development of each site, access conditions, seismic and environmental conditions for each site will be reviewed in site-ranking studies.

- Sites with extremely poor foundation conditions and other serious constraints related to seismic or environmental impact will be rejected.

- A summary report on this ranking study will be prepared.

(c) Discussion

By this stage of the study, costs of alternative power and energy will be available for economic comparison and development of cost-benefit ratios of each individual site, and by combination for each set of developments discussed above. It would appear from previous studies that the combination of Watana and Devil Canyon sites is the most promising development, and it is expected that the results of this

work will verify this. However, if the results of the study indicate otherwise, the layout, costs and details of the alternative arrangement will be brought to the same level as the studies for the 1979 report by the Corps of Engineers for the Watana and Devil Canyon sites. The evaluation will rank the sites or the combination of various sites with power capability at each, and establish associated costs and cost-benefit ratios for each combination studied. Alternatives will include combinations of Watana dam sites and power tunnels. The results of these studies will be documented in the form of a memorandum which will form a basis for further studies. The report will explain the mechanics of the evaluation process and the rationale of specific site and combinations of sites, foundation suitability and availability of construction materials. Economic comparisons from cost/benefit analysis will indicate the environmental impact on each such site. The selected alternative will be that which proves to be the most favorable for development of the Upper Susitna Basin.

(d) Schedule

Weeks 40 through 60

Subtask 6.04 - Evaluation of Arch Dam at Devil Canyon Site

(a) Objective

To make a preliminary assessment of the feasibility of an arch dam at the Devil Canyon site.

(b) Approach

The original development at the Devil Canyon site recommended by the Corps of Engineers incorporated a 635 foot high double curvature thin arch dam with a crest length of 1,370 feet. Following critical comment by the OMB, the Corps, in their Supplemental Feasibility Report (1979), proposed an alternative which would replace the arch dam with a more costly gravity dam. The primary rationale was the reduced sensitivity of the gravity dam to foundation and abutment conditions.

We will critically review the feasibility of an arch dam at the Devil Canyon site from both economic and technical aspects, as well as the overall safety aspect.

The review and evaluation will comprise the following:

(a) Assembly and review of all available material relating to the arch dam design recommended in the Corps' report and earlier in Bureau of Reclamation reports.

(b) A critical examination of all geotechnical data relating to the foundation and abutment conditions at the proposed dam site. These data may well include further information obtained in the course of the ongoing field investigations.

(c) A critical review of the seismic conditions at the site, particularly in the light of material developed in the course of Task 4 Seismicity Studies.

(d) A review of current design practice in relation to high arch dam design in seismically sensitive areas.

(e) The development of the draft design of an arch dam appropriate to the conditions at Devil Canyon. Design will be accompanied by associated schedule and cost estimate, including impact on associated structures.

(f) Review of proposed design by Special Consultants and modifications as required.

(g) Final evaluation of feasibility of the arch dam from the technical, economic and safety standpoints and development of a recommendation as to whether an arch dam or another design of dam should be carried through to the licensing documentation.

(c) Discussion

The arch dam design at Devil Canyon was supplemented with an alternative conventional gravity design by the Corps in the 1979 Supplemental Report. Economic feasibility of the project using more conservative design approaches was demonstrated. An underlying concern regarding the safety of arch dams in high zones is evinced by the recent decision regarding the Auburn dam.

However, it is of interest to note that as reported in a recent issue of Water Power and Dam Construction, April 1979, not one failure of a concrete dam directly caused by earthquakes has ever been recorded. Linear analytical techniques for evaluation of the response of concrete structures to seismic forces have evolved, the most widely used being the finite element technique. Acres recently utilized this technique to evaluate the Karun high arch dam proposed in Iran with a height of 325 meters. In general, concrete dams perform very well when subjected to earthquakes. Of the types available, arch dams generally have proven to perform the best and buttress dams have been subject to the severest damage because of abrupt change in section and the resultant stress concentrators.

The V-shape canyon with a ratio of 2.15 (width at crest level--1,370 feet to depth--635 feet) is favorable for a double curvature arch dam. As an example, the experience of dam building in Japan can be cited. The average seismic intensity experienced at various types of Japanese dams (in 12 point scale) is:

- gravity dams 9.8
- arch and arch gravity 10
- rockfill dams 8.5

Such high arch dams as Kurobe (186 m), Nagovado (155 m), Iagisawa (131 m), Takane (130 m), Kawamata (120 m) and others were built in areas with earthquake intensity 10 to 11 points.

There are a number of approaches which can be used to condition the abutments of arch dams to weaknesses of the rock. Stresses in the foundation may be reduced, not only by increasing the abutment thickness of the arch, but also by using abutment pads. In addition to being a very satisfactory means of spreading arch thrusts, abutment pads provide an efficient means of bridging faults and other weaknesses in the foundation. Abutment pads are applied on the world's highest arch dams at Ingury (U.S.S.R. 271 m) and were proposed for the Auburn dam (U.S.A. 209 m).

Severe weather conditions will cause serious problems for both dam types. Besides the necessity to prevent freezing and cracking of concrete during construction, a serious consideration will be consolidation of the dam body and rock base.

In Russian dams built in Siberia, grouting joints between monoliths were replaced by slots 1.2 m wide backfilled with concrete after cooling the monolith below the average annual temperature (the average annual temperature in the core of the dam is 2°C to 3°C higher than the average annual temperature of the area). If the area average temperature is below zero, the concrete should be cooled to a temperature of not more than +1 to +2°C. Such a procedure involves a long time and high cost. The Russian Mamakan and Zeya dams are hammerhead type (buttress type). This type of dam provides easy access to the slots from the hollow spaces. Concreting of the slots is performed after warming up the surfaces of slots by means of electric heaters. After filling the reservoir, the temperature of the dam body will rise and the concrete plugs will be compressed.

Another problem is prevention of the negative effect on the stress state of the dam caused by freezing of the downstream part of the dam. Static analysis and model tests performed for gravity dams located in Siberia (annual average temperature -2°C to -4°C) showed that for the winter, the frost can penetrate to the center of the dam, causing opening of the horizontal joints and, as a consequence, tensile stresses on the upper face of the dam (reductions in the compressive stresses of up to 30 percent were demonstrated). For this reason, hammerhead or massive buttress dams with heating inside the hollows were built in Russia (Mamakan, Zeya, Bratsk, Buchtarma) instead of massive gravity dams. At the Mamakan dam, the electric heating system is in operation for one to one and a half months a year, and the capacity of the heaters is 80 kW. Another method of preventing freezing is to insulate the downstream face of the dam.

Consolidation of an arch dam is much easier because arch dams do not have longitudinal construction joints. Concreting of the slots after cooling the monolith below the average temperature will produce an effect similar to heating gravity monoliths. In general, arch dams, since they are more flexible and smaller volume working structures, can cope more easily with severe temperature conditions than gravity dams.

Nonetheless, some improvements of the presently proposed arch dam are likely to be necessary.

(a) An abutment pad should be used. It functions as a transition structure between arch and rock, and as such, may be thickened, widened and reinforced as necessary. In addition, the abutment pad may be used to improve symmetry of the canyon profile.

(b) A two-centered dam layout with two separate pairs of lines of centers, one for each side of the dam, should be used to cope with the unsymmetrical shape of the canyon.

(c) The slenderness of the dam is $\frac{85.6}{635} = 0.135$ (base thickness to height), and it requires reevaluation in light of seismic and temperature conditions.

The slenderness coefficient should probably be increased to 0.16 and the base thickness to 0.16 x 635 = 101.6 feet (31 m).

Note, however, that even if it is considered that an earthfill, rockfill dam or concrete-gravity dam should be considered for FERC licensing application, some background information should be developed for an arch dam. Later studies may possibly indicate technical feasibility or economic and environmental desirability, and the option to revert to the arch design should be maintained open for as long as possible.

(d) Schedule

Weeks 45 through 65

Subtask 6.05 - Development Selection Report

(a) Objective

To document the results of the initial studies undertaken to establish the optimum development of the Susitna River.

(b) Approach

This task will essentially comprise the detailed documentation of the work undertaken in Subtask 6.03 to compare and evaluate alternative means of developing the full hydroelectric potential of the Susitna River. The end product report, in addition to providing APA with an interim recommendation as to the continued direction of the study, will be an essential vehicle for the transmission of information to other tasks of the overall study, and in particular to Task 7 - Environmental Studies, Task 8 - Transmission Studies and Task 9 - Cost Estimates and Schedules.

The principal activites in this subtask will comprise the following:

- Assembly and review of material developed in Subtasks 6.01 through 6.03.

- Assembly and review of material developed in other parallel tasks to date, with particular reference to environmental studies (Task 7), and to Tasks 3 through 5 covering hydrology, seismicity and geotechnical exploration. Of particular interest from these parallel studies will be the preliminary identification of major impacts on the feasibility of various alternatives under study.

- Assembly of a draft report incorporating the key findings of the studies to date and putting forward draft recommendations for the direction of continuing studies.

- Detailed review of the draft report with APA and Engineering Review Panel.

- Finalization and issue of report.

(c) Discussion

This report will be developed in close consultation with the APA and will be issued as a public document. A key facet will be the recommendation, arising from the studies in Subtask 6.01 through 6.03, as to whether or not the Watana/Devil Canyon combination is the most appropriate mode of development of the Susitna River. The balance of the study program set out in this Plan of Study has been assembled on the assumption that Watana/Devil Canyon will be selected. Should this not prove to be the case, a major reassessment will have to be made of the scope, cost and schedule for the balance of the work program leading to license application.

(d) Schedule

Weeks 50 through 65

Subtask 6.06 - Watana and Devil Canyon Staged Development

(a) Objective

Review the potential for staged development of Watana and Devil Canyon to best meet projected power and energy requirements and develop a staged construction plan.

(b) Approach

It is to be expected that the rate of load growth in the geographical area to which the Susitna Project will contribute will be such that it may be possible to obtain significant economies by a carefully-staged sequence of construction and power facility installation. This construction sequencing will have to be appropriately integrated with basic construction scheduling, diversion and impounding requirements for the two developments. The starting point and primary source of input data for this subtask will be the evaluation of alternative modes of development completed under Subtask 6.03. The principal activities to be undertaken include:

- From the power studies undertaken in Task 1, the anticipated rate (or range of rates) of load growth will be established and agreed upon with APA.

- Using the scheme of development recommended in Task 6.04 as a basis, a series of alternative sequences of development will be assembled. These alternative sequences will incorporate phasing of dam, power plant and transmission construction designed to match the rate(s) of load growth obtained above.

- Preliminary cost estimates will be developed for each stage of each of the development sequences.

- Estimates will be prepared of power and energy output throughout each sequence of development.

- Construction cost estimates will be converted to annual cash/flow figures.

- The comparative economics of the various sequences will be compared on a net present worth basis using Acres' ECON computer program to identify the most economic alternative. The comparisons will be made for a range of interest and discount rates.

- Other aspects of the two or three most attractive alternatives will be examined to assess potential environmental impacts.

- The most appropriate sequence of development for preliminary design of the Watana and Devil Canyon projects will be selected and design transmittal for APA review will be prepared.

(c) Discussion

The ultimate sequence of development could involve partial-height dam construction, as well as partial installations of power plant capacity. Those sequences which involve operation at intermediate water levels will require not only that special provisions be made in intake and spillway designs, but also that the units be capable of continuous, reliable and efficient operation at part head. Preliminary layout sketches will have to be prepared for each of the stages of development for each sequence, both to ensure that any potential construction or design problems are identified and to provide a basis for the take-off of preliminary quantities and costs.

Although it is obviously unwise to prejudge the issue at this stage, it may well be that any attempt to extend the construction/installation schedule to match the load demand will prove to be uneconomical because of the high costs associated with extended maintenance or restarting of a construction operation in the severe environment of the Susitna River sites. Costs associated with construction in this climate will be factored into the economic analyses.

(d) Schedule

Weeks 60 through 75

Subtask 6.07 - Preliminary Watana Dam Alternatives

(a) Objective

Establish the most appropriate type of dam for the Watana Site.

(b) Approach

On the assumption that the preliminary studies completed in Subtasks 6.01 through 6.03 show that the two-dam Watana/Devil Canyon scheme of development is preferred, this subtask will review all previously available data, and new information developed in the course of this program of study to determine the most appropriate design for the Watana Site. The following specific activities are envisaged:

- Assemble all available information for the Watana dam site with regard to the following:

  -- topography (from Task 2)
  -- soil conditions (Task 5)
  -- rock conditions (Task 5)
  -- construction materials (Task 5)
  -- seismic conditions (Task 4)

- Develop preliminary design of alternative dams; these may include:

  -- concrete gravity/buttress
  -- concrete arch
  -- rockfill/earthfill

- Prepare preliminary layout sketches of the selected designs and obtain preliminary estimates of principal quantities, including:

  -- excavation (soil and rock)
  -- grouting
  -- concrete and formwork
  -- rockfill/earthfill
  -- special fill materials such as transition or core material

- Review impact of alternative dam designs on other structures including:

  -- diversion tunnels and associated cofferdams
  -- spillway and outlet works
  -- intake/power tunnel/powerhouse systems

- Develop first-order cost estimates to measure ultimate effect on overall cost of the facility for the various types of dam

- Develop preliminary cost estimates for alternative types of dam, giving appropriate recognition to costs associated with:

  -- material sources
  -- weather conditions
  -- labor availability

- Prepare construction schedules for the alternative types of dam, and prepare annual cash flow estimates for the dams and for the significant costs associated with ancillary structures. Prepare summarized present-worth comparison of costs.

- Review "other" factors, such as unknown foundation conditions, construction considerations, seismicity and environmental effects which might influence the selection of dam type.

- Assemble and assess results of subtask analyses, and select type of dam for recommendation to the Engineering Panel and APA for ongoing studies.

(c) Discussion

The design proposed by the Corps of Engineers for the Watana dam comprises an 810 foot high rockfill structure with an inclined central impervious core; the core, and a "semi-porous fill" zone, is flanked by two fine/coarse filter zones. The Corps reports indicate that explorations to date have demonstrated the availability of sufficient quantities of material for the core and semi-pervious zones, and suggest that rockfill for the shells will be obtained from the excavations for the spillway and from quarries opened for the purpose.

The purpose of this subtask essentially will be to review the dam selection made by the Corps in the light of the preliminary studies and additional field exploration carried out to date during this study program. It is, of course, recognized that a rockfill/earthfill dam, which can be constructed from locally available materials and which may be less sensitive to unknown foundation conditions, is most likely to be the best choice for a site of this type. However, it will be appropriate to make a careful review of this selection before proceeding further with the design program to ensure that certain other features of concrete-type dams, such as reduced intake, spillway and diversion costs, might not offset the apparent advantages of the rockfill/earthfill design.

(d) Schedule

Weeks 60 through 75

Subtask 6.08 - Preliminary Devil Canyon Alternatives

(a) Objective

Establish the most appropriate axis and type of dam for the Devil Canyon Site.

(b) Approach

If the preliminary studies completed in Subtasks 6.01 through 6.03 show that the two-dam Watana/Devil Canyon scheme of development is preferred, this subtask will review all available data, collected previously and new information developed in the course of this program of study to determine the most appropriate design for the Devil Canyon Site. Subtask 6.04 provides input for reviewing the feasibility of an arch dam at Devil Canyon. After the most favorable alternative is selected, various axes for the dam will be selected for economic comparison. The following specific activities are envisaged:

- Assemble all available information for the Devil Canyon dam site with regard to the following:

  -- topography (from Task 2)
  -- soil conditions (Task 5)
  -- rock conditions (Task 5)
  -- construction materials (Task 5)
  -- seismic conditions (Task 4)

- Develop preliminary design of alternative dams; these may include:

  -- concrete gravity/buttress
  -- concrete arch (using, if appropriate, material developed in Subtask 6.04)
  -- rockfill/earthfill

- Prepare preliminary layout sketches of the selected designs and obtain preliminary estimates of principal quantities, including:

  -- excavation (soil and rock)
  -- grouting/draingage
  -- concrete and formwork
  -- rockfill/earthfill
  -- special fill materials such as transition or core material

- Review impact of alternative dam designs on other structures including:

  -- diversion tunnels and associated cofferdams
  -- spillway and outlet works
  -- intake/power tunnel/powerhouse systems

  Develop first-order cost estimates to measure ultimate effect on overall cost of the facility for the various types of dam

- Develop preliminary cost estimates for the alternative types of dam, giving appropriate recognition to costs associated with:

  -- material sources
  -- weather conditions
  -- labor availability

- Prepare construction schedules for the alternative types of dam, and prepare annual cash flow estimates for the dams and for the significant costs associated with the ancillary structures. Prepare summarized present-worth comparison of costs.

- Review "other" factors, such as unknown foundation conditions, construction considerations, seismicity and environmental effects which might influence the selection of dam type.

- Assemble and assess results of subtask analyses, and select type of dam for recommendation to Engineering Panel and APA for ongoing studies.

(c) Discussion

The original design recommended by the Corps of Engineers for the Devil Canyon site was a double curvature arch dam; as discussed in Subtask 6.04. This was subsequently supplemented by an alternative conventional gravity dam to ensure that the estimate contained sufficient cost to allow construction of either type should site conditions allow. The feasibility of the construction of an arch dam will be re-examined specifically in Subtask 6.04, and should results of that work indicate no reason why it should be eliminated from further contention, it will be included among the alternatives examined here.

(d) Schedule

Weeks 60 through 75

Subtask 6.09 - Establish Design Criteria for the Watana Development

(a) Objective

To establish preliminary design criteria for the Watana hydroelectric development.

(b) Approach

Documentation of the following criteria related to the design of the Watana development will be initiated in this subtask:

- Hydraulic:
  - reservoir levels
  - storage volumes
  - rule curves
  - power flows
- Geotechnical:
  - foundation conditions
  - foundation treatment requirements
  - construction materials properties
  - seismic design conditions
  - slope stability requirement, soil and rock
- Structural:
  - loading conditions
  - uplift pressures
  - wind loads
  - temperature conditions and loads
  - material design properties
  - stability analysis procedures
- Mechanical:
  - turbine design requirements
  - power plant mechanical systems
  - gate design requirements
  - crane design requirements
- Electrical:
  - generator design requirements
  - power plant electrical systems
  - transmission requirements
  - ancillary electrical equipment requirements
- General:
  - design codes and standards
  - special Alaska or site-related requirements
  - transportation limitations
  - ice conditions

(c) Discussion

It is anticipated that the assembly of this design criteria document will be undertaken over the period that the designs of the dam, spillway and power plant are developed, and that this document will provide the foundation of the design program in work subsequent to the license applications.

(d) Schedule

Weeks 80 through 95

Subtask 6.10 - Establish Design Criteria for the Devil Canyon Development

(a) Objective

To establish preliminary design criteria for the Devil Canyon hydroelectric development.

(b) Approach

Documentation of the following criteria related to the design of the Watana development will be initiated in this subtask:

- Hydraulic:
  - reservoir levels
  - storage volumes
  - rule curves
  - power flows
- Geotechnical:
  - foundation conditions
  - foundation treatment requirements
  - construction materials properties
  - seismic design conditions
  - slope stability requirement, soil and rock
- Structural:
  - loading conditions
  - uplift pressures
  - wind loads
  - temperature conditions and loads
  - material design properties
  - stability analysis procedures
- Mechanical:
  - turbine design requirements
  - power plant mechanical systems
  - gate design requirements
  - crane design requirements
- Electrical:
  - generator design requirements
  - power plant electrical systems
  - transmission requirements
  - ancillary electrical equipment requirements
- General:
  - design codes and standards
  - special Alaska or site-related requirements
  - transportation limitations
  - ice conditions

(c) Discussion

It is anticipated that the assembly of this design criteria document will be undertaken over the period that the designs of the dam, spillway and power plant are developed, and that this document will provide the foundation of the design program in work subsequent to the license applications.

(d) Schedule

Weeks 80 through 95

Subtask 6.11 - Preliminary Design of Watana Dam

(a) Objective

To prepare the preliminary design and associated cost estimate and construction schedule for the Watana Dam.

(b) Approach

This subtask will be initiated once the preliminary study of alternative dam sections, undertaken in Subtask 6.08, has been completed and approved. The primary input to this subtask, once the type of dam has been established, will be the results of the field investigations (Task 5) and the seismic studies (Task 4). Cost estimating data will be provided through Task 9. Specific activities to be undertaken will include:

- Assembly and review of most recent field and seismic study data;

- Preparation of a preliminary layout of the dam dimensioned to meet the basic requirements of the project design criteria;

- Development of appropriate preliminary design details, including grouting and pressure relief provisions, foundation and abutment preparation as required by the basic dam design within the context of the geotechnical conditions;

- Preparation of preliminary stability analyses for the critical conditions set out in the preliminary design criteria document (Subtask 6.09). Geotechnical design parameters to be provided on the basis of results obtained from the laboratory tests carried out in Task 5. Specific conditions will depend upon the type of dam selected, but for a rockfill dam with a central core, would typically include:

  -- end of construction conventional slope stability analysis
  -- analysis of rapid drawdown conditions utilizing residual pore pressures, and conventional stability analysis
  -- evaluation of maximum W.L. and seismic loads by dynamic analysis, utilizing excess pore pressure generation application tests
  -- examination of stress and deformations by finite element analysis

- Review and adjustment of design to accommodate anomalies indicated in the course of the stability studies undertaken above

- Reservoir studies, including:

  -- reservoir slope stability assessment in relation to thawing permafrost and generation of high pore pressures
  -- reservoir slope stability during seismic events, including impact on liquefaction-sensitive soils and mass instabilities
  -- snow slide assessment

- Computation of quantities and development of estimate of cost for the dam and associated cofferdams and diversion tunnels

- Development of dam construction schedule

- Preparation of material for input to dam selection report

(c) Discussion

In the development of the dam design, the following key aspects will be taken into account:

(1) Foundation and Abutment Conditions

Study of foundation and abutment conditions will include assessment of the available information on overburden, bedrock, structural geology including identification of local shear zones, faults and joint sets and the consolidation and strength characteristics. Based on the parameters from the assessment, the design will determine foundation seepage, permanent pressure relief, foundation treatment, consolidation and curtain grouting requirements, abutment stability, shaping of abutments, overburden and rock excavation requirements and excavation dewatering. Special considerations will be given to excavation of loose riverbed alluvium, talus materials near abutments.

(2) Construction Materials

Study in detail the availability and suitability of construction materials and their methods of exploitation for earth/rockfill and concrete dams and other associated concrete structures. Various sources of impervious material as well as a rock quarry for rockfill materials and concrete aggregates will be investigated in the field. Evaluation of the field data and laboratory test results will be done to determine the suitability of the construction materials and the parameters to be used in the design. Placing problems of impervious fills due to wet weather and cold climatic conditions will be studied on a preliminary basis. Shear behavior of impervious and shell materials will be studied under dynamic and high-confining stresses.

(3) Seismic Effects

Damages to dams during earthquakes can occur as deformation of the embankment collapses slopes, cracks cores and loosens the soil masses. Conventional methods cannot be employed for anything other than the collapse of slopes. In order to study the other two problems, it will be necessary to study the stresses and deformations produced in embankments at the time of an earthquake. The magnitude of deformations and stresses that develop will depend on the time of occurrence of inertia forces induced by the sudden ground displacements during an earthquake. A logical method of design requires:

- a determination of the variation of inertia forces with time
- an assessment of the embankment deformations and stresses induced by these forces.

Simplified numerical techniques which are comparable to dynamic finite element analysis, such as the Characteristic Method in combination with other simplified methods, will be used for the seismic analysis.

The ground motion characteristics, the cyclic stress-strain data and the dynamic material properties obtained from Task 4 studies will be utilized in the seismic design of earth/rockfill dams and embankments. The following measures will be included in the design to preclude the possibility of failure or major damage during an earthquake:

- avoidance of major faults in the foundation
- provision of sufficient vertical and horizontal drainage
- provision of ample freeboard
- use of wide transition zones of filter materials which are not vulnerable to cracking
- use of wide cores of materials with self-healing and erosion resistant properties
- appropriate provisions for handling wave effects due to earthquakes or landslides into the reservoir
- provision of appropriate crest details to minimize erosion
- appropriate measures to prevent slope failures or sliding of the dam on its foundations
- construction of well-compacted cofferdams to buttress main section

(4) Permafrost Studies

Permafrost studies will include application of the state-of-the-art in permafrost to the dam design, assessing the data from the field investigations and determining permafrost conditions on foundation and abutments and on the proposed foundation treatment such as grouting.

(5) Dam Sections

The design of dam fill sections will involve study of layouts, zoning arrangements for earth/rock-fill dams, optimization of dam slopes, requirements for filters, drains and slope protection riprap. Detail stability analyses, static and dynamic will be done for various loading conditions such as end of construction, long-term steady seepage and rapid drawdown. Dynamic loading conditions will be studied as mentioned in Section 3 under seismic effects. The design will include settlement and seepage analyses in the fill and foundations and determination of the type and scope of instrumentation to measure the performance of the structure.

(6) Construction Sequence and Method

The study will evaluate the effects of construction sequence and methods such as staged construction on cost and schedules. Also, it will determine effects on materials availability, method of placement and design of dam zoning and cofferdams and other river closure procedures. Construction period will be largely influenced by climatic conditions in the project region. This will particularly affect the placing of impervious fills and overall construction time of the structure. The study will include assessing the number of wet days during a construction season and the number of days of freezing in a year that will prohibit placing.

(d) Schedule

Weeks 85 through 110

Subtask 6.12 - Preliminary Design of Devil Canyon Dam

(a) Objective

To prepare the preliminary design and associated cost estimate and construction schedule for the Devil Canyon dam.

(b) Approach

This subtask will be initiated once the preliminary study of alternative dam sections, undertaken in Subtask 6.08, has been completed and approved. The primary input to this subtask, once the type of dam has been established, will be the results of the field investigations (Task 5) and the seismic studies (Task 4). Cost estimating data will be provided through Task 9. Specific activities to be undertaken will include:

- Assembly and review of most recent field and seismic study data;

- Preparation of a preliminary layout of the dam dimensioned to meet the basic requirements of the project design criteria;

- Development of appropriate preliminary design details, including grouting and pressure relief provisions, foundation and abutment preparation as required by the basic dam design within the context of the geotechnical conditions;

- Preparation of preliminary stability analyses for the critical conditions set out in the preliminary design criteria document (Subtask 6.10). Foundation design parameters are to be provided on the basis of results obtained from the laboratory tests carried out in Task 5. Specific conditions will, of course, depend upon the type of dam selected, but for a concrete gravity dam would typically include:

  -- conventional stability and sliding analyses and stress distribution on foundation
  -- determination of response of the concrete dam to seismic forces
  -- examination of stress and deformations by finite element analysis

- For the embankment section stability analyses as discussed in Subtask 6.11 will be performed.

- Review and adjustment of design to accommodate anomalies indicated in the course of the stability studies undertaken above

- Reservoir studies, including:

  -- reservoir slope stability assessment in relation to thawing permafrost and generation of high pore pressures
  -- reservoir slope stability during seismic events, including impact on liquefaction-sensitive soils and mass instabilities
  -- snow slide assessment

- Computation of quantities and development of estimate of cost for the dam and associated cofferdams and diversion tunnels

- Development of dam construction schedule

- Preparation of material for input to dam selection report

(c) Discussion

In the development of the dam design, the following key aspects will be taken into account:

(1) Foundation and Abutment Conditions

Study of foundation and abutment conditions will include assessment of the available information on overburden, bedrock, structural geology including identification of local shear zones, faults and joint sets, and consolidation and strength characteristics. Based on the parameters from the assessment, the design will determine foundation seepage, permanent pressure relief, foundation treatment, consolidation and curtain grouting requirements, abutment stability, shaping of abutments, overburden and rock excavation requirements and excavation dewatering. Special consideration will be given with regard to excavation of loose riverbed alluvium, and talus materials near abutments.

(2) Construction Materials

Study in detail the availability and suitability of construction materials and their methods of exploitation for earth/rockfill and concrete dams and other associated concrete structures. Various sources of impervious material as well as rock quarry for rockfill materials and concrete aggregates will be investigated in the field. Evaluation of the field data and laboratory test results will be done to determine the suitability of the construction materials and their parameters to be used in the design. Placing problems of impervious fills due to wet weather and cold climatic conditions will be studied on a preliminary basis. Shear behavior of impervious and shell materials will be studied under dynamic and high-confining stresses.

(3) Seismic Effects

For the concrete dam, the seismic impact and response will be evaluated by dynamic, finite element techniques commonly adapted for such analyses. Stress concentration and deformation in the body of the dam or at the foundation will be evaluated. Damages to dams during earthquakes can occur as deformation caused by shear failure in the concrete section of the dam.

The seismic effect on the embankment section is discussed in Subtask 6.11 and is not repeated here.

(4) Permafrost Studies

Permafrost studies will involve application of the state of the art in permafrost to the dam design. Data from the field investigations will be assessed to determine permafrost conditions in foundation and abutments, and to establish the proposed foundation treatment such as thawing, grouting, etc.

(5) Dam Sections

The design of concrete dam sections will involve study of layouts, jointing pattern and other concrete details,and for the fill dam, zoning arrangements, optimization of dam slopes, requirements for filters, drains and slope protection riprap. Detailed stability analyses, static and dynamic will be done for various loading conditions such as end of construction, long-term steady seepage and rapid drawdown. Dynamic loading conditions will be studied as mentioned in Task 4 under seismic effects. The design will include settlement and seepage analyses in the fill and foundations and will determine the type and scope of instrumentation to measure the performance of the structure.

(6) Construction Sequence and Method

The study will evaluate the effects of construction sequence and methods such as staged construction on cost and schedules. Also, it will determine its effects on materials availability, method of placement and design of dam zoning and cofferdams and other river closure procedures. The construction period will be largely influenced by varying climatic conditions in the project region. Acres is particularly experienced in cold weather construction techniques for large dams. These conditions will most certainly affect the placing of impervious fills and concrete and the overall construction time of the structure. The study will include assessing the number of wet days during a construction season and the number of days of freezing in a year that will prohibit placing.

(d) Schedule

Weeks 85 through 110

Subtask 6.13 - Dam Selection Report

(a) Objective

Prepare a report summarizing the results of the study dealing with the selection and preliminary design of dams and reservoirs for the Susitna Development.

(b) Approach

The primary input to this report will be derived from the preliminary design development studies undertaken under Subtasks 6.11 and 6.12. The report will address the following principal topics for each of the dams considered:

- principal hydraulic, geotechnical and structural design criteria
- selection of type of dam
- geology and foundation conditions
- staged construction considerations
- basic design concept
- stability analyses
- diversion and construction conditions
- construction materials
- reservoir conditions
- construction schedule
- estimate of cost

The report will be submitted in draft form to the Engineering Panel and to APA for review prior to finalization.

(c) Discussion

This report, which will contain major technical input to the license application, will provide a focus not only for the work undertaken in a number of the previous subtasks in Task 6 but also for data developed in other primary tasks such as Tasks 4 - Seismic Studies and Task 5 - Geotechnical Exploration.

(d) Schedule

Weeks 100 through 115

Subtask 6.14 - Spillway Design Criteria

(a) Objective

To establish the basic spillway and diversion design criteria for the Watana and Devil Canyon dam sites.

(b) Approach

Basic design criteria will be established and reviewed with APA and other State and Federal Agencies. These basic criteria define the accepted degree of risk to flood damage and include:

- Landslides. Landslide events due to seismicity or other causes are more difficult to deal with quantitatively. It is also often uneconomic to allow sufficient freeboard to prevent overtopping due to a reservoir slide. On the Mica dam project in British Columbia this was the case, and the reservoir crest was specifically designed to withstand a limited amount of overtopping. We will undertake a brief study to determine the freeboard requirement for such slide events and assess the economic impact of providing adequate freeboard versus protecting the dam crest. Input to this study would be derived for the study outlined in Task 3. Based on the results of this study the required freeboard and crest protection will be recommended.

- Spillway design flood. A design flood hydrograph of a high probability of succeedence such as the 10,000 years flood. The service spillway would be sized to accommodate the flood without the reservoir water level encroaching on the required dry freeboard.

- A catastrophic flood event. Normally specified as the probable maximum flood. The service spillway and, if required, emergency spillways would be designed to pass this flood but reservoir levels would be allowed to rise to dam crest level.

- Spillway cavitation criteria. A specification of the magnitude of design flood hydrograph above which limited cavitation/erosion damage will be accepted.

- Downstream erosion criteria. A specification of the magnitude of design flood above which erosion damage requiring subsequent remedial work will occur downstream.

- Freeboard criteria. A specification of the severity of the climatic and reservoir landslide event for which adequate dry freeboard is required. Climatic events which affect freeboard are high winds and it is usual to specify a design wind velocity having a return period of say 100 years.

- Diversion flood criteria. Brief economic studies will be undertaken to determine the economic level of flood protection during the diversion stages . Hydrologic and hydraulic input would be derived from the Task 3 studies and would include open water flood conditions as well as flood levels under ice cover and ice jam conditions.

- Low level outlet criteria. A study will be undertaken to determine the requirement for a low level outlet and, if necessary, the capacity for such an outlet. Aspects to be considered include:

  -- downstream water quantity and quality requirements

  -- control of reservoir filling rate

  -- requirement for emergency drawdown.

Once these basic criteria are finalized the information will be issued as a design transmittal.

(c) Discussion

The design criteria described above are those usually adapted by Acres for the design of large dams and we recommend them for the Susitna Project.

(d) Schedule

Weeks 70 through 80

Subtask 6.15 - Watana Spillway Alternatives

(a) Objective

Examine alternative potential spillway arrangements for the Watana site, and select the most appropriate for subsequent design development.

(b) Approach

Primary input for this study will be obtained from:

- Task 3 - Hydrology
- Task 5 - Geotechnical Exploration
- Subtask 6.14 - Spillway Design Criteria

Specific activities will include:

- Assembly and assessment of input data
- Preliminary layout of alternative spillway arrangements to meet the requirements set out in the design criteria document within the constraints imposed by the dam and other facilities
- Take-off of quantities and computation of costs of alternative arrangements
- Examination of operational aspects of the spillway alternatives and identification of possible measures required to mitigate adverse effects
- Selection of most appropriate spillway arrangement on the basis of net cost and operational characteristics

(c) Discussion

Since the energy head to be dissipated in the spillway works at Watana could be as much as 700 feet, and the safety of the entire development will depend upon the proper operation of the spillway, the selection and design of this facility will be one of the most critical aspects of the design development program. The selection of the optimum spillway arrangement will depend to a large extent on the ambient economics of the dam and spillway combination, not only in relation to the physical layout, but also in relation to the potential provision of rockfill for the dam construction from the excavations for the spillway chute.

In the current Corps of Engineers' designs, the spillway chute discharges at right angles to the alignment of Tsusena Creek, which may be less than attractive from the hydraulic standpoint; however, realignment may prove to be difficult to achieve without involving major excavations. Present indications are that the geology of the left (south) bank is marginally "better" than that of the right bank, and it may be possible to locate an improved orientation on this bank. However, any scheme which involves a shorter and steeper chute will almost certainly require concrete linings to prevent erosion under high velocity flows: This of course, will involve major additional costs and raises the spectre of cavitation and erosion damages experienced at so many other high-head spillway installations.

The spillway crest control structures will be of conventional concept, designed to accommodate appropriate ice loads/bubbler systems. One or more gates may require heating if spillway operation during freezing weather is required. If alternatives involving steep chutes are considered, then it will be necessary to examine various forms of energy-dissipating structures, such as chute blocks, stilling basins, and the like.

(d) Schedule

Weeks 80 through 95

Subtask 6.16 - Devil Canyon Spillway Alternatives

(a) Objective

To examine alternative potential spillway arrangements for the Devil Canyon site, and select the most appropriate for subsequent design development.

(b) Approach

Primary input for this study will be obtained from:

- Task 3 - Hydrology
- Task 5 - Geotechnical Exploration
- Subtask 6.14 - Spillway Design Criteria

Specific activities will include:

- Assembly and assessment of input data
- Preliminary layout of alternative spillway arrangements to meet the requirements set out in the design criteria document within the constraints imposed by the dam and other facilities
- Take-off of quantities and computation of costs of alternative arrangements
- Examination of operational aspects of the spillway alternatives and identification of possible measures required to mitigate adverse effects
- Selection of most appropriate spillway arrangement on the basis of net cost and operational characteristics

(c) Discussion

The most recent (1979) Corps of Engineers design for the spillway at Devil Canyon calls for a conventional arrangement discharging over the central section of the concrete gravity dam. For the originally proposed arch dam at this site, the Corps has proposed a ski-jump spillway arrangement discharging at the left abutment of the dam with the lip of the jump some 300 feet above downstream river level.

The ultimately selected arrangement of spillway will, of course, be heavily influenced by the type and arrangement of dam selected, and may in turn affect the selection of the dam. Various aspects influencing the selection of a chute-type spillway arrangement are discussed under Subtask 6.15 above. Design considerations affecting conventional spillway structures are well documented in the literature.

(d) Schedule

Weeks 85 through 95

Subtask 6.17 - Preliminary Design of Watana Spillway

(a) Objective

To design the spillway facilities and associated features for the Watana project.

(b) Approach

From the studies in Subtasks 6.14 and 6.15, the information on spillway design criteria and most suitable locations will be available to develop this subtask. We will critically review foundation conditions of the site and examine previously generated data for the project. Design tasks will include:

- Foundation design of the spillway, ogee section, piers, spillway channel and the chute structure including rock excavation, rock reinforcement, concrete dental work and pressure relief facilities.

- Hydraulic design to determine optimum gate dimensions and gate operating procedures. Development of a spillway operating rule curve based on headwater elevations in the reservoir and gate opening, detailed tailwater curve data and hydraulic profiles to satisfy all operating conditions expected at the project. Determination of the shape and height of piers, walls and chute block.

- Structural details and design of bridge, piers, gates, stoplogs, spillway channel walls and slab chute structures considering normal maximum headwater conditions, and seismic and extreme weather conditions.

- Design of gate facilities to operate under extreme weather and ice conditions. Both bubble formations and heating of necessary elements will be considered for the purpose of adequate cost provision in the estimate.

- Preliminary hydraulic and structural analyses of size, shape, and thrust requirements of the chute block; shape and trajectory of the jet under various flow and tailwater conditions will be reviewed to develop satisfactory solutions. Preliminary study of jet impact will be made and data will be developed for hydraulic modelling of the facilities.

- Appropriate arrangement and design of electrical/mechanical facilities for hoist operation under all conditions including emergency conditions will be developed.

- Safety of the spillway structure as an independent unit and as an integral part of the overall project will be checked.

- If the dam is an embankment structure adjacent to the spillway, the retaining walls will be designed and hydraulic approach conditions will be reviewed.

(c) Discussion

The review of flood routing studies for project design flood, probable maximum flood and other floods generated from Task 3 will provide data on the rule curve for operations of the spillway facility. Gate operation procedures will be developed to suit all flood conditions expected at the site. Flood rule curve data will provide relationships of gate opening and headwater elevation in the reservoir without topping the structure. Hydraulic profiles of the spillway channel will be determined from the gate, and size and type of chute will be designed to perform satisfactorily in all conditions with minimum environmental impact and consideration for safety of the dam and reservoir.

(d) Schedule

Weeks 90 through 115

Subtask 6.18 - Preliminary Design Devil Canyon Spillway

(a) Objective

To design spillway facilities and associated features for the Devil Canyon Project.

(b) Approach

This subtask involves critical review of the recommended arrangement of the spillway and design having regard to foundation conditions, location of the spillway and design project features compatible to these conditions. Design will include:

- Foundation design of the spillway, ogee section, channel and the chute structures will include rock excavation, rock reinforcement, concrete dental work and pressure relief facilities.

- Hydraulic design will define gate operating procedures and spillway operating curve based on the relationship of headwater surface elevation and gate opening. Preliminary hydraulic profile for variable flow will define the height and size of the piers, walks and geometery and configuration of ogee section and the chute block.

- In case a concrete gravity dam is selected at Devil Canyon, several kinds of energy dissipation structures will be evaluated including ski-jump, stilling-basin and chute-types and preliminary design will be made of the most suitable facility recommended for the project. Should an arch dam be recommended for the Devil Canyon project site a plunge pool-type facility would be the most suitable arrangement.

- Structural details and design will be drawn up for bridges, piers, gates, stoplogs, spillway channel walls and slab chute structures, considering seismic and extreme weather conditions imposed on the site.

- Design will include provision in the facilities for gate operation under ice conditions and extreme low temperatures and provision will be made for heating certain facilities for satisfactory performance of gates, hoists and guides.

- Hydraulic analyses will determine configuration of the chute and its hydraulic performance including impact trajectory of the jet for various flows, and pressure determination near the chute. Data will be developed for a hydraulic model testing program.

- Design will consider electrical and mechanical facilities for power hoist operation of gates under all weather conditions.

- The geometry and the trajectory of the jet and its impact on landing soil will be evaluated. Hydraulic model data will be developed for testing in the later phases of the detailed design of the project.

(c) Discussion

Energy dissipation of about a 600-foot head at the Devil Canyon site makes the design of the spillway structure critical. Dispersion of waves from the flood-regulated releases of the upstream Watana dam will need careful evaluation of its impact on the valley walls.

Extreme weather conditions at the project site will require special design consideration during the preliminary stage. Preliminary drawings from which quantities will be taken off will be prepared. The design will be accompanied by the associated schedule and cost estimate including impact on associated structures. The design will be compatible with the hydraulic requirements and will conform with the technical, economic and safety standards.

(d) Schedule

Weeks 95 through 115

Subtask 6.19 - Spillway Selection Report

(a) Objective

To prepare a report presenting the results of studies of alternative spillway design concepts for the Watana and Devil Canyon Sites and the selection and development of preliminary designs in each case.

(b) Approach

The spillway selection report will be assembled to document the results of Subtask 6.14 through 6.18 dealing with consideration of alternatives and preparation of preliminary designs for the Watana and Devil Canyon Spillways. Primary input to the report will be provided by memoranda prepared during the course of those studies to summarize the work undertaken, together with appropriate drawings, cost estimates and schedules.

Specific topics to be addressed in the report will include:

- basis of design flood analysis
- selected design floods
- selected spillway capacity
- selection of spillway type
- selection of discharge facilities
- flood routing analysis
- alternative spillway locations
- preliminary hydraulic design and rating curves
- optimization of crest widths/elevations
- downstream erosion control
- preliminary structural designs
- preliminary stability analysis
- foundation treatment
- construction cost and schedule summaries
- flood control and operational safety
- icing considerations

(c) Discussion

The report also will include a review of the interrelationship of the two reservoirs during floods and the advantages and disadvantages of adopting remote control operation. The technical, economic and environmental issues involved in the selected designs will be discussed together with recommendations for further studies to be undertaken prior to construction, including hydraulic modelling. Discussions also will be presented on equipment contract packaging alternatives.

The report will provide basic input to final design of spillway structures, including structural and hydraulic analyses, geotechnical conditions and hydraulic design of the spillways. The report will also address other problems needing further investigation for the detailed design such as geotechnical design, ice jamming conditions

and constraints, seismic loading, possible requirements for heating and other construction problems in extreme climatic conditions.

(d) Schedule

Weeks 110 through 120

Subtask 6.20 - Access and Camp Facilities

(a) Objective

To develop preliminary designs, arrangement drawings and cost estimates for permanent camp and access road facilities for construction and operation of the Devil Canyon, Watana and related project facilities.

(b) Approach

The results of access road route selection studies, surveys undertaken in Task 2, and geotechnical exploration in Task 5 will provide basic input to this task. The initial camp facilities also developed under Task 2 will provide the basis upon which the camp designs will be developed.

Ongoing Task 6 design activities together with Task 9 construction and resource scheduling input also will be used in the development of camp design.

Preliminary alignment profiles for roads and associated horizontal and vertical curve design criteria will be developed. Road width, loading criteria and data will be based on the heaviest and largest items of power plant equipment to be shipped to the site.

Preliminary plans and profiles will define cut and fill slopes based on geotechnical data and include designs for culverts and bridges. Bridge and culvert alignments and designs will be based on preliminary topographic, geologic and hydrologic input at each location. Tunnels may be used where appropriate. A total of 27 miles of access road to the Devil Canyon site from the area of Highway No. 3 or railroad close to Gold Creek, are envisioned. An additional 37 miles of road will be required from the Devil Canyon site to the Watana site. Access roads will be required to the airstrip to each power plant and other power facilities and to the dam and spillway for each site.

(c) Discussion

Permits required for construction of access roads and camp facilities will be obtained by CIRI/H&N, who will also provide support in the development of camp designs.

Access road and permanent camp facilities will probably be required at each of the damsites. At least one permanent camp facility with all-weather road access to all permanent installations will be necessary to support project operation and maintenance.

Permanent camp facilities will include permanent housing and recreation, medical and shopping facilities. This work will form the basis of permitting and contract documents for access roads scheduled to be constructed between 1982 and the end of 1987.

(d) Schedule

Weeks 70 through 80

Subtask 6.21 - Watana Diversion Schemes

(a) Objective

To examine alternatives and select a river diversion plan to satisfy the construction schedule requirements for construction of the Watana dam, outlet works, spillway, power plant and reservoir, and prepare conceptual designs, drawings and cost estimates for the selected scheme.

(b) Approach

The Watana diversion scheme will depend to a large extent on the type and size of dam selected for the ultimate development and for any intermediate stages of construction.

For a large earth or rockfill dam of the size currently proposed at Watana, the diversion scheme will comprise some combination of upstream and downstream cofferdams and an appropriate arrangement of tunnels, intakes and outlet structures to divert the flow. Consideration will be given to alternatives involving channel diversion schemes in the riverbed area during a portion of the construction period. For possible concrete dam alternatives considered under Subtask 6.07, somewhat different design concepts will be involved. These would most likely include diversion of river flow directly through or over partially completed dam structural elements.

Activities undertaken in this subtask will include the following:

- Selection of diversion design flood and development of other design criteria
- Study of alternative cofferdam design concepts, heights and placement methods
- Study of alternative tunnel alignments, sizes, methods of construction and lining requirements
- Review of requirements for flow control and conceptual design of intake and outlet structures
- Consideration of icing problems upstream and downstream of the damsite area
- Review of foundation cut-off and treatment requirements
- Consideration of requirements for dewatering of dam foundations
- Evaluation of methods of tunnel closure for reservoir impoundment
- Conceptual designs, drawings and cost estimates for the selected diversion scheme
- Diversion flood routing analyses.

(c) Discussion

The selected scheme will provide safe arrangements for dam construction at minimum cost. Consideration will be given to utilization of permanent project features such as power and tailrace tunnels as diversion facilities.

Input to this subtask will include the proposed dam construction schedule, diversion flood flow criteria, geotechnical exploration data and the type and location of the main dam and associated features. Diversion flood hydrographs and tailwater rating curves for these studies will be based on Task 3 output. The flood hydrograph data will be reviewed and selected for consistency with the risks associated with construction of the Watana dam. Diversion studies will determine the height of the upstream and downstream cofferdams with associated sizes of the diversion tunnel selected for the scheme. These studies will be used to determine an economical combination of size of the diversion tunnel and the cofferdam height.

The severe weather conditions at this site and the imposed restrictions on the construction schedule associated with the relatively well defined seasonal flow variations of the river will impose certain limitations on development of the design of the diversion scheme.

The crest elevation of the upstream diversion dam proposed in the 1979 Corps of Engineers report is about 100 feet above the existing river bed. The embankment of this cofferdam therefore appears to be founded on about 50 feet of gravel and other pervious materials. Construction of the embankment of the diversion dam itself is thus a major task and would probably require its own smaller cofferdam. A slurry trench or cut-off arrangement will probably be required to limit seepage.

Diversion dewatering problems under the core of the main dam will be aggravated because of the required excavation and removal of more than 50 feet of riverbed material.

(d) Schedule

Weeks 85 to 95

Subtask 6.22 - Devil Canyon Diversion Schemes

(a) Objective

To examine alternatives and select a river diversion plan to satisfy the construction schedule requirements for construction of the Devil Canyon dam, outlet works, spillway, power plant and reservoir, and prepare conceptual designs, drawings and cost estimates for the selected scheme.

(b) Approach

The Devil Canyon diversion scheme will depend to a large extent on the type and size of dam selected for the ultimate development and for any intermediate stages of construction. The scheme will be greatly influenced by the pattern of releases from the upstream Watana development which will probably already be in place.

For a concrete dam of the size currently proposed at Devil Canyon, the diversion scheme will probably comprise some combination of upstream and downstream cofferdams and an appropriate arrangement of tunnels, intakes and outlet structures to divert the flow. Consideration will be given to alternatives involving diversion of river flow directly through or over partially completed dam structural elements during at least a portion of the construction period. For possible rockfill dam alternatives considered under Subtask 6.08, somewhat different design concepts will be involved.

Activities undertaken in this subtask will include the following:

- Selection of diversion design flood based on Watana releases and development of other design criteria
- Study of alternative cofferdam design concepts, heights and placement methods
- Study of alternative tunnel alignments, sizes, methods of construction and lining requirements
- Diversion flood routing studies
- Review of requirements for flow control and conceptual design of intake and outlet structures
- Consideration of icing problems upstream and downstream of the damsite area
- Review of foundation cut-off and treatment requirements
- Consideration of requirements for dewatering of dam foundations
- Evaluation of methods of tunnel closure for reservoir impoundment

- Conceptual designs, drawings and cost estimates for the selected diversion scheme

- Consideration of concrete dam construction methods and risks involved in diversion of river flow through partially completed elements.

(c) Discussion

The selected scheme must provide safe arrangements for dam construction at minimum cost. Consideration will be given to utilization of permanent project features such as tunnels, power and tailrace as diversion facilities.

Construction planning and design of diversion facilities will take due account of these factors.

During spring and early summer, discharges from Watana spillway could impose severe limitations and design constraints for the development of the diversion plan for the Devil Canyon site.

Input to this subtask will include the proposed dam construction schedule, appropriate flood-flow criteria, geotechnical exploration data and the type and location of the main dam and associated features. If appropriate, diversion studies will determine the height of the upstream and downstream cofferdams with associated sizes of the diversion tunnel selected for the scheme. These studies will determine a reasonably economical combination of size of the diversion tunnel and the cofferdam height. Tailwater rating curves for these studies will be based on Task 3 output. The flood hydrograph data will be reviewed for its application and appropriately modified in accordance with the risks associated with such a high dam.

(d) Schedule

Weeks 85 to 95

Subtask 6.23 - Optimize Watana Power Development

(a) Objective

To study alternative Watana power plant locations, types and sizes, and associated intake, power conduit and outlet facilities within the context of selected dam and spillway arrangements, and select the optimum power development concept.

(b) Approach

The three major components of project cost at Watana are the dam, the spillway and the power development facilities. To this point in Task 6 studies, work will concentrate on establishing the requirements for feasible optimum dam and spillway design concepts. These studies generally will be developed on the basis of engineering judgment and experience and previous report data. This will not detract from the overall objective of this POS in that the further improvements and economies which may be made in the design of the power facilities are not likely to affect the overall technical and economic feasibility of the project significantly.

The location, type and size of the power plant associated with the selected dam and spillway structures will be considered in more detail. The installed capacity and annual generation data developed under Subtask 6.03 will be re-examined in the light of updated total project cost and any additional hydrological data which may have been developed. Additional available geotechnical data will be considered in designating alternative power plant locations and re-evaluation of power development costs.

Subjects of study will include the following:

- Confirmation of tailwater rating curves and hydraulic head computations
- Determination of optimum plant capacity and energy outputs as part of the Railbelt Region power system
- Surface and underground, left or right abutment, powerhouse locations
- Number, size and lining requirements for penstocks, tailrace tunnels and surge tank
- Number, type, size and setting of units
- Location and number of transformers
- Switchyard and cabling requirements

Selection of the optimum power development will be made on the basis of technical feasibility and safety at minimum cost.

(c) Discussion

The optimum scheduling of hydroelectric installions developed under Task 1 will be reviewed as input to this Subtask.

For the head and size of unit contemplated at Watana, vertical Francis units directly connected to synchronous generators are the most likely installation. Depending on the desired staging of development, modern trends generally suggest that fewer, larger units are most likely to provide maximum opportunities for economy of scale. Discussions will be held with manufacturers in determining the probable optimum size of unit. No problems are anticipated in selecting units at the size and head envisaged. A summary of recent large Francis unit designs is presented in Table A5.5.

The 1979 Corps of Engineers design for Watana indicates an underground power plant location. The scheduling advantages of such an installation are considerable in that year-round construction is facilitated. Nevertheless, surface alternatives may offer some advantages particularly in some of the possible limitations imposed by spillway location priorities.

(d) Schedule

Weeks 90 through 110

Subtask 6.24 - Optimize Devil Canyon Power Development

(a) Objective

To study alternative Devil Canyon power plant locations, types and sizes, and associated intake, power conduit and outlet facilities, within the context of selected dam and spillway arrangements, and select the optimum power development concept.

(b) Approach

As in the case of the Watana site (Subtask 6.23), Task 6 studies will initially concentrate on establishing the requirements for feasible optimum dam and spillway design concepts at Devil Canyon.

The location, type and size of the power plant associated with the selected dam and spillway structures will be considered in more detail. However, space restrictions in the narrow Devil Canyon will impose constraints on available powerhouse locations. The installed capacity and annual generation data developed under Subtask 6.03 will be re-examined in the light of updated total project cost and any additional hydrological data which may be developed. Additional available geotechnical data will be considered in alternative power plant locations and re-evaluation of power development costs.

Subjects of study will include the following:

- Impact of time release patterns from Watana
- Confirmation of tailwater rating curves and hydraulic head computations
- Determination of optimum plant capacity and energy outputs as part the Railbelt Region power system
- Surface and underground, left or right abutment, or integral dam powerhouse locations
- Number, size and lining requirements for penstocks, tailrace tunnels and surge tank (if required)
- Number, type, size and setting of units
- Location and number of transformers
- Switchyard and cabling requirements

Selection of the optimum power development will be made on the basis of technical feasibility and safety at minimum cost.

(c) Discussion

The optimum Devil Canyon power development will be significantly influenced by Watana plant operations.

As at Watana, for the head and size of unit contemplated at Devil Canyon, vertical Francis units directly connected to synchronous generations are the most likely installation. Discussions will again be held with manufacturers in determining the probable optimum size of unit.

The 1979 Corps of Engineers design for Devil Canyon also indicates an underground power plant location. The scheduling advantages of such an installation are considerable in that year-round construction is facilitated. Nevertheless, surface alternatives may offer some cost advantages, particularly if a power plant constructed integrally with the dam proves to be feasible.

(d) Schedule

Weeks 90 through 110

Subtask 6.25 - Optimize Dam Heights

(a) Objective

To consider alternative heights of selected Devil Canyon and Watana dam structures and associated development design concepts and select the optimum.

(b) Approach

At this point in the study the opportunity will be taken to reassess the costs and benefits of each development to confirm or modify the design concepts previously adopted. The Subtask will essentially be undertaken on the basis of the results of previous Task 6 studies of the dams, spillways and power developments. The following activities will be included:

- development of preliminary conceptual designs for alternative dam heights with associated spillway and power development modifications
- re-evaluation of development construction costs, power and energy outputs and system economics incorporating the modified development
- selection of the optimum development concept
- if necessary, modifications to conceptual designs and cost estimates of dams and spillways

(c) Discussion

This will essentially be the final step in the determination of project feasibility and in selection of the optimum development at each site in terms of maximum net benefits. In selecting the optimum development, due consideration will be given to relevant environmental issues.

(d) Schedule

Weeks 105 to 115

Subtask 6.26 - Preliminary Design Watana Power Development

(a) Objective

To develop preliminary conceptual designs, drawings and cost estimates for Watana power plant, intake, power conduits and outlet works.

(b) Approach

Preliminary designs, drawings and cost estimates will be prepared for the selected optimum power development facilities at Watana including:

- General arrangement
- Powerhouse arrangement
- Valve chambers
- Powerhouse crane
- Access and control room facilities
- Transformer area
- Draft tubes and gates
- Bus ducts and cable shafts
- Intakes and gates
- Penstocks and surge tank (if required)
- Tailrace and outlet structure
- Switchyard and transmission arrangements

The work will also include the following activities:

- Establish the turbine head and capacity rating and mechanical equipment required

- Establish the generator rating and other electrical equipment requirements

- Determine arrangement of mechanical and electrical equipment in the powerhouse layout for the most efficient use of space

- Prepare electrical single-line diagram

- Make preliminary analyses of transient pressures in the power conduit

- Design preliminary penstock steel/concrete lining

(c) Discussion

Studies will be made of the geotechnical aspects of the underground structures such as the powerhouse, tunnels and penstocks, with appropriate input from exploratory work. The assessment of geotechnical problems and the design analysis will be sufficient in depth to establish technical feasibility and to determine realistic capital cost and schedule requirements. The objective of these studies will be to locate a structurally sound block of rock within which the major openings may be sited with confidence.

As an extension of the field program, the assessment will include rock quality studies identifying and evaluating significant geological features such as faults, foliation, shear zones, principal joint systems, groundwater and seepage regimes. During this process, basic design parameters such as shear strength and rock modulus will be evaluated. Based on assessment and evaluation of the studies, the basic design criteria for rock excavation, rock reinforcement, rock support lining requirements and pressure relief systems for major openings to ensure rock mass stability will be confirmed.

The size of major openings such as the underground powerhouse will be largely dictated by mechanical and electrical equipment, hydraulic requirements, and orientation and shape of the openings. The design optimization of the geometry will depend on the strength characteristics of the mass rock relative to the stresses that may be imposed. Finite element stress analysis may be necessary during later project design phases after submission of the license application to check the stability of the openings.

Ice jamming conditions and other severe weather construction and post-construction conditions will be examined to provide a facility which is fully integrated with the hydraulic system of the conduits and power plant, and can serve under all weather conditions.

Preliminary concepts will be developed for structural details, along with concrete pour and jointing details and consideration of construction methods. To cope with water quality and environmental problems due to reservoir stratification, the intake structure should be capable of drawing water from several different levels. The conceptual design of an intake structure with various levels of withdrawal, power inlet transitions, emergency gates, and trashrack details will be undertaken. Information obtained from manufacturers for specific mechanical and electrical equipment items with associated costs and characteristics will be used in the conceptual layout drawings and also for the cost estimate.

Preliminary conceptual designs of gates, bridges, energy-dissipating structures, tunnels and all other hydraulic structures will be made to provide reliable cost data.

(d) Schedule

Weeks 95 to 115

Subtask 6.27 - Preliminary Design Devil Canyon Power Development

(a) Objective

To develop preliminary conceptual designs, drawings and cost estimates for Devil Canyon power plant, intake, power conduits and outlet works.

(b) Approach

As for the Watana Power Development, work under this Subtask will include preliminary designs, drawings and cost estimates for the selected optimum power development facilities at Devil Canyon. These will include:

- General arrangement
- Powerhouse arrangement
- Valve chambers
- Powerhouse crane
- Access and control room facilities
- Powerhouse crane
- Transformer area
- Draft tubes and gates
- Bus ducts and cable shafts
- Intakes and gates
- Penstocks and surge tank (if required)
- Tailrace and outlet structure
- Switchyard and transmission arrangements

The work will also include the following activities:

- Establish the turbine head and capacity rating and mechanical equipment required

- Establish the generator rating and other electrical equipment requirements

- Determine arrangement of mechanical and electrical equipment in the powerhouse layout for the most efficient use of space

- Prepare electrical single-line diagram

- Provide preliminary analysis of transient pressures in the power conduit

- Design preliminary penstock steel/concrete lining

(c) Discussion

As for Watana, the geotechnical aspects of the design of underground structures such as the powerhouse, tunnels and penstocks will be carefully assessed with due consideration of the results of exploratory work. The assessment of geotechnical problems and the design analysis will be sufficient in depth to establish technical feasibility and to determine realistic capital cost and schedule requirements.

The assessment will include identification of design parameters such as shear strength and rock modulus and evaluation of significant geologic features such as faults, foliation, shear zones, principal joint systems, groundwater and seepage regimes. The basic design criteria for rock excavation, rock reinforcement, rock support lining requirements and pressure relief systems for major openings to ensure rock mass stability will be confirmed.

The size of major openings such as the underground powerhouse will be largely dictated by mechanical and electrical equipment, hydraulic requirements, and orientation and shape of the openings. Finite element stress analysis may be necessary during later project design phases after submission of the license application to check the stability of the openings.

Evaluation of the impact of conjunctive operation of Devil Canyon and Watana will be undertaken, including the effects of ice jamming and other severe weather construction and post-construction conditions.

To cope with water quality and environmental problems due to reservoir stratification, the intake structure should be capable of drawing water from several different levels. The conceptual design of an intake structure with various levels of withdrawal, power inlet transitions, emergency gates, and trashrack details will be undertaken. Information obtained from manufacturers for specific mechanical and electrical equipment items with associated costs and characteristics will be used in the conceptual layout drawings and also for the cost estimate.

Preliminary conceptual designs of gates, bridges, energy dissipating structures, tunnels and all other hydraulic structures will be made to provide reliable cost data.

(d) Schedule

Weeks 95 to 115

Subtask 6.28 - Power Development Report

(a) Objective

To prepare a report presenting the results of studies of optimization of power development alternatives for the Watana and Devil Canyon Sites and the selection and development of preliminary conceptual designs in each case.

(b) Approach

The power development report will be assembled to document the results of Subtasks 6.06 and 6.23 through 6.27. The report will deal with consideration of alternatives and preparation of preliminary designs for the Watana and Devil Canyon power developments, including intakes, penstocks, surge tanks, power plants, tailrace, switchyard and transmission facilities for each site. Primary input to the report will be provided by memoranda prepared during the course of those studies to summarize the work undertaken, together with appropriate drawings, cost estimates and schedules.

Specific topics to be addressed in the report will include the following:

- staged power development considerations
- selection of generating capacity of installations
- geotechnical design considerations
- hydraulic design parameters
- conceptual design of power developments
- single-line diagrams
- cost estimates and schedules
- mechanical equipment selection
- electrical equipment selection
- accessory electrical equipment
- miscellaneous power plant equipment

(c) Discussion

The technical and economic issues involved in the selected designs will be discussed together with recommendations for further studies to be undertaken prior to construction. At least one of the power plants will incorporate an underground cavern installation. The selection of location and geologic considerations for the underground facilities will be fully discussed. Recommendations will be presented for equipment and construction contract packaging alternatives to be considered.

The report will provide basic input to final design of power development structures, including structural and hydraulic analyses, geotechnical conditions and hydraulic design of the intake, penstock and tailrace facilities. The report will address other problems needing further investigation for the detailed design such as geotechnical design, ice jamming conditions and constraints, seismic loading, possible requirements for heating and other construction problems in extreme climatic conditions.

(d) Schedule

Weeks 110 through 120

Subtask 6.29 - Watana General Arrangement

(a) Objective

To prepare general arrangement drawings for the Watana development for inclusion in the FERC license application.

(b) Approach

In this subtask the complete general arrangement of the Watana dam project will be developed. These arrangements will be based on preliminary designs prepared under preceding Task 6 activities for the major project components, including:

- reservoir area
- dam and access facilities
- spillway control structure and access facilities
- spillway discharge facilities
- intake structure and access facilities
- power plant and access facilities
- penstocks and surge tank (if required)
- tailrace arrangement
- switchyard and transmission facilities
- site access and camp facilities

The arrangement will be prepared in the form of reservoir and damsite area layout drawings appropriate for inclusion in the FERC license application.

(c) Schedule

Weeks 110 to 120

Subtask 6.30 - Devil Canyon General Arrangement

(a) Objective

To prepare general arrangement drawings for the Devil Canyon development for inclusion in the FERC license application.

(b) Approach

In this subtask the complete general arrangement of the Devil Canyon project will be developed. These arrangements will be based on preliminary designs prepared under preceding Task 6 activities for the major project components, including the following:

- reservoir area
- dam and access facilities
- spillway control structure and access facilities
- spillway discharge facilities
- intake structure and access facilities
- power plant and access facilities
- penstocks and surge tank (if required)
- tailrace arrangement
- switchyard and transmission facilities
- site access and camp facilities

The arrangement will be prepared in the form of reservoir and damsite area layout drawings appropriate for inclusion in the FERC license application.

(c) Schedule

Weeks 110 to 120

Subtask 6.31 - Project Feasibility Report

(a) Objective

To prepare report documenting the procedures followed in the evaluation of feasibility of the Susitna Hydroelectric Project, including the results of technical and economic studies, conceptual designs, preliminary environmental assessments and recommendations for the future development of the project.

(b) Approach

This report will assemble the results and documentation from all work undertaken in Task 6 and pertinent aspects of all other tasks. Previous reports prepared under Task 6 will be condensed into a single document, including The following:

Subtask 6.05 - Development Selection Report
Subtask 6.13 - Dam Selection Report
Subtask 6.19 - Spillway Selection Report
Subtask 6.28 - Power Development Report

The feasibility report will form the basis of the FERC license application and provide Alaska Power Authority with all technical and economic information necessary to decide whether or not to proceed, and how to proceed with the project.

Specific topics to be dealt with in the report will include the following, for each of the Watana and Devil Canyon sites:

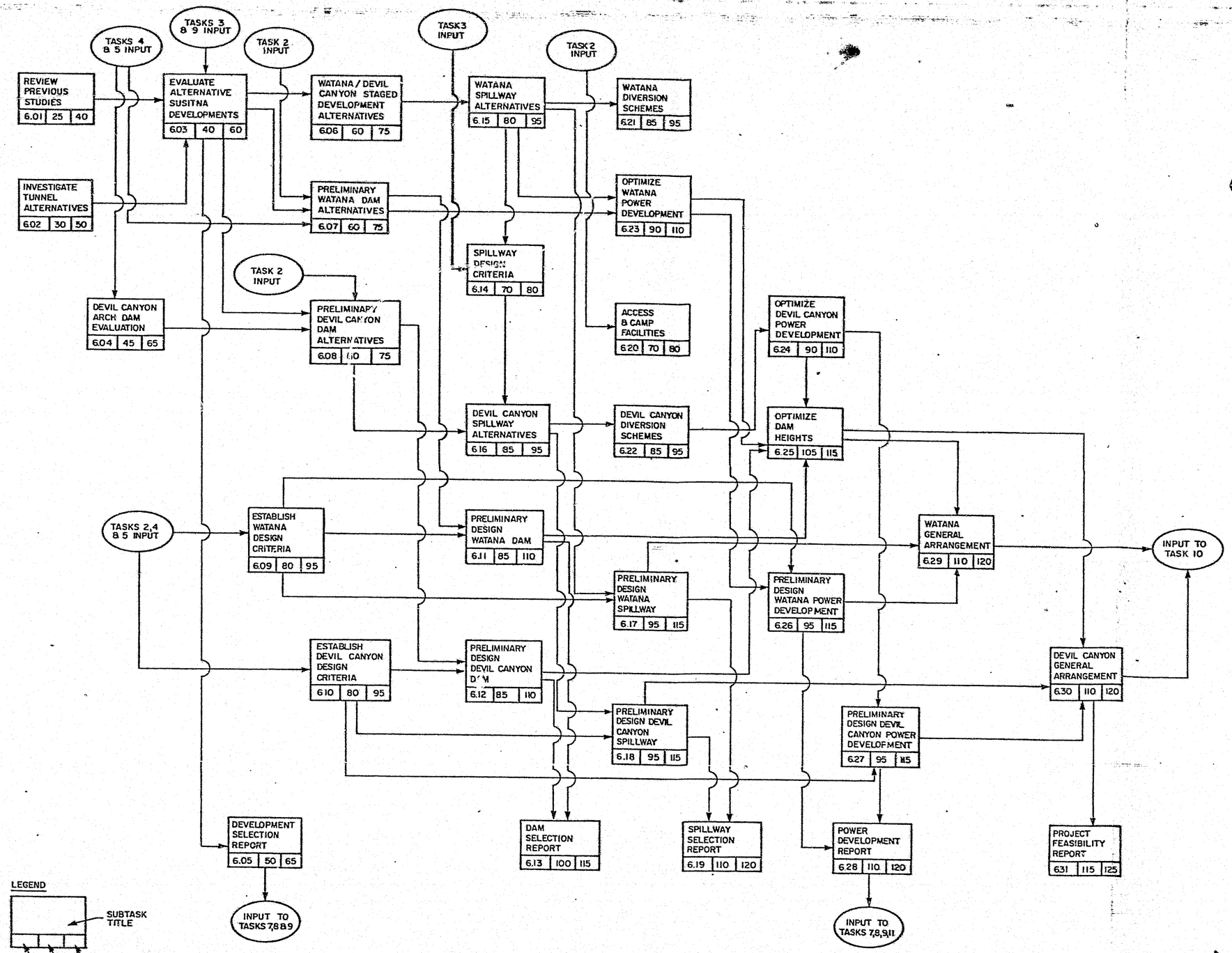
- Description of project
- Basic project data
- Design criteria
- Project staged development concepts
- Dam alternatives
- Consideration of Devil Canyon arch dam design
- River diversion schemes
- Spillway alternatives
- Power development alternatives
- Conceptual project designs and drawings
- Cost estimates and schedules
- Transmission
- Construction contract packaging
- Environmental considerations
- Power marketing studies
- Project feasibility assessments
- Recommendations for project development

(c) Discussion

The feasibility report will be submitted for comment by the external review panel and the Alaska Power Authority prior to completion and issue to the public. The report will form the basis of continued development and financing of the Susitna Project to meet the future power needs of the Railbelt Region.

(d) Schedule

Weeks 115 through 125



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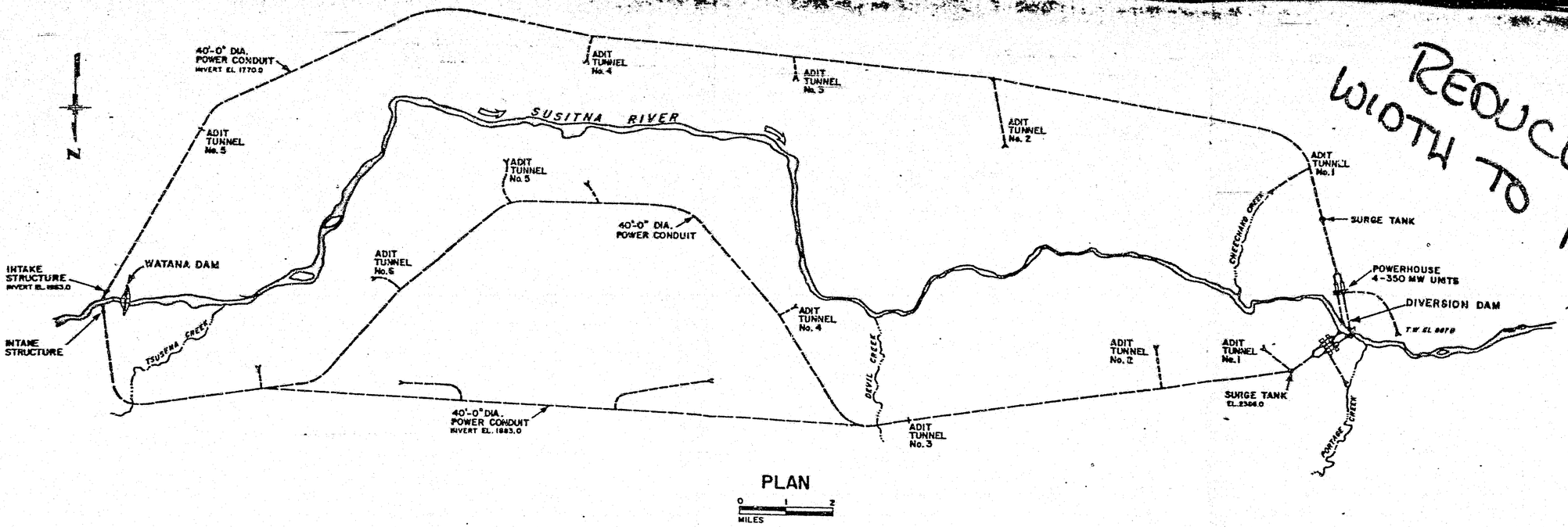
SUSITNA HYDROELECTRIC PROJECT
PLAN OF STUDY
PLATE T6.1 - TASK 6 SCHEDULE

REDUCE WIDTH TO 13½"



PLAN

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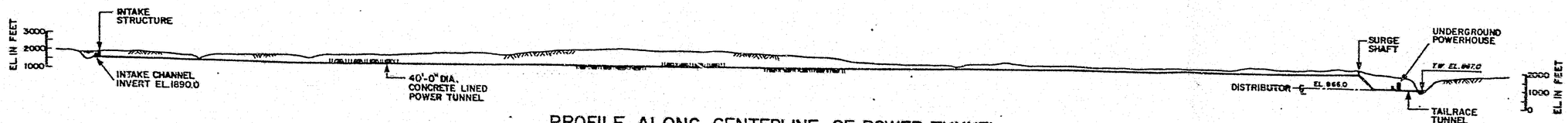

PROFILE ALONG CENTERLINE OF POWER TUNNEL

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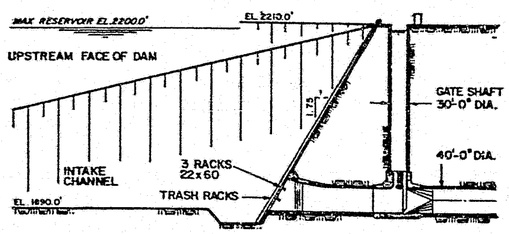

INTAKE SECTION

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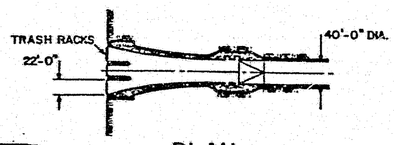
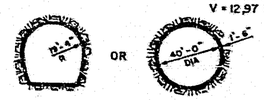


PLAN



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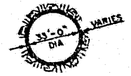
V = 12.97 FT/S

POWER TUNNEL SECTION



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INCLINED PENSTOCK SECTION

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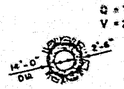
HORIZONTAL PENSTOCK SECTION



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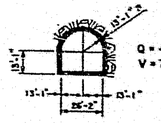

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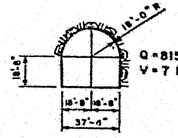
DRAFT TUBE SECTION



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V = 7 FT/S

TAILRACE SECTION

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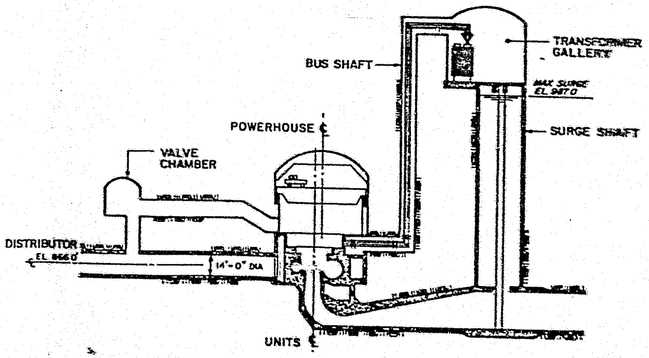

POWERHOUSE COMPLEX SECTION

0 40 80 FEET

SUSITNA HYDROELECTRIC PROJECT

PLATE 13 ALTERNATIVE TUNNEL SCHEMES