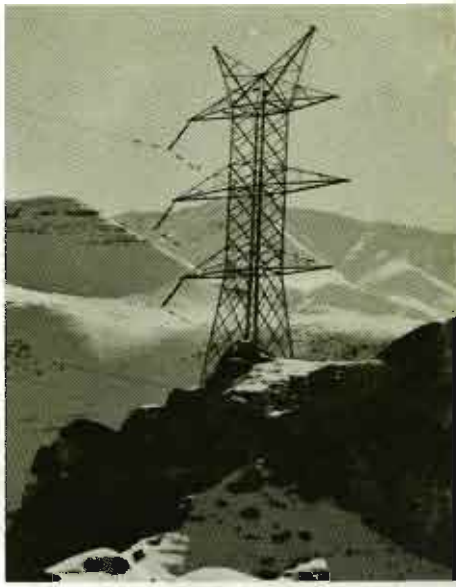
ALASKA POWER AUTHORITY
ANCHORAGE, ALASKA

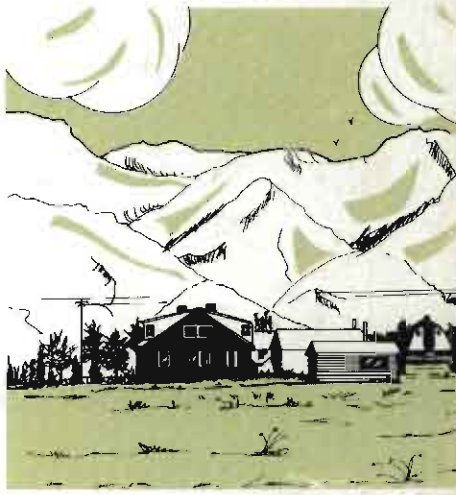
PLAN OF STUDY

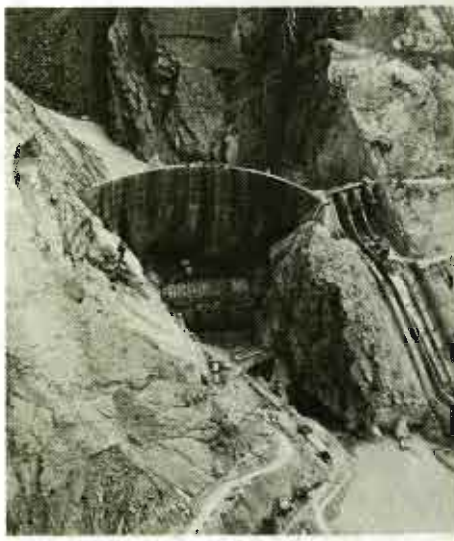
FOR
PROJECT FEASIBILITY AND
FERC LICENSE APPLICATION

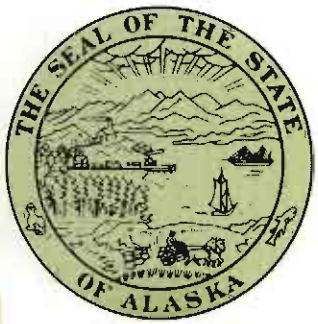
VOLUME IV - SUPPLEMENTAL INFORMATION

SUSITNA HYDROELECTRIC PROJECT









ENGINEERING COMPANY

AEBER 1979

VOLUME IV
SUPPLEMENTAL INFORMATION

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INTRODUCTION

This volume presents supplemental information on two of Harza's main study subcontractors: a. Woodward-Clyde Consultants (Seismic Geology and Seismology) and b. Fluor Power Services (Alternative Thermal Generation). Information includes general qualifications, project summaries, and a more detailed presentation of their work program.

Detailed information, on Harza's capabilities and qualifications were furnished to APA in our previous submittal of June 1, 1979.

RELEVANT EXPERIENCE AND QUALIFICATIONS

RELEVANT EXPERIENCE

General

Woodward-Clyde Consultants is a nationwide consulting firm practicing in the general fields of geotechnical engineering and environmental assessment. We offer such services as earthquake engineering, site selection, engineering, geology, seismology, environmental impact assessment, and decision analysis.

We have a staff of about 800 professional and support personnel, three-quarters of whom are graduate engineers and scientists or skilled technicians. Approximately 350 hold advanced degrees in the physical sciences (chemistry, geology, geophysics, hydrology, meteorology, physics, and physical oceanography), engineering (civil, geotechnical, mechanical, nuclear, chemical, and sanitary), the natural sciences (terrestrial and aquatic ecology and biological oceanography), and the social sciences (economics, land-use/urban planning, sociology).

WCC has conducted studies for a large number of projects to evaluate the characteristics of site ground motions during earthquakes and the potential for seismically-induced failure of in-situ soil deposits and earth and rockfill dams. Several of these projects are in Alaska. The attached table summarizes the earth and rockfill dams for which seismic stability evaluations have been made by WCC. Our scope of work for several of these dams is described in the project summaries following this section. The studies have ranged from regional to site-specific evaluations, and from feasibility to final design studies. The Offshore Alaska Seismic Exposure Study (OASES), which is summarized in the attachments, is particularly relevant to and useful for the probabilistic assessments of earthquake ground motions that will be made for the Susitna project.

QUALIFICATIONS AND EXPERIENCE/GEOLOGY-SEISMOLOGY-GEOPHYSICS

Woodward-Clyde consultants maintains a talented, multidisciplinary group of earth scientists engaged in geological, seismological, and geophysical investigations. The Director of the Geology-Seismology-Geophysics Professional Group is Lloyd S. Cluff, an internationally recognized expert in engineering geology and seismic geology. Until recently, the Chief Seismologist with Woodward-Clyde Consultants has been the late Dr. Don Tocher, a recognized authority in the fields of seismology and engineering seismology. The Geology-Seismology-Geophysics Group is composed of more than 125 professionals and is based in San Francisco, California. This group provides Woodward-Clyde Consultants with unmatched depth of experience and diverse capabilities in the earth science.

The Geology-Seismology-Geophysics Professional Group brings to the Susitna project, many hundreds of person-years involved with studies of regional seismicity, active faulting, and seismic hazard evaluation for major engineering projects. These past and present studies are world-wide in distribution and include extensive experience in Alaska. The fault study completed by Woodward-Clyde Consultants for Alyeska Pipeline Service Company in 1974 was a landmark investigation that established design parameters for active fault crossings and improved the knowledge of earthquake sources for the region of the Alyeska pipeline route. The area examined in detail in the study for Alyeska borders the study area for the proposed Susitna project. The Alyeska study demonstrated that the Woodward-Clyde Consultants project team has the capability to deliver the necessary and appropriate results of complex investigation carried out in Alaskan field conditions.

In addition, we have performed regional fault and seismicity studies for Alaska Outer Continental Shelf sites; the proposed NWAP gas pipeline in Alaska; regional and local fault, seismicity, and geophysical studies for marine terminal facilities proposed for Yakutat, Alaska; numerous seismicity and fault evaluations for nuclear power plant sites in California, Washington, Arizona, New Mexico, Texas, New York, Nicaragua, and Iran; regional seismicity and fault studies for numerous large dams; and fault mapping and earthquake recurrence evaluations in Alaska, California, Nevada, Arizona, Utah, Idaho, Washington, Italy, Venezuela, Argentina, Iran, Nicaragua, Guatemala, Colombia, and Ecuador. The experience gained in these investigations has resulted in the development of methodologies to effectively acquire, analyze, evaluate, document, and defend varied data analyses and interpretations for major engineering projects under close scrutiny of regulatory agencies. The attached descriptions illustrate the experience and services we have provided in some of our past projects.

QUALIFICATIONS AND EXPERIENCE - EARTHQUAKE ENGINEERING

In its Western Region, WCC has a permanent group engaged in earthquake engineering studies. The director of the Earthquake Engineering Group is Dr. I. M. Idriss, who is an internationally-known expert in this field. A staff of 13 engineers currently comprises the Earthquake Engineering Group in the San Francisco office of WCC's Western Region. An additional 3 engineers in the Earthquake Engineering Group are located in our Orange, California office. This group of engineers provides a depth of experience and capabilities for a variety of earthquake engineering applications.

The types of services engaged in by the Earthquake Engineering Group include: a) characterization of earthquake ground motions for design purposes; b) characterization of soil dynamic properties and cyclic strength characteristics; c) nonlinear analyses of the response of soil deposits to earthquakes, including development of improved procedures for analyses and material characterization; d) evaluations of the potential for seismically induced ground failures, including liquefaction and slope instability and ground deformations, and development of remedial measures; e) dynamic analyses of soil-structure interaction.

For use in characterizing ground motions and conducting dynamic response analyses, WCC has a data bank on computer files of recorded earthquake ground motions. The motions on file include all those digitized and processed at the California Institute of Technology and many other records from Alaska, Japan, South America and other locations acquired, digitized and processed by WCC.

For support in the evaluation of soil dynamic properties and cyclic strength, WCC has one of the finest soil laboratories in the country in Oakland, California. The laboratory has extensive experience in dynamic testing of soils. In addition, the laboratory has conducted extensive testing of frozen soils, mostly for the Alyeska pipeline project. Field support services for evaluation of soil dynamic properties include a strong geophysics capability, including proven equipment and techniques developed by WCC for the in situ measurements of shear wave velocity.

The types of earthquake engineering services summarized above have been applied to a variety of construction pro-

jects, including dams, nuclear power plants, offshore oil and gas platforms, port developments, bridges, LNG facilities, pipelines, and many other industrial and commercial projects.

PROJECT SUMMARIES

ALASKAN STUDIES

ALYESKA PIPELINE EXPERIENCE

Project: Trans-Alaska Oil Pipeline System

Client: Alyeska Pipeline Service Company

Location: Prudhoe Bay to Valdez, Alaska

Assignment: Geotechnical Engineering Consulting Services

General Statement - Woodward-Clyde Consultant personnel participated very widely in the extensive geotechnical engineering effort associated with the trans-Alaska pipeline project. Our involvement covered

- the early conceptual studies and government submittals
- the main design phase
- the preconstruction and construction phases
- preparation for pipeline operation.

From February of 1971 to April of 1978, we provided personnel working hand-in-hand with Alyeska personnel on engineering tasks. Additionally, personnel located in our offices performed on many specific tasks or projects such as the VSM tests and the earthquake fault studies. All along we made laboratory tests on soil samples shipped from Alaska to our Oakland, California soils laboratory.

Throughout this period we also participated with Alyeska in preparing documentation for submittals and presentations to, and discussions with, government review personnel.

The major identifiable technical tasks performed by WCC personnel fall in the following categories:

- geotechnical data gathering
- pipeline construction mode and design aspects
- VSM field tests
- earthquake fault studies
- participation in pipeline construction
- preparation for pipeline operation

In addition to accomplishing these specific tasks, senior WCC personnel also contributed significant concepts and ideas that established direction for the project in the engineering, engineering-management and government-relations fields. Several such contributions are outlined in a later section, following the discussions of the specific technical tasks.

Geotechnical Data Collection

Soil Exploration - We participated in planning soil and geotechnical exploration programs. During the field exploration, WCC personnel technically

evaluated drilling and sampling methods to provide for efficient field operation. At Valdez we made an offshore subsoil investigation utilizing a vibratory core sampler in support of the design of the ballast water outfall.

Laboratory Testing - In support of the design work, we conducted several laboratory test programs on samples recovered along the pipeline. These included tests to determine thaw strain due to thawing of initially frozen samples and the shear strength of initially frozen soil samples during and after thaw; the load-displacement-time (creep) behavior of frozen samples at controlled temperatures just below 32°F; the permeability to hot oil of compacted glacial till samples with and without bentonite admixture; and the thermal energy content (unfrozen moisture content) of frozen samples. Several of these testing programs were without precedent and required design of test equipment and development of test and analysis techniques.

Pipeline Design Aspects

Thaw Plug Stability - We investigated the "thaw plug" stability along the pipeline, i.e., the stability of the zone surrounding the buried pipeline or underlying the workpad of the elevated pipeline which is subject to thawing. We established design criteria for thaw plug stability, including consideration of earthquake forces, and made mile-by-mile evaluations for it. The results of this evaluation impacted on construction mode selection. An extensive program of field measurement of pore pressures and shear strengths in developing thaw bulbs complemented this effort.

Thaw Settlement - We participated in evaluation of methods to determine thaw settlement of thawing soils based on extensive thaw strain tests, and made mile-by-mile thaw settlement evaluations for use in determining construction modes.

Construction Mode Selection - For the most part, geotechnical considerations governed the selection of construction modes - conventionally buried, specially buried, and elevated on VSM bents. We participated in this selection both in preliminary studies and in detailed mile-by-mile evaluations.

Buried Pipeline Design - We investigated soil restraining characteristics (lateral and longitudinal) for bends and straight sections of buried pipeline, for both conventional and special burial. We also generated mile-by-mile geotechnical parameters for use in buried pipeline design, and evaluated foundation design for buried mainline valves.

Elevated Pipeline Design - WCC personnel had major responsibility in developing the types of VSM used for support of elevated sections of the line, in developing design criteria for these supports, and in generating mile-by-mile geotechnical information for use in mile-by-mile VSM design. This work was based in large part on the VSM field tests described later. A computer system to design each pile along the pipeline alignment was developed under the technical management of Woodward-Clyde personnel. The system was designed such that new pile designs for above ground pipeline sections could be generated rapidly if field conditions were found to be different during construction than

assumed during design. The loadings for the piles were taken from an existing program which produced the mile-by-mile design for the above-ground pipe accounting for thermal and structural loads.

As Built Data - Following up the design, computer systems were developed that recorded "as-built" pile data, materials used, and other related data. Also a system was set up to record and aid in evaluation of data generated during the hydrotesting that preceded the operational loading of the pipeline.

Pipeline Bridges - WCC personnel has major responsibility during the field investigation, design and construction of the foundations for all pipeline bridges except the Yukon River Bridge.

Remote Valve Sites - We developed foundation recommendations for the equipment building and propane tanks at all remote gate valve sites.

Construction Zone Design - WCC personnel participated in developing initial criteria for construction zone grading; i.e., need for and extent and details of grading, and determination of cut and fill slopes for different thawed or frozen materials. Individual cases of grading problems were evaluated and resolved.

VSM Field Tests

WCC personnel had responsible control of three generations of VSM field tests for the project. The first set of tests, conducted in 1970, resulted in initial design criteria, but also demonstrated that driven VSM without thermal protection would need to be unreasonably long. The second set of tests, in 1972, resulted in second-generation criteria and indicated the superiority of installing VSM in oversized predrilled holes and slurrying the annulus. The third set of VSM tests, in 1975, confirmed the tentatively adopted design criteria for thermal VSM in different soil types. The three sets of tests were instrumental in the evolution of VSM types and design criteria for the project, and resulted in the finally adopted design. WCC also participated in planning and documentation of other field VSM load tests made during construction, and supervised laboratory VSM load tests at the University of Illinois.

Earthquake Fault Studies

WCC geologists conducted a detailed study of potential active fault displacements along the pipeline route. This study permitted the pipeline designers to minimize the risk from possible future surface faulting, by delineating potentially active faults, estimating the "design" fault motions, and thus permitting specific pipeline design for these motions. Aerial reconnaissance and detailed analysis of aerial photographs were used to locate all linear features or lineaments which might be potentially active faults. Photogeologic interpretation included the use of Earth Resources Technology Satellite (ERTS) imagery, radar imagery and special low sun angle photography in selected locations. A later fault evaluation along the alignment of the suspected Clearwater Lake fault permitted elimination of any special design provision in this area.

Participation in Pipeline Construction

Preparation of Field Design Change Manual - WCC personnel generated the concept of the Field Design Change Manuals (FDCM) and prepared several drafts of both Volume I for VSM Construction and Volume II for belowground construction.

Field Engineering - WCC provided personnel for different field engineering functions, ranging from VSM hole logging to field engineering supervisor. In these capacities the personnel participated in all levels of field engineering work and decision making on pipeline construction. The work of the field engineers included inspecting construction, instructing the contractor, design change implementation and field documentation.

Office Support for Field Engineering - All through construction, WCC personnel were involved in office support of field engineering activities, including review of design changes, documentation, government interface, special field studies, and so forth. The fields for which WCC personnel took major responsibility included all aspects of VSM construction, belowground pipeline construction, and pipeline bridge foundations. For VSM in particular, there was further development of geotechnical design criteria, work on lateral load criteria, updating mile-by-mile design, and assistance to field engineers in solving VSM installation problems. For belowground construction there was review of bend design and development of overfill concept for as-built bends with insufficient cover.

Valdez Terminal and RCA Communication Towers - We provided field geotechnical engineering personnel for the Valdez Terminal and the RCA communication tower foundations. At Valdez we also participated in the evaluation of rock slope stability and embankment stability.

VSM Reliability Evaluation - The WCC Decision Analysis group made a fault tree analysis of the failure potential of elevated pipeline due to settlement of the VSM. The analysis showed extremely low probability of pipe wrinkling due to VSM settlement.

Preparation for Pipeline Operation

Surveillance and Monitoring Manual - In 1976 WCC personnel prepared a Geotechnical Surveillance and Monitoring Manual for the pipeline, pump stations and Valdez Terminal. This manual is being utilized by surveillance personnel.

Maintenance and Repair Manual - WCC personnel participated in preparing Maintenance and Repair Manuals for geotechnical aspects of both aboveground and belowground sections of the pipeline.

Major Concepts and Ideas

The previous paragraphs highlight the specific WCC accomplishments on the project. While these accomplishments were vital to the project, we believe that our contributions to the project in the form of concepts and ideas were just as significant. Several examples of these are presented below:

- A WCC team developed many of the concepts for pipe support in the early studies for the pipeline. These concepts form the basis for much of the stress analysis of the pipeline.

- We foresaw the need for a major field engineering and quality control effort and documented this with various memos to Alyeska. These memos developed into the organizational structure that was adopted and to the Field Design Change Manual, the concept of which was developed by WCC personnel

- WCC introduced the concept of the use of heat pipes for controlling degradation of the permafrost. The early concept was the use of heat pipes to permit burial of the pipe in high-ice-content soils. This concept did not work out, however, it progressed to the use of heat pipes in the VSM which became the basic design solution for the elevated pipeline.

- WCC promoted the concept of task-oriented organization rather than discipline-oriented organization resulting in a reorganization of the engineering effort which was successful in completing the design of the pipeline.

- WCC personnel developed the concept of prequalification of manufacturers of the heat pipe and pushed this concept through to successfully deliver heat pipes to the project to meet schedule needs.

- WCC personnel participated in developing many of the strategies that were adopted in developing the design and construction plan and securing approval from the Federal agencies. As a part of this effort, assistance was provided in detailed planning to support the strategies adopted.

Project: Proposed LNG Plant at Yakutat, Alaska

Client: Pacific Alaska LNG Co. and California Alaska LNG Co.

Location: Monti Bay - Yakutat, Alaska

Assignment: Preliminary Site Investigation

A preliminary study involving geology, seismology, geophysics, oceanography, and static and dynamic geotechnical engineering was performed on a 400-acre site and the surrounding area to determine the feasibility for a major plant site. The site is located on a terminal moraine underlain by outwash deposits. Major faults with a history of major earthquakes lie within a radius of 50 miles from the site. Tsunami effects have been recorded. Sufficient information was developed to warrant continued consideration of the site for the plant location.

Offshore Geophysics - Boomer, Sparker and Sidescan Sonar surveys were conducted over approximately 2.5 square miles of the bay to develop bathymetry, estimate thicknesses of various subsurface strata and to identify shoals or other shipping obstructions.

Geology and Seismology Studies - Using existing data and field reconnaissance, the geologic and seismic regimes which would constrain the use of the site were evaluated. Preliminary design earthquakes were established and tsunami and land level change potentials estimated.

Earthquake Engineering - Available data were analyzed in conjunction with the preliminary design earthquakes to develop preliminary design response spectra and to evaluate the potential for ground instability such as liquefaction or spreading. Bluff stability at the shoreline was also evaluated.

Foundation Engineering - Soil data were evaluated to establish preliminary design parameters for plant foundations.

Site Selection - Using results of the geophysical, geologic, seismologic, earthquake engineering and foundation engineering studies together with economic studies of grading and pier costs, recommendations were made as to the most suitable location of the plant within the site area.

Project: Proposed Northwest Alaskan Gas Pipeline

Client: Northwest Alaskan Pipeline Company, and Fluor Engineers and Constructors, Inc.

Location: Prudhoe Bay to Alaska/Yukon Border

Assignment: Geotechnical Engineering Consulting Services

Since 1977 Woodward-Clyde Consultants has been assisting the Northwest Alaskan Pipeline Company in their geotechnical efforts directed toward construction of the Alaskan portion of the Alaska Highway gas pipeline from Prudhoe Bay to the U. S. Midwest and West. Our work has included the following major tasks:

- Monitoring and evaluation of blasting tests
- Geotechnical and environmental data review
- Environmental review of access routes and realignments
- Fault study
- Laboratory testing of soil samples

These tasks are described in the following paragraphs.

Monitor and Evaluate Blast Tests

Woodward-Clyde Consultants monitored a series of trench blast tests conducted near Fairbanks, Alaska. The purpose of these tests was to demonstrate that effective trench blasting could be conducted very close to the trans-Alaska oil pipeline without generating damaging blast effects. At each of three test sites, geotechnical conditions were assessed using borings, trenches, aerial photography, geophysical techniques, and probings. Ground vibrations and air blast levels from each blast were monitored using seismographs to measure the particle velocities generated. The data generated were analyzed and presented in a detailed report which described all aspects of the tests, the data, and the theory to demonstrate that these blasts would not have significant impact on the oil pipeline. The report has been used by Northwest to demonstrate to the appropriate agencies that the Northwest construction blasting plans are credible.

Geotechnical and Environmental Data Review

Woodward-Clyde Consultants was retained to examine, catalog, describe, and evaluate existing data that could be used in the design of the Northwest Alaskan Gas Pipeline. This study covered open literature and proprietary data. In the open literature review technical publications, University of Alaska data, USGS information, Alaska Highway Department information and many other miscellaneous sources were examined and cataloged.

Proprietary data evaluated included the Canadian Arctic Gas files and the El Paso Natural Gas Company files relating to their efforts to bring Prudhoe Bay gas to the Continental U.S.

The final phase of this study was a review of the data generated by Alyeska Pipeline Service Company. The review included examination of the extensive data base, and appraisal of the validity and utility of the data to the gas pipeline project.

Environmental Review of Access Routes and Realignments

This project involved office and field investigations of access and alignments for the Delta Junction - Canada portion of the proposed gas pipeline. Biological, hydrologic, and land use evaluations were made. A preliminary office review of 250 access routes identified by Northwest was conducted using interpretation of aerial photographs (color 1:24,000), USGS topographic maps, marked alignment sheets, and literature available describing regional and local environmental characteristics. Based upon the results of our preliminary review, Northwest eliminated 51 routes from further consideration. The remaining 199 access routes were evaluated in the field in January 1978. Northwest used the evaluations to select environmentally suitable routes for its permit applications to State and Federal agencies.

Fault Study

This project identified candidate significant faults in the section of the gas pipeline between Delta Junction, Alaska, and the Alaskan-Canadian border. One objective of the study was to develop a definition of the term "significant fault" for the purpose of designing and constructing the pipeline. The study utilized existing seismographic records to identify microseismic clusters along the pipeline corridor, as these clusters may relate to faults. Geologic studies included extensive interpretations of aerial photographs and satellite images, and compilations of available geological data. A field reconnaissance of selected geological features of interest was included as part of the study. The results of the study were utilized to identify candidate significant faults and to assess the necessity of detailed field studies along these features.

Laboratory Testing of Soil Samples

The WCC Oakland laboratory conducted a massive laboratory testing program for the project, in support of the subsurface exploration program in the alignment section from Delta Junction to the Canadian border. The program included every-other-day pickup of samples along the alignment (a round trip of 750 to 800 miles out of Anchorage), an airlift of samples from Anchorage to San Francisco, and testing on a large scale in the Oakland laboratory. A total of about 1,500 samples from 150 borings were received; about two-thirds of the samples were frozen when they were recovered, and this frozen state was maintained from the recovery through shipment to Anchorage, San Francisco Airport and eventually to Oakland, where the samples were stored in a large freezing room. The large majority of the over 3,000 tests were index property tests, but a limited number of engineering property tests were also made.

PROJECT: Offshore Alaska Seismic Exposure Study (OASES)

CLIENT: Consortium of Oil Companies

LOCATION: Gulf of Alaska

ASSIGNMENT: Assessment of Seismic Exposure in Offshore Alaska

This study was conducted for a group of twenty-one oil companies and had as its principal objective the assessment of seismic exposure on stiff ground in nine future oil and gas areas in offshore Alaska. The key results of the study consisted of probabilistic estimates of the amplitudes of earthquake ground motions throughout the lease areas.

The study involved three broad steps. In the first step, offshore and onshore seismic sources were characterized in terms of their location, geometry, and the recurrence of earthquakes of various magnitudes. In the second step, the attenuation of ground motions with distance from the sources was characterized by developing probabilistic attenuation relationships. In the third step, the seismic exposure, i.e., the probability of exceedance of given amplitudes of ground motions within given time periods, was calculated for numerous locations within each lease area, and contour maps and tables were prepared to depict the results.

The study incorporated several special features not generally present in seismic exposure studies. First, several ground motion parameters of significance to design on offshore platforms, including peak accelerations, peak velocity, RMS acceleration, RMS velocity, and response spectral values at several structural periods were studied, rather than just a single parameter such as peak acceleration. Second, the most current knowledge of plate tectonics was incorporated to supplement the historic seismicity in assessing the frequency of occurrence of earthquakes in space and in time. Specifically, seismic "gaps" on major fault systems were assessed as having a higher potential for causing large future earthquakes in the recent past. For these assessments, formal analysis of probabilities of occurrence were facilitated using subjective (Bayesian) probability analysis procedures. Third, the different tectonic character of some of the seismic sources was explicitly incorporated in defining a seismic source model and in developing attenuation equations. Specifically, it was found that the ground motions caused by

earthquakes at large depths in major tectonic subduction zones would have a significantly different character than the ground motions caused by shallow-focus earthquakes. Thus, the attenuation relationships were developed by sorting available recorded data into two groups associated with different seismic source characteristics. In addition, separate attentuation relationships were developed for rock and stiff-soil subsurface conditions. As part of the study, analytical studies of ground response, including body-wave and surface wave analyses were also made.

The results of the seismic exposure studies were compared with current standard criteria describing seismic inputs to be used in the analysis and design of offshore platforms.

PROJECT: Clearwater Lake Scarp Study

CLIENT: Alyeska Pipeline Service Company

LOCATION: Clearwater Lake

ASSIGNMENT: Investigate Possible Active Earthquake Fault

The Clearwater Lake escarpment, near Big Delta, Alaska, was interpreted by a 1973 WCC study as possibly being related to active faulting. The escarpment is only a few miles from the pipeline route, and its projtion toward the route raised the question of whether or not it was due to faulting and, if so, where it may have crossed the pipeline.

Geophysical studies were made in 1976 that consisted of detailed gravity, ground magnetic, aeromagnetic, and electromagnetic surveys of an area larger than 100 square miles. These studies were oriented toward determining the configuration of the bedrock surface beneath the Quaternary sedimentary fill of the area and toward identifying zones of fault gouge.

Detailed logging of the pipeline trench was part of the geologic study as well as new trenches that cross the escarpment. Quaternary geology of the area was mapped, and age dating was accomplished by carbon-14 and paleomagnetic dating and by studying pollen chronology and minerology in the Quaternary materials.

Field work was accomplished under conditions of low temperature and safety problems of unstable trench walls. Results of the study showed that no fault is present.

PROJECT: Kodiak Shelf Geotechnical Study

CLIENT: Confidential

LOCATION: Kodiak Outer Continental Shelf, Alaska

ASSIGNMENT: Preliminary Evaluation of Geotechnical Conditions

Woodward-Clyde Consultants provided a preliminary evaluation of geotechnical conditions on the Kodiak Outer Continental Shelf, designated as a potential lease sale area for offshore oil and gas development. The purpose of this study was to interpret the geologic history of the area to provide preliminary evaluations of the characteristics of the foundation materials to be encountered and to identify, map and discuss active faults and other potential geologic hazards such as slope instability, liquefaction, strong ground shaking and tsunamis in the area. The study was conducted using available published records and maps and offshore marine geophysical survey results.

PROJECT: Yakutat Marine Terminal

CLIENT: Earl & Wright, Structural Engineers

LOCATION: Yakutat, Alaska

ASSIGNMENT: Geotechnical Investigation for Onshore and Offshore Facilities

An investigation was made of two potential sites for a marine terminal. The proposed facilities include a timber dock at one site and a concrete dock pier to be supported on steel H piles at the other site. Proposed onshore facilities consist of storage tanks and buildings.

Woodward-Clyde Consultants monitored a field investigation consisting of several borings and test pits onshore and five offshore borings. Laboratory testing by another firm was reviewed and evaluated.

A study was made of regional and local geology and regional historic seismicity. This study included an assessment of earthquake effects, including potential surface faulting, liquefaction and tsunamis.

Recommendations were made for preliminary criteria for site development and foundation design, including allowable bearing presures for spread footings, pile capabilities, site grading rip-rap, and slope stability.

PROJECT: Earthquake Fault Studies, Alaska

CLIENT: Alyeska Pipeline Service Company

LOCATION: Prudhoe Bay to Valdez, Alaska

ASSIGNMENT: Active Fault Study

In 1973, a team of 15 geologists from Woodward-Clyde Consultants conducted a study of active faults in Alaska for Alyska Pipeline Service Company. The study covered an area of Alaska that extended from Juneau on the south to west of Anchorage, and north to Prudhoe Bay. The study was mainly conducted as an exploration effort to search for active faults, although land erosion and fill, and geomorphic processes were also considered.

A thorough review of all pertinent geological literature of Alaska was completed, followed by a geologic photointerpretation of Side-Looking Airborne Radar (SLAR), Earth Resources Technology Satellite (ERTS) imagery and mosaics, infrared (IR) imagery, low-sun-angle aerial photography, and standard black-and-white aerial photography that covered an area larger than 240,000 square miles of Alaska. The interpretation of these images and the literature review produced approximately 8,000 lineaments that were evaluated in the field for their possible relationship to recent fault activity. Field studies of these lineaments and of other features noted in the field were concentrated into four months of helicopter time and 800 hours of fixed-wing aircraft time were utilized. The field studies consisted mainly of on-site evaluation of landforms and geologic units, and included geophysical studies at selected locations. Special low-sun-angle aerial photographs were taken by the Woodward-Clyde Consultants' staff and interpreted during the field season.

The studies resulted in identifying and mapping more than 25 potentially active faults in Alaska, some of which were previously unknown, and providing significant new data with regard to surface fault activity and tectonics in Alaska. Detailed studies were undertaken of four potentially active faults crossed by the pipeline design at fault crossings.

PROJECT: Offshore Drilling Platforms

CLIENT: Consortium of Oil Companies

LOCATION: Gulf of Alaska

ASSIGNMENT: Earthquake Ground Response Studies

Woodward-Clyde Consultants has performed a series of studies in 1973-1977 to evaluate the seismic response of soft clays offshore in the Gulf of Alaska. This was done for a group of oil companies, prior to and after lease sales, as part of preliminary seismic design studies for drilling platforms.

In one part of these studies, clay samples from one offshore boring and from onshore were subjected to laboratory cyclic loading tests to determine the stress-strain behavior of the soil during earthquakes. On the basis of the measured behavior of these and other clays, a new stress-strain model was developed and a new ground response computer program was written.

In another part of these studies, the seismic response of one offshore site was evaluated using the new computer program as well as existing state-of-the art procuedres. The evaluation included estimating the ground shaking characteristics near ground surface for seismic design of the structure, the deformations of the soil at different depths for seismic design of piles, and the evaluation of the stability of the ground under the induced seismic loading. This was done for a range of assumed earthquake rock motions which could affect the site.

The most recent part of the studies involved a new series of cyclic tests, from which results the stress-strain model and computer code was extended to enable prediction of seismic deformations of soft clay profiles underlying mildly sloping seafloors. In addition the stress-strain characteristics of overconsolidated clays were investigated.

PROJECT: Providence Hospital Additions

CLIENT: Skidmore, Owings & Merrill, Architects

LOCATION: Anchorage, Alaska

ASSIGNMENT: Foundation Investigation and Ground Response Studies

A soil investigation was made and foundation recommendations presented. The regional seismicity was assessed to establish a design earthquake. Ground response analyses were made for the design earthquake and site response values obtained for use in the structural design.

PROJECT: Gastineau Channel Bridge No. 740

CLIENT: State of Alaska Department of Highways

LOCATION: Juneau, Alaska

ASSIGNMENT: Evaluation of Liquefaction Potential in the Foundation Soils

Woodward-Clyde Consultants conducted studies to evaluate the liquefaction potential of the foundation soils underlying the bridge piers and abutments.

The studies included a preliminary assessment of cyclic strength of the material on the basis of the blow count data determined from field borings.

Using currently available empirical procedures, the potential for liquefaction of the foundation soils was evaluated for specified design earthquakes occurring on faults in the vicinity of the structure. In addition, the study provided a qualitative assessment of the possible lateral movements in sloping ground at the location of one of the bridge piers.

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SEISMIC GEOLOGY AND SEISMOLOGY

DETAILED ACTIVITY DESCRIPTION

SUSITNA HYDRO: PLAN OF STUDY

TASK A SEISMIC GEOLOGY AND SEISMOLOGY

The Susitna hydropower project is located in a seismically active region that is poorly understood in terms of its seismic potential. Previous studies of the seismic geology of the project area are limited to a two-week reconnaissance by Kachadoorian and Moore of the U.S. Geological Survey, and limited geologic mapping by personnnel of the University of Alaska. These two groups are in conflict with regard to a major issue that must be resolved during the detailed feasibility studies proposed in this task. The personnel of the University of Alaska have mapped a major fault, named the Susitna fault, that may be active and have located it across the Susitna River downstream from the proposed Watana damsite; the fault branches from the Denali fault in the Alaska Range. However, Kachadoorian and Moore were unable to identify the fault during their reconnaissance, and they reported no evidence for active faulting along any of the known and inferred faults of the area; they did report scarps with relief as great as 15 feet in bedrock which may have resulted from earthquake activity.

The studies outlined in Task A are oriented toward resolving the question of whether or not the Susitna fault is present, whether or not it is active, and whether or not it may impact the proposed project. In addition, the proposed studies are oriented toward identifying and resolving the origins of scarps and other lineaments that may be noted during field surveys, and in evaluating their impact, if any, upon the seismic design of the project.

The potential for reservoir-induced seismicity is another major issue that Task A studies will address. Woodward-Clyde Consultants has previously completed studies of reservoir-induced earthquakes for dams in many areas of the world. Based upon this experience, it appears that dams and reservoirs in the Susitna area are likely to be subjected to earthquakes, whether or not the earthquakes are induced by the proposed reservoirs impounded by dams on the Susitna river. The reservoirs are not likely to increase the maximum size of earthquakes that may occur, but the frequency of earthquakes may be increased and they may present a trigger-source. The subject needs to be addressed and a comprehensive review is proposed.

The results of seismic geology and seismologic studies in Task A will provide data regarding the regional earthquake setting and these data will be applied to design in Task B. Task A results will include identification of the maximum sizes of earthquakes on faults, their frequency of occurrence, their focal mechanisms (earthquake types), and their locations. In addition, the potential for surface faulting will be addressed on a regional basis, with emphasis on potential faulting at proposed damsites and other spatial critical facilities.

TASK A. SEISMIC GEOLOGY AND SEISMOLOGY

Subtask 1. Review of Available Data

(a) Objective

The objective of this subtask is to acquire, compile, and review existing data that are useful in identifying the earthquake setting of the Susitna River area. These data will be used to define the seismologic investigations (Subtask 2), of the seismic geology field reconnaissance (Subtask 4), and the seismologic investigations (Subtask 2).

(b) Approach

Available geological, seismological, and geophysical data for the region will be gathered from sources such as Woodward-Clyde Consultants' (WCC) files, the Department of Geology and the Geophysical Institute of the University of Alaska, the Alaska Geological Survey, the U.S. Geological Survey, and major colleges and universities involved in research pertinent to the project. In addition, independent 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 main aim of the geological data collecting exercise will be to obtain information on structural features of the earth which may represent 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. Typically, regional gravity and magnetic data are useful in identifing major discontinuities

in the crust of the earth; these discontinuities may be along faults that could produce large earthquakes and surface fault ruptures. Other types of geophysical data, if available, may also be of use in identifying active faults; these other types of data may include seismic refraction, seismic reflection, or electrical resistivity measurements.

Seismological data will be acquired for the project area. These data will include historical information about 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 of reviewing the acquired information will consist of maps that identify faults, lineaments, and epicenter clusters or alignments. These maps will provide a basis for further geological and seismological studies in subsequent subtasks.

In addition to the data acquired for the project area, other data will be compiled with regard to reservoir-induced seismicity. 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.

(c) Discussion

The seismicity and seismic sources of the Alaskan interior have only recently begun to be studied in significant

detail. Major interest in the seismicity of continental Alaska was stimulated by the occurrence of the 1964 earthquake and consisted of initiation of regional microearthquake monitoring and augmentation of geological investigations to understand 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 20 km; and earthquake activity in a Benioff zone (depth range of 50 to 150 km) 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 understanding of the present-day tectonic activity. The past occurrence of 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. These past regional evaluations have been for the Trans-Alaska Pipeline Project, 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.

Past evaluations of reservoir-induced seismicity have been completed by Woodward-Clyde Consultants for numerous dams in the western hemisphere, and selected dams in the eastern hemisphere. These past evaluations provide a data bank that will be utilized to evaluate the potential for reservoir induced earthquakes in the Susitna hydroelectric project.

The specific products of this subtask include the following:

a. 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 will be evaluated to estimate completeness level of the catalog with respect to magnitude, focal depth, and spatial location.

b. 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.

c. Tectonic model: Based on available seismologic and geologic data, a preliminary kinematic tectonic model will be developed for the region within about 200 miles of the

site. This model will be modified as needed by studies in later subtasks and provides 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.

TASK A SEISMIC GEOLOGY AND SEISMOLOGY

Subtask 2. Seismologic Investigations

2.1 Monitoring Program

(a) Objective

The objective of this subtask is to provide required basic seismological data regarding potential earthquake sources within the Susitna River area.

(b) Approach

Since the study area is in a remote but seismically active area, additional detailed earthquake source data will be collected by installing and operating localized microearthquake recording networks. This work is felt to be essential because the sensitivity of the present network operated by the Geophysical Institute is about Magnitude 2 1/2 or larger and does not provide the desired regional information. The initial microearthquake studies will be carried out for a period of three or more months and will provide data on location, focal depth, and causative stresses orientations of small earthquakes (Magnitude less than about 3) within the study area. These data will supplement the existing regional network operations and will provide needed accuracy and low detection threshold. The short term study will provide the information needed to properly site the long-term network and to select instrumentation for it. Also, it will aid in planning the seismic geology field studies. Subsequently, long-term microearthquake studies will be implemented using a permanent radio-telemeter network to collect microseismicity data necessary for the evaluation of the possible occurrence of reservoir-induced seismicity.

1. Short-term Microearthquake Monitoring: During the summer of 1980 a program of microearthquake monitoring will be carried out in the region. Eight to ten recorders with station spacing of 6 to 15 miles will record microearthquake activity with sensitivity of about Magnitude 1.0 or less. Low-power radio telemetery will be used to make the field operation as efficient as possible. Helicopter support will be required for installation and maintenance. During the course of the study, some of the stations may be moved to study specific areas of activity. Initial station deployment will be guided by a review of the available data (Subtask 1) and preliminary field reconnaissance. Data analysis will be carried out to locate active seismic sources, evaluate their spatial extent and focal depth, to establish causative stress orientations based on focal mechanism studies, to evaluate seismic attentuation, and to evaluate the statistical features of the microearthquake activity. Liaison will be maintained with the Geophysical Institute of the University of Alaska and the U.S. Geological Survey to maximize the data base used in our analyses. The recording period is initially planned as three months; however, this is dependent on the information collected and may need to be modified. Appropriate recommendations will be made during the course of the study.

2. Long-term Microearthquake Monitoring: Following the completion of the short-term monitoring, a detailed program of long-term monitoring will be prepared, including recommended station locations, instrumentation, and long-term operation and data analysis. This study will be designed to establish the background level of seismic activity on shallow crustal faults to provide a data base for the project area. Consequently, emphasis in the monitoring program will be on inexpensive but reliable data collection and for flexibility in data analysis.

3. Source and Wave Propagation Assessment: This analysis effort will utilize the collected data to make assessments of the study area seismicity. Specific results to be obtained include the association of larger earthquakes (such as the 1904 and 1912 events) with probable source structures, determination of depth of the Benioff zone of deeper seismic activity, and attenuation characteristics of subduction zone earthquakes. Seismic source zonation in terms of maximum earthquake potential on the Benioff zone will be done. Comparisons will be made with seismic activity in other comparable tectonic areas to assess attenuation and maximum earthquake potential. The scope of these studies may need to be modified based on the results obtained as the work progresses.

2.2 Reservoir-Induced Seismicity

(a) Objective

The potential for the possible future occurrence of reservoir-induced seismicity will be evaluated in this task.

(b) Approach

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 will be applied to the known factors for the Susitna project in order to statistically evaluate the potential for reservoir-induced seismicity. This analysis will result in a quantitative assessement 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 selected Susitna dam

sites with the same parameters for the world's deep and/or very large reservoirs. Based on this comparison, the probability of reservoir-induced seismicity at the selected Susitna dam sites will be assessed. A description of known cases of reservoir-induced seismicity will be discussed emphasizing the relationship between filling of the reservoir and the length of time to the first and largest earthquakes. The relevance of these data to the Susitna dam sites will also be discussed.

TASK A SEISMIC GEOLOGY AND SEISSMOLOGY

Subtask 3. Interpretation of Remote Sensing Images

(a) Objective

The objective of this subtask is to interpret available remote sensing imagery in order to identify topographic features that may be associated with active faulting. These data will be used during the seismic geology reconnaissance (Subtask 4) and field studies of controlling features (Subtask 5) to identify youthful faults that may produce future earthquakes and surface fault rupture.

(b) Approach

Remote sensing imagery and aerial photography of the study area will be obtained for a lineament analysis. These remote sensing data will include available Landsat, SLAR (side-looking airborn radar), and Skylab photography; high altitude U-2 or RB-57 color infrared photographs; and black-and-white aerial photographs. The analysis of these data will provide the basis for scoping the field program for the fault study.

(c) Discussion

The remote sensing and high altitude imagery and aerial photographs obtained 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. Epicenter clusters and alignments identified during the seismicity evaluation (Subtask 2) 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, as well as distinguishing these from similar features that result from non-tectonic geologic processes.

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. On this task, aerial photography may be obtained. Low-sun-angle color infrared and black-and-white photography at a scale of approximately 1:24,000 is proposed.

Low-sun-angle aerial photography has proven valuable in delineating subtle topographic features that may be fault-related. The long shadows cast by the low-sun-angle high light subtle topographic features related to faults, such as scarps or offsets, that would be undetectable with conventional vertical aerial photographs. This technique is particularly effective in topography of low relief such as the proposed reservoir area.

Color infrared photography has proven extremely useful to 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.

Woodward-Clyde Consultants has had extensive experience in utilizing remote sensing imagery for geologic investigations, and continually uses this approach in the study of fault activity. Low-sun-angle photography is an evaluation technique that was developed specifically for fault studies, and has been used by Woodward-Clyde Consultants on projects in Alaska.

A map of lineaments within the project area will be produced as a guide for Subtask 4 and Subtask 5. The lineament map will be supplemented by mapped faults from Subtask 1, in order to compare known faults with lineaments of various origins.

TASK A SEISMIC GEOLOGY AND SEISMOLOGY

Subtask 4. Seismic Geology Reconnaissance

(a) Objective

The objective of this subtask is to complete a reconnaissance investigation of lineaments that may be faults and known faults in the Susitna River area, in order to identify active faults and to establish priorities for detailed field investigations.

(b) Approach

The data developed from work described in previous subtasks (Subtask 1) and aerial photographic interpretation (Subtask 3) will be utilized to finalize the plan for 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 and whether it may impact the project area by either being associated with a large previous earthquake or being capable of producing future surface fault rupture. Features within the project area will be studied during the reconnaissance and each lineament and fault will be identified by a unique number. In addition, regional reconnaissance of major features such as the Denali fault and the Castle Mountain fault may extend as far as 200 miles from the project area. 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 considered further in the field reconnaissance by 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 geologic units. 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.

(c) Discussion

The Susitna River area is in a complex tectonic area that is poorly known geologically. Previous work by Kachadorian and Moore indicated 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. Although some surface features may yield their origins with reconnaissance-level study, other features may require detailed mapping, trending, borings, or geophysical data in order for their origins to be identified.

Woodward-Clyde Consultants has conducted seismic geology reconnaisssance investigations over large regions of Alaska and in many other seismically active areas of the world. Based upon this experience, we estimate that reconnaissance-level investigations as proposed in this subtask will definitively identify the origins of about 90% of the lineaments identified on remote sensing images. The remaining features will be considered for further detailed investigations during the 1981 field season, if these features are identified as being possible faults important for dams and other critical facilities.

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 studies, and preliminary estimates of the maximum credible earthquake and faulting, along with the recurrence of faulting, will be made for each active fault and features that may be faults.

TASK A SEISMIC GEOLOGY AND SEISMOLOGY

Subtask 5. Field Studies of Controlling Features

(a) Objectives

The objectives of Subtask 5 are to provide input to Subtask 6 by identifying faults that may be active and are in the vicinity of selected dam sites. 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.

(b) Approach

Subtask 5 field studies will be based upon results of the Subtask 4 seismic geology reconnaissance, and upon the results of the Subtask 3 seismologic investigations. In addition, field studies will be pursued along features that may affect the selected dam sites.

Subtask 5 will include the following investigations that will be specifically designed for each feature to be studied: geologic mapping at a scale of 1:24,000, trenching selected features, borings, test pits, geophysical investigations, and,or age dating.

(c) Discussion

The geologic mapping during Subtask 5 will include both more detailed Quaternary data, and also bedrock mapping at selected places along specific lineaments and geologic features, such as the Susitna fault and other features that may be fault-related. Age-dating studies may be required 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, are anticipated to aid in evaluating these features.

The trenching (or boring) sites will be selected during the geologic mapping phase and will reflect areas considered to be the more favorable to assess the nature of the faults and the degree of fault activity.

As a firsst estimate, we anticipate approximately 3 trenching sites, with 2 trenches each, will be identified along the Susitna fault, and an additional 3 trenching sites (with 2 trenches each) along other features may be identified as important features. Geophysical investigation, such as seismic refraction may aid in locating and evaluating the faults and the nature of the faulting. During the course of the study, other methods of geophysical investigation, such as gravity or magnetic studies may be considered, as warranted.

The data derived from these geologic studies on important features will be evaluated with regard to their potential 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 selected 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. These data will form the basis for design values derived in Subtask 6. In addition, the seismic effects in the area of the dam and reservoir will be assessed with regard to landslides and liquefaction that may affect past the dam and other engineered structures either directly or indirectly.

Products derived from Subtask 5 will include:

1) Documentation, tabulation, and an assessment of linea-

ments, mapped faults, and epicenter locations identified as potential important features.

2) A map (scale 1:24,000) of the selected important features in the vicinity of the selected dam sites.

3) A geologic map (scale 1:24,000) and selected areas along the important features.

4) Trench logs or core data of excavation or borings made to further evaluate the important features.

5) The interpretation of geophysical data collected along the important features.

6) Estimate 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 selected dam sites, and the frequency of occurrence of earthquakes of that magnitude along each important feature.

7) An evaluation of significant, related seismic effects that may occur in the selected dam sitea and reservoir area.

TASK A SEISMIC GEOLOGY AND SEISMOLOGY

Subtask 6. Evaluation and Reporting

(a) Objectives

The objectives of this subtask are to complete the evaluations of the seismic environment of the project, to define the earthquake source parameters required for earthquake engineering input in design, to document the studies in reports suitable for use in design studies (Task B), and to provide overall management and coordination of seismic geology and seismology tasks.

(b) Approach

The approach of this subtask will be to provide a probabilistic analysis of earthquakes along controlling active faulting, and to estimate maximum credible earthquakes for each active fault. These analyses will first be estimated by an interdisciplinary team using reconnaissance-level information. These data will later be refined, based upon Subtask 5 data. 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

Thorough presentations of conclusions, evaluations and data are desirable for projects that are being carefully reviewed by permitting agencies. Woodward-Clyde Consultants has completed previous similar projects in Alaska and other states where permitting agencies, or other interested groups or agencies, are closely scrutinizing a project. Based upon our past experience, we believe that the Susitna Hydropower Project will undergo close scrutiny, and that the reports of the project should be complete and thorough.

In addition to the technical reporting, we propose to present management reports on a monthly basis that contain indications of our technical and financial progress with respect to plan. These management reports will provide a basis for early identification of potential changes that may be desirable, and they will minimize the potential for last-minute surprises.

The submittals from this subtask include:

1) Technical report with supporting documentation near the end of 1980.

2) Final technical report with complete documentation at the end of 1981.

3) Monthly management reports during the course of the investigation.

ATTACHMENT B

TASK B. EARTHQUAKE ENGINEERING

TASK B. EARTHQUAKE ENGINEERING

Subtask 1. Assessment of Ground Motions During Earthquakes

(a) Objective

The objective of this subtask is to estimate the ground motions (ground shaking) to which proposed project facilities may be subjected during earthquakes. 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).

(b) Approach

Ground motions will be estimated using a probabilistic approach. In this approach, usually called a seismic exposure analysis, the probability of exceedance of various amplitudes of ground motions are estimated taking into account the frequency of occurrence of earthquakes on all significant seismic sources and the attenuation of ground motions from each source to the locations of project facilities. Earthquakes of various magnitudes, up to the magnitudes of maximum credible events, are considered. Attenuation relationships are derived from examination and analyses of earthquake recordings made in similar tectonic environments and on similar subsurface geologic conditions, including available recordings from Alaska. Woodward-Clyde Consultants 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 will be extremely valuable in the present study.

The end products of this subtask will consist of estimates of the probability of exceedance 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 access roads, the probability estimates will be given for appropriate segments of the systems. These estimates will be presented and documented in a report. The report will include a discussion of probability levels and corresponding amplitudes of ground motions that may be considered in selecting project seismic design criteria. For major dams, ground motion criteria will be consistent with ground motions associated with maximum credible earthquakes, but for less critical project facilities, ground motions having a higher probability of being exceeded would likely be used as criteria for elastic design of structures.

(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 certainty. In fact, there is considerable uncertainty involved in such predictions even when they are based on the best available data and models and are made by experts. The approach outlined above recognizes and explicitly includes the uncertainties and consequently the ground motion estimates are presented in a probabilistic

framework. The resulting estimates of probability of exceedance of various ground motion aplitudes constitute the seismic exposure of a project facility at a certain location.

Although the terms "seismic exposure" and "seismic risk" have often been used interchangeably, it should be recognized that adverse consequences are involved in risk estimates but not necessarily in exposure estimates. For example, a well-designed dam in a highly seismic region may have a very high seismic exposure but a very low seismic risk. In this example, the dam has been designed recognizing the very high exposure to seismicity and, by virtue of its design, has a very low chance of failing during an earthquake.

TASK B. EARTHQUAKE ENGINEERING

Subtask 2. Preliminary Evaluations of Seismic Stability of Earth and Rockfill Dams

(a) Objective

The objective of this subtask is to make preliminary evaluations of the seismic stability of proposed earth and rockfill dams. These evaluations will be in the detail needed to evaluate aspects that could have a major impact on dam costs and project feasibility e.g., foundation materials, embankment cross-section, embankment materials and placement requirements.

(b) Approach

A preliminary evaluation of the adequacy of designs of earth and rockfill dams to resist seismic ground shaking involves the following steps:

(1) Evaluation of strength characteristics under seismic loading conditions of any insitu soils that may be considered to be left in place in the dam foundation.

(2) Evaluation of key static and dynamic properties of embankment materials; particularly important properties are static and cyclic strength characteristics, and permeability.

(3) Assessment of the potential for landsliding and large deformations through the embankment 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. If unfrozen sands are present in the foundation, blow counts from standard penetration tests (SPT's) in borings will be very useful in evaluating the resistance of the soils to liquefaction. Properties of embankment materials will be estimated on the basis of general descriptions, grain size distributions, and compaction requirements of proposed borrow materials. The basic field boring and routine laboratory test data, plus experience of WCC and Harza staff and published data, are presently felt sufficient to evaluate the key soil properties for this study. Dynamic tests may be recommended for final design studies, depending on the nature of the materials and findings of this feasibility study.

The potential for landsliding in the embankment and foundation will be analyzed using simplified analytical approaches and experience in similar studies. The key evaluations that are needed in the assessment of dam behavior are: first, an evaluation of the potential for generation and dissipation of pore water pressures in the materials during and following an earthquake (strongly dependent on permeability), and second, an evaluation of the potential for sliding using conventional sliding arc or wedge approaches and taking into account the effect of seismically-induced pore pressures on soil and rockfill strengths. Dynamic finite-element analyses of the embankment are not needed for the feasibility study but will be considered during the final design phase.

The evaluations made in this subtask will be presented and documented in a report.

(c) Discussion

It is generally acknowledged that well-designed and constructed earth and rockfill dams have a large degree of inherent stability to resist earthquake ground shaking. The thrust of this subtask is to provide evaluations of embankment cross-sections, embankment materials and placement requirements, and foundation materials, which have an important influence on embankment stability and project costs. The conduct of this task will likely involve an iterative approach. Experience of the project team will initially be used in establishing broad guidelines for materials and design. Initial designs will be evaluated for seismic stability. These results may be used to modify, if necessary, designs which may then be checked by a second evaluation.

FLUOR CORPORATION

FLUOR CORPORATION

The Fluor Corporation began over 75 years ago as a general contracting firm. As it grew during the years, it began to emphasize one major area - the design and construction of petroleum and petrochemical plants. Its mainstay was - and still is - people. People who helped the company achieve a reputation for strong project management and construction competence for all-around technical capabilities and for excellent cost control and scheduling performance.

By the 1950's, Fluor was one of less than a dozen U.S. firms capable of designing and building major process plants - in the $240 million range and larger - on an international basis. Throughout that decade, the firm expanded in both geographic and technological terms.

In the 1960's, a surge of capital spending by U.S. processing firms for new facilities took place. Fluor, along with other engineering contractors in the U.S., experienced a heavy demand for engineering/construction services. During this period of growth, Fluor also looked into diversification to build technical and marketing strengths so that it could better serve clients in the processing and other energy-related industries.

In 1968, Fluor established Fluor Ocean Services, Inc. to offer offshore engineering and construction capabilities to clients. It also added two oil field supply companies to its organization.

A year later, Fluor extended its services to the metals and mining industries by acquiring the engineering and construction division of Utah Construction & Mining Company. This division became a new subsidiary renamed Fluor Mining & Metals, Inc.

In 1971, Fluor restructured its major operation - the engineering and construction of refineries, petrochemical and process plants. It formed a separate subsidiary, Fluor Engineers and Constructors, Inc., to oversee the company's work in these technologies throughout the world.

In 1974, the formation of Fluor Pioneer Inc., later renamed Fluor Power Services, Inc., extended Fluor's services into the utility power field and brought the total capability of Fluor's engineering and construction experience into another quarter of the energy producing community.

In 1977, the acquisition of Daniel International Corporation greatly expanded Fluor's construction services in commercial, industrial, chemical, and power plant projects. Daniel is a leading constructor of power plants in the United States. In particular, nuclear and fossil power plant construction contracts at that time represented a generating capacity in excess of 16,000 MW.

In 1978, the construction organization of Fluor E&C was restructured as a separate operating entity called Fluor Constructors, Inc. This arrangement gives E&C and the other Fluor companies added flexibility to use either Daniel International or Fluor Constructors for a project's construction services, depending on the unique needs of the project.

The advantages to Fluor and its clients of having these diverse resources in one company are substantial. On both large and small projects a high level of quality is assured because every project team has convenient access within the company to the technical expertise required to solve most types of problems. This access takes on many forms including lines of communication for information or assistance, cooperation in executing a project jointly, and transfer of personnel. Uniformity of personnel policies permits easy transfer of personnel among subsidiaries on a temporary or permanent basis.

Frequent interaction among groups working in the areas of environmental engineering, nuclear technology, computers, mathematical and physical modeling, purchasing, and others tends to keep the entire organization up-to-date on the latest trends and developments in these fields. It also allows the whole company to benefit from any important experience gained on a particular project.

On large projects, the extensive capabilities of Fluor are utilized to the fullest extent. By giving a single organization the total responsibility for design and construction, the client can benefit from an earlier construction start and a closer interface between engineering and construction. Where several technologies are involved, e.g., power generation, mining, refining, chemicals, coal gasification/liquefaction, offshore pipelines, etc, the entire project can be performed by a combination of Fluor offices and subsidiaries under one contractual agreement with Fluor. The project management system used throughout the Fluor organization assures the client that interface among subsidiaries is easily accommodated. This project management system has been proven on several multibillion dollar projects and hundreds of smaller ones. Fluor's experience on these projects has afforded the opportunity to develop a corps of experienced project managers and directors qualified to handle projects of all sizes and types.

Fluor's worldwide procurement organization is an essential contributor to the success of large projects. The staff of engineers, expediters, and inspectors in strategic locations all over the world has been responsible for obtaining substantial economies, maintaining quality, and directing the flow of huge quantities of materials and equipment to project sites in many countries.

In summary, the diversity of the Fluor organization gives us the capability to handle large or small projects, domestic or international, performing any scope of work from engineering only to single responsibility in virtually any energy technology.

FLUOR POWER SERVICES, INC.

Fluor Power Services, Inc., the power engineering division of the Fluor Corporation, has achieved a proud record of over 75 years of service to the energy industry. With this solid and successful background in the field, Fluor Power Services (FPS) is well qualified and experienced in all phases of power generation engineering, design, procurement, and construction management and related services for utility and industrial clients. Because of the integrated service capabilities within the Fluor network of companies, FPS is able to provide complete single-responsibility services for all types of fossil-fueled and nuclear-powered installations.

Fossil-fuel power plants designed by Fluor Power Services have used a variety of fuels, including coal, coke, distillate, residual oils and natural gas. These fossil-fuel steam electric generating stations have ranged from 5 MW to 550 MW and included both subcritical and supercritical units.

Fluor Power Services has extensive experience in detailed engineering, design, procurement, and expediting for simple and combined-cycle gas turbine projects. In the past ten years alone, the company has completed over one hundred simple cycle installations. In many of these gas turbine projects, services have also included start-up assistance, performance testing and construction management, plus responsibility for all phases of construction.

As one of the first engineering firms to be involved in the design of nuclear power installations, Fluor Power Services maintains solid state-of-the-art capabilities in the nuclear power generation field. FPS was an early leader in the design of liquid waste systems for nuclear power plants, and recently designed a 3800 MW Standard Nuclear Reference Plant which was issued a Preliminary Design Approval (PDA) by the Nuclear Regulatory Commission (NRC).

In the area of wastewater treatment, Fluor Power Services has served many utility and industrial clients with a team of engineers qualified to solve unique problems and familiar with federal and state pollution compliance.

Fluor Power Services also provides expertise in transmission, substation and power distribution systems. Hundreds of projects in these areas have been completed; many with special requirements and features.

FPS maintains its own construction management staff, which is backed by the construction resources of Fluor Engineers & Constructors and Daniel International Corporation. With the collective resources of the Fluor organization FPS has exceptional capability for supervising the construction of major steam and electrical power generating plants, as well as for other heavy construction work.

COMPANY SERVICES

Fluor Power Services, Inc. offers complete engineering services including conceptual planning, economic analysis and feasibility studies, engineering and design, procurement, construction management and construction services for fossil-fueled and nuclear power generation installations.

In providing any or all of these services, Fluor can supplement a client's skills in areas of new technology, establish international supply sources for materials and equipment; and provide a cost & scheduling system to meet project requirements and client's budget.

The following highlights the four major services that Fluor can provide:

ENGINEERING STUDIES & ANALYSES

Fluor Power Services' projects have encompassed a wide range of engineering studies. They have included in-depth investigations in such vital areas as mechanical pipe stress analysis, vibration analysis, wastewater disposal, load flow analysis, seismic analysis and radiation shielding and radioactive effluent analysis.

Several recent studies conducted by Fluor Power Services have included combined-economics operations, conductor selection, steam distribution, electric distribution, present versus future equipment and load requirement methods, system planning, joint ownership versus independent operation and material handling.

ENGINEERING

Fluor Power Services maintains a highly qualified and experienced staff of engineers and related technical professionals to expertly service every phase of the power generation project. Since the beginning of modern electrical power, Fluor Power Services has proved a capable and innovative leader in its field. Up to the present day, Fluor Power Services maintains its leadership in quality state-of-the-art engineering practice.

Among the engineering services that Fluor Power Services can offer for power generation projects are the major activities in planning and design, environmental, scheduling, purchasing, expediting, quality assurance and regulatory compliance. Fluor Power Services also offers expertise in site selection and other areas related to the specific sites for power plants.

PROCUREMENT

Fluor Power Services' procurement service is available to coordinate its activities and cooperate with other Fluor divisions to provide a worldwide

organization with the experience and expertise necessary to support the client's projects. The procurement function at Fluor Power Services and Fluor incorporates purchasing, expediting, inspection, traffic and subcontracting services.

Fluor maintains fourteen permanent worldwide procurement offices staffed by over 1500 personnel. Each office maintains accurate data relating to source of supply, financial condition, price levels, deliveries and general market conditions in its individual trade area.

CONSTRUCTION MANAGEMENT

Fluor Power Services maintains qualified, knowledgeable personnel in construction management expertise which spans a broad range of activities. These include the three prime areas of preconstruction activities, construction organization and construction cost control. This capability is complemented by the availability of the world-wide resources of the Fluor Corporation.

Initial construction management involvement undertakes various preconstruction tasks including environmental report input, site layout review, the development of construction schedule logic, consideration of advanced construction techniques, consideration of local trends and general construction interface activities.

During actual construction, the construction management team coordinates the field and home office task force to meet planned goals and schedules. The team works to make the same progress objectives of each contractor. Emphasis on this concept provides the flexibility to incorporate the client's available personnel resources in a timely and effective manner.

Following is a general company services listing of specific engineering categories and various applications which utilize one or more of the major services explained above:

FOSSIL-FUELED POWER GENERATION PLANTS

FLUOR POWER SERVICES, INC.

FOSSIL-FUELED POWER GENERATION EXPERIENCE

Fluor Power Services has been designing fossil-fueled power generation installations for over 75 years. The company has consistently been a leader in the planning and technology of this field. Serving both public and private concerns, FPS provides engineering, design, procurement, construction management and construction services for fossil-fuel projects; along with knowledgeable and timely guidance in the multi-faceted area of environmental considerations.

Since 1952, Fluor Power Services has engineered approximately 100 steam electric generating units at 28 stations. Among these installations are plants designed to incorporate co-generation operation to provide steam, as well as electrical power, for heating and processing.

Services provided by FPS include site selection, preparation of environmental reports, project scoping and planning, preparation of estimates and schedules, engineering, designing, preparation of specifications, bid evaluations and procurement, construction management and actual construction.

The capabilities of Fluor Power Services cover the entire scope of engineering and design services required from boiler selection to coal handling equipment and systems design to flue gas desulfurization plus precipitator and/or baghouse selection to ash and sludge disposal. Also included with these and other phases are accurate cost estimating and scheduling techniques, refined and proven by Fluor on numerous power project, providing the client with efficient and effective control methods.

POWER GENERATION PLANTS
(50 to 200 MW)

Following are representative steam electric power generation projects, utilizing coal, oil, or gas fuels, designed and/or constructed by Fluor and its divisions during the past 30 years.

- BURBANK PUBLIC SERVICE DEPARTMENT

  Steam Power Plant
  Burbank, California

  Engineering and construction management of a two unit 90 MW power plant. Unit 1, 44 MW, includes one 425,000 lb/hr gas or oil-fired boiler operating at 1250 psig and 950°F; one 44 MW preferred standard turbo generator; 38,920 sq ft surface condenser; one 34,000 gpm induced draft cooling tower; and all accompanying auxiliaries (oil or gas-fired). Unit 2, 55 MW, includes one 440,000 lb/hr reheat boiler operating at 1500 psig and 1000°F/1000°F; one 55 MW turbine generator; one 38,000 sq ft surface condenser; one 36,000 gpm induced draft cooling tower; and all accompanying auxiliaries.

- CALIFORNIA ELECTRIC POWER COMPANY

  Steam Power Plant
  Highgrove, California

  Engineering, procurement, and construction of a four-unit 154 MW power plant. Units 1 and 2, 66 MW, include two 320,000 lb/hr oil or gas-fired boilers, both operating at 950 psig and 900°F; two 33 MW each preferred standard turbines; two 27,500 sq ft surface condensers. Unit 3, 44 MW, includes one 435,000 lb/hr oil or gas-fired boiler operating at 1250 psig and 950°F; one 44 MW preferred standard turbine; one 35,000 sq ft surface condenser; one 33,000 gpm induced draft cooling tower; and all accompanying auxiliaries. Unit 4, 44 MW, includes one 425,000 lb/hr oil or gas-fired boiler operating at 1250 psig and 950°F; one 44 MW turbo generator; one 35,000 sq ft surface condenser; one 33,000 gpm induced draft cooling tower; and all accompanying auxiliaries.

  Steam Power Plant
  San Bernardino, California

  Engineering, procurement, and construction of a two-unit 132 MW power plant, including two 475,000 lb/hr throttle steam/reheat steam boilers, both operating at 1850 psig and 1000°F/1000°F reheat; two 66 MW preferred standard turbo generators; two 42,500 sq ft surface condensers; two 38,700 gpm induced draft cooling towers; and all accompanying auxiliaries including demineralization systems and deep well systems.

- CALIFORNIA ELECTRIC POWER COMPANY (Cont)

  Cool Water Steam Plant
  Daggett, California

  Engineering, procurement, and construction of a two-unit, 137 MW power plant. Unit 1, 62 MW, includes one 475,000 lb/hr throttle steam/reheat gas or oil-fired steam boiler operating at 1850 psig and 1000°F/1000°F reheat; one 62 MW turbo generator; one 62,000 sq ft surface condenser; one 39,000 gpm induced draft cooling tower, and all accompanying auxiliaries, including demineralization system and deep well system. Unit 2, 75 MW, includes one 575,000 lb/hr reheat boiler operating at 1850 psig and 1000°F; one 75 MW turbine generator, one 47,500 sq ft condenser; one 49,000 gpm induced draft cooling tower; and all accompanying auxiliaries. Both units involved engineering, procurement, and construction.

- IOWA SOUTHERN UTILITIES

  Bridgeport Station

  Engineering and procurement for a three-unit 66 MW power plant including three 160,000 lb/hr coal-fired boilers, all operating at 850 psig and 900°F; and three turbine generators totalling 66 MW.

- IMPERIAL IRRIGATION DISTRICT

  Imperial, California

  80 MW steam power plant - Unit #4 addition to El Centro Steam Station. Including one 575,000 lb/hr 1500 psig 1000°F reheat boiler, one 80 MW turbine generator, one 45,000 sq ft condenser, one gpm induced draft cooling tower plus all auxiliary plant systems. Also included one 18,500,000 gal storage basin and one 3,580,000 gal settling basin. Also 45,000 bbl oil storage tank. Oil and gas-firing. Engineering procurement and construction.

- KANSAS POWER & LIGHT COMPANY

  Steam Power Plant
  Lawrence, Kansas

  Construction of a 50 MW power plant, including one 400,000 lb/hr oil, coal, or gas-fired boiler, one 50 MW turbine, and all accompanying auxiliaries.

  Steam Power Plant
  Tecumseh, Kansas

  Steam power plant addition - including one 942,000 lb/hr boiler unit, one 175 MW turbogenerator, and accompanying auxiliaries (coal, oil, or gas-fired). Construction.

- MADISON GAS & ELECTRIC COMPANY

  Blount Street Station
  Madison, Wisconsin

  Engineering and procurement for two units, totalling 88 MW, including two 425,000 lb/hr boiler, both operating at 1250 psi and 950°F; and two turbine generators totalling 88 MW.

- OKLAHOMA GAS & ELECTRIC COMPANY

  Mustang Station

  Engineering and procurement for a two-unit 100 MW power plant, including two 500,000 lb/hr coal or gas-fired boilers operating at 850 psi and 900°F, and two turbine generators totalling 100 MW.

- OMAHA PUBLIC POWER DISTRICT

  North Omaha Station
  Omaha, Nebraska

  Engineering and procurement of a two-unit 200 MW power plant, including two 750,000 lb/hr coal or gas-fired boilers, both operating at 1800 psi and 1000°F with 1000°F reheat; and two turbine generators totalling 200 MW.

- SAN DIEGO GAS & ELECTRIC COMPANY

  Silver Gate Station

  Engineering and procurement for a three-unit 180 MW power plant including three 660,000 lb/hr oil or gas-fired boilers operating at 850 psi and 900°F; and three turbine generators totalling 180 MW.

- WISCONSIN PUBLIC SERVICE CORPORATION

  Weston Station

  Engineering and procurement for a two-unit 141 MW power plant. Unit 1 has a 650,000 lb/hr coal-fired boiler operating at 850 psi and 900°F; Unit 2 has a 600,000 lb/hr coal-fired boiler operating at 1450 psi and 1000°F with 1000°F reheat. Both have turbine generators which total 141 MW.

POWER GENERATION PLANTS
(200 to 600 MW)

Following are representative steam electric power generation projects, utilizing coal, oil, or gas fuels, designed and/or constructed by Fluor and its divisions during the past 30 years.

• LOUISVILLE GAS AND ELECTRIC COMPANY

Mill Creek Station

This station consists of four generating units designed for an ultimate capacity of 1600 MW. All units burn coal as main fuel which is received by rail in standard hopper-bottom cars. The track layout has been designed to accommodate unit trains and provisions have been made for future barge delivery. Environmental considerations have dictated the need for closed cooling tower systems for Units 2, 3, and 4. All units have high efficiency electrostatic precipitators and Units 3 and 4 will have, in addition, SO_2 removal scrubber systems.

Trimble County Station

This station consists of four generating units designed for an ultimate capacity of 2560 MW. All units will burn high sulfur, midwestern coal and will be equipped with electrostatic precipitators, sulfur dioxide removal system and natural draft cooling towers. A fully automated coal handling system designed to accommodate barges will serve the station.

• NORTHERN STATES POWER COMPANY

Allen S. King Station

A single unit, 590 MW coal-fired, supercritical boiler with cyclones, which has been designed to accommodate an additional unit. Facilities for unloading coal barges are located adjacent to the lake shore. The station has two, 99% efficient electrostatic precipitators and a 785-foot stack. The plant's two cooling towers meet environmental standards set for St. Croix River by governmental agencies.

Black Dog Station

Engineering and procurement for a four-unit 416 MW power plant, including four 575,000 lb/hr coal or gas-fired boiler; Unit 1 operates at 850 psi and 950°F; Units 2 and 3 each operate at 1450 psi and 1000°F with 1000°F reheat; and Unit 4 operates at 1850 psi and 1000°F with 1000°F reheat. Also included are four turbine generators totalling 416 MW.

High Bridge Station

Engineering and procurement of a two-unit 256 MW plant including two coal or gas-fired boilers; Unit 1 operates at 1,250,000 lb/hr at 1800 psi and 1000°F reheat; and two turbine generators totalling 256 MW.

Riverside Station

Engineering and procurement for a three-unit 320 MW power plant, including three boilers operating at 570,000 lb/hr. Two units operate at 850 psi and 900°F, and the third, 2400 psi and 1000°F with 1000°F reheat; and three turbine generators totalling 320 MW.

- OMAHA PUBLIC POWER DISTRICT

North Omaha Station
Omaha, Nebraska

Engineering and procurement of a two-unit 200 MW power plant, including two 750,000 lb/hr coal or gas-fired boilers, both operating at 1800 psi and 1000°F with 1000°F reheat; and two turbine generators totalling 200 MW.

- SAN DIEGO GAS & ELECTRIC COMPANY

Encina Station

A five unit station with a total capacity of approximately 1000 MW. Oil is received by tanker and stored in an on-site tank farm comprised of six storage tanks with a total capacity of approximately 1,340,000 barrels. Units 1-3, totalling 330 MW, include three oil or gas-fired boilers; Unit 1, 700,000 lb/hr; Unit 2, 775,000 lb/hr; Unit 3, 800,000 lb/hr; all operating at 1450 psi and 1000°F reheat; and three turbine generators totalling 330 MW. Units 4 and 5, totalling 627 MW, include one 1,980,000 lbs/hr and one 2,350,000 lbs/hr oil or gas-fired boilers, both operating at 1800 psi; Unit 4 at 950°F with 950°F reheat; and Unit 5 at 1000°F and 1000°F reheat; and two turbine generators totalling 627 MW.

South Bay Station

A four unit station with a total capacity of 648 MW. Power plant includes four 930,000 lb/hr oil or gas-fired boilers; Units 1-3 operate at 2000 psi and 1000°F with 1000°F reheat; and Unit 4 at 1800 psi and 950°F with 950°F reheat; and four turbine generators totalling 648 MW.

- WISCONSIN PUBLIC SERVICE COMPANY

  Pulliam Station

  Engineering and procurement of a five-unit 340 MW power plant, including five coal-fired boilers. Unit 4, 312,000 lb/hr; Unit 5, 500,000 lb/hr; Unit 6, 600,000 lb/hr; Unit 7, 625,000 lb/hr; Unit 8, 650,000 lb/hr. Unit 4 operates at 650 psi and 900°F; Units 5 and 6 at 850 psi and 900°F; Unit 7 at 1450 psi and 1000°F with 1000°F reheat; and Unit 8 at 1800 psi and 1000°F with 1000°F reheat. Also included are five turbine generators totalling 340 MW.

CENTRAL STATION GENERATING UNITS
(Representative Listing)

UNIT	DATE	FUEL	RATING (MW)	CYCLE	TYPE OF BOILER	PRECIPITATOR OR BAGHOUSE	ASH HANDLING SYSTEM	COOLING WATER SYSTEM
IOWA SOUTHERN UTILITIES COMPANY								
Bridgeport								
1	1953	coal	22	850 psig-900 F	S	Mechanical	Dry	CCMW
2	1953	coal	22	850 psig-900 F	S	Mechanical	Dry	CCMW
3	1957	coal	22	850 psig-900 F		Mechanical	Dry	CCMW
LOUISVILLE GAS & ELECTRIC COMPANY								
Cane Run								
1	1954	coal/gas	100	1450 psig-1000 F	PC	Electrical	Wet	OT
2	1955	coal/gas	100	1450 psig-1000 F/1000 F	PC	Electrical	Wet	OT
3	1958	coal/gas	125	1800 psig-1000 F/1000 F	PC	Electrical	Wet	OT
4*	1962	coal/gas	156	1800 psig-1000 F/1000 F	PC	Electrical	Wet	OT
5*	1966	coal/gas	180	1800 psig-1000 F/1000 F	PC	Electrical	Dry	OT
6*	1968	coal/gas	250	2400 psig-1000 F/1000 F	PC	Electrical	Wet	OT
Mill Creek								
1*	1972	coal	350	2400 psig-1000 F/1000 F	PC	Electrical	Wet	OT
2*	1974	coal	350	2400 psig-1000 F/1000 F	PC	Electrical	Wet	CCMW
3*	1977	coal	417	2400 psig-1000 F/1000 F	PC	Electrical	Wet	CCMW
4*	1979	coal	530	2400 psig-1000 F/1000 F	PC	Electrical	Wet	CCMW

Type of Boiler

C - Cyclone
PC - Pulverized Coal
S - Stoker

Cooling Water Systems

OT - Once through without Supplementary Cooling
OTMW - Once through with Mechanical Draft, Wet Towers
OTCP - Once through with Cooling Ponds
CCMW - Closed Cycle with Mechanical Draft, Wet Towers
CCNW - Closed Cycle with Natural Draft, Wet Towers

* Installation for SO_2 Removal

UNIT	DATE	FUEL	RATING (MW)	CYCLE	TYPE OF BOILER	PRECIPITATOR OR BAGHOUSE	ASH HANDLING SYSTEM	COOLING WATER SYSTEM
Paddy's Run								
3	1947	coal/gas	60	850 psig-900 F	PC	Electrical	Wet	OT
4	1949	coal/gas	60	850 psig-900 F	PC	Electrical	Wet	OT
5	1950	coal/gas	60	850 psig-900 F	PC	Electrical	Wet	OT
6*	1952	coal/gas	60	850 psig-900 F	PC	Electrical	Wet	OT
Trimble County**								
1*	1983	coal	550	2400 psig-1000 F/1000 F	PC	Electrical	Wet	CCNW
MADISON GAS & ELECTRIC COMPANY								
Blount Street								
6	1957	coal	44	1250 psig-950 F	PC		Dry	OT
7	1961	coal	44	1250 psig-950 F	PC		Dry	OT
NEVADA POWER COMPANY								
Reid Gardner								
4	1983	coal	295	2400 psig-1000 F/1000 F	PC	Baghouse	Dry	CCMW
Warner Valley								
1	1984	coal	295	2400 psig-1000 F/1000 F	PC	Baghouse	Dry	CCMW
2	1985	coal	295	2400 psig-1000 F/1000 F	PC	Baghouse	Dry	CCMW
NORTHERN STATES POWER COMPANY								
Allen S. King								
1	1968	coal	550	3500 psig-1000 F/1000 F	C	Electrical	Wet	OT

*Installation for SO_2 removal

**Engineering released for Unit 1 only, site being developed for ultimate 4 units with Unit 2 nominal 550 MW and Units 3 and 4 nominal 730 MW each.

UNIT	DATE	FUEL	RATING (MW)	CYCLE	TYPE OF BOILER	PRECIPITATOR OR BAGHOUSE	ASH HANDLING SYSTEM	COOLING WATER SYSTEM
Bison								
1	1949	coal	5	400 psig-725 F	S		Wet	OT
2	1952	coal	5	400 psig-725 F	S		Wet	OT
Black Dog								
1	1952	gas/coal	60	850 psig-950 F	PC	Electrical	Wet	OTCP
2	1954	gas/coal	100	1450 psig-1000 F	PC	Electrical	Wet	OTCP
3	1955	gas/coal	100	1450 psig-1000 F/1000 F	PC	Electrical	Wet	OTCP
4	1960	gas/coal	156	1850 psig-1000 F/1000 F	PC	Electrical	Wet	OTCP
High Bridge								
5	1956	coal/gas	100	1450 psig-1000 F/1000 F	PC	Electrical	Wet	OT
6	1959	coal/gas	156	1800 psig-1000 F/1000 F	PC	Electrical	Wet	OT
Lawrence								
1	1948	coal/gas	12	650 psig-825 F	S	Electrical	Dry	OTMW
2	1949	coal/gas	12	650 psig-825 F	S	Electrical	Dry	OTMW
3	1951	coal/gas	22	850 psig-950 F	PC	Mechanical	Dry	OTMW
Riverside								
6	1949	coal	60	850 psig-900 F	PC	Electrical	Wet	OT
7	1950	coal	60	850 psig-900 F	PC	Electrical	Wet	OT
8	1954	coal	200	2400 psig-1000 F/1000 F	PC	Electrical	Wet	OT
Wilmarth								
1	1948	coal	12	650 psig-825 F	S	Electrical	Wet	OT
2	1951	coal	12	650 psig-825 F	S	Electrical	Wet	OT

UNIT	DATE	FUEL	RATING (MW)	CYCLE	TYPE OF BOILER	PRECIPITATOR OR BAGHOUSE	ASH HANDLING SYSTEM	COOLING WATER SYSTEM
OKLAHOMA GAS & ELECTRIC COMPANY								
Horseshoe Lake								
Topping Unit	1948		10	1250 psig-950 F		non-condensing turbine	Wet	
Mustang								
1	1950	coal/gas	50	850 psig-900 F	PC		Wet	CCMW
2	1951	coal/gas	50	850 psig-900 F	PC		Wet	CCMW
OMAHA PUBLIC POWER DISTRICT								
North Omaha								
2	1957	coal/gas	100	1800 psig-1000 F/1000 F	PC	Electrical	Wet	OT
3	1959	coal/gas	100	1800 psig-1000 F/1000 F	PC	Electrical	Wet	OT
SOUTHERN COLORADO POWER								
Pueblo								
3	1949	coal/oil/ gas	18	650 psig-825 F	PC	Mechanical	Wet	OTMW
WISCONSIN PUBLIC SERVICE								
Pulliam								
4	1947	coal	30	650 psig-900 F	PC	Electrical	Wet	OT
5	1949	coal	50	850 psig-900 F	PC	Electrical	Wet	OT
6	1951	coal	60	850 psig-900 F	PC	Electrical	Wet	OT
7	1958	coal	75	1450 psig-1000 F/1000 F	PC	Electrical	Wet	OT
8	1964	coal	125	1800 psig-1000 F/1000 F	PC	Electrical	Wet	OT
Weston								
1	1954	coal	66	850 psig-900 F	PC	Electrical	Wet	OT
2	1960	coal	75	1450 psig-1000 F/1000 F	PC	Electrical	Wet	OT

COMBUSTION TURBINE PROJECTS

The qualifications of Fluor Power Services as an engineer/constructor for combustion turbine projects have developed from extensive experience with simple cycle and combined cycle combustion turbines, and fuel facility projects. Responsibilities for these projects ranged from engineering and design only to engineering, design, procurement and construction.

A recently completed single responsibility combustion turbine project, Gallatin Station for Tennessee Valley Authority, included the engineering, design, procurement, and construction of a four unit 300 MW total combustion turbine plant, including tank farm and river barge fuel unloading terminal. This project was engineered, designed, constructed and started-up within a twelve month period.

Our most significant experience using aircraft type combustion turbines were three installations, Hallam, McCook, and Hebron Stations for Nebraska Public Power District. The combustion turbines were jet engine twin-unit type with evaporative cooler generating approximately 50 MW. Engineering and design, procurement, and construction management for all three stations were provided.

Currently, FPS is working on the 150 MW oil-fired combustion turbine project at Rancho Seco Station for Sacramento Municipal Utility District and two 75 MW units at Clark Station for Nevada Power Company.

COMBUSTION TURBINE PROJECTS (1968-78)

In the past ten years, Fluor Power Services has been responsible for over one hundred simple cycle and combined cycle combustion turbine installations. Representative projects for the past ten years are listed below.

- COMMONWEALTH EDISON COMPANY

Waukegan Station (1968)	4 oil/JP jet engine units of 27.25 MW each.
Calumet Station (1969)	12 gas/oil industrial turbine units of 15.5 MW each.
Lombard Station (1969)	6 gas/JP jet engine units of 17.2 MW each.
Joliet Station (1969)	8 gas/oil industrial turbine units of 15.5 MW each.
Rockford Station (1969)	4 gas industrial turbine units of 15.5 MW each.
Calumet Station (1970)	4 gas/oil industrial turbine units of 16.5 MW each.
Rockford Station (1970)	4 gas/oil industrial turbine units of 16.5 MW each.
Naperville Station (1970-71)	16 gas/oil industrial turbine units of 16.5 MW each.
Chicago Heights Station (1971)	8 gas/oil industrial turbine units of 20.65 MW each.

- MADISON GAS & ELECTRIC COMPANY

Sycamore Station (1967)	1 gas/oil industrial turbine unit of 15.25 MW.
Fitchburg Station (1973)	2 gas/oil industrial turbine units of 21.45 MW.

- MISSOURI PUBLIC SERVICE COMPANY

Nevada Station (1974)	1 oil industrial turbine unit of 20 MW.
Greenwood Station (1975)	2 oil industrial turbine units of 55 MW each.

- NEBRASKA PUBLIC POWER DISTRICT

Hallam Station (1973)	1 oil jet engine twin-unit with evaporative cooler of 49.7 MW.
McCook Station (1973)	1 oil jet engine twin-unit with evaporative cooler of 47.7 MW.
Hebron Station (1973)	1 oil jet engine twin-unit with evaporative cooler of 49.6 MW.

- NEVADA POWER COMPANY

Clark Station (1979)	2 oil industrial turbine units of 75 MW each.

- SACRAMENTO MUNICIPAL UTILITY DISTRICT

Rancho Seco Station (198)	1 oil industrial turbine unit of 150 MW.

- SAN DIEGO GAS & ELECTRIC COMPANY

Division Station (1968)	1 gas/oil industrial turbine unit of 14.75 MW.
El Cajon Station (1968)	1 gas/oil industrial turbine unit of 14.75 MW.
Encina Station (1968)	1 gas/oil industrial turbine unit of 14.75 MW.
Combined Cycle Plant	2 350 MW combined cycle units, each consisting of four gas turbines, and two steam turbines; new site; distillate and residual oil capability; electrostatic fuel washing. Project later cancelled.

Kearney Station (1969)	8 gas/oil industrial turbine units of 15.8 MW each.
North Island Station (1972)	2 oil industrial turbine units of 20 MW each.
Kearney Station (1972)	1 oil industrial turbine unit of 20 MW.
Miramar Station (1972)	2 gas/oil industrial turbine units of 20 MW each.

- TENNESSEE VALLEY AUTHORITY

Gallatin Station (1975)	4 oil industrial turbine units of 75 MW each; single responsibility project including engineering, design, procurement and field construction.

- UNITED STATES NAVY/APPLIED ENERGY, INC.

Naval Training Center San Diego, California (1971)	Heat recovery boiler generating 119,000 lb/hr saturated steam at 200 psig from gas turbine exhaust. Also includes a 160,000 lb/hr gas/oil-fired package boiler to augment steam supply.
U.S. Naval Station San Diego, California (1975)	Heat recovery boiler generating 127,700 lb/hr saturated steam at 300 psig from gas turbine exhaust. Also includes a 150,000 lb/hr gas/oil-fired package boiler to augment steam supply.

SCOPE OF WORK

FLUOR POWER SERVICES, INC.

SCOPE OF WORK

INTRODUCTION

Fluor Power Services will prepare a study covering alternate sources of power generation for the Railbelt area, using oil, gas, coal, or uranium as fuel. The fuel(s) considered will depend on location. In the Fairbanks and Anchorage area oil, gas, coal, and uranium will be investigated. In the Beluga and Healy areas minemouth coal plants using the area's low Btu and low sulfur coal and nuclear plants will be considered.

The total generating capacity as determined from load growth studies performed by Harza will be the basis for siting the generating station(s). The capacity of each unit will depend on the area's power requirement. Both interconnection of the Anchorage and Fairbanks load centers and isolated plants serving each area will be evaluated.

The assumed operating date for the thermal power capacity will correspond to that for the hydro generation.

The study will be prepared in two phases. Each phase will be of approximately four months duration. The anticipated start date of the Phase I portion is January 1, 1980.

PHASE I

Using load growth studies prepared by Harza Engineering and assuming the following three sources of fossil fuel:

a) Fairbanks Area (Alaska Pipe Line Oil available)
Oil, Gas and Coal;

b) Anchorage (Local Natural Gas available)
Gas, Coal and Oil;

c) Beluga & Healy Area (Low Btu, Sulfur Coal found in the area)
Minemouth Coal;

Fluor Power Services will develop the following:

1.0 Identify Alternate Sources of Generation

- 1.1 Gas-Fired Plants
- 1.2 Oil-Fired Plants
- 1.3 Coal-Fired Plants
- 1.4 Combined Cycle Plants
- 1.5 Nuclear

2.0 Based on Load Growth Studies, identify:

- 2.1 Required number of Generating Plants
- 2.2 Location of Plants
- 2.3 Type of Fuel
- 2.4 Transmission Requirements

3.0 Identify Critical Items affecting Established Environmental Criteria for each Proposed Site (environmental investigations to be performed by Harza):

- 3.1 Cooling Water Makeup
- 3.2 Particulate Emissions
- 3.3 SO_2, NO_x and others
- 3.4 Noise

4.0 Prepare Drawings to include proposed Power Plant Sitings

5.0 Evaluate Thermal Plant Alternatives

- 5.1 Conceptual Cost of Power Plant, Transmission Line and other Site-Related Costs
- 5.2 Fuel Cost including transportation
- 5.3 Maintenance Cost
- 5.4 Operating Cost
- 5.5 Replacement Cost (based on 30-year plant life)
- 5.6 Transmission Cost

6.0 Prepare a report to Harza, comparing the thermal alternatives and selecting the most favorable thermal generation scheme for serving the Railbelt power demand as an alternative to the Susitana River Project.

Phase II will be started after Fluor Power Services receives authorization from Harza.

PHASE II

1.0 A more detailed study of the scheme selected in Phase I. All the studied conditions indicated in Phase I, Item 5, are to be reviewed in greater detail.

2.0 Develop Preliminary Site Arrangement and Preliminary General Arrangement Drawings of the final selected site(s).

3.0 Final report based on detailed study of selected site(s) to Harza.

POWER PLANT SITING

The Phase I study, which includes the site selection process, will be based on water availability, terrain, geotechnical aspects and environmental factors including the New Source Performance Standards (NSPS) and Ambient Air Quality Standards.

The data base will include, but not be limited to:

1. U.S. Geological Survey for geologic and topographic maps and reports

2. Department of Energy report and maps

3. Fluor's experience gathered and data collected during the Alaska Oil Pipe Line Project

4. Articles and maps published in the technical literature, state historical society for historic areas, state agencies and National Park Service.

The Phase I study of the alternate sources of fossil fuel power will consist of two stages:

Stage I - Determination of candidate sites

Stage II - Determination of proposed site(s)

As the study proceeds from Stage I to Stage II, the evaluation becomes more detailed and refined until a number of proposed sites are established, with location determined by the load centers and growth patterns.

The candidate sites will be selected based on a number of parameters including, but not limited to the following:

1. Fuel Availability.

2. Water Availability: The impact of this parameter will be minimized by closed cycle cooling.

3. Environmental Impact: One of the parameters for selecting the candidate sites will be the potential to meet State and Federal requirements for significant deterioration increments of sulfur dioxide and particulates. The proposed sites must be environmentally acceptable. This will be verified by the Harza environmental staff.

4. Geophysical Impact: The geology, topography and geotechnical aspects of the candidate sites which, in turn, have major impact on cost and schedule of power plant construction will be

reviewed. The region is seismically active which will require careful consideration of slope stability, soil liquefaction and expected seismic acceleration. Permafrost is generally not a factor in the region between Anchorage and Fairbanks, but if encountered, will be a factor in site selection.

5. Transmission Corridor: Availability of land and right-of-ways with terrain which allows expeditious and economical construction of towers will impact the cost of a power plant site.

6. Road, Rail and Waterway Access: Availability of transportation impacts the cost and schedule of a power plant.

Maps showing exclusion regions will be used to narrow down the region from which candidate sites will be selected. Data gathered during the Phase I study will be utilized to rank the candidate sites or areas.

Drawings showing the proposed site location(s) will be made in Phase I. These drawings will provide further opportunity to study the proposed sites and rank them in the order of their cost and environmental impact. Determination will also be made at this stage as to whether there are any localized conditions which render a particular site unacceptable. Information gathered during site visits will be utilized at this stage of the process. The data will be used with load data to determine the number of units per station and the total number of station (sites).

ELECTRICAL WORK ACTIVITY

PHASES I & II

Fluor Power Services will provide assistance in site selection, recommend transmission voltage levels and logical transmission routes from the new sites, develop input for load flow studies to be made by Harza to conform reasonable transmission system selection, assist in plant costing and report preparation.

It is assumed that Harza will develop the basic data for any load flow studies required and that Fluor Power Services input will be limited to providing generation levels and transmission line data for the lines serving the various sites. It is further assumed that Harza will provide transmission line costing including right-of-way costs to maintain consistent costs between the hydro and thermal alternatives.

EVALUATION OF THERMAL PLANT ALTERNATIVES

The economic evaluation of all generating plants that have been sited will compare the following:

a) Fuel Cost (coal, oil and gas cost to be supplied by Harza)

b) Added Fuel Transportation Installation Cost

c) Maintenance Cost

d) Operating Cost

e) Replacement Cost (based on 30-year plant life)

f) Transmission Line Cost (Fluor Power Services will define the carrying capacity and routing, and Harza will provide the installed cost.

Estimated power plant costs will be based on construction costs of similar plants in the 48 contiguous states with appropriate adjustment in the labor rates, transportation costs, and construction schedules to reflect conditions in Alaska. The experience gained by Fluor Corporation on the design and construction of the Alaskan Pipe Line & Storage Facilities will be applied to the installation of the power plant(s) in Alaska.

Evaluation results will include a recommendation of number, location, and fuel for thermal plants to best meet the load growth.

For the sake of consistency, economic factors and evaluation techniques will be supplied by Harza.

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August 14, 1979

FILE NO.

Mr. Richard L. Meagher
Harza Engineering Company
150 South Wacker Drive
Chicago, Illinois 60606

Legal Services for Obtaining a License
for the Susitna River Project

Dear Dick:

Your letter of August 6, 1979 inquiring about the scope of possible legal services for a project on the Susitna River raises a number of interesting questions. I will attempt to respond.

You have requested suggestions that would expedite the efforts to obtain a license. Most of my comments will relate to legal services, but one general comment might be in order. Too many utilities fail to implement an effective and aggressive public relations program. It is not sufficient to run newspaper advertisements after the opposition has started or to solicit public participation as the studies progress. Rather, what is needed, from the earliest possible point in time, is a large and coordinated effort of meetings with local officials and residents to inform them in great detail of the range of studies to be undertaken and that their input will be sought and utilized. Too often the opposition to similar projects has effectively organized local opposition by playing on the fears of an uninformed public.

As you are well aware, any effort to obtain a license from the Federal Energy Regulatory Commission ("FERC") requires a coordinated and, unfortunately, extensive effort among engineering, environmental and legal consultants. Legal consultation requires both local counsel, who would deal with state and local agencies, access to lands, etc., and counsel familiar with the requirements and procedures of FERC.

In the initial stages of the licensing effort, the FERC counsel would normally be involved in assisting the client to assure that all of the studies required for a complete application for license are being conducted. This necessarily involves knowledge of the Federal Power Act, FERC's Regulations, the implications of the National Environmental Policy Act and recent developments at FERC and in related areas, such as the Clean Water Act (discharge permits, dredge and fill permits, state certifications). A detailed list of studies needs to be developed and a careful assignment of responsibilities made. Among other matters, counsel should work with the engineering and environmental consultants to assure the completeness of their studies, review load forecasting methodology, which is becoming a major issue because of the heavy emphasis on conservation, and be certain that the analyses of alternative forms of generation and of alternative hydroelectric sites are sufficient.

As the studies are nearing completion and an application is being prepared, counsel would be concerned with the legal sufficiency of the application including such key exhibits as the environmental impact report. Once the application is filed, the legal efforts for perhaps a year are likely to focus on responding to interventions and other pleadings, responding to Federal, State, and local agency comments on the application and ultimately on FERC's Draft Environmental Impact Statement. During the entire licensing period, counsel should be alert to developments at FERC and at other agencies, such as the Forest Service, Environmental Protection Agency and the Corps of Engineers that would impact on either the licensing process or the construction of the project.

For any project the size you have suggested, and especially where environmental opposition is strong, FERC will hold a hearing. This is when counsel's time is likely to increase dramatically as testimony is prepared, the hearing held and briefs written. Finally, after an Administrative Law Judge's Initial Decision, the Commission's procedures call for briefs on exceptions and replies thereto before the full Commission acts. Of course, appellate review is always a possibility.

Several factors make it difficult to develop a budget estimate for outside legal costs. Perhaps the greatest intangible is the amount of opposition that will surface. If, as is the case with Appalachian Power Company's pumped storage project, a group such as the Sierra Club decides to undertake

an all-out battle, costs can run up quickly. Other major unknowns are the extent to which counsel will coordinate consulting activities or play a major role in writing or editing the environmental impact report.

Based on the time our firm spent in assisting Virginia Electric and Power Company in obtaining the license for the Bath County Pumped Storage Project, I have attempted to prepare a budget estimate. The estimate might be a little on the high side since our firm served as both local counsel and FERC counsel and we spent considerable time in coordinating the various consulting activities and in preparing the environmental report. However, the environmental opposition never reached a particularly high level. (The environmental sensitivity in Alaska may well require substantial additional time.) As difficult as it is to quantify total dollars, it is even more difficult to try to establish a quarterly projection. Too many variables can change even the most carefully anticipated schedule. The schedule I have assumed reflects my idea of an orderly proceeding without undue delays. It could move a little more quickly or a lot more slowly depending on the opposition.

Since I would strongly urge that any counsel selected be involved at the time when the scope of consultants' work is being developed, the first quarter shown is designed to cover the initial strategy sessions even before any detailed feasibility studies have begun.

Quarter	Activity	Cost
1	Selection of consultants; scoping of studies	$25,000
2	Coordination and review of detailed engineering, environmental and economic studies	$15,000
3	"	$15,000
4	"	$15,000
5	"	$15,000
6	"	$20,000

Quarter	Activity	Cost
7	Preparation of license application including environmental report	$40,000
8	"	$50,000
9	Coordination with FERC Staff; responses to interventions, pleadings, agency comments	$20,000
10	"	$25,000
11	"	$20,000
12	"	$20,000
13	"	$20,000
14	Review and response to Draft Environmental Impact Statement	$40,000
15	Preparation for hearing	$50,000
16	"	$50,000
17	Hearing and briefing	$75,000
18	"	$50,000
19	Judge writing decision	$ 5,000
20	Briefs on exception, opposing exceptions	$45,000
21	Waiting for Commission action	$ 5,000
22	"	$ 5,000
23 - ?	Appellate review	?

I trust these costs will not deter the Alaska Power Authority from seeking a license. It is important, however, for the Authority to recognize the substantiality of the undertaking and to proceed on the basis of a realistic estimate. It will do them little good to have too low an estimate that is constantly exceeded. These figures contemplate a fight, but not a blood-letting. The cost of possible appellate review is too speculative for inclusion.

Unless there is some question of FERC's jurisdiction over the proposed project, I see no reason to file a Declaration of Intent. If either the Susitna River is navigable or federal lands are involved, FERC would clearly have jurisdiction. The best way to speed the licensing process is to be certain that a complete application is filed. FERC's Staff has been and is likely to be extremely helpful in assisting an applicant toward that end.

I have no objection to your integrating these comments and cost estimates into your overall presentation to the Alaska Power Authority and your citing me as the source. I would be delighted to provide additional information if you think that would be helpful.

Sincerely yours,

Arnold H. Quint

Arnold H. Quint

87/cp

nuveen
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September 5, 1979

Mr. D. L. Glasscock
Vice President and Project Manager
Susitna Hydro Development
Harza Engineering Company
150 South Wacker Drive
Chicago, IL 60606

Dear Dwight:

We are pleased to provide the information requested in your letter of August 23, 1979 regarding financing arrangements for the proposed Susitna River hydroelectric project.

Prior to financing the APA should enter into various "power sales agreements" which collectively provide for the sale of the entire project output. Commitments for the purchase of the power should be on a "take or pay" basis. The agreement should include the following provisions among others:

(1) Term - at least co-extensive with debt service on all bonds issued

(2) Billing and method of payment

(3) Sale of excess power

(4) Obligation to pay--take or pay from initial operating date, or a fixed date certain, whichever is sooner. Binding commitment regardless of whether or not power is taken or plant is operating

(5) Scheduled cost of power based on a formula providing for pro-rata allocation of operating costs, debt service (including a coverage factor of between .1% or .2% of maximum annual debt service) and funding of reserve accounts

(6) Default--in the event of default on the part of any purchaser, the obligations of all remaining purchasers may be automatically increased, pro-rata, up to 25% of their original share of project output.

For municipally owned systems, the execution of such an agreement presents no legal problem but participants will carefully examine expected costs of power and potential liability for cost overruns and project delays. For non-exempt systems (such as REA co-ops) various IRS rulings impose limits on the aggregate amount of project output which they can purchase on a "take or pay basis."

The mechanical details of implementing such agreements are relatively straightforward. The APA adopts an annual budget providing for the items required for operation or financial security and a monthly billing rate is established for each participant according to their share of total projected output. As costs, output or other factors deviate from budget, the budget and corresponding monthly bills are amended.

Nuveen's interest in the Susitna project will be to act as senior managing underwriter. We are prepared to work with APA, its consultants and engineers and provide any and all advisory services necessary, on a contingent basis. Our compensation will be realized from the underwriting when bonds are issued to finance the project. There would be no need to budget up-front costs.

APA may utilize an independent financial advisor to compliment our investment banking services. It is difficult to say what a financial advisor's fees would be and whether or not an advisor would work on a contingent basis. However, if we assume that the financing for the first project would total $1.5 billion, we think that the total advisory fee would be in the order of $1 million. Approximately $50,000 might be paid in equal increments quarterly during the development period prior to financing. The balance would be paid at the conclusion of each financing based on a formula which relates to the sale of specific bond issues.

I hope these brief comments meet your immediate needs. If you have questions or seek greater detail regarding any of these items, please don't hesitate to call me.

Sincerely,

Anthony T. Dean
Assistant Vice President

ATD/rs