FINAL REPORT

MAY 1982

VOLUME I

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EVALUATION OF STRUCTURAL CONCEPTS
FOR
NORTON SOUND LEASE SALE AREA

FINAL REPORT

MAY 1982

VOLUME I

FLUOR OCEAN SERVICES, INC.

HOUSTON, TEXAS

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2.0 PROGRAM OVERVIEW

2.1 INTRODUCTION

OCS Lease Sale 57, scheduled for November of this year, will open the Norton Sound area to exploration. This area is an elongate, east-west trending marine re-entrant off the coast of Northwestern Alaska. Should exploration encounter significant oil deposits, development of the reserves must be evaluated with due consideration for this severe arctic environment.

Structural demands in Norton Sound differ considerably from those in the developed areas of the Beaufort Sea. Wave climate, storm surge, and seismic risks are greater; while ice conditions are less severe. To identify attractive structural concepts for development of Norton Sound, Standard Oil Company of California (SOCAL) conducted a feasibility study to assess capital costs and performance characteristics for various structural alternates. The initial study identified two promising structural concepts. Subsequently, SOCAL retained Fluor Ocean Services Inc. (FOS) and ABAM Engineers Inc. as consultants and approached the members of the Alaska Oil & Gas Association and other interested parties to participate in a joint industry study to further assess the two concepts.

Acting as operator, SOCAL obtained the necessary level of industry participation and initiated this "Evaluation of Structural Concepts for Norton Sound Lease Sale Area" program on the 14th of October 1981. Organizations participating in the program include:

- Gulf Research and Development Company
- Marathon Oil Company
- Mobil Oil Corporation
- Occidental Exploration and Production Company
- Pennzoil Company

- Phillips Petroleum Company
- SOHIO Petroleum Company
- Standard Oil Company of California
- Texaco, Incorporated

FOS and ABAM executed the required engineering, construction planning, and cost/schedule estimating summarized hereafter during the remainder of 1981 and the first quarter of 1982. Periodic program meetings were conducted during this period to advise the participants of progress and to receive input from them. The purpose of this final report is to formally present the findings to the participating parties. The document is divided into two volumes: Volume I contains discussions of the major conclusions and Volume II contains basic data in support of the findings.

2.2 PREVIOUS STUDY

In preparation for the joint industry study, SOCAL initiated and directed a feasibility study earlier in 1981 to evaluate various drilling and production alternatives for future development of Norton Sound. PMB Systems Engineering Inc. acted as prime contractor; and performed the study in close association with Ben C. Gerwick, Harding-Lawson Associates, and Ken Vaudrey.

Candidate concepts included retained or unretained gravel island, monocone, monopod, tower (Lower Cook Inlet type), and concrete barge structures. Each concept was pursued through limited engineering, construction planning, and cost/schedule estimating. Definition of environmental and functional criteria was based on public and proprietary information and on the collective experience of the project team.

The initial study successfully identified two structural concepts, considering capital costs and performance characteristics, as the most attractive alternatives for development of Norton Sound. The study concluded that a concrete barge with an integrated deck configuration would be well suited for shallow to intermediate water depths, while a steel jacket with a modular deck should be feasible for all water depths within the Sound. The above concepts were proposed for further study, considering the critical engineering problems identified.

2.3 PURPOSE AND OBJECTIVES

As proposed and accepted by the program participants, the mission of this joint industry study was to provide additional planning data for future development of Norton Sound prior to the upcoming concessionary lease sale. Project objectives for the two recommended structural concepts included: (1) Design criteria, (2) Preliminary designs, (3) Feasible construction procedures, (4) Estimated capital costs and development schedules, and (5) Cost/schedule sensitivities.

2.4 STRATEGY

To satisfy the mission and objectives, this study was conducted in the following manner. Previous SOCAL studies provided the basis for each concept's further development through preliminary engineering and planning. Preliminary efforts were limited to three non-specific site locations, base cases, selected to represent the different environmental conditions within the sale area. Thus, four base cases were considered: (1) 30 foot water depth jacket (2) 50 foot water depth jacket, (3) 70 foot water depth jacket, and (4) 30 foot water depth barge platform.

A major field production scenario would be common to all base cases. The facilities would be self-contained and outfitted with all necessary equipment for drilling, production, and quartering. Oil production will be shipped to a remote terminal, or shore facility, through a subsea pipeline. Excess gas production and produced water would be reinjected into the formation. Oil storage/transport, tanker mooring, and equipment for sour production would be beyond the scope of the study. Preliminary designs for the above base cases would provide the basis for all cost/schedule estimating.

2.5 PROJECT EXECUTION

Under SOCAL's adminstrative direction, FOS acted as prime contractor in close association with ABAM to bring this joint industry study to fruition. FOS was responsible for the evaluation of all drilling/production facilities, decks, and jacket structures; while ABAM was responsible for the evaluation of the barge structures.

PRELIMINARY DESIGN RESULTS

3.0 PRELIMINARY DESIGN RESULTS

3.1 GENERAL

The findings presented herein are based on the results of the preliminary engineering for the four base cases. Included are discussions of topside facilities, jacket substructures, and barge substructures. All designs are based on criteria approved by consensus of the participatnts. These criteria are incorporated in the "Design Specifications" document provided for reference in Volume II, Addendum A of this report. Preliminary equipment lists and design drawings for the structures are in Addendums B and C, respectively, of Volume II.

3.2 TOPSIDE FACILITIES

3.2.1 Engineering and Design

The philosophy of modular packaging for topside facilities is common to both the jacket and barge concepts. Facilities for the jacket concept will be erected offshore in Norton Sound, while facilities for the barge concept will be integrated with the substructure nearshore in close to the barge construction site prior to its voyage to Norton Sound.

One of the critical problems identified by the previous study concerns the resupply of platforms in Norton Sound. In less hostile environments bulk stores are transported to the platform by supply vessels, where conventional boat landing and/or barge bumper systems permit vessels to moor against the platform during offloading. Such a mooring system in an arctic environment would be severely damaged during the winter months by ice floes and rubble. In the North Sea where many operators do not permit supply vessels to moor against the platform, motion compensators (e.g. Rucker Mooring Systems) are often used. With this system the supply vessel moors away from the platform and maintains its position with opposing thrust. Topside facility designs for both the jacket and barge concepts include such motion compensator mooring systems in combination with long-reach cranes. This combination should facilitate offloading during the winter months of ice-breaking supply vessels positioned outside the platforms rubble field.

Substructures for both the jacket and barge concepts are designed to be self-floating during transportation and installation. During platform operation their ballast compartments will be used for bulk liquid storage (drill water, service water, diesel, produced water surge, and oily waste). This below water level location was prefered over liquid storage at a higher elevation (e.g. within the jacket's legs and/or box beams and upon the barge's tank top) for several reasons. Although required pumping head was increased, liquid heating requirements were materially decreased due to the more favorable temperature regime below the water surface. Since the jacket's compartments would have been flooded and the barge's compartments filled to provide proper foundation pressures, the overall platform deck loadings were reduced. Moreover, the compartments' submersible pumps can be used for ballast control during voyage and on-site deballasting if necessary. For the jacket concept, utility pumps were located within the upper transverse box beams to reduce required deck space and can be used to further assist with ballasting operations.

Major drilling and production equipment for both concepts were based on the same 120,000 BOPD major field production scenario. Preliminary sizing of major equipment, using the FOS "P001" two-stage separation computer program, was performed in accordance with the "Design Specifications" in Volume II.

Two 50 percent trains are used for each major production system. Two-stage separation was prefered to provide both low pressure fuel gas and high pressure injection gas and to minimize compression requirements. The combination of high GOR and reservoir pressure necessitated substantial compression equipment for these facilities. Dual-fuel turbine prime movers were prefered over diesel and/or electric drives considering power-to-weight ratios and start-up requirements.

Space air conditioning by steam generation was considered for study purposes. However, future design efforts should fully investigate the use of waste heat recovery for space conditioning.

The drilling facilities consist of two self-contained, semi-independent drilling systems. Equipment layout and structural design for both concepts considered the removal of one drilling system upon completion of the developmental drilling program. Drilling systems, with storage capacities based on a two week resupply interval, are capable of drilling in excess of 12,000 feet and are fully winterized.

Structural design of the topside facilities was expedited to permit closer examination of the substructures and analysis consisted of manual calculations. Module designs for both concepts included static inplace and lift loadings. Appurtenance weights were based on conventional factors or in-house historical information. Except for the drilling rig reactions, all module designs and reactions were developed using uniformally distributed loads in conjunction with suitable load reduction factors. Complete dynamic and seismic analysis of the topside facilities was not required to attain the desired level of estimating accuracy, but must be performed for final designs in Norton Sound.

Frame members were sized by conventional pinned-truss analysis methods using suitable allowances for seismic loads and deflection induced moments. A limited number of unrealistically heavy members are included in a few module designs. Further development of these designs should optimize frame configurations to provide more efficient sizes. Care must be exercised in future detailing of frame connections to avoid tension cracking during fabrication, based on North Sea fabrication experience with joints of similar materials and thicknesses.

The jacket concept's topside general arrangement is similar to many existing platforms in the North Sea. This type of configuration was prefered to and minimize onsite erection time. The layout consists of three principal levels:

(1) Lower Production Level -
  - One 52' x 157' x 31' module, and
  - Three 39' x 75' x 28' modules.

(2) Intermediate Drilling Level-
  - Seven 36' x 75' x 28' modules, and
  - Two 40' x 50' x 75' rig modules.

(3) Upper Accommodation Level-
  - Two 50' x 75' x 28' modules.

Principal deck area for this type of arrangement can be increased by approximately 15 percent for future development requirements by adding an additional module to the lower level. Preliminary weight estimates for the outfitted modules described above, along with major appurtenances, are provided in Table 3-1. (See Drawing Nos. J-101 thru 106, Addendum C, Volume II.)

NORTON SOUND STUDY

JACKET CONCEPT TOPSIDES

MODULE/PACKAGE	STEEL WT. (SHT)	DRY WT. (SHT)	MAX. WET WT. (SHT)
DRILL MOD DA	200	418 (58%) (2)	1980
DRILL MOD DB1	189	567 (87%)	1970
DRILL MOD DB2	184	562 (86%)	1970
DRILL MOD DC1	178	481 (74%)	1960
DRILL MOD DC2	172	476 (73%)	1960
DRILL MOD DB1	199	521 (80%)	1090
DRILL MOD DB2	199	521 (80%)	1090
WELL MOD WA	856	1100 (76%)	2640
PROD MOD PB	498	941 (65%)	1510
PROD MOD PC	444	1040 (72%)	1450
PROD MOD PD	483	1010 (70%)	1490
QTRS PKG CQ-1A	360	400 (57%)	720
QTRS PKG CQ-1B	360	400 (57%)	720
DRILL RIG RM-1A	344	575 (79%)	1075
DRILL RIG RM-1B	344	575 (79%)	825
FLARE FB-1A	90	100 (14%)	104
FLARE FB-1B	90	100 (14%)	104
MISC PKGS	139	290 —	390
SUB-TOTALS	5329 (1)	10100	23300

NOTES:

(1) EXTERIOR STEEL AT 56% AND INTERIOR STEEL AT 44%.

(2) PERCENTAGE OF MAXIMUM LIFT WEIGHT PER DESIGN SPECIFICATIONS.

TABLE 3–1

The barge concept's topside general arrangement is similar to many land based facilities. This type of configuration was prefered to minimize required derrick vessel capacity. The layout consists of two principal levels:

(1) Lower Drilling/Production/Accommodation Level-
    - Twenty 38' x 78' x 28' modules

(2) Upper Drilling Level-
    - Two 40' x 50' x 50' rig modules

For future development requirements, five additional modules can be added to increase principal deck area by about 25 percent. Table 3-2 provides preliminary weight estimates for outfitted modules and major appurtenances. (See Drawing Nos. B-101 thru 105, Addendum C, Volume II.)

3.2.2 Fabrication and Outfitting

Other than certain material constraints, structural assembly and outfitting of the topside modules and appurtenances for both concepts will follow standard industry practices. Several construction yards throughout the world are capable of providing these facilities. For timely completion, two or more yards should probably be contracted.

Exterior structural members for the topside facilities should be of quenched and tempered steel to accommodate the low service temperatures that will be encountered. Initial mill orders for this steel should be placed early in the final design program considering the large quantities required and limited sources of supply. These materials presently can be obtained from the eastern United States, Japan, or Europe. Special welding consumables are required for these steels, however, the necessity of stress relief heat treatment during fabrication is not anticipated.

NORTON SOUND STUDY

BARGE CONCEPT TOPSIDES

MODULE/PACKAGE	STEEL WT. (SHT)	DRY WT. (SHT)	MAX.WET WT. (SHT)
DRILL MOD A/1-2	250	390 (54%) (2)	2240
DRILL MOD B/1-2	194	654 (90%)	2190
DRILL MOD D/1-2	194	527 (73%)	2190
DRILL MOD E/1-2	214	376 (52%)	2210
DRILL MOD A/3-4	207	370 (51%)	2200
DRILL MOD B/3-4	187	521 (72%)	2180
DRILL MOD D/3-4	187	648 (89%)	2180
DRILL MOD E/3-4	244	573 (79%)	2240
PROD MOD A/5-6	144	483 (67%)	792
PROD MOD B/5-6	115	331 (46%)	763
PROD MOD C/5-6	108	262 (36%)	756
PROD MOD D/5-6	121	253 (35%)	769
PROD MOD E/5-6	144	393 (54%)	792
PROD MOD B/7-8	120	489 (67%)	768
PROD MOD C/7-8	144	319 (44%)	792
PROD MOD B/9-10	144	293 (40%)	792
WELL MOD C/1-2	245	316 (44%)	744
WELL MOD C/3-4	239	310 (43%)	738
QTRS PKG C/9-10	360	400 (55%)	609
QTRS PKG D/9-10	360	400 (55%)	609
DRILL RIG RM-1A	344	550 (76%)	1050
DRILL RIG RM-1-B	344	550 (76%)	800
FLARE FB-1A	90	100 (14%)	104
FLARE FB-1B	90	100 (14%)	104
MISC PKGS	77	325 —	500
SUB-TOTALS	4870 (1)	9930	29100

NOTES:

(1) EXTERIOR STEEL AT 59% AND INTERIOR STEEL AT 41%.

(2) PERCENT OF MAXIMUM LIFT WEIGHT PER DESIGN SPECIFICATIONS.

TABLE 3–2

Other enhanced steel grades are not anticipated to be required for the interior structural members since they will be within a controlled environment. Furthermore, conventional welding consumables can be used with these steels.

3.2.3 Transportation and Erection

a. Jacket Concept

Design of the topside facilities for the jacket concept was based on the premise that erection of the modules will occur on-site during the ice free season in Norton Sound. Total platform installation is expected to be completed within one construction season. Conventional marine construction and support equipment, without winterization, was considered in the design. The modules and appurtenances will be transported from the fabrication yard(s) by cargo barge and lifted onto the substructure by derrick vessel(s). Derrick vessel lift requirements are controlled by the lower production modules (See Table 3-1) and by water depth. One 1600/ 2000 ton derrick vessel will be required for the 50 and 70 foot water depth cases, while two 800/1000 ton derrick vessels will be required for the 30 foot water depth case. Both derrick vessel spreads provide generous (weight) growth allowances for final design. Only the two inside production modules require skidding to final position, other modules and appurtanences are set in place.

b. Barge Concept

Topside facilities design for the barge concept was based on the assumption that the modules would be erected nearshore, close to the barge construction site. Modules and appurtenances will be shuttled between the yard and the moored barge by multiple cargo barges and lifted onto the substructure by derrick vessel. One 800/1000 ton derrick will be required based on the estimated lift weights provided on Table 3-2. All inboard modules will require skidding to final position, while the other modules and appurtenances can be set in place.

3.2.4 Hook-Up, Start-Up, and Commissioning

A staged structural and mechanical completion program for the topside facilities is recommended for both concepts. Weldout is of the highest priority and should be expedited. Flashing (additional plate cladding) can be installed during hook-up, but must be installed before the winter months to maintain a controlled interior eironment.

For the jacket concepts, five phases are suggested for placing the platform in operation:

(1) Accommodation and Hook-Up Support
(2) Drill Rig "A" Activated
(3) Drill Rig "B" Activated
(4) Limited Production
(5) Full Production

The platform's crew quarters, helidecks, and pedestal cranes should first be made operational to expedite and support subsequent activities. Since the well conductors are scheduled to be installed during the jacket's installation, developmental drilling can commence immediately after each rig is commissioned. Selected plant and temporary provisions would then be commissioned to facilitate initial production. Additional plant would finally be commissioned to accommodate incremental production increases through full production.

The three suggested phases for the barge concept are:

(1) Accommodation and Hook-Up Support
(2) Hook-Up
(3) Start-Up and Commissioning

Again; the platform's crew quarters, helidecks, and pedestal cranes should first be made operational to expedite and support subsequent activities. Hook-up would be carried out while the barge is still in close proximity to its construction site. After the voyage to the Norton Sound site, remaining conductor driving, start-up, and commissioning will be sequenced similar to the jacket concept's later phases.

3.3 JACKET SUBSTRUCTURES

3.3.1 Engineering and Design

The preliminary designs of the 30, 50, and 70 foot water depth jackets are based on the findings of the previous study. Critical engineering problems identified in the study have been resolved through preliminary engineering during this study or have been recommended for further evaluation.

a. Geometry

Conventional T, K, and Y bracing normally associated with standard template type jackets are not practical for substructures in Norton Sound. Although their use improves structural redundancy, global loading of the structure would be increased and local ice loading of the braces would at best minimize their contribution to the structural integrity. Tower jackets, not unlike those currently used in the Lower Cook Inlet area, are therefore prefered. The jacket's legs are unbraced between framing plans and are 100 feet on center longitudinally and transversly. Upper and lower framing plan elevations vary, controlled by each water depth's splash and ice zones respectively.

b. Framing

Upper framing alternatives for support of the topside facilities were limited by the above tower's portal frame configuration. A girder network, such as used in many North Sea substructures, is not practical due to the absence of intermediate bent bracing for support of the girders. Thus, the preliminary designs use only two skid beams between the legs to provide support for the relatively long production modules. The efficient use of cantilevers for support of these lower level modules and the relocation of service pumps to the transverse box girders reduces the number of required modules and allows accommodation of drilling and production equipment in two levels. (See Drawing No. J-107, Addendum C, Volume II.)

Leg framing, as proposed by the initial study, was revised for fabrication and performance considerations. Although the basic make-up is unchanged, preliminary engineering identified that significant changes in leg sizes and stiffening was required. Outside diameters for the smaller riser legs were held to a minimum of 20 feet. Future riser legs can be increased for stability considerations to the well leg's 28 feet without a large increase in global ice loading. Increases in global ice forces, above those considered in the preceding study, resulted from higher ice unconfined compression strength and required all leg sleeves to be slightly thicker. A combination of ring and longeron stiffeners is used for the leg sleeves to facilitate assembly during fabrication and prevent local buckling. Leg annuluses remain concrete filled to resist local ice forces, while leg interiors provide a dry environment to permit in-service inspection. (See Drawing J-108, Addendum C, Volume II.)

Revisions in lower framing and piling were dictated by tower installation and performance requirements. Expensive rock armoring was avoided by providing for further jetting of the tower below the ice rubble and designing for generous scour allowances. To resist the increased global ice loads and to minimize loss of resistance due to group action, both pile size and spacing are larger. Leg skirts, previously employed for buoyancy and pile connections, are replaced by enlarged lower box girders. These girders provide adequate buoyancy for tower floatation, while repositioning the stiffness to reduce required pile penetrations. Shear plates are used to connect pile sleeves directly to the legs. (See Drawing Nos. J-108 and 109, Addendum C, Volume II.)

c. Corrosion Protection

As will be discussed later, the tower substructures are weight critical due to fabrication/transportation draft limitations and transportation/installation stability. Therefore, corrosion protection using sacrificial anodes or corrosion allowances is not recommended. Preliminary tower designs include provisions for impressed current cathodic protection systems. Anodes and wiring should be located in exterior leg risers for protection from ice floes and rubble.

d. Global Analysis

The design of the jacket substructure for the inplace conditions is based on three-dimensional (3-D) space frame computer analysis. The computer model was subjected to various inplace design loadings. The large diameter tower legs were modeled using five elements, one central bending member and four radial axial members. This representation of the stiffness was selected to more accurately account for the vertical deflections at the outer sleeve/girder interfaces.

The jacket substructure's foundation piling were modeled using a "point-of-fixity" concept. Pile stiffness was modeled for an effective length to approximate the lateral deflections of the inelastic pile-soil system. The validity of the results was verified by comparing computer generated deflections with hand calculations using the shear values at the pile head. Good correlations were found. However, more accurate modeling of the pile-soil system must be used for final designs. The conductors were conservatively omitted from the model. Future designs should include these foundation members as a means to reduce required pile penetrations.

Initially; design loadings included wave and current, ice floe, ice accretion, earthquake, wind, dead, and various live loads. All design forces were calculated in accordance with the "Design Specifications". For the initial analysis of the 70 foot water depth case, thirty basic load cases were used to develop twenty-four load combinations. The interdependence of these load combinations are shown in Figure 3-1.

Wave and current forces were generated using the FOS "SEALOAD" wave program. For ice forces, the following four assumptions were made:

(1) Rubble pile forces are the controlling ice feature loading.

(2) A mass of solid rubble bridges between all four legs.

(3) There is a consistency of direction for the ice mass.

(4) The ice forces are distributed to each leg in proportion to its relative stiffness (i.e. moment of inertia).

Other ice loading scenarios are entirely possible. However, this loading scenario should facilitate cost estimates to the desired level of accuracy.

Seismic forces were calculated based on API's response spectrum method conservatively using a uniform 0.15g horizontal acceleration in the event's direction. A reduction of jacket weight should be possible through future dynamic and fatigue analyses.

Member deflections, rotations, forces, and moments were obtained from the 3-D space frame analyses. After the initial 70 foot water depth case analysis, structural analyses for the remaining water depth cases were limited to only the controlling load

NORTON SOUND STUDY

JACKET DESIGN LOADING

SUBSTRUCTURE LOAD COMBINATIONS

	MAJOR EVENTS					
LOADS	NORMAL OPER. ENVIRON.	EXTREME WAVES	EXTREME ICE (HORIZ.)	EXTREME ICE (VERT.)	EXTREME SEISMIC + H ICE	EXTREME SEISMIC + NORMAL WAVES
1 YEAR WAVE, TIDE & SURGE	●					●
100 YEAR WAVE, TIDE & SURGE		●				
1 YEAR STEADY CURRENT	●				●	●
5 YEAR STEADY CURRENT				●		
100 YEAR STEADY CURRENT		●	●			
SEISMIC ICE FLOE					●	
100 YEAR ICE FLOE			●			
100 YEAR ICE ADHESION				●		
100 YEAR EARTHQUAKE					●	●
1 YEAR ICE ACCRETION	●			●	●	●
100 YEAR ICE ACCRETION		●	●			
1 YEAR SUSTAINED WIND	●				●	●
5 YEAR SUSTAINED WIND				●		
100 YEAR SUSTAINED WIND		●	●			
STRUCTURAL DL & LL	●	●	●	●	●	●

NOTE; INITIAL ANALYSIS TO INCLUDE N AND E EARTHQUAKE DIRECTIONS AND N, NE, E, SE & S STORM DIRECTIONS. SUBSEQUENT ANALYSES TO CONSIDER ONLY CONTROLLING COMBINATIONS FOR DESIGN OF MAJOR STRUCTURAL COMPONENTS.

FIGURE 3–1

combinations. It was found that the 100 year ice flow and seismic plus ice flow load combinations controlled the design.

The structural behavior of the model was controlled by its dominant features, the relatively stiff legs and pile groups. Frame action, normally associated with fixed offshore platforms, was minimal and the legs behaved more as individual pile supported caissons. More frame action was exhibited during seismic loadings than for ice floes since the majority of the seismic condition's lateral forces were at a higher elevation. The leg's large moment of intertia connected rigidly to a large diameter pile group, itself possessing a large effective moment of inertia, resulted in the majority of the moment at the bottom of the legs being transfered directly to the piles. In turn, the pile group resisted this moment by a combination of axial load and bending. Because of the extremely large lateral loads imposed on the jacket substructure, large compression and tension forces were present in each group of piles. The repositioning of stiffness, resulting from the substitution of floation girders for legs skirts, significantly enhanced frame action to substantially reduce pile design penetrations.

Pile design entailed consideration of both axial and lateral loads. Controlling axial and lateral forces were provided by the computer analysis previously discussed. Required pile penetrations were determined in accordance with the soil criteria in the "Design Specifications". Wall thicknesses for the piles are held constant over their lengths to promote driveablity. Pile field splices are positioned to facilitate handling.

e. Transportation Analysis

Structural loadings during transportation were not analyzed during the preliminary design. However, the tower is undoubtedly structurally adequate for these forces. It would be prudent to verify this assumption during the final design process.

f. Local Analyses

Localized design of structural elements included consideration of hydrostatic pressure, buckling, and localized ice pressure. The floatation girders were designed for a submergence to 80 feet for all water depth cases. Hydrostatically induced stresses for the floatation girders were suitabily limited to prevent overstressing when combined with inplace loads. Internal stiffening for all members was designed for the material to yield prior to local buckling. Primary local buckling considerations included inplane axial compression and web-shear buckling, using classical plate buckling theory (23). (See Addendum G, Volume II for all references.)

For local ice pressures, the following four assumptions were made:

(1) Maximum ice pressure is 400 psi over 50 square feet and 240 psi over 175 square feet for the 28 foot diameter well legs.

(2) Maximum ice pressure is 400 psi over 50 square feet and 270 psi over 110 square feet for the smaller riser legs.

(3) The combination of the ring plates and the concrete annulus allows the transfer of horizontal shear so as to develop a "beam-like" cross section with the internal and external sleeves as flanges.

(4) Concrete within the annulus uniformly distributes the forces around the leg as radial shear.

To prevent local buckling and to help insure that the concrete distributes the forces around the leg, WT stiffeners were selected and positioned within the annulus. With the above assumptions, the following maximum stresses were obtained for the 70 foot water depth case:

Description	Well Leg	Riser Leg
Shear Stress (Fv = 27 ksi)	7.9 ksi	7.5 ksi
Hoop Stress (Fa = 40 ksi)	6.3 ksi	4.3 ksi
Bending Stress (Fb = 40 ksi)	0.66 ksi	0.59 ksi
AISC Interaction Ratio (Allow. = 1.0)	0.17	0.12

Thus, based on the above assumptions, the legs of the tower are not sensitive to local ice intensity.

g. Results of Analyses

Generally, seismic loading controlled the tower's upper framing and ice loadings controlled the tower's remaining framing and piling. The following listing provides the controlling loading condition for each member. Load case definitions and design conditions for the 30, 50, and 70 foot water depth cases are provided in Tables 3-3, 3-4, and 3-5 respectively.

Members	Load Case No.
Center Span Skid Beams	4
North Cantilever Skid Beams	5
South Cantilever Skid Beams	4
Transverse Girders	5
Well Legs	1
Riser Legs	5
Floatation Girders	2

NORTON SOUND STUDY
INPLACE CONTROLLING CONDITIONS
30 FOOT JACKET SUBSTRUCTURE

LOAD COMBINATION	HORIZONTAL FORCE (KIPS)	VERTICAL FORCE (KIPS)	OVERTURNING MOMENT (FT–KIPS)
N.E. HORIZONTAL ICE FLOE (LC - 1)	34,300	73,700	1,970,000
E. HORIZONTAL ICE FLOE (LC -2)	27,600	69,900	1,590,000
S.E. HORIZONTAL ICE FLOE (LC -3)	34,300	73,000	2,010,000
N. EARTHQUAKE & HORIZ. ICE FLOE (LC—4)	25,100	76,500	2,080,000
E. EARTHQUAKE & HORIZ. ICE FLOE (LC—5)	24,900	74,500	2,060,000

1. Horizontal Force Includes Wind, Wave, Ice, Earthquake, And Current Forces On Structure And Drilling Packages.
2. Vertical Force Can Be Itemized As Follows (UNITS=KIPS):

ITEM		LOAD COMBINATION				
		LC -1	LC -2	LC -3	LC -4	LC -5
A	SUPERSTRUCTURE WT.	45,200	41,400	44,500	46,800	44,800
B	SUBSTRUCTURE WT.	39,000	39,000	39,000	40,200	40,200
C	SUBSTRUCTURE BUOYANCY	10,500	10,500	10,500	10,500	10,500

3. Overturning Moment Approximated About Pile Head 30 Feet Below Mudline.
4. Design Loads For Piles Are As Follows:

A. MAXIMUM PILE BENDING MOMENT ——— 34,200 FT.—KIPS
B. MAXIMUM PILE COMPRESSION LOAD ——— 15,200 KIPS
C. MAXIMUM PILE TENSION LOAD ——— 8,350 KIPS
D. MAXIMUM PILE LATERAL LOAD ——— 2,940 KIPS

TABLE 3–3

NORTON SOUND STUDY
INPLACE CONTROLLING CONDITIONS
50 FOOT JACKET SUBSTRUCTURE

LOAD COMBINATION	HORIZONTAL FORCE (KIPS)	VERTICAL FORCE (KIPS)	OVERTURNING MOMENT (FT–KIPS)
N.E. HORIZONTAL ICE FLOE (LC-1)	34,300	75,500	2,490,000
E. HORIZONTAL ICE FLOE (LC-2)	27,000	71,700	2,010,000
S.E. HORIZONTAL ICE FLOE (LC-3)	34,400	74,700	2,490,000
N. EARTHQUAKE & HORIZ. ICE FLOE (LC–4)	26,000	78,400	2,500,000
E. EARTHQUAKE & HORIZ. ICE FLOE (LC–5)	25,800	76,400	2,500,000

1. Horizontal Force Includes Wind, Wave, Ice, Earthquake, And Current Forces On Structure And Drilling Packages.
2. Vertical Force Can Be Itemized As Follows (UNITS=KIPS):

ITEM		LOAD COMBINATION				
		LC-1	LC-2	LC-3	LC-4	LC-5
A	SUPERSTRUCTURE WT.	45,200	41,400	44,400	46,800	44,800
B	SUBSTRUCTURE WT.	42,600	42,600	42,600	43,900	43,900
C	SUBSTRUCTURE BUOYANCY	12,300	12,300	12,300	12,300	12,300

3. Overturning Moment Approximated About Pile Head 25 Feet Below Mudline.
4. Design Loads For Piles Are As Follows:

A. MAXIMUM PILE BENDING MOMENT ——— 36,900 FT.—KIPS
B. MAXIMUM PILE COMPRESSION LOAD ——— 17,900 KIPS
C. MAXIMUM PILE TENSION LOAD ——— 10,900 KIPS
D. MAXIMUM PILE LATERAL LOAD ——— 3,040 KIPS

TABLE 3–4

NORTON SOUND STUDY
INPLACE CONTROLLING CONDITIONS
70 FOOT JACKET SUBSTRUCTURE

LOAD COMBINATION	HORIZONTAL FORCE (KIPS)	VERTICAL FORCE (KIPS)	OVERTURNING MOMENT (FT–KIPS)
N.E. HORIZONTAL ICE FLOE (LC-1)	34,400	78,800	2,490,000
E. HORIZONTAL ICE FLOE (LC-2)	27,700	75,000	2,010,000
S.E. HORIZONTAL ICE FLOE (LC-3)	34,500	78,000	2,500,000
N. EARTHQUAKE & HORIZ. ICE FLOE (LC-4)	29,300	82,900	2,600,000
E. EARTHQUAKE & HORIZ. ICE FLOE (LC-5)	29,200	80,900	2,600,000

1. Horizontal Force Includes Wind, Wave, Ice, Earthquake, And Current Forces On Structure And Drilling Packages.
2. Vertical Force Can Be Itemized As Follows (UNITS=KIPS):

ITEM		LOAD COMBINATION				
		LC-1	LC-2	LC-3	LC-4	LC-5
A	SUPERSTRUCTURE WT.	45,200	41,400	44,400	46,800	44,800
B	SUBSTRUCTURE WT.	45,900	45,900	45,900	48,400	48,400
C	SUBSTRUCTURE BUOYANCY	12,300	12,300	12,300	12,300	12,300

3. Overturning Moment Approximated About Pile Head 5 Feet Below Mudline.
4. Design Loads For Piles Are As Follows:

A. MAXIMUM PILE BENDING MOMENT ——— 35,240 FT.–KIPS
B. MAXIMUM PILE COMPRESSION LOAD ——— 18,700 KIPS
C. MAXIMUM PILE TENSION LOAD ——— 10,900 KIPS
D. MAXIMUM PILE LATERAL LOAD ——— 2,910 KIPS

TABLE 3–5

Piles:	
Compression	3
Tension	1

h. Installation Design

The extent of installation analyses performed on the towers was somewhat limited by project constraints. As the 70 foot water depth case controls the concept for buoyancy, stability and foundation requirements; the 30 and 50 foot water depth cases were not fully investigated. Buoyancy/stability analysis consisted of hand calculatons, while pile driveability was based on the FOS "TTIWAVE" wave equation computer program.

Although available displacement is adequate for the tower inyard floatation, its stability during transportation and onsite ballasting is marginal. The tower's light draft condition, with pile sleeves capped, provides nominal freeboard with respect to the floatation girders. With minimal heeling the floatation girders would be awash and the GM would be negative due to loss of water plane area. However, auxiliary sponson tanks attached to each of the tower's legs can mitigate the loss of water plane area and should render the structure stable. A promising, cost effective solution would be to cap and attach four pile sections to each leg. These tanks could be rotated 45 degrees from the pile sleeves to permit extension of two tanks below the water surface. With this arrangement, the additonal length required for ballasting stability would be compensated by additional buoyancy. After tower positioning, the sponson tanks could be refurbished and used as piling. Future designs for these tower configurations should early strive to minimize their weight and later to optimize any required buoyancy/stability aids.

The feasibility of installing 12 foot diameter piles to design penetrations of 330 feet (70-foot water depth case) was assessed by driveability analysis. This analysis was based on the assumed soil profile and considered conventional steam and under-water hydraulic 1.5 MM foot-pound hammers. Results indicate that both hammers are capable of overcoming the driving resistance and achieving design penetration. Estimates presented hereafter are based on the under-water hammer due to its higher efficiency. Although currently in short supply, this under-water hammer eliminates the requirement for followers thus permitting continuous driving near design penetration.

i. Design Results

Preliminary weight estimates for the piles and outfitted towers are provided in Table 3-6.

NORTON SOUND STUDY

JACKET WEIGHTS

	30 FOOT (MLLW) WATER DEPTH CASE	50 FOOT (MLLW) WATER DEPTH CASE	70 FOOT (MLLW WATER DEPTH CASE
TOWER:			
STRUCTURAL STEEL	6590 SHT	7510 SHT	7620 SHT
EQUIPMENT	210	210	210
SUB—TOTAL	6800	7720	7830
FOUNDATION:			
PILING	9350	13400	13900
CONDUCTORS	900	984	1070
SUB—TOTAL	10300	14400	15000
MISCELLANEOUS:			
CONCRETE	2210	2710	2840
GROUT	170	170	170
SUB—TOTAL	2380	2880	3010
INSTALLED WEIGHT	19500 SHT	25000 SHT	25800 SHT

TABLE 3–6

3.3.2 Fabrication and Outfitting

a. Materials

The fabrication of jacket substructures for a service temperature of -30°F requires special low temperature steels and special fabrication restrictions to maintain acceptable properties in these steels. In general, the increased ductility and toughness of low temperature plate material will degrade with forming and with welding. However, the relatively large tubulars that are used in conjuction with box girders fabricated from plate for the preliminary designs should prevent significant loss of toughness and ductility during forming. However, attention must be given to weld heat-affected zone properties and selection of low temperature weld metal and welding process.

There are three temperature zones in the jacket design which will require different welding considerations. The enclosed heated areas of the tower can be welded with standard structural welding techniques. All primary components below the water line require low hydrogen welding processes which are also common welding techniques. The section of the tower exposed to air must be welded with special welding consumables, process control, and inspection to assure the fracture toughness of the weld metal and heat-affected zones are adequate for service. Standard inspection techniques are anticipated in this application.

Table 3-7 provides the specific materials recommended for the jacket substructures. This list addresses materials subject to submerged service (29°F) and exposed service (-30°F). For materials subject to the lower temperature, specially processed quenched and tempered steel are specified. These steels have guaranteed fracture toughness properties down to -60°F in the as-received condition. An allowance of 30°F is made for degradation during

NORTON SOUND STUDY
JACKET MATERIALS

APPLICATION	YIELD	MATERIAL
ALL PLATES AND SHAPES ABOVE WATERLINE	50 KSI UP TO 2" 60 KSI UP TO 3"	ASTM A633-C QUENCHED AND TEMPERED. (1) ASTM A678-C QUENCHED AND TEMPERED. (1)
LOW STRENGTH STRUCTURAL PIPE ABOVE WATERLINE	35 KSI	ASTM A333 GRADE 6
HIGH STRENGTH PLATES AND SHAPES BELOW WATERLINE	50 KSI UP TO 2.5" 50 KSI UP TO 1.5"	ASTM A633-C (2) ASTM A537 -I (2) ASTM A678- A (2)
LOW STRENGTH PLATES AND SHAPES BELOW WATERLINE	34 KSI UP TO 2"	ASTM A131-E
ALL NODES AND SECTIONS SUBJECT TO LAMELLAR TEARING	AS ABOVE	AS ABOVE PLUS SPECIALLY PROCESSED TO MEET SUPPLEMENT S–4 OF API 2H AND ULTRASONICALLY TESTED TO ASTM A578 LEVEL II.
PILING	50 KSI UP TO 2.5	ASTM A633-C (2)

NOTES:

(1) CHARPY IMPACT TESTED TO 25 FOOT–POUNDS AT –60° F.

(2) CHARPY IMPACT TESTED TO 25 FOOT–POUNDS AT –40° F.

TABLE 3–7

forming and welding, yielding anticipated satisfactory properties at -30°F.

The steels specified for submerged service are normalized high strength steels frequently used in offshore fabrication. These materials have adequate fracture toughness provided they are not used below 0°F.

The preliminary design of the tower include stiffeners inside the jacket legs and box girders. These features require base metal thicknesses and weld joint designs that are subject to lamellar tearing. It will be necessary to obtain specially produced and tested steel for such welded joints. It appears that much of the leg and girder construction will require this steel which is produced by desulfurization, through-thickness mechanical testing, and ultrasonic examination.

The preliminary designs do not require the relatively small diameter tubulars used in typical offshore jacket construction. The cylindrical shapes anticipated are in the 16-28 foot diameter range so that steel deformation of less than 5% will be required. This should be adequate to preclude the need for stress relief heat treatment. Forming at ambient temperature is recommended to further preserve the material properties. As some of the components are 2½ inches thick, this will require massive equipment but should be practical. If heating is required to allow forming, stress relief heat treatment is necessary. In either case, a forming procedure must be qualified including fracture toughness testing after forming and aging.

All welding for jacket substructures major components should be the low hydrogen process. The preferred welding processes are shielded metal arc welding and submerged arc welding. All welding procedures must be qualified including fracture toughness testing of the weld metal, heat affected zone, and base metal. The suitable level of fracture toughness should be 25 foot-pounds on full size Charpy samples at the minimum design temperature. The welding procedures should be performed on plate formed to the maximum deformation intended for that material. All welds will have weld profile requirements and may require grinding to maintain these requirements. Weld preheat will be necessary above 1½ inch and may range from 150-250°F. Other weld preheat may be required as a result of welding procedure qualifications.

The weld materials for use in submerged components of jacket substructures should be low hydrogen: 70,000 psi tensile strength materials such as AWS E7016, E7018, or E7028 for shielded metal arc welding and F72-EM12K for submerged arc welding. For tower sections subject to -30°F temperatures, special nickel-alloyed weld consumables are necessary to provide adequate weld metal fracture toughness at the minimum service temperature. Examples inclued: shielded metal arc welding with AWS E8018-C3 and submerged arc welding with F84-ENI1.

All full penetration welds accessible from both sides should be 100% radiographed. Weld joints not accessible should be 100% inspected by ultrasonic testing. Weld profile shall be examined to assure limits on contour and maximum reinforcement are met. All non-destructive test personnel will be ANSI Level II qualified. Ultrasonic examination for lamellar tearing shall be part of the inspection of critical weld joints as designated on construction drawings.

b. Assembly

Timely fabrication of the jacket substructure's major components will require a minimum of three facilities, two rolling mills and one main assembly yard. The two rolling mills will initially provide the main assembly yard with formed plate sections for the tower's tubular legs. Later, these rolling mills will form and assemble the substructure's piling and hammer adapters. Preliminary designs provided herein require maximum plate thicknesses of 1-3/4, 2, 2-1/2, and 2-1/2+ inch for the substructure's legs, pile sleeves, piling, and hammer adapters respectively. Although several rolling mills are capable of forming these plates, final selection should be based on logistics and their ability to roll and assemble full width plates to specifications.

The main fabrication yard will receive a large portion of the tonnage as unformed plates and shapes directly from the steel mills; while some prefabricated joints, stiffeners, girders, and other weldments may be subcontracted. The entire tower will be assembled within the fabricator's dry dock (or graving yard). Box sections for the lower flotation girders, skid beams, and transverse girders will be fabricated concurrent with initial mill activities. First deliveries from the mills should include formed plates for assembly of the tower's corner nodes and interior leg sleeves. With these materials, subassemblies can be horizontally fabricated, uprighted, and welded to the prefabricated flotation girders. Erection and weldout of the tower's prefabricated skid beams and transverse girders would follow. Installation of the leg's outer sleeves would next proceed from ground the level up to facilitate attachment of pile sleeves and sponson tanks (if required). Simultaneously, interior portions of the tower would be outfitted with necessary installation aids, pumps, and piping.

c. Loadout

The tower, complete with flotation girders and sponson tanks (if required), will be fabricated within the graving dock as described above. Launching will commence with the precharging of the lower leg portions, flotation girders, and capped pile sleeves. Precharging pressures should provide a suitable contingency for hydrostatic pressures resulting from displacement during launching, towout, voyage, and installation. To initially prevent the tower from floating, ballast will be pumped into the structure. The barrier separating the graving dock from the sea will then be breached, flooding the dry dock. After the barrier has been removed and the tower rigged for towout, the structure will be floated at light draft by deballasting. Tugs will provide a seaward pull, while multiple part falls and winches dockside will provide restraining force and lateral control. Each fall at the desired time will be released and retrieved by the dockside winches. After clearing the dry dock, tugs will tow the tower to a sheltered location for final ballasting and voyage preparation.

d. Fabrication Contractors

The prime criterion for contracting the main fabricator will be dry dock capacity, as the tower's beam and minimum draft are approximately 153 and 31 feet respectively (70 foot water depth base case). Suitable facilities at the time of this writing include:

(1) Hyundai Heavy Industries, Ulsan Works-
  - 2160 ft x 302 ft x 43.3 ft dry dock,
  - 1640 ft x 262 ft x 41.7 ft dry dock, and
  - 1310 ft x 262 ft x 41.7 ft dry dock.

(2) Hitachi Shipbuilding, Osaka Works-
  - 1160 ft x 197 ft x 36.1 ft dry dock,
  - 820 ft x 184 ft x 36.1 ft dry dock,
  - 492 ft x 184 ft x 36.1 ft dry dock, and
  - 328 ft x 203 ft x 36.1 ft dry dock.

(3) Kaiser Steel, Oakland Assembly Yard-
Dry dock (some excavation required).

(4) Ishikawajima, Harima Richi Works-
2660 ft x 302 ft x 46 ft dry dock.

Yard acreage, craneage, fabrication shops, and logistics are additional criteria that should be considered for contracting the main fabricator.

3.3.3 Transportation and Installation

a. Delivery Voyage

The tower's tow from sheltered waters near the fabrication yard will commence upon a forecast of ice break-up in Norton Sound. To enhance the probability of completing platform installation within the first construction season, the departure should be timed for the tower to arrive on site for the optimistic date. Bristol Bay can most likely be used for rendezvous and lay-over of installation spreads. For over-weathering, additional sheltered waters along the proposed route must be pre-identified for all installation spreads. It was assumed that two 6000 BHP oceangoing tugs can tow the tower with an equalizing bridle at an average of 6 knots for the purposes of this study. These tugs are readily available, however, optimization of the tow spread should occur during the final design.

b. Route and Site Survey

A survey vessel will precede the tower to site. Enroute, the vessel will perform bathymetric and side scan surveys to buoy a safe passage for the tower. The vessel will identify and buoy the towers intended onsite location using a satellite navigation system. A sub-bottom profiling of the immediate area should also be performed to verify seabed conditions.

c. Tower Installation

The derrick vessel spread will be mobilized to arrive on site just prior to the tower. Radar will be used to position and anchor, referencing from the pre-installed buoys. Upon arrival, the tower will be rigged to derrick vessel winches for positioning and restraint during ballasting. (For the 50 and 70 foot water depth cases, only one derrick vessel is required and opposing restraint will be provided by the tower's towing tugs.) Control for selective ballasting can be situated either on the tower or the derrick vessel. The tower's internal pumps can deballast the structure should the need arise. After the tower's position has been verified, the tasks of jetting and leveling can commence. Compressors of suitable capacity will be placed directly on the tower's skid beams and connected to the structure's internal jetting/airlift systems. These tasks can be accelerated with additional ballast. Derigging and preparation for piling activities follow jetting to design penetration and leveling within acceptable tolerances.

d. Piling and Conductor Installation

As two derrick vessels are required to erect the topside modules for the 30 foot water depth case, both will be used in a dual pile driving operation. For the 50 and 70 foot water depth cases, a second derrick vessel would not be cost-effective. All sixteen 12 foot diameter piles are installed in a similar fashion. After flooding, the sponson tank (if required) and upper pile sleeve cap will be removed by either a remote latch mechanism or diver. The lead pile section will be stabbed into the pile sleeve and lowered to rupture the lower cap. Restricting piling operation to the top of the tower is not recommended as the lengths of pile sections would be severely limited and additional pile guides required. Hence, the lead section will be driven by the 1.5 MM foot-pound hammer to an elevation 18 foot above the water surface. The first add-on pile will then be stabbed, welded-out, and inspected using a suitably designed rigging platform. After driving, the second add-on will be enjoined to the pile in a similar manner. The pile will then be continuously driven to grade.

For final driving, either an underwater hydraulic hammer or a conventional steam hammer and followers may be used. The underwater hammer is preferred given the engineering concerns discussed earlier and because of the additional expense and time consuming operations associated with followers. Moreover, required boiler capacity for the steam hammer will eliminate some of the available derrick vessel discussed hereafter. Currently available pile driving hammers with 1.5 MM foot-pounds or greater rated energy include:

(1) Koehring GMBH, Menck -
    o MHU 1700 (underwater) and
    o MRBS 12500 (steam).

(2) Vulcan Iron Works -
    o Model 6300 (steam) and
    o Model 6250 (steam).

(3) Hollandsche Beton, Hydroblok -
    o HBM 7000 (underwater) and
    o HBM 4000 (underwater).

Each derrick vessel should be provided with two hammers, primary and back-up, to promote continuous operations. All of the above hammers will require adapters to transition from their anvil diameter to the 12 foot pile diameter. At least three adapters should be provided considering the potential for damage.

After all piles at the well end of the tower have been driven to grade, the grout/concrete spread can be maneuvered in. Conventional techniques will be employed to grout the pile/sleeve annuluses completing the foundation. After which, the leg/sleeve annuluses will be filled in stages through a stinger to prevent segregation. Mobilization of this spread should be suitably timed such that tasks at each end are completed simultaneously and the derrick vessel(s) and grout/concrete spread can exchange ends allowing conductors to be driven while the riser end annuluses are filled. Conventional and readily available hoppers, conveyors, and batch plants can be mounted atop a standard cargo barge to complete the above tasks.

To prepare for module erection, the tower will be cleared of equipment and debris. Skid beams should be inturn be greased and cables strung for module skidding. Finally, the derrick vessel will winch into position and prepare to receive the first module transport barge.

e. Installation Contractors

The primer criterion for selecting the installation contractor will be derrick vessel capacity with due consideration for operating drafts. Existing derrick vessels, available and capable of executing the aforementioned tanks, are provided in Table 3-8.

NORTON SOUND STUDY
JACKET DERRICK VESSELS

OPERATOR	VESSEL	CAPACITY (SHT)	MIN. WATER DEPTH (FT.)
BROWN AND ROOT	ATLAS 1	1600/2000	25
	HERCULES	1200/1600	25
	HUGH W. GORDON	800/1100	30
	L.B. MEADERS	800/1100	30
	OCEAN BUILDER	1600/2000	50
McDERMOTT	D.B. 12	800/900	30
	D.B. 16	800/900	30
	D.B. 22	800/1100	35
	TOLTECA	1600/2000	40
	SEA LION I	1600/2000	40
	ORCA	800/800	40
HEEREMA	CHAMPION	800/1150	40
	CHALLENGER	800/800	40
	ODIN	2700/3000	50
	THOR	2000/2000	50
MICOPERI	M—26	1600/2000	45
	PM—27	1600/2000	50
UGLANDS REDERI	SARITA	1600/2000	40
	BERGE WORKER	1600/2000	45
E.T.P.M.	1601	1600/2000	50
HYUNDAI	1200	1000/1200	30
NIPPON	KUROSHIO II	800/800	30

TABLE 3–8

3.4 BARGE SUBSTRUCTURES

3.4.1 Task Description and Objectives

The objective of this project is to provide the program participants with planning information prior to OCS Lease Sale 57. More specifically, this planning information involves the determination of the feasibility, cost and schedule aspects of constructing a drilling and production platform.

This section of the report discusses the development of planning information for production platforms consisting of concrete gravity substructures. These structures offer the advantage of construction and outfitting at a remote site with relatively inexpensive labor prior to a delivery voyage to the deployment site, thus minimizing transportation requirements and more expensive site work. Additional advantages include the durability and reduced substructure maintenance offered by concrete materials and the performance of concrete in extreme cold environments.

In order to accomplish the above objectives, a preliminary design for a barge in 30 foot water depth and a feasibility study for a caisson structure in 70 foot water depth have been completed. These efforts include the development of design criteria, geometry, construction scenario, deployment plan, cost estimates and schedules.

Cost and schedule sensitivities have been identified for the following parameters:

- o Multi-directional extreme event wave loading.
- o Variations in foundation characteristics.
- o Increased ice loadings.
- o Production capabilities.

3.4.2 Assumptions

During the course of the study, various assumptions have been made to identify the scope of application of these structures. Primary assumptions are identified below:

- The design life of the structure is to be 30 years.
- The structure is to be constructed at a location on the West Coast of North America. Costs for the delivery voyage tow have been determined assuming a construction site in Tacoma, Washington.
- Draft limitations are assumed as water depth at the site and those which are associated with candidate construction sites.
- Extreme event wave headings at the deployment site are unidirectional from a southwesterly direction ($\pm 35^{o}$). The barge structure will be oriented on site to align its long axis with this extreme event wave heading.

3.4.3 General Arrangement and Characteristics

The general arrangement and characteristics of the barge design are shown on Drawing Number B-106. Significant characteristics of the structure are summarized below.

The displacement of the outfitted barge is 86,270 short tons, including 2280 tons of trim ballast. This creates an effective draft of 25.5 feet. The barge structure and superstructure is composed of 35,420 cubic yards of lightweight concrete at a density of 130 pcf and 3,250 cubic yards of normal weight concrete at a density of 160 pcf. Both of these densities include an allowance for reinforcing steel. Normal weight concrete is used in the ice abrasion zone of the exterior bulkheads only.

The concrete barge concept has a rectangular configuration with plan dimensions of 220 feet by 480 feet between perpendiculars. It was determined that extreme event wave headings would be from the southwest. For this reason, the long dimension of the barge is oriented parallel to this extreme event wave heading.

The depth of the main barge cross section is 40 feet. A concrete bulwark emcompasses the perimeter of the barge and extends an additional 15 feet in elevation, to Elevation (+)25 foot, where datum elevation 0.0 is MLLW. This elevation was established by consideration of expected ice rubble pile buildup and wave form. The concrete bulwark is flared in shape such that it deflects the energy of a wave outward and upward and prevents runup wave pressures from impacting the equipment modules. An additional 39 inch concrete parapet has been provided as an added safety measure for personnel on the steel weatherdeck.

A sloped steel weather deck enclosure is provided at Elevation (+)25 foot in order to quickly carry shipped green water from the deck during the delivery voyage. Scuppers are provided in the 39 inch concrete parapet to allow water to run overboard. A steel wave deflector is mounted on the deck near the forward end of the barge subjected to extreme event wave encounters. This barrier directs windblown overtopping water off the deck.

A skid beam system has been provided to support up to 25 production modules. These skid beams run the full transverse dimension of the barge, and are supported by a system of concrete columns and shear walls. The soffit elevation of the skid beam system is located at Elevation (+)50 foot, and was established by setting the air gap requirements for the extreme event wave. Model testing of the effectiveness of the wave deflector may allow the skid beam elevation to be reduced.

During installation of the barge structure, granular ballast is placed in the compartments in the barge below the main deck at Elevation (+)10 foot. This ballast provides the necessary sliding stability in the foundation to resist global wave, ice and seismic loadings which are expected during the life of the facility. Four of the below deck compartments are used for storage of various materials used in the operation of the facility. Each of these provides storage below the stillwater line, hence minimizing compartment heating requirements.

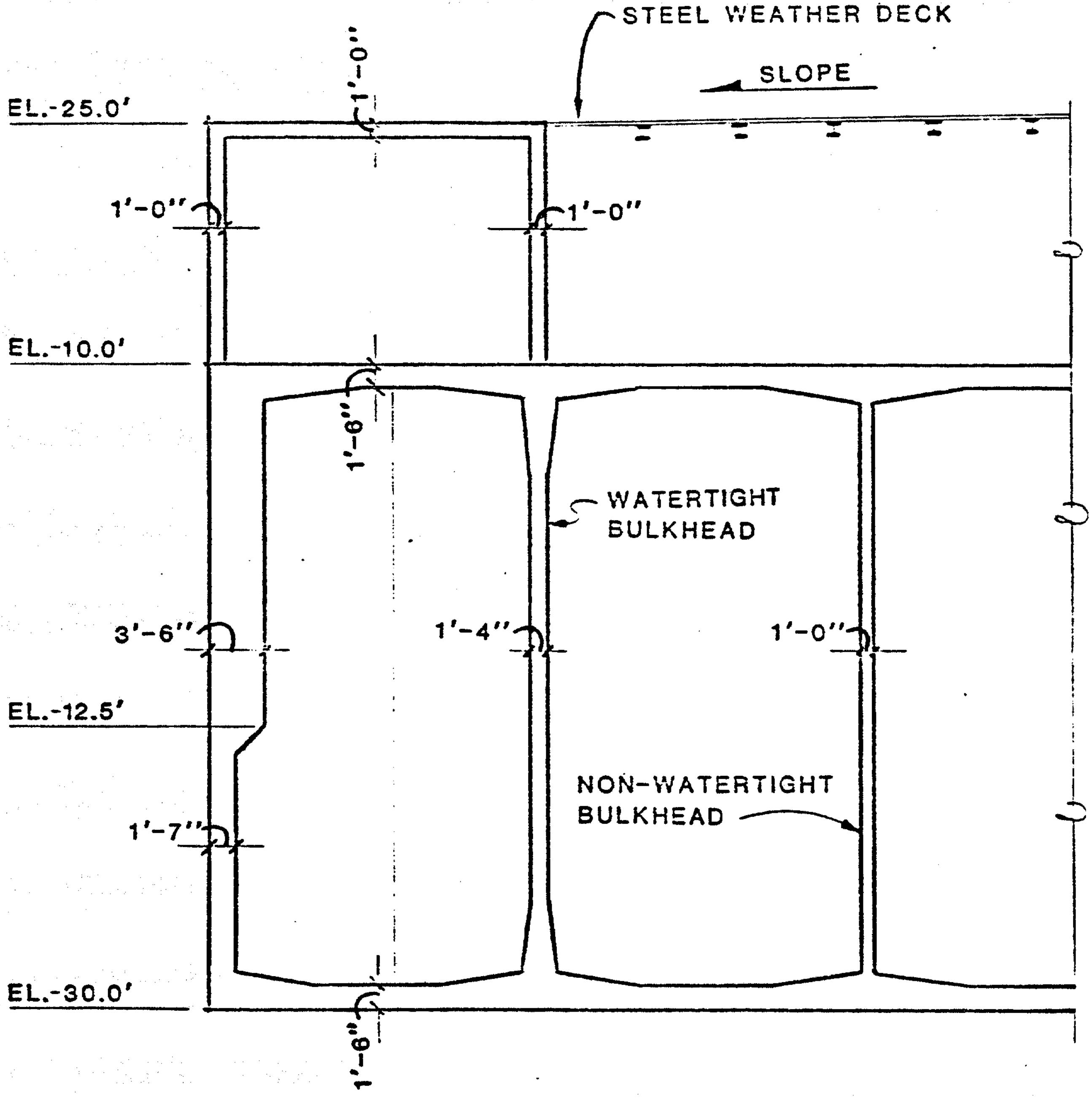
3.4.4 Structural Concept

a. Alternate Framing Concepts

The selection of the below deck framing arrangement, as shown on Drawing B-107, was based upon a comparison of three alternate framing concepts. These concepts have been compared in regard to the resulting draft of the barge as well as subjective considerations of constructability and cost. Transverse cross sections showing the three concepts are shown in Figures 3-2 through 3-4.

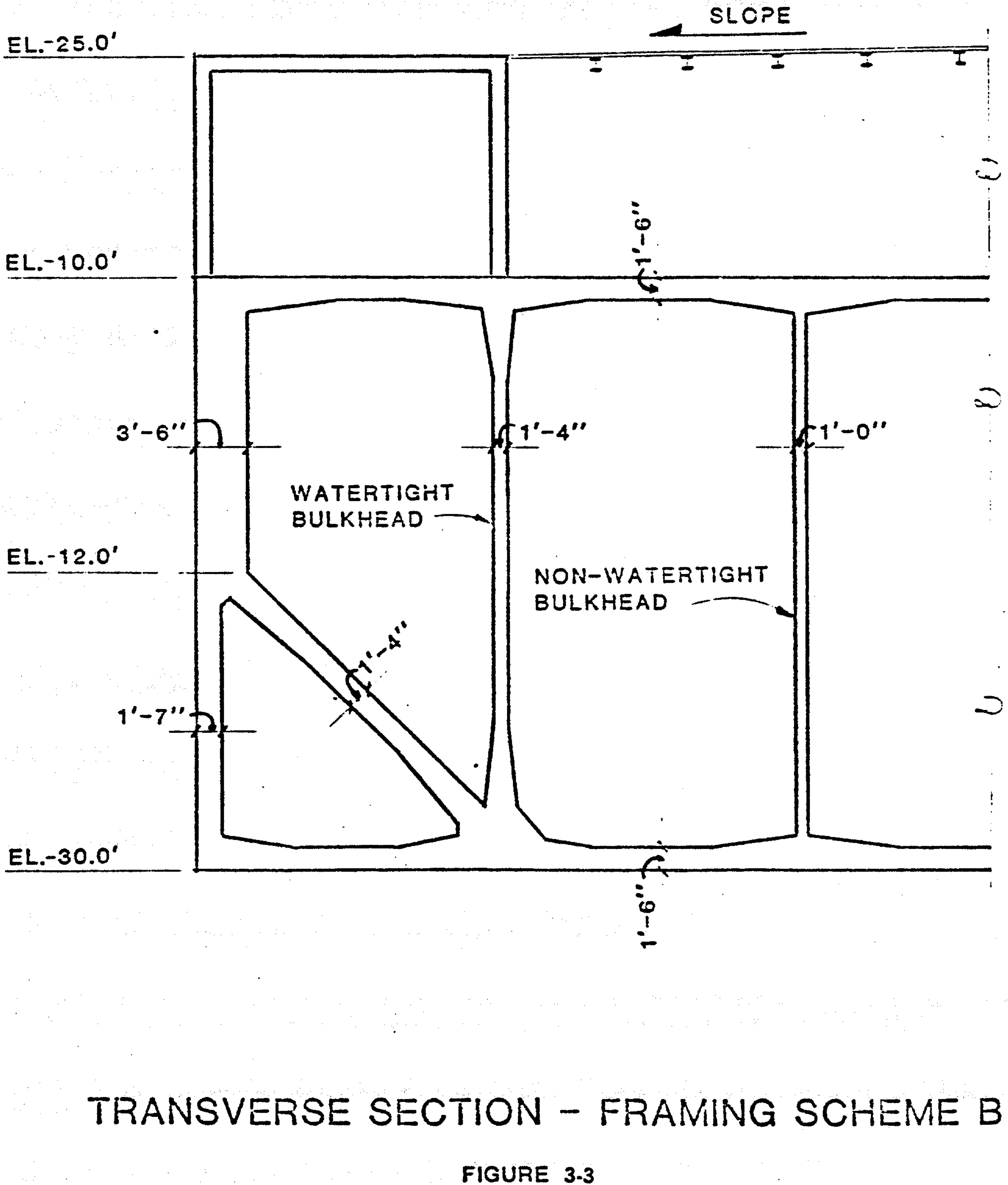
Based upon this investigation, a comparison of concrete volumes and drafts of the three framing schemes is presented in the table below. The drafts are calculated assuming lightweight concrete throughout and include an allowance of 35,000 kips for production modules, skid beams and support members.

Framing Scheme	Draft	Concrete Volume
A	24.6 feet	33,500 C.Y.
B	25.6 feet	35,100 C.Y.
C	24.5 feet	33,200 C.Y.



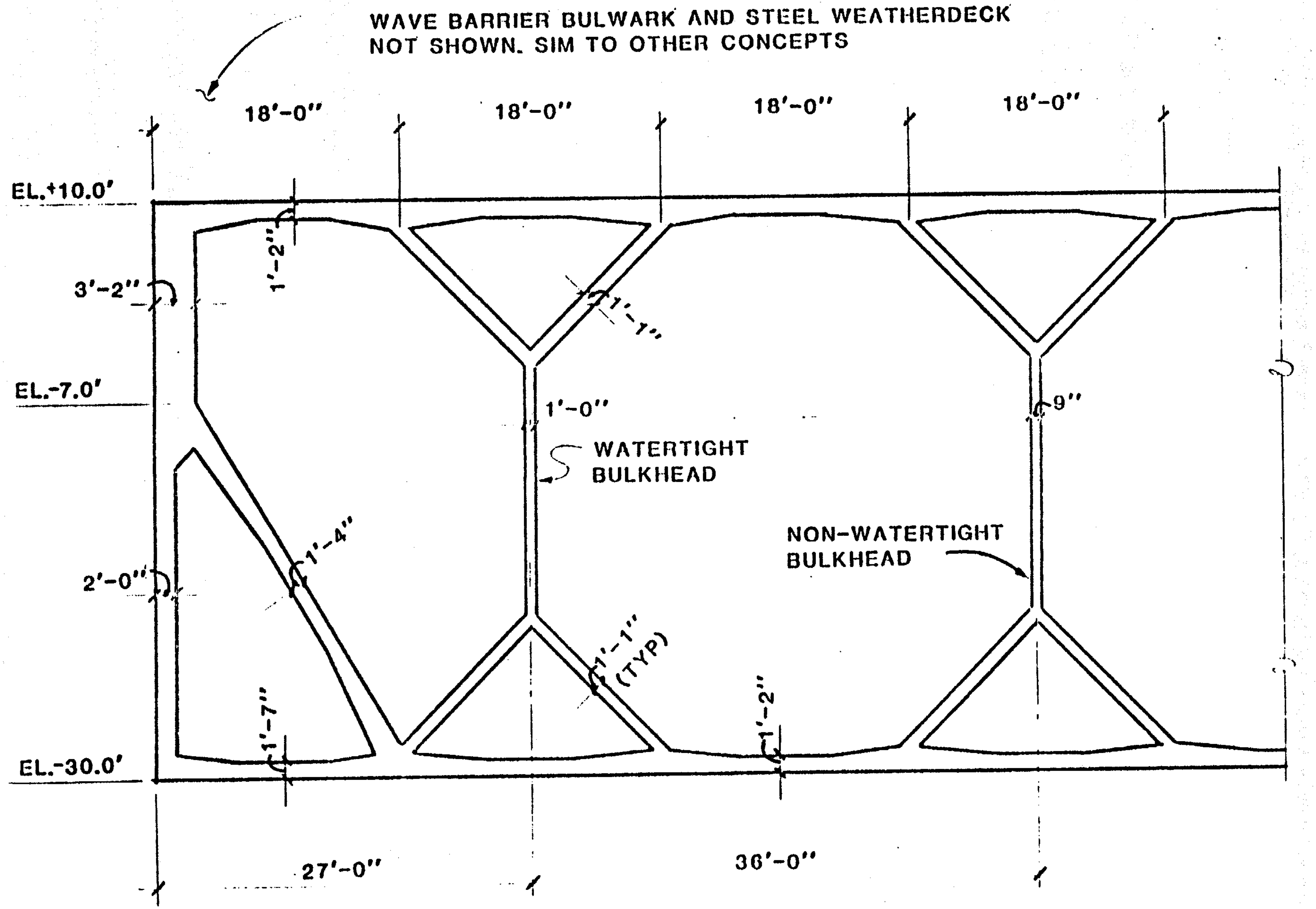
TRANSVERSE SECTION - FRAMING SCHEME A

FIGURE 3-2



TRANSVERSE SECTION – FRAMING SCHEME B

FIGURE 3-3



TRANSVERSE SECTION – FRAMING SCHEME C

FIGURE 3–4

While Framing Scheme C offers a slight reduction in draft of the platform, the increased complexity of construction of this concept led to the selection of Framing Scheme A for further development. It has been recognized however that Framing Scheme C would offer increased weight benefits in barges with hull depths exceeding 40 feet.

b. Framing Arrangement

The below-deck framing (below Elevation (+)10 foot) consists of a rectangular grid of bulkheads. Longitudinal bulkheads are spaced at 20 foot centers and transverse bulkheads are spaced at 40 foot centers. The horizontal span of the exterior bulkhead is maintained at 20 feet around the entire perimeter of the barge through the use of "delta" plates at each end of transverse bulkheads.

The barge is compartmentalized for damage control by watertight bulkheads. Penetrations are provided through non-watertight bulkheads to prevent unbalanced hydrostatic pressure on these elements.

Four below deck compartments are provided for storage of diesel fuel, drill water, produced water and storage water. Forty 29" O.D. well slots are provided in three below deck compartments. Upon grounding of the barge, all compartments will be filled with granular ballast except the storage compartments and the triangular "delta" compartments. A total of 184,400 tons of ballast at 115 pcf is provided.

The above deck framing arrangement (above Elevation (+)10 foot) is shown on Drawing B-108. This framing consists of the concrete bulwark, and concrete skid beams, columns and shear walls which support the production modules and the steel weather deck. Concrete has been selected for the skid beams, column and shear walls in order to eliminate the requirement for special steels having low temperature impact resistance.

Ten skid beams are spaced at 40 foot centers and each extends the full 220 foot width of the barge. The skid beams are located directly above barge transverse bulkheads. Each skid beam is supported by 5 columns at approximately 40 foot centers. The skid beam cantilevers an additional 11.5 feet beyond exterior columns. The columns are centered below the lower chords of trusses in adjacent topside production modules.

Concrete shear walls are used to carry lateral forces to the concrete deck. Shear is carried by the shear walls, and the resulting overturning moment is resisted by a couple in the columns at the perimeter of the shear wall.

Transverse forces (forces parallel to the 220 foot dimension) are resisted by individual shear walls which are in plane with each skid beam. Transverse shears from individual modules are transferred to these shear walls by axial tension or compression in the skid beams. Longitudinal forces are resisted by two discrete sets of six shear walls. Steel pipe sections are used to transfer longitudinal shears to these shear walls (see detail 4 on Drawing B-108).

Lateral forces are transferred into the skid beam-column connection by a welded connection between the lower chord of the module truss and a skid plate which is embedded in the skid beam. The beam-column connection can be detailed to provide sufficient shear friction capacity to transfer the lateral forces into the shear walls.

The shear walls are located to minimize thermal forces resulting from expansion and contraction of the concrete skid beams and the steel modules. Expansion joint details are required in the skid beams at the B.O.P. handling area in order to prevent the development of thermal forces in the skid beam.

The elevation of the top of the shear walls has been established to provide a clearance below the skid beam or the bottom chord of the module truss, thus preventing the application of vertical loadings to the shear wall.

Alternate above deck framing concepts with steel elements have not been addressed in this effort, thus preventing a comparison of relative costs and drafts. It is felt that a potential increase in efficiency may result by an investigation of diagonal steel bracing to replace the concrete shear walls.

c. Load Paths

All individual plating elements behave as two-way plates. Elements which are controlled by hydrostatic or ballast pressures make use of haunched construction to provide greater capacity at negative moment regions of the panel. Elements with an aspect ratio of approximately 2-to-1 behave essentially as one-way plates in the middle portion of the panel.

The exterior bulkheads span primarily in the short horizontal direction, except in the vicinity of the deck and keel slabs. Thus hydrostatic pressures and the ice and wave loadings are carried through plate bending of the exterior bulkhead to the supporting bulkhead or delta elements. The longitudinal and transverse bulkheads react these loadings and carry them to the keel diaphragm and the foundation through shear wall action.

Wave loadings applied to the concrete bulwark are carried to the bulkhead elements through the diaphragm walls and the deck diaphragm.

During the delivery voyage, global moments and shears resulting from stillwater and wave bending are resisted by the barge structure which acts as a multi-celled box girder. The deck and keel slabs behave as flanges of the girder, and the bulkheads behave as webs. The concrete bulwarks behave compositely with the barge cross section in resisting these moments.

3.4.5 Controlling Design Conditions

a. General

The design conditions discussed in this section indicate those which have had a significant effect on the design of the barge substructure and skid beam. These conditions are those most sensitive to changes in criteria or requirements.

b. Draft

The draft of the barge is critical at two stages. Initially, in order to allow construction in more than one existing facility, it is necessary to provide a barge structure and construction procedures which limits the draft at the time of launch to 13 feet or less. Additionally, the requirement to float the outfitted barge into 30 foot water depths dictates the barge waterplane area. Lightweight concrete has been used extensively to limit this waterplane area requirement.

c. Longitudinal Global Force

The controlling global force in the longitudinal direction of the barge is the 100 year return wave which is a breaking wave in the 30 foot water depth. Wave forces due to breaking waves have been calculated using methods outlined in the Shore Protection Manual. These forces have been combined with the effects of the 100 year return current and wind.

This load combination gives a longitudinal global force of 482 kips per foot of barge width or a net longitudinal global force of 106,000 kips.

This load combination dictates the quantity of granular ballast necessary to provide foundation sliding stability. It also dictates the long dimension of the barge in order to provide sufficient ballast capacity in below-deck compartments.

d. Transverse Global Force

The controlling global force in the transverse direction of the barge is a seismic event combined with ice loadings. An inertial acceleration equaling the 0.10g ground acceleration has been applied to the mass of the barge, ballast, superstructure and added masses of seawater and ice. Due to the fact that an 8 foot ice thickness results from rafted ice at limited times of the year, a seismic event has been combined with the more probable 4-foot ice thickness.

The transverse global force resulting from this load combination equals 108,600 kips with a maximum topside load. This is a global force of 226 kips per foot of barge length, which includes the global ice loading resulting from the brittle crushing strength of the ice. This brittle crushing strength is equal to 60% of the ice sheet load (Reference 1) or 63 kips per foot. This force due to the seismic and ice combination is slightly greater than the 210 kips per foot force resulting from an 8 foot ice thickness.

Waves less severe than the extreme event may occur from any direction. The capacity of the barge and the foundation is sufficient to accommodate a breaking wave height of 22 feet with a period of 10 seconds and a wave heading from any direction.

e. Local Ice Loadings

Local ice pressures control the design of the exterior bulkhead plating in the ice contact zone. Bending moments in the exterior bulkheads are obtained by loading various combinations of spans in order to maximize moments at critical sections. Punching shears are investigated for ice loadings applied to contact areas of 50 and 160 square feet.

f. Local Wave Dynamic Pressures

Local wave pressures control the design of the plating and diaphragms of the wave bulwark. The pressure distribution gives peak dynamic wave pressures of 249 psi due to the 100 year return wave, 271 psi due to the 5 year return wave and 269 psi due to the 1 year return wave.

g. Seismic

The on site seismic condition creates the controlling lateral forces for the design of the skid beam support system. Seismic inertial accelerations have been calculated using the response spectrum in API RP 2A. Inertial accelerations resulting during the delivery voyage have been estimated, and found to be less critical.

3.4.6 Design Methodology

a. Barge Structure Design

(1) General: The concrete barge has been designed as a prestressed and reinforced concrete structure. Prestressing is designed in order to assure a serviceable behavior of the structure in response to recurring service level loadings. Mild steel reinforcement is provided in order to control cracking and supplement strength of the structure in response to construction and extreme event loadings.

The barge structure has been prestressed in three directions. Approximate prestress levels are 900 psi in the longitudinal direction, 500 psi in the transverse direction and 500 psi vertically. The longitudinal prestress is provided primarily for the longitudinal global bending of the barge cross section. The longitudinal prestress also acts to resist longitudinal local bending moments in the plating elements. The transverse prestressing in the keel is provided for transverse global bending of the barge and transverse local bending moments in the plating elements. The horizontal and vertical prestressing in the bulkhead elements is provided primarily to improve the global shear capacity of these elements; however, prestressing in the exterior bulkhead provides serviceability and watertightness functions. The vertical and horizontal prestressing in the bulkhead elements greatly improves the global shear capacity of the concrete, improving the fatigue resistance and reducing the mild steel requirement for shear. The prestressing in the bulkhead elements also provides local plate bending capacity in these elements.

(2) Delivery Voyage Global Strength: Stillwater bending moments are calculated using the actual distribution of weights of the barge, superstructure and trim ballast. Due to the weight of the exterior bulkheads and the concrete bulwark, a large hogging stillwater moment results.

Wave bending moments are calculated using ABS Rules For Building and Classing Steel Vessels, 1979. The wave bending moments calculated using this document are divided by 1.15 since ABS does not require the use of a corrosion allowance in the design of concrete vessels.

The longitudinal global moments resulting from the superposition of the stillwater and wave bending are resisted by the full cross section of the barge structure including the concrete bulwarks. The longitudinal prestressing is designed to allow no net tension due to the combined stillwater and wave bending moments and provide a factor of safety of 1.5 with respect to cracking. The combination of longitudinal prestressing and mild steel reinforcing steel provide a factor of safety of 1.95 with respect to the ultimate flexural capacity of the cross section. The allowable tensile stress and cracking criteria for hogging moments has been applied at the deck at Elevation (+)10 foot. Small tensile stresses have been allowed in the deck of the concrete bulwark at Elevation (+)25 foot.

Transverse global bending moments have been calculated using ABS Rules for wave bending, and the weight distribution tributary to individual bulkhead girder elements for stillwater bending. As for the longitudinal direction, a hogging stillwater moment results. The transverse prestress level provided for combined global and plate bending is more than adequate to provide sufficient global bending capacity.

(3) Exterior Bulkhead Design: The exterior bulkhead has been analyzed as a one-way slab spanning horizontally, except in the regions near the deck and keel plates. As a result of the magnitude of the ice loading, the exterior bulkhead design varies between the ice contact zone and the lower portion of the plate, which is designed for hydrostatic pressures. The ice contact zone is assumed between Elevations (+)5.8 and (-)7.1 foot. The maximum design ice thickness for Norton Sound is eight feet.

In the ice contact zone, the exterior bulkhead is nearly balanced between a flexure controlled and a shear controlled design. This results in a design with a span-to-thickness ratio of 6.67. The concentrated nature of the ice loading as well as the reduction in ice contact pressure with larger contact areas results in nearly equal positive and negative design moments and thus a plate with a constant thickness of 36 inches.

The design ice loadings have been determined as follows: The 400 psi confined compressive strength of the ice is applied to a contact area of 50 square feet. This ice loading is superimposed with ice contact pressures which are a function of the size of the ice contact area. These additional ice contact pressures are determined using the curve in Section 1.1.5.3 of the "Design Specifications".

The exterior bulkhead has been designed to provide sufficient ultimate strength to resist these ice loadings. A local factor of 1.1 is applied to the confined strength of the ice and a load factor of 1.3 is applied to lower contact pressures.

Punching shear capacities for the 50 square foot contact area have been calculated using an ultimate capacity of 4 $(f'_c)^{0.5}$ in accordance with ACI 318-77. Shear capacities for full span ice loadings have been based upon empirical data presented in Reference 2. This reference presents ultimate strength data for simply supported, circular reinforced concrete slabs subject to uniform static loadings. Using a conservative design relationship developed in this reference, the ultimate punching shear capacity of the exterior bulkhead is greater than 17 $(f'_c)^{0.5}$ at the face of the support. The design has considered a slab width equal to the loaded area plus the slab thickness as effective in resisting this shear.

While the extrapolation of this empirical data to prestressed concrete slabs with edge restraint appears conservative, we recommend testing of specimens representative of the exterior bulkhead prior to final design of the barge. This test program would allow verification of the design procedure and identify potential cost benefits resulting from less conservative designs. A further goal of this testing program should be to establish design procedures which address the serviceability of prestressed concrete slabs subject to large punching shears.

The ultimate flexural capacity of the exterior bulkhead plating has also been investigated. Various combinations of ice loaded spans have been investigated in order to maximize bending moments at critical sections. The flexural design of the bulkhead has considered a slab width equal to the loaded area plus 3 times the slab thickness as effective in resisting the load. This is based upon effective slab widths allowed by ACI 318-77 for the design of flat plates.

The provision of prestressing in the exterior bulkhead will provide a more serviceable response to these extreme ice loadings. Providing that yielding of the reinforcing steel and prestressing steel is prevented, the prestress will tend to close cracks after the loading is removed.

Improvements in the service level design of elements subject to ice loadings could result if it were possible to develop a better understanding of the repeatability of ice contact pressures.

For ice loadings at the lower extreme of the contact zone, the exterior bulkhead has been assumed to behave as a one-way slab spanning horizontally. Vertical plate bending has also been investigated for ice loadings at the highest design elevation.

The design of the exterior bulkhead in the region below the ice contact zone is controlled by plate bending resulting from hydrostatic pressures. The bulkhead is designed as a one-way slab spanning horizontally, except in the vicinity of the keel slab where the vertical moments result from two-way plate action. The plate bending serviceability criteria have been applied to the hydrostatic pressures resulting at a wave crest during the delivery voyage. This results in a 50 foot head at the keel. Sufficient ultimate strength is provided for the 70 foot head resulting from a wave crest elevation for the 100 year return wave at the deployment site.

(4) Interior Bulkhead Design: The interior bulkheads have been designed as post-tensioned plate elements. The post-tensioning in these elements provides the following functions:

- control cracking resulting during handling and erection of the precast panels;
- resist local plate bending resulting from damaged condition hydrostatic pressures and ballast loadings; and
- increase the concrete global shear capacity of these elements.

High strength Dywidag post-tensioning bars have been provided for the vertical prestress in these elements.

This allows the application of stress prior to handling, release of prestress after erection and subsequent restressing in order to provide compression in the cast-in-place concrete connections between the precast elements.

The global shear capacity accounts for the vertical and horizontal prestress in these elements, as allowed in Section 11.4.2.2 of ACI 318-77. This allows the full global shear to be carried by the concrete in these elements. Global shears are transferred from the deck diaphragm to the bulkhead by mild steel reinforcement.

In order to assure ductility in the event of seismic overload, a load factor of 2.0 has been applied to global shears resulting from seismic events.

The global ice and wave forces create compressive stresses in the bulkheads which are maximum at exterior compartments and reduce in magnitude along the length of the bulkhead due to shear transfer to the keel slab. The buckling capacity of the bulkhead plates is sufficient to accommodate these stresses.

The interior bulkhead elements have been analyzed as two-way plates for local loadings resulting from hydrostatic or ballast loadings. The analysis assumed fixed panels. However, the distribution of moments between the support and midspan has been modified based upon an estimate of the actual fixity at the support. This was based upon a moment distribution analysis of a unit slice of adjoining plating elements in the cellular structure.

Watertight bulkheads have been designed to provide sufficient ultimate capacity to resist plate moments and shears resulting from a damaged condition. This analysis has been based upon a conservative assumption of seawater completely filling a compartment. Penetrations have been provided in non-watertight bulkheads to prevent unbalanced hydrostatic pressures. The plate bending and shear capacity of the non-watertight bulkheads is sufficient to allow an 18 foot unbalance of granular fill between adjacent compartments.

The delta plates have been designed to resist plate bending resulting from damaged conditions, ballast loadings and the effects of concentrated ice loadings applied to the exterior bulkheads. Moments resulting from these loadings have been determined by a plane frame computer analysis. The analysis model consists of a plan section of the exterior bulkhead, delta plates and adjoining spans of longitudinal and transverse bulkheads. Separate models were prepared for the ice contact zone and the lower portion of the structure.

Special bulkhead designs will be required around the perimeter of storage compartments. Current weight estimates and materials quantities have been based upon provision of watertight bulkheads in these locations. Minor design modifications are expected to have insignificant effects on draft or construction costs.

(5) Keel Design: The keel behaves as a flange for the hull girder in response to global bending which results during the floating or grounded conditions. Since global tensile stresses are nearly uniform through the entire thickness of the plating element, they would result in cracks through the thickness of the keel plate. Longitudinal and transverse post-tensioning has been provided to avoid this condition and meet the serviceability criteria for no net tension.

The design of the keel includes the superposition of the global stresses with local plate bending moments. Tensile stresses of $6\ (f'_c)^{0.5}$ are allowed for this superposition. This tensile stress is below the modulus of rupture of the concrete. Since local stresses produce compressive and tensile stresses on opposite faces of the plate, through-thickness cracking is prevented. This serviceability criteria has been applied to hydrostatic pressures resulting at a wave crest during the delivery voyage (50 foot head). This condition is more severe than the superposition of ballast loadings and soil reactions at the deployment site.

Ultimate strength capacity has been investigated for the 50 foot head and for a condition where one compartment is unsupported by the foundation. Sufficient ultimate capacity is available to carry the reversed moments resulting from the weight of the ballast in this unsupported condition.

(6) Deck Design: The deck at Elevation (+) 10 foot also behaves as a flange for the hull girder in response to global bending. The serviceability criteria discussed above for the keel also apply to the deck plate.

The deck has sufficient capacity to accommodate plate bending stresses resulting from a loading of 1000 psf. This design loading was used to provide reserve capacity for granular ballast and also provides significant storage capacity. Since sufficient ballast capacity has been provided in the below deck compartments, a potential weight and cost reduction may result by reducing the thickness of the deck slab.

A further cost benefit may result in future design efforts by eliminating the concrete deck and providing global capacity with enlarged prestressed concrete bulbs at the top of each bulkhead. This will require careful investigation of buckling of the bulkheads due to global bending stresses.

(7) Barge Segment Construction Joint: The barge has been detailed to allow segmental construction, since existing

construction facilities are not available to accommodate the full plan dimension of the barge. A nominal 6 inch closure pour has been provided to accommodate a post-tensioned connection between barge segments. Joint details are shown on Drawing B-112.

The construction joint is parallel to the long direction of the barge. This minimizes joint post-tensioning requirements since transverse global bending moments are small in comparison with longitudinal bending. The construction joint is centered on a watertight longitudinal bulkhead.

The joint bulkhead is detailed to allow construction in a standard watertight bulkhead form. This bulkhead has been designed to accommodate hydrostatic pressures resulting after launch of the barge segment and prior to the jointing operation. In order to minimize the required thickness of these bulkheads, they have been pretensioned vertically and, smaller 4-strand post-tensioning ducts are used for longitudinal prestress. Mild steel reinforcement has been used to provide ultimate strength capacity at the joint with the keel since prestress strand will not be fully developed at this point.

The transverse splice tendons which cross the joint are designed to provide continuity of global strength across the 6 inch joint. Additional compressive stresses result in the compartments adjacent to the joint where the splice tendons overlap the typical transverse tendons. These increased stresses do not require a thickening of the plating elements, however. Some haunches in this area have been enlarged to accommodate post-tensioning tendon anchorages.

The joint is aligned with special hardware cast into the barge segments. Partial post-tensioning is provided prior to joint construction in order to maintain bearing at these alignment details during joint construction operations. After the joint has been grouted and cured, all splice tendons will be stressed. A description of jointing construction operations is included in Section 3.4.9-e of this report.

(8) Concrete Bulwark: Preliminary investigation of wave run-up on a vertical sided barge structure indicated a requirement for some form of wave deflector to be incorporated into the barge design. The flared geometry of the concrete bulwark is the result of investigation by The Glosten Associates, a Naval Architectural firm who acted as a subcontractor to ABAM. The wave deflector design is discussed in Section 3.4.7-d. Documentation of the wave deflector design is included in Volume II of the report.

The concrete bulwark has been designed to withstand the dynamic wave pressures experienced due to breaking waves at the deployment site. Wave pressures have been computed using the Minikin pressure distribution as presented in the Shore Protection Manual. The location of the peak wave pressure has been located to maximize the effects on the concrete bulwark. The dynamic pressures resulting from the extreme event wave (100 year return) have been used to design the concrete bulwark at grid line 1. Dynamic pressures resulting from the 1 year return wave have been applied to the concrete bulwark on remaining sides of the barge.

The sloped face of the bulwark spans horizontally between diaphragm walls which are spaced at ten foot centers around the perimeter of the barge. The diaphragms carry the wave reactions into the deck of the barge as reinforced concrete shear walls. The sloped bulwark plating has been designed using the empirical punching shear data which has been discussed in Section 3.4.5.

The bulwark behaves compositely with the barge girder cross section to resist global bending. Horizontal post-tensioning has been provided in the bulwark to prevent cracking due to this global behavior.

(9) Steel Weather Deck: The steel weather deck has been provided in order to remove green water from the deck during the delivery voyage. The use of steel framing for this function allowed the depth of the concrete barge cross section to remain at 40 feet as dictated by global strength requirements.

The weather deck has been designed to withstand hydrostatic pressures resulting from wave overtopping during delivery and at the deployment site. A 15 foot head has been used as the design pressure. This is the difference in elevation between the 100 year return wave crest at the site and the elevation of the weather deck.

Model testing of the behavior of the wave deflector is recommended. The results of these tests may allow a reduction in the weather deck design pressure.

(10) Steel Wave Deflector: A steel wave deflector has been provided near the end of the barge which is exposed to the extreme event waves. Water which overtops the concrete

bulwark is directed off the side of the barge by this wave deflector.

A conservative approach has been used to estimate the volume of water which overtops the barge. This volume of water has been computed using Shore Protection Manual methods to compute runup assuming a flat-sided barge. The overtopping volume of water has been assumed to have a velocity equal to the orbital velocity at the crest of the approaching wave. The wave deflector has been designed to resist the dynamic forces resulting from redirecting this flow of water.

b. Foundation Design

(1) Foundation Capacities: The foundation bearing capacity which has been used in the preliminary design is taken from Reference 3. This report gives an allowable bearing pressure of 15,000 psf, which includes a factor of safety of 3.0. The sliding capacity is based upon a friction coefficient equal to the tangent of the angle of internal friction of the granular foundation soils. The angle of internal friction is taken as 30°. A capacity reduction factor of 1.20 has been provided, as recommended in ACI 357, for sandy soils.

(2) Analysis Method: Vertical bearing pressures are calculated assuming the vertical loadings are uniformly distributed over the plan area of the foundation and that the barge behaves as a rigid body. The maximum bearing pressure calculated in this manner is 3500 psf. Approximately 85 percent of this reaction results from the uniformly distributed effects of barge weight, ballast and buoyancy. Overturning effects have been computed assuming the barge

behaves as a rigid body. Overturning bearing pressures computed in this manner amount to approximately 600 psf for the critical longitudinal loading and 800 psf for the critical transverse loading.

The magnitude of bearing pressures computed by these simplified methods is well below allowable bearing capacities and indicates that the barge foundation is not bearing critical for the defined soils. Once site specific soils information becomes available, a more thorough foundation analysis of the barge substructure should be performed. This analysis should account for expected variations of soil properties at a specific site.

The sliding resistance of the soil is developed through friction. For this structure on the given soils, skirts are not necessary to mobilize sliding resistance. In order to assure the critical sliding failure occurs in the soil rather than in the soil-keel interface, provision must be made in the construction of the keel to assure a rough surface texture on the base of the keel.

The quantity and density of ballast within the barge structure is required in order to mobilize sliding resistance in the granular foundation. In order to provide the sufficient vertical reaction, it is necessary to completely fill the below deck compartments, excluding delta compartments and four compartments provided for materials storage. A ballast density of 115 pcf has been assumed for the granular fill. This will require a dewatering system in each compartment in order to densify the fill.

(3) Erosion Protection: Structures in Norton Sound will be subject to severe wave action. Thus it is necessary to provide means which prevent the erosion and scour of the foundation soils around the perimeter of the barge. Erosion can be controlled by placing a riprap berm around the perimeter of the structure, and/or by utilizing skirts around the perimeter of the structure in order to penetrate and confine the soils. Since skirts are not required to mobilize sliding resistance in the foundation, erosion protection has been provided by a riprap berm. Additionally, should skirts have been necessary, they would have had an adverse impact on net draft of the vessel, further complicating construction and narrowing the bottom clearance for installation in 30 foot water depths.

Prior to final design, model testing should be undertaken to determine the most effective means for erosion/scour protection.

c. Concrete Superstructure Design

The superstructure described herein is used to support the production drilling modules and related equipment. The superstructure consists of skid beams, support columns and supporting shear walls as shown in Drawing B-108.

The skid beams are designed as precast concrete box beams which are erected as simple span units and made continuous with cast-in-place concrete connections at the columns. The beams are pretensioned to accommodate construction stresses resulting from handling and beam dead load during construction of the beam-column connection. After this connection is completed, the beams are post-tensioned to create a continuous girder.

The flexure and shear design of the girder considers the maximum moments and shears resulting during module skidding operations. After module erection has been completed, the skid beam behaves as a tie member to carry transverse horizontal forces from the modules to the shear walls. The skid beam reinforcement provided for flexure during skidding operations is sufficient to react to these forces.

A typical cross section has been used for all skid beams. Due to the significant difference in weight between drilling modules and production modules, two reinforcement designs have been developed.

In order to allow for potential removal of the steel weather deck, the concrete column design has included slenderness effects considering the unsupported length of column to be 40 feet. The vertical design load in the column is determined using module reactions developed by Fluor Ocean Services. Vertical seismic inertial forces and vertical loads resulting from seismic overturning effects have been superimposed with these module reactions. Eccentricity due to unsymmetrical reactions from adjacent modules has been considered.

The seismic response spectra in API RP 2A has been used to develop spectral accelerations which are applied to the mass of the superstructure. The short natural period of the shear wall system results in a spectral acceleration which is equal to the ground acceleration of 0.1 g. In accordance with API RP-2A, a spectral acceleration of 0.10 g in one direction is combined with an acceleration of 0.067 g in an orthogonal horizontal direction and an acceleration of 0.05 g in the vertical direction. In order to provide shear wall ductility in the event of an overload, a load factor of 2.0 has been applied to shears resulting from seismic loadings.

d. Wave Deflector Design

Initial calculations of wave runup on a flat sided barge structure were based upon procedures outlined in the Shore Protection Manual. These calculations indicated wave runup resulting from design wave conditions at 30 foot water depths would be unacceptable. This led to the conclusion that special measures would be necessary in order to minimize wave overtopping and the application of wave pressures to the modular superstructure.

The Naval Architectural firm of L. R. Glosten and Associates has been charged with the task of defining the requirements of a wave deflector which will prevent this wave runup. Their recommendation was to incorporate a curved geometry into the concrete bulwark which extends between barge Elevations (+)10 and (+)25 foot. This geometry was based upon bow flare geometries which are utilized in ship design.

The function of this wave deflector is to redirect the energy of the oncoming wave to an upward and outward direction, thus breaking oncoming wave energy. Wind acting on the resulting vertical sheet of water can cause spray which overtops the deck. However, the energy imparted to this spray is small.

As a conservative measure, a steel wave barrier has been provided on the steel weather deck to direct any overtopping waves or spray from the deck of the barge prior to encountering the concrete shear walls. This steel wave barrier has been designed conservatively assuming waves overtopping a flat sided barge with no wave deflector. The barrier provides sufficient strength to resist the hydrodynamic forces resulting from wave overtopping rates computed using the Shore Protection Manual. The geometry of the steel wave barrier is based upon ship design procedures.

The Glosten Associates have also recommended the incorporation of a concrete parapet around the perimeter of the barge. This parapet is attached to the concrete bulwark and extends to Elevation (+)28.25 foot. The function of this parapet is to provide protection to personnel on the weather deck in the event of rare wave encounters.

The L. R. Glosten and Associates report on the wave deflector design is included in Volume II of the report.

e. Naval Architecture

(1) Barge Hydrostatic Properties: Hydrostatic properties of the outfitted barge structure are summarized below. These properties indicate that barge stability will be acceptable for the delivery voyage and ballasting operations at the site. All properties for the floating structure include dry module weights and trim ballast.

Length Between Perpendiculars	480'
Beam Between Perpendiculars	220'
Displacement	86270 S.T.
Draft	25.5'
KG	37'
GM_T	135'
GM_L	735'
$MT1_T$	4380 ST-FT
$MT1_L$	10920 ST-FT

(2) Freeboard Analysis: L. R. Glosten and Associates, Naval Architects, has performed a brief motions analysis of the outfitted barge structure to assess the minimum freeboard requirements for the delivery voyage.

The study was conducted using the NSRDC Ship Motions and Sea Loads computer program to solve the equations of motion for the caisson in all six degrees of freedom for rigid body motions. The program CARGO was utilized to post-process the frequency response operators from the NSRDC program to obtain the motion statistics in the design irregular sea spectra, and to obtain the relative motions in those spectra. Relative motions were examined at six locations around the periphery of the caisson. These locations include three points at the foreward perpendicular, two locations at the midships perpendicular and one location at the aft perpendicular.

The design sea conditions were characterized by sea states with 25 and 28 foot significant wave heights with 12 and 13 second mean periods respectively. These sea states were specified as 50 year return storms for summer delivery voyages from the U.S. west coast and Japan respectively. The sea spectral formulation used in this study was the ISSC (1967) two-parameter spectrum.

The study considered the caisson laboring in the design sea at zero speed at headings of 180 degrees (head seas), 135 degrees and 90 degrees (beam seas). The zero speed is appropriate since tows like that for the Norton Sound caisson would be incapable of making headway into the seas of the severity represented by the design sea states.

Freeboard requirements were judged against the criteria established in an earlier report to ABAM Engineers from The Glosten Associates, titled "Review of Rational Freeboard Determination for an OTEC Platform," (report dated May 1979).

As a result of this investigation, it was found that the top of the concrete bulwark at Elevation (+)25 foot provides sufficient freeboard for both head seas and quartering seas. Beam sea encounters would require a deck Elevation of (+)31 foot.

Based upon discussions with The Glosten Associates, it is not felt justified to provide freeboard for beam seas encounters. In the event that the design sea state is encountered, tugs will head into the waves in order to maintain control of the tow. Thus, it is concluded that the bulwark Elevation at (+)25 foot is sufficient for delivery voyage freeboard.

The freeboard analysis indicates that the shipping of green water is probable in the design sea state. This has led to the requirement for the steel weather deck in order to assure that shipped water is quickly carried from the deck.

The Glosten report and the background report which develops the freeboard criteria are included in Volume II.

3.4.7 Lightweight Concrete Materials Evaluations

Lightweight concrete is a feasible material for the construction of structures in this area. As a result of this investigation, it has been found that with proper mix design, lightweight concrete can be economically produced with properties that can readily be accommodated in design. Indications are that lightweight concrete properties could be significantly improved through developmental testing. Such work can offer economy in subsequent design efforts.

Construction techniques for lightweight concrete are essentially the same as those for normal weight concrete, with the exception of special considerations necessary to accommodate the absorptive nature of lightweight aggregates.

Normal weight concrete should be used in the ice abrasion zone due to the results of a limited number of tests which indicate its superior abrasion resistance properties as compared to lightweight concrete. Abrasion testing methods which simulate ice abrasion should be developed in order to obtain wear rates for normal and lightweight concretes and thus provide design requirements in the ice abrasion zone.

The current supply of lightweight aggregate in western North America can supply sufficient materials for a project of this magnitude, and these aggregates can furnish concrete with acceptable properties. Uncertainties in future supply and demand of lightweight aggregate will require an investigation of aggregate sources in the early planning stages of a project. In the event of a significant increase in demand for lightweight aggregate, sufficient raw materials exist and additional manufacturing facilities can be made available if given sufficient lead time.

Lightweight concrete mix designs should be developed in order to obtain the maximum possible concrete strength and minimum concrete density. If concrete strengths exceeding 6000 psi or fresh concrete densities lower than 120 pcf can be achieved, economies will result in the barge structure. Further economy can result by more accurately defining shear and tensile properties, bond length and prestress losses for specific lightweight concrete.

3.4.8 Construction Scenario

a. Background

The preliminary design of the barge structure indicates that construction is feasible utilizing existing facilities with state-of-the-art construction technology. Design details have been incorporated which allow utilization of existing gravity dock facilities and proven construction methodology. Recent concrete floating structures which have utilized similar technology include:

- A floating container handling dock which is currently under construction for the City of Valdez, Alaska. The facility is a 100 foot wide x 700 foot long x 30 foot deep structure which is constructed as two individual elements which are joined together while floating.
- Replacement pontoons for the Hood Canal Floating Bridge in Washington State. These pontoons are each 60 feet wide x 360 feet long x 18 feet deep and are joined together while floating to provide a continuous structure 3775 feet long.
- A floating LPG storage and transfer vessel which has been in service for 5 years in Indonesia for ARCO. This vessel is 461 feet long x 136 feet wide x 56 feet deep.
- Two floating ferry terminals in Vancouver, B.C., which have been operating for 5 years by the province of British Columbia. Each terminal consists of six individual pontoons which were joined together while floating.

b. Existing Construction Facilities

Three existing West Coast facilities have been identified as capable of accommodating construction of this facility. These facilities are briefly described below.

- Concrete Technology Corporation, Tacoma, Washington

  Concrete Technology Corporation (CTC) is a precast, prestressed concrete fabricator. CTC has a graving dock which is approximately 150 feet x 500 feet in plan dimension and has an available draft of 13-14 feet. CTC is presently considering lowering the bottom of their graving dock. Access to Puget Sound from this facility is through a bridge with 150 foot clearance between abutments.

- J. A. Jones General Contractors, Tacoma, Washington

  J. A. Jones has a facility which is on land leased from the Port of Tacoma. Their graving dock is approximately 600 feet square and has an available water depth of approximately 14 feet. Access to Puget Sound from this facility is through the bridge discussed above.

- Hunters Point, San Francisco Harbor, California

  Hunters Point is a former Naval shipyard which currently is unused by the Navy. A portion of the facility has been leased to a machine shop. The facility has six graving docks, the largest of which is 143 feet wide x 1000 feet long, with an available water depth of 45 feet. Over 800 acres of land are available in the facility, which includes a long pier with 45 foot water depth.

> This site appears to have significant potential as a barge construction facility. In order to better define it's capabilities, a condition survey of the facility is recommended.

In addition, many ports on the West Coast, particularly in Washington and Oregon, have available land and an interest in developing new industry. There is a significant potential for new barge construction facilities, given sufficient time for permits and development. Chicago Bridge and Iron is currently applying for permits for the construction of a facility to be used in constructing offshore structures in Anacortes, Washington.

The cost effectiveness of a new facility, would probably be dependent upon multiple use. It should be noted, however, that the J. A. Jones facility discussed above was built specifically for constructing the Hood Canal Bridge pontoons.

c. Construction Concept

The barge construction concept has been developed to allow construction in a graving dock with a width of 140-150 feet and an available water depth of 13-14 feet. This concept would be constructable in at least three existing facilities. In the event larger or deeper graving docks are available, barge details can be simplified and costs reduced.

In order to accommodate the above limitations, the barge is designed to be built in two segments which are joined with a post-tensioned connection while floating. Additionally, each segment is partially constructed in a graving dock and completed while floating. The skid beam system is constructed while the segments are floating and modular superstructures are erected after the segments are joined. The barge structure is constructed with a cost-effective combination of precast and cast-in-place concrete elements. This allows a maximum re-use of forms and offers schedule benefits as compared with fully cast-in-place concrete construction.

d. Barge Construction Scenario

The various operations anticipated for barge assembly are shown on Drawing B-111. These operations are briefly described below.

(1) Precast Bulkhead Elements: The initial operation for construction of the barge is the fabrication of precast bulkhead panels. These panels are cast on relatively simple flat form tables with steel form bulkheads around the perimeter of each panel. Construction on the flat form tables allows easy access for placing of reinforcement and concrete. External vibrators will be mounted on the forms to facilitate consolidation of the concrete. Jet pipes should be installed in the precast vertical panels to facilitate water jetting in order to break suction bond during initial floating of the barge in the graving dock.

Accelerated curing techniques will be used to allow the construction of one concrete panel per day in each form, thus minimizing the number of forms required. Bulkhead panels are post-tensioned vertically with dywidag bars. A portion of these bars will be stressed prior to removing the panel from its form in order to resist handling stresses.

Extensive use of modular bulkhead framing leads to repeatable fabrication with the associated cost and schedule benefits. Precast panels are sized to minimize the number of panels to be handled while keeping the panel weight within reasonable crane capacity. The maximum panel weight is that of a watertight transverse bulkhead, which weighs approximately 56 tons. Between fabrication and erection the panels must be stored in a yard adjacent to the casting area and/or graving dock. Panels can be transported with specially designed truck beds.

(2) Erect Precast Bulkheads: The precast panels are erected in the drydock. All panels can be handled at the expected reach with a 200 ton mobile crane on crawlers. In order to accommodate the construction schedule, two 200 ton cranes are required. After erection, the precast panels must be braced in order to provide stability.

(3) Place Cast-in-Place Pilasters: The arrangement of precast panels is shown on details 2 and 3 of Drawing B-111. The connection between precast panels is made with cast-in-place concrete. An epoxy bonding agent is used to bond the fresh concrete to the precast panels. The use of epoxy and the application of prestressing force across all construction joints provide a watertight joint. The use of superplasticized concrete and special placing techniques are to assure proper consolidation of the concrete in these connections.

(4) Place Cast-in-Place Keel: The keel is constructed with cast-in-place concrete. This can be economically accomplished by using the floor of the drydock as a form. Reinforcing steel and post-tensioning ducts are provided across all construction joints between precast panels and

the keel. As above, an epoxy bonding agent is used on all joints.

(5) Post-tension: Prior to launch, all post-tensioning tendons which will be below the waterline are stressed and grouted according to a predetermined sequence. Blockouts for tendon anchorages are patched to prevent corrosion of anchors and tendons.

(6) Launch Partial Hull: At this stage, the barge segment is launched for completion while floating. The draft of the small segment (80' x 480') is 12.5 feet at this stage, including trim ballast.

(7) Complete Exterior Bulkhead: The exterior bulkhead is completed with cast-in-place concrete while the segment is floating. Staging is required to facilitate placement of reinforcement and concrete. Formwork is supported from the lower portion of the bulkhead. Sufficient clearance is available within the exterior bulkhead cross section to allow placement of concrete with a pumpline or trunk. The forms are externally vibrated to facilitate compaction of the concrete.

The exterior bulkhead must be placed in two lifts in order to provide sufficient freeboard during construction. Ballast will be required to trim the barge segment during construction.

(8) Construct Deck: Precast, prestressed deck panels are utilized to provide a form for deck construction. After the topping has cured, these panels behave compositely with the cast-in-place topping. Shear transfer between precast panels and cast-in-place topping is provided by

roughened concrete and, where necessary, vertical mild steel reinforcement. These panels are erected from shore with a mobile crane. Prior to casting the topping, the panels are made continuous with a welded connection at the longitudinal bulkheads and a concrete closure pour between adjacent panels. The cast-in-place deck topping is constructed in finite pour segments which can be finished with a vibrating screed similar to those used for bridge deck construction.

(9) Post-tension: After the deck has gained sufficient strength, post-tensioning tendons above the waterline can be stressed and grouted. At this stage, the barge segments are ready to be integrated into a continuous structure.

e. Segment Jointing

(1) Jointing Concept: The connection between barge segments is accomplished by a cast-in-place concrete closure pour which is post-tensioned to provide sufficient global strength continuity through the joint. Continuity is achieved by using short splice post-tensioning tendons which overlap the typical transverse tendons in each barge segment.

(2) Jointing Operations: Prior to mating, a portion of the joint in the vicinity of the keel and all transverse bulkheads must be cleaned to remove any marine growth which may have formed during segment construction operations. This can be accomplished with divers and a high pressure water jet system.

In order to accommodate mating, the barges are outfitted with alignment hardware which is cast into each of the segments. Details of this hardware and other jointing details are presented on Drawing B-112. This alignment hardware consists of flat bearings near the keel and pintels near the deck. All alignment hardware must be accurately located with proper relative positioning in order to maintain tolerances which allow the splice tendons to be threaded between the segments.

The segments are ballasted to provide equal drafts at the joint bulkheads and a trim which maintains a gap at the pintel with contact at the lower bearings. Initial seating of the pintel is achieved using deck mounted winch lines which run across the joint. At this point, a portion of the deck splice tendons are threaded through ducts and stressed to achieved final seating of the pintel. The splice tendons used to close the joint and mate the pintels are not assumed fully effective in prestressing the joint.

Ballast is adjusted to assure positive bearing at the keel. This will prevent separation due to environmental loadings and compress deformable seal which has been provided around the perimeter of the joint. The joint is then dewatered to allow threading and stressing of a portion of the keel splice tendons.

The function of these initial splice tendons is to prevent joint separation due to environmental and construction loadings during joint concreting operations. The number of tendons stressed at this stage will be dependent upon the exposure of the construction site to the environment. Seals are incorporated around all splice tendons to prevent the entry of joint concrete into the splice tendon ducts. Splice tendons should be threaded through the joint prior to concreting in order to allow stressing of these tendons in the event of leakage.

The nominal width of the joint has been set at six inches. This will allow for construction tolerances and yet allow placement of joint concrete with a pump line. Vibration of the lower portion of this joint will be difficult. Thus, a superplasticized pea gravel concrete is recommended in order to assure flowable, well compacted, dense concrete.

The joint concrete should be placed in lifts which are a maximum of six feet in order to minimize pressures on the joint bulkheads. Such pressures tend to separate the joint between segments. In order to control deflections of the joint bulkheads, form ties should be used between barge segments. Each lift should be cast continuously for the full length of the joint. After the joint concrete has gained sufficient strength, all splice tendons can be stressed and grouted.

f. Concrete Superstructure Construction

The concrete superstructure consists of the concrete bulwark, skid beams, columns and shear walls. Most of these elements could be constructed of either cast-in-place or precast concrete. The construction schedule and cost estimate have been developed considering precast skid beams and cast-in-place construction for other elements.

The concrete superstructure is constructed while floating. It has been assumed that this work is accomplished at the same shoreside facility used for the barge deck construction. Construction materials access is provided from a work dock. In order to facilitate handling of formwork, reinforcement and concrete placement, two tower cranes are required on the deck of the concrete barge.

The precast concrete skid beams are erected using a floating derrick. Each single span skid beam weighs approximately 26 tons. The ends of the beams are supported on shoring while the cast-in-place beam-to-column connection is made. The construction schedule has allowed time for these cast-in-place connections to cure prior to erection and skidding of the production modules. The steel weather deck is also constructed at this time. The weather deck is prefabricated in large panels and erected using the tower cranes.

In order to minimize the overall construction schedule, concrete superstructure construction will begin on the initially completed barge segment prior to jointing operations.

3.4.9 Deployment

a. General

The deployment of the barge structure includes preparation of the foundation, the delivery voyage tow of the fully outfitted barge and final positioning and ballasting of the structure to its foundation. The procedures and costs developed for the deployment of the barge should be taken as conceptual in nature at this stage. Future levels of design will need to address towing response, foundation design requirements for specific sites and mechanical design for dredging, ballasting and dewatering systems. The deployment plan is shown on Drawing B-113.

b. Delivery Voyage Tow

The development of deployment cost has made the assumption that the barge would be constructed and outfitted in Puget Sound prior to its delivery to Norton Sound. Thus the delivery voyage tow distance is approximately 2300 nautical miles.

The design sea state, as given in the design specification for a June/July tow, is a significant wave height of 25 feet with a period of 12 seconds. Design one minute average wind speeds for the delivery voyage are 55 knots.

Tow resistance has been computed for the rectangular barge using Reference 16. Using a criteria that the tugs can maintain zero forward speed in the above sea state, the computed tow resistance indicates a requirement of approximately 60,000 horsepower for the tow, or 7-9000 BHP class tugs. The practicality of such a tow is questionable. As a result of these computations the following recommendations are made:

- Reconsider the acceptable level of risk for the delivery voyage tow. Discussions with Naval Architects indicate that the design sea state is common for spring tows in the North Pacific; however it is more severe than sea states typically used for June or July tows.
- Perform model testing of the vessel to verify tow resistance calculations and to assess tow speed.
- Consider various bow shapes in model testing in order to determine their benefits in minimizing tug power requirements.

The delivery voyage costs included in this study have been based upon a tow using 3-9000 BHP class ocean going tugs with one 9000 BHP tug as standby. The standby tug is used for refueling operations and in the event of an emergency. Additionally, four tugs are desired for barge positioning at the deployment site.

Based upon tow resistance calculations, the three tugs can maintain zero forward progress in a sea state with a 20 foot significant wave height and a period of 9 seconds.

Based upon our discussions with towing companies and Naval Architects, an average tow speed of 2 to 3 knots appears reasonable for a large gravity structure such as this. An average speed of 2.5 knots has been used to compute the duration of tow.

c. Deployment Site Activities

(1) Barge Positioning: Barge positioning for ballasting to the foundation can be accomplished through the use of a fixed mooring system or using tugs to maintain position during ballasting.

A fixed mooring system has the advantage of accurate location tolerances for the barge (within a few feet) and can be designed to be relatively insensitive to environmental conditions. The primary disadvantage of a fixed mooring system is the cost of the components and their installation.

The use of tugs has the advantage of low cost, assuming sufficient tugs are available from the delivery voyage. The disadvantage of positioning with tugs is the lower level of accuracy of the grounded location of structure. If the barge is to be positioned over existing wells, this positioning method would not be acceptable. An additional disadvantage is the dependence on environmental conditions for positioning.

Positioning costs have been based upon the use of tugs for positioning the structures. This will be the most economical method for positioning if the positional tolerance is feasible. It is anticipated that final barge positioning can be maintained within a 70 foot radius of planned touchdown using this system.

(2) Ballasting: Ballasting the barges to the foundation consists of the following steps:

- Fill the barge with seawater ballast to ground the vessel and maintain stability during subsequent operations.
- Replace seawater ballast with granular ballast.
- Densify ballast.

It is necessary to fill the below deck compartments with seawater in order to provide sliding stability during placement of the granular fill. The approximate quantity of seawater is 26 million gallons. Since a hydraulic dredge is used to place the granular fill, it can also be used to perform the water ballasting. A 26 inch diameter dredge unit has a capacity of 35,000 gallons per minute. Thus water ballasting can be completed in slightly over 12 hours, limiting weather exposure periods.

This quantity of seawater provides sufficient sliding stability to prevent sliding due to the 1 year return wave (significant wave height = 17 feet, maximum wave height = 26 feet) for wave forces parallel to the long axis of the barge. This amount of water ballast can resist a wave height of 21 feet for wave forces perpendicular to the long axis of the barge.

The granular ballast is placed with a hydraulic suction dredge unit which is mounted on a sea going barge. Discussions with dredging companies have indicated that small portable dredging units would not be suitable for use in the severe wave environment of Norton Sound. A single dredge unit with a diameter between 20 and 26 inches is capable of filling the barge with the necessary ballast within a time period of one month. The hydraulic dredge would obtain materials from the bottom in the vicinity of the barge and transport it to the deck of the barge through pipes. There a manifold system would be used to distribute the fill to the various compartments. The barge which supports the dredge unit would also be outfitted with a crane for handling dredge lines. A tug is used to transport the dredge unit around the site.

In order to achieve a fill density of 115 pounds per cubic foot, a dewatering system will be required to remove water from the bottom of each compartment. This system would most economically be installed prior to delivery of the concrete barge. The cost estimate for deployment includes an allowance for a dewatering system.

(3) Scour Protection: Riprap materials have been used to provide protection of the soils around the perimeter of the barge from erosion and scour due to wave action.

Reference 3 discusses the availability and price of riprap materials at Nome. These materials are assumed available dockside at Nome and are transported to the site in two 300 cubic yard flatbed barges. The riprap is placed on the foundation using the barge-mounted crane with a clamshell bucket. A total of 7000 yards of riprap are required and can be placed around the perimeter of the barge in 18 days.

(4) Site Preparation: The requirements for preparation of the foundation for the barge structure will be site-specific. In general, the foundation must provide a relatively uniform support of the barge in order to minimize global stresses in the barge structure. The keel plating of the barge has been designed to accommodate lack of foundation support of one entire compartment. Local foundation high spots may result in cracking and distress locally in the keel plating without affecting the global behavior of the barge structure. Should such local distress occur, the cellular structure of the barge will prevent catastrophic collapse of additional structure, thereby mitigating the importance of local failures. Such failures are only important if it is desired to refloat the barge at some future date. Repairs may be required at that time.

Large lenses of soft organic materials will require dredging and replacement with suitable granular material. These soft materials can be removed with a hydraulic suction dredge. Lenses of hard materials can be removed with a barge-mounted crane equipped with a clamshell bucket. These hard spots may require jetting in order to allow their removal. Desired profile tolerances can be accomplished by passing a weighted screed over the foundation. The foundation for the caissons on Dome Petroleum's Tarsiut Island was recently leveled using load blocks on a derrick to maneuver repeated passes of a screed.

Well before the barge final design stage a knowledge of the local soils at a specific deployment site will be necessary. The necessary soils explorations will likely be undertaken during exploratory drilling and should be available for comparative siting analyses.

The basic cost for installation of the barge does not include an allowance for foundation preparation. The sensitivity analyses discuss potential foundation preparation costs.

3.4.10 Caisson Structure for 70 Foot Water Depth

a. Summary

A conceptual design has been developed to establish the feasibility of a concrete gravity structure for deployment in 70 foot water depths in Norton Sound. This design has utilized the basic modular, cellular construction of the 30 foot water depth structure as a substructure to support four large diameter columns (towers) which penetrate the waterplane to provide the necessary wave clearance for protection of the production modules. These towers provide a significant reduction in global wave and ice forces by reducing the exposed structural area at the waterplane. Using this structural concept, the applied global and local loadings can be accommodated in a cost-effective manner.

Skid beams span the towers to support the production modules. The geometry of the towers has been established to accommodate the same modular superstructure intended for steel jacket structures.

Solutions have been identified which indicate that the concept is feasible although further detailed investigations are required. The following items are critical to the feasibility of the concept; freeboard and stability for the delivery tow, stability during deployment, module erection and removal, design for wave pressure and form and ice loading.

b. Structural Concept

The general arrangement of the concrete gravity structure is shown on Drawing B-114. The caisson structure consists of three elements: the cellular base, four large diameter towers and the skid beams. Key dimensions and characteristics of the outfitted platform at time of delivery are as follows:

Length Overall	400 ft
Beam	280 ft
Height-Bottom of Keel Slab to Top of Skid Beam	177 ft
Bottom of Skid Beam Elevation	+72 ft
Draft	30.6 ft
Displacement	109,200 ST
GM_T	173 ft
Concrete Volume	48,900 CY

The displacement and draft include a 10% margin on the gross structure weight. No additional margin was placed on production module weight.

The caisson structure is 40 feet deep with a 15 foot high perimeter enclosure (wave bulwark) for a total height of 55 feet. The wave bulwark provides additional freeboard for the delivery voyage. A steel, watertight weatherdeck encloses the opening between the wave bulwark and towers. The weatherdeck is removed at the site after the delivery voyage and the void space between the main deck and top of the wave bulwark is ballasted with sand topped by riprap.

At the site, the structure will be placed in a 10 foot deep excavation. In so doing, an additional 10 feet of draft, or 25 feet total, will be available directly above the base. This will be sufficient to allow operation of service vessels and derrick barges to remove topside modules, if necessary. Removing the top 10 feet of native material also enables the use of improved soil properties in the design of the structure. The result is a higher sliding friction resistance as described in the following section of this report. The excavation will also assure a more uniform foundation surface. Hard points or soft pockets will be minimized during foundation preparation and will thus provide a more uniform bearing. The need for special grouted foundations is also greatly reduced.

No skirts are required for scour protection for the 70 foot water depth structure. Once grounded, the structure will be backfilled and riprap placed around the full perimeter.

One unique aspect of the structural configuration is a sloped face on the wave bulwark. This is to temper the otherwise abrupt change in bottom profile and to reduce wave forces on the structure. The exact benefits to sloping the face or the manner in which the structure influences the wave form as a wave passes over the structure needs further definition. As pointed out earlier, the wave height determines the skid beam and equipment module elevations. These elevations are critical in the design of the structure since they have a direct influence on overturning moments in the towers and thus soil bearing stresses, the stability during delivery voyage, and erection costs.

A skid beam soffit Elevation of (+)72 foot has been established by comparison with wave-structure interaction of a similar structure, and allows for an air gap of 5 feet with respect to extreme event wave profiles.

Well slots will be provided in two of the four towers. Space requirements for the well slots were not specifically investigated since the structural framing is believed to be sufficient to accommodate the wells.

c. Design Considerations

(1) Environmental Forces

Dynamic wave forces at the 70 foot water depth site governed the choice of structural configuration. Initial investigations considered an extrapolation of the flat sided barge configuration to 70 foot water depths. For this concept, wave pressures calculated per the Minikin method of the <u>Shore Protection Manual</u>, Reference 17, resulted in a maximum pressure of 717 psi. This is due to a 5 year wave. This pressure must be applied over the full length of structure exposed to waves as the coherent wave crest reduction factor per Section 1.1.3.6 of the Design Specification results in only a 4 percent reduction in wave force. This wave force is approximately 3 times as large as the global ice force.

To reduce global wave forces to a managable level, a conceptual design involving minimum structural area exposed to the dynamic wave pressure zone was selected. Also, the selection of a circular cross section enabled using the Morison equation for determining wave forces as outlined in paragraph 2.3.1 of API RP 2A. The Morison equation results in a more reliable force calculation than the Minikin Method since the latter neglects the influence of reflected waves on incoming waves. For all calculations, a drag coefficient $C_D = 1.0$ and a mass coefficient $C_m = 2.0$ were assumed. The diameter to wave length (D/L) ratio ranged between 0.07 for the 100 year wave and 0.11 for the 1 year wave.

Ice loads on the towers were calculated for both global and local conditions. For the global condition, the exposed area consisted of the diagonal distance between towers plus one tower diameter. The resulting total global ice force is this diagonal distance times 210 kips per foot. The local ice load on one tower was comprised of 400 psi on 50 square feet and 210 psi on 350 square feet.

Lateral wind and seismic forces were computed using a bottom of skid beam Elevation of (+)102 foot. This elevation was selected for conceptual design to allow ample margin for wave crest elevation plus air gap. Based upon wave-structure interaction of a similar submerged structure, it appeared that the bottom of skid beam elevation can be +72 as is shown on Drawing B-114.

Seismic forces were calculated in accordance to the requirements of API RP 2A. The mass associated with the barge structure was accelerated by a spectral acceleration of 0.1g. This assumes that the structure is very rigid and moves with the seabed during an earthquake.

Included with the structure mass was an added mass of water equivalent to the displaced volume of water. For the towers, skid beams and equipment, the spectral acceleration and hence, the seismic force, will be a function of the tower period of vibration. For this study, the maximum spectral acceleration determined using Figure 2.3.6-2 of API RP 2A was applied to the superstructure. This acceleration is 0.25g for an effective horizontal ground acceleration of 0.1g.

(2) Structural Design

The caisson base structural elements are very similar to the 30 foot water depth barge concept. Interior bulkheads are identical since all spans remain the same. The exterior elements, however, are more substantial due to the increased hydrostatic pressures. The deck, in particular, is thicker due to the combination of ballast and hydrostatic pressure. The entire barge structure is constructed of lightweight concrete.

Delivery voyage stillwater plus wave bending stresses are acceptable. Due to the central location of the towers, there exists a stillwater sag moment with the keel plate in tension. The combined stillwater and wave tensile stress is 540 psi. The maximum compressive stress is 770 psi and occurs in the deck of the wave bulwark. Prestressing is provided to assure the serviceability criteria are achieved with these superimposed stresses.

The design of the towers is an iterative procedure based on bending stresses at the base of the tower and local stresses due to ice loads. The existing design represents only one iteration. Overturning moment stresses were governed by loading combination B as defined in Section 4.6.2.2 of the "Design Specifications". This combination includes seismic forces. To satisfy working stress limits, a section is required with a 50 foot outside diameter and a 3 foot wall thickness at the base. This wall thickness was subsequently increased to 4 feet to satisfy ultimate strength criteria for the local ice loading.

The towers are constructed of both normal and lightweight concrete. The lower portion from the main deck to Elevation (+)10 foot is normal weight. This segment is located in the ice zone. The remainder of the tower, Elevation (+)10 to (+)97 foot, is constructed with lightweight concrete.

The circular cross section of the tower is beneficial in distributing the local ice loads. In addition to punching shear or through thickness shear capacity, there will be arching action present which distributes the load in tangential shear. To analyze local forces in the tower walls, Table VIII, Cases 15 and 25 of Reference 18, were superimposed. Case 15 represents uniform radial pressure on the perimeter of the towers and is a simplification of the actual contact pressure distribution.

As in the design of the exterior bulkhead for the 30 foot water depth structure, the ice force was distributed over an area 1-1/2 times the wall thickness on either side of the loaded area. Also, the section was sized for ultimate strength. In a final design, serviceability based on acceptable crack width or steel stress criteria will also need to be addressed. To provide the ultimate moment capacity, the section must have a reinforcement ratio approximately equal to 1.8%. Also, shear reinforcement is provided through the wall thickness to satisfy ultimate shear capacity requirements. This shear reinforcement may be shown unnecessary by testing of the response of the tower structure to large punching shears.

Due to the larger span, the skid beams for the 70 foot water depth structure will be significantly larger than those used for the 30 foot water depth structure. Reactions from the equipment module trusses will be located along the span rather than directly above columns. In addition, there will be two levels of modules thereby increasing each reaction. The skid beams were sized utilizing the same total maximum operating loads as used for the 30 foot water depth structure. This resulted in larger reactions than final operation weights for the jacket structure modules. The skid beams are constructed using lightweight concrete. One factor not considered at this time which will need to be addressed during final design is concrete creep due to sustained loadings. Modular superstructures must be able to accommodate expected long-term deflections in the skid beam/tower system.

Prestress levels are similar to the 30 foot water depth structure. For this concept, the longitudinal prestress is 1000 psi. The transverse post-tensioning stress is 1000 psi which is twice the prestress for 30 foot water depth concept. This is necessitated by the larger hydrostatic pressures on the keel and the hydrostatic plus sand ballast pressures on the deck. Both of these elements span transversely in the 280-foot dimension direction of the structure. Tower vertical and hoop prestress is also 1000 psi. Prestress for the remaining structural elements is summarized on Drawing B-115.

(3) Foundation Analysis

Loading combinations analyzed are described in the Design Specification, in Section 4.6.4. Loading combination B which includes seismic forces controlled. Bearing stresses due to combined vertical load and overturning moment are approximately 5000 psf compared to an allowable of 15000 psf.

The determination of seismic loadings on the foundation has been based upon a unidirectional ground acceleration of 0.10 g. The provision of API RP 2A which combines seismic acceleration in two orthogonal horizontal directions has not been applied to the foundation analysis. However, vertical seismic accelerations have been combined with the horizontal accelerations.

The lateral shear force which the structure must withstand is governed by loading combination B per Section 4.6.4 of the Design Specification. This combination includes seismic forces. The structure dead weight includes compacted sand ballast topped by riprap in the 15 foot space above the main deck, non-compacted granular ballast in below deck and perimeter enclosure compartments, and seawater ballast in the tower below elevation 0.0 and water ballast in all interior barge compartments including below the stillwater line in the towers. Ballast amounts are indicated below:

Compacted Sand (Submerged Weight)	$34,400^k$
Riprap (Submerged Weight)	$5,700^k$
Granular Ballast - Base	$359,000^k$
Water Ballast - Tower	$14,200^k$

Foundation sliding resistance is provided by a combination of passive soil pressures on the exterior bulkheads and frictional resistance between the keel and the foundation. Passive soil pressures resulting from the 10 foot embedment below mudline amount to less than 4 percent of the total sliding resistance. Frictional resistance is based on granular soils with $\phi = 30°$.

d. Constructability

(1) Base Structure

The base structure for the caisson will be less complicated and less costly per cubic yard to construct. This is made possible by eliminating much of the massive, cast-in-place exterior bulkhead in the ice zone and the wave bulwark with a curved vertical face. All exterior bulkheads and the elements of the perimeter enclosure may be of precast construction. Formwork will be more conventional without the need for special curved surfaces or shoring for cast-in-place construction.

(2) Tower Construction

Due to the height of the towers, slipforming or self-lifting jump forms are the most likely construction methods. Slipforming is an operation where the forms are continuously moving. The lifting mechanism is an integral part of the slipform and jacks against previously poured concrete. Jump forms are moved in stages or lifts where a typical lift may take 2 or 3 days. Slipforming technology has been demonstrated on many of the North Sea gravity structures. Jump forming is common for high rise building construction.

(3) Skid Beam and Module Erection

Skid beams will likely be precast, with an integral joint formed by prestressing the precast beam to the towers. These elements may be erected in the same manner selected for modular superstructure erection. Potential methods for this activity are discussed below.

One potential method to erect equipment modules includes lifting completely assembled skid beams and all equipment modules simultaneously with the slip or jump forms. This requires considerable falsework to support the large vertical load from the integrated deck structure. This falsework would be supported from the deck of the barge structure.

A second method of equipment erection is to ballast the caisson to the bottom in deep water and float the integrated skid beam and equipment module deck on barges, deballast the structure and float the equipment over the towers. One difficulty with this method of construction is stability of the structure during the ballasting/deballasting operation. However, methods and equipment can be developed which provide auxiliary stability. Additionally, the barge would require design for additional hydrostatic pressures. This method of superstructure erection is not a preferred method.

Another method would be practical with smaller equipment modules. Special skid beams may be designed to provide lifting equipment support. This concept requires a third skid beam centered between those supported on the towers. In addition, the outer skid beams would be cantilevered beyond the center skid beam by one module width. Winches or other lifting devices are located on the outer skid beams and used to raise the shorter modules between the two outside skid beams. Next, temporary skidding members spanning between skid beams would be moved into position under the module and the module would be skidded into position on the platform.

Without further development, the most suitable method to erect modules in the configuration shown on Drawing J-101 is the use of landbased heavy lift equipment. This equipment was developed for use in nuclear power plant construction. It has also been successfully used for steel jacket fabrication in Scotland. Depending on soil properties adjacent to waterside construction sites, use of this equipment may require the construction of a special support structure such as a large pile support cap. The Lampson Transi-Lift is an example of this type of lifting equipment. A single unit can lift the heaviest module weighing 1100 tons at a radius of 100 feet.

e. Delivery Voyage and Deployment

For the tow to the site, the outfitted structure will have a draft of 30.6 feet. For this condition, the stillwater line will be located on the base structure and the freeboard will be 24.4 feet. This compares with a freeboard requirement of 26.4 feet for the 30 foot water depth structure and tows from Puget Sound. Further assessment by a Naval Architect is suggested to determine if this freeboard is adequate for the delivery voyage. Additional freeboard can be achieved if necessary by increasing the elevation of the perimeter bulwark. The minimum metacentric height (transverse) is 173 feet which likewise should be verified for adequate stability during the tow. The magnitude of the metacentric height appears to indicate suitable stability, however.

Excavation of the foundation surface should commence in advance of the platform arrival at the site. However, some of the excavated material may be suitable for the sand ballast on the deck, thus coordination of activities will be necessary. Approximately 50,000 cubic yards of materials must be removed. The most expediant method is to use suction dredges. At the conclusion of dredging, dragging the excavation with special plows or screeds may be needed to obtain a uniform bearing surface.

The sand ballast on the deck must be densified in order to provide sufficient reaction to mobilize frictional sliding resistance in the soil. This can be accomplished using vibro-compaction. Riprap is placed above the sand in order to prevent sand from washing out under the action of waves passing over the structure.

Grounding of the platform may be accomplished in several ways. One method is to lower one end of the structure by controlled ballasting until the end touches bottom. At this point, the structure may be inclined up to 7 degrees. The ballasting operation would continue by placing ballast in the opposite end of the base until enough weight is inside the base to gently settle the platform on the prepared surface. Calculations are required to check stresses in the barge, towers and equipment connections prior to selecting the details of this method.

A second method involves the use of auxilliary flotation such as steel barges. With this method, the structure would be ballasted to a near neutrally bouyant condition and the flotation attached (say one barge along each side) with heavy mooring lines and winches. The next step would be to purposely heel the structure to engage one of the auxilliary flotation barges. Additional ballast is then placed to retrim the structure and engage the remaining flotation barges. Winches on all barges would be coordinated to slowly lower the structure. Additional ballasting will be required to displace the buoyancy of the towers.

Both of the above methods are conceptually feasible solutions. However, more study must be undertaken on the deployment method in order to identify suitable details for this operation.

COST AND SCHEDULE SUMMARIES

4.0 COST AND SCHEDULE SUMMARIES

4.1 GENERAL

The findings presented herein are based on the preliminary designs developed for the four base cases and the conceptual design developed for the 70 foot barge concept sensitivity case. Moreover, the objectives of this section are:

(1) To present the guidelines which were used for the preparation of the estimates.

(2) To provide the participants with the methods and formulas used in the development of the estimates.

(3) To serve as the information source for any required future estimates.

The estimates included are conceptual in nature, providing accuracy of ±20%. All pricing reflects 1st Quarter 1982 U.S. Dollars based on worldwide procurement. There are no allowances for escalation beyond this period.

The estimated costs are based upon an assumed project execution plan that encompasses cost for project management, detail design, procurement, construction management, facilities, fabrication, transportation, installation, hook-up, and start-up of each respective facility concept. Detailed cost and schedule break-downs are provided in Addendum D of Volume II. (See Drawing No. B-116, Addendum C, Volume II for concrete barge concept schedule.)

4.2 STEEL JACKET CONCEPT

4.2.1 Direct Costs

Direct Costs are those costs associated with the permanent physical facilities, and include: (1) Equipment Cost, (2) Material Cost, and (3) Fabrication and Installation Costs. The format utilized for estimating the costs for the offshore platforms are shown in the following summary level outline:

I. Onshore Work
  A. Structural In-Yard Fabrication
  B. Module In-Yard Outfitting

II. Offshore Work
  A. Transportation
  B. Installation/Erection
  C. Hook-Up/Start-Up/Commissioning

a. Structural In-Yard Fabrication

The structural in-yard fabrication costs are comprised of the structural steel material and fabrication costs. The following table displays these costs.

DESCRIPTION	MATERIAL COST ($/Ton)	FABRICATION COST ($/Ton)	TOTAL COST ($/Ton)
Jacket Substructure	677	4,300	4,977
Modular Superstructure	680	3,300	3,980
Piling	675	700	1,375
Conductors	675	500	1,175
Flare Booms	675	6,300	6,975

These material and fabrication costs are based on preliminary quotations from a U.S. West Coast fabricator and reflect the magnitude of this project. The unit costs shown include all costs necessary for completing the structural portion of the onshore work.

b. Module In-Yard Outfitting

The major equipment and bulk material costs associated with assembly and the outfitting of the modules were developed from a combination of major equipment factoring and estimated quantity take-off methods of estimating. Major process equipment was identified by module; utilizing preliminary process flow diagrams, equipment specifications, equipment data sheets, and general arrangement plans. Each piece of equipment was priced based on informal vendor quotations and historical in-house cost data. All costs necessary to install the equipment and related bulk materials into each module was obtained using the factored estimating method. Factors applied to the equipment costs were derived from historical data. The following table provides the average Bulk Material Factor and the average Onshore Fabrication Factor for module outfitting:

CONCEPT	EQPT. COST ($x1000)	BULK MTL. FACTOR	ONSH. FAB. FACTOR	TOTAL FACTOR	TOTAL COST ($x1000)
Jacket	20,296	1.525	.815	2.340	47,495
Barge	20,296	1.651	.872	2.523	51,205

The following modules, packaged units, and miscellaneous equipment items are assumed to be delivered to dockside completely outfitted; and hence do not require the application of the above material or contractor factors:

DESCRIPTION	QTY. (ea)	UNIT COST ($)	TOTAL COST ($x1000)
Drilling Modules	2	18,530	37,060
Quarters Modules	2	3,000	6,000
Logging Unit Packages	2	78	156
Pedestal Cranes	2	225	450
Survival Crafts	4	150	600
Rucker Mooring Systems	2	80	160
Nav-Aids	4 sets	25	100
Track Vehicle	1	250	250
TOTAL			$44,776

The total cost of all equipment for both the jacket and barge concepts is $65,100,000, which is a summation from the two previous tables. The Bulk Material Factor includes the major direct cost elements (i.e. structural, buildings, piping, electrical, instrumentation, insulation and painting). All tasks are assumed to be performed in a controlled environment at a U.S. West Coast fabrication yard(s). The Yard Contractor Factor includes the following cost elements:

(1) Direct Labor
(2) Fabrication Equipment and Facilities
(3) Consruction Equipment for Assembly
(4) Labor Burdens and Indirects
(5) Contractor Indirects
(6) Insurance
(7) Overhead and Fees

c. Transportation

The transportation scope of work varies between the jacket and barge concepts. In the jacket concept, FOS cost estimates include the transport of the steel substructure and topside facilities from the fabrication yard to the project site location in Norton Sound. For the concrete barge concept, transportation cost estimates are divided between FOS and ABAM. FOS estimates include costs necessary to loadout and shuttle the modularized topside facilities from the fabrication yard to the concrete substructure. The estimated cost for the voyage of the outfitted barge to the project site is included in ABAM's estimate and is discussed in Section 4.3.1-e of this report.

The marine transportation spread required to shuttle the modules in the barge concept is comprised of four 300' x 90' x 20' cargo barges and two 3000 BHP tugs. The total activity will span nine days at at an estimated cost of $42,000 per day. The total cost is provided in the installation cost section (d) for clarity.

The marine transportation spread for the jacket concept is more complex, comprised of six 400' x 105' x 25' cargo barges and eight seaworthy 6000 BHP tugs. The following table defines the spread costs associated with the 50 foot water depth base case.

MARINE SPREADS	QTY. (ea)	TOTAL PERIOD (days)	DAILY RATE ($/day/ea)	TOTAL RATE ($/day)	COST PER SPREAD ($)
Jacket Tugs	2	60	10,000	20,000	1,200,000
Piling/Conductors					
Barges	1	119	8,000	8,000	950,000
Tugs	1	119	10,000	10,000	1,190,000
Modules/Packages					
Barges	5	205	8,000	40,000	8,200,000
Tugs	5	205	10,000	50,000	10,250,000
TOTAL					$21,790,000

The time period for the three transportation spreads represent the total duration that the marine equipment will be required, inclusive of: loadout and seafastening, towing to site, standby time while unloading, and the return voyage. The duration required to loadout, seafasten, and tow ranges from 21 to 30 days for the jacket 50 foot water depth base case. The remaining time is required for standby while unloading and the trip back to the point of origin. (Refer to the schedule in Addendum D, Volume II for a more detailed break-down of these activities.) The point of origin for all transportation spreads was assumed to be the San Francisco Bay area.

d. Installation and Erection

The installation costs for the steel jacket concept are based on estimated durations for installation of the jacket, piles, conductors, and modules into a complete integral offshore drilling/ production unit. Four separate marine construction spreads were identified for the various portions of the installation sequence. The four spreads are listed in the following table and reflect the unit cost per spread, the total installation time, and cost for each major activity. Included in the estimated duration is an allowance for weather downtime in accordance with Table 4-1. Weather downtimes vary depending on the month that the activity occurs. This allowance ranges from 25 to 33 percent for the periods between May and Mid-September respectively.

STEEL JACKET CONCEPT

INSTALLATION SPREADS	30' WATER DEPTH ($)	50' WATER DEPTH ($)	70' WATER DEPTH ($)
Survey Spread:			
Unit Spread Daily Rate	10,000	10,000	10,000
Times No. of Days	9	9	9
SUB-TOTAL	90,000	90,000	90,000
Jacket/Piles/Conductors Spread:			
Unit Spread Daily Rate	238,000	204,000	204,000
Times No. of Days	49.8	90.6	91.5
SUB-TOTAL	11,850,000	18,480,000	18,665,000
Concrete Spread:			
Unit Spread Daily Rate	28,000	28,000	28,000
Times No. of Days	34.4	37	38
SUB-TOTAL	965,000	1,035,000	1,065,000
Material Cost:			
SUB-TOTAL	100,000	120,000	125,000
Modules/Packages Spread:			
Unit Spread Daily Rate	182,000	162,500	162,500
Times No. Days	28.0	24.6	24.6
SUB-TOTAL	5,095,000	4,000,000	4,000,000
GRAND TOTAL INSTALLATION	$18,100,000	$23,725,000	$23,945,000

NORTON SOUND STUDY
INSTALLATION AND ERECTION

WEATHER DOWNTIME
(DAYS)

EVENTS (FREQUENCY)	MONTHS												
	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
ICE ACCRETION (MEAN)	0	0	0	1	7	1	0	0	3	4	3	2	21
EXCESSIVE WINDS (MEAN)	9	9	6	4	2	1	1	2	3	7	9	9	62
EXCESSIVE WAVES (MEAN)	—	—	—	—	9	7	7	8	11	15	7	—	64
PRESENCE OF SEA ICE (MEAN)	31	28	31	30	29	0	0	0	0	0	18	31	198
MAX DOWNTIME (95 PERCENTILE)	31	28	31	30	31	17	14	16	25	31	30	31	315
MIN. WORKTIME (5 PERCENTILE)	0	0	0	0	0	13	17	15	5	0	0	0	50
EXPECTED WORKTIME (MEAN)	0	0	0	0	1	22	24	23	18	13	5	0	106
MAX WORKTIME (95 PERCENTILE)	0	0	0	1	26	26	28	27	24	22	20	13	187

TABLE 4–1

For the concrete barge concept, only one installation spread is required. This spread will erect the modules and packaged units upon the barge's skid beams. The following table provides the installation spread as well as the transportation "Shuttle Spread".

CONCRETE BARGE CONCEPT

INSTALLATION SPREADS	30' WATER DEPTH ($)
Modules/Packages Transportation Spread:	
Unit Spread Daily Rate ($)	42,000
Times No. of Days	9.05
SUB-TOTAL	380,000
Modules/Packages Installation Spread:	
Unit Spread Daily Rate ($)	128,000
Times No. of Days	24.7
SUB-TOTAL	$3,165,000
GRAND TOTAL INSTALLATION	$3,545,000

The survey spread is based on a preliminary vendor quotation, manned and equipped to lead the jacket substructure from Bristol Bay to the project site location. The total spread cost is $10,000 per day. This cost is constant for all cases studied in the jacket concept.

The installation spreads for the jacket 50 and 70 foot water depth cases are the same. The jacket/piling/conductor spreads for these cases include one 1600/2000 ton derrick vessel with tugs, crewboat, and operation/maintenance crews. Also included are two 1.5 MM foot-pound pile driving hammers, jetting/airlift equipment, miscellaneous construction equipment, a diving crew and gear, and a 70 man construction crew working two 12 hour shifts per day. The average all-in rate per manhour for offshore Alaska is assumed to be $60. The total daily rate for the above, based on Brown & Root 1st Quarter 1982 offshore rates in Alaska, is $204,000.

The jacket/piling/conductor installation spread for the 30 foot water depth case differs in that two 800/1000 ton derrick vessels must be used instead of the single larger capacity vessel. This difference was necessary for the derrick vessel to operate in shallow water for any sustained period. This requirement, along with the addition of a third hammer, results in the total spread rate increase to a total of $238,000 per day.

The installation spread for erecting the modules and packaged units in the 50 and 70 foot water depth cases include one 1600/2000 ton derrick vessel with tugs, crewboat, and operation/maintenance crews. Also included are two skidding devices (e.g. Luckers), miscellaneous construction equipment, x-ray equipment, painting and sandblasting equipment, a workboat, and helicopter service. The construction labor force consists of 50 men working two 12 hour shifts for a total spread cost of $162,000 per day.

The installation spread for erecting modules and packaged units for the 30 foot water depth case again uses initially two 800/1000 ton derrick vessels (one will be demobilized after the lower level production modules are erected) increasing the total spread cost to $182,000 per day.

The concrete installation spread - at $28,000 per day - is utilized for concrete/grouting operations to fill leg and pile/sleeve annuluses and consists of a 400' x 105' x 25' cargo barge outfitted with a concrete batch plant capable of transporting, storing, mixing, and pouring concrete in an offshore environment. Also included in this spread is fresh water storage, a front-end loader, and a tug boat with operating/maintenance crew.

The commissioning of the living quarters modules and the pedestal cranes were assumed to be performed by the module/package installation spread for all cases to permit early demobilization of the derrick vessel spread. The estimated duration for this activity is two weeks.

The estimated installation durations for driving the piling and conductors were based on driveability analyses which provided the number of blows required to drive the piles to grade. All remaining durations for the installation sequence were based on historical in-house data.

e. Hook-Up, Start-Up, and Commissioning

Manhours and costs for hook-up were arrived at using an extension of the factored estimating technique. It was then assumed that 85 percent of the hook-up effort would be performed onshore. The remaining 15 percent effort was assumed to be performed offshore. An appropriate productivity factor (1.5) was applied to these manhours to establish the total hook-up duration.

The hook-up construction spread consists of 100 men, 50 men per 12 hour shift. Also included are miscellaneous tools and equipment with standby helicopter service totalling $119,600 per day.

The total hook-up cost was then developed by multiplying the total hook-up duration by the total spread cost per day. All costs, percentages, and productivity factors used were based on preliminary quotations and historical data for similar projects.

The start-up and commissioning phase assumed 10 men, 2 shifts per day assisting the operation. The staff of 10 men would gradually drop to 2 men day over a period of 30 days. The average all-in daily rate for this service is $21,000 per day.

4.2.2 Indirect Costs

The indirect costs included herein, as they relate to the concrete barge concept, are inclusive of the superstructure only. The indirect costs for the concrete substructure are discussed in Section 4.3.1-b.

a. Mobilization/Demobilization

The San Francisco Bay area was assumed as the mobilization point for marine equipment. The following table provides the costs estimated for mobilization and demobilization of the marine equipment and construction personnel:

JACKET CONCEPT - 50 and 70 FOOT WATER DEPTH CASES	
1600/2000 Ton Derrick Vessel w/Tug	$1,600,000
Survey Vessel	370,000
Concrete Barge w/Tug	1,120,000
Construction Labor	585,000
TOTAL MOB/DEMOB	$3,675,000

JACKET CONCEPT - 30 FOOT WATER DEPTH CASE	
2 - 800/1000 Ton Derrick Vessel w/4 Tugs	$3,000,000
1 - Survey Vessel	370,000
1 - Concrete Barge w/Tug	1,120,000
Construction Labor	585,000
TOTAL MOB/DEMOB	$5,075,000

BARGE CONCEPT	
800/1000 Ton Derrick Vessel w/Tug	120,000
Construction Labor	480,000
TOTAL MOB/DEMOB	$600,000

b. Inland Freight

An allowance was made for inland freight on major equipment and bulk material items at 2 percent of the total direct field material cost.

c. Construction Supplies and Expenses

An allowance of $1,000,000 was included for the estimated costs of construction supplies and expenses incurred for any additional storage requirements, operation infrastructures land based in Alaska and/or the lower 48, and any consultant costs (e.g. third party verification agents) not considered by this estimate.

4.2.3 Other Costs

a. Construction Management

These costs were estimated at 3 percent of the total installed cost for both concepts which includes the work performed on the concrete substructure for the barge concept.

b. Management, Engineering, and Procurement

These costs for the jacket concept were estimated at 7 percent of the total installed cost. This is based on historical data for projects of similar scope and was deemed adequate to provide the following services:

(1) Construction Management Support
(2) Project Management
(3) Design
(4) Procurement

For the barge concept, these costs were calculated by FOS for the superstructure only. This was estimated at 10 percent of the total installed cost of the topside facility.

c. Contingency

A contingency analysis was performed for the major elements of work for both concepts and the results are as follows:

JACKET CONCEPT

DESCRIPTION	30' WATER DEPTH ($x1000)	50' WATER DEPTH ($x1000)	70' WATER DEPTH ($x1000)
Structural In-Yard Fab.	8,540	9,635	9,790
Module In-Yard Outfitting	19,280	19,280	19,280
Transportation	2,000	2,185	2,225
Installation & Erection	970	1,185	1,195
Hook-Up & Check-Out	2,720	2,720	2,720
Start-Up & Commissioning	60	60	60
Engr. & Constr. Mgmt.	4,245	4,350	4,360
Indirects	420	350	355
TOTAL CONTINGENCY	$38,235	$39,765	$39,985

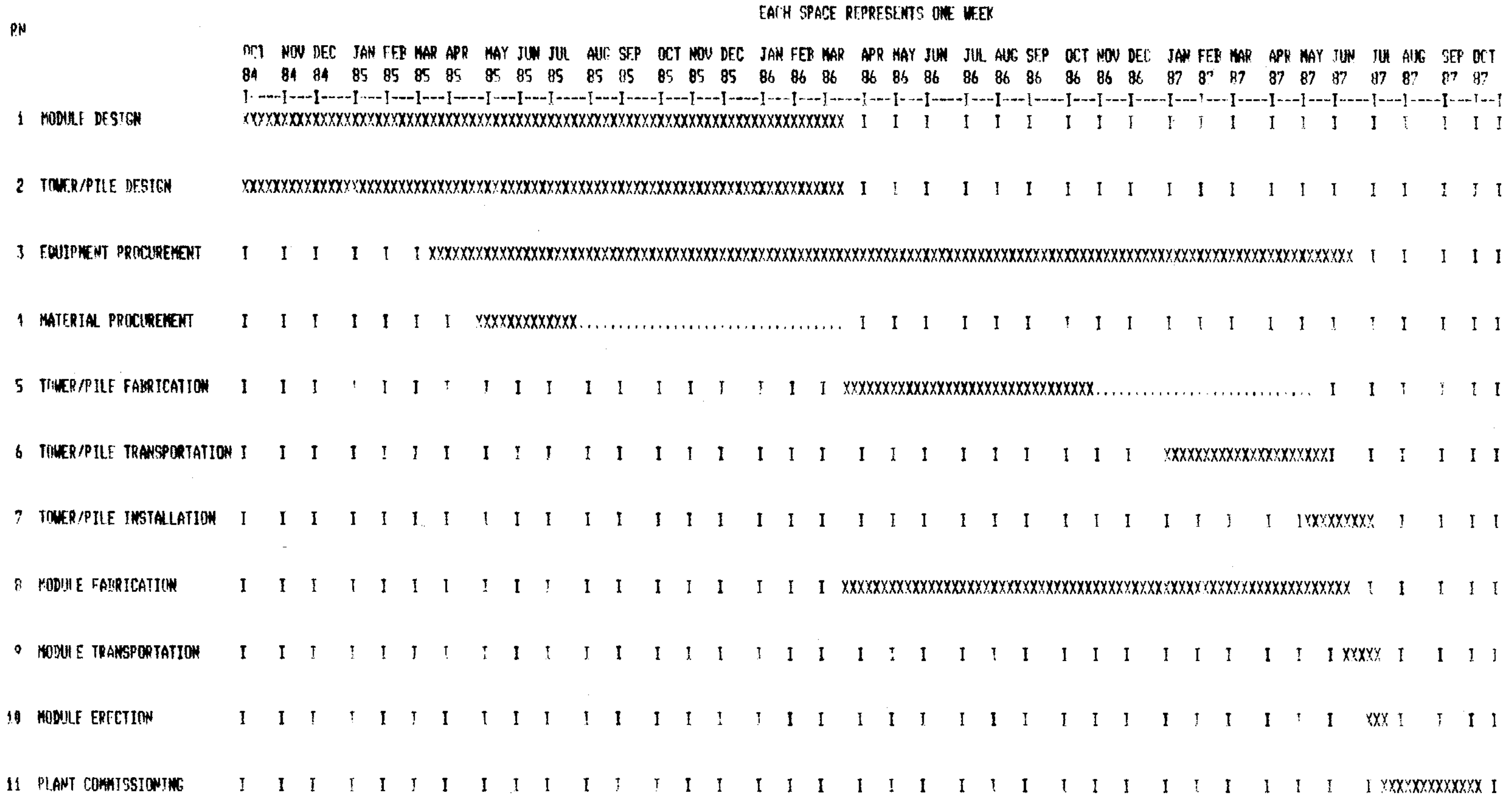
BARGE CONCEPT

DESCRIPTION	30' WATER DEPTH ($x1000)
Structural In-Yard Fab.	2,210
Module In-Yard Outfitting	20,080
Installation & Erection	180
Hook-Up & Check-Out	2,700
StartUp & Commissioning	60
Engr. & Constr. Mgmt.	3,320
Indirects	185
TOTAL CONTINGENCY	$28,735

4.2.4 Schedules

The following Level I Summary Schedules - Figures 4-1, 4-2, and 4-3 - are representative of future development programs for the jacket concept's 30, 50, and 70 foot water depth base cases. These reflect the major tasks necessary for a complete project plan including: management, engineering, procurement, fabrication, transportation, installation, and commissioning. These schedules are condensations of the detailed schedules presented in Addendum D of Volume II. Detailed schedules for the jacket concept were developed based on earlier discussions using the Critical Path Method (CPM). The above schedules do not include weather downtime.

```
CLIENT:                                                                              FLUOR OCEAN SERVICES
LOCATION: NORTON SOUND                                                               REPORT FOARSPAGE:    1
                              NORTON SOUND STUDY SCHEDULE
                          30 FOOT MLLW JACKET CONFIGURATION
                               (LEVEL-I SUMMARY SCHEDULE)
CONTRACT: 411093                                                                     STATUS DATE:16-MAR-82
PROJECT MANAGER: JE LACY/BR PIER                                                     DATE: 17-MAR-82
```



```
RN                                 DU IN    EARLY       EARLY
                                   WEEKS    START       FINISH
 1  MODULE DESIGN                   77.9  17-OCT-84    8-APR-86
 2  TOWER/PILE DESIGN               77.9  17-OCT-84    9-APR-86
 3  EQUIPMENT PROCUREMENT          118.1   3-APR-85    2-JUL-87
 4  MATERIAL PROCUREMENT            13.9  15-MAY-85   13-AUG-85
 5  TOWER/PILE FABRICATION          32.0   9-APR-86   12-NOV-86
 6  TOWER/PILE TRANSPORTATION       20.6  27-JAN-87   13-JUN-87
 7  TOWER/PILE INSTALLATION          8.9  30-MAY-87   24-JUL-87
 8  MODULE FABRICATION              65.9   9-APR-86    7-JUL-87
 9  MODULE TRANSPORTATION            4.7   2-JUL-87    2-AUG-87
10  MODULE ERECTION                  3.3  24-JUN-87    9-AUG-87
11  PLANT COMMISSIONING             13.3   9-AUG-87    3-NOV-87

-- NOTES:
(1)  EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2)  CALENDAR DURATIONS BASED ON:
     (A)  8 HR. DAYS, 5 DAYS/WEEK FOR MANAGEMENT, ENGINEERING & PROCUREMENT ACTIVITIES
     (B)  8 HR. DAYS, 6 DAYS/WEEK FOR FABRICATION, LOADOUT, & SEAFASTENING ACTIVITIES
     (C)  24 HR. DAYS, 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES
```

FIGURE 4-1

```
CLIENT:                                                                                                   FLUOR OCEAN SERVICES
LOCATION: NORTON SOUND                                                                                    REPORT RBARSPAGE:    1
                                             NORTON SOUND STUDY SCHEDULE
                                          50 FOOT MLLW JACKET CONFIGURATION
                                              (LEVEL-I SUMMARY SCHEDULE)
CONTRACT: 411093                                                                                          STATUS DATE:16-MAR-82
PROJECT MANAGER: JE LACY/BR PIER                                                                          DATE: 17-MAR-82
--------------------------------------------------------------------------------------------------------------------------------

                                                                    EACH SPACE REPRESENTS ONE WEEK                                                      DU IN  EARLY      EARLY
RN                                                                                                                                                      WEEKS  START      FINISH
                              NOV  DEC JAN  FEB MAR APR MAY  JUN JUL AUG  SEP OCT  NOV DEC JAN  FEB MAR APR MAY  JUN JUL  AUG SEP OCT  NOV DEC JAN  FEB MAR APR  MAY JUN JUL  AUG SEP OCT  NOV
                              84   84  85   85  85  85  85   85  85  85   85  85   85  85  86   86  86  86  86   86  86   86  86  86   86  86  87   87  87  87   87  87  87   87  87  87   87
                              I----I---I----I---I---I---I----I---I---I----I---I----I---I---I----I---I---I---I----I---I----I---I---I----I---I---I----I---I---I----I---I---I----I---I---I----I--I
  1 MODULE DESIGN             IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX     I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I  I  77.9 14-NOV-84  6-MAY-86

  2 TOWER/PILE DESIGN         IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX     I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I  I  77.9 14-NOV-84  6-MAY-86

  3 EQUIPMENT PROCUREMENT     I    I   I    I   I   I   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXI   I   I    I  I 118.1  1-MAY-85 30-JUL-87

  4 MATERIAL PROCUREMENT      I    I   I    I   I   I   I    XXXXXXXXXXXXXX.................................     I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I  I  13.9 12-JUN-85 18-SEP-85

  5 TOWER/PILE FABRICATION    I    I   I    I   I   I   I    I   I   I    I   I    I   I   I    I   I   I   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX............ I   I    I   I   I    I  I  44.4  7-MAY-86  7-MAR-87

  6 TOWER/PILE TRANSPORTATION I    I   I    I   I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   XXXXXXXXXXXXXX   I    I   I   I    I  I  14.9  7-MAR-87 12-JUN-87

  7 TOWER/PILE INSTALLATION   I    I   I    I   I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I  XXXXXXXXXXXX  I   I    I  I  12.9 30-MAY-87 21-AUG-87

  8 MODULE FABRICATION        I    I   I    I   I   I   I    I   I   I    I   I    I   I   I    I   I   I   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXI   I   I    I  I  65.9  7-MAY-86  4-AUG-87

  9 MODULE TRANSPORTATION     I    I   I    I   I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I   XXXXXI   I    I  I   4.4  4-AUG-87 28-AUG-87

 10 MODULE ERECTION           I    I   I    I   I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I XXX   I    I  I   1.7 22-AUG-87  3-SEP-87

 11 PLANT COMMISSIONING       I    I   I    I   I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   XXXXXXXXXXXXX  13.1  4-SEP-87 28-NOV-87

NOTES:
(1)  EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2)  CALENDAR DURATIONS BASED ON:
     (A)  8 HR. DAYS, 5 DAYS/WEEK FOR MANAGEMENT, ENGINEERING & PROCUREMENT ACTIVITIES
     (B)  8 HR. DAYS, 6 DAYS/WEEK FOR FABRICATION, LOADOUT, & SEAFASTENING ACTIVITIES
     (C)  24 HR. DAYS, 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES
```

FIGURE 4–2

```
CLIENT:                                                                                          FLUOR OCEAN SERVICES
LOCATION: NORTON SOUND                                                                           REPORT RBARSPAGE:    1
                                          NORTON SOUND STUDY SCHEDULE
                                      70 FOOT MLLW JACKET CONFIGURATION
                                           (LEVEL-I SUMMARY SCHEDULE)
CONTRACT: 411093                                                                                 STATUS DATE:16-MAR-82
PROJECT MANAGER: JE LACY/BR PIER                                                                 DATE: 17-MAR-82
-----------------------------------------------------------------------------------------------------------------------
                                                                EACH SPACE REPRESENTS ONE WEEK                                                       DU IN   EARLY      EARLY
RN                                                                                                                                                   WEEKS   START      FINISH
                             NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV
                             84  84  85  85  85  85  85  85  85  85  85  85  85  85  86  86  86  86  86  86  86  86  86  86  86  86  87  87  87  87  87  87  87  87  87  87  87
                             I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I
 1 MODULE DESIGN             IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   77.9 15-NOV-84  7-MAY-86

 2 TOWER/PILE DESIGN         IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   77.9 15-NOV-84  7-MAY-86

 3 EQUIPMENT PROCUREMENT     I   I   I   I   I   I   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXI   I   I   I   I  118.1  2-MAY-85 31-JUL-87

 4 MATERIAL PROCUREMENT      I   I   I   I   I   I   I   IXXXXXXXXXXXXXX.................................I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   13.9 13-JUN-85 11-SEP-85

 5 TOWER/PILE FABRICATION    I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX.........I   I   I   I   I   I   46.0  8-MAY-86 19-MAR-87

 6 TOWER/PILE TRANSPORTATION I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXXX  I   I   I   I   I   I   14.0  9-MAR-87  8-JUN-87

 7 TOWER/PILE INSTALLATION   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XXXXXXXXXXXXXI   I   I   I   13.0 30-MAY-87 22-AUG-87

 8 MODULE FABRICATION        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXI   I   I   I   I   65.9  8-MAY-86  5-AUG-87

 9 MODULE TRANSPORTATION     I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXI  I   I   I    4.4  5-AUG-87 29-AUG-87

10 MODULE ERECTION           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I XXX   I   I   I    2.7 23-AUG-87  4-SEP-87

11 PLANT COMMISSIONING       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXX  13.1  5-SEP-87 29-NOV-87

NOTES:
(1)  EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2)  CALENDAR DURATIONS BASED ON:
     (A)  8 HR. DAYS, 5 DAYS/WEEK FOR MANAGEMENT, ENGINEERING & PROCUREMENT ACTIVITIES
     (B)  8 HR. DAYS, 6 DAYS/WEEK FOR FABRICATION, LOADOUT, & SEAFASTENING ACTIVITIES
     (C)  24 HR  DAYS, 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES
```

FIGURE 4-3

4.2.5 Cost Estimates

a. Steel Jacket Platform

The work break-down structure, Figure 4-4, exemplifies the scope of work and related costs for the steel jacket concept by providing data for the 50 foot water depth base case. Table 4-2 summarizes the estimated costs for all three jacket platforms while Tables 4-3, 4-4, and 4-5 provide capital costs in a more detailed format for the concept's 30, 50, and 70 foot water depth cases respectively.

JACKET CONCEPT COST SUMMARY

DESCRIPTION	30' WATER DEPTH ($x1000)	50' WATER DEPTH ($x1000)	70' WATER DEPTH ($x1000)
Structural Fabrication	66,110	76,330	77,670
Module In-Yard Outfitting	92,270	92,270	92,270
Transportation	10,000	10,930	11,115
Installation	18,100	23,725	23,945
Hook-Up/Start-Up/Commissioning	11,490	11,490	11,490
Indirect Costs	8,385	7,050	7,060
Engineering/Construction Mgmt.	21,240	21,740	21,795
Contingency	38,235	39,765	39,985
GRAND TOTAL	$265,830	$283,300	$285,330

TABLE 4-2

JACKET COSTS
30 FOOT (MLLW) BASE CASE

	AMOUNT (US $ x 1000)
ONSHORE WORK	
Structural In-Yard Fabrication	66,110
Module In-Yard Outfitting	92,270
SUB-TOTAL ONSHORE COST	158,380
OFFSHORE WORK	
Transportation	10,000
Installation and Erection	18,100
Hook-Up/Start-Up/Commissioning	11,490
SUB-TOTAL OFFSHORE COST	39,590
TOTAL DIRECT COST	197,970
Mobilization/Demobilization	5,075
Inland Freight on Equipment/Material	2,310
Construction Supplies & Expenses	1,000
TOTAL INDIRECT COST	8,385
Construction Management	5,940
Engineering and Procurement	15,300
Contingency	38,235
TOTAL OTHER COST	59,475
GRAND TOTAL PROJECT COST	$265,830

Table 4-3

JACKET COSTS
50 FOOT (MLLW) BASE CASE

	AMOUNT (US $ x 1000)
ONSHORE WORK	
Structural In-Yard Fabrication	76,330
Module In-Yard Outfitting	92,270
SUB-TOTAL ONSHORE COST	168,600
OFFSHORE WORK	
Transportation	10,930
Installation and Erection	23,725
Hook-Up/Start-Up/Commissioning	11,490
SUB-TOTAL OFFSHORE COST	46,145
TOTAL DIRECT COST	214,745
Mobilization/Demobilization	3,675
Inland Freight on Equipment/Material	2,375
Construction Supplies & Expenses	1,000
TOTAL INDIRECT COST	7,050
Construction Management	6,440
Engineering and Procurement	15,300
Contingency	39,765
TOTAL OTHER COST	61,505
GRAND TOTAL PROJECT COST	$283,300

Table 4-4

JACKET COSTS
70 FOOT (MLLW) BASE CASE

	AMOUNT (US $ x 1000)
ONSHORE WORK	
Structural In-Yard Fabrication	77,670
Module In-Yard Outfitting	92,270
SUB-TOTAL ONSHORE COST	169,940
OFFSHORE WORK	
Transportation	11,115
Installation and Erection	23,945
Hook-Up/Start-Up/Commissioning	11,490
SUB-TOTAL OFFSHORE COST	46,550
TOTAL DIRECT COST	216,490
Mobilization/Demobilization	3,675
Inland Freight on Equipment/Material	2,385
Construction Supplies & Expenses	1,000
TOTAL INDIRECT COST	7,060
Construction Management	6,495
Engineering and Procurement	15,300
Contingency	39,985
TOTAL OTHER COST	61,780
GRAND TOTAL PROJECT COST	$285,330

Table 4-5

Compared to the 50 foot water depth base case; the 30 foot base case is 6 percent less expensive, while the 70 foot base case is less than 1 percent more expensive. Capital costs for the 50 and 70 foot cases are essentially the same. The only notable difference is in the jacket structural costs and jetting requirements. There are two major cost differences between the 50 and 30 foot cases. Primarily due to the piling requirements in each these are: (1) Structural Fabrication Onshore and (2) Installation Offshore. The required pile penetration in the 30 foot case is 280 feet, while the 50 foot case penetration is 330 feet.

b. Concrete Barge Platform

The work break-down structure for the barge concept 30 foot water depth base case, Figure 4-5, shows the scope of work for its topside facilities. Tables 4-6 and 4-7 present the total capital cost estimates for the concrete barge concept's 30 foot water depth base case and 70 foot water depth sensitivity case respectively. The tables incorporate the costs for both the superstructure and the concrete substructure into a single summary to facilitate cost comparisons.

BARGE COSTS
30 FOOT (MLLW) BASE CASE

	AMOUNT (US $ x 1000)
ONSHORE WORK	
Structural In-Yard Fabrication	16,630
Module In-Yard Outfitting	95,980
* Concrete Substructure Construction	13,325
SUB-TOTAL ONSHORE COST	125,935
OFFSHORE WORK	
* Concrete Substructure Assembly	7,900
Module Installation	3,545
* Transportation	6,075
* Deployment	10,680
Hook-Up/Start-Up/Commissioning	11,405
SUB-TOTAL OFFSHORE COST	39,605
TOTAL DIRECT COST	165,540
Mobilization/Demobilization	600
Inland Freight/Spare Parts	2,120
Construction Supplies & Expenses	1,000
* Indirect Costs (Substructure)	16,165
TOTAL INDIRECT COST	19,885
Construction Management	4,965
Superstructure Engineering	12,760
* Substructure Engineering	3,265
Superstructure Contingency	28,735
TOTAL OTHER COST	49,725
GRAND TOTAL PROJECT COST	$235,150

* DENOTES Cost Estimated by ABAM

Table 4-6

BARGE COSTS
70 FOOT (MLLW) SENSITIVITY CASE

	AMOUNT (US $ x 1000)
ONSHORE WORK	
Structural In-Yard Fabrication	16,630
Module In-Yard Outfitting	95,980
* Concrete Substructure Construction	38,100
SUB-TOTAL ONSHORE COST	152,410
OFFSHORE WORK	
* Concrete Substructure Assembly	(in above)
Module Installation	3,545
* Transportation	9,000
* Deployment	19,000
Hook-Up/Start-Up/Commissioning	11,405
SUB-TOTAL OFFSHORE COST	41,750
TOTAL DIRECT COST	194,160
Mobilization/demobilization	600
Inland Freight/Spare Parts	2,120
Construction Supplies & Expenses	1,000
* Indirect Costs (Substructure)	(in TDC)
TOTAL INDIRECT COST	3,720
Construction Management	4,965
Superstructure Engineering	12,760
* Substructure Engineering	4,100
Superstructure Contingency	28,735
TOTAL OTHER COST	50,560
GRAND TOTAL PROJECT COST	$247,940

* DENOTES Cost Estimated by ABAM

Table 4-7

4.3 CONCRETE BARGE CONCEPT

4.3.1 Barge Substructures for 30-Foot Water Depth

a. General

Costs for the concrete production platform are summarized in Table 4-8. All costs are developed based on first quarter 1982 U.S. dollars. Also, costs are based on construction and outfitting of the concrete production platform in the Puget Sound area. The costs are developed in conjunction with the schedule shown on Drawing B-116. The schedule was developed using a standard work week for all Puget Sound construction as 40 hours with exceptions for critical activities as identified in the following sections. On-site construction is based on 84 hour work weeks and two shifts.

The cost of the deployed concrete structure, exclusive of all modular drilling and production equipment, is $57.4 million. This amount does not include taxes. This price further reduces to $31.5 million F.O.B. Puget Sound including the steel weatherdeck, which represents a unit price of $815 per cubic yard. The cost of concrete construction alone amounts to $27.9 million, or $722 per cubic yard F.O.B. Puget Sound. This unit price compares favorably with bid prices on existing floating structures, such as the Valdez floating dock which is currently under construction, and thus lends credibility to the cost estimate.

Overall price for the platform is sensitive to many conditions which cannot be accounted for in an engineering estimate. For instance, current prices for many materials in the Puget Sound area are depressed due to a slow economy.

Availability of suitable facilities and land change dramatically with time and also have great impact on costs. Another consideration which will have an effect on the bidding process is the method of contracting and the risks associated with project scheduling. The proposed schedule has been based upon fast tracking the project where design is not complete at the time of bidding. An important consideration in developing an estimate is whether a general contractor or precaster performs the work. For these items, simple escalation factors are not sufficient for projecting future prices.

b. Indirect Costs

This category includes the following groups of costs: Construction Facilities, Mobilization and Demobilization, Field Staff, and Profit. These categories are an estimate of a contractor's overhead and other hidden costs and are in part speculative. In particular, profit can vary depending on a contractor's current workload. The profit also reflects risks associated with construction techniques and method of contracting (i.e., fast track design and construct). This cost estimate is based on a 15 percent profit on all cost items except marine tow insurance.

Construction facilities includes the cost for key pieces of equipment and land required to perform the work. Included with facilities are the graving dock and nearby storage area and a waterfront site to complete overwater construction items. For the present estimate, availability of property and lease rates were obtained from the Port of Tacoma. This estimate includes a suitable graving dock for $75,000 per month and a 5 acre tract of adjacent land for storage and precasting activities. Also included is a 10 acre site with 500 feet of frontage with adequate draft and no navigational obstructions for the fully assembled platform.

It is recommended that those considering construction of concrete structures should maintain a complete list of West Coast graving docks and routinely monitor their availability. Availability may be assured and rental premiums avoided by reserving these facilities well in advance of their actual need. Should it be possible to foresee construction of more than one production platform, land purchase and construction site development should be considered.

Key pieces of equipment include two 200 ton cranes, one 70 ton crane and four 20 ton cranes. Additionally, two tower cranes are provided for deck and concrete superstructure construction. An activity critical to the overall schedule is the erection of precast panels. To keep a balance between graving dock and crane rental costs and maintain schedule, the two 200 ton cranes are assumed to be working two shifts per day. The 70 ton and one 20 ton crane are used in the storage area to support precast panel storage and erection and also work two shifts per day. All other cranes work single shifts. The crane rental costs include labor.

Small tools, consumable supplies, construction bonds and other similar items are lumped into a general overhead category. These costs are based on 10% of the major materials costs.

Field Staff includes the contractors' salaried employees assigned to the project. Among these are engineers, drafters, accounting, clerical, maintenance and security personnel. Field staff does not include the deployment site contractors' field staff. Deployment costs include a 15% overhead rate applied to deployment costs.

The mobilization category includes costs for establishing a field office and maintaining the office for the duration of the project. Also included are costs for mobilizing and demobilizing equipment such as cranes, tugs, barges, etc. Mobilization costs for both barge assembly and deployment have been included.

c. Direct Costs

Actual costs for acquiring the materials and the labor to complete the structure are included in this category. Labor rates are based on a general contractor performing this work. An average labor rate for the several unions involved of $22 per hour was assumed for all work. This rate includes 40 percent for benefits and taxes. Another method of estimating the work would be to assume a certain percentage of the work completed by a precast concrete supplier. Average labor rates in the precast plants are about $17 per hour, including taxes and benefits. The difference in labor rates is attributable to a specific labor union covering all work in the precast plant.

The labor cost was determined by the labor rate multiplied by the estimated time to perform specific tasks. The time estimate was based on discussions with contractors, using estimating guides such as References 20 and 21, and experience based upon similar construction activities. A factor of 20 percent was included on labor to account for lost time due to equipment failures, weather, accidents and other unforeseeable interruptions.

Material prices were determined by completing a materials quantity take-off and multiplying by unit prices. Unit prices were obtained from vendors. All prices for the barge construction are based on F.O.B. Puget Sound.

Concrete was assumed to be ready-mix delivered to the site. The unit price for lightweight concret (120 lb/cf) was $120 per cubic yard. This is approximately twice the cost of normal weight concrete. The difference is accountable by the high cost of lightweight aggregate. Should projects of this magnitude be considered, developing or locating a more economical source for this aggregate may save possibly $2 million.

In light of the large volume of concrete and in order to assure consistent quality of the concrete supplied to the site, it may well be desirable to establish an on-site batch plant to produce the concrete. Such a plant should have a capacity of approximately 250 cy/day. It should be noted that such a facility would be available in the event the work is performed by a precast concrete fabricator.

Included as material costs in this estimate are concrete forms. The amount of formwork is a function of schedule since a majority of the forms are reuseable.

d. Other Costs

As identified on Table 4-6, Other Costs include design engineering, inspection and project construction management. Each of these costs was determined by applying a percentage rate multiplier to the construction cost.

Design engineering for the concrete structure, excluding equipment and equipment modules, is based on the F.O.B. Puget Sound price of $31.5 million. The rate for this estimate was 4 percent. Compared to industry guidelines for compensation, Reference 22, this rate is low. However, based on actual experience designing other similar modular structures, this fee should be adequate to complete the design. The final design fee could vary between 4 and 7 percent depending upon development of detailed work statements.

The design fee is sensitive to several considerations. One is the availability of timely information from other members of the project team. Information such as modular equipment loads, soils data, bathymetry and so forth must be carefully coordinated. This is especially critical for fast track design which was the basis for the schedule. Engineering for the barge structure commences only 8 months prior to construction start-up. Bid documents would be released about four months into the design. Another factor which influences the design fee is the level of experience of the contractor performing the work.

The design fee for the concrete structure does not include compensation for a soils consultant to do exploratory drilling and develop soils data. Nor do the costs include fees for obtaining bathymetry. These costs were omitted due to potential availability of some of these data from the exploratory oil drilling program. The design fee does not include an estimate for marine engineering. This work would address delivery voyage and deployment requirements such as:

- tow hardware
- towing configuration
- ballasting mechanical system
- ballasting sequence
- ballast dewatering
- positioning arrangements

No costs have been included for review or classification by any certification agencies such as ABS.

e. Deployment Costs

Deployment costs include the cost of a delivery voyage tow from the barge construction site to the deployment site, the costs of site foundation preparation and the costs to position and ballast the gravity structure to its foundation. The basis and assumptions for the deployment cost estimate is described below.

(1) Delivery Voyage: Delivery voyage towing costs have been based on the assumption that the barge structures are constructed and outfitted in Puget Sound, Washington, and delivered to Norton Sound, Alaska. A tow distance of 2300 nautical miles was used for this estimate.

A discussion of tug horsepower requirements is included in Section 3.4.10 of the report. Towing costs have been based upon the use of four 9000 BHP class tugs for the tow. Availability and cost of these tugs was verified through discussion with towing companies. Tug mobilization costs have assumed two of these tugs are available in Puget Sound, one is mobilized from California and one is mobilized from the Gulf of Mexico. Tug demobilization costs assume tugs are demobilized to their previous location.

An average tow speed of 2.5 knots was assumed to determine the 38 day duration of the tow. Additionally, 7 days of weather downtime have been included in the estimate. The cost of demobilization is based upon an 8 knot return voyage.

An estimate for tow insurance has been included in the delivery tow costs. This estimate was based upon discussions with insurance firms with marine insurance background. The cost for tow insurance is based upon a rate of 1-1/2% of the cost of the outfitted structure.

An overhead of 15% has been included on all delivery costs excluding the tow insurance.

Delivery voyage costs do not include a provision for certification or approval of the tow by a classing society such as ABS, nor do they include the fees of naval architects and/or marine engineers who may be responsible for the determination of tug requirements and towing hardware.

(2) Site Construction: Site construction costs have been based upon discussion with dredging companies, who have assisted in the development of durations for various site construction activities, made recommendations for suitable construction equipment spreads, and provided input to equipment and labor rates. The site construction costs include the following:

- mobilization and demobilization of equipment;
- costs to position and initially ballast the barge to the foundation with seawater ballast;
- costs to replace the seawater ballast with granular fill material obtained from the surrounding floor of Norton Sound;
- costs to densify the ballast through dewatering; and
- costs to place riprap material around the perimeter of the structure.

The assumed major site construction equipment:

- One 2000 HP ocean going tug.

- One 26" diameter hydraulic suction dredge mounted on an ocean going barge.
- One 140 ton crane mounted on the above barge.
- One 50 ton mobile crane mounted on the deck of the barge.
- Two 300 cubic yard flatbed barges to transport riprap.

The site construction costs have been based upon the following assumptions:

- Suitable granular fill materials are available within 5000 feet of the foundation.
- Riprap materials are available dockside at Nome. Prices for these materials were discussed in the PMB Report. Current prices are assumed to be $50 per ton. The transportation distance from Nome to the site is 70 nautical miles one way. No port charges have been included.
- An allowance for weather downtime of 20% has been included for each operation.
- Four days have been allowed for a suitable weather window for positioning and initial ballasting.
- An allowance has been made for mechanical systems for ballasting and dewatering. These allowances are order of magnitude estimates only.
- An overhead of 15% has been applied to all site construction costs.

The baseline site construction costs do not include an allowance for site preparation other than scour protection. These costs will be site specific. A discussion of potential magnitudes of these costs is included in the sensitivity study.

Costs for site soil, bathymetric and location surveys are not included in the estimate. Costs for environmental and construction permits are not included in these costs.

f. Schedule

As noted earlier, the schedule per Drawing B-116 assumes a fast track design and construction approach for the concrete barge structure. On the critical path for meeting this target is a June 1 tow-out from Puget Sound. This schedule shows 1987 as the target date for production startup. This is the direct result of working back from the 1 June 1987 tow-out using time required to complete equipment design, procurement, fabrication and erection. A two month minimum allowance is desirable between equipment and barge design startup to develop equipment module design loads and other inputs to the barge design process.

A fast track schedule requires that all supportive data be complete and available at the start of barge design. The data includes:

- results of detailed wave/structure interaction analyses and model tests;
- results of punching shear verification tests;
- soils properties and foundations recommendations;

- bathymetry;

- sufficient topside equipment data; and

- all permits be obtained.

Once the barge structure design had commenced, changing any of the above data will lengthen the schedule or create a cost premium. Missing the schedule with regard to Alaskan construction may mean a year's delay in the project.

For a project of this size, a contractor needs from 30 to 60 days to prepare a thorough bid. An additional 30 days are required to select a contractor and make all contractual arrangements. With other time allowances for assembling a field staff and acquiring facilities and equipment, 4 to 6 months lead time is required for releasing bid tender documents. Drawings at this stage would include principal concrete outlines and main prestress and mild steel reinforcement arrangements. Many of the details such as tendon profiles, auxiliary reinforcement at post-tensioning anchorages and at joints of structural members would be missing. Bids would be higher to cover all these incidentals. In addition, fewer contractors may actually submit bids.

As an alternative, pushing back the design schedule about 8 months would enable obtaining bids on a 100 percent complete design. Another alternative may be to award a design/ construct contract for the barge structure. This was successfully employed for a floating concrete LPG facility for ARCO.

4.7.3 Caisson Structure for 70 foot Water Depth

a. Cost Estimate

A detailed cost estimate for the conceptual design of a 70 foot water depth structure was not attempted. Instead, costs were extrapolated from the estimate for the 30 foot water depth concrete structure. Some investigations were undertaken to enable estimating some of the unique features of this concept.

The base portion of this structure is less complicated than the 30 foot water depth structure. This is due to the 30 foot water depth structure requiring thick, cast-in-place exterior bulkheads and a substantial curved wave bulwark structure. Also shear walls and columns are not needed. By eliminating these components, the entire structure, except the towers, may be precast.

The estimate for the base portion of the structure was based on a concrete unit price for the 30 foot water depth structure. Only those costs up to and including the jointing procedure were included to determine the unit price. This price is approximately $700 per cubic yard. To complete the basic barge structure plus construct precast skid beams will cost $29.3 million including overhead and profit.

Cost of the towers was based on using a jump form construction method. Two towers were constructed simultaneously and two tower cranes were used to support the construction activities. Prices for the jump forms (self-lifting) were based on information obtained from vendors. The cost of all materials and labor required to complete the tower was based on $500 per cubic yard which includes no overhead and profit. This represents the most costly structural component to construct on the 30 foot water depth structure which is the heavily reinforced cast-in-place exterior bulkhead. Total construction cost for the towers is estimated as $6.0 million which includes formwork, overhead and profit.

The cost for erection of equipment modules has been determined by FOS based upon use of floating derick vessels for this function. Cost benefits may result from the use of land based derrick cranes for this function. Cranes exist with the capability to erect the 1100 ton modules while the caisson structure is floating shoreside. Future efforts on the caisson configuration should pursue the cost trade off between land based and floating cranes for erection.

Tow to the site was based on 2 knots for this structure. Duration of tow was 48 days plus 10 days downtime. Total towing cost is $9.0 million including overhead and profit. This includes 1½ percent of the total outfitted structure for tow insurance. Equipment modules were assumed to cost $166 million for determining insurance costs. No profit was included on the tow insurance.

Deployment costs include a 500 foot by 380 foot by 10 foot deep excavation for the platform. The assumed method of grounding is to lower one end of the barge into the excavation first, followed by the opposite end as described in Section 3.5.5. No additional equipment is assumed required to complete this activity. However, the four oceangoing tugs which towed the structure to Norton Sound are assumed to remain at the site and assist through the grounding operation. The additional tug costs are $1.9 million. As an alternate to the tugs, a mooring system could be used if this results in reduced costs.

Disassembly of the weatherdeck is included in the deployment costs. No cost is included however, to transport the structural steel to the mainland. It is assumed that the salvage value of the material is adequate to cover these transportation costs.

Total cost for the deployment activity is $19.0 million. This compares to approximately $12.0 million (including overhead and profit) for the 30 foot water depth structure.

A summary of all individual costs and the total cost of the deployed platform, excluding equipment is summarized in Table 4-9.

It should be noted that the accuracy of this estimate is less than that for the 30 foot water depth due to the preliminary nature of design completeness.

b. Schedule

The 70 foot water depth structure requires 21 more days to tow and deploy at the site than does the 30 foot water depth structure. The schedule for the latter structure showed a mid-September completion date. Few working days, as noted in the "Design Criteria", are available during October. At the opposite end of the construction season, starting the tow too soon may result in more weather down-time during the delivery voyage. The most practical solution is to commence towing the 70 foot water depth structure about 1½ weeks earlier, say mid-to-late May and expect construction to be complete by late September.

Equipment and skid beam erection and module hook-up and check-out should take about the same length of time or about 3 months.

Tower construction is the one task which may be adjusted to accommodate schedule. Using two sets of forms requires about 11 months to complete. Four sets of forms would reduce the construction period in half. However, additional forms would be required and additional equipment such as tower cranes.

Caisson base construction is expected to require approximately 18 months to complete.

It is estimated that the overall schedule for design and construction of the caisson structure will increase by six months with respect to the overall schedule for design and construction of the barge structure.

COST SENSITIVITIES

5.0 COST SENSITIVITIES

5.1 GENERAL

The cost interpolations and extrapolations presented in this section are based on independent engineering assessments of both the steel jacket and concrete barge concepts. Assessments were conducted using sensitivity analyses, where a given parameter was varied within realistic limits while other parameters were held constant. The parameters analyzed were accepted by consensus of the participants. Common to both concept studies are the parameters of water depth, production rate, and ice force intensities. Other parameters assessed include an integrated deck scheme for the jacket concept, and foundation characteristics and wave directionality for the barge concept. Cost break-downs for each sensitivity study are provided in Addendum D of Volume II.

5.2 STEEL JACKET CONCEPT

5.2.1 Water Depth

The scope of work for development of the steel jacket concept included preliminary designs for 30, 50, and 70 foot of water; which bracket the vast majority of water depths within the scheduled lease sale area. Items directly controlled by water depth include:

(1) Leg length and thicknesses
(2) Skid beam dimensions
(3) Transverse girder dimensions
(4) Pile pentration and wall thickness
(5) Jetting requirements
(6) Derrick vessels

With topside weight shedding and lesser capacity derrick vessels, the 30 water depth base case can be extended shallower to a 20 foot water depth limited only by the minimum keel clearance (2 fathoms) of the derrick vessel. The 70 foot water depth case can be extended deeper to an unknown depth where economics will necessitate a change in concept. Between the 50 and 70 foot water depth cases, due to the required jetting of the tower below the mudline, the substructure's height change is minimal and the height of ice loading relative to its lower centroid is constant. The jetting is required to situate the tower's lower framing plan below the ice rubble pile. Thus, the incremental rate of cost increase between these cases is relatively small. The break-over points for this effect are about at 45 and 75 feet of water. For shallower and deeper waters, the structure's height changes significantly. Water depth versus cost is assumed to be a linear function between the above discontinuities. Base case costs are provided earlier in Table 4-2 and in Figure 1-4. Data for the remaining parameters were developed from the jacket concept's 50 foot base case, using similar analytical techniques.

5.2.2 Production Rate

Production requirements for both jacket and barge preliminary designs were based on a major field production scenario of 120,000 BOPD (Case II). Two alternate flow rates were assessed: Case I - 60,000 BOPD and Case III - 180,000. The variability of flow rate principally changes major equipment retention time, injection requirements, and supporting structure. Items of equipment directly affected by flow rate include:

(1) High pressure separators
(2) Produced water injection pumps

(3) Crude oil booster pumps
(4) Main oil line pumps
(5) Injection gas compressors
(6) Injection gas coolers

The only structurally significant change for Case I is the elimination of one train of injection equipment. Neither the modules nor the substructures would alter configurations and topside weight would decrease only insignificantly.

For Case III, the structurally significant changes are more numerous. One additional module for two injection gas trains and pumps, and one additional module for one separator and a crude oil booster pump would be required for the barge concept. For the jacket concept, the changes would be as follows:

(1) Module PA (North of Module WA) -
    (a) Motor Control Center (EE-1)
    (b) Control Room (EE-3)
    (c) Produced Water Filters (ME-7)
    (d) Diving System (SP-5)

(2) Module PB -
    (a) High Pressure Separator (V-1C, Added)
    (b) Crude Oil Booster Pump (P-1C, Added)

(3) Module PC -
    (a) Main Oil Line Pump (P-2C, Added)

(4) Module PD -
    (a) Injection Gas Compressor (C-1D & E, Added)
    (b) Injection Gas Coolers (E-1D & E, Added)

Except for the steel associated with the added 25' x 156' x 30' module WA, the only structural change in the tower is the extension and enlargement of the north cantilever skid beams. Differential costs between Cases I, II, and III for the steel jacket concept are shown in Table 5-1 and Figure 1-5.

JACKET CONCEPT
PRODUCTION RATE
DIFFERENTIAL COSTS

DESCRIPTION	AMOUNT (US $ x 1000) 60,000 BOPD CASE I	120,000 BOPD CASE II	180,000 BOPD CASE III
ONSHORE WORK			
Structural In-Yard Fabrication	76,330	76,330	78,200
Module In-Yard Outfitting	87,600	92,270	102,140
TOTAL ONSHORE COST	163,930	168,600	180,340
OFFSHORE WORK			
Transportation	10,930	10,930	10,930
Installation and Erection	23,725	23,725	23,725
Hook-Up/Start-Up/Commissioning	10,415	11,490	13,820
TOTAL OFFSHORE COST	45,070	46,145	48,475
TOTAL DIRECT COST	209,000	214,745	228,815
Mobilization/Demobilization	3,675	3,675	3,675
Inland Freight/Spare Parts	2,315	2,375	2,510
Construction Supplies & Expenses	1,000	1,000	1,000
TOTAL INDIRECT COST	6,990	7,050	7,185
Construction Management	6,270	6,440	6,865
Engineering and Procurement	14,630	15,300	16,020
Contingency	38,850	39,765	42,455
TOTAL OTHER COST	59,750	61,505	65,340
GRAND TOTAL PROJECT COST	$275,740	$283,300	$301,340

TABLE 5-1

5.2.3 Ice Force Intensities

Global and local ice force intensities used in development of the jacket concept's preliminary designs were based on maximum confined and unconfined compressive strengths of 400 and 250 psi respectively (Case II). With the assumption that the concrete within the leg annulus uniformly distributes the local ice forces around the leg, as discussed earlier, it was found that the tower legs are not sensitive to local ice force intensity. However, all structures impacted by ice are sensitive to the global loadings. Two additional maximum unconfined compressive strengths, therefore, were assessed: Case I - 188 psi and Case III - 312 psi. The structural elements directly controlled by global ice force intensity include:

(1) Leg wall thicknesses
(2) Pile penetration and wall thickness

The jacket concept is highly sensitive to global ice intensity as the member changes provided in Table 5-2 show. Differential costs between Cases I, II, and III for the steel jacket concept are shown in Table 5-3 and Figure 1-6.

NORTON SOUND STUDY
JACKET CONCEPT
GLOBAL ICE CHANGES (50 FOOT CASE)

STRUCTURAL ELEMENTS	CASE I (188 PSI)	CASE II (250 PSI)	CASE III (312 PSI)
WELL LEG	24' Ø x 0.75" 28' Ø x 1.50"	24' Ø x 1.00" 28' Ø x 1.50"	24' Ø x 1.00" 28' Ø x 2.00"
RISER LEG	16' Ø x 1.00"(–) 20' Ø x 1.75"(–)	16' Ø x 1.00" 20' Ø x 1.75"	16' Ø x 1.25" 20' Ø x 2.00"
PILING:			
SIZE	12' Ø x 2.00"	12' Ø x 2.50"	12' Ø x 3.00"
PENETRATION	270'	330'	400'

TABLE 5–2

JACKET CONCEPT
GLOBAL ICE FORCE
DIFFERENTIAL COSTS

DESCRIPTION	AMOUNT (US $ x 1000) 188 PSI CASE I	250 PSI CASE II	312 PSI CASE III
ONSHORE WORK			
Structural In-Yard Fabrication	69,015	76,330	85,780
Module In-Yard Outfitting	92,270	92,270	92,270
TOTAL ONSHORE COST	161,285	168,600	178,050
OFFSHORE WORK			
Transportation	10,930	10,930	10,930
Installation and Erection	16,585	23,725	33,925
Hook-Up/Start-Up/Commissioning	11,490	11,490	11,490
TOTAL OFFSHORE COST	39,005	46,145	56,345
TOTAL DIRECT COST	200,290	214,745	234,395
Mobilization/Demobilization	3,675	3,675	3,675
Inland Freight/Spare Parts	2,310	2,375	2,460
Construction Supplies & Expenses	1,000	1,000	1,000
TOTAL INDIRECT COST	6,985	7,050	7,135
Construction Management	6,010	6,440	7,030
Engineering and Procurement	14,020	15,300	16,400
Contingency	37,280	39,765	43,450
TOTAL OTHER COST	57,310	61,505	66,880
GRAND TOTAL PROJECT COST	$264,585	$283,300	$308,410

TABLE 5-3

5.2.4 Integrated Deck

The jacket concept's preliminary designs are based on a modular scenario for fabrication, outfitting, transportation, and erection of topside facilities. The feasibility of integrating the modules and mechanically completing these facilities within the fabrication yard, transporting one unit to site, and erecting the unit in one operation was alternately assessed. A potentially cost effective construction scenario is discussed below.

The tower would be fabricated in two sections, above and below EL(+) 6 foot. Tasks associated with the lower section's fabrication, transportation, and installation would remain as described earlier. The tower's minimum draft would be reduced to nominally 21 feet, while its stability would be significantly enhanced by 10 feet of freeboard.

In-yard tasks associated with the integrated deck would include fabrication, outfitting, and loadout. The upper tower section would incorporate all necessary framing to accommodate the facilities. To the maximum extent possible; all equipment would be installed, piped, and mechanically completed. The assembled unit would be skidded out of the yard to the water front along a piled skidway. There; two cargo barges would be brought along each side of the unit, deballasted, and secured for towout. Further deballasting would lift the unit off the skidways to permit towout.

After towout, trim ballasting, and final preparations for voyage; the spread would depart for Norton Sound. Two ocean-going tugs would tow the integrated deck barges to the installation site using an equalizing bridle. Erection would commence immediately upon arrival, given suitable seas and forecast.

The tugs would maneuver the unit alongside the pre-anchored derrick vessel. After lines have been attached from the vessel's onboard winches to one barge, the two tugs would attach lines to the other barge. The derick vessel would pay-out sufficient line to position the unit midway between, then the barges would be deballasted to a suitable draft for maneuvering over the lower tower section. The cargo barges' anchors would be deployed and lines tightened for setting the unit.

With due care, the cargo barges would then be ballasted to set the unit onto the lower tower section, aligned by temporary guides on the lower section. Weld-out of the internal leg sleeves from inside the legs would commence at the earliest opportunity, followed by removal of the guides and weld-out of the legs' external sleeves. The leg annuluses would be filled with concrete while the platform is commissioned and conductors are being driven.

Clearly, several naval architectural and structural engineering considerations must be resolved before adopting such a method. The most salient of these considerations include:

(1) Catamaran vs. Independent Barge System -
  - o Hull stability,
  - o Deck accelerations,
  - o Primary support, and
  - o Secondary reinforcement.

(2) Pin Joint vs. Rigid Connections -
  - o System behavior,
  - o Deck fatigue,
  - o Constructability, and
  - o Onsite derigging.

(3) Miscellaneous -
  - Tension reactions during quartering seas and
  - Economics of loadout civil work.

Because of these considerations, it would be premature to offer a more definitive rationale at this time. However, cost benefits for an integrated deck scheme inclued:

(1) Less Topside Structural Materials and Weight
(2) Mechanical Completion within Fabrication Yard
(3) Improved Tower Draft and Stability
(4) Reduced Onsite Craneage Requirements (one 800/1000 ton derick vessel only)
(5) Fewer Transportation Spreads
(6) Shorter Onsite Construction
(7) Earlier Drilling and Production

Savings associated with the benefits, not considering the early production, could be in the order of $25 MM provided that technical and cost effective solutions are found for the earlier expressed concerns. Thus to fully exploit the potential benefits, future design must early establish the feasibility of the scheme and then optimize the topside configuration.

5.2.5 Other Significant Parameters

During the preliminary design process, numerous parameters were identified which significantly influence the jacket concept's costs. Candidate parameters for sensitivity analyses were limited to a select few, believed to have the greatest influence on jacket costs. Provided in Table 5-5 are the remaining parameters, not subjected to sensitivity analysis.

NORTON SOUND STUDY
JACKET CONCEPT
SIGNIFICANT PARAMETERS

PARAMETERS	COST SENSITIVITY INDICIES
AMBIENT AIR TEMPERATURE	6
WEATHER DOWNTIME	10
SEABED SOIL CONSOLIDATION	7
SUBSURFACE SOIL CHARACTERISTICS	8
UNDERLYING BEDROCK	9
RESERVOIR CONDITIONS (PERMEABILITY & POROSITY)	10
SPARING PHILOSOPHY (OPERATING & MAINTENANCE)	9
WELLHEAD FLOWING CONDITIONS (PRESSURE & TEMPERATURE)	8
WELL FLUID COMPOSITION (GOR & MATERIAL BALANCE)	7
TRANSPORT CONDITIONS (STABILIZATION, VISCOSITY, & FRICTION LOSS)	6
RE–SUPPLY/WASTE DISPOSAL	4
MANNING LEVEL	2

TABLE 5–4

along with a sensitivity index derived by engineering judgement. The index ranges from 1 to 10, with the higher numbers assigned to parameters for which the jacket concept would probably be more sensitive.

5.3 CONCRETE BARGE CONCEPT

Varying levels of uncertainty exist among the environmental criteria which control the design of various components of the barge structures. Additionally, criteria such as foundation characteristics and production requirements are site specific and can vary to some extent. For these reasons, the cost sensitivity to variations of specific controlling criteria have been identified in order to assist the planning efforts of the participants. Cost sensitivities have been determined by applying unit costs from the basic design to quantity variations which result from changes in specific criteria. Where appropriate, factors have been applied to account for increased complexity of construction. The following cost sensitivities have been investigated:

- Increased water depth.
- Multi-directional extreme event wave loadings.
- Global and local ice loadings.
- Foundation characteristics.
- Production capabilities.

5.3.1 Increased Water Depth

A feasibility study has been performed of a caisson structural concept for application in 70 foot water depths. This concept is discussed in detail in Section 3.5 of the report, including a definition of the costs for construction and deployment of this facility.

As discussed in Section 3.5, the level of accuracy of the cost estimate for the caisson structure is less than that of the barge concept for 30 foot water depths or the basic steel jacket concept costs. The accuracy of the costs of the installed caisson structure alone may be on the order of +40%, -20%, while the costs of the modular superstructure should be within ±20%. Figure 5-1 shows the relationship between water depth and the installed cost of concrete platform structures. In order to allow comparison with steel jacket costs which are within the ±20% level of accuracy, the concrete caisson substructure costs (items denoted by an asterisk in table 4-7) have been increased by 20%. Thus the level of accuracy of the upper curve is +20%, -40%. Figure 5-1 also indicates that the cost of concrete gravity structures will begin to increase at some water depth less than 30 feet. This results from the increased significance of platform draft in shallower waters.

5.3.2 Multi-Directional Extreme Event Wave Loadings

The basic design for the barge substructure in 30 foot water depths is based upon the criteria that the heading of extreme event wave loadings is from a southwesterly direction. It was assumed that the long axis of the barge would be aligned with the principle direction of wave progress. From an operational standpoint, it may be desirable to orient the barge without regard to environmental considerations, thus the costs associated with multi-directional wave heading have been addressed.

A barge structure with plan dimensions of 280 feet by 400 feet is able to accommodate the global loadings resulting from the 100 year return wave at any wave heading.

This structure can be constructed with the same modular bulkhead arrangement as was used in the basic design, except with

NORTON SOUND STUDY

WATER DEPTH
VS.
CONCRETE PLATFORM INSTALLED COST

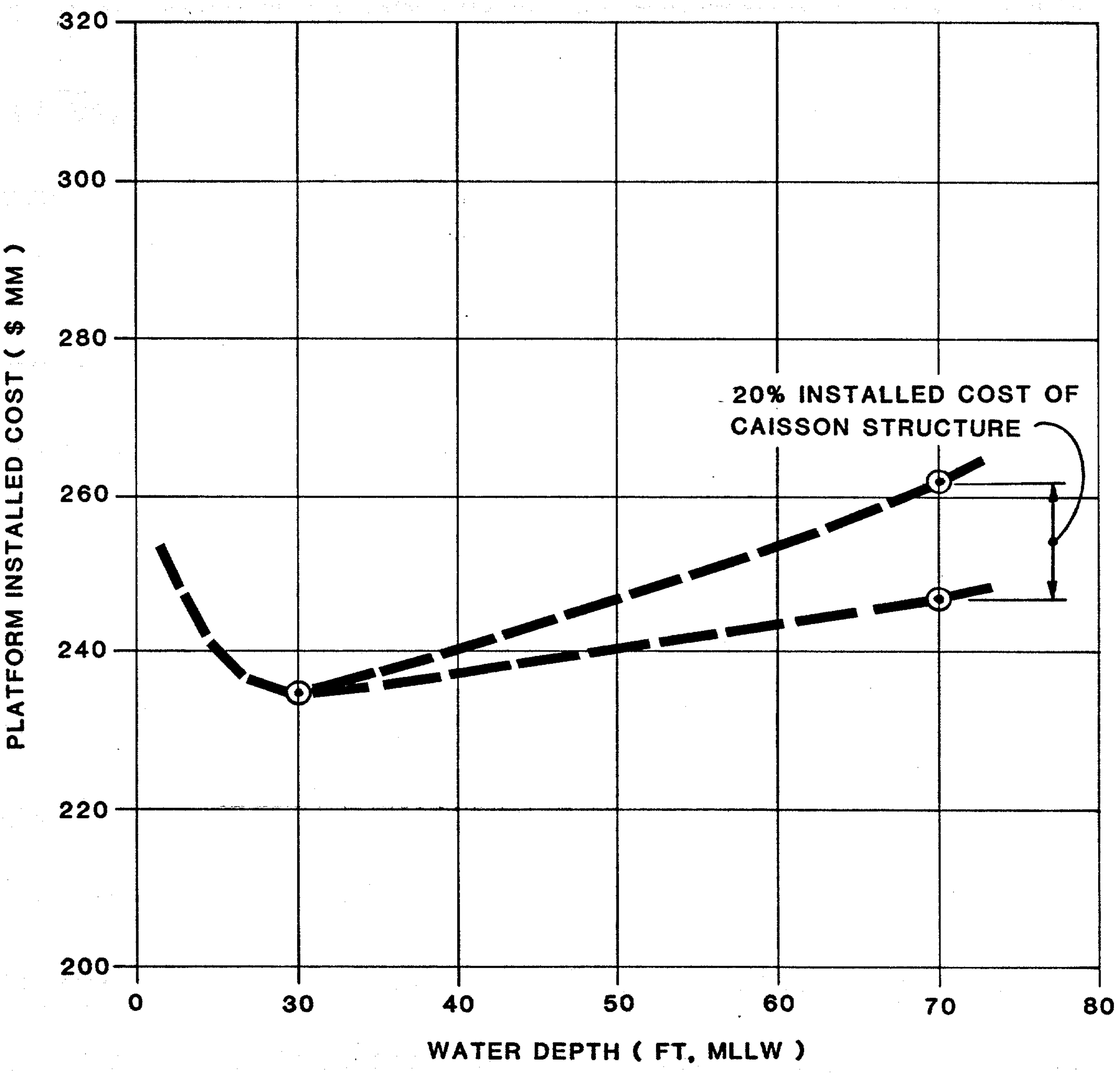


FIGURE 5-1

longitudinal bulkheads spaced at 40 feet and transverse bulkheads spaced at 20 feet. Delta plates have been used at each end of the longitudinal bulkheads in order to maintain an exterior bulkhead span of 20 feet. This arrangement allows the thickness of bulkhead elements to remain equal to those in the basic design.

With this framing arrangement the primary span of the keel and deck plates is in the longitudinal direction; however the reduction in length of the barge reduces longitudinal global bending stresses and allows the use of the same level of longitudinal prestress. In order to accommodate the increased dynamic wave pressures, the width of the concrete bulwark must increase to 40 feet around the perimeter of the barge. The dynamic wave pressures applied to the long face of the barge requires the provision of approximately 9 feet of granular ballast above the main deck level at Elevation (+)10 foot.

The computation of global wave forces in this direction has included a reduction factor which accounts for the probability of a coherent wave crest applied to the full 400 foot dimension. This factor is taken from Section 1.1.3.6 of the "Design Specifications".

In order to be constructed in existing facilities, this structure is assembled in 3 segments. Two are 140 feet by 280 feet in plan dimensions and one is 120 feet by 280 feet. This increases the total length of barge construction joint and requires two jointing operations. In addition, the complexity of the joint increases due to the higher magnitude of prestress in the longitudinal direction. This arrangement of construction joints is selected since the 40 foot spacing of longitudinal bulkheads will not allow construction in two 140 foot wide segments. The 280 foot by 400 foot plan dimensions will allow the existing arrangement of production modules and skid beam system to be utilized without change. While the quantity of bulkhead elements increases, the resulting increase in waterplane area will provide sufficient bottom clearance for deployment in 30 foot water depths.

As a result of these considerations, the cost of the deployed barge substructure (exclusive of the costs to furnish, erect and hook up production modules) increases by $3,960,000 with respect to the basic design. The schedule for design and deployment of a concrete barge structure designed for multi-directional extreme event wave headings will increase by an estimated 2-3 months with respect to that for the basic design.

5.3.3 Global and Local Ice Loadings

The basic designs for Norton Sound Production Structures is based upon a confined ice compressive strength of 400 psi.

This results in a global ice force equal to 210 kips per foot and local ice contact pressures which are a function of the loaded area. This relationship is presented in Section 1.1.5.3 of the "Design Specification".

Cost and schedule sensitivities have been determined for an increase in the confined ice compressive strength to 600 psi. It has been assumed that this results in global ice loadings of 315 kips per foot and local ice loadings which are obtained by increasing ice pressures from Section 1.1.5.3 of the "Design Specification" by 50 percent. It has also been assumed that the maximum thickness of ice remains at 8 feet.

As a result of the increased ice pressures, the thickness of the exterior bulkhead in the ice contact zone must increase to

42 inches. Additionally, the increased ice loading results in the requirement to increase the thickness of non-watertight transverse bulkheads to 14 inches in order to provide sufficient global shear capacity. As a result of the increased weight of these elements the draft of the barge increases by approximately 0.6 feet, still allowing sufficient bottom clearance for 30 foot water depths. The impact on draft at the time of launch from a graving dock is less severe since the exterior bulkhead is constructed subsequent to launch.

The increased global ice loading and the increase in the combined sesimic-plus-ice load combination does not result in an increased requirement for granular ballast fill since the ballast quantity required is controlled by global wave loadings.

As a result of the increased ice loadings, the estimated increase in the cost of barge construction and deployment is $712,000 with respect to the basic design. The schedule impact will be negligible.

It should be noted that the impact of the increased ice loadings is not totally reflected in the cost change given above. The 36 inch exterior bulkhead thickness in the basic design is based upon a design for lightweight concrete with a 28 day compressive strength of 6000 psi. The 42 inch thickness is based upon the current position that the exterior bulkhead will be normal weight concrete with a compressive strength of 7000 psi.

5.3.4 Foundation Characteristics

The basic cost for the concrete barge structure for 30 foot water does not include an allowance for foundation preparation since these costs are site-specific. Cost and schedule sensitivities have been identified for assumed worst case soil conditions. These conditions have assumed a 10 foot thick lens of organic material throughout the plan area of the barge foundation.

Organic materials have been assumed removed with the hydraulic suction dredge unit which is used for barge ballasting operations. Gravel has been used as a backfill material. According to Reference 3 suitable gravel is available at Nome. Material costs given in the reference have been used and escalated to $8.50 per cubic yard. These materials have been transported to the deployment site with 5 tugs--each towing two 300 cubic yard flatbed barges. It is assumed that backfilled materials are leveled using screed pulled by tugs.

A quantity of 86,000 cubic yards has been used for the excavation and backfill materials. This accounts for the estimated positional tolerances of ±70 feet, assuming barge positioning by tugs. These quantities can be reduced through the use of a fixed mooring system for positioning and a study of the tradeoff between the cost of this mooring system and the reduced foundation preparation costs is recommended.

The estimated cost of foundation preparation for this assumed worst case soil condition is $12,309,000. This degree of site preparation will increase the duration of deployment site construction activities an estimated 48 days. This activity can be accomplished prior to arrival of the barge, and thus has no impact on the overall platform construction schedule.

The foundation bearing capacities given in the "Design Specification" are more than adequate to resist the applied foundation loadings. This will allow the use of additional ballast in the event soil sliding capacities are lower than those given in the Design Specification. The main deck of the basic barge structure has sufficient capacity to accommodate approximately 9 feet of granular ballast at a density of 115 pcf. This would allow an additional vertical reaction of approximately 75,000 kips or a total ballast capacity of 443,874 kips which would resist the design global longitudinal wave force with soils having a friction coefficient of 0.4, or an angle of internal friction of 22°.

Thus, the basic barge design is expected to provide sufficient sliding resistance in granular soils without a requirement for skirts and without exceeding foundation bearing capacities. In the event clay soils are expected the soil/structure interface would require further investigation. An extensive skirt system may be necessary in this event to mobilize sufficient sliding resistance and yet remain within the lower bearing capacities of clay soils.

5.3.5 Production Capabilities

In order to extend production capabilities it may be necessary to add one additional module. The basic design has provided a skid beam system to accommodate up to 25 modules while only 20 have been used. The barge bottom clearance would be reduced approximately 0.4 feet with an additional weight of 1250 tons.

Differential costs between Cases I, II, and III for the concrete barge concept - as prepared by FOS and discussed in Section 5.2.2 - are shown in Table 5-5 and Figure 1.5.

BARGE CONCEPT
PRODUCTION RATE
DIFFERENTIAL COSTS

DESCRIPTION	AMOUNT (US $ x 1000) 60,000 BOPD CASE I	 120,000 BOPD CASE II	 180,000 BOPD CASE III
ONSHORE WORK			
Structural In-Yard Fabrication	16,630	16,630	17,105
Module In-Yard Outfitting	90,660	95,980	107,195
TOTAL ONSHORE COST	107,290	112,610	124,300
OFFSHORE WORK			
Transportation	(In Installation Costs)		
Installation and Erection	3,545	3,545	3,775
Hook-Up/Start-Up/Commissioning	10,205	11,405	13,790
TOTAL OFFSHORE COST	13,750	14,950	17,565
TOTAL DIRECT COST	121,040	127,560	141,865
Mobilization/Demobilization	600	600	600
Inland Freight/Spare Parts	2,055	2,120	2,270
Construction Supplies & Expenses	1,000	1,000	1,000
TOTAL INDIRECT COST	3,655	3,720	3,870
Construction Management	4,765	4,965	5,390
Engineering and Procurement	12,100	12,760	14,185
Contingency	27,245	28,735	31,850
TOTAL OTHER COST	44,110	46,460	51,425
BARGE WORK TOTAL COST (See Table 4-6)	57,410	57,410	57,410
GRAND TOTAL PROJECT COST	$226,215	$235,150	$254,570

TABLE 5-5

FUTURE INVESTIGATIONS

6.0 FUTURE INVESTIGATIONS

6.1 GENERAL

The engineering concerns expressed hereafter represent the most salient problems, and thus considerations for further development of both the steel jacket and concrete barge concepts. It is not unusual for a study of this nature to uncover more concerns than orginally confronted with. The following are not necessarily offered in order of relative importance.

6.2 TOPSIDE FACILITIES

6.2.1 Emergency Egress

A paramount consideration in design of any platform is means for abandonment during emergencies. Survival craft, personnel basket/standby vessel, and rung ladder systems today are used throughout the industry to provide primary, secondary, and tertiary egress. All of these systems are present in the preliminary designs presented herein and should well serve the platform in the absence of sea ice. However, the suitability of a normal survival craft for primary egress in Norton Sound's hostile environment is questionable considering winter sea ice and the durability of fiber glass. Alternate primary egress systems were not investigated during the preliminary design process as their cost would be insignificant compared to other items and operations. Potential alternates include air transport and/or retractable stair towers for the winter months. Future designs for Norton Sound must include the determination of suitable primary egress systems.

6.2.2 Waste Heat Recovery

A common practice today is to situate heat exchanges within turbine exhausts to inexpensively recover heat for various uses. The topside facilities preliminary designs presented in this study use steam to heat internal spaces. These designs also use gas turbine drivers for various tasks. Using heat exchangers in lieu of steam generators should be a lighter, less space consuming, and less expensive means to heat the platform. Waste heat recovery should probably be used for future designs in Norton Sound with due consideration for creature comfort and structural integrity should turbine start-up be delayed.

6.3 JACKET SUBSTRUCTURES

6.3.1 Sea Ice

The tower's foundation piling is highly sensitive to global ice loads as learned through the sensitivity analyses. The preliminary tower designs in this study are based on one of many ice loading scenarios and an assumed distribution amongst the legs. This basis for design provides adequate information for cost estimating to the desired level of accuracy, but is perhaps insufficient for future final designs. Model tests should be performed for this configuration prior to the design for determining appropriate loading scenarios and distribution patterns. The model tests could also be used in development of the appropriate criteria.

6.3.2 Foundation

Conservative geotechnic criteria used in development of tower preliminary designs was based on the limited information currently available for Norton Sound. Since piling fabrication and installation costs are a major cost component, future site investigations could dramatically change each case's estimated costs and schedules. Further soil borings will no doubt be made to provide suitable criteria for future final design.

The stiffness and contribution of the conductors to the tower's foundation was not considered in the preliminary designs. These conductors are in fact a significant component of the tower's foundation because of their number, location, and penetration. Future design efforts should endeavor to optimize the joint piling/conductor foundation.

For the purposes of this cost study, it was initially assumed that the tower's piling could be attached to the legs by conventional pile sleeves with shear lugs and annulus grouting. Conventional grouting will in fact require a substantially longer length to transfer the load than currently provided by the preliminary designs' pile sleeves. Potential alternatives to conventional grout include high-strength grout, underwater welding, hyperbaric welding, and mechanical connections. These alternatives were not examined in detail. Moreover, optimization of the sleeve/leg connections by substituting truss framing for shear plates was not performed. The shear plate connections, however, provide a good approximation of the quantity of steel that will be required to make such a connection. Future designs using the jacket concept must early address both areas to develop a cost-effective solution.

6.3.3 Construction

Climatic conditions in Norton Sound severely limit the available workingtime during the relatively short construction season. Although the preponderence of evidence supports completing the entire platform installation within one season, future final designs must optimize required construction tasks in terms of cost and time.

Based on sensitivity analysis, an integrated deck construction scenario could make a major contribution to the above endeavor. The integrated deck construction scenario warrants future investigation.

6.4 BARGE SUBSTRUCTURES

The following investigations are recommended in order to reduce the level of uncertainty in various criteria, to allow optimization of barge costs or to verify certain design procedures which have been based upon extrapolated empirical data.

6.4.1 Punching Shear Design Procedures

Empirical data has been extrapolated to determine the punching shear capacity of the exterior bulkheads and concrete bulwarks. This data determined ultimate capacities of small scale specimens of circular, simply supported slabs with mild steel reinforcement. This data indicates shear capacities which are significantly greater than those indicated in ACI 318-77. A test program is recommended to verify the punching shear capacity of slabs having the geometry, edge restraint and reinforcement arrangements of the exterior bulkhead panels. This testing program should have the following goals:

- Verify the punching shear capacities which have been used in the design.

- Determine optimum arrangements of prestressing and reinforcing steel.

- Investigate provisions necessary to furnish serviceability in plates subject to large punching shears.

6.4.2 Wave/Structure Interaction

The effects of waves appear to have the greatest impact on the design of gravity structures in Norton Sound. More detailed wave diffraction analyses and model tests are recommended to obtain a better indication of the wave/structure interaction. The following should be investigated:

- The magnitude of global and local wave pressures which are applied to the bulkhead and bulwark plating.

- The effectiveness of the wave deflector design and a comparison with alternate deflector designs.

- The effectiveness of alternate methods of erosion/scour protection.

- Wave form over the submerged base of the caisson structure.

6.4.3 Lightweight Concrete Development

Various lightweight concrete mix designs should be investigated in order to optimize critical properties of the material. It appears that the potential exists to extend lightweight concrete strengths well beyond 6000 psi, thus allowing more efficient designs. Additionally, the determination of tensile, shear and bond properties can eliminate the requirement to use general code reduction factors for lightweight concretes, thus resulting in cost benefits. Testing should also define freeze-thaw and abrasion characteristics of lightweight concretes. Concrete mix designs should be developed which allow placement of concrete by pumping. The consequences of pre-saturated aggregates on freeze-thaw durability should be determined.

6.4.4 Delivery Voyage Tow Response

Model testing should be performed to verify tug horsepower requirements for the delivery voyage. Calculations indicate the requirement of a large number of tugs resulting from the design delivery voyage seastate. Model testing should verify tug power requirements and investigate methods to reduce tow resistance.

6.4.5 Optimization of Structural Design

Detailed analysis of load paths in the barge plating elements are likely to result in an optimization of barge costs and weight. Areas of particular interest is the exterior bulkhead element and its supporting plate elements.

Additionally, an investigation of the removal of the main deck at Elevation (+)10 foot may provide significant cost and weight savings. This would require stiffening of the top of the bulkhead elements in order to accommodate global hogging and sagging stresses.

Once site-specific soils data are available a detailed analysis of the load paths in bulkhead elements and the soil/structure interaction will be able to better define foundation preparation requirements.

6.4.6 Concrete Gravity Structure for 70 foot Water Depths

The concrete gravity structure concept developed in the feasibility study appears to offer significant benefits in the reduction of global forces. Further development of this concept is recommended. The following items should be addressed:

- Detailed analyses of global and local loadings.
- Optimization of tower construction, skid beam construction and modular superstructure erection procedures.
- Investigation of response to delivery voyage seastates.
- Further development and optimization of ballasting requirements to assure stability of the structure during grounding operations.

FUTURE INVESTIGATIONS

FINAL REPORT

MAY 1982

VOLUME II

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EVALUATION OF STRUCTURAL CONCEPTS
FOR
NORTON SOUND LEASE SALE AREA

FINAL REPORT

MAY 1982

VOLUME II

FLUOR OCEAN SERVICES, INC.

HOUSTON, TEXAS

CONTRACT NO. 411093

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DESIGN SPECIFICATIONS

ADDENDUM A

Design Specifications For Evaluation Of Structural Concepts for Norton Sound Lease Sale Area, Revision 3.

INTRODUCTION

The Evaluation of Structural Concepts for Norton Sound Lease Sale Area was a joint industry study commissioned by the following organizations:

- Gulf Research and Development Company
- Marathon Oil Company
- Mobil Oil Corporation
- Occidental Exploration and Production Company
- Pennzoil Company
- Phillips Petroleum Company
- SOHIO Petroleum Company
- Standard Oil Company of California
- Texaco, Incorporated

The mission of this project was to provide the program's participants with additional planning information prior to the OCS Lease Sale 57, anticipated November 1982. Project objectives included preliminary designs, feasible construction procedures, estimated capital costs and development schedules, and cost/schedule sensitivities for: (1) Steel Piled Jackets with Modular Decks concept, and (2) Concrete Gravity Barges with Integrated Decks concept.

The intent of this document, Design Specifications, was to furnish the program's participants with the criteria that both Fluor Ocean Services and ABAM Engineers would work to for the preliminary design of these structures. This control document was subject to periodic revision based on knowledge gained during the project. Construction planning not specifically addressed herein, required further evaluation.

Structural demands in Norton Sound, centered on the 64th parallel off Alaska's West Coast, differ from those of the Beaufort Sea. Wave climate, storm surge, and seismic risks are greater; while ice conditions are less severe.

A major field production scenario is common to all designs. Facilities are self-contained, and outfitted with all equipment necessary for drilling, production, and quartering. Oil production is transported to a remote terminal or shore facility through a submarine pipeline. Gas production, in excess of onboard fuel-gas requirements , is reinjected. Produced water is also reinjected. Oil storage, tanker mooring, or equipment for sour production is not considered.

Three non-specific site locations are evaluated to represent the different environmental conditions present in this area. The jacket concept is considered for 30, 50, and 70 feet water depths; while the barge concept is considered for a 30 feet water depth.

The information presented in this document is organized into four major sections. Section 1, Uniform Design Criteria, presents specifications common to all structural components. Component specific criteria is provided within Sections 2, 3, and 4: Design Basis-Modules, Design Basis-Jacket Substructures, and Design Basis-Barge Substructures.

1.0 UNIFORM DESIGN CRITERIA

The study was conducted using a series of design criteria which are especially applicable to the local climate, geotechnic and seismic extremes of Norton Sound; and additionally to the degree of remoteness of this area to the industrial regions where steel and concrete structures are being fabricated.

Some items of equipment are highly sensitive to variations in the magnitude of specific parameters, while others are not. One goal for this study was to make comparisons of the structural concepts. It follows that the validity of the comparisons, to a considerable extent, depended on the successful specification of design criteria for the area. A rational basis for comparisons of these concepts could begin only after an adoption of a uniform set of controlling parameters.

In addition to a presentation of the design criteria associated with the natural phenomena of Norton Sound, this section presents the criteria for the drilling/production facilities and common criteria for the structures.

1.1 LOCATION

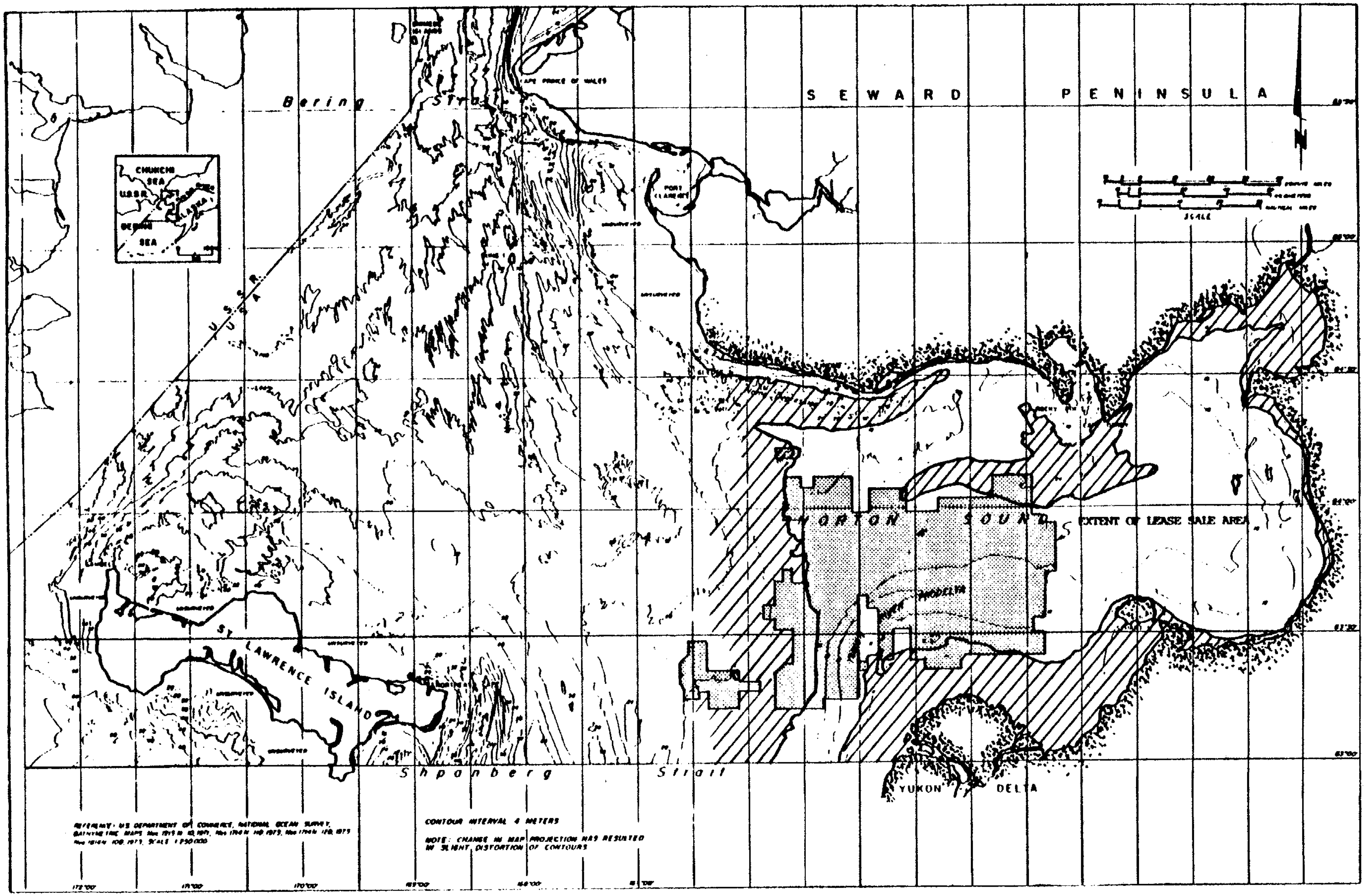
1.1.1 Geographic

The OCS Lease Sale 57 is comprised of areas within Norton Sound, a portion of the Bering Sea, as shown in Figure 1. This area has irregular boundaries; however most of the concession areas are confined within a rectangle defined by latitudes 63°15' north and 64°08' north and longitudes 163°15' west and 163°45' west. This rectangle measures 53 N. miles north-south and 90 N. miles east-west.

PMB Systems Engineering has completed a preliminary investigation of the Norton Sound area. They provide the following description of the locale: "Norton Sound is an elongate, east-west trending marine re-entrant in Northwestern Alaska, bounded on the north by the Seward Peninsula and on the southwest by the Yukon Delta. The floor of the sound is nearly flat, lacking topographic irregularies except for a broad, shallow trough in the northern part." Further development of the concepts was based on water depths ranging from 30 to 70 feet, as the vast majority of water depths in the lease sale area are within this range.

NORTON SOUND STUDY

LEASE SALE AREA



Source; Harding-Lawson Associates

▒ Extent of Lease Sale Area

▨ Less than 30' and more than 70' Water Depths

FIGURE 1

1.1.2 Meteorologic

1.1.2.1 Ambient Air Temperatures Over Norton Sound

NORMAL TEMPERATURES (°F)

ANNUAL MEANS			JULY		JANUARY	
Daily Min.	Daily Mean	Daily Max.	Mean Daily Min.	Mean Daily Max.	Mean Daily Min.	Mean Daily Max.
22	27.5	33	46	56	-2	12

EXTREME TEMPERATURES (°F)

Limits	Return Period (YEARS) 1	5	100
Maximum	60	65	80
Minimum	-30	-40	-50

A service temperature of -28°F is considered for material selection, and should be considered later for displacements of joints and the creation of thermal stresses within all structures. The heating and ventilation system for the modules are sized for the above temperature extremes.

1.1.2.2 Winds

(A) Occurrence of Wind Directions:

AVERAGE PERCENTAGE FREQUENCY OF OCCURENCE

Direction (1) (±22.5°)	SEASON Dec.-Feb.	Mar.-May	June-Aug.	Sept.-Nov.	Annual (2)
N	20	16	8	23	17
NE	22	18	7	21	17
E	23	19	8	16	17
SE	6	7	12	7	8
S	3	6	15	6	8
SW	2	6	20	6	8
W	4	9	19	5	9
NW	8	10	8	11	9
Calm	12	9	3	5	7
TOTAL	100	100	100	100	100

(1) Direction from which wind blows.
(2) Any percentage different from 12.5% represents a bias, a plus or minus relative to random probabilities.

(B) Occurence Of Extreme Wind Speeds:

EFFECTIVE WIND SPEEDS (KNOTS)

Elevation (1)	RETURN PERIOD (YEARS) 1		5		100	
	V_1 (2)	Gust	V_1	Gust	V_1	Gust
0	60	78	70	91	85	110
30	60	78	70	91	85	110
60	65	82	76	96	93	117
90	69	85	80	99	98	120
120	71	87	83	101	101	123
150	73	88	86	103	104	125
180	75	90	88	104	106	127
210	77	91	89	106	108	128
250	78	92	91	107	111	130

(1) Feet Above Mean Lowest Low Water (MLLW).
(2) V_1 is a One Minute Average Wind Speed.

Severe winds have been reported to occur from all directions. The assumption is made that there is no preferred direction of orientation for a structure to reduce the exposure of its areal profile. Wind forces are calculated in accordance with API RP 2A.

1.1.2.3 Ice Accretion

RETURN PERIOD (YEARS)	AVERAGE MAXIMUM ACCRETION DURING STORM (INCHES)
1	0.5
5	1.25
100	2.50

Weight of accumulated ice is used for calculating additional structural loads during site topside erection and platform operation. Ice loads are developed based on a 0.95 specific gravity.

1.1.3 Oceanographic

1.1.3.1 Seawater Temperatures

AVERAGE TEMPERATURE Month	(°F)
February	29
May	29
August	49
November	30

Seawater temperature is a prime consideration for selection of immersed plant and structural materials.

1.1.3.2 Seawater Salinity

AVERAGE SALINITY

Month	(PPT)
February	33
May	27
August	32
November	33

The assumed uniformity of salinity with depth and values are used in selecting immersed plant and structural materials.

1.1.3.3 Astronomical Tides

PARAMETER (FEET)	CHART DEPTH (FEET)		
	30	50	70
Extreme High Water Level	4.3	4.0	3.8
Mean Higher High Water Level	3.0	2.9	2.8
Mean Tide Level	1.3	1.2	1.2
Mean Lower Low Water Datum	0.0	0.0	0.0
Extreme Low Water Level	-0.6	-0.6	-0.6

Ranges in astronomical tides are a determining factor in design of substructures and associated appurtenances.

1.1.3.4 Storm Water Depths

30 FOOT CHART DEPTH SITE

PARAMETER (FEET)	STORM RETURN PERIOD (YEARS)		
	1	5	100
MLLW Depth	30	30	30
Astronomical Tide Rise	3	3	3
Storm Surge	3	6	10
Total Depth, Still Water Level	36	39	43

50 FOOT CHART DEPTH SITE

PARAMETER (FEET)	STORM RETURN PERIOD (YEARS)		
	1	5	100
MLLW Depth	50	50	50
Astronomical Tide Rise	3	3	3
Storm Surge	3	5	9
Total Depth, Still Water Level	56	58	62

70 FOOT CHART DEPTH SITE

PARAMETER (FEET)	STORM RETURN PERIOD (YEARS)		
	1	5	100
MLLW Depth	70	70	70
Astronomical Tide Rise	3	3	3
Storm Surge	2	3	6
Total Depth, Still Water Level	75	76	79

The total depth of the water is used for establishing the characteristics of the water surface waves.

1.1.3.5 Peak Wave Crest Elevations

30 FOOT CHART DEPTH SITE

PARAMETER (FEET)	STORM RETURN PERIOD (YEARS)		
	1	5	100
Significant Wave Height (Ft)	17	25	29
Maximum Wave Height (Ft)	26	28	32
Wave Period (Sec)	10	11	14
Crest Elevation of Maximum Wave			
Above MLLW Level (Ft)	27	32	40
Above Bottom (Ft)	57	62	70

50 FOOT CHART DEPTH SITE

PARAMETER (FEET)	STORM RETURN PERIOD (YEARS)		
	1	5	100
Significant Wave Height (Ft)	17	27	37
Maximum Wave Height (Ft)	32	41	45
Wave Period (Sec)	10	11	14
Crest Elevation of Maximum Wave			
Above MLLW Level (Ft)	29	40	49
Above Bottom (Ft)	79	90	99

70 FOOT CHART DEPTH SITE

PARAMETER (FEET)	STORM RETURN PERIOD (YEARS)		
	1	5	100
Significant Wave Height (Ft)	17	27	37
Maximum Wave Height (Ft)	32	50	57
Wave Period (Sec)	10	11	14
Crest Elevation of Maximum Wave			
Above MLLW Level (Ft)	25	43	55
Above Bottom (Ft)	95	113	125

The directions of attack by waves whose heights are specified above are limited to traverses from the Bering Sea, thus the exposure is in the sector between southwest and northwest. The wave characteristics listed above provide a basis for determining the water surface profiles. For the jackets, the water particle velocities and accelerations are calculated using Dean's Stream Function Theory. The means for calculating these forces is set forth in API RP 2A, Section 2.3.1. Necessary hydrodynamic coefficients are obtained from Section 7.315, Volume II, Shore Protection Manual, U.S. Army Coastal Engineering Research Center.

Barge structures reflect incident waves and consequently a wave model different from above is required for establishing the wave's water surface elevations adjacent to the barge, and the water force on the barge.

1.1.3.6 Crest Profiles of Maximum Waves

For large, inertia dominated substructures; it is not probable that the full length of the structure will be subjected to a coherent wave crest. Thus; global wave forces for the barges are calculated in accordance with the Shore Protection Manual, U.S. Army Coastal Engineering Research Center and divided by a correction factor calculated:

$$F = ((L1) / (0.6) (L2))^{0.5},$$

where F is a factor greater than or equal to 1.0, L1 is the length of the structure, and L2 is the length of the approaching wave considered. This correction is based upon measurements of wave pressures acting on the Hood Canal Floating Bridge in Washington State, as reported in the paper by Professor B. J. Hartz, Dynamic Response of the Hood Canal Floating Bridge, Seattle, WA: ASCE, 1981, and the paper by K. Scott Hunziker, The Hood Canal Bridge: Dynamic Loading From Wind and Waves, Pacific Northwest Section, SNAME, 1981.

1.1.3.7 Steady Currents

MAXIMUM CURRENT SPEEDS

Relative Water Depth	Return Period (YEARS)		
	1	5	100
Surface (kts)	2.0	2.5	3.0
Mid-Depth (kts)	1.5	2.0	2.5
One-Foot Above Bottom (kts)	1.0	1.5	2.0

The steady current direction is concurrent with the direction of wave attack; and is added vectorially to the wave particle velocity, in accordance to API RP 2A, in order to develop the total drag force on exposed areas of the substructures.

1.1.4 Towing Meteorology-Oceanography

(A) Season: June and July
(B) Exposure Period: 19-22 days
(C) Chance Of Encounter: 1 tow in 30 tows

PARAMETERS	FROM SEATTLE	FROM JAPAN
Waves:		
Significant Height (ft)	25	28
Maximum Height (ft)	46	52
Period (sec)	12	13
Wind Speed (knots):		
Average For One Minute	55	57

The above information is used as criteria for evaluating performance during transportation of the self-floating substructures and modules. Storm winds may occur from any direction.

1.1.5 Sea Ice

The thickness of the sea ice in Norton Sound is limited due to the fact that the ice completely thaws during the springtime. The age of the local ice will not exceed one year. Sea ice will be a hinderance to marine navigation and a hazard for structures during the period from early December to early June. The incidence of severe ice forces is most likely to occur between late February and late April.

1.1.5.1 Ice Properties

SIGNIFICANT CHARACTERISTICS

Parameters	Maximum Value
Maximum Unconfined Compressive Strength	250 psi
Maximum Confined Compressive Strength	400 psi
Maximum Flexural Strength	75 psi
Maximum Sheet Thickness	4 ft
Maximum Pressure Ridge Consolidation	8 ft
Surface Elevation, Reference SWL	+1.5 ft
Bottom Elevation, Reference SWL	-6.5 ft
Specific Gravity Of Ice Floes	0.82

The above parameters are used for the developing horizontal and vertical ice loadings on the structures.

1.1.5.2 Rubble Piles

Rubble piles in Norton Sound consist of large amounts of fractured ice blocks above and below the zone of reconsolidation. The consolidated ice will exhibit properties as shown above, whereas, the fractured ice blocks have negligible mechanical strength.

CHARACTERISTICS OF GREATEST RUBBLE PILES

Parameters	Dimensions
Floating Rubble Piles:	
Greatest Keel Depth	45 ft below SWL
Greatest Sail Height	10 ft above SWL
Greatest Overall Height	55 ft
Grounded Rubble Piles:	
Greatest Grounding Depth	45 ft below MLLW
Greatest Overall Height	65 ft

The elevations of the jackets' skid beams and barges' freeboard are sufficient to provide protection from rubble ice.

1.1.5.3 Horizontal Ice Forces

(A) Global

The total horizontal ice sheet or rubble pile load upon a substructure is created by the motion of the ice as a result of wind and/or current forces. The magnitude of the ice force is limited by the crushing strength of the ice. This crushing force is calculated:

$$F = I\ f\ c\ t\ k,$$

where F is the force per foot of the structure exposed to the ice contact, I is the indentation factor (assumed to be 1.2), f is the contact factor (assumed to be 0.5), c is the unconfined compressive strength of ice (250 psi per Section 1.1.5.1), and t is the ice thickness (8 ft per Section 1.1.5.1) and k is the ice adhesion or rubble amplification factor (assumed to be 1.2). Thus:

$$F = (1.2)\ (0.5)\ (250\text{ psi})\ (8\text{ ft})\ (1.2)\ (12\text{ in/ft}),$$
$$F = 17{,}300\text{ lbs/in or }210\text{ kips/ft}.$$

The ice sheet or rubble pile total horizontal load, therefore, is calculated:

$$P = 210\ W\text{ kips},$$

where P is the total global ice load and W is the width of the substructure in feet. This width is the outboard dimension of the substructure which will intercept the moving ice mass and impede its displacement. The above is used for the 100 year return event, while half its resulting global loads (4 ft maximum sheet thickness) is used for the earthquake loading scenarios.

Horizontal forces on a structure resulting from contact with independent ice floes, including those which periodically slam into structural members as a result of wave motions, will be limited by the crushing strength of the ice. These forces, to which all sites are periodically exposed, shall not exceed those described above. Hence, these global and local loads control for all cases.

The orientation of an ice load may occur from any direction. The determination of the lateral loads is required for the design of substructures and their foundations.

(B) Local

To account for nonuniform ice loading, local panels of the substructures are designed to resist higher pressures. Local loads applied to an area of 50 square feet or less are based on an effective ice pressure of 1.6 times the unconfined compressive strength (1.6 x 250 psi = 400 psi). Loads applied to an area greater than 50 square feet are calculated in accordance with Figure 2.

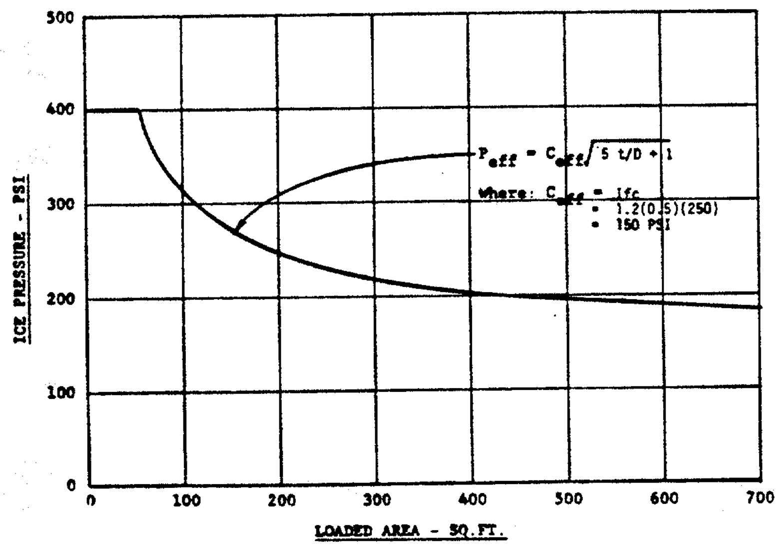


FIGURE 2

1.1.5.4 Vertical Ice Forces

Sheet ice and rubble piles in contact and adhering to the surface of a structure will exert vertical loads upon the structure when the ice is in a state of motion associated with the ebb and flood of tidal waters. The maximum loads per lineal foot of perimeter of the columns or gravity structure, are calculated as follows:

(A) Downward Load: 3.5 kips/perimeter foot

(B) Uplift Force: 4.0 kips/perimeter foot

The vertical ice loads are required for designing the substructures and their appurtenances.

1.1.6 Geotechnic

The following soil conditions are based on geotechnical data developed for SOCAL by Harding-Lawson Associates, as presented in the PMB Systems Engineering report. This previous data are organized into best-case/worst-case scenarios to envelope the range in soil property values anticipated in the lease sale area. The load capacities of local foundations are calculated using an average of these scenarios. The results shown below are used to design the substructures' foundations.

1.1.6.1 Seabed Conditions

SOIL PROPERTIES
(ASSUMED UNIFORM WITH DEPTH)

Parameters	Values
Dry Density (pcf)	95
Moisture Content (%)	30
Liquid Limit (%)	29
Plastic Limit (%)	26
Plasticity Index (%)	3
Void Ratio	0.57
Saturated Density (pcf)	115
Effective Angle Of Internal Friction (degrees)	30
Effective Cohesion (psf)	0
Undrained Shear Strength (psf)	0

1.1.6.2 Subsurface Conditions

(A) Permafrost: There is no significant potential for permafrost soil conditions within OSC Lease Sale Area 57.

(B) Gas Hydrates: With the absence of freezing conditions within the Norton Sound soil, the creation of high local pressures as a result of thawing activity is not a phenomenon common to Norton Sound.

(C) Soil Properties: The magnitude of any parameter evaluated is the average of the greatest and the least values associated with the Harding-Lawson's worst-case.

(D) Ultimate Pile Capacities: The design pile penetration is sufficient to develop an adequate capacity to resist maximum computed axial bearing and pull out loads with an appropriate factor of safety. This factor and the method of computation are in accordance with API RP 2A.

(E) Lateral Load Capacity: Load-deflection (p-y) curves and bearing capacities of the soil are calculated according to API RP 2A procedures.

These considerations are necessary to design the jackets and piles.

1.1.6.3 Seismic Conditions

(A) Seismic Zone: Zone 2

(B) Horizontal Ground Acceleration: 0.1G

(C) Liquefaction Potential: From previous work, the cyclic shear stress associated with an API Zone 2 earthquake is below the stress required for large shear strains. On this basis, the risk of in-place soil liquefaction is assumed to be negligible. However, where required, new sand fill shall be compacted in order to prevent local liquefaction.

1.2 FACILITIES

1.2.1 Production Parameters

The following fundamental assumptions provide the basis for the further development of all facilities. Design philosophy includes two (2), 50 percent trains on each major system.

1.2.1.1 Reservoir Characteristics

(A) Field Life: 30 yrs
(B) Pay Zone Depth: 12,000 ft
(C) Gas-Oil Ratio (GOR): 1,000:1
(D) Bottom Hole Static Pressure: 4,000 psi
(E) Bottom Hole Temperatures: 200°F
(F) Mudline Temperature: 100°F

1.2.1.2 Crude Properties

(A) Oil Gravity: 36° API
(B) Oil Viscosity: 37-SSU (@ 100 °F)
(C) Condensate Gravity: 48° API
(D) Gas Specific Gravity: 0.65

1.2.1.3 Well Flow Composition

COMPONENTS	MOL %
Methane	52.45
Ethane	6.36
Propane	4.66
i-Butane	1.52
n-Butane	2.27
i-Pentane	1.37
n-Pentane	1.37
Hexanes	3.41
Heptanes plus(1)	26.59

(1) Specific Gravity Equals 0.8811.

1.2.1.4 Production Particulars

(A) Number Of Producing Wells: 32
(B) Number Of Injection Wells: 8
(C) Well Completion: Single Type
(D) Flow Rate Per Well: 3,750 BOPD (Average)
(E) Total Field Flow Rate: 120,000 BOPD
(F) Total Reservoir Flow Volume: 180,000 BPD
(G) Flowing Pressure: 1,000 psia (Well Manifold)
(H) Flowing Temperature: 100°F (Well Manifold)
(I) Watercut: 10%

1.2.2 Drilling Systems

The drilling facilities consists of two (2) self-contained, semi-independant drilling systems. Necessary drilling equipment for the facilities is based on the drilling depth requirement. A two (2) week re-supply interval determines all storage requirements.

1.2.2.1 Drilling Rigs (2)

(A) Derrick: 147 ft mast, 30' x 30' x 32' high floor
(B) Draw Works: 2000 hp, diesel electric
(C) Wireline: 22500 ft drum (0.105 in), 80 hp
(D) Blow-Out Preventor: Annular and 3 ram stack
(E) Hydraulic Power Unit: 5000 psig, 150 gal, air driven
(F) Drill Water Storage: 1800 bbls (Within Substructure)

1.2.2.2 Mud Systems (2)

(A) Mud Tanks: 2100 bbls (5 Active, 4 Reserve)
(B) Mud Pumps: Two, 2000 hp (Intermittent)
(C) Solids Processing Unit: Shale shaker, degasser, and decanting centrifuge (Closed Loop)

1.2.2.3 Diesel Systems (2)

(A) Diesel Day Tank: 125 bbls (Within Module Skids)
(B) Diesel Generator: 1400 kw (Five Total, Both Rigs)
(C) Steam Boiler: 6×10^6 BTU/hr @ 150 psig

1.2.2.4 Storage Units (2)

(A) Open Pipe Racks: 5500 sf
(B) P-Tanks: 1200 cf each, 8 total
(C) Sack Storage: 3000 sf

1.2.2.5 Miscellaneous (2)

(A) Bulk-Air System: 600 cfm @ 40 psi
(B) Cement Unit: 300 bbl/hr, two 450 hp diesel pumps
(D) Exploration Logging Unit: Drilling and well completion
(E) Engineering Shack: Mud lab and core handling (One Only, Both Rigs)

1.2.3 Production System

Facilities are self-contained, and outfitted with all equipment necessary for well testing and production. Oil production is transported to a remote terminal or shore facility through a submarine pipeline. Gas production, in excess of onboard fuel-gas requirements, is reinjected. Produced water is also reinjected. Oil storage, tanker mooring, or equipment for sour production is not considered.

(A) Test Header: Single zone, independent well
(B) Production Header: 32 well connections
(C) Test Separators: Two, 5000 BOPD, three phase, 1500 psig

(D) High Pressure Separators: Two, 60000 BOPD, two phase, 1000 psig
(E) Low Pressure Separators: Two, 60000 BOPD, three phase, 350 psig
(F) Produced Water:
    (a) Filters - Vertical high rate mixed media
    (b) Storage - 2100 bbls (Within Substructure)
(G) Oily Waste:
    (a) Separator - CPI
    (b) Storage - 170 bbls (Within Substructure)
(H) Well Clean-Up:
    (a) Separator - 5000 BOPD, Two Phase, 1500 psig
    (b) Storage - 500 bbls (Leased, On Piperack)

1.2.4 Injection System

(A) Compressors: Three, gas injection, 2 stage, 30 MMSCFPD, 4500 psig, dual-fuel turbine driven
(B) Injection Gas Coolers: Three, 30 MMSCFPD
(C) Pumps: Three, water injection, 4000 BWPD @ 1000 psig, motor driven
(D) Manifolds: Two, 8 well connections (Gas or Water)

1.2.5 Transport System

(A) Main Oil Line Pumps: Two, 60000 BOPD, 1400 psig discharge, motor driven
(B) Meter/Prover: Positive displacement
(C) Pig Launcher: 30 in dia
(D) Riser: 24 in dia (Within Smaller Leg)
(E) Submarine Pipeline: 24 in dia (Outside Study Scope)

1.2.6 Utility Systems

(A) Power Generation:
    (a) Prime Movers - Three, dual-fuel turbines
    (b) Standby/Start Up Generator - Diesel driven
    (c) Motor Drives - TEFC or explosion proof type
(B) Potable Water:
    (a) Desalinization Units - Two, 6000 GPH
    (b) Storage - 1200 bbls (Within Module Skids)
(C) Fire Water: Seawater, 1000 GPM with foam generator
(D) Service Water Storage: Seawater, 3500 bbls (Within Substructure)
(E) Diesel Oil: 2500 bbls (Within Substructure)
(F) Fuel Gas: 15 normal, 30 MMSCFPD max capacity
(G) Service Air: 200 CFM @ 145 psig
(H) Instrument Air: 400 CFM @ 100 psig
(I) Chlorination/Hypochlorite Generators: Two 20 cell units, chemical feed package, six pumps and reservoirs

(J) Steam Generation:
  (a) Boilers - Three, 5 MMBTUPH
  (b) Feed Water Storage - 800 bbls (Within Module Skids)
(K) Pressure Relief: Two, 150 ft. flare booms
(L) Drainage: Open and closed systems (Stored With Produced Water)

1.2.7 Waste Disposal Systems

In accordance with regulations, no pollutants shall be released into the environment during operation of the facilities.

(A) Liquid Waste: Incineration
(B) Solid Waste:
  (a) Disposal - Incineration
  (b) Temporary storage - 275 bbls (Within Module Skids)

1.2.8 Control Systems

(A) Emergency Shut Down: Total plant, production, and/or any unit
(B) Effluent Monitoring: Positive displacement with turbine flow meters

1.2.9 Accommodation/Transportation

1.2.9.1 Crew Quarters (2)

(A) Construction: Steel
(B) Capacity: 100 men total

1.2.9.2 Helidecks (2)

(A) Construction: Steel, above crew quarters
(B) Capacity: S-61 service

1.2.9.3 Survival Crafts (4)

(A) Type: Lifeboat
(B) Capacity: 44 men

1.2.9.4 Utility Vehicle

(A) Type: Tracked Van
(B) Capacity: 6 Men Plus Equipment

1.2.10 Ancillary Systems

1.2.10.1 Corrosion Protection

(A) Jacket Substructures: Two, impressed current
(B) Barge Substructures: Not required

1.2.10.2 Platform Craneage (2)

(A) Type: Pedestal mounted
(B) Capacity: 60 sht
(C) Boom: 140 ft

1.2.10.3 Mooring System (2)

(A) Type: Rucker
(B) Capacity: 60 sht

1.2.10.4 Substructure Ballast/Deballasting

(A) Equipment: Drilling and utility submersible lift pumps
(B) Capacity: 24 hr re-floating

1.2.10.5 Diving System

(A) Type: Bounce diving support
(B) Major Equipment: Decompression chamber

1.2.10.6 Navigation Aids (4)

(A) Type: Signal beacon and horn
(B) Specifications: USCG

1.3 STRUCTURES

1.3.1 Configurations

1.3.1.1 Jacket Concept

(A) Modularized Superstructure
(B) Steel Tower Substructure
(C) Design Depths: 30, 50, & 70 ft (MLLW)

1.3.1.2 Barge Concept

(A) Modularized Superstructure
(B) Concrete Gravity Substructure
(C) Design Depth: 30 ft (MLLW)

1.3.2 Geometrical Constraints

1.3.2.1 Well Slots

(A) Number: 40
(B) Inside Diameter: 28 in
(C) Spacing: 4'-6" x 7'-0" c/c

1.3.2.2 Orientation

(A) Jacket Substructures: Variable through 360 deg
(B) Barge Substructures:
  (a) 30 Ft Chart Depth - Variable, major axis aligned plus or minus 35 deg with direction of principle wave progress
  (b) Greater Charter Depths - Variable through 360 deg

1.3.3 Analytical Considerations

1.3.3.1 Fabrication

(A) Temperature fluxuations and dimensional tolerances between fabrication site and Norton Sound

(B) Framing: Simplified fabrication

1.3.3.2 Transportation

(A) Risk: Per section 1.1.4
(B) Route Conditions: Stability
(C) Shallow Water Depths: Draft requirements on site

1.3.3.3 Substructure Installation

(A) Risk: 1 yr event
(B) Low Seawater Temperatures: Prolonged grout and concrete curing
(C) Climatic Conditons: Short construction season

1.3.3.4 Superstructure Erection

(A) Risk: 1 yr event
(B) Ice Accretion: Decreased module payloads

1.3.3.5 Operation

LOADS	POTENTIAL COMBINATIONS					
	1	2	3	4	5	6
Dead	X	X	X	X	X	X
Operating	X	X	X	X	X	X
Ice Accretion	1	100	100	1	1	1
Wind	1	100	100	5	1	1
Wave	1	100				1
Current	1	100	100	5	1	1
Horizontal Ice			100		X	
Vertical Ice				100		
Seismic					100	100

The above matrix identifies the simultaneous occurrance of loads that can be reasonably expected. The maximum level of risk associated with the occurrence of each natural phenomena is denoted by its return interval in years. This matrix is the basis for developing each structural components' loading scenarios. For combination cases 2 and 3, a lesser return event is examined to satisfy the requirements of API RP 2A.

1.3.3.6 Fatigue

(A) Useful Life: 30 yrs
(B) Design: Based on engineering judgement

1.3.3.7 Salvage

(A) Superstructures: Lifting
(B) Substructures: Refloating

1.3.3.8 Miscellaneous

(A) Catastrophic Events: Redundancy
(B) Local Ice Loading: Stiffening
(C) Climatic Conditions: Weather barriers
(D) Leveling Tolerance: ±0.25 deg.

2.0 DESIGN BASIS - MODULAR SUPERSTRUCTURES

The philosophy of modular packaging for topside facilities is common to both the jacket and barge concepts. Facilities for the jacket concept will be erected on site; while facilities for the barge concept will be integrated with the substructure either at the fabrication yard or in close proximity at sea. Although the equipment layout and structural framing is different for each concept, modular packaging will facilitate installation and expedite hook-up. This section prescribes criteria specific to the design of these modular superstructures.

2.1 APPLICABLE REGULATIONS AND CODES

2.1.1 United States Geological Survey

Outer Continental Shelf Order Nos. 1-10

2.1.2 American Petroleum Institute

(A) API RP 2A, Planning, Designing and Constructing Fixed Offshore Platforms; 1981

(B) API SPEC 2E, Drilling Rig Packaging for Minimum Self-Contained Platforms, 1973

(C) API SPEC 2G, Production Facilities on Offshore Structures, 1974

(D) API Bulletin 2N; Planning, Designing, and Constructing Fixed Offshore Platforms in Ice Environments; June 1981 Draft

2.1.3 American Institute of Steel Construction

Specification for the Design, Fabrication and Erection of Structural Steel for Buildings; 1978

2.1.4 American Welding Society

AWS D1.1, Structural Welding Code, 1979

2.2 MATERIALS

2.2.1 Structural Steel

2.2.1.1 Exterior Members

(A) Rolled Shapes and Plate:

(a) ASTM A633-C, quenched and tempered, charpy impact tested to 25 ft-lbs at-60°F, 50 ksi yield to 2 in thk

(b) ASTM A678-C, quenched and tempered, charpy impact tested to 25 ft-lbs at-60°F, 60 ksi yield to 3 in thk (Plates Only)

(B) Pipe: ASTM A333 Grade 6, 35 ksi yield

2.2.1.2 Interior Members

(A) Rolled Shapes and Plate:
    (a) ASTM A36 - 36 ksi yield
    (b) ASTM A588 - 50 ksi yield (Shapes)
    (c) ASTM A537 Class I - 50 ksi yield (Plates)
(B) Pipe: ASTM A53 Grade B, 35 ksi yield

2.3 CORROSION PROTECTION

In this dry zone, a conventional four (4) coat system is used to retard corrosion of structural members.

2.4 CONSTRUCTION CONSTRAINTS

2.4.1 Fabrication

2.4.1.1 Forming

Ambient temperature forming of tubular members is recommended to preserve material properties. Should heat forming be required due to equipment limitations, stress relief heat treatment will be necessary. Both methods' forming procedures must be qualified to include fracture toughness testing after forming and aging.

2.4.1.2 Welding

All welding should be by the low hydrogen process, shielded metal arc and submerged arc welding methods prefered. Welding procedures must be qualified to include testing of weld metal, heat affected zone, and base metal. Weld preheat, 150 to 250°F, will be necessary for thickness greater than 1.5 inch. Other weld preheat may be required resulting from welding procedure qualifications.

Conventional welding consumables may be used for deck Interior Members. Special nickel-alloyed consumables required for deck Exterior Members are:

(A) Shielded Metal Arc Method: AWS E8018-C3 (Typical)
(B) Submerged Arc Method: F84-ENi 1 (Typical)

Welds on Exterior Members will have profile requirements, and grinding may be necessary to maintain these requirements.

2.4.1.3 Inspection

All full penetration welds accessible from both sides require 100% radiographic testing, while 100% ultrasonic testing will be required for non-accessible welds. Joints subject to lamellar tearing shall require additional ultrasonic testing. Non-destructive testing personnel will be qualified to ASNT Level II.

2.4.2 Transportation

2.4.2.1 Jacket Concept Modules

(A) Cargo Barges: 400' x 105' x 25'
(B) Oceangoing Tugs: 6000 BHP

2.4.2.2 Barge Concept Modules

(A) Cargo Barges: 250' x 80' x 20'
(B) Oceangoing Tugs: 3000 BHP

2.4.3 Installation

2.4.3.1 Jacket Concept Modules

(A) Maximum Outside Dimensions:

MAJOR LIFTS	DIMENSIONS (FEET)		
	Width	Length	Height
Lower Level:			
Wellhead Module	52	157	31
Process Modules	36	157	30
Intermediate Level:			
Rig Base and Substructures	40	50	75
Drilling Modules	36	75	28
Upper Level:			
Quarters/Helideck Modules	50	75	28

(B) Maximum Lift Weights:

MAJOR LIFTS	30 FEET C. D. SITE	50 & 70 FEET CHART DEPTH SITES	
		REVL.	FIXED
Lower Level:			
Wellhead Module	1450	1675	1800
Process Modules	1450	1675	1800
Intermediate Level:			
Rig Base and Substructures	725	1675	1800
Drilling Modules	650	1625	-
Upper Level:			
Quarters/Helideck Modules	700	1200	-

NOTES:

(1) Units are short-tons with 2% and 5% deduction for rigging and shock load respectively.

(2) Erection in 30 feet requires two 800/1000 Ton Derrick Vessels (Fully Revolving).

(3) Erection in 50 and 70 feet requires one 1600/2000 Ton Derrick Vessel.

(4) To avoid weight-shedding in 30 feet, optimum design weights are those shown for this depth less a conservative growth allowance.

(C) Weather Downtime: (See Section 3.4.3)

2.4.3.2 Barge Concept Modules

(A) Maximum Outside Dimensions:
(a) Wellhead Modules - 38' W X 78' L X 29' H
(b) Rig Base and Substructures - 40' W X 50' L X 50' H
(c) Remaining Modules - 38' W X 78 ' L X 28' H

(B) Maximum Lift Weights: 725 and 750 sht fully revolving and fixed respectively (Weights Include 7% Allowance For Rigging and Shock Load for 800/1000 Ton Derrick Vessel.)

(C) Weather Downtime: 5% (Nearshore Erection)

2.5 GEOMETRICAL CONSTRAINTS

2.5.1 Module Plans

2.5.1.1 Trussline Allowances

(A) Lower Level: 2 ft x 3 ft c/c
(B) Intermediate Level: 1 ft x 2 ft c/c
(C) Upper Level: 1 ft x 2 ft c/c

2.5.2 Module Elevations

Minimum Clear Height

(A) Drilling Area: 22 ft
(B) Production Areas: 20 ft
(C) Storage Areas: 10 ft
(D) Accommodation Areas: 8 ft
(E) Accessways: 7 ft

2.6 ANALYTICAL CONSIDERATIONS

2.6.1 Transportation and Installation

2.6.1.1 Load Conditions

(A) Dead: Primary members plus 15%
(B) Uniform Live: 50 psf (Includes Piping)
(C) Equipment Live: Dry weights plus 20%
(D) Ice Accretion: 2.5 psf (Exterior Surface)
(E) Impact Factor: 1.35

2.6.1.2 Allowable Stresses

For controlling module(s), interaction ratios do not exceed 1.0 against basic AISC allowable stresses.

2.6.2 Operation

2.6.2.1 Loads Conditions

(A) Dead: Primary members plus 15%
(B) Uniform Live/Drilling: 1000 psf
(C) Uniform Live/Production: 500 psf
(D) Uniform Line/Wellslots: 250 psf
(E) Uniform Live/Accommodation: 100 psf
(F) Uniform Live/Accessways: 100 psf
(G) Uniform Live/Helideck: 50 psf
(H) Uniform Live/Piping: 50 psf
(I) Hydrotest Live: Wet weights plus 10%

(J) Concentrated Live/Drilling:
    (a) Rig Weight - 575 sht
    (b) Hook Load - 500 sht
    (c) Set Back - 250 sht
(K) Ice Accretion: 6.25 & 12.5 psf (5 & 100 yr Events, Exterior Surfaces)
(L) Wind: Per Section 1.1.2.2 (0.0833 pcf Air Density)
(M) Distributed Live Load Reduction Factors:
    (a) Deck Plate - 1.0
    (b) Deck Beams - 1.0
    (c) Transverse Girders - 0.80
    (d) Longitudianal Girders - 0.70
(N) Seismic Acceleration: Per Section 1.1.6.3

2.6.2.2 Allowable Stresses

For controlling module(s), interaction ratios do not exceed 1.0 against basic or increased AISC allowable stresses.

3.0 DESIGN BASIS - JACKET SUBSTRUCTURES

This section identifies the applicable codes, materials, constraints and analytical procedures which were adopted as criteria for the design of the jacket, piles, and interfacing.

3.1 APPLICABLE REGULATIONS AND CODES

3.1.1 United States Geological Survey

(A) Outer Continential Shelf Order No. 1

(B) Outer Continental Shelf Order No. 8

3.1.2 American Petroleum Institute

(A) API RP 2A; Planning, Designing, and Constructing Fixed Offshore Platforms, 1981

(B) API Bulletin 2N Planning, Designing, and Constructing Fixed Offshore Platforms in Ice Environments; June 1981 Draft

3.1.3 American Bureau of Shipping

Rules for Building and Classing Mobile Offshore Drilling Units

3.1.4 American Institute of Steel Construction

Specifications for Design, Fabrication and Erection of Structural Steel for Buildings; 1978

3.1.5 American Welding Society

AWS D1.1, Structural Welding Code, 1979

3.2 MATERIALS

3.2.1 Structural Steel

3.2.1.1 Exposed Members

(A) Rolled Shapes and Plate:

(a) ASTM A633-C, quenched and tempered, charpy impact tested to 25 ft-lbs at -60°F, 50 ksi yield to 2 in thk

(b) ASTM A678-C, quenched and tempered, charpy impact tested to 25 ft-lbs at -60°F, 60 ksi yield to 3 in thk (Plates Only)

(B) Pipe: ASTM A333 Grade 6, 35 ksi yield

3.2.1.2 Submerged Members

Rolled Shapes and Plate:

(A) ASTM A131-E, 34 ksi yield to 2 in thk

(B) ASTM A678-A, charpy impact tested to 25 ft-lbs at -40°F, 50 ksi yield to 1.5 in thk

(C) ASTM A537-I or A633-C, charpy impact tested to 25 ft-lbs at -40°F, 50 ksi yield to 2.5 in thk

3.2.1.3 Nodal Plate (Joints)

As above plus API 2H Supplement S-4 and ultrasonically tested to ASTM A578 Level II

3.2.1.4 Piling Plate (Cans)

ASTM A633-C, charpy impact tested to 25 ft-lbs at -40°F 50 ksi yield to 2.5 in thk

3.2.2 Grout

Bond stresses in accordance with API RP 2A

3.2.3 Concrete

f'c = 3000 psi, density = 150 pcf

3.3 CORROSION AND ABRASION PROTECTION

3.3.1 Impressed Current

This system is for immersed and imbeded zones of jacket and piles.

3.3.2 Protective Paint Coatings

System comprised of four (4) coats is used to retard corrosion of the jacket above the level of EL (-) 7 feet (MLLW).

3.3.3 Ice Abrasion Protection

A film of high density polyurethane, or an equal material, is to be applied to the column cans located between EL (-) 8 and EL (+) 4 feet (MLLW).

3.4 CONSTRUCTION CONSTRAINTS

3.4.1 Fabrication

3.4.1.1 Forming

(See Section 2.4.1.1 for specifications.)

3.4.1.2 Welding

Special nickel-alloy consumables are required for jacket's Exposed Members, and include:

(A) Shielded Metal Arc Method: AWS E8018-C3 (Typical)
(B) Submerged Arc Method: F84-ENi 1 (Typical)

The weld materials for the jacket's Submerged Members will be:

(A) Shielded, Metal Arc Method: AWS E7016, E7018, or E7028 (Typical)
(B) Submerged Arc Method: F 72-EM 12 K (Typical)

Welds on all jacket members will have weld profile requirements, and grinding may be necessary to maintain these requirements. (See Section 2.4.1.2 for general specifications.)

3.4.1.3 Inspection

(See Section 2.4.1.2 for specifications.)

3.4.2 Transportation

3.4.2.1 Jacket

(A) General: ABS Rules
(B) Minimum Keel Clearance: 3 ft
(C) Oceangoing Tugs: Two, 6000 BHP

3.4.2.2 Piling and Conductors

(A) Cargo Barge: 400' x 105' x 25'
(B) Oceangoing Tug: 6000 BHP

3.4.3 Installation

WEATHER DOWNTIME
(DAYS)

EVENTS (FREQUENCY)	MONTHS												ANNUAL
	J	F	M	A	M	J	J	A	S	O	N	D	
Ice Accretion (Mean)	0	0	0	1	7	1	0	0	3	4	3	2	21
Excessive Winds (Mean)	9	9	6	4	2	1	1	2	3	7	9	9	62
Excessive Waves (Mean)	-	-	-	-	9	7	7	8	11	15	7	-	64
Presence of Sea Ice (Mean)	31	28	31	30	29	0	0	0	0	0	18	31	198
Max Downtime (95 Percentile)	31	28	31	30	31	17	14	16	25	31	30	31	315
Min Worktime (5 Percentile)	0	0	0	0	0	13	17	15	5	0	0	0	50
Expected Worktime (Mean)	0	0	0	0	1	22	24	23	18	13	5	0	106
Max. Worktime (95 Percentile)	0	0	0	1	26	26	28	27	24	22	20	13	187

NOTES:
(1) Frequencies are assumed normally distributed.
(2) Site ice accretion will shut down operations.
(3) Wind velocities greater than 30 knots will shut down site operations.
(4) Significant wave heights greater than 5 feet will shut down site operations.
(5) Site operation will be carried out only in the absence of all ice.

3.5 GEOMETRICAL CONSTRAINTS

3.5.1 Skid Beams

(A) Minimum Elevations (BOS, MLLW):

(a) 30 ft Chart Depth Sites - EL (+) 45 ft
(b) 50 ft Chart Depth Sites - EL (+) 55 ft
(c) 70 ft Chart Depth Sites - EL (+) 60 ft

(B) Maximum Spacing: 100 ft c/c

3.5.2 Well Legs

Minimum I.D.: 24 ft

3.5.3 Riser Legs

Minimum I.D.: 16 ft.

3.5.4 Skirt Piling

(A) Minimum Spacing: 3 times Pile O.D.
(B) Maximum Elevation for Top of Sleeves (MLLW):

- (a) 30 ft Chart Depth Sites - EL (-) 30 ft
- (b) 50 ft Chart Depth Sites - EL (-) 45 ft
- (c) 70 ft Chart Depth Sites - EL (-) 45 ft

3.5.5 Bottom Bracing

Elevation (TOS, MLLW):

(A) 30 ft Chart Depth Sites - EL (-) 30 ft
(B) 50 ft Chart Depth Sites - EL (-) 45 ft
(C) 70 ft Chart Depth Sites - EL (-) 45 ft

3.6 ANALYTICAL CONSIDERATIONS

3.6.1 Transportation

3.6.1.1 Load Conditions

(A) Dead: Stiffened primary members plus 7%
(B) Live: Ballast waters
(C) Equipment Live: Ballasting system
(D) Environmental:
    (a) Wind - Per Section 1.1.4
    (b) Wave - Per Section 1.1.4
    (c) Ice Accretion - 2.5 psf (Exterior Surfaces)
(E) Tow Forces: (For Future Investigation.)

3.6.1.2 Allowable Stresses

Stresses in accordance with API RP 2A Section 2.5.

3.6.2 Installation

3.6.2.1 Load Conditions

(A) Dead: Stiffened primary members plus 7%
(B) Live: Ballast and equipment
(C) Environmental:
    (a) Ice Accretion - None
    (b) Wind - 1 year event
    (c) Current - 1 year event
    (d) Wave - 1 year event

3.6.2.2 Allowable Stresses

Maximum soil bearing stresses in accordance with API RP 2A, Para. 2.6.12d.

3.6.3 Operation

3.6.3.1 Load Conditions

(A) Dead: Primary members plus 15%
(B) Live Deck Loads: Reactions as calculated
(C) Environmental Loads:
  (a) Ice Accretion - 6.25 & 12.5 psf (5 & 100 year Events, Exterior Surfaces)
  (b) Wave Loads - Per Section 1.1.3.5
  (c) Wind Loads - Per Section 1.1.2.2 (0.0833 PCF Air Density)
  (d) Seismic Load - Per Section 1.1.6.3

3.6.3.2 Load Combinations

	MAJOR EVENTS					
LOADS	NORMAL OPERATING ENVIRON.	EXTREME WAVES	EXTREME ICE: HORIZONTAL	EXTREME ICE: VERTICAL	EXTREME SEISMIC + HOR. ICE	EXTREME SEISMIC + NORM. WAVES
Max. Wave, Tide, & Surge:						
1-Yr.	X					X
100-Yr.		X				
Max. Steady Current:						
1-Yr.	X				X	X
5-Yr.				X		
100-Yr.		X	X			
Ice Floe:						
Seismic					X	
100-Yr.			X			
Max. Ice Adhesion:						
100-Yr.				X		
Earthquake:						
100-Yr.					X	X
Ice Accretion:						
1-Yr.	X			X	X	X
100-Yr.		X	X			
One-Min. Avg. Wind:						
1-Yr.	X				X	X
5-Yr.				X		
100-Yr.		X	X			
Substructure:						
Self-Wt. & Buoy.	X	X	X	X	X	X
Storage & Ballast	X	X	X	X	X	X
Pump Room Eqpt.	X	X	X	X	X	X
Mooring Reactions	1-System					
Production Modules:						
Dry Weights	X	X	X	X	X	X
Design Live Loads	Varies	Varies	Varies	Varies	Varies	Varies
Flare Reactions	1 or 2-Sets	1 or 2-Sets	1 or 2-Sets	2-Sets	2-Sets	2-Sets
Crane Reactions	1-Set					
Drilling Modules:						
Dry Weights	1 or 2-Sys.	1 or 2-Sys.	1 or 2-Sys.	2-Systems	2-Systems	2-Systems
Design Live Loads	Varies	Varies	Varies	Varies	Varies	Varies
Drilling Rigs:						
Dry Weights	1 or 2-Rigs	1 or 2-Rigs	1 or 2-Rigs	2-Rigs	2-Rigs	2-Rigs
Hook-Loads	1-Well					
Set-Backs	1-Well	2-Wells	2-Wells	2-Wells	2-Wells	2-Wells
Quarters/Helidecks:						
Dry Weights	1 or 2-Units	1 or 2-Units	1 or 2-Units	2-Units	2-Units	2-Units
Design Live Loads	Varies	Varies	Varies	Varies	Varies	Varies

Note: Initial analysis to include five (5) directions for each major event: North, Northeast, East, Southeast, and South. Seismic analysis, however, is in accordance with API's response spectrum approach.

3.6.3.4 Allowable Stresses

Stresses are in accordance with API RP 2A Section 2.5.

4.0 DESIGN BASIS - BARGE SUBSTRUCTURES

These criteria were the basis for the preliminary design of the barge (caisson) structure for 30 foot and 70 foot water depths in Norton Sound, Alaska. Additionally, criteria for the design of the skid beam supporting the above deck production modules are included.

4.1 APPLICABLE REGULATIONS AND CODES

The basic code for determination of capacities of concrete elements is ACI 318-77, Building Code Requirements for Reinforced Concrete. The following codes were used as reference documents. Specific sections of these codes are referenced in these criteria:

(A) ACI 357 78, Guide for the Design and Construction of Fixed Offshore Concrete Structures, 1978

(B) API RP 2A; Recommended Practice for Planning, Designing and Construction Fixed Offshore Platforms; 1981

(C) API Bulletin 2N; Planning, Designing and Constructng Fixed Offshore Structures in Ice Environments; June 1981 Draft

(D) American Bureau of Shipping, Rules for Building and Classing Steel Vessels, 1979

4.2 MATERIALS

4.2.1 Concrete

A. Normal Weight Concrete: fc' = 7000 psi, density = 160 pcf
B. Light Weight Concrete: fc' = 6000 psi, density = 130 pcf

4.2.2 Structural Steel

4.2.2.1 Reinforcing Steel

(A) ASTM A615, Grade 60
(B) ASTM A706, Grade 60 (Weldable For Welded Reinforcing)

4.2.2.2 Prestressing Steel

(A) Strand: ASTM A416, Grade 270
(B) Bars: ASTM A722, Type II

4.2.2.3 Rolled Shapes and Plate

(A) ASTM A633-C, quenched and tempered, charpy impact tested to 25 ft-lbs at -60°F, 50 ksi yield to 2 in thk

(B) ASTM A678-C, quenched and tempered, charpy impact tested to 25 ft-lbs at -60°F, 60 ksi yield to 3 in thk (Plates Only)

4.2.2.4 Pipe

ASTM A333 Grade 6, 35 ksi yield

4.3 CORROSION AND ABRASION PROTECTION

4.3.1 Concrete

Normal weight concrete is used on the exterior bulkheads in the elevations subject to ice abrasion.

4.3.2 Steel

All non-imbedded steel is in the dry zone, thus, a conventional four (4) coat system is used to retard corrosion of structural members.

4.4 CONSTRUCTION CONSTRAINTS

4.4.1 Fabrication

4.4.1.1 Concrete

(See Volume I.)

4.4.1.2 Steel

(Same as Section 2.4.1 specifications for Exterior Members.)

The draft of the barge is an important consideration during both construction of the barge and delivery to the deployment site. In order to minimize draft, alternate framing arrangements have been investigated and lightweight concrete is utilized to maximum extent possible. The weight of all deck-mounted equipment and structures has been included in draft calculations as they will be installed prior to delivery.

4.4.3 Installation

(See Volume I.)

4.4.4 Salvage

It will be necessary to remove the barge (caisson) at the end of its service life. Prior to refloating, any major distress resulting from extreme environmental loadings may require repair.

4.5 GEOMETRICAL CONSTRAINTS

4.5.1 Skid Beams

(A) Maximum Spacing: 100 ft c/c
(B) Minimum Elevation (BOS, MLLW):
  (a) 30 Foot Chart Depth Site - EL (+) 50 ft
  (b) 70 Foot Chart Depth Site - EL (+) 72 ft

4.5.2 Freeboard

Freeboard requirements for the delivery voyage sea state are investigated for head and bow quartering seas to assure that the following criteria are met:

Location	Maximum Allowable Probability of Shipping Water
Fore Perpendicular	0.40
Midships	0.00
Aft Perpendicular	0.50

4.6 ANALYTICAL CONSIDERATIONS

4.6.1 Loads

4.6.1.1 Global Loads

(A) Delivery Voyage

Stillwater bending moments are calculated using the distribution of weight during the delivery voyage.

Delivery voyage wave bending moments are calculated in accordance with the ABS Rules for Building and Classing Steel Vessels, 1979. Wave bending moments are calculated according to the method in Section 6.3.2b of this document, and divided by 1.15 since an allowance for corrosion is not necessary for the concrete structures.

(B) Wind

Wind pressures are calculated in accordance with API RP 2A.

(C) Current

Current forces and the current profile are calculated in accordance with the provisions of API RP 2A.

(D) Waves

Forces due to breaking waves encountering the barge (caisson) at the development site are calculated in accordance with the "Shore Protection Manual," U. S. Army Coastal Engineering Research Center. Various wave characteristics and stillwater elevations are considered to determine the critical condition.

The magnitude of the global wave force is a function of the wave length and the size of the structure, and is calculated in accordance with Section 1.1.3.6

(E) Ice

The design global ice loading is 210 kips per foot of structure length.

(F) Seismic

The barge (caisson) is designed for a seismic event using an equivalent static force in accordance with the Uniform Building Code, 1979 Edition. The added mass of the internal ballast as well as the surrounding seawater and/or ice is considered in the analysis.

(G) Grounding

The distribution of the reaction of the soils against the base of the barge (caisson) considers an allowance for a foundation soil profile which deviates from a plane surface, variations in soil properties over the plan area of the structure, or the failure to fully drive skirts. Global stresses resulting from the distribution of storage compartments is considered.

(H) Construction Loads

Construction loadings are identified during the preliminary design and the necessary provisions are made to accommodate these loadings.

4.6.1.2 Local Loads

(A) Dead Loads

The dead load consists of all barge (caisson) elements as well as all deck-mounted equipment and structures.

(B) Hydrostatic Loads

The hydrostatic pressure resulting from critical water elevations during both floating and grounded conditions is considered in the design.

(C) Ballast/Internal Storage

Bulkhead elements and the bottom plating elements consider the lateral and vertical loading resulting from ballast loadings. The allowable amount of differential ballast in adjacent compartments is identified. Where a compartment is used for materials storage, the bulkheads on the perimeter of this compartment consider the unbalanced loadings that are expected.

(D) Waves

The exterior bulkheads at the elevations subject to wave loadings are designed for the maximum pressures determined in accordance with the "Shore Protection Manual," U.S. Army Coastal Engineering Research Center.

(E) Ice

Global and local ice forces are in accordance with Section 1.1.5.

(F) Current

Current pressures and profiles are determined in accordance with API RP 2A.

(G) Wind

Wind pressure are determined in accordance with API RP 2A.

(H) Grounding

Design of the bottom plate considered potential concentration of reactions of the soil resulting from foundation profile deviations, variations in soil properties over the plan area of the structure or the failure to fully drive skirts.

(I) Thermal Gradients

The design of the exterior bulkhead plating elements considered the internal stresses resulting from a thermal gradient of 58°F across the thickness of plate. This results from a ambient temperature of -28°F at the exterior surface and a temperature of 30°F due to unfrozen ballast at the interior surface.

(J) Seismic

The design of the bulkhead elements considered an increase in lateral ballast and hydrostatic pressures due to seismic accelerations.

(K) Deck Loadings

The reactions from deck-mounted equipment and structures are considered in the design.

4.6.2 Ultimate Strength Design

4.6.2.1 General

The ultimate strength capacity of the structure and all elements of the structure are determined in accordance with ACI 318-77. (The determination of the punching shear capacity of the plating elements, however, consider the membrane action of the slab in resisting high concentrated and uniform loadings. Technical sources outside ACI 318-77 used for such formulations are referenced accordingly.)

The structure and all elements of the structure are designed to provide the ultimate strength determined by the combinations of factored loads as shown in this section. Below is a list of symbols and definitions which form the basis for the ultimate strength load combinations.

(A) D: Dead load of the barge (caisson) structure and the deck mounted production modules

(B) G: Moments and shears resulting from non-uniform support of the barge (caisson) structure in the grounded condition

(C) B: Ballast loadings in the internal compartments of the barge (caisson)

(D) W_{100}: Wave loading at deployment site (100 year event)

(E) WI_{100}: Wind loading at deployment site (100 year event)

(F) WI_1: Wind loading at deployment (1 year event)

(G) C_{100}: Current loading at deployment site (100 year event)

(H) C_1: Current loading at deployment site (1 year event)

(I) EQ: Seismic loading (100 year event)

(J) ICE_{global}: Global ice loading

(K) SW: Stillwater bending moments and shears

(L) W_{deliv}: Delivery voyage wave bending moments and shears

(M) H: Hydrostatic pressures

(N) ICE_{local}: Local concentrated ice loading

(O) ICE_{eq}: Global Ice Loading (4 ft maximum sheet thickness)

4.6.2.2 Global Design

(A) $1.2\ (D + G + B) + 1.3\ W_{100} + 1.3\ WI_{100} + 1.3\ C_{100}$

(B) $1.2\ (D + G + B) + 1.3\ EQ + 1.3\ C_1 + 1.3\ ICE_{eq}$

(C) $1.2\ (D + G + B) + 1.3\ ICE_{global} + 1.3\ C_{100} + 1.3\ WI_1$

(D) $1.95\ SW + 1.95\ W_{deliv.}$ (floating condition - delivery voyage)

Note: For dead loads D, the load factor 1.2 is replaced by 1.0 if it produces a more unfavorable load combination.

4.6.2.3 Local Design

(A) $1.2\ D + 1.2G + 1.6\ H + 1.6\ B$

(B) $1.2\ (D + G + H + B) + 1.1\ ICE_{local} + 1.3\ C_1$

(C) $1.2\ (D + G + H + B) + 1.3\ ICE_{global} + 1.3\ C_{100}$

(D) $1.2\ (D + G + H + B) + 1.3\ EQ + 1.3\cdot C_1 + 1.3\ ICE_{eq}$

(E) $1.2\ (D + G + H + B) + 1.3\ W_{100} + 1.3\ C_{100}$

Note: For dead loads D, the load factor 1.2 is replaced by 1.0 if it produces a more unfavorable load combination.

4.6.2.4 Capacity Reduction Factors

Capacity reduction factors are applied in accordance with ACI 318-77.

4.6.3 Service Load Design

The design of the structure and the individual elements of the structure included the following considerations for the serviceability of the structure. Symbols and definitions of individual loadings are included in Section 4.6.2.

4.6.3.1 Global Design

Floating Condition - Delivery Voyage:

(A) Allowable Tension - 0
(B) Allowable Compression - $0.45\ f'_c$

where f'_c = concrete cylinder compressive strength at 28 days, per ACI 318 77

(C) $M_{cracking}/M_{actual}=1.5$

4.6.3.2 Local Design

(A) Floating Condition - Delivery Voyage:

(a) Prestressed Elements-

- Allowable Tension: $6 (f'_c)^{0.5}$
- Allowable Compression: $0.45 f'_c$

(b) Reinforced Elements-

Serviceability is provided by detailing of reinforcing steel in accordance with ACI 318-77.

(B) Deployed Barges (Caisson):

Serviceability is provided by detailing of reinforcing steel in accordance with ACI 318 77.

4.6.4 Soil/Structure Interface

The interface between the soil and the structure is designed such that sliding and bearing failures do not result due to the global load combinations defined below.

Measures are taken to prevent scour, erosion, or piping of the soil structure interface.

Final design for a specific site shall additionally consider foundation instability in underlying soil layers and soil instability of a global nature.

The soil/structure interface is investigated for the following load combinations. Symbols and definitions of the individual loadings are included in Section 4.6.2.

(A) $D + B + W_{100} + WI_{100} + C_{100}$

(B) $D + B + EQ + C_1 + ICE_{eq}$

(C) $D + B + ICE_{global} + C_{100} + WI_1$

The allowable bearing capacities resulting from the above load combinations are shown in the following table. These capacities are from the PMB Systems Engineering Study which indicates they correspond to a factor of safety of 3.0.

FOUNDATION (1) WIDTH B (FEET)	EMBEDMENT DEPTH D (FEET)	ALLOWABLE BEARING PRESSURE Q (PSF)
25	0	6,200
	6	8,800
50	0	12,000
	6	14,800
100+	0	15,000(2)
	6	15,000

(1) Length of 500 feet.

(2) Suggested maximum allowable for preliminary design.

The resistance to sliding is based upon the tangent of the effective angle of internal friction, as given in Section 1.1.6.1. A soil capacity reduction factor of 1.2 has been applied to this sliding resistance, as recommended in ACI 357.

4.6.5 Barge Skid Beam Design Criteria

The skid beam and its supporting structure are designed to transmit reactions from the topside modules to the deck of the barge (caisson). The design is in accordance with API RP 2A.

4.6.5.1 Load Conditions

(A) D: Empty Weight of Modules/Equipment

(B) D_o: Operational Weight of Modules/Equipment

(C) DE: Reactions due to dynamic loadings during delivery voyage-

- (a) Maximum logitudinal acceleration (pitch)
- (b) Maximum transverse acceleration (roll)
- (c) Vertical accelerations corresponding with the above conditions
- (d) Reactions corresponding to maximum hogging and sagging conditions during the delivery voyage

(D) W_D: Wind during the delivery voyage

(E) W_s: Reactions due to wind at deployment site

(F) ICE: Reactions due to ice accretion at deployment site

(G) EQ: Reactions due to seismic events at deployment site

4.6.5.2 Load Combinations

(A) $D + W_D + DE$

(B) $D + D_o$

(C) $D + D_o + W_s + ICE$

(D) $D + D_o + EQ$

FACILITIES EQUIPMENT LIST

ADDEMDUM B

Equipment List, Norton Sound Study, 11 Sheets

FLUOR OCEAN SERVICES

EQUIPMENT LIST

CONTRACT NO. 411093

CUSTOMER

SHEET 1 OF 11

LOCATION NORTON SOUND

VESSELS/PRODUCTION

REVISION DATE 2/10/81

REVISION NO. 2

ITEM NO.	TITLE	FLOW SHEET NO.	MANUFACTURER	P.O. NO.	WEIGHT		BRIEF DESCRIPTION
					SHIP	WET	
V-1 A/B	HIGH PRESSURE SEPARATORS (2)				20	34	HORIZONTAL, 2 PHASE, 1500#WP, GAS/LIQUID, 10' D X 25 L X 14' H
V-2 A/B	LOW PRESSURE SEPARATORS (2)				15	49	HORIZONTAL, 3 PHASE, 350# WP, W/WATER SEP. BOOT (10'D X 2.5'L) 10'D X 25'X14'H
V-3 A/B	TEST SEPARATORS (2)				12	16	HORIZONTAL, 3 PHASE, 1500# WP, METERING, 6'D X 25'L X 14'H, DUAL MOUNTED ON TOP
V-4 A/B	FLARE SYSTEM KO DRUMS (2)				5	9	HORIZONTAL, 2 PHASE, 50# WP, 10'D X 25'L X 15'H
V-5	OILY WATER CPI SEPARATOR				15	45	OILY SLUDGE & SOLIDS REMOVAL SYSTEM, 170 BBL-CAP, SLUDGE TO BM, 8'W X 12'L X 10'H
V-6	WELL CLEAN UP SEPARATOR				12	16	HORIZONTAL, 2-PHASE, 1500# WP 6' D X 25'L X 14'H
							NOTE: ALL WEIGHTS IN SHORT-TONS.

FLUOR OCEAN SERVICES

EQUIPMENT LIST

CONTRACT NO. 411093
CUSTOMER
SHEET 2 OF 11

LOCATION NORTON SOUND
STORAGE CAPACITY/DRILL & PRODUCTION
REVISION DATE 12/21/81
REVISION NO. 2

ITEM NO.	TITLE	FLOW SHEET NO.	MANUFACTURER	P.O. NO.	WEIGHT		BRIEF DESCRIPTION
					SHIP	WET	
MS-1/9 A/B	MUD STORAGE COMPARTMENTS (18)		WITHIN DRILLING MODULES		98	758	FIVE ACTIVE & FOUR RESERVE TANKS, 2100 BBL EACH SYSTEM
DS-1	DIESEL STORAGE COMPARTMENT		WITHIN SUBSTRUCTURE		NIL	300	2500 BBLS - NOM CAPACITY, W/P-7 A/B DIESEL PUMPS
FWS-1	DRILL WATER COMPARTMENT		WITHIN SUBSTRUCTURE		NIL	625	1800 BBLS NOM CAP, FOR GRAVITY FEED FINAL DESIGN
PWS-1	PRODUCED WATER COMPARTMENT		WITHIN SUBSTRUCTURE		NIL	400	2100 BBLS NOM CAPACITY, PRODUCED WATER SURGE, W/PUMPS P-8 A/B
SWS-1 A/B	SERVICE WATER COMPARTMENTS (2)		WITHIN SUBSTRUCTURE		NIL	750	1750 BBLS, NOM CAP, W/P-4 A/B & P-6 A/B
DS-2 A/B	DIESEL DAY TANKS (2)		WITHIN DRILLING MODULES		9	30	125 BBL CAP.
DWS-2 A/B	POTABLE WATER TANKS (2)		WITHIN DRILLING MODULES		42	147	600 BBL CAP.
BFW-1 A/B	BOILER FEED WATER TANKS (2)		WITHIN DRILLING MODULES		28	98	400 BBL CAP.
SWS-1 A/B	SOLID WASTE TANKS (2)		WITHIN DRILLING MODULES		20	65	138 BBL CAP.
PR-1 A/B	PIPE RACK NO. 1 (2)		ROOF OF DRILLING MODULES		69	694	2750 SF OPEN TUBULAR STORAGE
PR-2 A/B	PIPE RACK NO. 2 (2)		ROOF OF DRILLING MODULES		69	694	2750 SF OPEN TUBULAR STORAGE

FLUOR OCEAN SERVICES

EQUIPMENT LIST

CONTRACT NO. 411093

CUSTOMER

SHEET 3 OF 11

REVISION NO. 1

LOCATION NORTON SOUND

PUMPS/PRODUCTION

REVISION DATE 12/18/81

ITEM NO.	TITLE	FLOW SHEET NO.	MANUFACTURER	P.O. NO.	WEIGHT		BRIEF DESCRIPTION
					SHIP	WET	
P-1 A/B	CRUDE OIL BOOSTER PUMPS (2)				6	6	INLINE CENTRIFUGAL (ELECTRIC), 3700 GPM, 200 HP 4'W X 4'L X 3'H
P-2 A/B	M.O.L. PUMPS (2)				20	20	CENTRIFUGAL (ELECTRIC) 3700 GPM, 1300 HP, 5'W X 13'L X 5'H
P-3 A/B/C	PRODUCED WATER INJECTION PUMPS (3)				30	30	CENTRIFUGAL (ELECTRIC) 300 HP, 175 GPM, 5' W X 20' L X 6'H
P-4	AUXILIARY FIREWATER PUMP				4	4	CENTRIFUGAL (DIESEL), 215 HP, VERTICAL LIFT 100' SHAFT, 2000 GPM, 3'W X 3'L X 3'H
P-5 A/B	FIREWATER JOCKEY PUMPS (2)				4	4	INLINE CENTRIFUGAL (ELECTRIC), 100 GPM, 7HP, 3'W X 3'L X 3'H
P-6 A/B/C/D	SERVICE WATER PUMPS (4)		MOUNTED WITHIN SUBSTRUCTURE		4	4	SUBMERSIBLE, ELECTRIC, P-6 A/B-2000 GPM-100 HP, P-6 C/D - 750 GPM-35 HP, 3'W X 3'L X 3'H
P-7 A/B	DIESEL FUEL TRANSFER PUMPS (2)		MOUNTED WITHIN SUBSTRUCTURE		4	4	SUBMERSIBLE, (ELECTRIC), 750 GPM, 35 HP, 3'W 3'L X 3'H
P-8 A/B	PRODUCED WATER BOOSTER PUMPS (2)		MOUNTED WITHIN SUBSTRUCTURE		4	4	SUBMERSIBLE (ELECTRIC), 750 GPM, 35 HP
P-9	SLOP OIL SKIM PUMP				2	2	CENTRIFUGAL (ELECTRIC), 65 GPM, 25 HP, 3'W X 3'L X 3'H

FLUOR OCEAN SERVICES

EQUIPMENT LIST

CONTRACT NO. 411093

CUSTOMER

MATERIAL PROCESSING/PRODUCTION

SHEET 4 OF 11

LOCATION NORTON SOUND

REVISION DATE 12/22/81

REVISION NO. 1

ITEM NO.	TITLE	FLOW SHEET NO.	MANUFACTURER	P.O. NO.	WEIGHT		BRIEF DESCRIPTION
					SHIP	WET	
ME-1 A/B	HYPOCHLORITE GEN. MODULES (2)				5	5	SERVICE WATER CHLORINATION, 10 PPM RESIDUAL CHLORINE TOTAL, 9'W X 15'L X 6'H
ME-2	FIRE FIGHTING FOAM GENERATOR				3	13	BALANCED PRESSURE BLADDER TANK, 6'D X 13L X 6'H
ME-3	PROD. CHEMICAL FEED PACKAGE				1	5	SIX 200 GALLON RESERVOIRS, SIX INJ. PUMP MANIFOLDED, 5'W X 13'L X 8'H
ME-4	AIR COMPRESSOR UNIT				8	8	W/FILTERS & AIR RECEIVERS, 200 CFM - INST. AIR, 400 CFM - SERVICE AIR, 10'W X 16'L X 8'H
ME-5	SEAWATER DESALINIZATION UNITS				4	8	BOILER FEED WATER & POTABLE WATER, 6000 GPD 6'W X 6'L X 8'H
ME-6 A/B/C	SERVICE STEAM GENERATORS (3)				25	28	175 HP @ 5MMBTU/HR EA., 160 & 400 PSIG STEAM, 7'W X 5'L X 8'H
ME-7	PRODUCED WATER FILTERS				68	73	VERTICAL, UPFLOW, INTERNAL BW, SS -BELOW, 25 MICRON 100# WP, 22'W X 15'L X 15'H
ME-8 A/B	PEDESTAL CRANES (2)				75	135	60 SHORT TON LOAD CAP @ 50', 145' BOOM
ME-9 A/B	RUCKER MOORING SYSTEMS (2)				2	--	120 SHORT TON LOAD CAPACITY

FLUOR OCEAN SERVICES

EQUIPMENT LIST

CONTRACT NO. 411093

CUSTOMER

SHEET 5 OF 11

LOCATION NORTON SOUND

GEN./COMP./PRODUCTION

REVISION DATE 12/1/81

REVISION NO. 0

ITEM NO.	TITLE	FLOW SHEET NO.	MANUFACTURER	P.O. NO.	WEIGHT		BRIEF DESCRIPTION
					SHIP	WET	
C-1 A/B/C	INJECTION GAS COMPRESSORS (3)				80		TURBO COMPRESSORS, 3830 HP, UNITIZED & ENCL., 7'6"W X 50'L X 18'H
E-1 A/B/C	INJECTION GAS COOLERS (3)				20		W/SCRUBBERS & ANCILLIARIES, FOR C-1 A/B/C, 10'W X 24'L X 12'H
TG-1 A/B/C	ELECTRIC POWER GENERATORS (3)				23		TURBO GENERATORS, 2850 KW EACH, UNITIZED & ENCL, W/COOLER & ANCILLIARIES, 7'W X 31'L X 10'H
DG-1	AUXILIARY GENERATOR				70		DUEL FUEL (DIESEL), 800 KW, UNITIZED PACKAGED, 14'W X 27'L X 13'H

FLUOR OCEAN SERVICES

EQUIPMENT LIST

CONTRACT NO. 411093 CUSTOMER ______ SHEET 6 OF 11

LOCATION NORTON SOUND

SPECIAL PIPING ITEMS/PRODUCTION

REVISION DATE 12/1/81 REVISION NO. 0

ITEM NO.	TITLE	FLOW SHEET NO.	MANUFACTURER	P.O. NO.	WEIGHT		BRIEF DESCRIPTION
					SHIP	WET	
SP-1	WELL HEAD MANIFOLD AREA				34	38	PRODUCTION HEADER 24"D - 32 WELLS, TEST HEADER 6"D ONE WELL, INJECTION HEADER (GAS) -16"D-8 WELLS, INJECT. HEADER (WATER)-6"D-8 WELLS, STEAM COILS/ INT. FOR TEMP. CONTROL, 7'W X 40'L X 6'H
SP-2	FLOW METERING MANIFOLD AREA				10	12	P.D. METERS AND/OR TURBINES W/PROVERS FOR 3 PHASES, 15'W X 25'L X 5'H
SP-3	PIG LAUNCHER				3	3.5	1000# ANSI 30"D X 30'L X 4'H
SP-4	PIPELINE RISER		MOUNTED WITHIN SUBSTRUCTURE		21	27	24"D FROM PRODUCTION DECK
SP-5	DIVING SYSTEM				2.0	2.0	ONE MAN DECOMPRESSION HORIZONTAL CHAMBER, 60"D X 8'L X 5'H

FLUOR OCEAN SERVICES

EQUIPMENT LIST

CONTRACT NO. 411093

CUSTOMER

SHEET 7 OF 11

LOCATION NORTON SOUND

ELECTRICAL/PRODUCTION

REVISION DATE 12/22/81

REVISION NO. 1

ITEM NO.	TITLE	FLOW SHEET NO.	MANUFACTURER	P.O. NO.	WEIGHT		BRIEF DESCRIPTION
					SHIP	WET	
EE-1	MOTOR CONTROL CENTER		COMPLETED ENCL. SKID MOUNTED BLDG.		60.0		SWITCH GEAR - 20 KV, 6.3 KV, 0.4 KV, TRANSFORMERS - 10 MKVA & 1250 KVA, 1400 SF X 18'H
EE-2 A/B/C/D	NAV AIDS (4)				0.5		LIGHTS, FOG HORNS, STORAGE BATTERIES W/SOLAR COLLECTOR
EE-3	CONTROL ROOM				5.0		MASTER CONTROL, ESD ETC, 400 SF X 10'H

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EQUIPMENT LIST

CONTRACT NO. 411093
CUSTOMER
SHEET 8 OF 11
LOCATION NORTON SOUND
DRILLING PLANT
REVISION DATE 12/1/81
REVISION NO. 0

ITEM NO.	TITLE	FLOW SHEET NO.	MANUFACTURER	P.O. NO.	WEIGHT		BRIEF DESCRIPTION
					SHIP	WET	
RM-1 A/B	DRILLING RIGS (2)				575	1075	FULLY EQUIPPED DERRICK, SUBSTRUCTURE, AND SKID FRAME, (SEE SPECS FOR DETAILS)

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EQUIPMENT LIST

CONTRACT NO. 411093

CUSTOMER

DRILLING PLANT

SHEET 9 OF 11

REVISION NO. 1

LOCATION NORTON SOUND

REVISION DATE 12/22/81

ITEM NO.	TITLE	FLOW SHEET NO.	MANUFACTURER	P.O. NO.	WEIGHT		BRIEF DESCRIPTION
					SHIP	WET	
MP-1/2 A/B	MUD PUMPS (4)				32		TRIPLEX, 2000 HP, RECIP, ONE OPERATING & ONE SPARE, 14'L X 10'W
SPS-1 A/B	SOLIDS PROCESSING SYSTEMS (2)				9		SHALE SHAKERS, DEGASSERS, & CENTRIFUGE, 8'W X 8'L
ML-1 A/B	MUD LABS (2)				NIL		ENGINEERING BLDG, 8'W X 8'L X 8'H
EL-1 A/B	LOGGING UNITS (2)				35		WIRE LINE (ELECTRIC), 22500 FT. DRUM, 0.105 in. 80 HP, 15'W X 15'L X 25'H

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EQUIPMENT LIST

CONTRACT NO. 411093

CUSTOMER

SHEET 10 OF 11

LOCATION NORTON SOUND

DRILLING PLANT

REVISION DATE 12/22/81

REVISION NO. 1

ITEM NO.	TITLE	FLOW SHEET NO.	MANUFACTURER	P.O. NO.	WEIGHT		BRIEF DESCRIPTION
					SHIP	WET	
PT 1/8 A/B	PNUEMATIC TANKS (16)				5.2	9.5	BARITE OR CEMENT, DRY STORAGE, VERTICAL, 11'D X 15'H
PC-1 A/B	AIR COMPRESSORS (2)				4	--	PNUEMATIC SYSTEMS, 600 CFM @ 40 PSI 4'W X 11'L X 4'H
SG-1	STEAM GENERATOR				25	28	DIESEL FIRED, 6 MMBTU/HR, 7'W X 5'L X 8'H

FLUOR OCEAN SERVICES

EQUIPMENT LIST

CONTRACT NO. 411093
CUSTOMER
DRILLING PLANT
LOCATION NORTON SOUND
SHEET 11 OF 11
REVISION DATE 12/21/81
REVISION NO. 1

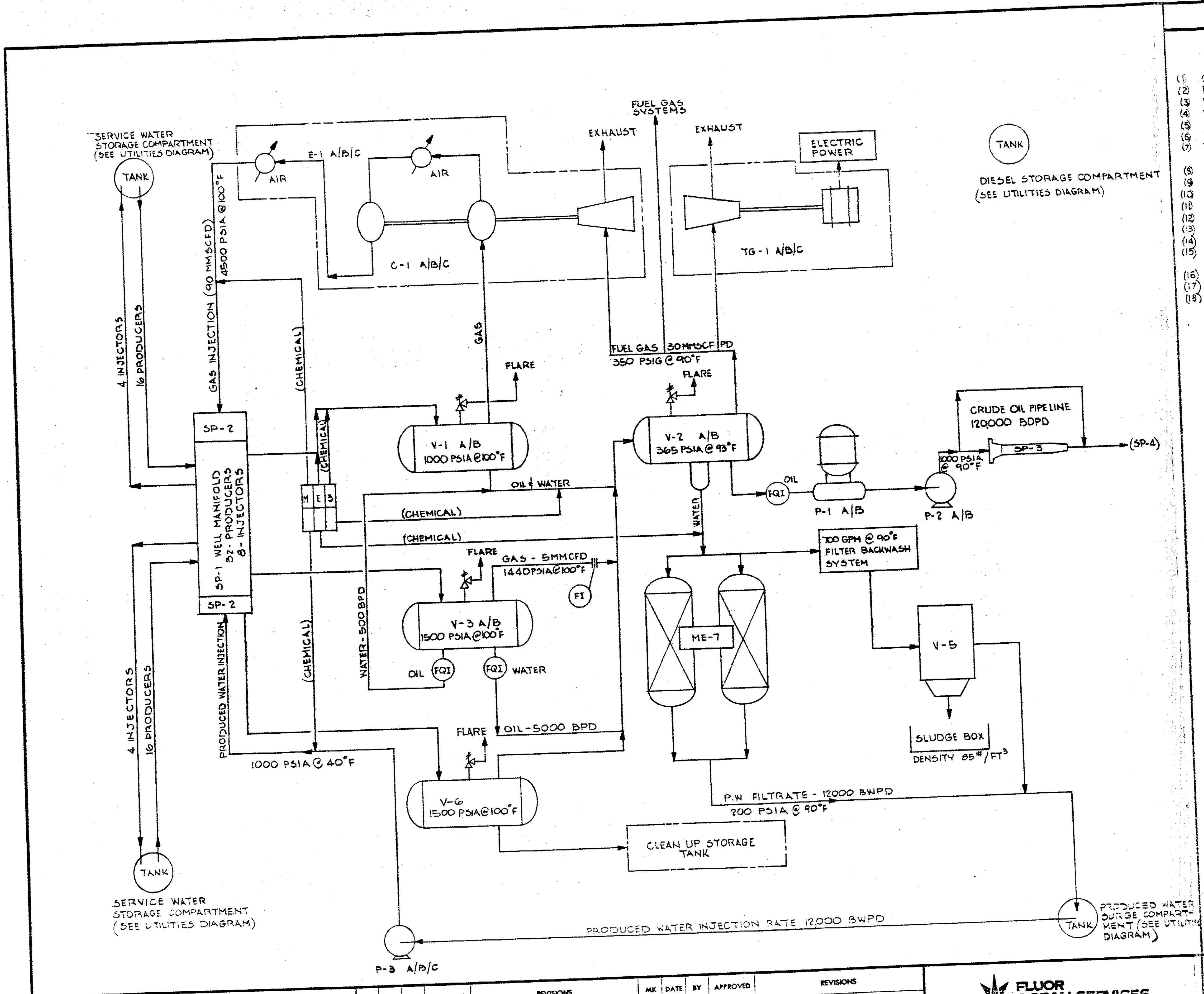
ITEM NO.	TITLE	FLOW SHEET NO.	MANUFACTURER	P.O. NO.	WEIGHT		BRIEF DESCRIPTION
					SHIP	WET	
CP-1 A/B	CEMENTING UNITS (2)				65	115	HOPPER & MIXING TANK, 300 BPH, 175 BBL CAP, CEMENT PUMPS - 450 HP, DIESEL, 9'W X 22'L X 10'H
DG-2 A/B	DIESEL GEN. SETS (2)				70	70	DIESEL FIRED - 700 KW EACH, 2-OPERATING 30'W X 8'L X 7'H
DG-3 A/B/C	DIESEL GEN. SETS (3)				70	70	DIESEL FIRED - 700 KW EACH, 2 OPERATING W/ COMMON SPARE, 30'W X 8'L X 7'H
EE-5 A/B	SWITCHGEAR ROOM (2)				10	10	CONTROL ROOM, 12'W X 28'L X 8'H
EE-4	SWITCHGEAR SUBSTATION				33	33	TRANSFORMERS, 10'W X 30'L X 8'H
			MISCELLANEOUS	ITEMS			
IC-1 A/B	CORROSION PROTECTION SYSTEM (2)				2	2	IMPRESSED CURRENT (JACKET ONLY), 4'W X 4'L X 4'H
FB-1 A/B	FLARE BOOMS (2)				100	108	150 FT W/FLARE TIP & MOLECULAR SEAL, AUTOMATIC SYSTEM
CQ-1 A/B	PERSONNEL QUARTERS (2)				400	720	50 MAN W/HELIDECK
SC-1 A/B/C/D	SURVIVAL CRAFT (4)				7	7	44 MAN

PRELIMINARY DESIGN DRAWINGS

ADDENDUM C

PRELIMINARY DESIGN DRAWINGS

DWG. NO.	TITLE	REV. NO.
F-101	Topside Facilities, Process Flow Diagram	0
F-102	Topside Facilities, Utility Flow Diagram	0
J-101	Steel Jacket Concept, General Arrangement & Installation	0
J-102	Steel Jacket Concept, Equipment Layout-Production Deck	0
J-103	Steel Jacket Concept, Equipment Layout-Drilling Deck	0
J-104	Steel Jacket Concept, Framing Plans & Elevations-Modules, Sh. 1 of 3	0
J-105	Sh. 2 of 3	0
J-106	Sh. 3 of 3	0
J-107	Steel Jacket Concept, Framing Plans & Elevations-Jackets	0
J-108	Steel Jacket Concept, Framing Details-Jacket, Sh. 1 of 3	0
J-109	Sh. 2 of 3	0
J-110	Sh. 3 of 3	0
B-101	Concrete Barge Concept, General Arrangement & Installation	0
B-102	Concrete Barge Concept, Equipment Layout, Sh. 1 of 2	0
B-103	Sh. 2 of 2	0
B-104	Concrete Barge Concept, Framing Plans & Elev's - Modules, Sh. 1 of 2	0
B-105	Sh. 2 of 2	0
B-106	General Arrangement, Barge Concept for 30' Water	0
B-107	Framing Arrangement, Barge Concept for 30' Water	0
B-108	Deck Framing Plan and Details	0
B-109	Reinforcing and Prestressing Arrangement	0
B-110	Miscellaneous Details	0
B-111	Construction Plans, Barge Concept for 30' Water	0
B-112	Segment Joining & Superstructure Erection	0
B-113	Deployment Plan, Barge Concept for 30' Water	0
B-114	General Arrangement, Barge Concept for 70' Water	0
B-115	Framing Arrangement, Barge Concept for 70' Water	0
B-116	Design & Construction Schedule, Concrete Platform	0



GENERAL NOTES

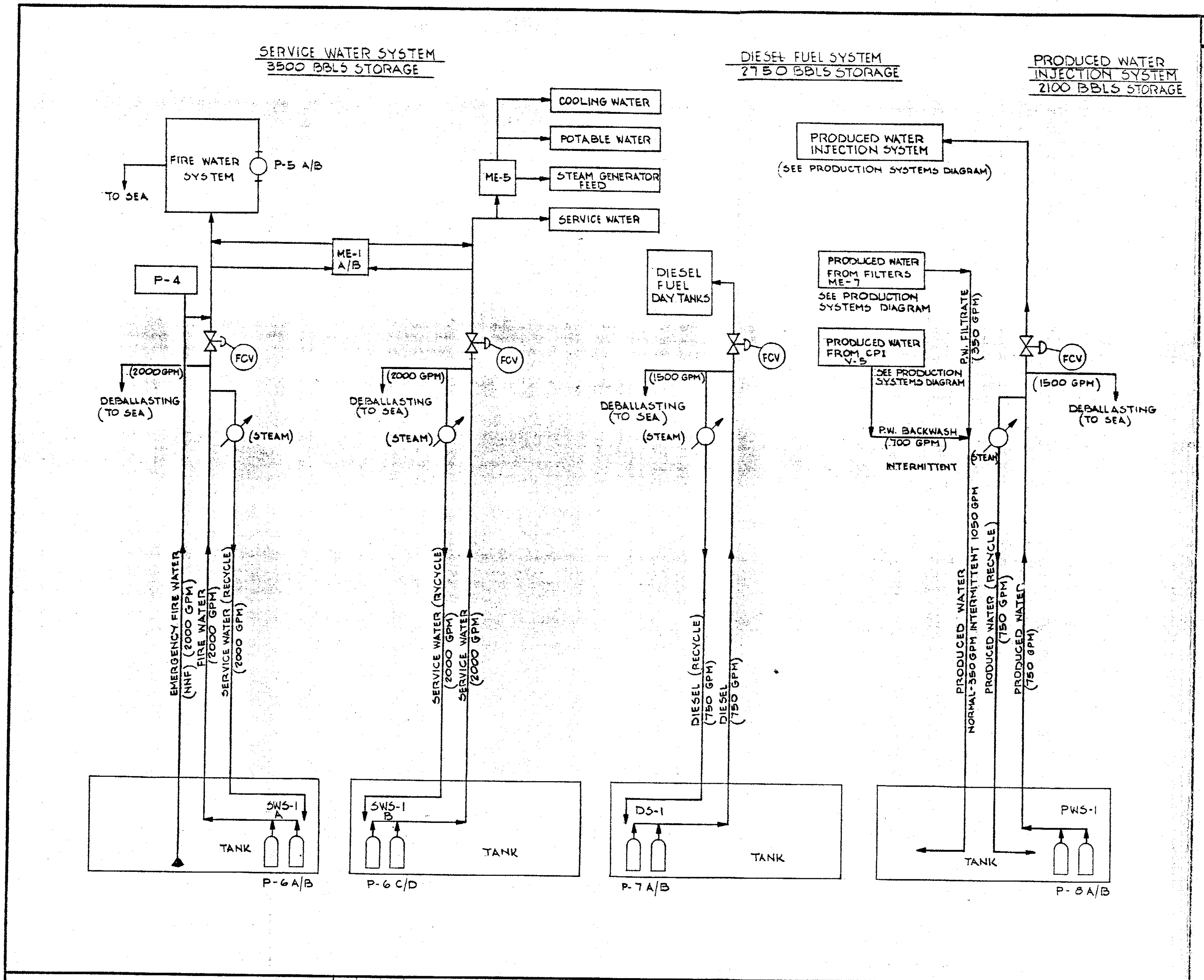
(1) C-1 A/B/C TURBO COMPRESSORS 3330 H.P. ENCLOSED
(2) E-1 A/B/C COOLERS & ANCILLIARY EQUIPMENT FOR C-1 A/B/C
(3) V-1 A/B H.P. SEPARATORS 10'φ x 25' T/T 1500# WP. 2 PHASE
(4) V-2 A/B H.P. SEPARATORS 10'φ x 25' T/T 500# WP. 3 PHASE
(5) V-3 A/B TEST SEPARATOR 6'φ x 25' T/T 1500# WP. 3 PHASE.
(6) ME-7 PRODUCED WATER FILTRATION UNIT 6'φ x 10' O.C. 100# WP.
(7) TG-1 A/B/C TURBO GENERATORS 2850 KW EA., ENCLOSED AND UNITIZED W/ ANCILLIARIES
(8) P-1 A/B CRUDE OIL BOOSTER PUMPS, 3700 GPM, 200 H.P.
(9) P-2 A/B M.O.L PUMPS 3700 GPM, 200 HP.
(10) P-3 A/B/C PRODUCED WATER INJECTION PUMPS
(11) SP-1 WELL MANIFOLD
(12) SP-2 METERING UNIT THREE PHASE
(13) SP-3 CRUDE OIL PIPELINE 24"φ PIG LAUNCHER 30"x 30' 1500# WP.
(14) V-5 OILY WATER, CPI SEPARATOR 8' x 12' x 10' HIGH 170 BBL-CAP
(15) ME-3 PRODUCTION CHEMICAL FEED PACKAGE 6-200 GALLON RESERVOIRS AND 6 CHEMICAL INJECTION PUMPS
(16) SP-4 24"φ PIPELINE RISER
(17) V-6 WELL CLEAN UP SEPARATOR 6'φ x 25' T/T 1500# WP. 2 PHASE.
(18) (TEMPORARY) CLEAN UP STORAGE TANK. 500 BBLS CAP (RENTED)

REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

FLUOR OCEAN SERVICES

DRAWN BY M. NETZER
DATE 12-21-81
CHECKED BY
DATE 2-1-82
ENGINEER
DATE 2/1/82
FOS APPROVAL
CLIENT APPROVAL

TITLE TOPSIDE FACILITIES
PROCESS FLOW DIAGRAM
OWNER
LOCATION NORTON SOUND, ALASKA
SCALE NONE
CONTRACT NO. 411093
DRAWING NO. F-101
REV. 0



GENERAL NOTES

(1) SERVICE WATER SUMP PUMPS: P-6 A/B 2000 GPM, 100 HP
P-6 C/D 750 GPM, 35 HP.

(2) ME-1 A/B HYPOCHLORITE GENERATOR (10Mg/L CHLORINE RESIDUAL)

(3) ME-5 A/B SEAWATER DESALINIZATION, R.O. UNIT 6000 GPM

(4) P-7 A/B DIESEL FUEL TRANSFER PUMPS 750 GPM, 35 HP.

(5) P-8 A/B PRODUCED WATER BOOSTER PUMP 750 GPM, 35HP.

(6) P-4 AUXILIARY FIREWATER LIFT PUMP, DIESEL 2000 GPM, 215 HP.

REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

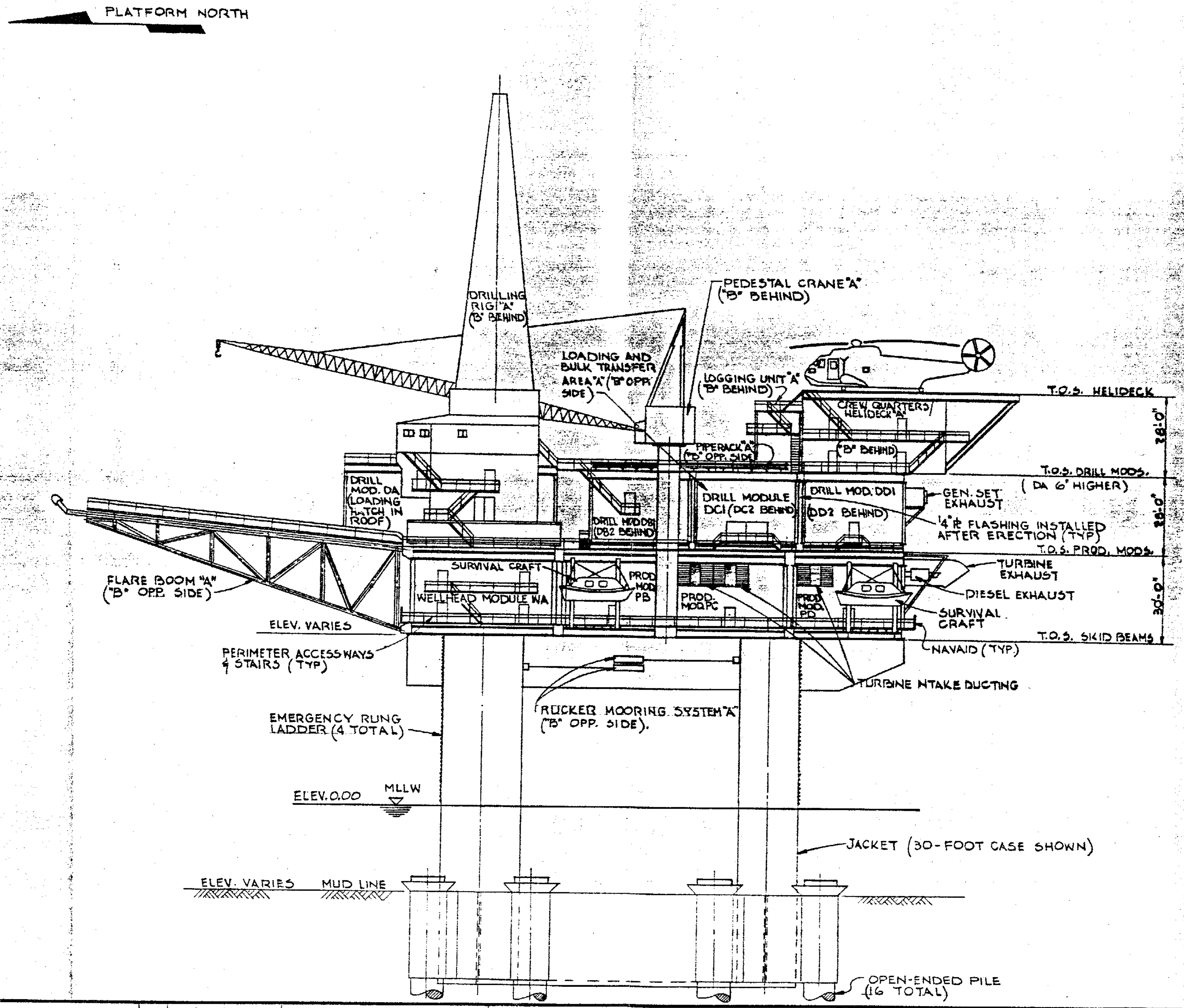
FLUOR OCEAN SERVICES

DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER			
DATE	DATE	DATE	CLIENT APPROVAL
12-22-81	2-1-82	2/1/82	

TITLE TOPSIDE FACILITIES
UTILITY FLOW DIAGRAM
OWNER
LOCATION NORTON SOUND, ALASKA

SCALE	CONTRACT NO.	DRAWING NO.	REV.
NONE	411093	F-102	0

BROADSIDE ELEVATION



MODULE ERECTION SCHEDULE

LIFT NO.	PACKAGE	DRY WT. (SHT)	REMARKS
1	PB	955	SKID TO POSITION
2	PC	1040	SKID TO POSITION
3	WA	1100	SET IN PLACE
4	PD	1010	SET IN PLACE
5	DB1	567	SET IN PLACE
6	DC1	481	SET IN PLACE
7	DD1	521	SET IN PLACE
8	EL-1A	35	SET IN PLACE
9	ME-8A	106	SET IN PLACE
10	DB2	562	SET IN PLACE
11	DC2	476	SET IN PLACE
12	DD2	521	SET IN PLACE
13	EL-1B	35	SET IN PLACE
14	ME-8B	106	SET IN PLACE
15	CQ-1B	400	SET IN PLACE
16	CQ-1A	400	SET IN PLACE
17	DA	418	SKID TO POSITION
18	RM-1A	575	SET IN PLACE
19	FB-1A	100	SET IN PLACE
20	RM-1B	575	SET IN PLACE
21	FB-1B	100	SET IN PLACE
SUB TOTAL		10100	SEE DWG NO'S J-102 & 103 FOR PACKAGE PLAN LOCATIONS.

NOTES:

(1) FOR EQUIPMENT LAYOUTS, SEE DWG. NO'S J-102 & 103.
(2) FOR MODULE STRUCTURES, SEE DWG. NO'S J-104 105 & 106.
(3) FOR JACKET STRUCTURES, SEE DWG. NO'S J-107, 108, 109 & 110.

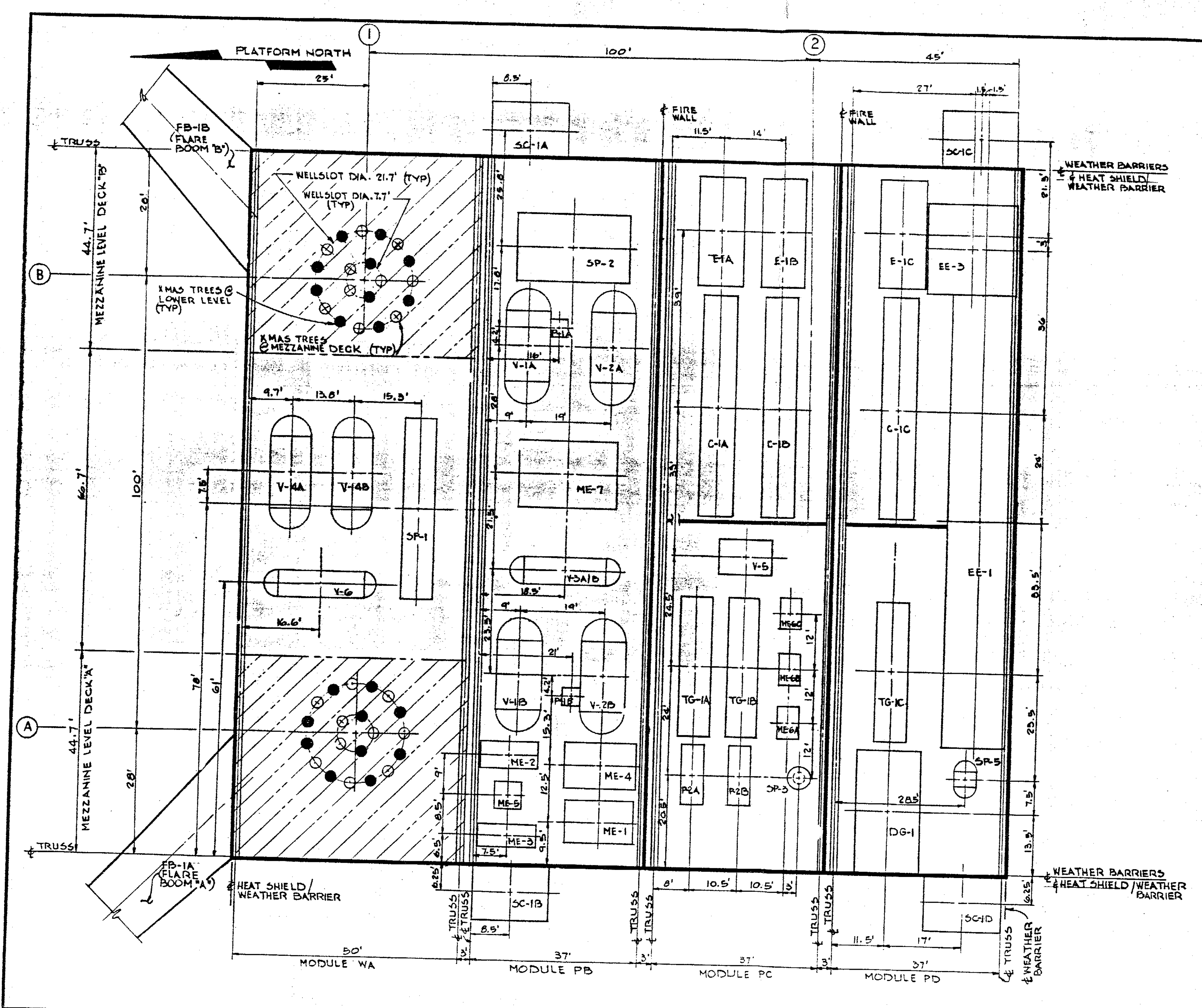
REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

FLUOR OCEAN SERVICES

DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER	CL BRODEUR		
DATE 2-2-82	DATE 2-5-82	DATE 2/5/82	CLIENT APPROVAL

TITLE STEEL JACKET CONCEPT
GENERAL ARRANGEMENT & INSTALLATION
OWNER
LOCATION NORTON SOUND, ALASKA.

SCALE	CONTRACT NO.	DRAWING NO.	REV.
1"= 20'	411093	J-101	0



GENERAL NOTES

(1) STORAGE LOCATIONS:

- (a) DRILL PIPE (3000 SHT) - SETBACKS = 500 SHT, PIPERACKS = 2500 SHT
- (b) SACK STORAGE - MODULE DA
- (c) DRILL WATER (3600 BBLS) - JACKET FLOATATION GIRDER '1' (HEATED)
- (d) SERVICE WATER (3500 BBLS) - JACKET FLOATATION GIRDER 'B' (HEATED)
- (e) PRODUCED WATER/SURGE (2270 BBLS) JACKET FLOATATION GIRDER 'A' (HEATED)
- (f) DIESEL FUEL (2500 BBLS) - JACKET FLOATATION GIRDER 'B' (HEATED)
- (g) DIESEL FUEL DAY (250 BBLS) - MODULES DB1 & DB2
- (h) POTABLE WATER (1200 BBLS) - MODULES DC1 & DC2
- (i) BOILER FEED WATER (800 BBLS) - MODULES DB1 & DB2
- (j) SOLID WASTE (275 BBLS) - MODULES DC1 & DC2

(2) FOR MAJOR EQUIPMENT DESCRIPTIONS, SEE SEPARATE EQUIPMENT LIST.

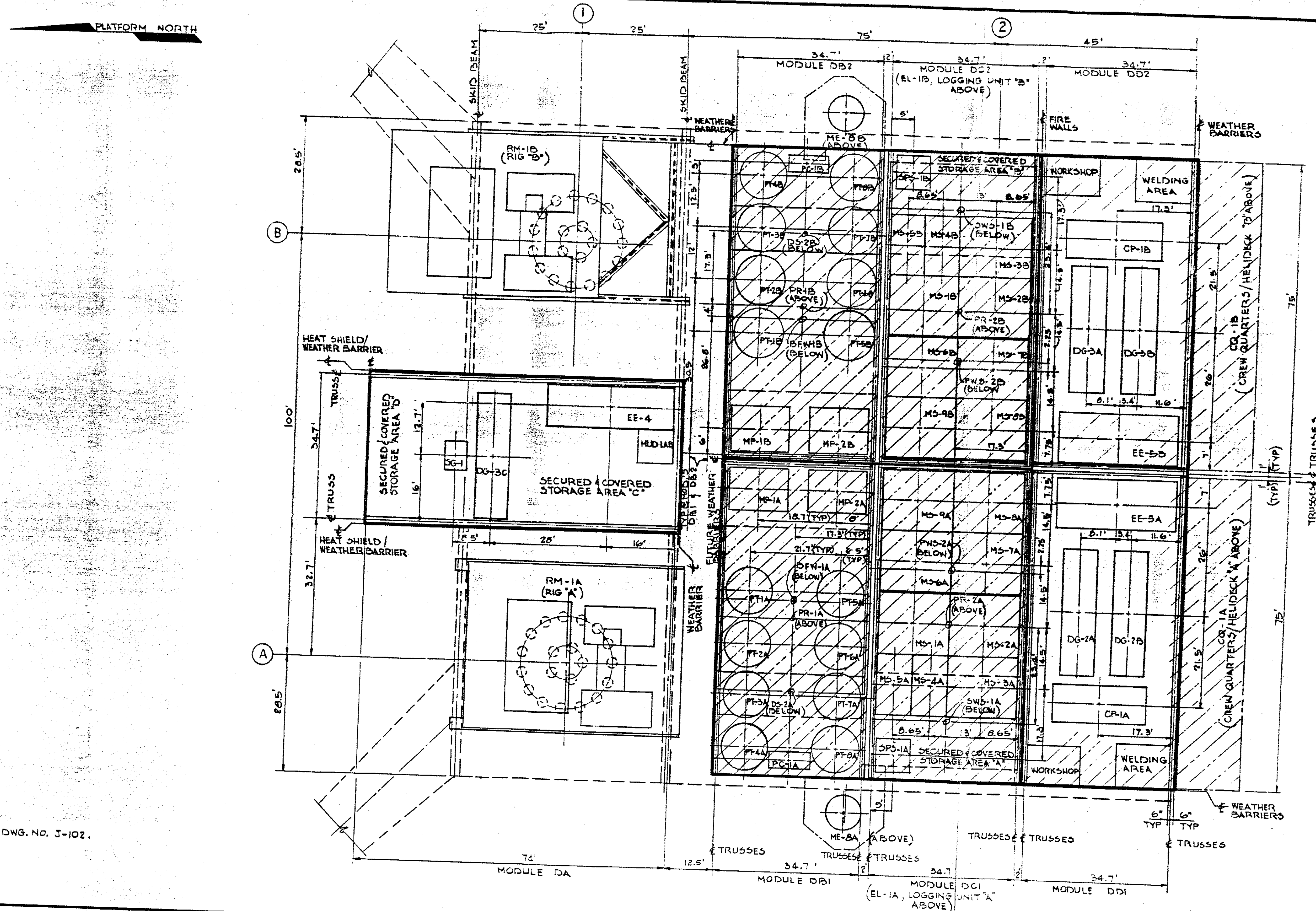
REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

FLUOR OCEAN SERVICES

DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER	Jakeley	Casey	
DATE 1-21-82	DATE 2/5/82	DATE 2/5/82	CLIENT APPROVAL

TITLE STEEL JACKET CONCEPT
EQUIPMENT LAYOUT – PRODUCTION DECK
OWNER
LOCATION NORTON SOUND, ALASKA

SCALE	CONTRACT NO.	DRAWING NO.	REV.
3/32"=1'0"	411093	J-102	0



NOTE:
FOR GENERAL NOTES, SEE DWG. NO. J-102.

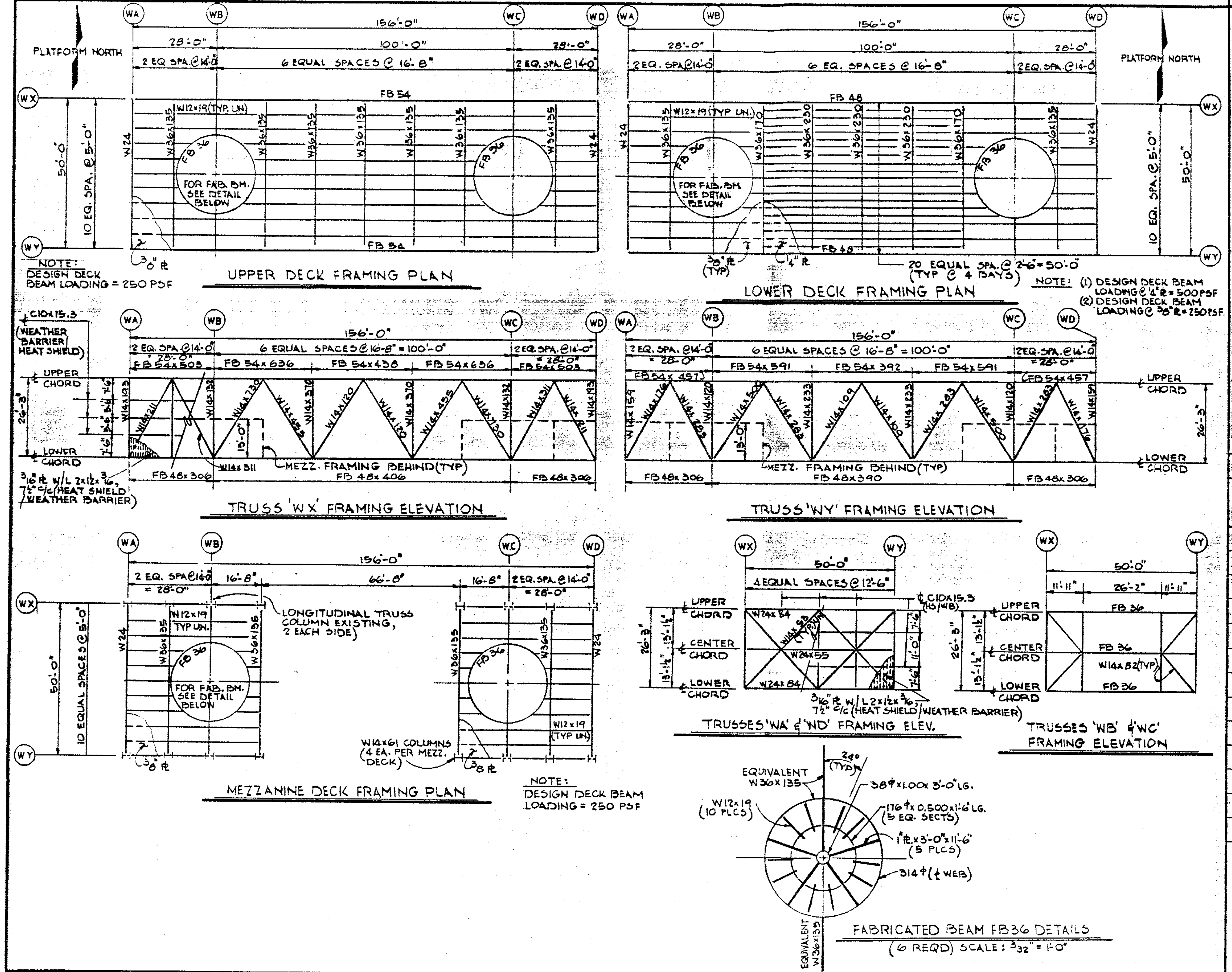
REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

FLUOR OCEAN SERVICES

DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER			
DATE 1-19-82	DATE 2/5/82	DATE 2/5/82	CLIENT APPROVAL

TITLE STEEL JACKET CONCEPT
EQUIPMENT LAYOUT - DRILLING DECK
OWNER
LOCATION NORTON SOUND, ALASKA
SCALE 3/32"=1'-0"
CONTRACT NO. 411093
DRAWING NO. J-103
REV. 0

WELLHEAD MODULE



GENERAL NOTES

(1) FOR BILL OF MATERIALS (STEEL) SEE DWG. NO. J-106.

FABRICATED BEAM SCHEDULE

DESIGNATION	WEB (IN.)		FLANGES (IN.)		REMARKS
	tw	d-2tf	tf	bf	
FB 48x306	0.875	45.5	1.25	20.0	
FB 48x390	1.00	44.5	1.75	20.0	
FB 48x406	1.00	44.5	1.875	20.0	
FB 54x392	0.875	51.5	1.25	28.0	
FB 54x438	0.875	51.0	1.50	28.0	
FB 54x457	1.25	51.5	1.25	28.0	
FB 54x503	1.25	51.0	1.50	28.0	
FB 54x591	1.50	50.5	1.75	28.0	
FB 54x656	1.50	50.0	2.00	28.0	

REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

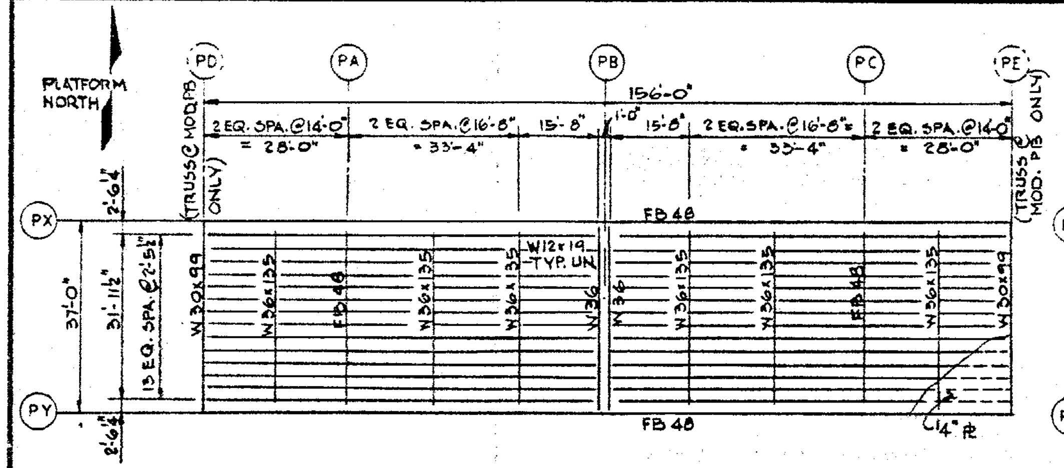
FLUOR OCEAN SERVICES

DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER	CL BRODEUR	Dairy	
DATE 1-25-82	DATE 2-5-82	DATE 2/5/82	CLIENT APPROVAL

TITLE STEEL JACKET CONCEPT
FRAMING PLANS & ELEVS-MODULES, SH. OF 3
OWNER
LOCATION NORTON SOUND, ALASKA

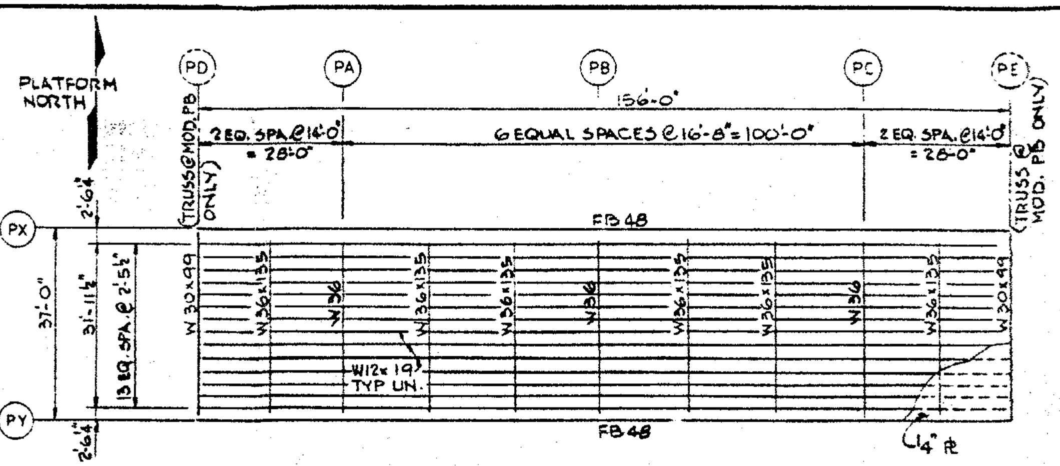
SCALE	CONTRACT NO.	DRAWING NO.	REV.
1/16" = 1'-0" UN	411093	J-104	0

PRODUCTION MODULES



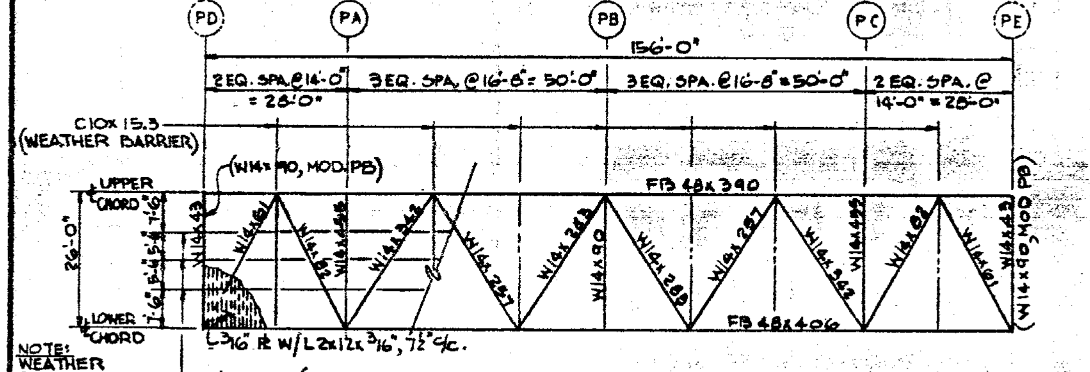
UPPER DECK FRAMING PLAN

NOTE: DESIGN DECK BEAM LOADING = 500 PSF



LOWER DECK FRAMING PLAN

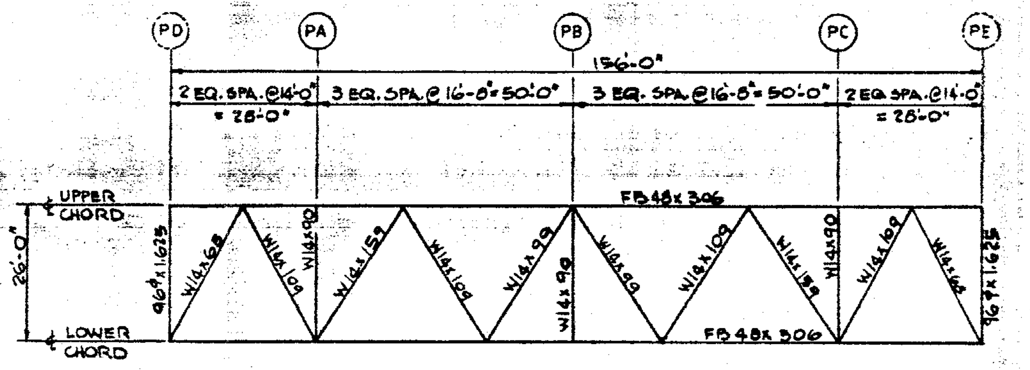
NOTE: DESIGN DECK BEAM LOADING = 500 PSF



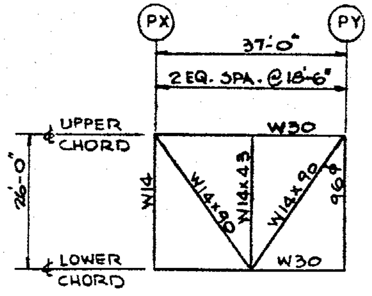
NOTE: WEATHER BARRIERS AT TRUSS 'PX' MOD-PD ONLY.

TRUSS 'PX' (MODULES PB, PC & PD) FRAMING ELEVATION

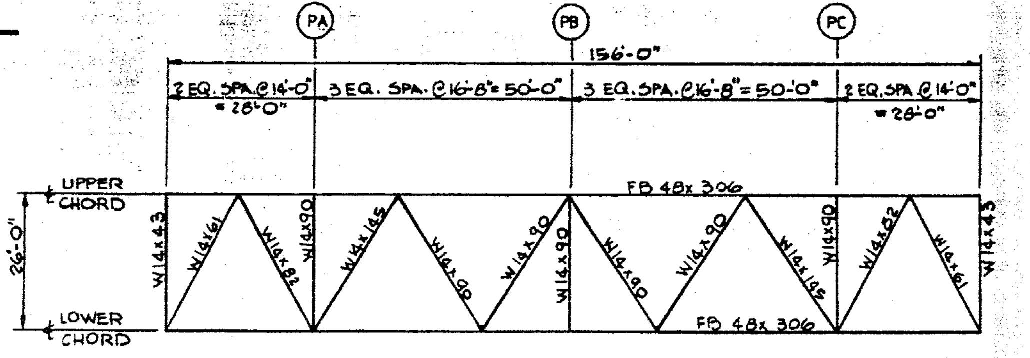
TRUSS 'PY' (MODULE PD) FRAMING ELEVATION



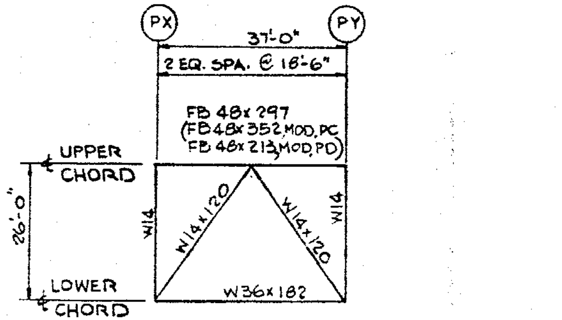
TRUSS 'PY' (MODULE PB FRAMING ELEVATION



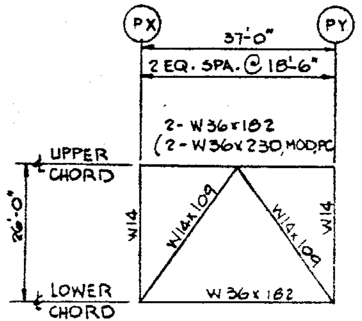
TRUSS 'PD' & 'PE' (MOD. PB) FRAMING ELEVATION



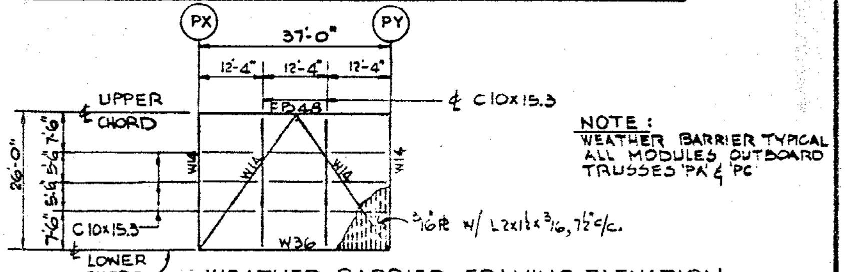
TRUSS 'PY' (MODULE PC) FRAMING ELEVATION



TRUSSES 'PA' & 'PC' FRAMING ELEVATION



TRUSS 'PB' FRAMING ELEVATION



NOTE: WEATHER BARRIER TYPICAL ALL MODULES OUTBOARD TRUSSES 'PA' & 'PC'

WEATHER BARRIER FRAMING ELEVATION

FABRICATED BEAM SCHEDULE

DESIGNATION	WEB (IN.)		FLANGE (IN.)		REMARKS
	tw	d-2tf	tf	bf	
FB 48x213	0.750	46.0	1.00	14.0	
FB 48x297	0.875	45.0	1.50	16.0	
FB 48x306	0.875	45.5	1.25	20.0	
FB 48x352	0.875	45.0	2.00	16.0	
FB 48x390	1.00	44.5	1.75	20.0	
FB 48x406	1.00	44.25	1.875	20.0	

NOTES:

(1) FOR BILL OF MATERIALS (STEEL) SEE DWG. NO. J-106.

REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

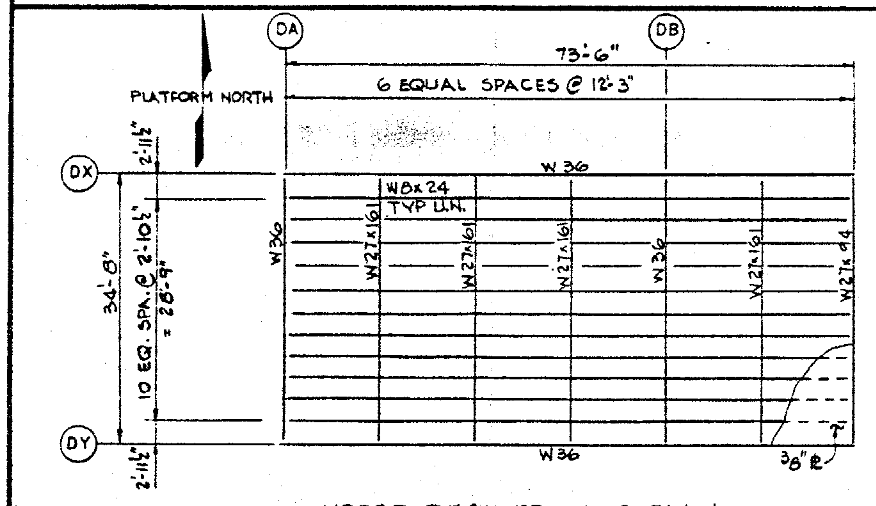
FLUOR OCEAN SERVICES

DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER	C. BRODEUR	Barry	
DATE 1-26-82	DATE 2-5-82	DATE 2/5/82	CLIENT APPROVAL

TITLE STEEL JACKET CONCEPT
FRAMING PLANS & ELEV'S-MODULES, SH. 2 OF 3
OWNER
LOCATION NORTON SOUND, ALASKA

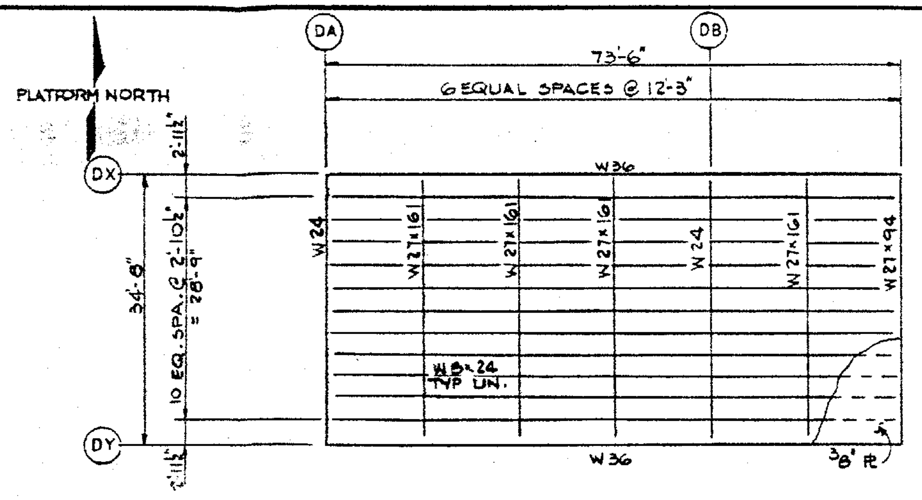
SCALE	CONTRACT NO.	DRAWING NO.	REV.
1/16"=1'-0"	411093	J-105	0

DRILLING MODULES



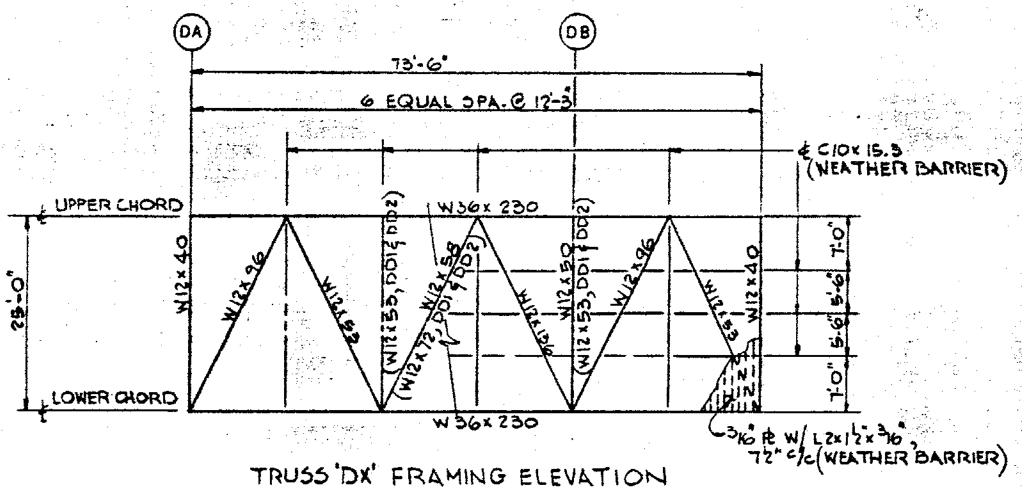
UPPER DECK FRAMING PLAN

NOTE: DESIGN DECK BEAM LOADING = 1000 PSF



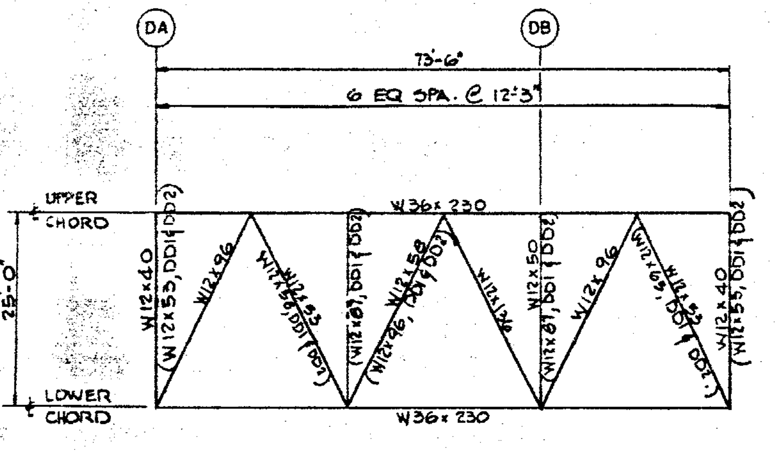
LOWER DECK FRAMING PLAN

NOTE: DESIGN DECK BEAM LOADING = 1000 PSF

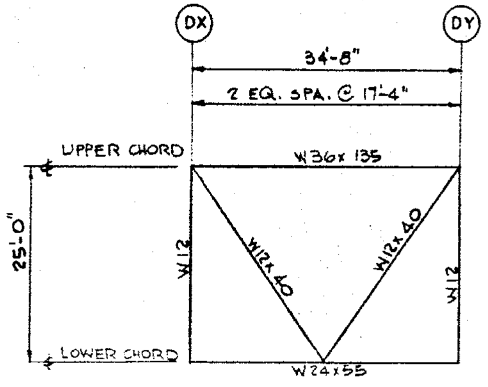


TRUSS 'DX' FRAMING ELEVATION

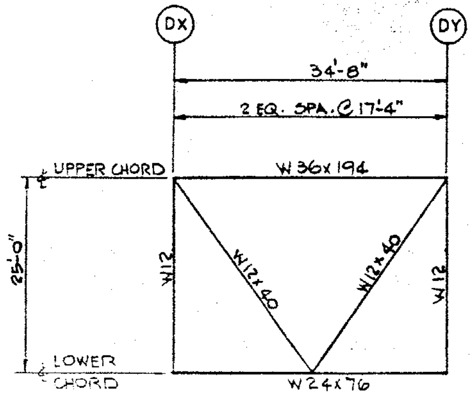
NOTE: WEATHER BARRIER, AS REQUIRED, TYPICAL AT TRUSSES 'DX' & 'DY'.



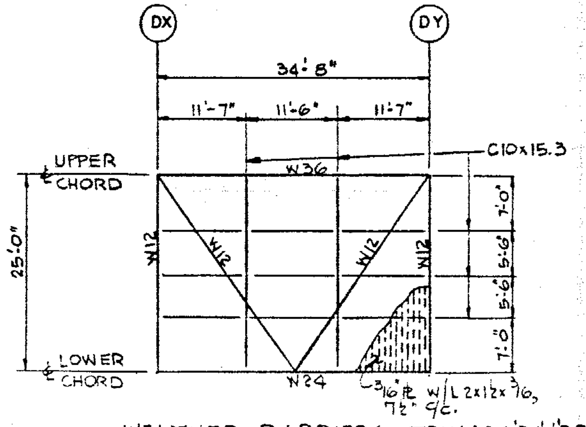
TRUSS 'DY' FRAMING ELEVATION



TRUSS 'DA' FRAMING ELEVATION



TRUSS 'DB' FRAMING ELEVATION



WEATHER BARRIERS–TRUSSES 'DA' & 'DB'

NOTE: WEATHER BARRIER, AS REQUIRED, TYPICAL AT AND OUTBOARD TRUSSES 'DA' & 'DB'.

BILL OF MATERIALS (STEEL)

MODULES & MISC. PCKGS.	ASTM PLATE A633-C	ASTM PLATE A537 CLASS I	ASTM PLATE A36	ASTM ROLLED SHAPES A633-C & A333GDB	ASTM ROLLED SHAPES A588 & A678-A	ASTM ROLLED SHAPES A36	SUB-TOTALS
DA	47	24	1	95	27	6	200
DB1	37	26	1	60	59	6	189
DB2	34	28	1	53	62	6	184
DC1	30	31	1	37	73	6	178
DC2	26	31	1	31	77	6	172
DD1	22	46	1	57	67	6	199
DD2	19	49	1	52	72	6	199
WA	308	137	4	204	171	32	856
PB	215	64	2	57	142	18	498
PC	138	100	2	71	123	16	450
PD	61	188	2	96	122	17	486
CQ-1A	106	71	0^{5}	106	71	5^{5}	360
CQ-1B	106	71	0^{5}	106	71	5^{5}	360
RM-1A	123	41	2	123	41	14	344
RM-1B	123	41	2	123	41	14	344
FB-1A				90			90
FB-1B				90			90
SP-4					21		21
ME-8A	31						31
ME-8B	31						31
EL-1A	14			14			28
EL-1B	14			14			28
GRAND TOTALS	1485	945	22	1479	1240	164	5333 SHT
PERCENTAGES	27^{8}	17^{8}	0^{4}	27^{7}	23^{3}	3^{0}	100%

NOTES:

(1) FOR GENERAL NOTES, SEE DWG. NO. J-104.

(2) INTERIOR MEMBERS INCLUDE: UPPER DECK PLATE AND BEAMS (MODULES SUPPORTING PRIMARY DRILLING MODULES AND QUARTERS), UPPER LEVEL TRANSVERSE GIRDERS, LOWER DECK PLATE AND BEAMS, UPPER TRUSS CHORDS (AFOREMENTIONED QUALIFICATION), AND INSIDE TRUSS COLUMNS AND DIAGONALS.

(3) MISCELLANEOUS STEEL ESTIMATES INCLUDE: 0.5% A36 PL, 45% A36 ROLLED SHAPES, AND 10% A633-C AND A537 PL RATIONED BY UNFACTORED EXTERIOR TO INTERIOR STEEL QUANTITIES.

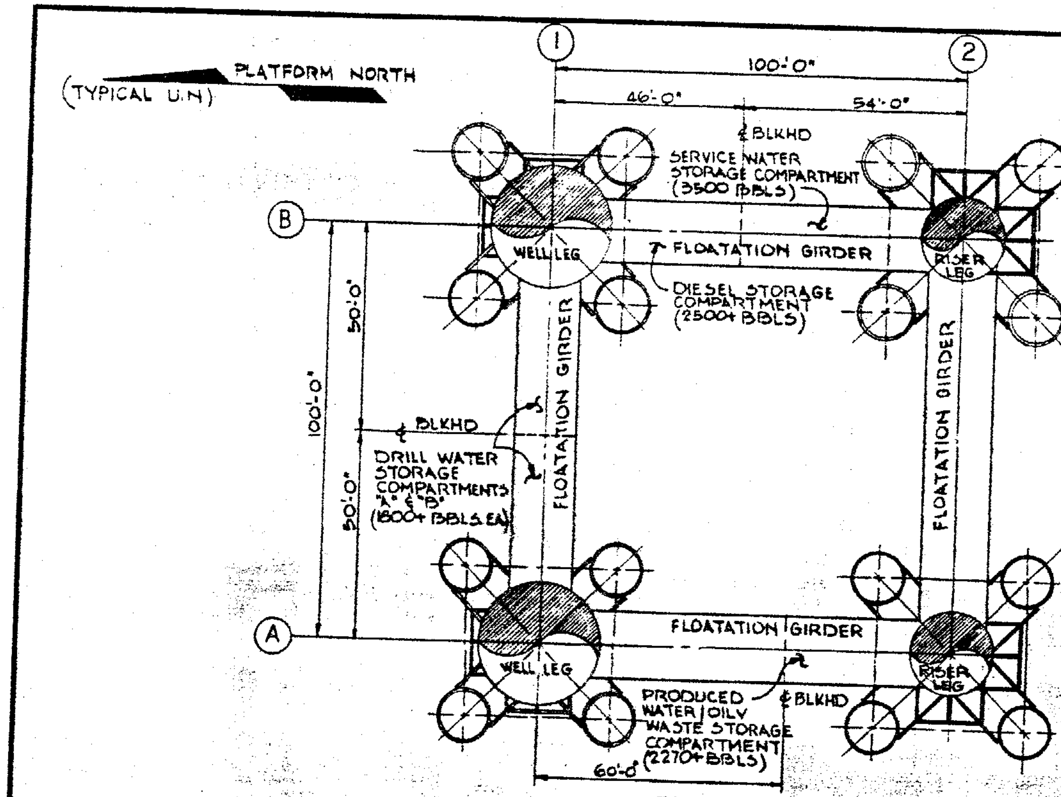
REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

FLUOR OCEAN SERVICES

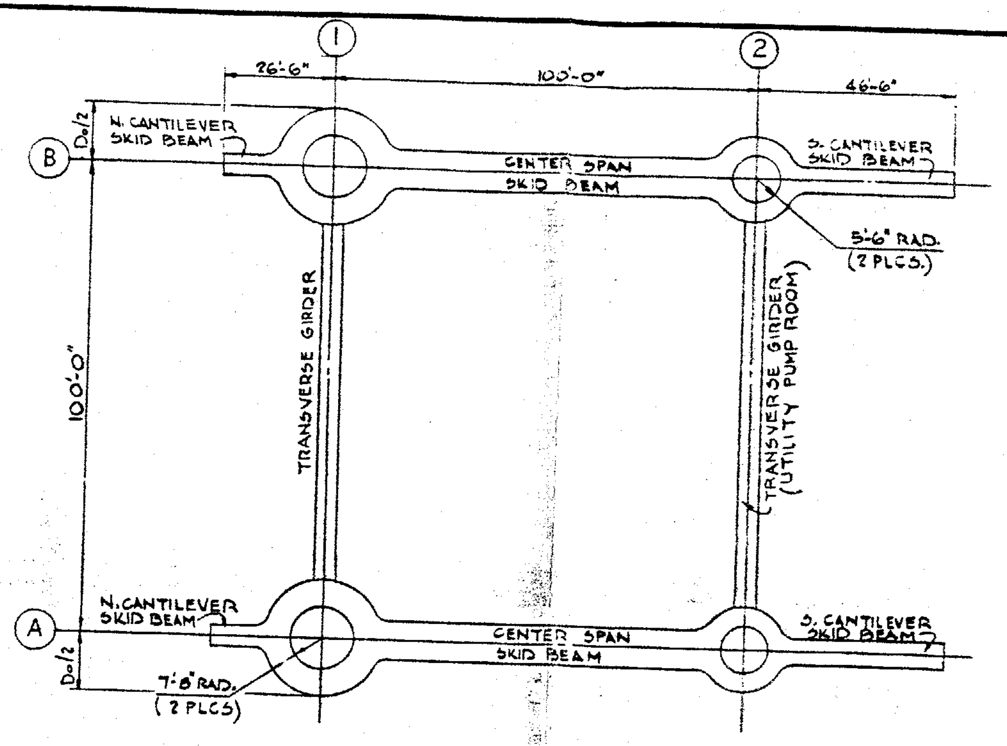
DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER	CL BROVEUR	Sauy	
DATE 2-1-82	DATE 2-5-82	DATE 2/5/82	CLIENT APPROVAL

TITLE STEEL JACKET CONCEPT
FRAMING PLANS & ELEV'S – MODULES SH. 3 OF 3
OWNER
LOCATION NORTON SOUND, ALASKA

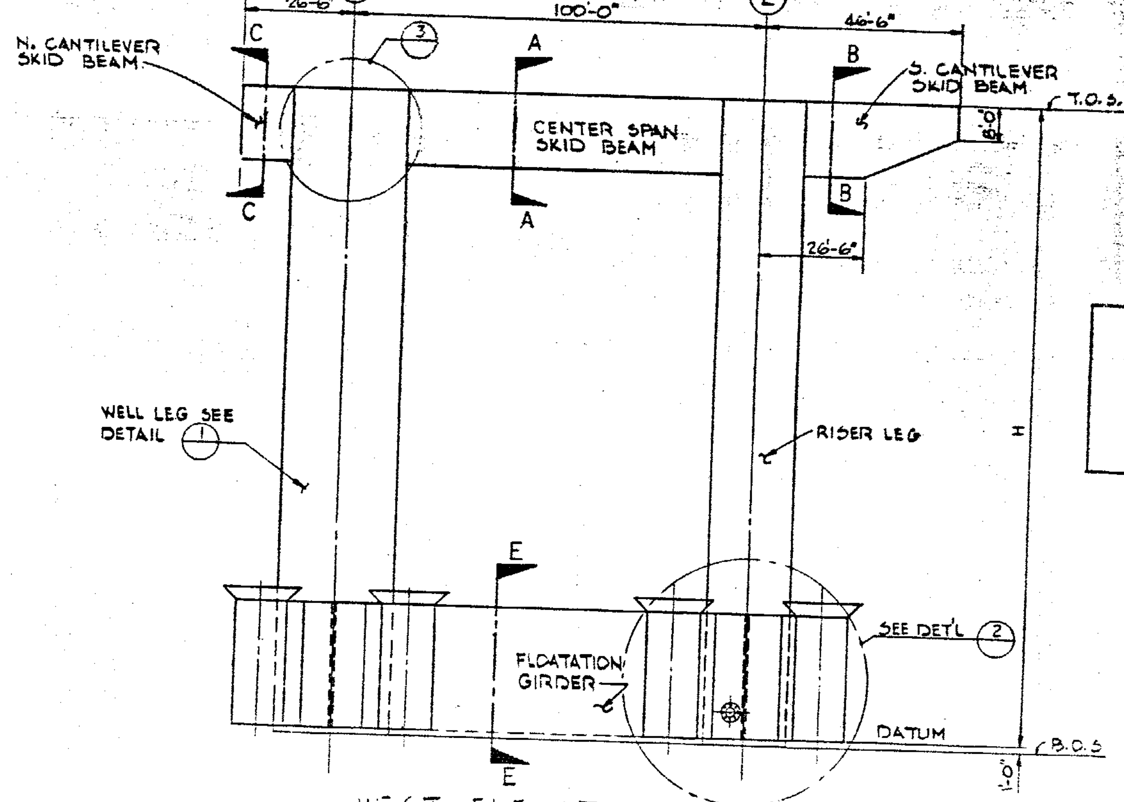
SCALE	CONTRACT NO.	DRAWING NO.	REV.
3/32"=1'-0"	411093	J-106	0



FRAMING PLAN - BOTTOM OF STEEL
SCALE: 1" = 20'

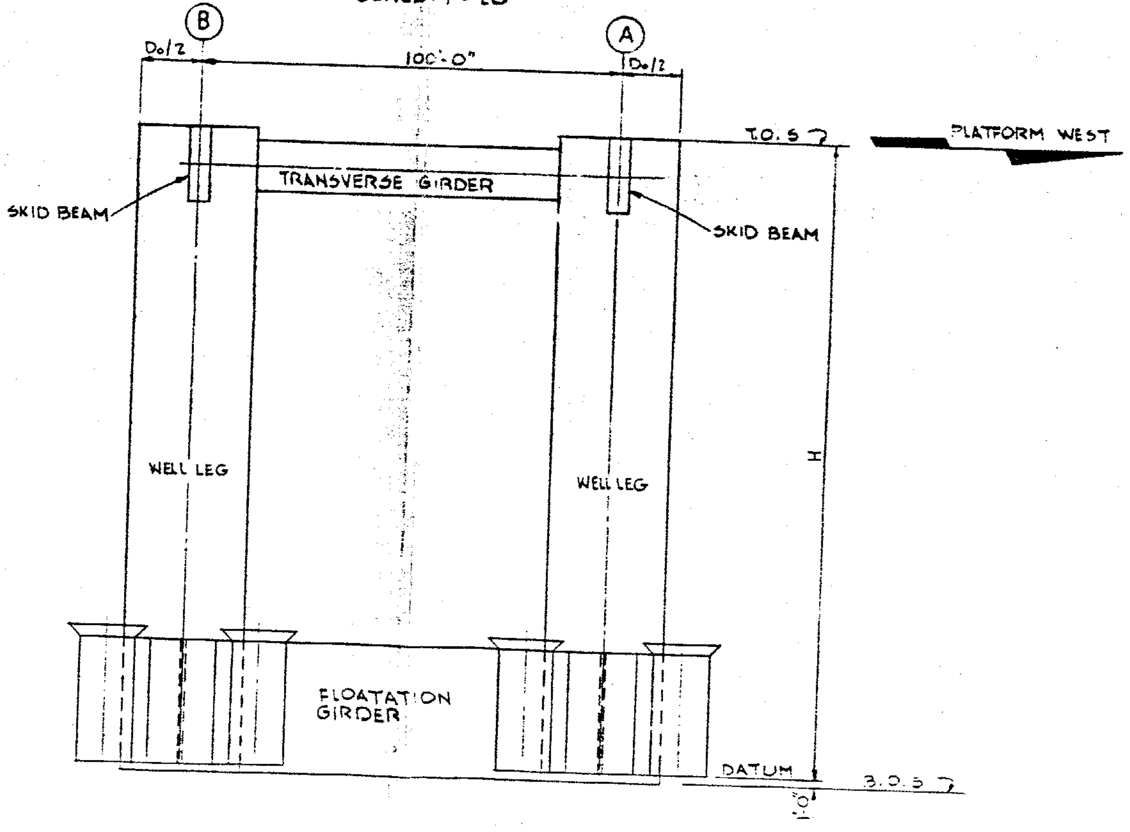


FRAMING PLAN - TOP OF STEEL
SCALE: 1" = 20'



WEST ELEVATION
SCALE: 1" = 20'

NOTES:
(1) FOR DETAILS, SEE DWG. No's J-108 & J-109.
(2) FOR DIMENSIONS & B.O.M. SEE DWG. No. J-110.



NORTH ELEVATION
SCALE: 1" = 20'

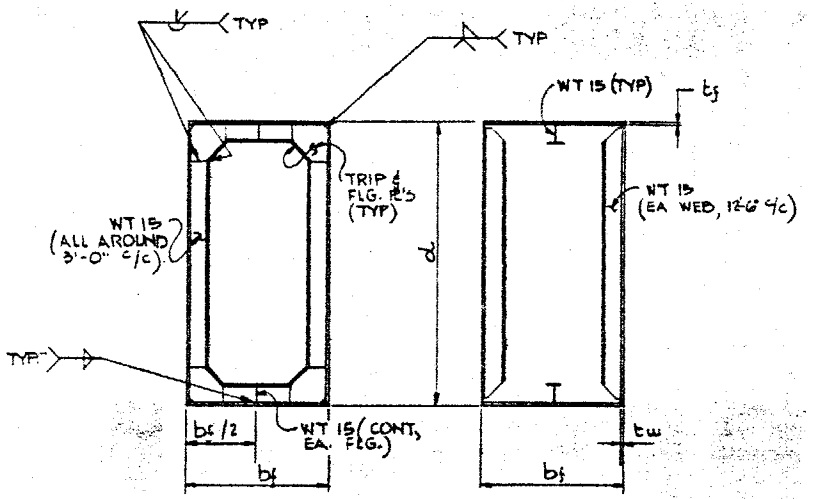
REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

FLUOR OCEAN SERVICES

DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER	CL. BRODEUR		
DATE 3-2-82	DATE 3/9/82	DATE 3/9/82	CLIENT APPROVAL

TITLE STEEL JACKET CONCEPT
FRAMING PLANS & ELEVATIONS - JACKETS
OWNER
LOCATION NORTON SOUND, ALASKA

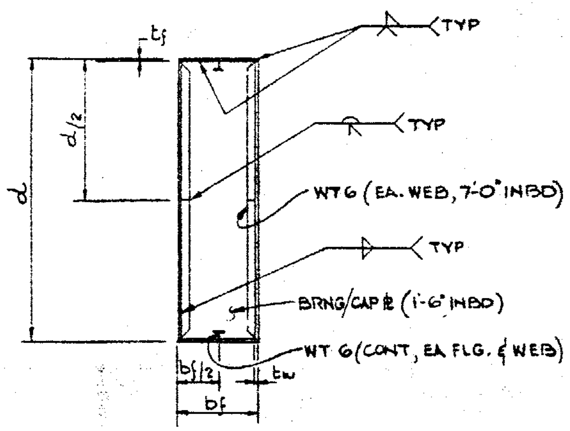
SCALE	CONTRACT NO.	DRAWING NO.	REV.
1" = 20'	411093	J-107	0



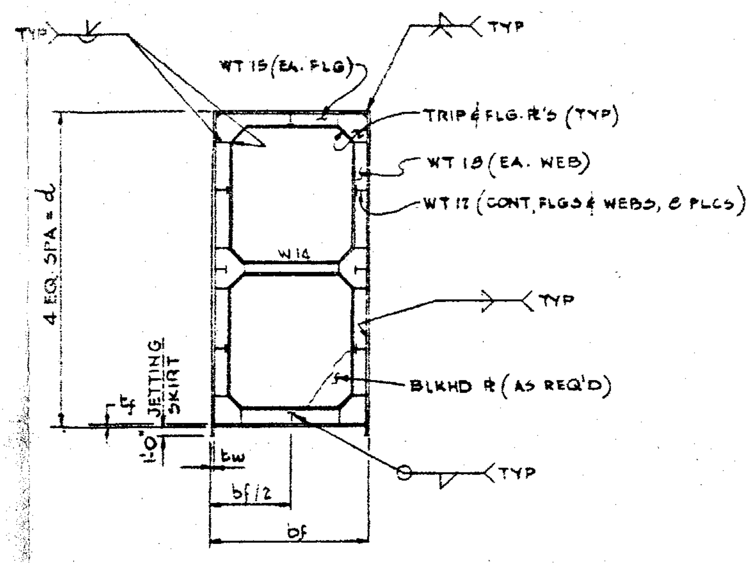
BEARING STIFFENERS
(4 PLACES)

SHEAR & COMPRESSION STIFFENERS
(3 PLACES)

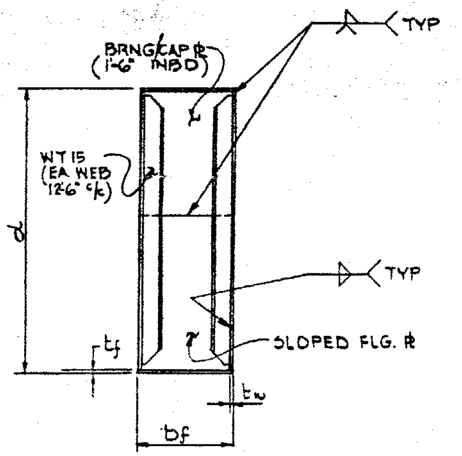
CENTER SKID BEAM DETAILS
SECT. 'A-A'



N. CANTILEVER SKID BEAM DETAILS
SECT. "C-C"

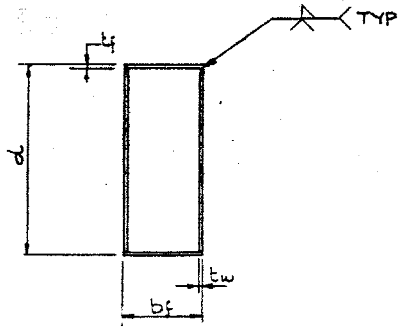


FLOATATION GIRDER DETAILS
SECT. "E-E"

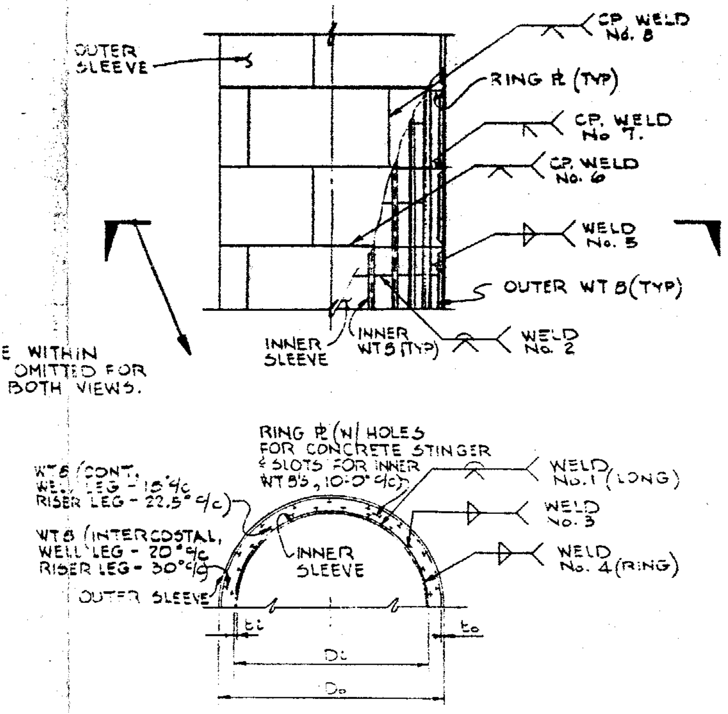


(2 PLACES)

S. CANTILEVER SKID BEAM DETAILS
SECT. 'B-B'



UPPER TRANSVERSE GIRDER DETAILS
SECT. 'D-D'



NOTE:
CONCRETE WITHIN ANNULUS OMITTED FOR CLARITY, BOTH VIEWS.

LEG ASSEMBLY DETAILS
DETAIL "1"

REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

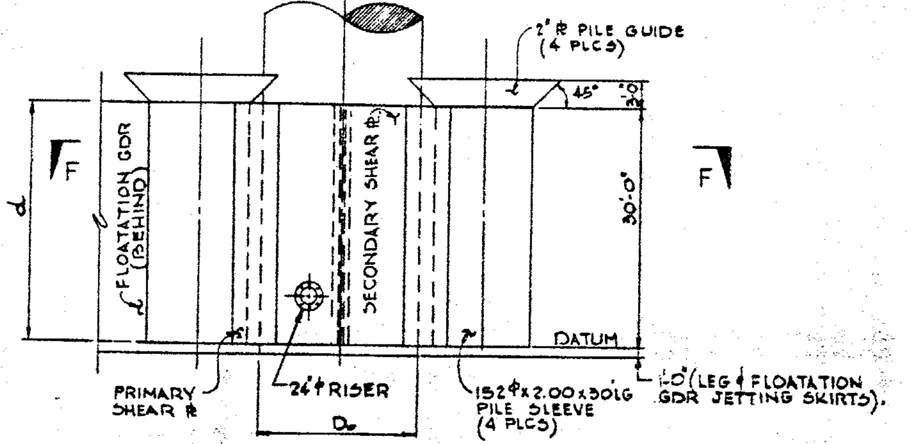
FLUOR OCEAN SERVICES

DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER	C.L. BRODEUR		
DATE 3-2-82	DATE 3/9/82	DATE 3/9/82	CLIENT APPROVAL

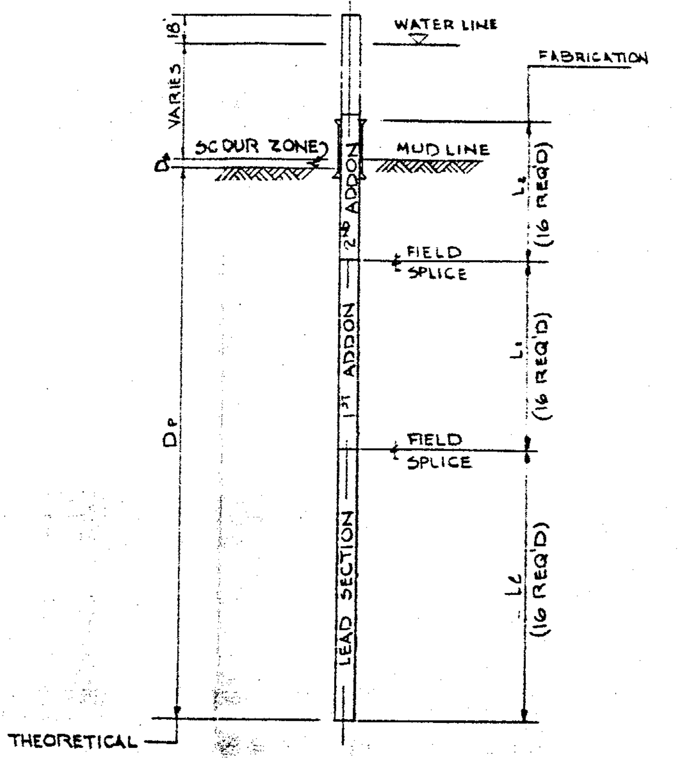
TITLE STEEL JACKET CONCEPT
FRAMING DETAILS-JACKETS SH. 1 OF 3
OWNER
LOCATION NORTON SOUND, ALASKA

SCALE	CONTRACT NO.	DRAWING NO.	REV.
3/32"=1'-0"	411093	J-108	0

NOTE:
LEG INNER SLEEVE & STIFFENING OMITTED FOR CLARITY.

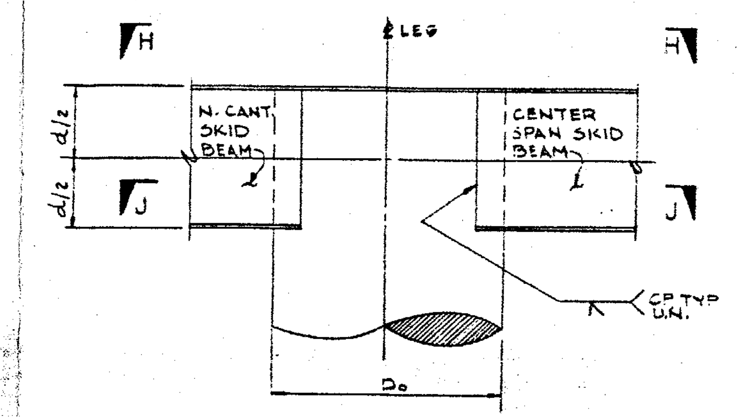


LOWER LEG DETAILS
(RISER LEG SHOWN, WELL LEG SIMILAR)
SECT. "G-G"
SCALE: 3/32" = 1'-0"



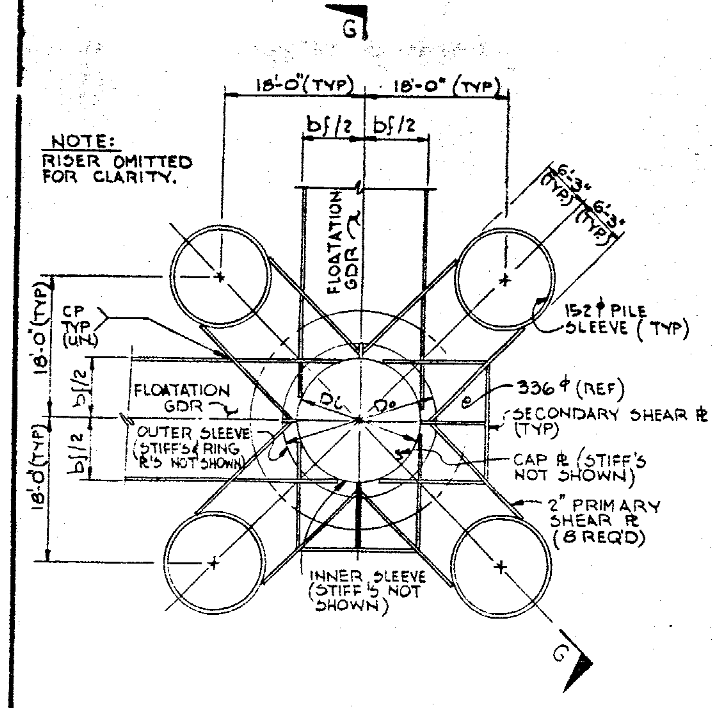
Dxt PILE MAKE-UP
N.T.S.

NOTE:
LEG INNER SLEEVE & STIFF'S OMITTED FOR CLARITY.



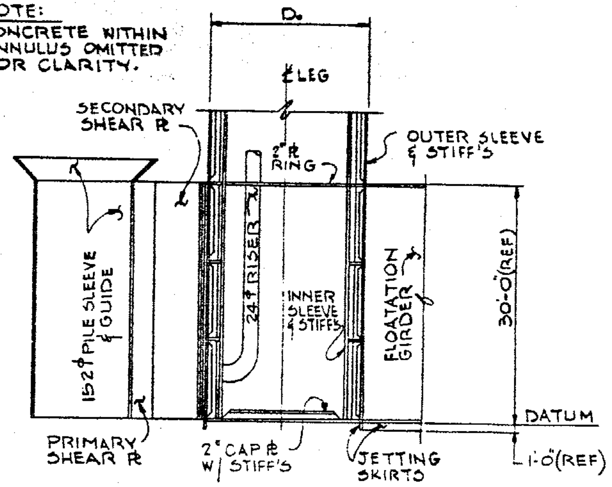
UPPER LEG DETAILS
(WELL LEG SHOWN, RISER LEG SIMILAR)
DETAIL "3"
SCALE: 3/32" = 1'-0"

NOTE:
RISER OMITTED FOR CLARITY.

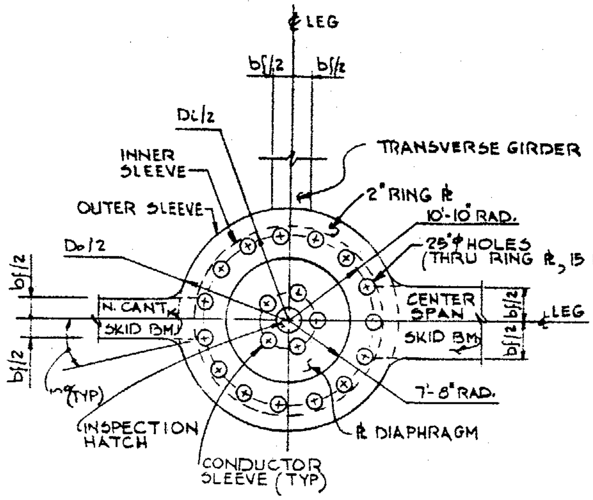


SECTION "F-F"
SCALE: 3/32" = 1'-0"

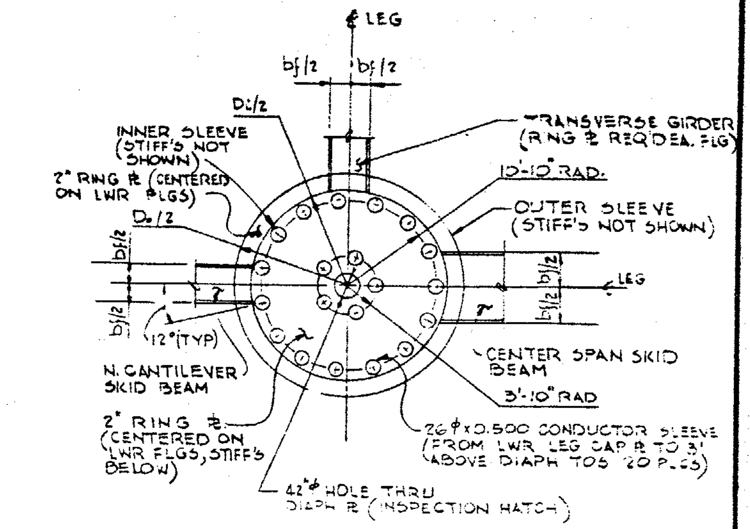
NOTE:
CONCRETE WITHIN ANNULUS OMITTED FOR CLARITY.



SECTION "G-G"
SCALE: 3/32" = 1'-0"



VIEW "H-H"
SCALE: 3/32" = 1'-0"



SECTION "J-J"
SCALE: 3/32" = 1'-0"

REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

FLUOR OCEAN SERVICES

DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER	L. BRODEUR		
DATE	DATE	DATE	CLIENT APPROVAL
3-5-82.	3/9/82	3/9/82	

TITLE STEEL JACKET CONCEPT
FRAMING DETAILS-JACKETS SH. 2 OF 3
OWNER
LOCATION NORTON SOUND, ALASKA

SCALE	CONTRACT NO.	DRAWING NO.	REV.
NOTED	411093	J-109	0

FRAMING DIMENSIONS

DIMENSIONS		CONFIGURATIONS	70 FT. MLLW	50 FT. MLLW	30 FT. MLLW
ELEV	DATUM H	DEPTH BELOW MUDLINE (FT) OVERALL HEIGHT (FT)	5 153	25 147	30 123
CENTER SPAN SKID BEAM	d	DEPTH (FT)	18	18	18
	b_f	WIDTH (FT)	9	9	8
	t_f	FLANGE THICKNESS (IN)	2	2	2
	t_w	WEB THICKNESS (IN)	2	2	2
S. CANTIL. SKID BEAM	d	DEPTH (FT)	18	18	18
	b_f	WIDTH (FT)	6	6	6
	t_f	FLANGE THICKNESS (IN)	2	2	2
	t_w	WEB THICKNESS (IN)	2	2	2
N. CANTIL. SKID BEAM	d	DEPTH (FT)	18	18	18
	b_f	WIDTH (FT)	5	5	5
	t_f	FLANGE THICKNESS (IN)	1	1	1
	t_w	WEB THICKNESS (IN)	1	1	1
UPPER TRAV. GIRDER	d	DEPTH (FT)	12	10	10
	b_f	WIDTH (FT)	5	4	4
	t_f	FLANGE THICKNESS (IN)	2	2	2
	t_w	WEB THICKNESS	2	2	2
FLOAT GIRDER	d	DEPTH (FT)	30	30	30
	b_f	WIDTH (FT)	15	15	15
	t_f	FLANGE THICKNESS (IN)	2	2	2
	t_w	WEB THICKNESS (IN)	2	2	2
WELL LEG	D_i	INNER SLEEVE OUTSIDE DIA (FT)	24	24	24
	t_i	INNER SLEEVE WALL THK. (IN)	1	1	3/4
	D_o	OUTER SLEEVE OUTSIDE DIA. (FT.)	28	28	28
	t_o	OUTER SLEEVE WALL THK. (IN)	1½	1½	1¼
RISER LEG:	D_i	INNER SLEEVE OUTSIDE DIA. (FT)	16	16	16
	t_i	INNER SLEEVE WALL THK. (IN)	1	1	3/4
	D_o	OUTER SLEEVE OUTSIDE DIA. (FT)	20	20	20
	t_o	OUTER SLEEVE WALL THK. (IN)	1¾	1¾	1¼
PILE	D	OUTSIDE DIAMETER (FT)	12	12	12
	t	WALL THICKNESS (IN)	2½	2½	2
	D_s	DISIGN SCOUR (FT)	5	10	15
	D_p	DESIGN PENETRATION (FT)	330	330	280
	L_L	LEAD SECTION LENGTH (FT)	175	175	155
	L_1	FIRST ADDON LENGTH (FT)	125	125	90
	L_2	SECOND ADDON LENGTH (FT)	100	85	90

BILL OF MATERIALS (STEEL)

MATERIALS	CONFIGURATIONS	70 FT. MLLW	50 FT. MLLW	30 FT. MLLW
YARD MATERIALS	ASTM A633-C PLATE (SHT)	6700	6590	5810
	ASTM A633-C SHAPES (SHT)	313	326	270
	ASTM A678-A SHAPES (SHT)	606	592	510
	SUB-TOTALS (SHT)	7620	7510	6590
SITE MATERIALS	LEAD SECTION PILES (ASTM A633-C, SHT)	6080	6080	4330
	FIRST ADDON PILES (ASTM A633-C, SHT)	4340	4340	2510
	SECOND ADDON PILES (ASTM A633-C, SHT)	3470	2960	2510
	HAMMER ADAPTORS (3 OFF, ASTM A537 - GRADE I, SHT)	255	255	255
	GROUT (HI- STRENGTH, CY)	170	170	170
	CONCRETE ($f'c$ = 3000 PSI, γ= 150 PCF, CY)	2840	2710	2210
	CONDUCTORS (40 OFF, ASTM A633-C, SHT)	1070	984	900

NAVAL CHARACTERISTICS

CHARACTERISTICS / CONFIGURATIONS	70 FT MLLW	50 FT MLLW	30 FT MLLW
DEADWEIGHT (SHT)	7790	7650	6720
NET TONNAGE (SHT)	210	210	210
GROSS TONNAGE (SHT)	8000	7860	6930
VERTICAL C.G (FT. ABOVE B.O. S)	58.4	55.6	45.5
HORIZONTAL C.G. (FT. FORWARD, NORTH, MIDSHIP)	1.7	1.6	0.5
MINIMUM DRAFT (FT)	31	30	27

GENERAL NOTES

(1) FRAMING SHOWN FOR 70 FT. MLLW JACKET, OTHER CONFIGURATIONS SIMILAR.

(2) ALLOWANCES FOR SITE MATERIALS INCLUDE:

- (A) 12' CUTOFF FOR LEAD AND FIRST ADDONS.
- (B) 12' OVERDRIVE EA. PILE.
- (C) 50% GROUT CONTINGENCY.
- (D) 15% CONCRETE CONTINGENCY.

(3) CONDUCTORS ASSUMED TO BE 24 Ø x 0.750 x 250', 15% CONTINGENCY INCLUDED.

(4) ACTIVITIES ASSOCIATED WITH JACKET INSTALLATION ARE AS FOLLOWS:

- (A) PERFORM ROUTE AND SITE SURVEYS, BUOY SITE.
- (B) TOW JACKET AND SITE MATERIALS TO NORTON SOUND VIA BRISTOL BAY.
- (C) POSITION JACKET AND BALLAST TO SEAFLOOR.
- (D) JET JACKET INTO SEABED AND LEVEL.
- (E) DRIVE PILES AND GROUT.
- (F) POUR CONCRETE FOR LEG ANNULUSES.
- (G) DRIVE CONDUCTORS.

(5) PILE MAKE-UPS FOR MENCK MHU 1700 UNDER-WATER HAMMERS. CONVENTIONAL ABOVE-WATER HAMMERS (e.g. MENCK MRBS 12500) AND FOLLOWERS SHOULD DRIVE PILES TO GRADE, BUT ARE LESS EFFICIENT.

REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

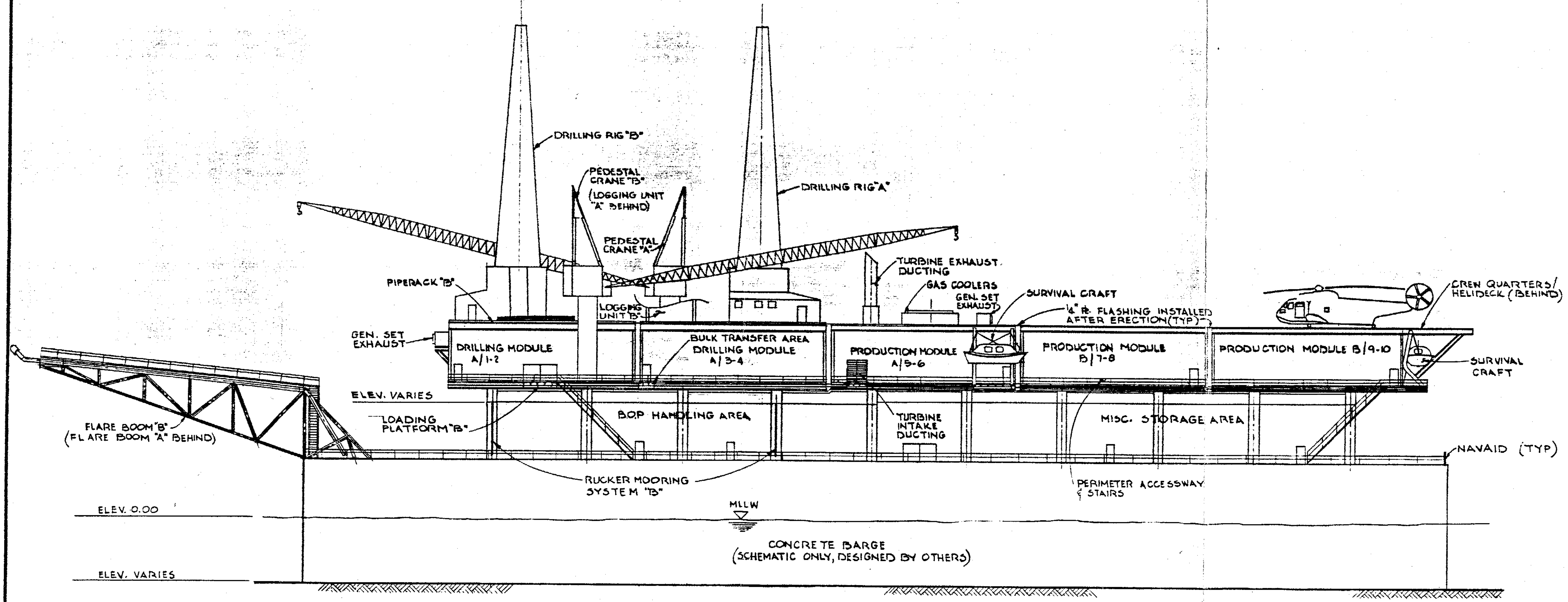
FLUOR OCEAN SERVICES

DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER	Cl. BRODEUZ	Bailey	
DATE 3-5-82	DATE 3/9/82	DATE 3/9/82	CLIENT APPROVAL

TITLE STEEL JACKET CONCEPT
FRAMING DETAILS SH. 3 OF 3
OWNER
LOCATION NORTON SOUND, ALASKA
SCALE NONE
CONTRACT NO. 411093
DRAWING NO. J-110
REV. 0

MODULE ERECTION SCHEDULE

LIFT NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	SUB-TOTAL
PACKAGE	C/5-6	C/3-4	RM-1A	C/7-8	C/1-2	RM-1B	C/9-10	B/5-6	B/7-8	B/3-4	EL-1B	B/9-10	B/1-2	D/5-6	D/9-10	D/3-4	D/1-2	EL-1A	E/5-6	E/3-4	ME-8A	E/1-2	A/3-4	A/1-2	ME-8B	A/5-6	SC-1B	SC-1C	SC-1D	SC-1A	FB-1A	FB-1B	—
DRY WT.(SHT)	262	310	550	319	330	550	400	345	489	521	35	293	654	253	400	648	527	35	400	573	75	376	370	390	75	490	7	7	7	7	100	100	9930
REMARKS	SKID TO CENTER	SKID TO CENTER	SET IN PLACE	SKID TO CENTER	SKID TO CENTER	SET IN PLACE	SKID TO CENTER	SKID TO POSITION	SKID TO POSITION	SKID TO POSITION	SET IN PLACE	SKID TO POSITION	SKID TO POSITION	SKID TO POSITION	SKID TO POSITION	SKID TO POSITION	SKID TO POSITION	SET IN PLACE	SET IN PLACE	SET IN PLACE	SET IN PLACE	SET IN PLACE	SET IN PLACE	SET IN PLACE	SET IN PLACE	SET IN PLACE	SET IN PLACE	SET IN PLACE	SET IN PLACE	SET IN PLACE	SET IN PLACE	SET IN PLACE	SEE KEY PLAN, DWG. NO. B-102.



BROADSIDE ELEVATION

REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

FLUOR OCEAN SERVICES

DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER			
DATE 1-12-82	DATE 2-1-82	DATE 2/1/82	CLIENT APPROVAL

TITLE CONCRETE BARGE CONCEPT
GENERAL ARRANGEMENT & INSTALLATION
OWNER
LOCATION NORTON SOUND, ALASKA

SCALE	CONTRACT NO.	DRAWING NO.	REV.
1"=20'	411093	B-101	0

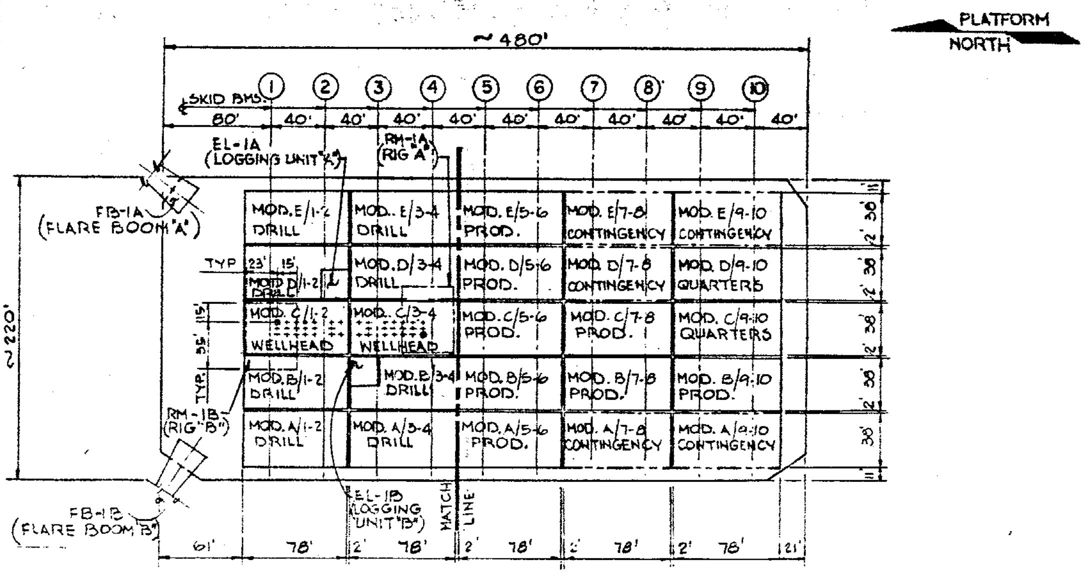
GENERAL NOTES

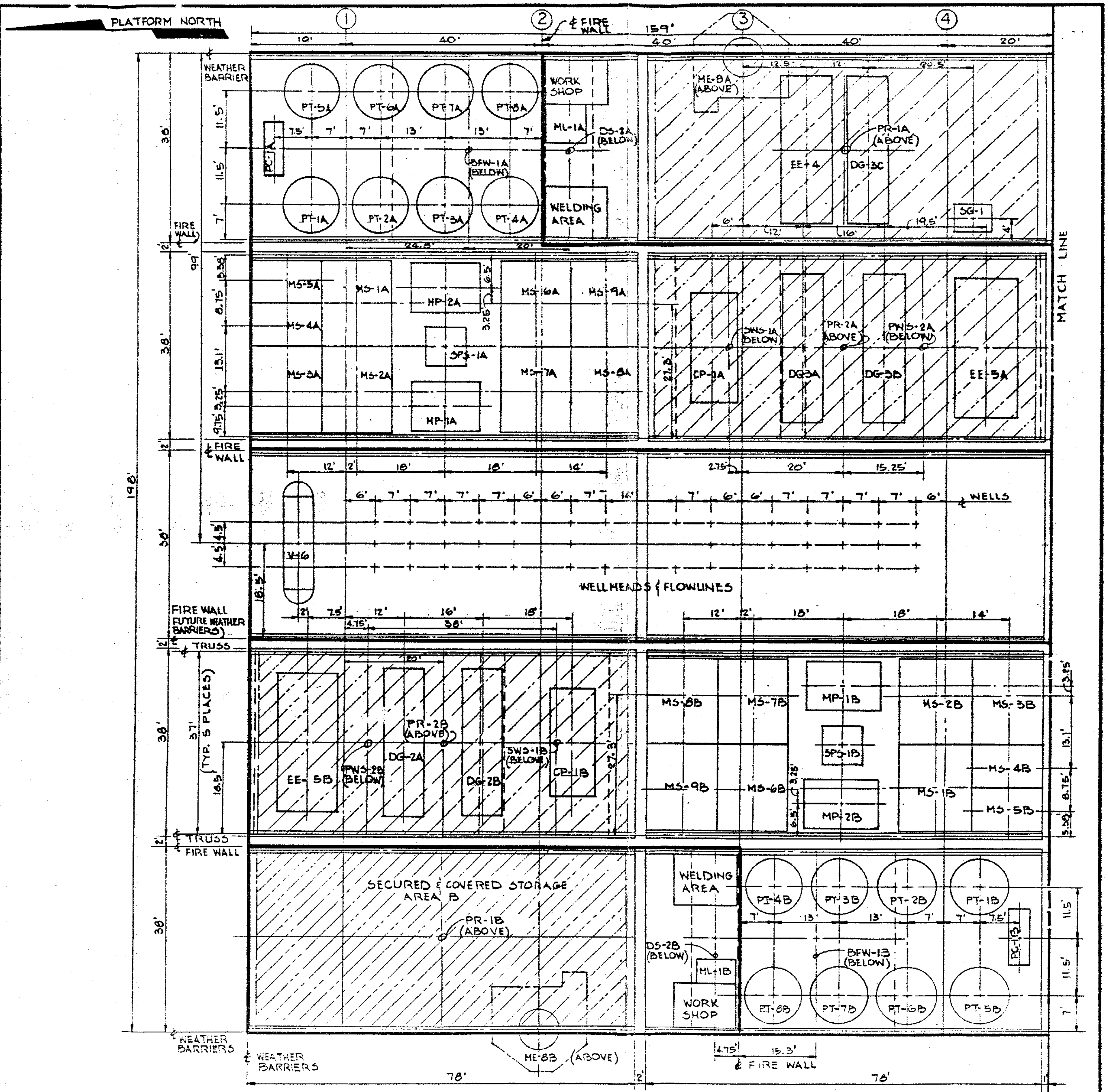
(1) BOP'S LOCATED BELOW WELLHEADS ON TANK TOP. WEATHER PROTECTION AND OVERHEAD CRANEAGE REQUIRED.

(2) STORAGE LOCATIONS:
- (a) DRILL PIPE (3000 SHT) - SETBACKS = 500 SHT, PIPE RACKS = 2500 SHT
- (b) SACK STORAGE - MODULES A/1-2 & E/3-4
- (c) DRILL WATER (3600 BBLS) - WITHIN BARGE (HEATED)
- (d) SERVICE WATER (3500 BBLS) - WITHIN BARGE (HEATED)
- (e) PRODUCED WATER/SURGE (2270 BBLS) WITHIN BARGE (HEATED)
- (f) DIESEL FUEL (2500 BBLS) - WITHIN BARGE (HEATED)
- (g) DIESEL FUEL/DAY (250 BBLS) - MOD. A/3-4 & E/1-2
- (h) POTABLE WATER (1200 BBLS) - MOD. B/1-2 & D/3-4
- (i) BOILER FEED WATER (800 BBLS) MOD. A/3-4 & E/1-2
- (j) SOLID WASTE (275 BBLS) - MOD. B/1-2 & D/3-4

(3) FOR MAJOR EQUIPMENT DESCRIPTIONS, SEE SEPARATE EQUIPMENT LIST.

KEY PLAN





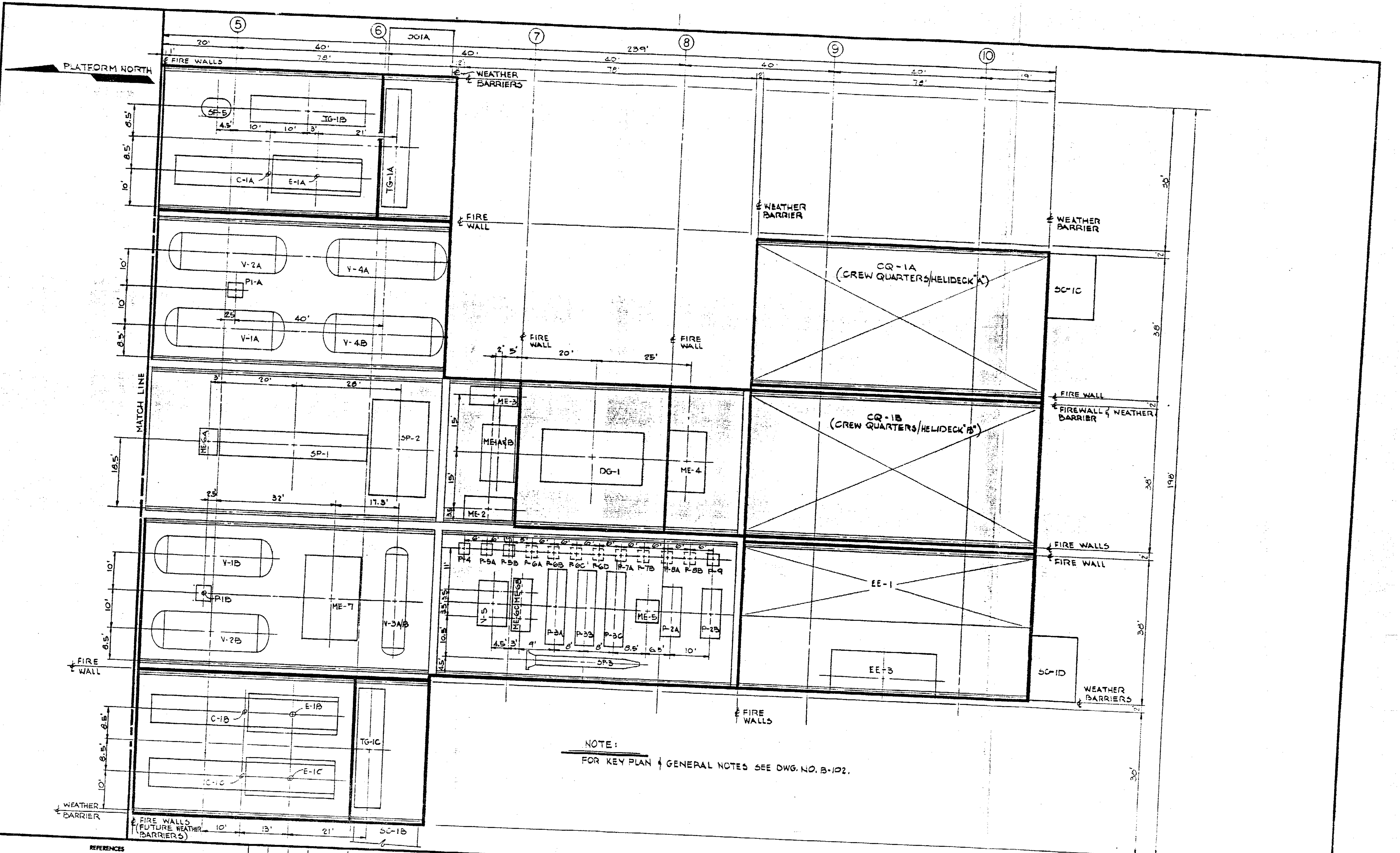
REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

FLUOR OCEAN SERVICES

DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. METZER			
DATE 12-30-81	DATE 2-1-82	DATE 2/1/82	CLIENT APPROVAL

TITLE CONCRETE BARGE CONCEPT
EQUIPMENT LAYOUT SHEET 1 OF 2
OWNER
LOCATION NORTON SOUND, ALASKA

SCALE	CONTRACT NO.	DRAWING NO.	REV.
3/32"=1'-0"	411093	B-102	0



NOTE:
FOR KEY PLAN & GENERAL NOTES SEE DWG. NO. B-102.

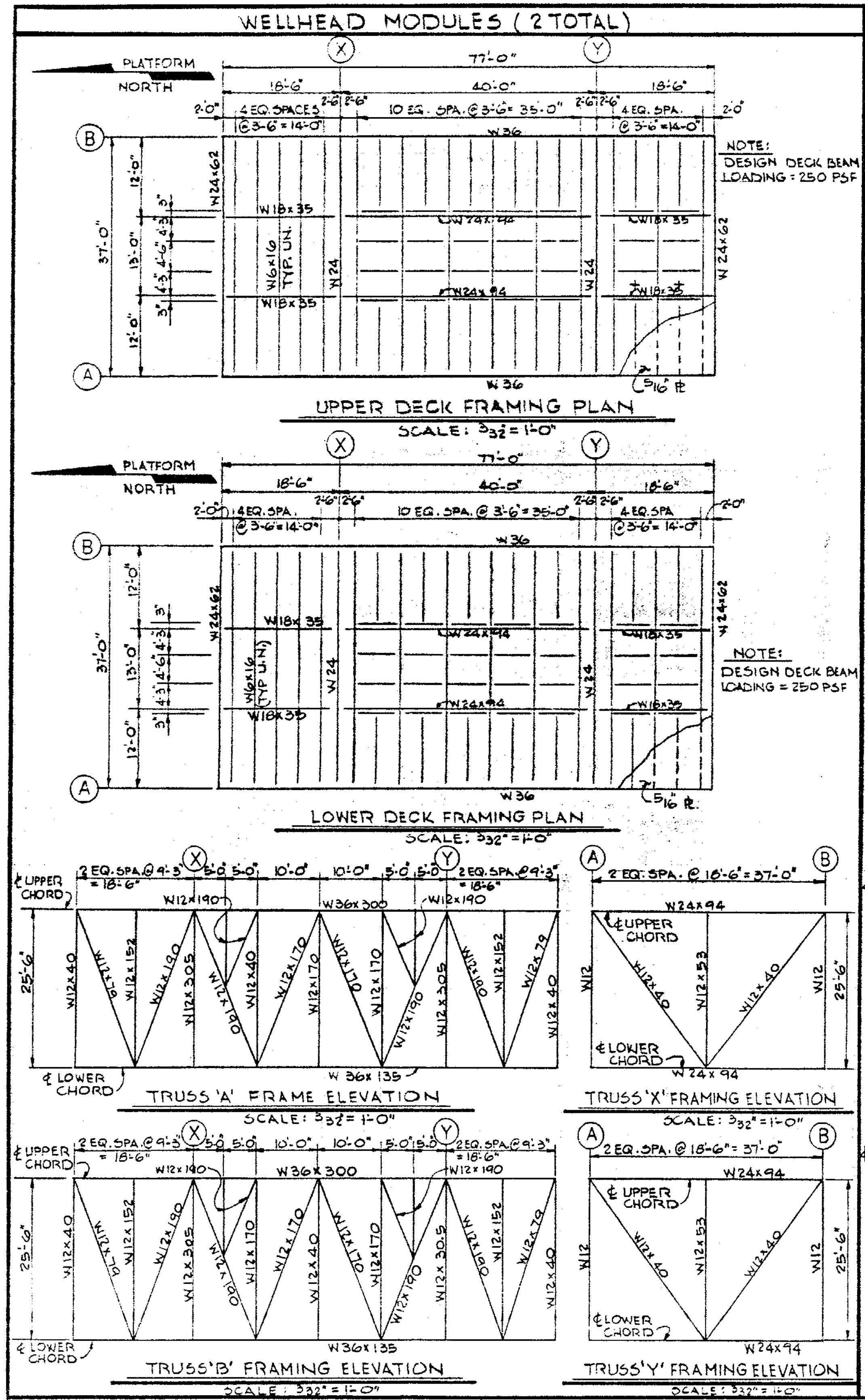
REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

FLUOR OCEAN SERVICES

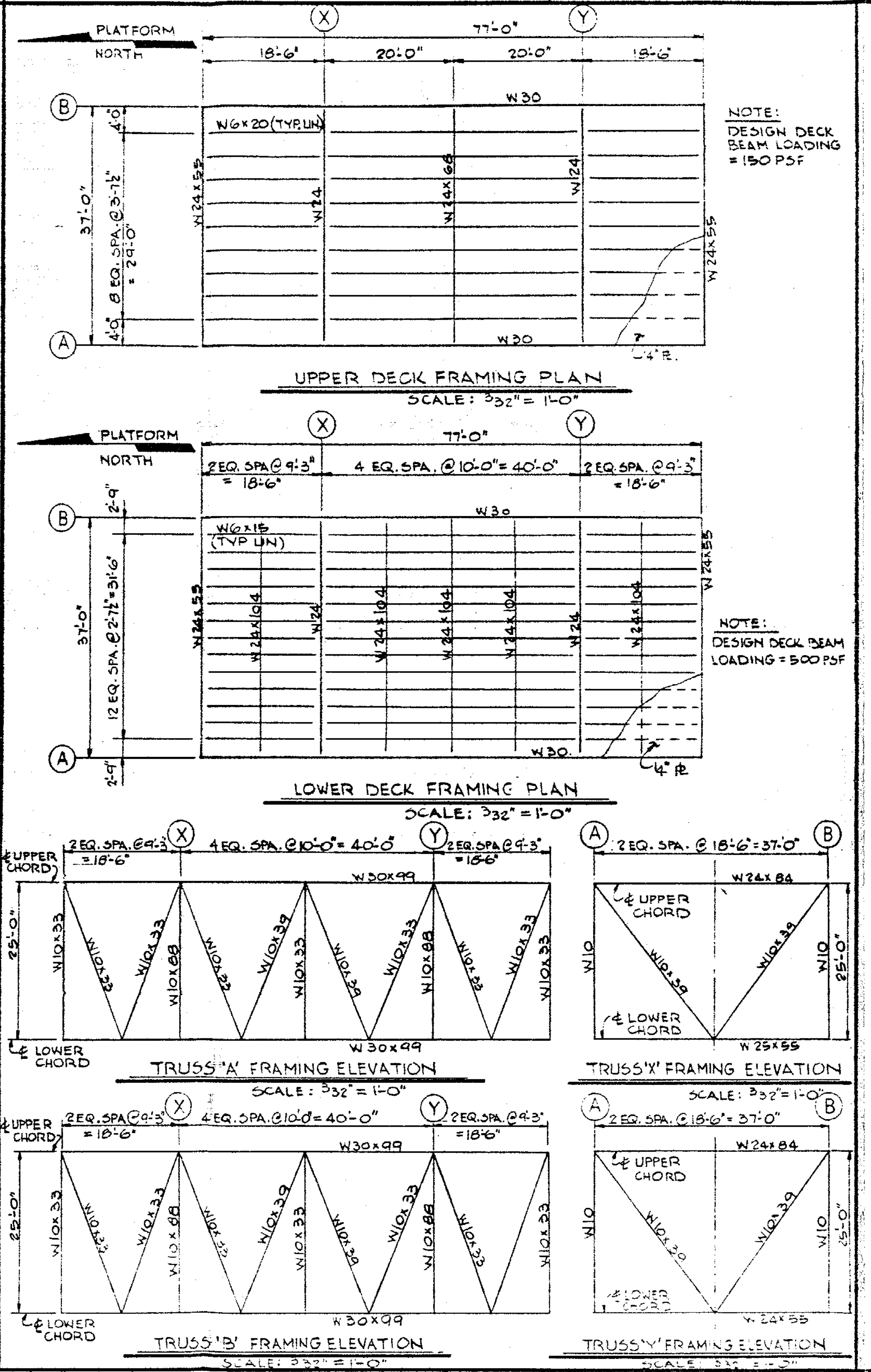
DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER			
DATE 1-4-82	DATE 2-1-82	DATE 2/1/82	CLIENT APPROVAL

TITLE CONCRETE BARGE CONCEPT
EQUIPMENT LAYOUT SHEET 2 OF 2
OWNER
LOCATION NORTON SOUND, ALASKA
SCALE 3/32"=1'-0"
CONTRACT NO. 411093
DRAWING NO. B-103
REV. 0

WELLHEAD MODULES (2 TOTAL)



PRODUCTION MODULES (8 TOTAL)



GENERAL NOTES

(1) FOR BILL OF MATERIALS (STEEL), SEE DWG. NO. B-105.

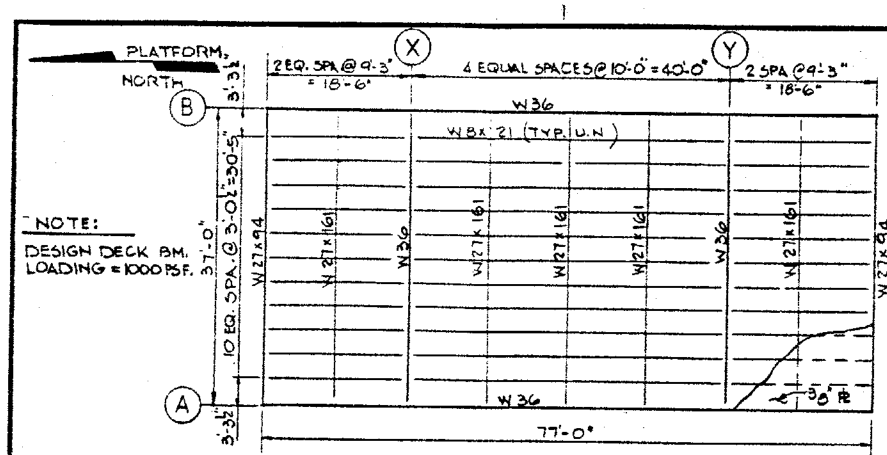
REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

FLUOR OCEAN SERVICES

DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER	C. BRODEUR		
DATE 1-7-82	DATE 2-1-82	DATE 2/1/82	CLIENT APPROVAL

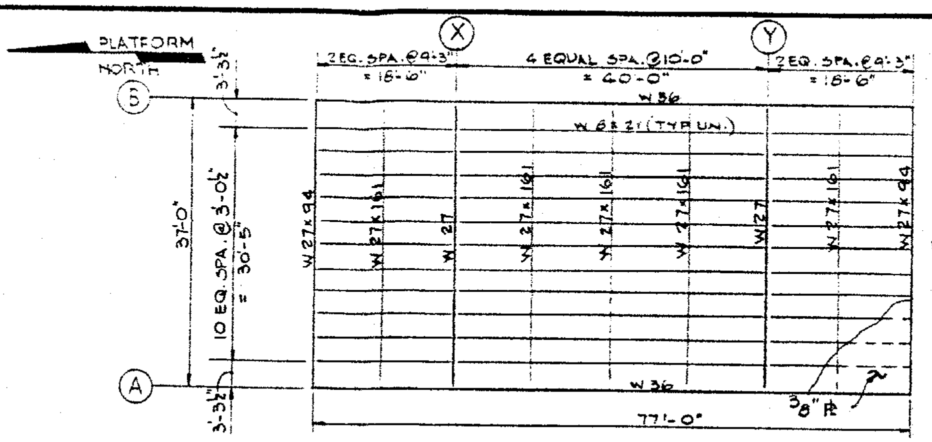
TITLE CONCRETE BARGE CONCEPT
FRAMING PLANS & ELEV'S - MODULES, SH. 1 OF 2
OWNER
LOCATION NORTON SOUND, ALASKA

SCALE	CONTRACT NO.	DRAWING NO.	REV.
3/32" = 1'-0"	411093	B-104	0



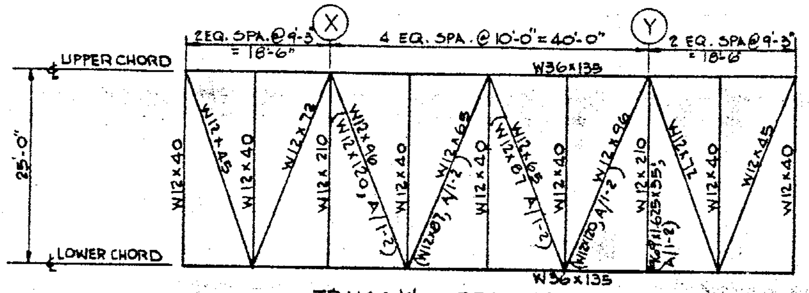
NOTE:
DESIGN DECK BM. LOADING = 1000 PSF.

UPPER DECK FRAMING PLAN
SCALE: 3/32" = 1'-0"

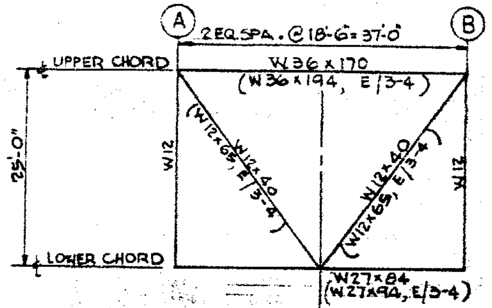


NOTE:
DESIGN DECK BEAM LOADING = 1000 PSF

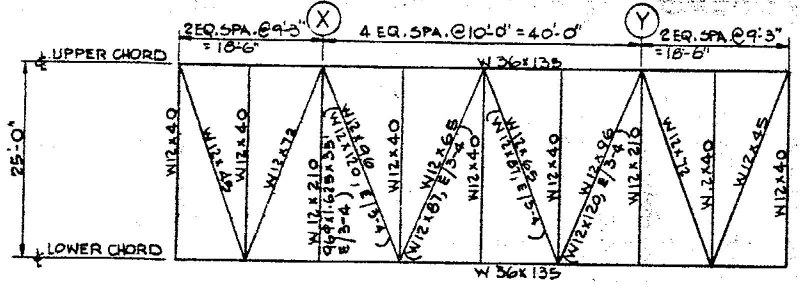
LOWER DECK FRAMING PLAN
SCALE: 3/32" = 1'-0"



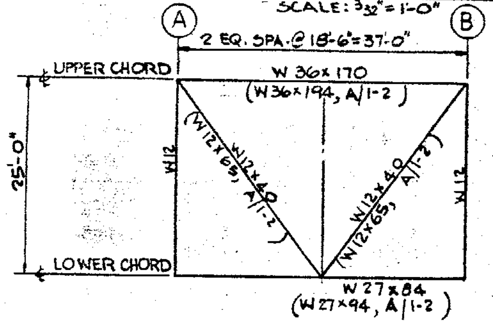
TRUSS 'A' - FRAMING ELEVATION
SCALE: 3/32" = 1'-0"



TRUSS 'X' FRAMING ELEVATION
SCALE: 3/32" = 1'-0"

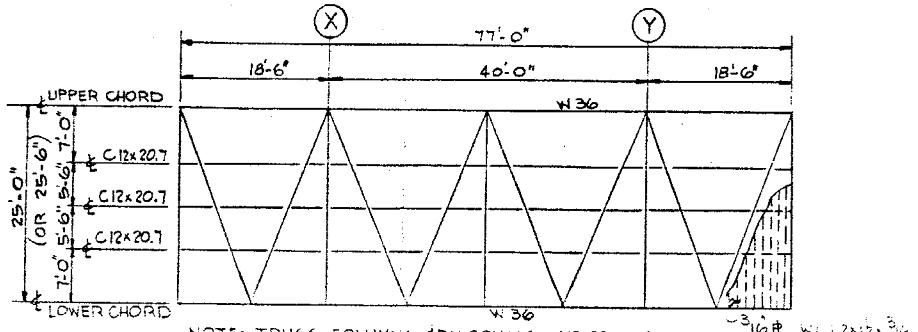


TRUSS 'B' - FRAMING ELEVATION
SCALE: 3/32" = 1'-0"



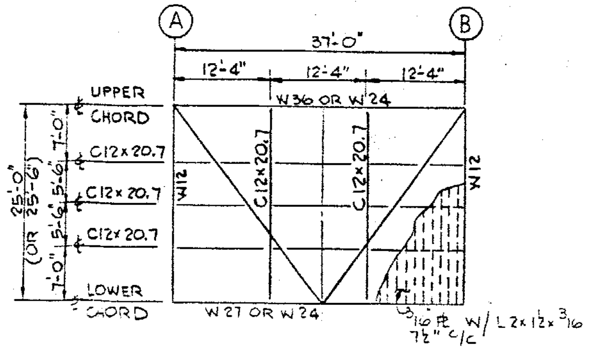
TRUSS 'Y' FRAMING ELEVATION
SCALE: 3/32 = 1'-0"

DRILLING MODULES (8 TOTAL)



NOTE: TRUSS COLUMNS & DIAGONALS W12 OR W10

FRAMING ELEVATION AT TRUSSES 'A' & 'B'
SCALE: 3/32" = 1'-0"



FRAMING ELEVATION OUTBOARD TRUSSES 'X' & 'Y'
SCALE: 3/32" = 1'-0"

WEATHER BARRIERS (AS REQ'D)

BILL OF MATERIALS (STEEL)

MODULES & MISC. PCKGS	ASTM PLATE			ASTM ROLLED SHAPES			SUB-TOTALS
	A633-C	A537 CLASS I	A36	A633-C & A333GD6	A588 & A678-A	A36	
A/1-2	43	35	1	104	59	8	250
B/1-2	33	31	1	54	68	7	194
C/1-2	39	32	1	99	66	8	245
D/1-2	33	31	1	54	68	7	194
E/1-2	40	33	1	77	56	7	214
A/3-4	37	33	1	73	56	7	207
B/3-4	28	31	1	52	68	7	187
C/3-4	35	32	1	97	66	8	239
D/3-4	29	31	1	52	68	7	187
E/3-4	41	34	1	101	59	8	244
A/5-6	33	27	0^{5}	54	32	3^{5}	150
B/5-6	23	19	0^{5}	39	29	4^{5}	115
C/5-6	20	19	0^{5}	36	29	3^{5}	108
D/5-6	23	22	0^{5}	39	32	4^{5}	121
E/5-6	30	30	0^{5}	51	35	3^{5}	150
B/7-8	27	18	0^{5}	48	23	3^{5}	120
C/7-8	26	31	0^{5}	48	35	3^{5}	144
B/9-10	30	27	0^{5}	51	32	3^{5}	144
C/9-10(CQ-1A)	106	71	0^{5}	106	71	5^{5}	360
D/9-10(CQ-1B)	106	71	0^{5}	106	71	5^{5}	360
RM-1A	123	41	2	123	41	14	344
RM-1B	123	41	2	123	41	14	344
FB-1A				90			90
FB-1B				90			90
SP-4					21		21
EL-1A	14			14			28
EL-1B	14			14			28
GRAND-TOTALS	1055	740	19	1795	1126	143	4878 SHT
PERCENTAGES	21^{6}	15^{2}	0^{4}	36^{8}	23^{1}	2^{9}	100%

NOTES:

(1) FOR GENERAL NOTES, SEE DWG. NO. B-104.

(2) INTERIOR MEMBERS INCLUDE: UPPER LEVEL TRANSV. GIRDERS, LOWER LEVEL DECK PLATE AND BEAMS, AND INSIDE TRUSS COLUMNS AND DIAGONALS.

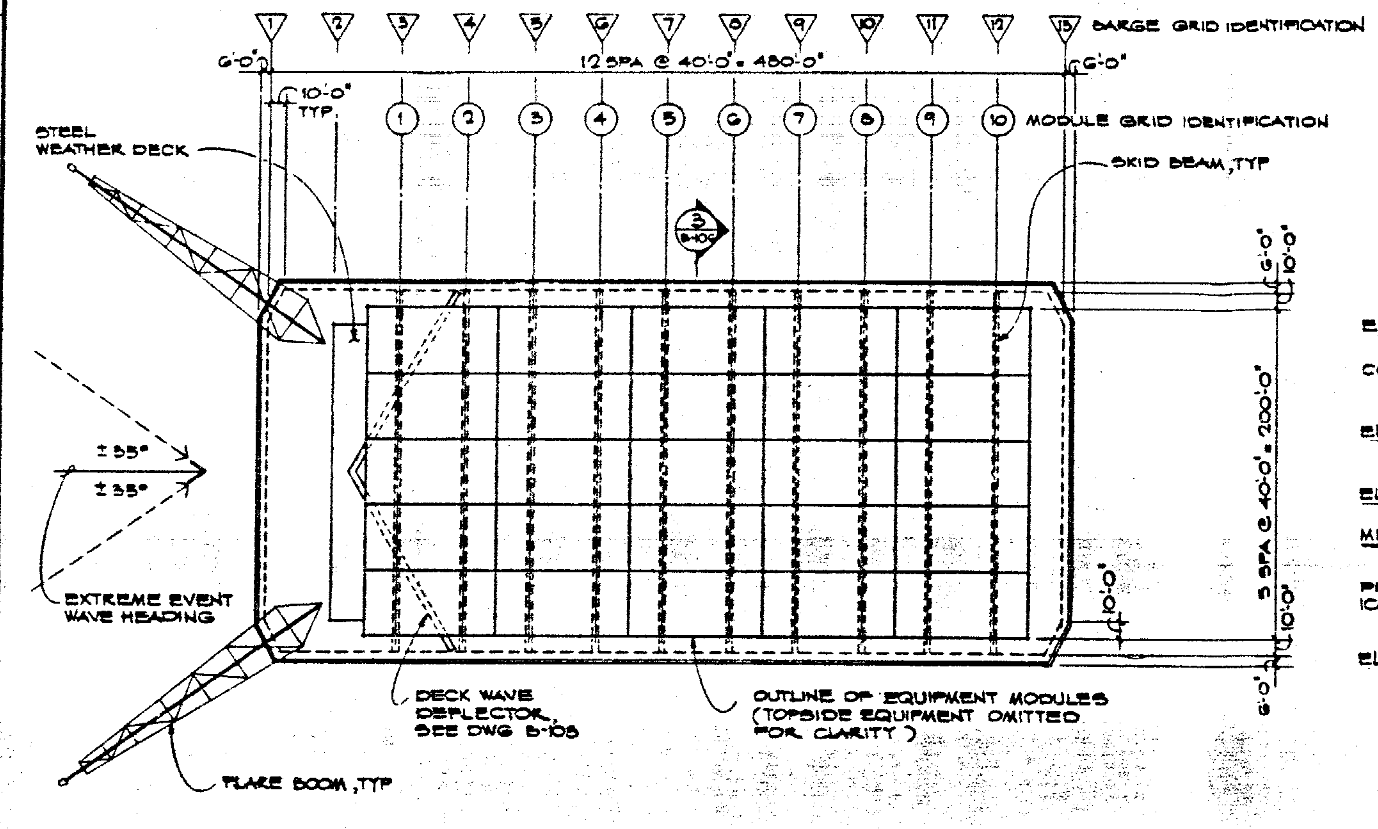
(3) MISCELLANEOUS STEEL ESTIMATES INCLUDE: 0.5% A36 PL, 4.5% A36 ROLLED SHAPES, AND 10% A633-C AND A537 PL RATIOED BY ROLLED SHAPE QUANTITY.

REFERENCES	MK	DATE	BY	APPROVED	REVISIONS	MK	DATE	BY	APPROVED	REVISIONS

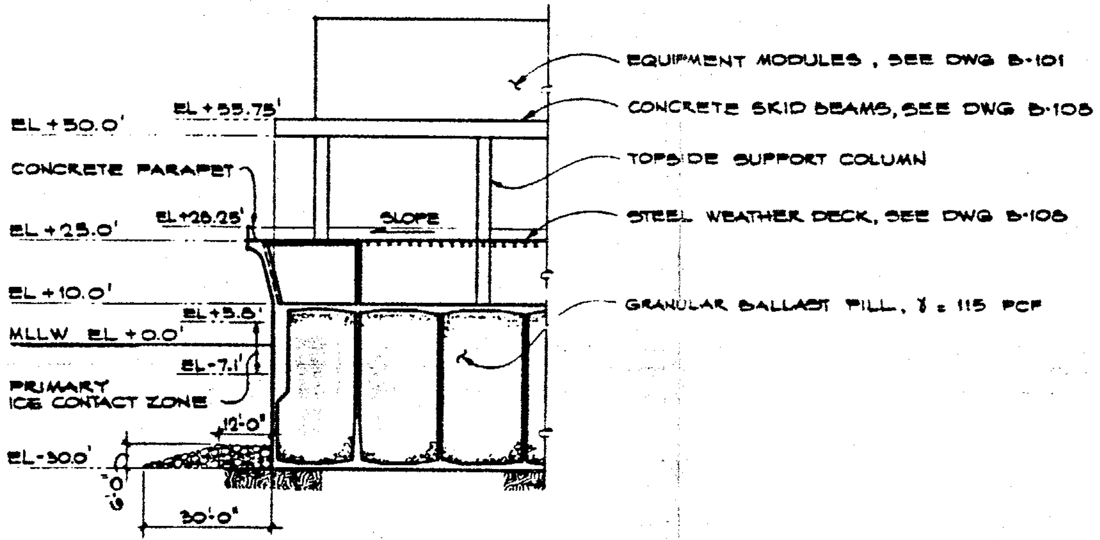
FLUOR OCEAN SERVICES

DRAWN BY	CHECKED BY	ENGINEER	FOS APPROVAL
M. NETZER	C. BRODEUR	Barry	
DATE 1-5-82	DATE 2-1-82	DATE 2/1/82	CLIENT APPROVAL

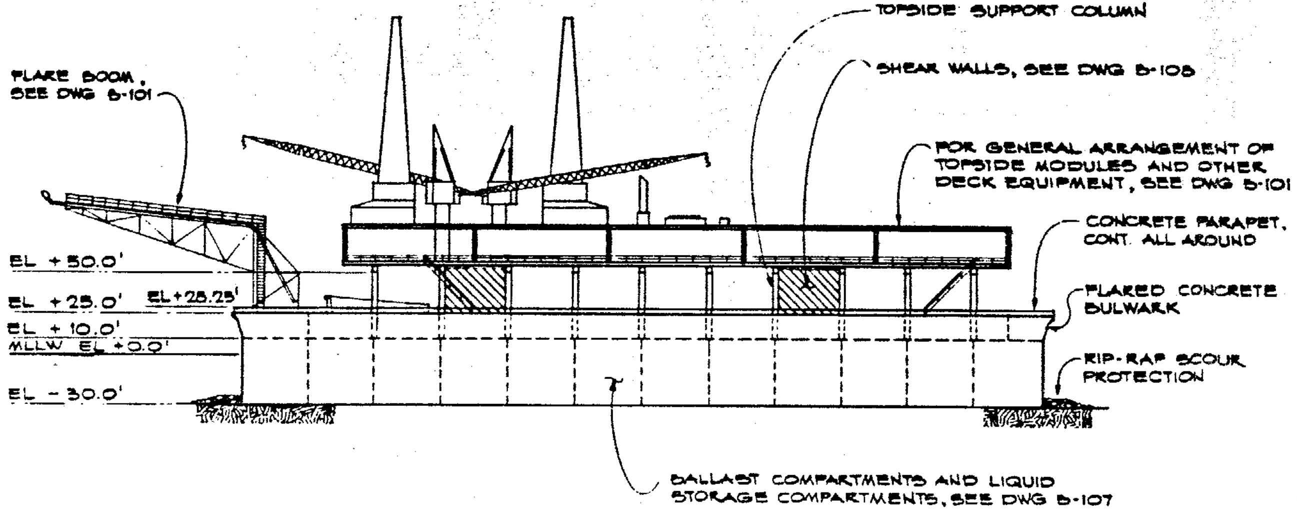
TITLE CONCRETE BARGE CONCEPT
FRAMING PLANS & ELEVS. – MODULES. SH. 2 OF 2
OWNER
LOCATION NORTON SOUND, ALASKA
SCALE 3/32" = 1'-0"
CONTRACT NO. 411093
DRAWING NO. B-105
REV. C



① PLAN
1" = 50'-0"



③ SECTION
1" = 20'-0"



② ELEVATION
1" = 50'-0"

NOTES:

1. BARGE CHARACTERISTICS:

DRAFT .... = 25.5 FT INCL. TRIM BALLAST
DISPLACEMENT .... = 58,270 ST
METACENTRIC HEIGHT ($\overline{GM}_T$) ... = 155 FT (BALLASTED, DELIVERY VOYAGE)
MOMENT TO TRIM 1 INCH : MTL1 = 10,920 ST-FT (" " ")
MOMENT TO HEEL 1 INCH : MTT1 = 4,380 ST-FT (" " ")

CONCRETE VOLUME ...... : 35,420 CU.YD LIGHT WEIGHT CONC @ 130 PCF
3,250 CU.YD NORMAL WEIGHT CONC @ 160 PCF
GRANULAR BALLAST ..... : 116,800 CU.YD COMPACTED TO 115 PCF

CONCRETE STRENGTH ... : f'_c = 7,000 PSI, NORMAL WEIGHT
f'_c = 6,000 PSI, LIGHT WEIGHT
REINFORCING STEEL ..... : f_y = 60,000 PSI
PRESTRESSING STRAND .. : f_{ULT} = 270,000 PSI, STRESS RELIEVED, 1/2" φ
PRESTRESSING BARS .... : f_{ULT} = 150,000 PSI

2. DELIVERY VOYAGE:

DESIGN WAVE .... : $H_{1/3}$ = 25 FT, T = 12 SEC

3. FOUNDATION CHARACTERISTICS:

ALLOWABLE BEARING PRESSURE = 15,000 PSF
SLIDING RESISTANCE : μ = TAN φ
φ = 30° (GRANULAR SOIL)

4. EXTREME EVENT WAVE CHARACTERISTICS (100 YR RETURN):

WAVE AT DEPLOYMENT SITE : MAXIMUM BREAKING WAVE HT = 32 FT
WAVE PERIOD = 14 SEC

5. DESIGN WAVE CHARACTERISTICS (ANY WAVE HEADING):

MAXIMUM BREAKING WAVE HT = 22 FT
WAVE PERIOD = 10 SEC

6. ICE CHARACTERISTICS:

UNCONFINED COMPRESSIVE STRENGTH = 250 PSI
CONFINED COMPRESSIVE STRENGTH : 400 PSI (50 SQ FT CONTACT AREA)
GLOBAL ICE FORCE : 210 KIPS/FT (8 FT RAFTED THICKNESS)

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CONSULTING ENGINEERS

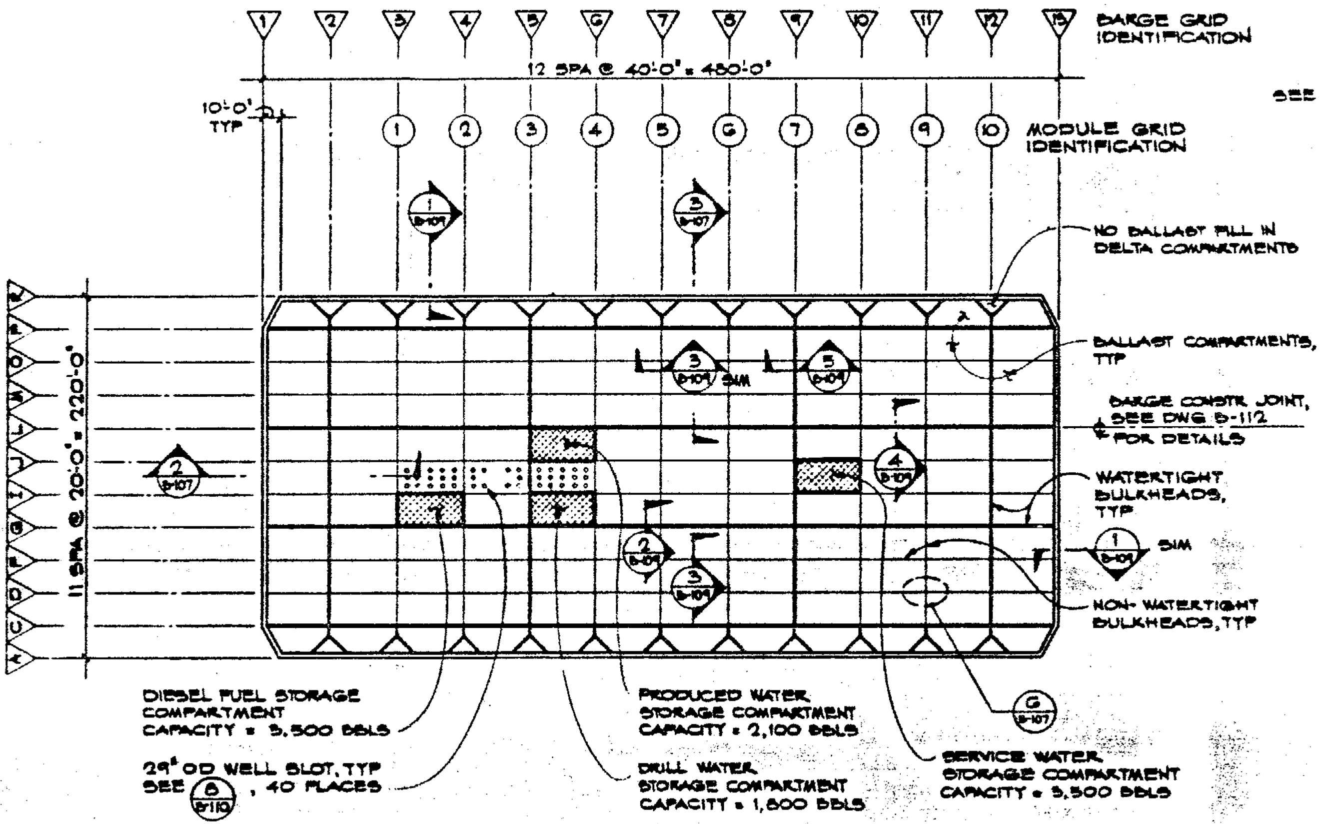
PROJECT TITLE
NORTON
SOUND
STRUCTURES

SHEET TITLE
GENERAL
ARRANGEMENT
BARGE
CONCEPT FOR
30' WATER

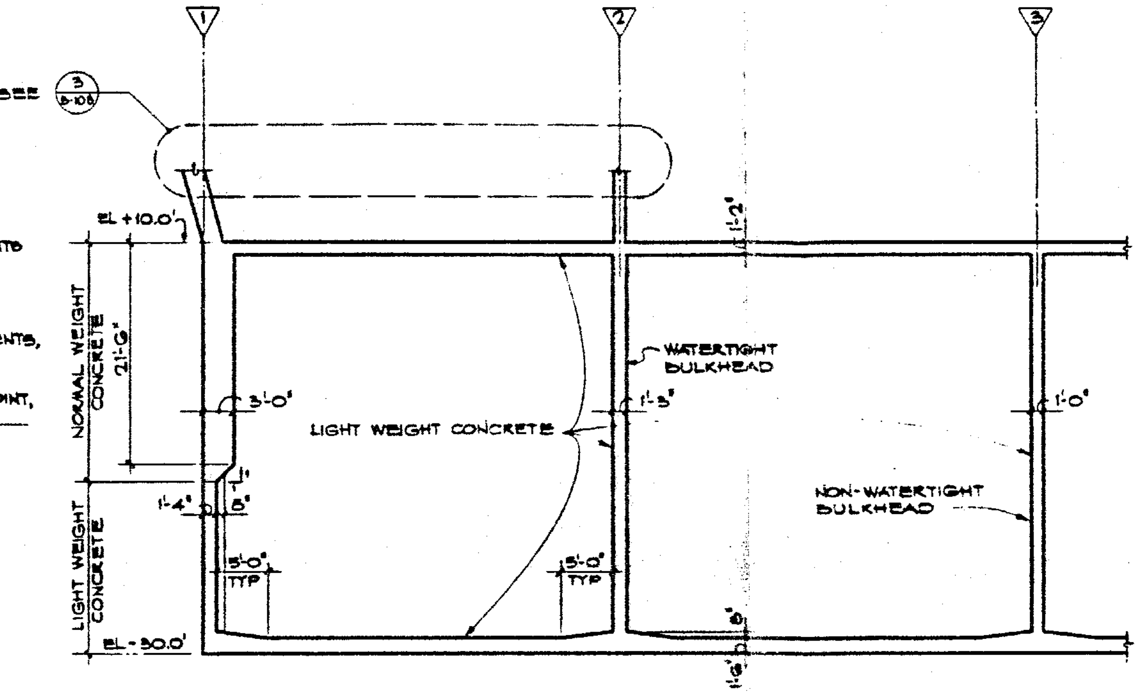
DESIGN BY JJP
DRAWN BY BTH
DATE 27 APRIL 1982
FILE NO A82001
DRAWING NUMBER B-106

NO.	DATE	REVISION	BY

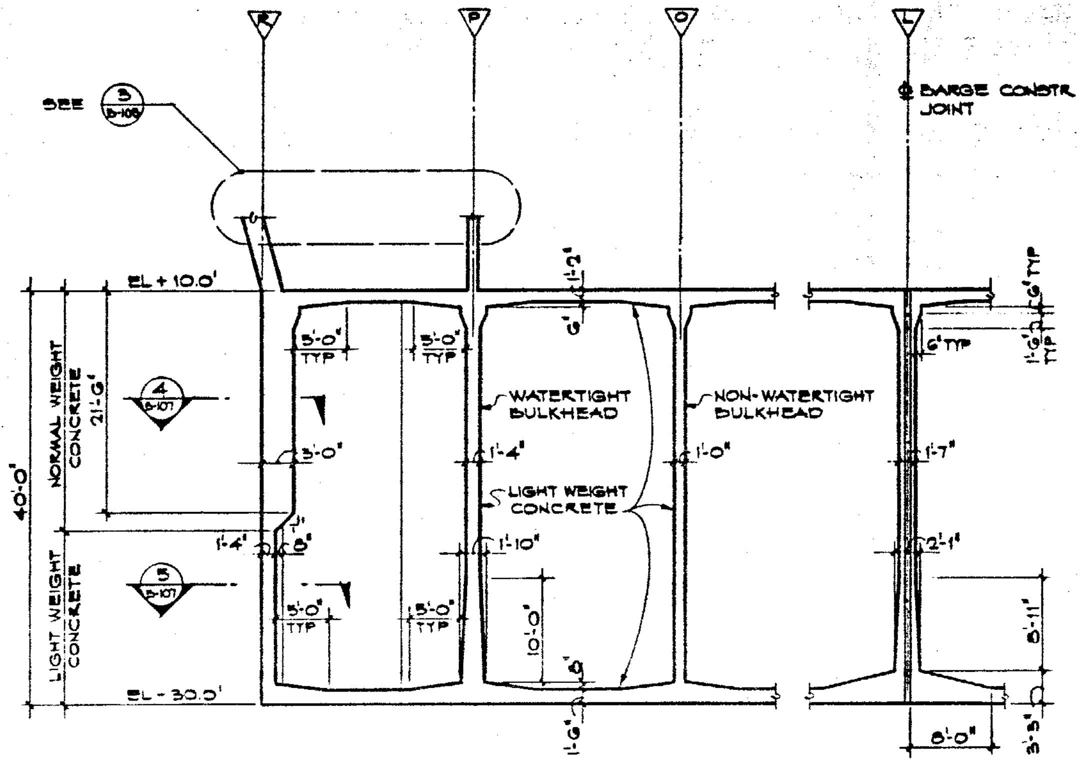
PRINTS TO DATE



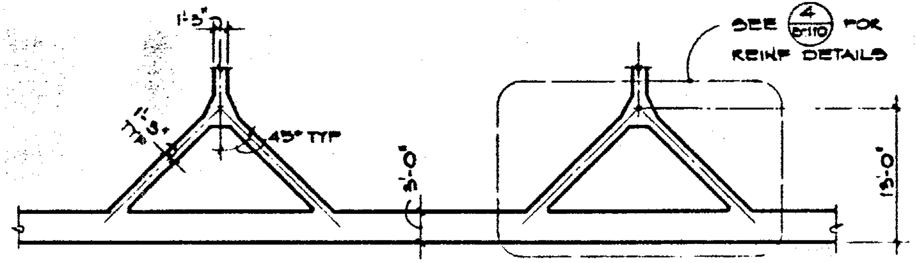
1 B-107 FRAMING PLAN
1" = 50'-0"



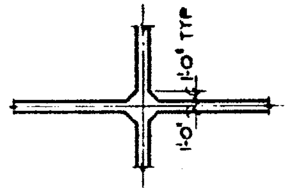
2 B-107 LONGITUDINAL SECTION
1/8" = 1'-0"



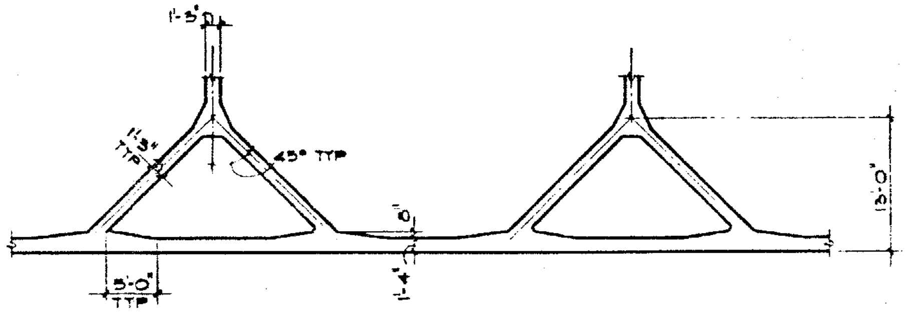
3 B-107 TRANSVERSE SECTION
1/8" = 1'-0"



4 B-107 SECTION - DELTA BULKHEADS @ ICE ZONE
1/8" = 1'-0"



6 B-107 DETAIL - BULKHEAD INTERSECTION
1/8" = 1'-0"



5 B-107 SECTION - DELTA BULKHEADS BELOW ICE ZONE
1/8" = 1'-0"

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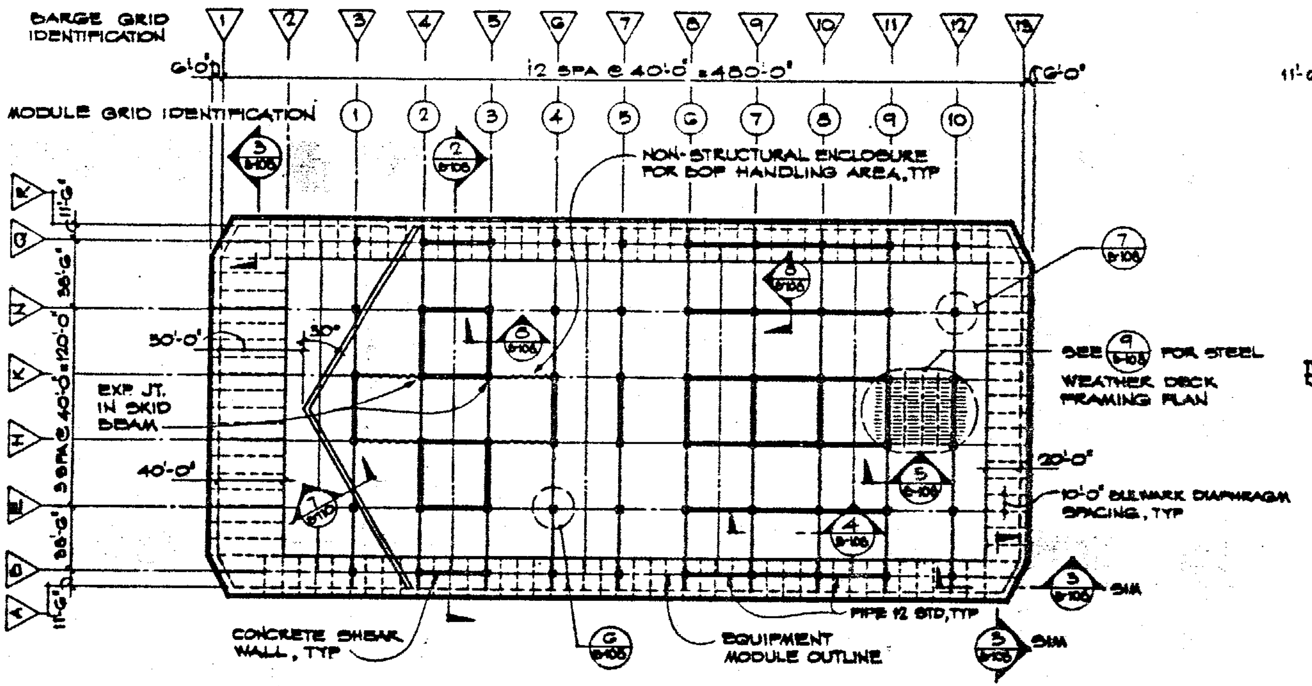
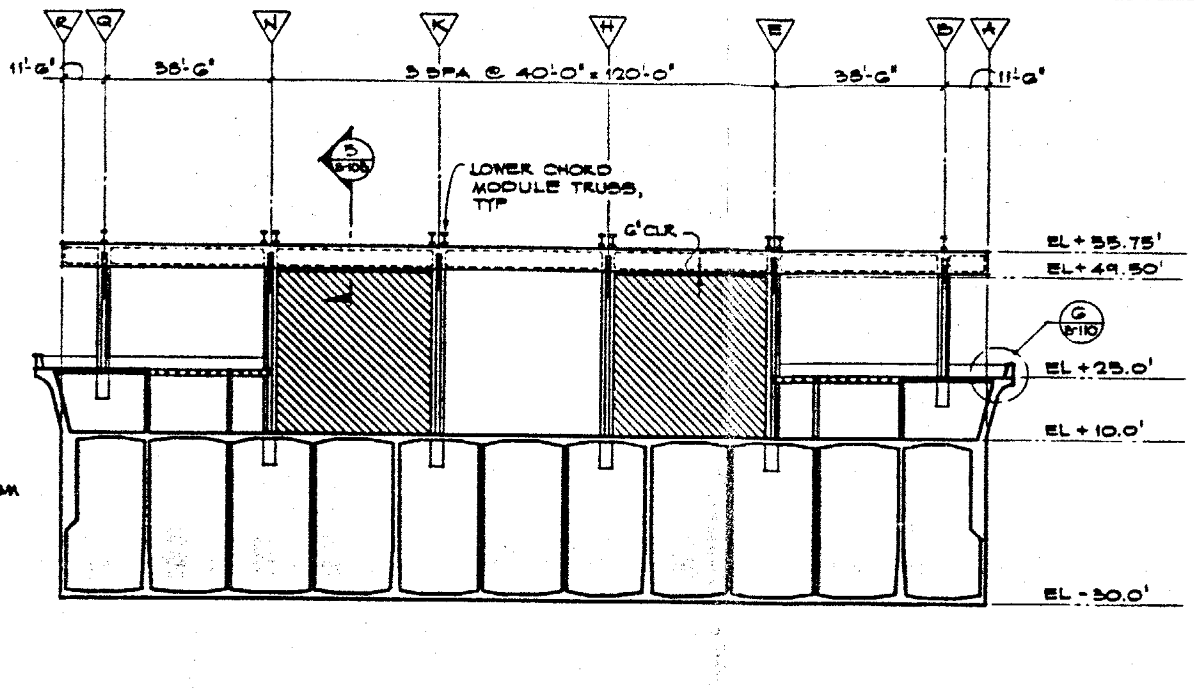
PROJECT TITLE
NORTON SOUND STRUCTURES

SHEET TITLE
FRAMING ARRANGEMENT BARGE CONCEPT FOR 30' WATER

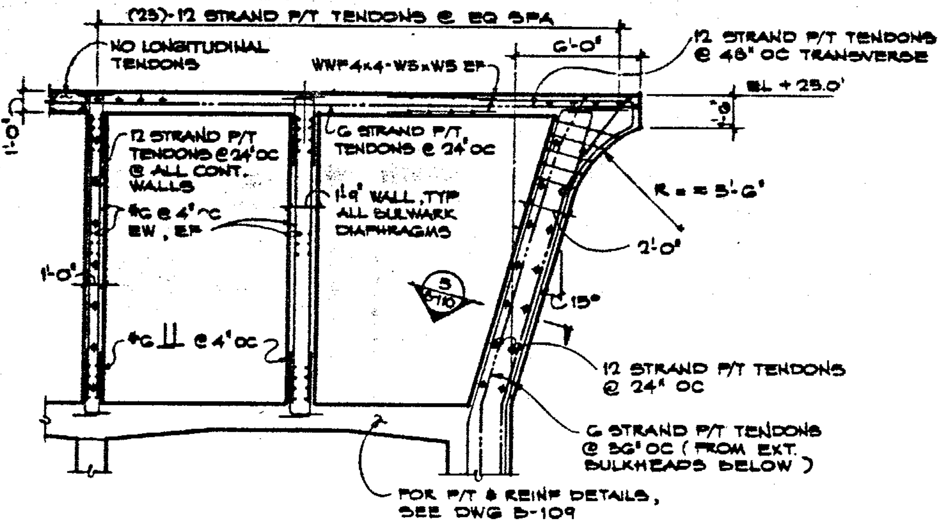
DESIGN BY JJP
DRAWN BY BTH
DATE 27 APRIL 1982
A52001
DRAWING NUMBER **B-107**



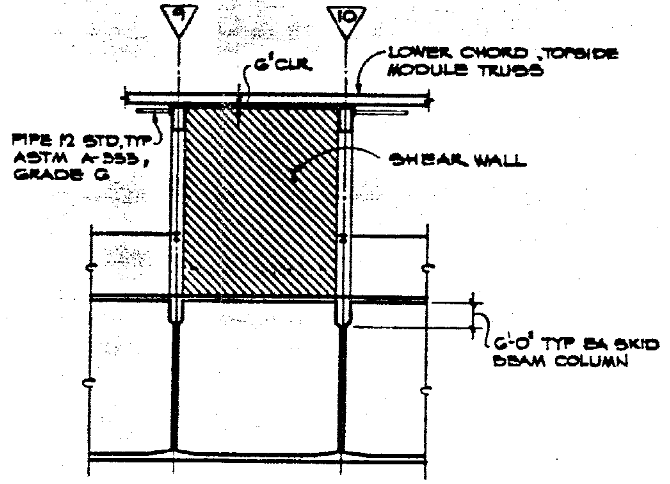
1 B-108 PLAN- FRAMING ABOVE WEATHER DECK
1" = 50'-0"



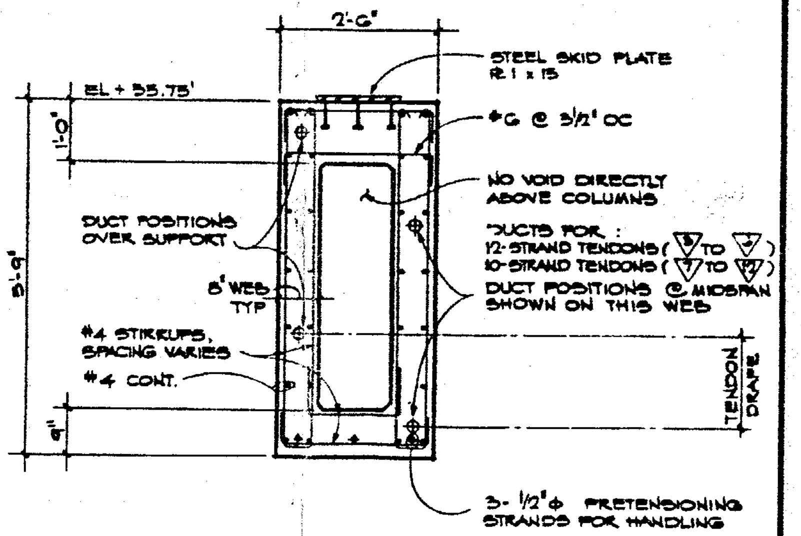
2 B-108 ELEVATION - SKID BEAM
1" = 20'-0"



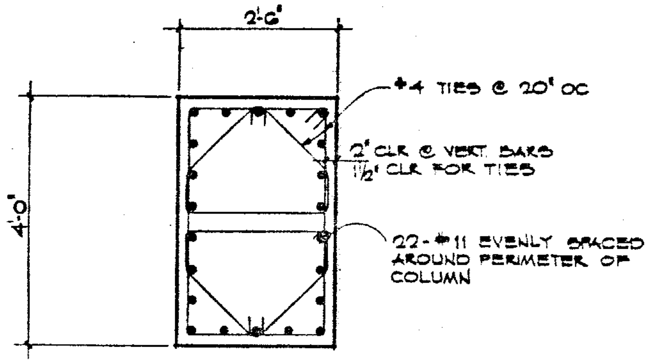
3 B-108 SECTION - WAVE BULWARK
1/4" = 1'-0"



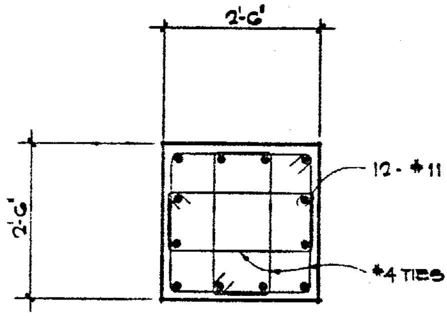
4 B-108 ELEVATION - SHEAR WALL @ E
1" = 20'-0"



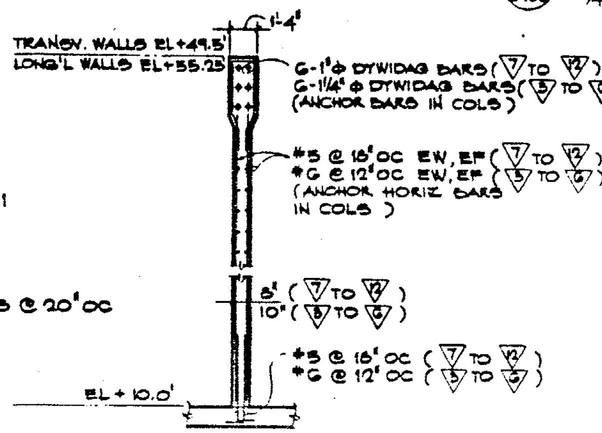
5 B-108 SECTION - SKID BEAMS GRID 1 TO 4
3/4" = 1'-0"



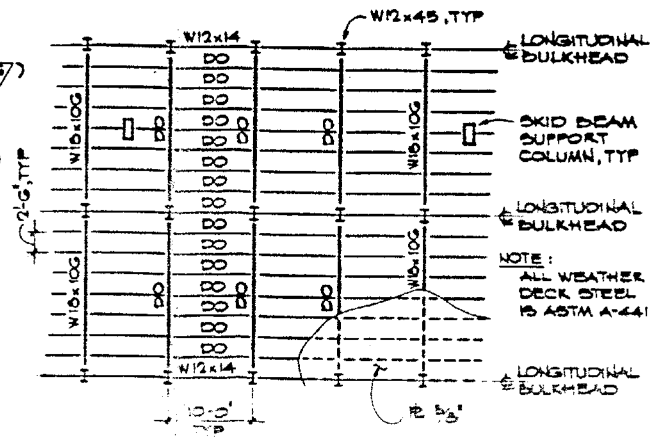
6 B-108 DETAIL - INTERIOR COLUMNS @ 3 THRU 6
3/4" = 1'-0"



7 B-108 DETAIL - COLUMNS @ B, Q & 7 THRU 12
3/4" = 1'-0"



8 B-108 SECTION - SHEAR WALL
1/4" = 1'-0"



NOTE :
ALL WEATHER DECK STEEL IS ASTM A-441

9 B-108 STEEL WEATHER DECK FRAMING PLAN
1" = 10'-0"

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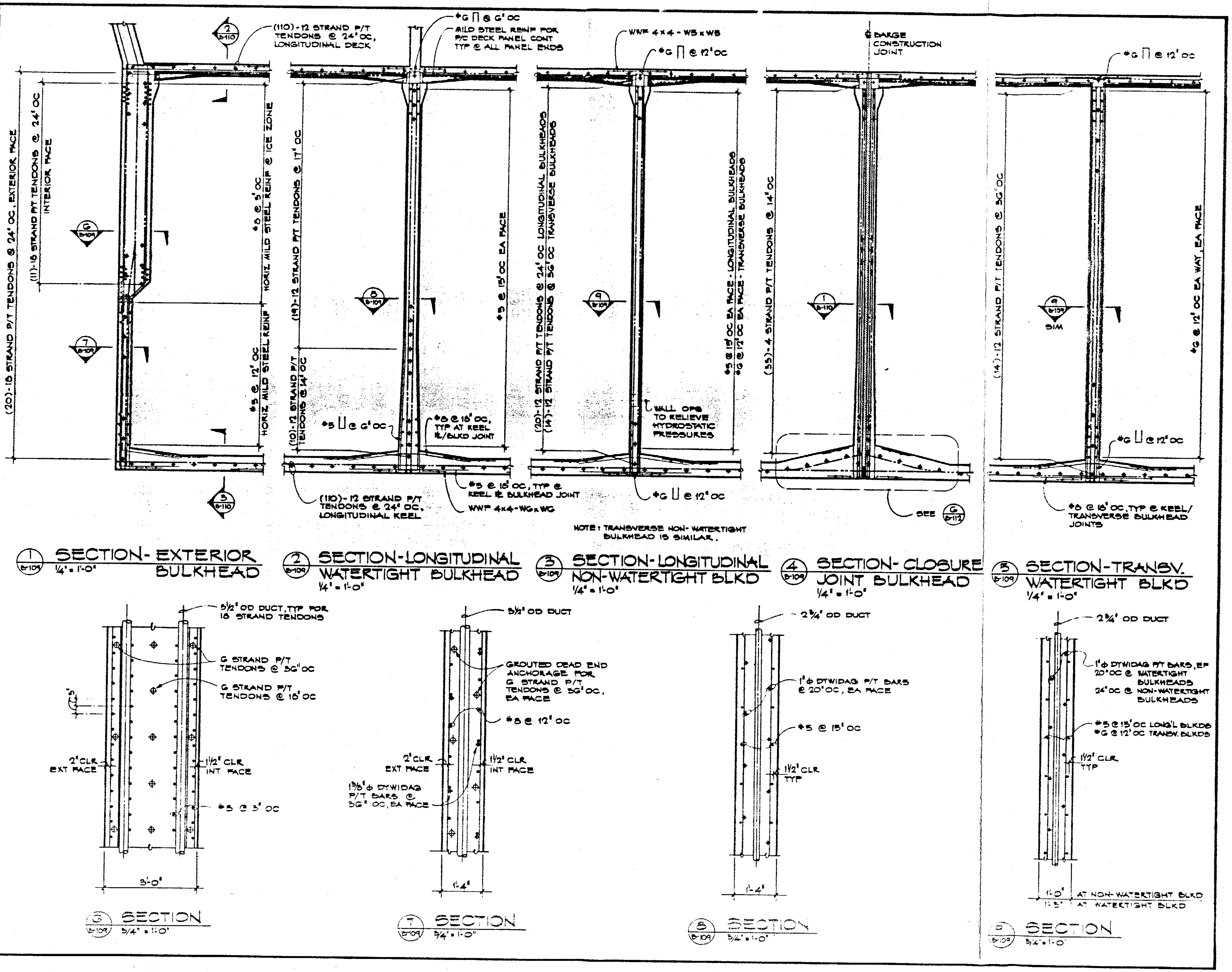
PROJECT TITLE
NORTON SOUND STRUCTURES

SHEET TITLE
DECK FRAMING PLAN AND DETAILS

DESIGN BY EWO
DRAWN BY BTH
DATE 27 APRIL 1982
FILE NO 482001
DRAWING NUMBER B-108

NO.	DATE	REVISION	BY



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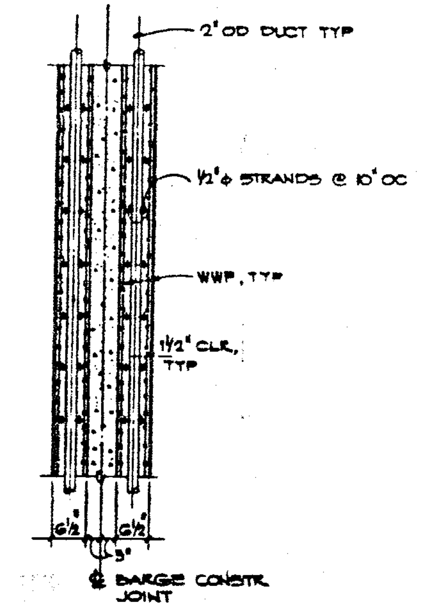
PROJECT TITLE
NORTON SOUND STRUCTURES

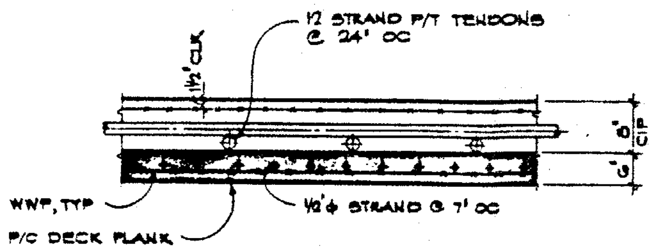
SHEET TITLE
REINFORCING AND PRESTRESSING ARRANGEMENT

DESIGN BY EWO
DRAWN BY BTH
DATE 27 APRIL 1982
FILE NO. A52001
DRAWING NUMBER **B-109**

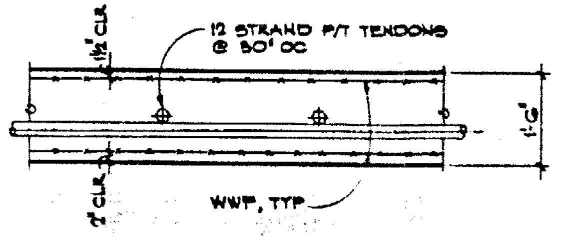
NO.	DATE	REVISION	BY



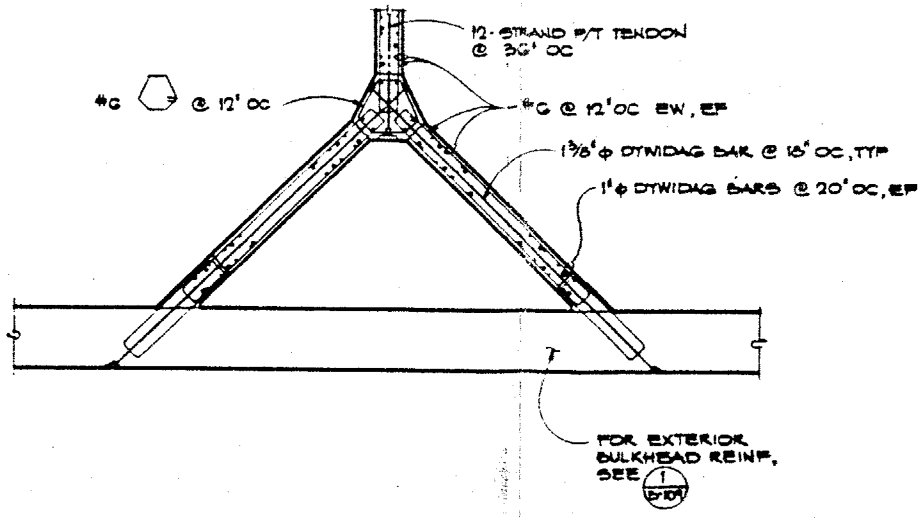
① SECTION
B-110 3/4" = 1'-0"



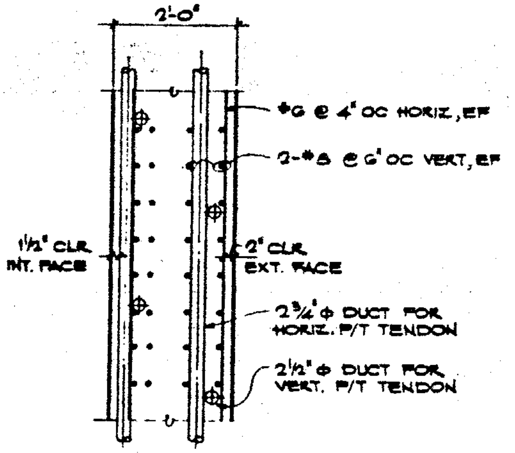
② SECTION
B-110 3/4" = 1'-0"



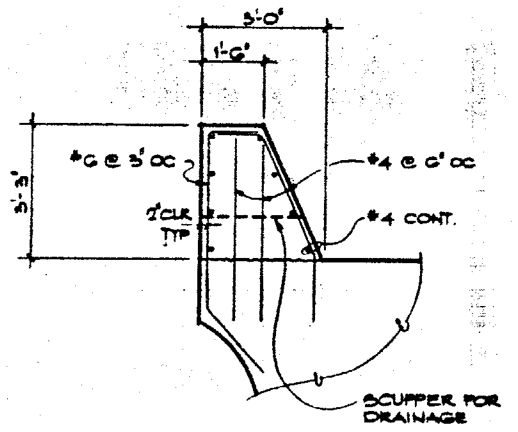
③ SECTION
B-110 3/4" = 1'-0"



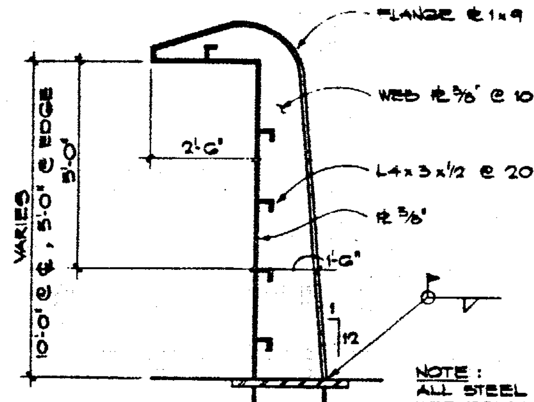
④ SECTION - DELTA BULKHEAD
B-110 1/4" = 1'-0"



⑤ SECTION - CONCRETE BULWARK
B-110 3/4" = 1'-0"



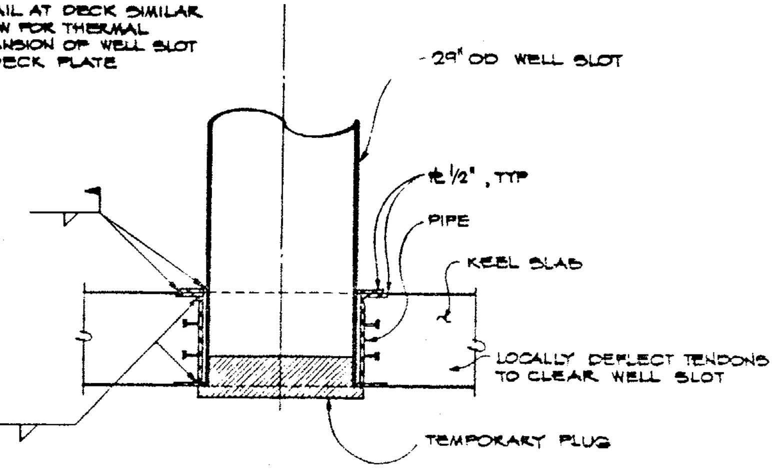
⑥ DETAIL - CONCRETE PARAPET
B-110 1/2" = 1'-0"



NOTE:
ALL STEEL FOR WAVE DEFLECTOR IS ASTM A633-C, SEE DESIGN SPECIFICATION.

⑦ SECTION - STEEL WAVE DEFLECTOR
B-110 1/2" = 1'-0"

NOTE:
DETAIL AT DECK SIMILAR
ALLOW FOR THERMAL
EXPANSION OF WELL SLOT
AT DECK PLATE



⑧ DETAIL - WELL SLOT PENETRATION AT KEEL
B-110 3/4" = 1'-0"

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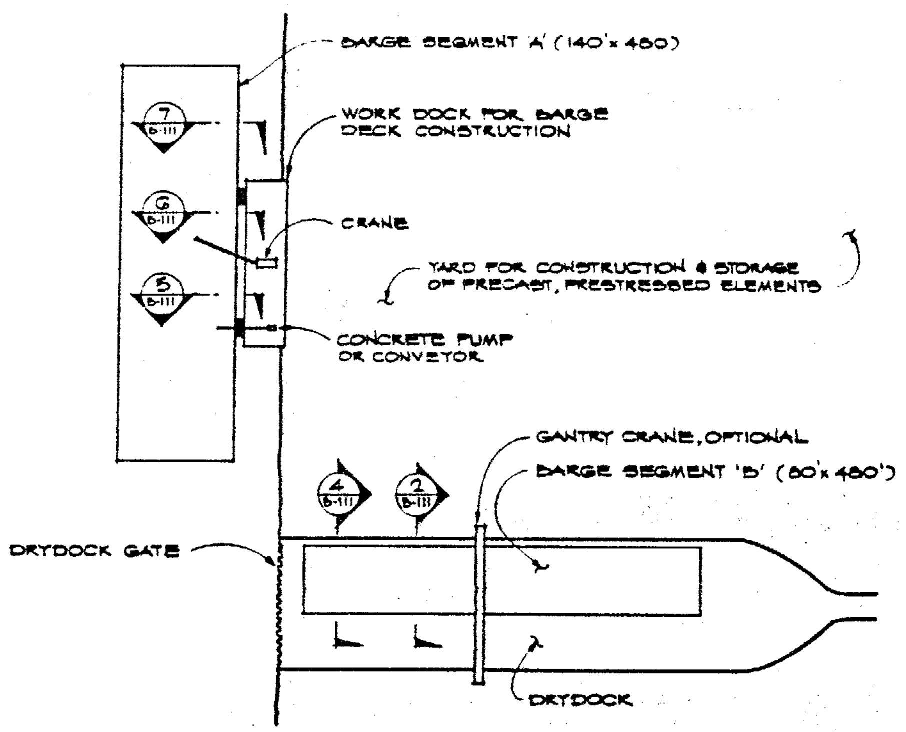
STRUCTURES

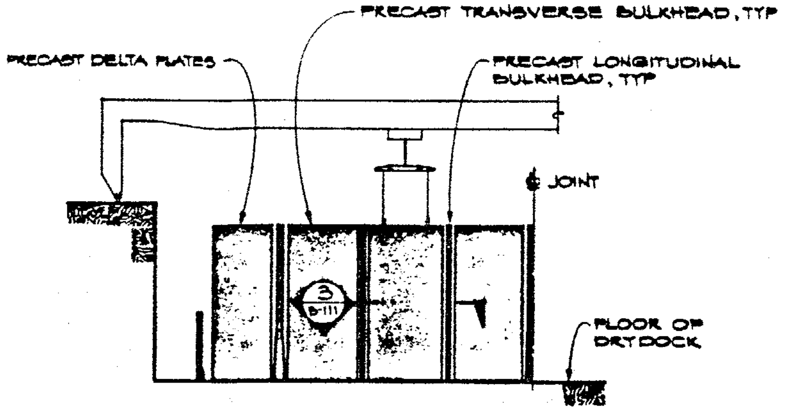
SHEET TITLE
MISCELLANEOUS
DETAILS

DESIGN BY EWO
DRAWN BY BTH
DATE 27 APRIL 1982
FILE NO. AB2001

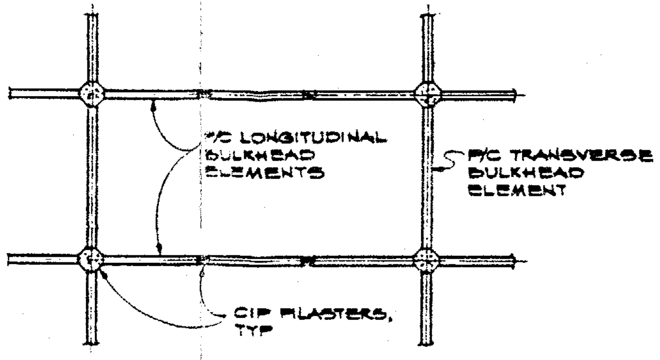
DRAWING NUMBER B-110



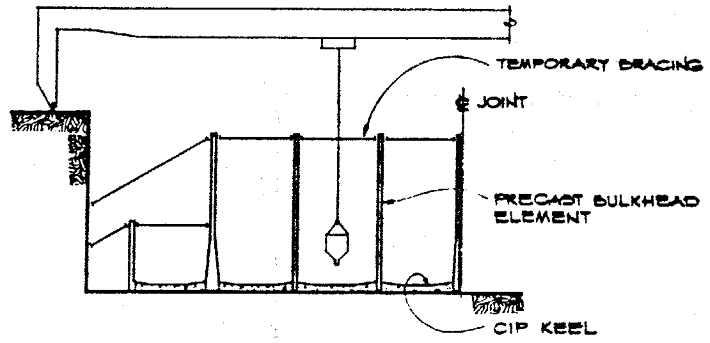
① B-111 PLAN - BARGE CONSTRUCTION FACILITY
1" = 100'-0"



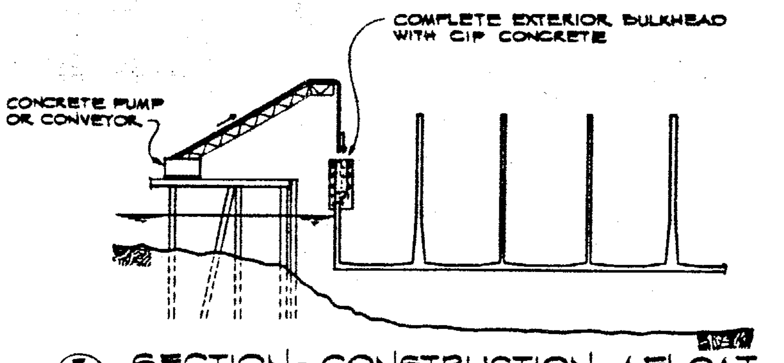
② B-111 SECTION - ERECTION OF P/C BULKHEADS
1" = 20'-0"



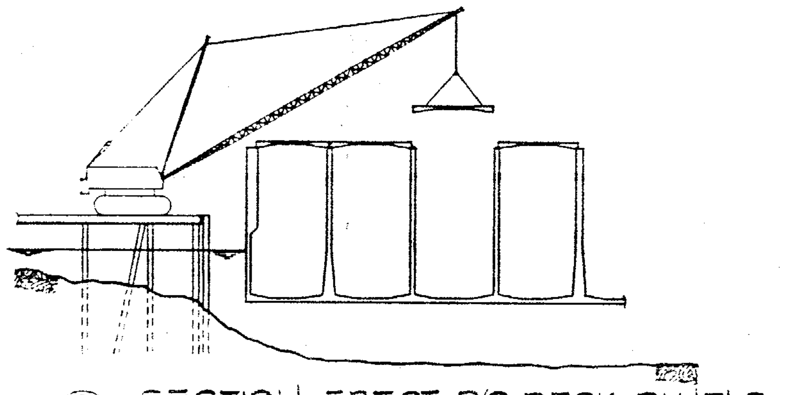
③ B-111 SECTION - P/C BULKHEAD ELEMENTS
1" = 20'-0"



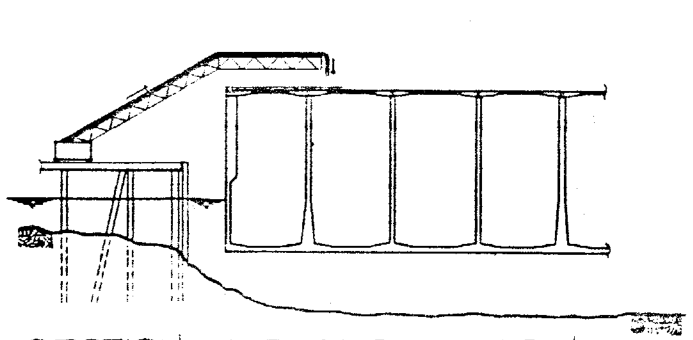
④ B-111 SECTION - KEEL CONSTRUCTION
1" = 20'-0"



⑤ B-111 SECTION - CONSTRUCTION AFLOAT
1" = 20'-0"



⑥ B-111 SECTION - ERECT P/C DECK PANELS
1" = 20'-0"



⑦ B-111 SECTION - CIP DECK TOPPING
1" = 20'-0"

SEQUENCE :

1. PRECAST BULKHEAD ELEMENTS.
2. ERECT BULKHEAD ELEMENTS FOR BARGE SEGMENT 'A' IN DRYDOCK. MAXIMUM ELEMENT WEIGHT = 56 T (TRANSVERSE WATERTIGHT BULKHEAD).
3. FORM AND PLACE CAST-IN-PLACE PILASTERS BETWEEN BULKHEAD ELEMENTS. PILASTER IS POURED TO CREATE CONSTRUCTION JOINT IN KEEL.
4. PLACE REINFORCEMENT AND CAST-IN-PLACE CONCRETE IN KEEL.
5. POST-TENSION AND GROUT ALL TENDONS BELOW WATERLINE OF COMPLETED BARGE SEGMENT.
6. LAUNCH PARTIALLY COMPLETED BARGE SEGMENT. DRAFT REQUIREMENT IS 12'-6" INCLUDING TRIM BALLAST. MOOR AT WORK DOCK FOR SUBSEQUENT CONSTRUCTION. BEGIN STEP 2 FOR SEGMENT 'B'.
7. PLACE REINFORCEMENT AND CAST-IN-PLACE CONCRETE TO COMPLETE EXTERIOR BULKHEAD WHILE BARGE SEGMENT IS FLOATING. BULKHEAD MUST BE PLACED PLACED IN TWO LIFTS TO PROVIDE SUFFICIENT FREEBOARD DURING CONSTRUCTION.
8. ERECT PRECAST DECK PANELS. PANEL WEIGHT FOR 6'-0" WIDE PANEL = 5T.
9. PLACE REINFORCEMENT AND CAST-IN-PLACE DECK TOPPING
10. COMPLETE POST-TENSIONING ABOVE WATERLINE.
11. REPEAT FOR BARGE SEGMENT 'B'.

NO. DATE REVISION BY
PRINTS TO DATE

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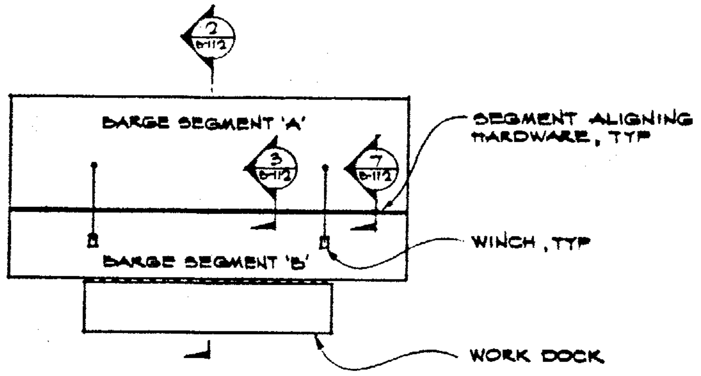
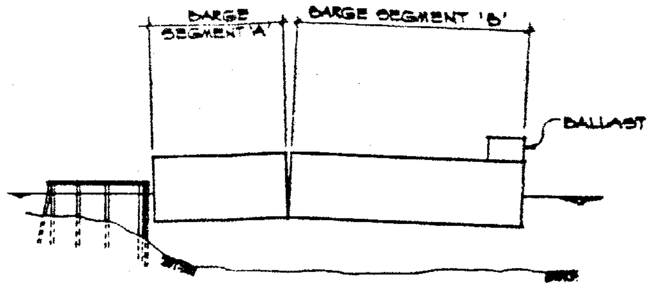
PROJECT TITLE
NORTON
SOUND
STRUCTURES

SHEET TITLE
CONSTRUCTION
PLANS
BARGE
CONCEPT FOR
30' WATER

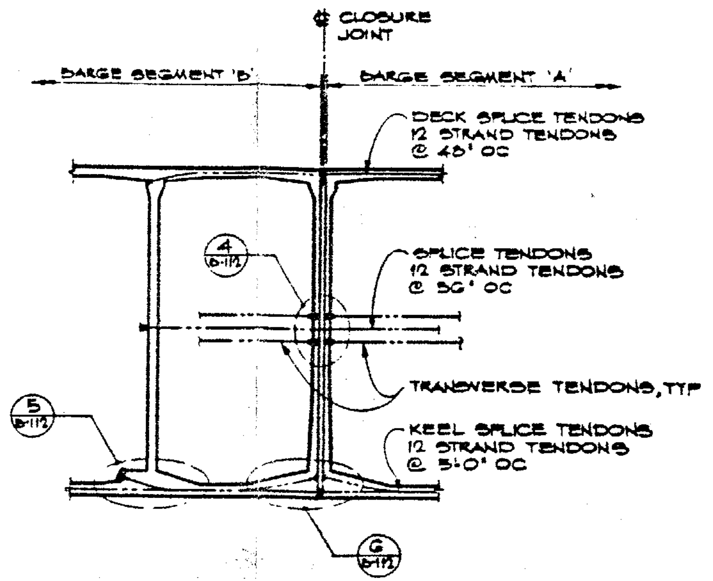
DESIGN BY JJP
DRAWN BY BTH
DATE 27 APRIL 1982
FILE NO A52001
DRAWING NUMBER B-111



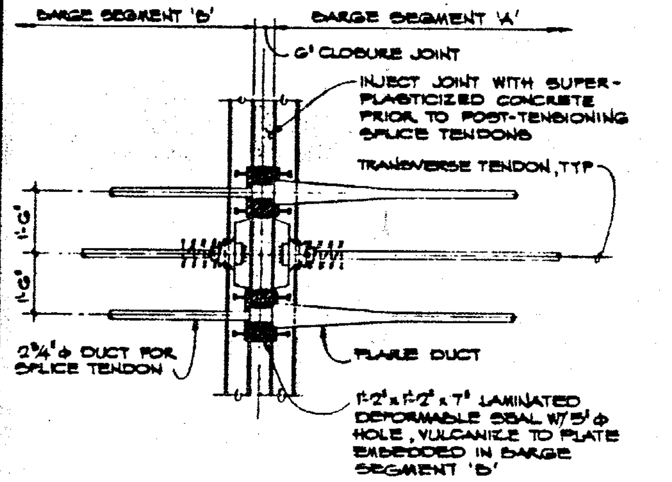
1 B-112 PLAN - SEGMENT JOINTING
1" = 100'-0"



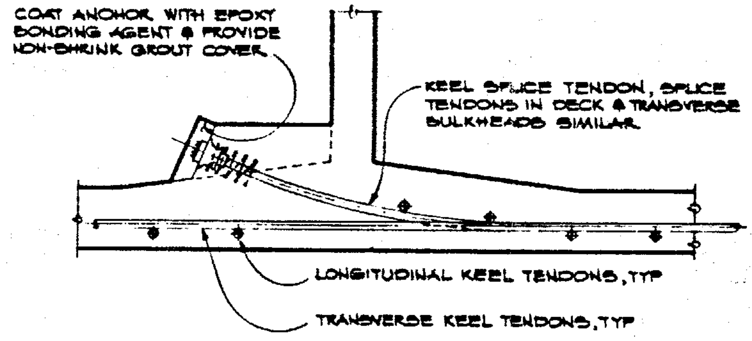
2 B-112 SECTION - SEGMENT JOINTING
1" = 50'-0"



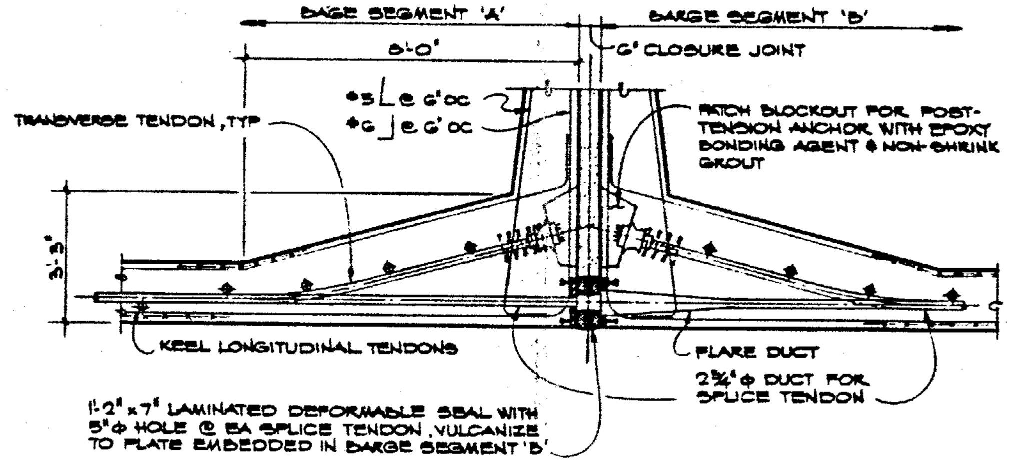
3 B-112 SECTION - JOINT BETWEEN SEGMENT
1" = 10'-0"



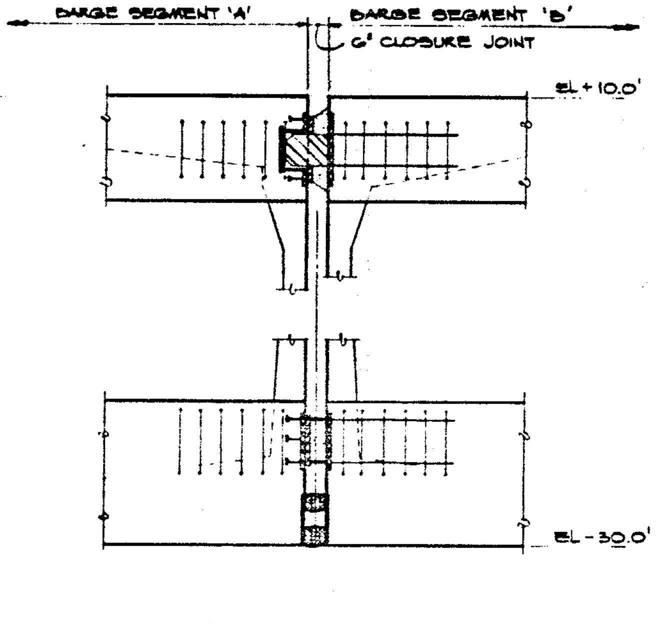
4 B-112 DETAIL - SPLICE TENDON ANCHORAGE
1/2" = 1'-0"



5 B-112 DETAIL - DUCT SPLICE
1/2" = 1'-0"



6 B-112 DETAIL - CLOSURE JOINT
1/2" = 1'-0"



7 B-112 SECTION - SEGMENT ALIGNMENT HARDWARE
1/2" = 1'-0"

SEQUENCE OF JOINTING OPERATION

1. CLEAN SURFACE OF JOINT BULKHEAD ON BOTH BARGE SEGMENTS.
2. BALLAST BARGE SEGMENTS TO ACHIEVE EQUAL DRAFT AT JOINT AND A GAP AT THE JOINT ALIGNMENT PIN NEAR DECK LEVEL.
3. PROVIDE INITIAL SEATING OF JOINT ALIGNMENT PINS WITH WINCH LINES ACROSS JOINT.
4. POST-TENSION A PORTION OF THE DECK SPLICE TENDONS. THE NUMBER OF TENDONS STRESSED AT THIS POINT WILL BE DEPENDANT UPON EXPOSURE OF CONSTRUCTION SITE.
5. ADJUST BALLAST TO PROVIDE POSITIVE COMPRESSION AT BOTTOM BEARING DETAILS.
6. DEWATER JOINT.
7. CAST JOINT WITH SUPERPLASTICIZED PEA GRAVEL CONCRETE, WITH A MAXIMUM LIFT OF 4'-0".
8. AFTER CONCRETE HAS ACHIEVED SUFFICIENT STRENGTH, POST-TENSION AND GROUT SPLICE TENDONS.

SUPERSTRUCTURE ERECTION SEQUENCE

1. CONSTRUCT CONCRETE BULWARK WITH CAST-IN-PLACE AND/OR PRECAST CONCRETE CONSTRUCTION.
2. CONSTRUCT SKID BEAM SUPPORT COLUMNS WITH CAST-IN-PLACE CONCRETE.
3. CONSTRUCT SHEAR WALLS WITH CAST-IN-PLACE OR PRECAST CONCRETE CONSTRUCTION.
4. ERECT PRECAST SKID BEAMS WITH WATER BORNE OR DOCK-SIDE MOUNTED CRANES. SUPPORT SKID BEAM ON SCAFFOLDING WHILE FORMING COLUMN TO SKID BEAM CONNECTION WITH CAST-IN-PLACE CONCRETE. SKID BEAM WEIGHT = 26T.
5. TWO BARGE MOUNTED TOWER CRANES CAN ACCOMMODATE CAST-IN-PLACE CONCRETE SUPERSTRUCTURE CONSTRUCTION.
6. ERECT STEEL WEATHERDECK FRAMING WITH MOBILE CRANES ON BARGE DECK.

ABAM
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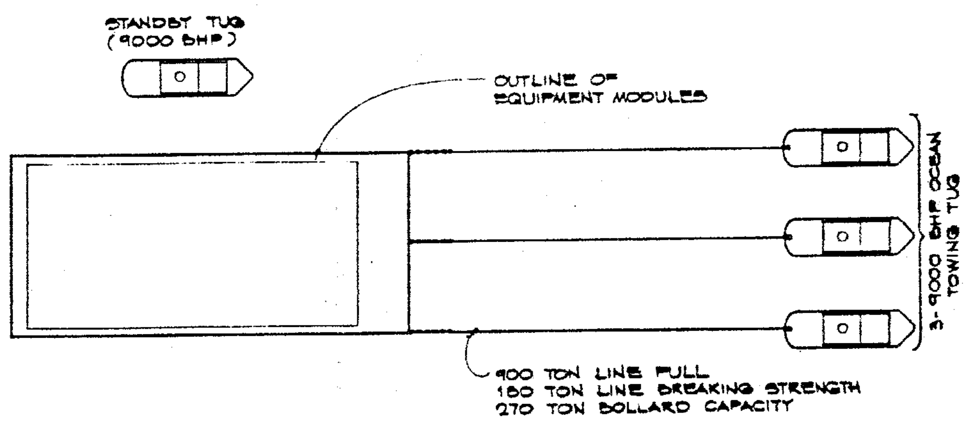
PROJECT TITLE
NORTON
SOUND
STRUCTURES

SHEET TITLE
SEGMENT
JOINTING
& SUPER-
STRUCTURE
ERECTION

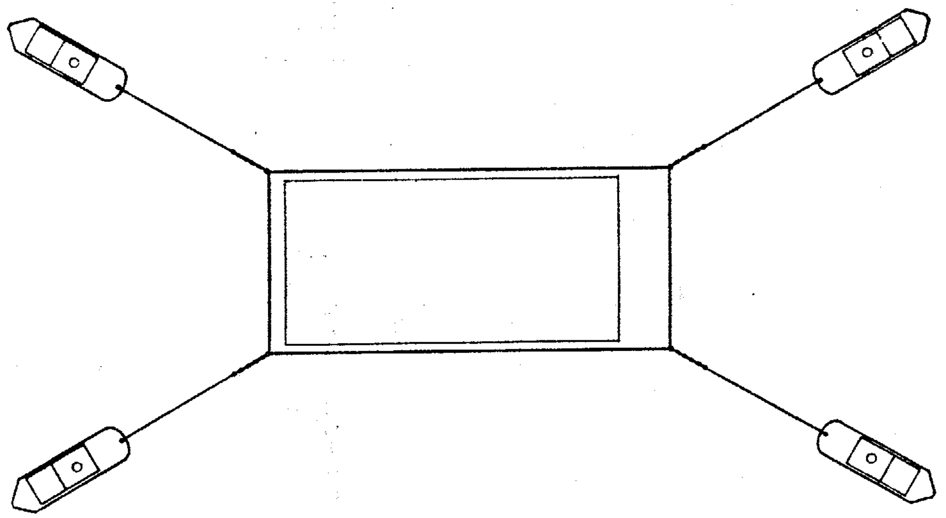
DESIGN BY JJP
DRAWN BY DTH
DATE 27 APRIL 1982
FILE NO. A52001
DRAWING NUMBER B-112

NO.	DATE	REVISION	BY

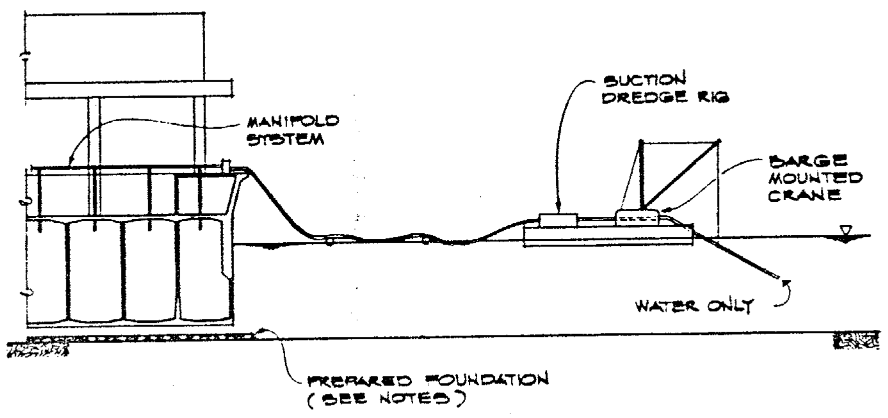
PRINTS TO	DATE



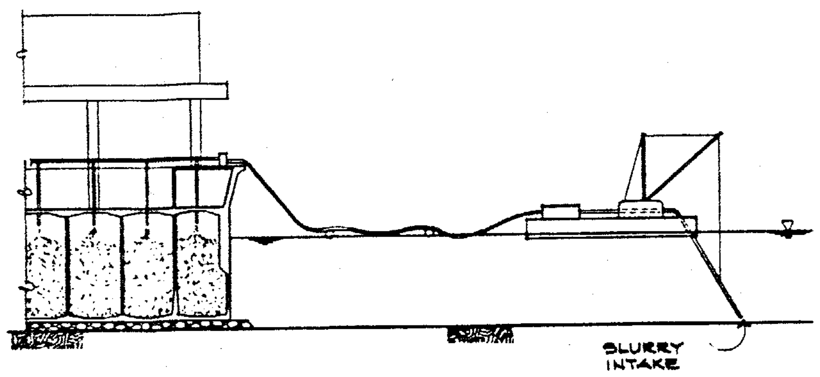
① B-113 TOWING PLAN
NTS



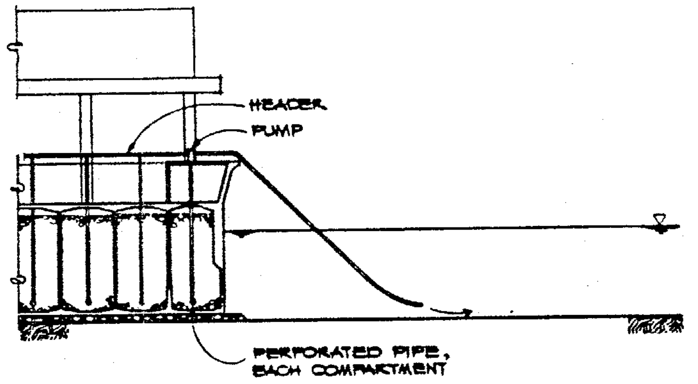
② B-113 PLAN - BARGE POSITIONING SCHEME
NTS



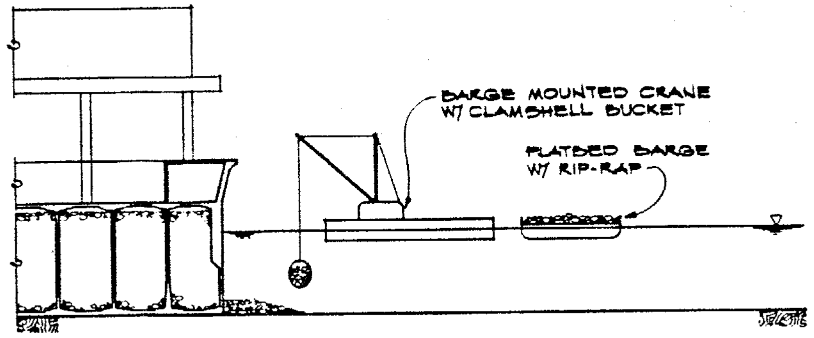
③ B-113 WATER BALLAST
NTS



④ B-113 GRANULAR BALLAST FILL
NTS



⑤ B-113 DEWATERING GRANULAR FILL
NTS



⑥ B-113 RIP-RAP SCOUR PROTECTION
NTS

NOTES :

1. TOWING ASSUMPTIONS:
   - a. Mobilize a total of four tugs, all of U.S. Registry and all of the 9000 BHP class. Standby tug is used during planned shuttle refueling and for emergency.
   - b. The towing distance is approximately 2300 nautical miles for the assumed tow from Puget Sound to Norton Sound.
   - c. Estimated towing speed is 2 to 3 knots in calm water.
   - d. Estimated tow duration is 45 days, including a 7 day allowance for inclement weather.
2. POSITIONING ASSUMPTIONS:
   - a. Use four 9000 BHP tugs to position and control the the barge during initial water ballasting.
   - b. Four days have been allowed as a weather window for barge positioning.
   - c. The proposed scheme assumes the island horizontal position tolerance is described by a 75 foot radius.
   - d. Where island location must be located over existing wells, a fixed mooring system will be necessary.
3. FOUNDATION PREPARATION:
   - a. Survey site and perform soil investigation. Use direct soundings employing buoyant sounding tubes. Collect soil samples.
   - b. Provide a stable work platform.
   - c. Dredge to remove undesirable materials:
     - Soft material - use suction dredge or ejectors.
     - Firm material - use clamshell buckets.
   - d. Prelevel foundation base by placing crushed coarse rock (6 inch max size) and top with a layer (20 to 40 inches) of screed rock (1 to 3 inch max size).
   - e. Consolidate Foundation:
     - Granular materials may be consolidated by vibro compaction.
   - f. Airlift extraneous material.
   - g. Protect foundation from scour during landing by covering with a fabric mattress anchored with gravel.
   - h. Final level foundation with fine gravel as required.
4. INITIAL WATER BALLASTING:
   - a. While barge location is controlled by the tugs, fill barge with 26 million gallons of seawater ballast. This can be accomplished in approximately 12 hours with a 26 inch diameter dredge unit with a capacity of 35,000 gallons per minute.
   - b. The on deck manifold system must be designed to allow sufficient control to allow a uniform landing. The design of the detailed ballasting system will be determined during future design phases.
5. BALLASTING WITH GRANULAR FILL:
   - a. Approximately 120,000 cu. yds. of granular fill (γ = 115 pcf) will be placed within the barge structure. The assumed granular fill is assumed available within 5000 feet of the foundation.
   - b. A barge mounted hydraulic dredge is used to transport fill to the barge.
   - c. Two cranes are required to assist in the dredging operation, one mounted on the same barge as the suction dredge and one on the barge itself.
   - d. The duration of the filling operation is 37 days including 6 days for weather down time.
   - e. The desired density of the fill is achieved by dewatering of the hydraulic dredge slurry within each compartment.
   - f. To avoid overstressing the barge bulkheads, it is assumed the diffferential head of fill material between adjacent cells will be less than 18 feet.
6. RIPRAP SCOUR PROTECTION:
   - a. Riprap is assumed available dockside at Nome. Riprap is transported to the barge foundation by 2 - 300 cu. yd. flatbed barges. A transport distance of 70 nautical miles has been assumed.
   - b. Approximately (7000 cu. yds.) of riprap is placed around the perimeter of the barge with a barge mounted crane with a clam shell bucket.
   - c. The duration of the riprap placing is 22 days, including 4 days of weather down time.
7. ERECT FLARE BOOMS:
   - a. Flare booms are erected at deployment site to prevent their exposure to dynamic loadings resulting from the delivery voyage seastate.

NO.	DATE	REVISION	BY

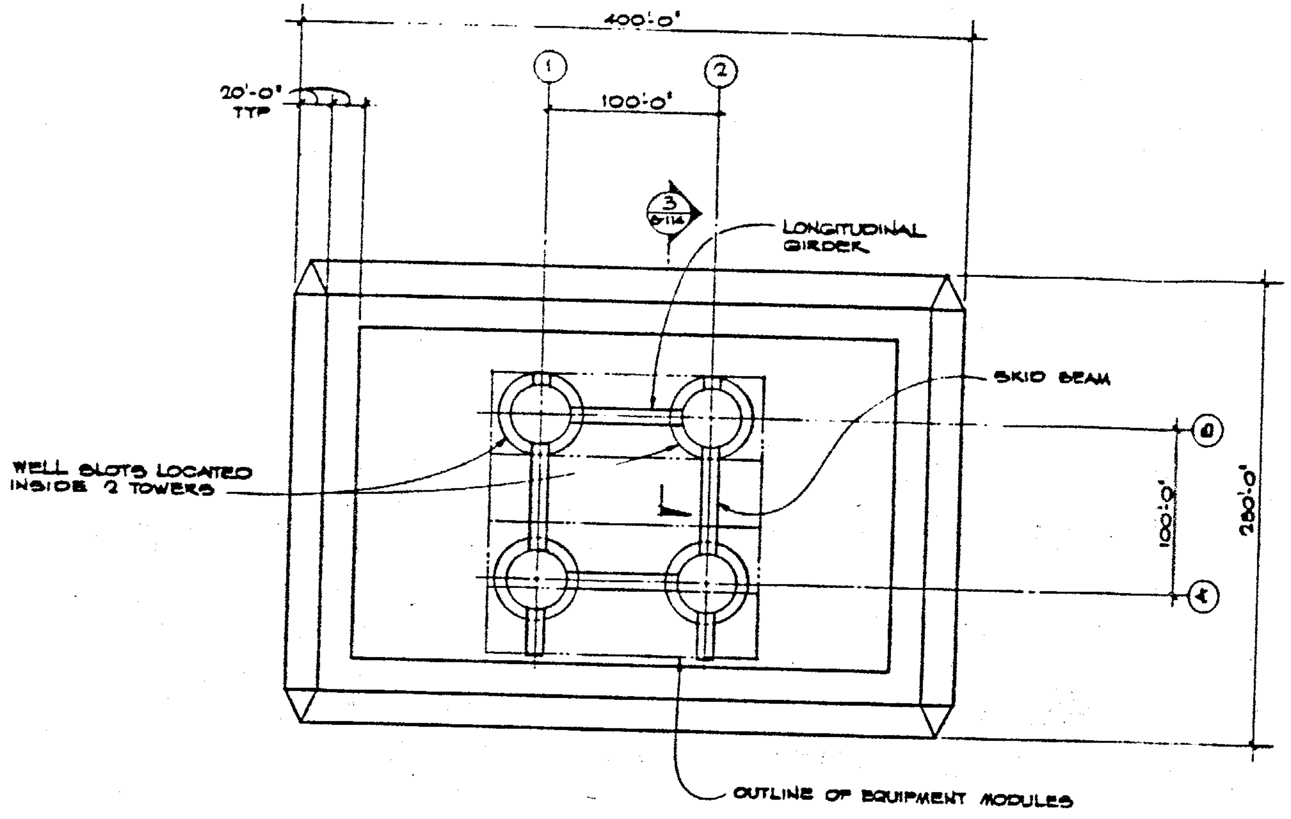
PRINTS
TO DATE

ABAM
CONSULTING ENGINEERS

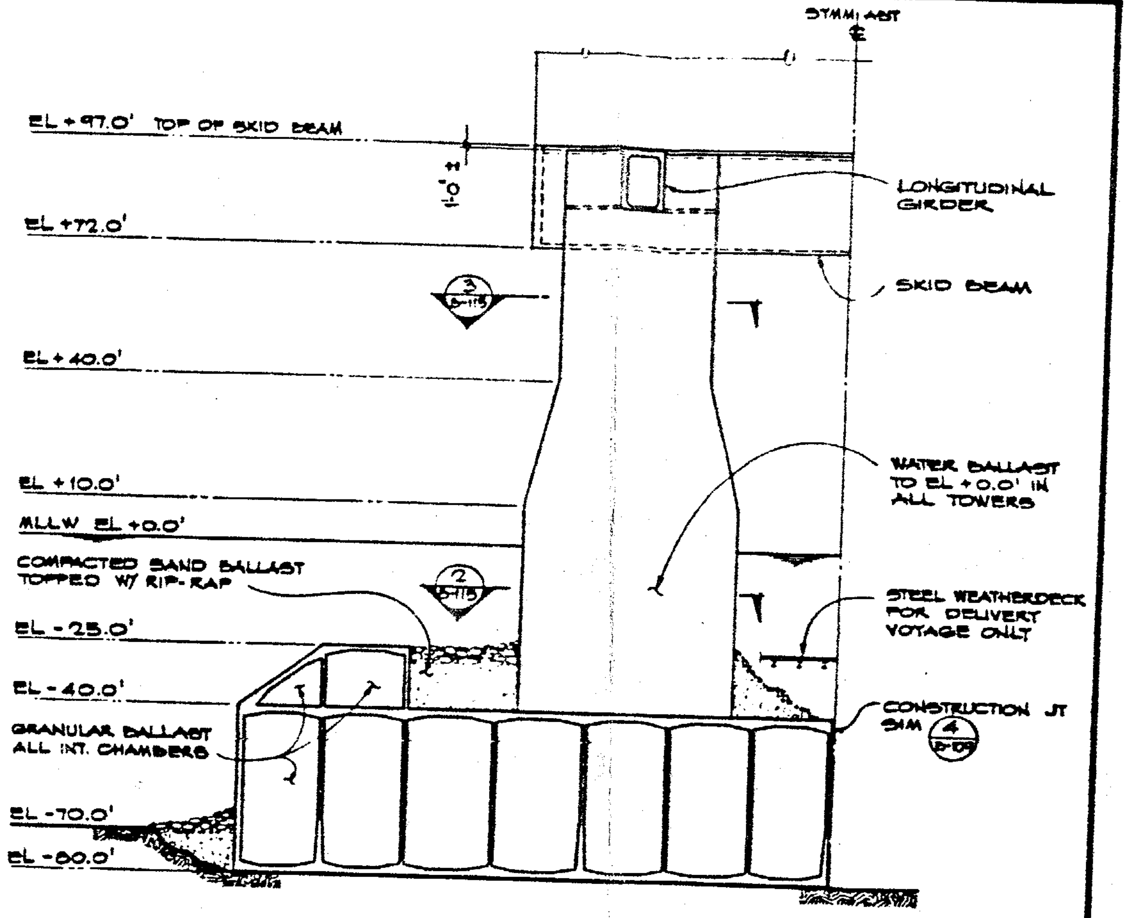
PROJECT TITLE
**NORTON
SOUND
STRUCTURES**

SHEET TITLE
**DEPLOYMENT
PLAN
BARGE
CONCEPT FOR
30' WATER**

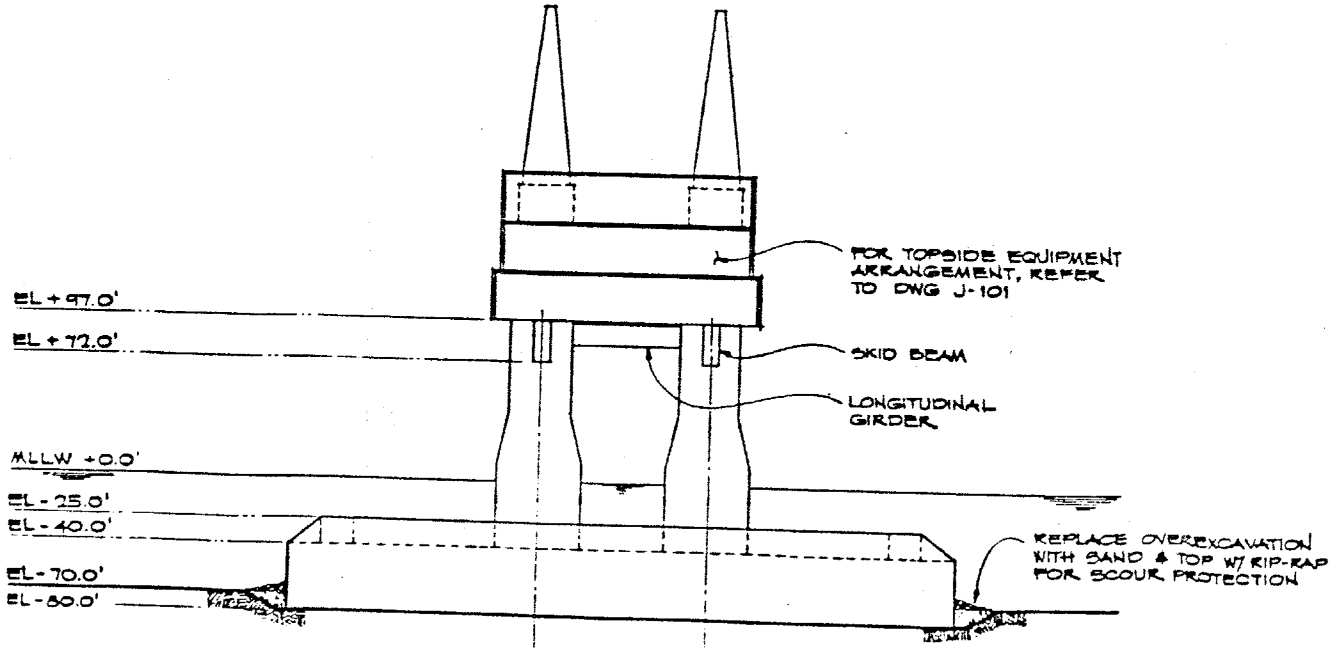
DESIGN BY JJ
DRAWN BY BTH
DATE 27 APRIL 1982
A52001
DRAWING NUMBER **B-113**



1 B-114 PLAN
1" = 50'-0"



3 B-114 SECTION
1" = 20'-0"



2 B-114 ELEVATION
1" = 50'-0"

NOTES:

1. BARGE CHARACTERISTICS:

DRAFT ....: 30.6 FT
DISPLACEMENT ....: 109,300 ST
METACENTRIC HEIGHT ($\overline{GM_T}$) ...: 173 FT
MOMENT TO TRIM 1 INCH .... : MTL1 = 9,011 ST-FT
MOMENT TO HEEL 1 INCH .... : MTT1 = 5,620 ST-FT

CONCRETE VOLUME : 49,000 CY (LIGHT WT = 46,000 CY, NORMAL WT = 3,000 CY)

GRANULAR BALLAST... : 25,000 CY COMPACTED TO 115 PCF (ABOVE EL -40)
145,700 CY AT 90 PCF (INT. CHAMBERS)

RIP-RAP ....: 5,800 CY WITH A DENSITY = 110 PCF

WATER BALLAST......: 1,658,000 GALLONS (TOWERS)

2. EXTREME EVENT (100 YR RETURN):

WAVE AT DEPLOYMENT SITE : MAXIMUM BREAKING WAVE HT = 55 FT
WAVE PERIOD = 14 SEC

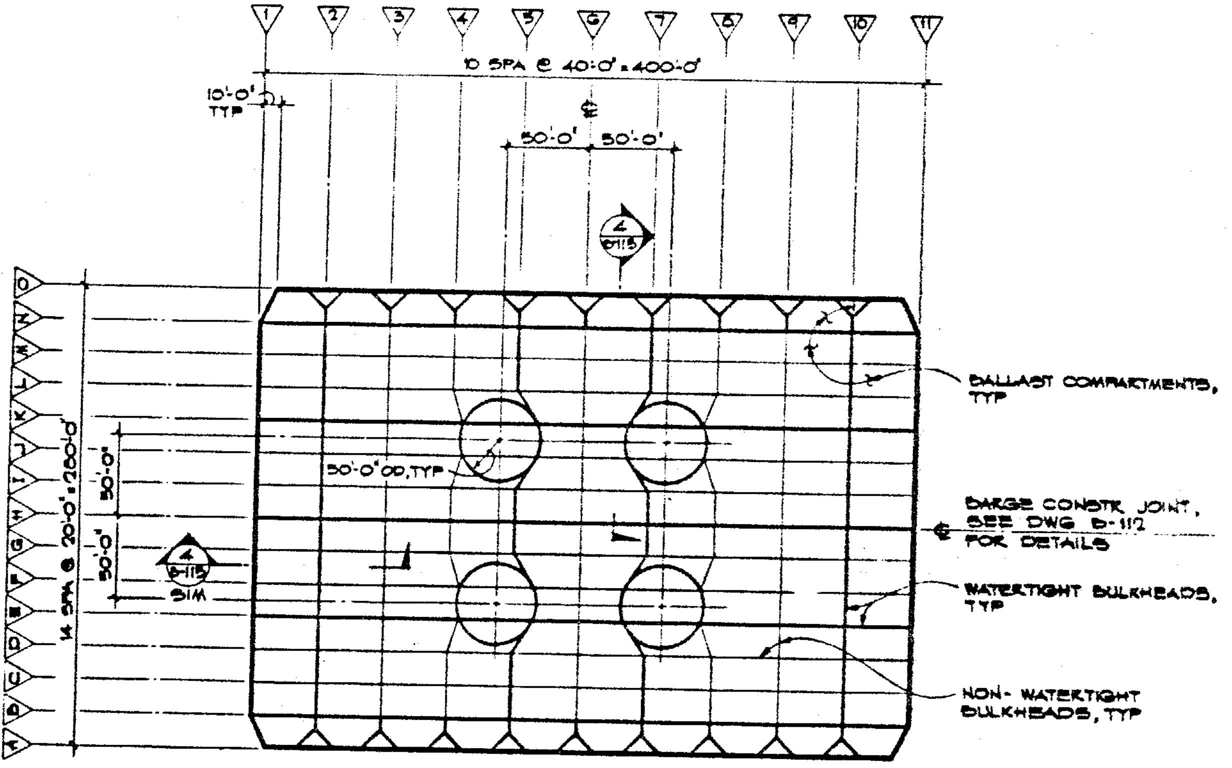
3. FOR OTHER NOTES, REFER TO DWG B-106.

ABAM
CONSULTING ENGINEERS

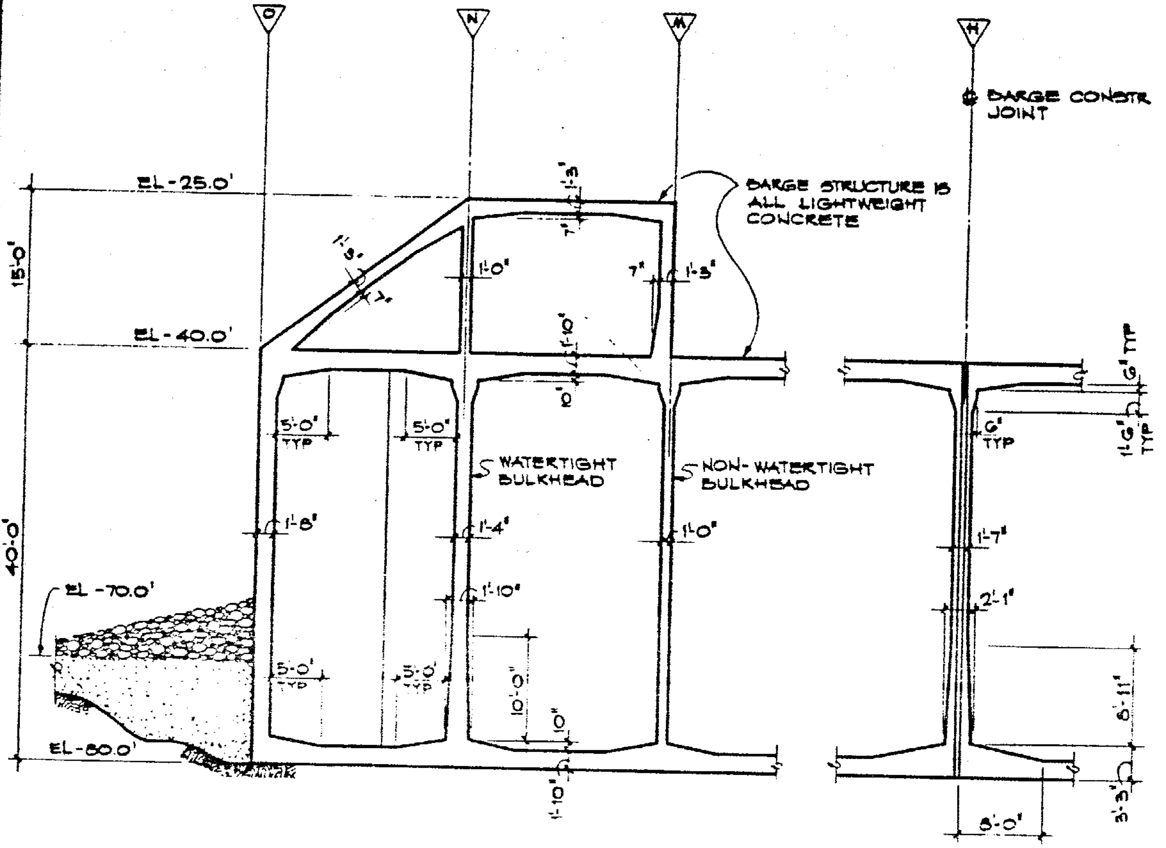
PROJECT TITLE
NORTON
SOUND
STRUCTURES

SHEET TITLE
GENERAL
ARRANGEMENT
BARGE
CONCEPT FOR
70' WATER

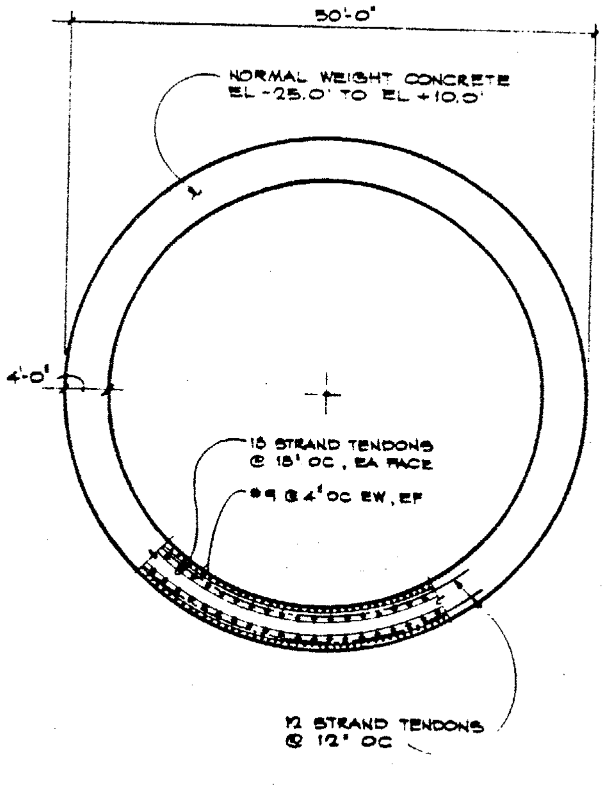
DESIGN BY EWO
DRAWN BY DTH
DATE 27 APRIL 1982
FILE NO A82001
DRAWING NUMBER B-114



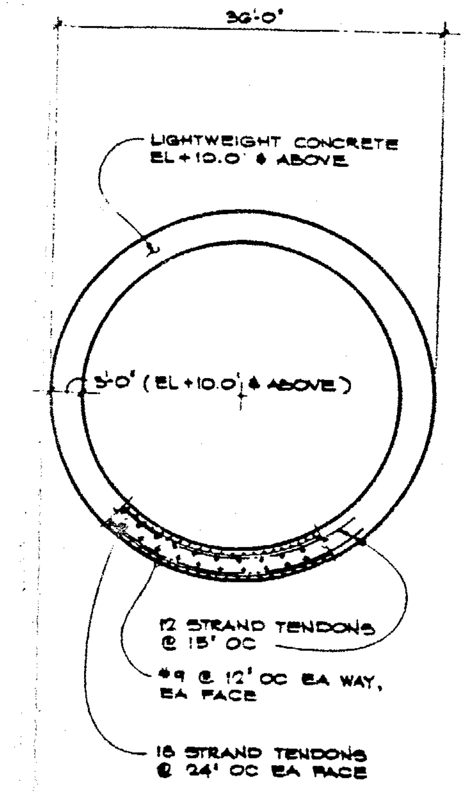
1 / B-115 FRAMING PLAN
1" = 50'-0"



TRANSVERSE SECTION
1/8" = 1'-0"



2 / B-115 SECTION
1/8" = 1'-0"



3 / B-115 SECTION
1/8" = 1'-0"

NOTES:

1. PRESTRESS SUMMARY

STRUCTURAL ELEMENT	PRESTRESS LEVEL
LONGITUDINAL DECK, KEEL & BULKHEADS	1.00 KSI
TRANSVERSE DECK, KEEL & BULKHEADS	1.00 KSI
VERTICAL PRESTRESS	0.50 KSI
WAVE BULWARK	0.50 KSI
TOWERS VERTICAL & CIRCUMFERENTIAL	1.00 KSI
SKID BEAMS	1.10 KSI

ABAM
CONSULTING ENGINEERS

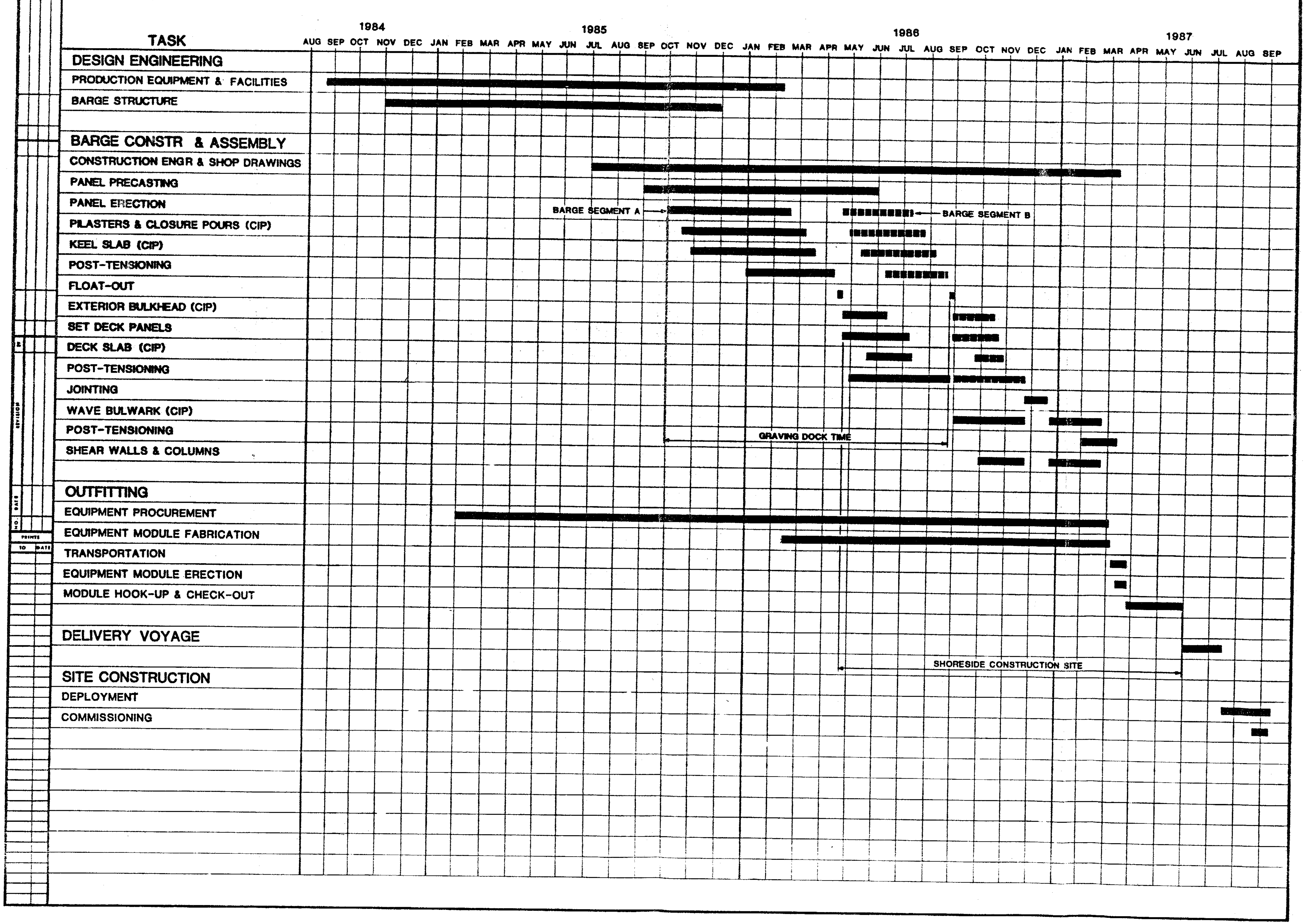
PROJECT TITLE
NORTON
SOUND
STRUCTURES

SHEET TITLE
FRAMING
ARRANGEMENT
BARGE
CONCEPT FOR
70' WATER

DESIGN BY EWO
DRAWN BY BTH
DATE 27 APRIL 1982
A82001

DRAWING NUMBER B-115

DESIGN & CONSTRUCTION SCHEDULE - CONCRETE PRODUCTION PLATFORM IN 30′ WATER



ABAM
CONSULTING ENGINEERS

PROJECT TITLE
NORTON
SOUND
STRUCTURES

SHEET TITLE
DESIGN &
CONSTRUCTION
SCHEDULE
CONCRETE
PLATFORM

DESIGN BY EWO
DRAWN BY BTH
DATE 27 APRIL 1982
FILE NO A82001
DRAWING NUMBER B-116

COST AND SCHEDULE BREAK-DOWNS

ADDENDUM D

DESCRIPTION	REV. NO.	PAGES
Jacket Concept, 30' Water Depth	3	9
30 Foot MLLW Jacket Configuration; Level III Control Schedule	17/3/82	4
Barge Concept, 30' Water Depth (FOS & ABAM)	3	9
Jacket Concept, 50' Water Depth	3	9
50 Foot MLLW Jacket Configuration; Level III Control Schedule	17/3/82	4
Jacket Concept, 70' Water Depth	3	9
70 Foot MLLW Jacket Configuration; Level III Control Schedule	17/3/82	4
Project Execution Network/Jacket Concept	3/9/82	2
Construction Spreads/Jacket Concept	3/12/82	7
Project Execution Network/Barge Concept	3/10/82	2
Cost Estimate Summary - 30' Concrete Structure	12/3/82	33
Cost Estimate Summary - 70' Concrete Structure	18/3/82	8

FACTOR TYPE COST ESTIMATE

FLUOR OCEAN SERVICES

CUSTOMER Socal
LOCATION Alaska
PROJECT Norton Sound Study

DESCRIPTION Jacket Concept
30' Water Depth
" Main Summary "

PROP. NO. 82-110-02
W.O. NO. 411093
CONT. NO.
MADE BY MG
APPROVED

A/C NO.	ITEM & DESCRIPTION	QTY.	ESTIMATED COST / 1st QUAR. '82 US $ × 1000				
			LABOR	MAT'LS	EQUIPMENT	SUB-CONTRACTS	TOTALS
	<u>ONSHORE WORK</u>						
	PLATFORM FABRICATION IN YARD	[illegible]		14,710		51,400	[illegible]
	MODULE ASSEMBLY AND OUTFITTING			75,725		16,545	92,270
	<u>OFFSHORE WORK</u>						
	TRANSPORTATION					10,000	10,000
	INSTALLATION					13,100	13,100
	HOOKUP/CHECKOUT STARTUP/COMM.					1,490	1,490
	DIRECT FIELD COSTS			90,435		107,535	197,970
	INDIRECT FIELD COSTS			2,610		5,775	8,385
	TOTAL FIELD COSTS			93,045		113,310	206,355
	FIELD CONST. MGMT	5% OF DFC					5,940
92-000	HOME OFFICE CONSTRUCTION MGMT.						
93-000	PROJECT MANAGEMENT						
94-000	CENTRAL ENGINEERING						
95-000	DRAFTING & TECH. SERVICES						
96-000	PURCHASING	7.8% OF DFC					15,300
97-000	BUSINESS SERVICES	(340,000 MHRS × $45/MH.)					
97-000	OFFICE EXPENSE						
98-000	OFFICE PAYROLL BURDEN						
99-500	INDIRECT OFFICE COSTS						
	TOTAL OFFICE COSTS						21,240
	TOTAL FIELD & OFFICE COSTS						227,575
99-100	ESCALATION						
99-200	CONTINGENCY 16.8%						38,235
99-600	FEE						
99-300	SALES TAX						
	TOTAL						265,330

F.O.S. 1917

DATE 3/15/82 REVISION NO. 4 REVISION DATE 4/28/82 PAGE NO. 1 OF 9

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study AREA ONSHORE
DESCRIPTION JACKET CONCEPT FOR 30' WATER DEPTH ACCOUNT
PLATFORM FABRICATION IN YARD

ESTIMATE NO. 82-110-02
SHEET NO. 2 OF 9
PREPARED BY MG DATE 3/15/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS				COST / QUAR. '82 US $							BASIS DWG/P.O.
				MAT'L	EQUIP.	S/C	MAN HR	LABOR (MH)	MAT'LS		EQUIPMENT		SUB CONTR.		
	JACKET	TONS	6590	677		4300			4,460	000			28,340	000	
	PILES	TONS	9605	675		700			6,485	000			6,725	000	
	CONDUCTORS	TONS	900	675		500			605	000			450	000	
	MODULE SUPERSTRUCTURE	TONS	4470	690		3300			3,090	000			14,750	000	
	FLARE BOOMS	TONS	180	675		6300			122	000			1,135	000	
	SUBTOTAL	TONS	21,745												
REMARKS							SUB TOTALS		14,712	000			51,400	000	
							ADJUSTMENTS								
							RATES								

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study
DESCRIPTION Jacket Concept 30' Water Depth
Module Assembly & Outfitting in Fab. Yard
AREA Onshore
ACCOUNT

ESTIMATE NO. 82-110-02
SHEET NO. 3 OF 9
PREPARED BY MG DATE 3/10/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ Quar.'82 US $ LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	BASIS DWG/P.O.
				Factor		Factor						
	Module No DA											
	Equip. Cost	M$	1150	1.41		.60			1,622 000		690 000	
	Module No DB1											
	Equip. Cost	M$	1425	1.45		.87			2,066 000		1,240 000	
	Module No DB2											
	Equip. Cost	M$	1425	1.45		.87			2,066 000		1,240 000	
	Module No DC1											
	Equip. Cost	M$	643	2.09		.89			1,344 000		572 000	
	Module No DC2											
	Equip. Cost	M$	643	2.09		.89			1,344 000		572 000	
	Module No DD1											
	Equip. Cost	M$	585	1.37		.59			801 000		345 000	
	Module No DD2											
	Equip. Cost	M$	585	1.37		.59			801 000		345 000	
	Module No WA											
	Equip. Cost	M$	531	2.38		1.39			1,264 000		738 000	
	Module No PB											
	Equip. Cost	M$	1000	2.35		1.56			2,350 000		1,560 000	
	Module No PC											
	Equip. Cost	M$	6796	1.43		.77			9,718 000		5,233 000	
	Module No PD											
	Equip. Cost	M$	5493	1.35		.73			7,416 000		1,010 000	
	SUB TOTALS								30,972 000		16,545 000	
	ADJUSTMENTS											
	RATES											

REMARKS Factors used are based on current
Modules being assembled & outfitted on the
US West Coast. Equipment costs from

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study
DESCRIPTION Jacket Concept 30' water depth
Module Assembly & Outfitting in Fab. Yard

AREA Onshore
ACCOUNT

ESTIMATE NO. 82-110-02
SHEET NO. 4 OF 9
PREPARED BY MG DATE 3/10/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ 1st Quar. US$ '82 LABOR (MH)	COST MAT'LS	COST EQUIPMENT	COST SUB CONTR.	BASIS DWG/P.O.
	From Previous Page								30,972 000		16,545 000	
	Package No RM-1A											
	Equip. Cost	M$	18530				1.0		18530 000			
	Package No RM-1B											
	Equip. Cost	M$	18530				1.0		18530 000			
	Package No EL-1A											
	Equip. Cost	M$	78				1.0		78 000			
	Package No EL-1B											
	Equip. Cost	M$	78				1.0		78 000			
	Module No CQ-1A	M$	3000				1.0		3000 000			
	Module No CQ-1B	M$	3000				1.0		3000 000			
	Pedestal Cranes	EA	2	225,000			1.0		450 000			
	Survival Crafts	EA	4	150,000			1.0		600 000			
	Nav-Aids	Sets	4	25,000			1.0		100 000			
	Rucker Mooring System	EA.	2	80,000			1.0		160 000			
	Flare Tips	EA	2	10,000			1.0		155 000			
	Track Vehicle	EA.	1	[illegible]					[illegible]			

REMARKS

SUB TOTALS: MAT'LS 75,725 000; SUB CONTR. 16,545 000
ADJUSTMENTS
RATES

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT NORTON SOUND STUDY
DESCRIPTION JACKET CONCEPT 30' WATER DEPTH
TRANSPORTATION

AREA OFFSHORE
ACCOUNT

ESTIMATE NO. 82-110-02
SHEET NO. 5 OF 7
PREPARED BY MG DATE 3/12/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ 1st QUAR. '82 US $ LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	BASIS DWG/P.O.
	JACKET	DAYS	60			$20,000/DAY					1200 000	
	2 - 6000 HP TUGS @ $10,000/DAY EA. = $20,000/DAY											
	PILING & CONDUCTORS	DAYS	82 ~~119~~			$18,000/DAY					1,475 000 ~~2,142 000~~	
	1 - 400' x 105' x 25' BARGE w/ 1 - 6000 HP TUG @ $8,000/DAY + $10,000/DAY RESPECTFULLY											
	[illegible] 25% OF [illegible] DAYS	DAYS	[illegible]			[illegible]					[illegible]	
	MODULES & PACKAGES	DAYS	185			$18,000/DAY					3,330 000	
	5 - 400' x 105' x 25' BARGES w/ 5 - 6000 HP TUGS											
	[illegible]	DAYS	[illegible]			[illegible]					[illegible]	
	DURATION/SPREAD = 37 DAYS x 5 SPREADS = 185 TOTAL DAYS @ $18,000/DAY											
	NOTE: DURATIONS INCLUDE TIME FOR STANDBY WHILE UNLOADING											
	LOADOUT MODULES	DAYS	20			[illegible]					360 000	
	TOW INSURANCE		[illegible]								[illegible]	

REMARKS TOW INS. BASED ON [illegible]

SUB TOTALS 10,000 000
ADJUSTMENTS
RATES

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study
DESCRIPTION Jacket Concept / 30 Water Depth
Installation

AREA OFFSHORE
ACCOUNT

ESTIMATE NO. 82-110-02
SHEET NO. 6 OF 1
PREPARED BY MG DATE 3/15/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ 1st QUAR. '82 US $ LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	BASIS DWG/P.O.
	JACKETS/PILES/CONDUCTORS											
	SURVEY & BUOY SITE	DAYS	7									
	WEATHER	DAYS	2									
	SUBTOTAL	DAYS	9			$ 10,000/DAY					90 000	
	SETUP & SINK TOWER	DAYS	1.75									
	JET-IN & LEVEL TOWER		6.00									
	SETUP FOR PILING & REMOVE BUOY CAPS		2.30									
	DRIVE 12'Ø PILES		24.30									
	DRIVE 2'Ø CONDUCTORS		5.50									
	SUBTOTAL		39.85									
	25% WEATHER		9.95									
	SUBTOTAL		49.8			$ 238,000/DAY					11,850 000	
	CONCRETE JACKET LEGS	DAYS	27.5									
	25% WEATHER		6.9									
	SUBTOTAL		34.4			$ 28,000/DAY					965 000	
	CONCRETE MATERIAL	CY	2380	$ 41/CY					100 000			
	SET MODULES/PACKAGES	DAYS	15.60	△4								
	28% WEATHER		4.4	△4								
	SUBTOTAL		20.00	△4		$ 182,000/DAY					3,640 000	△4
	COMMISSION CRANES & QUARTERS	DAYS	6.0									
	33% WEATHER		2.0									
	SUBTOTAL		8.0			$ 182,000/DAY					1,455 000	

REMARKS

SUB TOTALS				100 000		18,000 000	
ADJUSTMENTS							
RATES							

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study, AREA Offshore
DESCRIPTION Jacket Concept 30' Water Depth ACCOUNT
Hookup / Checkout / Startup / Commissioning

ESTIMATE NO. 82-110-02
SHEET NO. 7 OF 9
PREPARED BY MG DATE 3/12/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST / 1st Quar. '82 US $ LABOR (MH)	COST MAT'LS	COST EQUIPMENT	COST SUB CONTR.	BASIS DWG/P.O.
	Hookup / Checkout	Days	91			$119,600/Day					10,885 000	
	Startup / Commissioning	Days	14			$31,000/Day					435 000	
	2 shifts of 10 men											
	per shift for 14 days											
	is 240 MHRS/Day x $80											
	per MHR.											
	Labor:											
	268,000 ÷ 14 Days = 19,200/Day											
	Helicopter = 3,000/Day											
	Misc/Tools = 8,600/Day											
	30,800/Day											
	Say $31,000/Day											
	Misc. Punch List Work	Days	14			$12,000/Day					170 000	
	2 Men, 24 Hrs/Day											

REMARKS

	LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.
SUB TOTALS				11,490 000
ADJUSTMENTS				
RATES				

ESTIMATE WORK SHEET

OCEAN SERVICES

CUSTOMER SOCAL

LOCATION US WEST COAST/ALASKA

PROJECT NORTON SOUND STUDY

DESCRIPTION FACTORED ESTIMATE FOR A DRILLING AND PRODUCTION FACILITY OUTFITTING & HOOKUP JACKET CONCEPT 30' WATER DEPTH

PROP. NO. 82-110-02

W.O. NO.

CONT. NO. 411093

MADE BY MG

APPROVED

A/C NO.		MHRS. USWC	ON SHORE %	OFF SHORE %	ONSHORE YARD MHRS.	OFFSHORE HOOKUP MHRS.
20	STRUCTURAL STEEL					
40	EQUIPMENT					
50	PIPING					
60	ELECTRICAL					
70	INSTRUMENTATION					
80	PAINTING					
85	INSULATION					
	TOTAL DFC MHRS.	486,600	85	15	413,625	73,000
	ONSHORE MHRS. USWC				413,625	
	ALL-IN YARD RATE PER MHR.				$40.00	
	TOTAL SUBCONTRACT YARD COST				16,545,000	
	OFFSHORE MHRS USWC					73,000
	OFFSHORE PRODUCTIVITY ADJ					1.5
	OFFSHORE ADJ'D MHRS.					109,500
	100 MAN WORK CREW FOR HOOKUP w/ 50 MEN PER 12 HOUR SHIFT = 1200 MHRS./DAY					91 DAYS
	WEATHER DOWNTIME					—

DATE 3/12/82 REVISION NO. REVISION DATE PAGE NO. 8 OF 9

F.O.S. 1918 V

ESTIMATE DETAIL SHEET

FLUOR OCEAN

PROJECT Norton Sound Study
DESCRIPTION Jacket Concept - 30' W.D.
Indirect Field Costs
AREA
ACCOUNT
ESTIMATE NO. 82-110-02
SHEET NO. 7 OF 9
PREPARED BY Mg DATE 3/16/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS				COST /				BASIS
				MAT'L	EQUIP.	S/C	MAN HR	LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	DWG/P.O.
	MOB/DEMOB											
	Derrick Barges w/Lab.	EA	2								3,585 000	
	Survey Vessel	EA	1								370 000	
	Conc. Barge	EA.	1								1,120 000	
	Freight @ 2% of Mat + Equip.								1,810 000			
	(.02 x 90,435,000 = 1,810,000											
	Misc Services & Expenses		Allow						300 000		700 000	
	Spare Parts		Allow						500 000			
REMARKS							SUB TOTALS		4,610 000		5775 000	
							ADJUSTMENTS					
							RATES					
							TOTALS					

```
                                                                                                                           FLUOR OCEAN SERVICES
                                                                                                                           REPORT RBAR3PAGE:    1
CLIENT:
LOCATION: NORTON SOUND
                                                N O R T O N   S O U N D   S T U D Y   S C H E D U L E
                                            3 0   F O O T   M L L W   J A C K E T   C O N F I G U R A T I O N
                                                                (LEVEL-III CONTROL SCHEDULE)
                                                                                                                           STATUS DATE:16-MAR-82
CONTRACT: 411093                                                                                                           DATE: 17-MAR-82
PROJECT MANAGER: JE LACY/BR PIER
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
MANAGEMENT, ENGINEERING, & PROCUREMENT                                                                                                                                DURATION    EARLY     EARLY
                                                                                  EACH SPACE REPRESENTS ONE WEEK                                                      IN WEEKS    START     FINISH
RN        DESCRIPTION
                                         OCT  NOV DEC  JAN FEB MAR APR  MAY JUN JUL  AUG SEP  OCT NOV DEC  JAN FEB MAR  APR MAY JUN  JUL AUG SEP  OCT NOV DEC  JAN FEB MAR  APR MAY JUN  JUL AUG
                                         84   84  84   85  85  85  85   85  85  85   85  85   85  85  85   86  86  86   86  86  86   86  86  86   86  86  86   87  87  87   87  87  87   87  87
                                         I----I---I----I---I---I---I----I---I---I----I---I----I---I---I----I---I---I----I---I---I----I---I---I----I---I---I----I---I---I----I---I---I----I---I--I
                                         I    I   I    I   I   I   I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I
  1  SCOPE PROCESS                       XXXX I   I    I   I   I   I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      4.0   17-OCT-84 13-NOV-84
  2  REVIEW TECHNOLOGY                   XXXXXX....    I   I   I   I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      6.0   17-OCT-84 27-NOV-84
  3  SIZE DECKS                          I   XX....    I   I   I   I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      2.0   14-NOV-84 27-NOV-84
  6  DEVELOP CONSTRUCTION PHILOSOPHY     I    IXXXX....... I   I   I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      4.0   28-NOV-84 25-DEC-84
  4  SIZE MODULES                        I    IXXXXXX....  I   I   I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      6.0   28-NOV-84  8-JAN-85
  5  SIZE MAJOR EQUIPMENT                I   XXXXXXXXXXI   I   I   I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     10.0   14-NOV-84 22-JAN-85
  7  SIZE SKIDS                          I    I   I    XX  I   I   I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      2.0   23-JAN-85  5-FEB-85
  8  SIZE SKID BEAMS                     I    I   I    I X I   I   I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      1.0    6-FEB-85 12-FEB-85
 11  LAYOUT EQUIPMENT                    I    I   I    XXXXI   I   I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      4.0   23-JAN-85 19-FEB-85
 10  LAYOUT MODULES                      I    I   I    I XXX.  I   I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      3.0    6-FEB-85 26-FEB-85
110  TAKEOFF SKIDS                       I    I   I    I   XX  I   I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      2.0   20-FEB-85  5-MAR-85
  9  OPTIMIZE TOWER                      I    I   I    I  XXXX I   I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      4.0   13-FEB-85 12-MAR-85
111  CALCULATE REACTIONS                 I    I   I    I   I X I   I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      1.0    6-MAR-85 12-MAR-85
 14  PREP. LONG LEAD EQUIP. SPECS        I    I   I    I   XXXXXX  I    I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      6.0   20-FEB-85  2-APR-85
 15  SIZE ANCILLARY EQUIPMENT            I    I   I    I   I   I XXXX   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      4.0    3-APR-85 30-APR-85
 12  SIZE TOWER/PILES                    I    I   I    I   I  XXXXXXXXX I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      9.0   13-MAR-85 14-MAY-85
 13  SIZE MODULE FRAMING                 I    I   I    I   I XXXXXXXXXX I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     10.0    6-MAR-85 14-MAY-85
 17  FINALIZE EQUIPMENT LIST             I    I   I    I   I   I   I XX I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      2.0    1-MAY-85 14-MAY-85
 20  PREPARE ANCILLARY SPECS             I    I   I    I   I   I   I XXXXXXXXXXXX    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     12.0    1-MAY-85 23-JUL-85
112  PROCURE BULK MAT'L & CONTRACT FAB.  I    I   I    I   I   I   I   XXXXXXXXXXXXX....................................I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     13.0   15-MAY-85 13-AUG-85
 18  DETAIL TOWER                        I    I   I    I   I   I   I   XXXXXXXXXXXXXXXX  I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     16.0   15-MAY-85  3-SEP-85
 19  DETAIL MODULES                      I    I   I    I   I   I   I   XXXXXXXXXXXXXXXXXXXXXXXI   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     23.0   15-MAY-85 22-OCT-85
 24  DETAIL FACILITIES                   I    I   I    I   I   I   I    I   I   IXXXXXXXXXXXXXX   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     14.0   24-JUL-85 29-OCT-85
 21  DETAIL PILES                        I    I   I    I   I   I   I    I   I   I    I XXXXXXXXXXXX   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     12.0    4-SEP-85 26-NOV-85
 28  PROCURE ANCILLARY EQUIPMENT         I    I   I    I   I   I   I    I   I   IXXXXXXXXXXXXXXXXXXXX....................................I   I    I   I   I    I   I   I    I   I   I    I   I  I     20.0   24-JUL-85 10-DEC-85
 29  PROCURE COMMODITIES                 I    I   I    I   I   I   I    I   I   I    I   I    IXXXXXX....................................I   I    I   I   I    I   I   I    I   I   I    I   I  I      6.0   30-OCT-85 10-DEC-85
 23  DETAIL APPURTENANCES                I    I   I    I   I   I   I    I   I   I    I   I    XXXXXXXXI    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      8.0   23-OCT-85 17-DEC-85
 22  DETAIL INSTALLATION AIDS            I    I   I    I   I   I   I    I   I   I    I   I    I   IXXXXXXXXX   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      9.0   27-NOV-85 28-JAN-86
 25  DETAIL ERECTION AIDS                I    I   I    I   I   I   I    I   I   I    I   I    I   I   XXXXXX   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I      6.0   18-DEC-85 28-JAN-86
 26  PREPARE HOOK-UP PROCEDURES          I    I   I    I   I   I   I    I   I   I    I   I    IXXXXXXXXXXXXX   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     13.0   30-OCT-85 28-JAN-86
 30  CONTRACT INSTALLATION               I    I   I    I   I   I   I    I   I   I    I   I    I   I   I    IXXXXXX..........................................................I   I   I    I   I  I      6.0   29-JAN-86 11-MAR-86
 16  PROCURE LONG LEAD EQUIPMENT         I    I   I    I   I   I XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX....................I   I    I   I   I    I   I   I    I   I   I    I   I  I     52.0    3-APR-85  1-APR-86
 27  PREP INSTALL. & OPER. MANUALS       I    I   I    I   I   I   I    I   I   I    I   I    I   I   I    IXXXXXXXXXX  I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     10.0   29-JAN-86  8-APR-86

NOTES:
(1)  EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2)  CALENDAR DURATIONS BASED ON:
     (A)  8 HR. DAYS, 5 DAYS/WEEK FOR MANAGEMENT, ENGINEERING & PROCUREMENT ACTIVITIES
     (B)  8 HR. DAYS, 6 DAYS/WEEK FOR FABRICATION, LOADOUT, & SEAFASTENING ACTIVITIES
     (C)  24 HR. DAYS, 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES
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CLIENT:
LOCATION: NORTON SOUND

FLUOR OCEAN SERVICES
REPORT RBAR3PAGE: 2

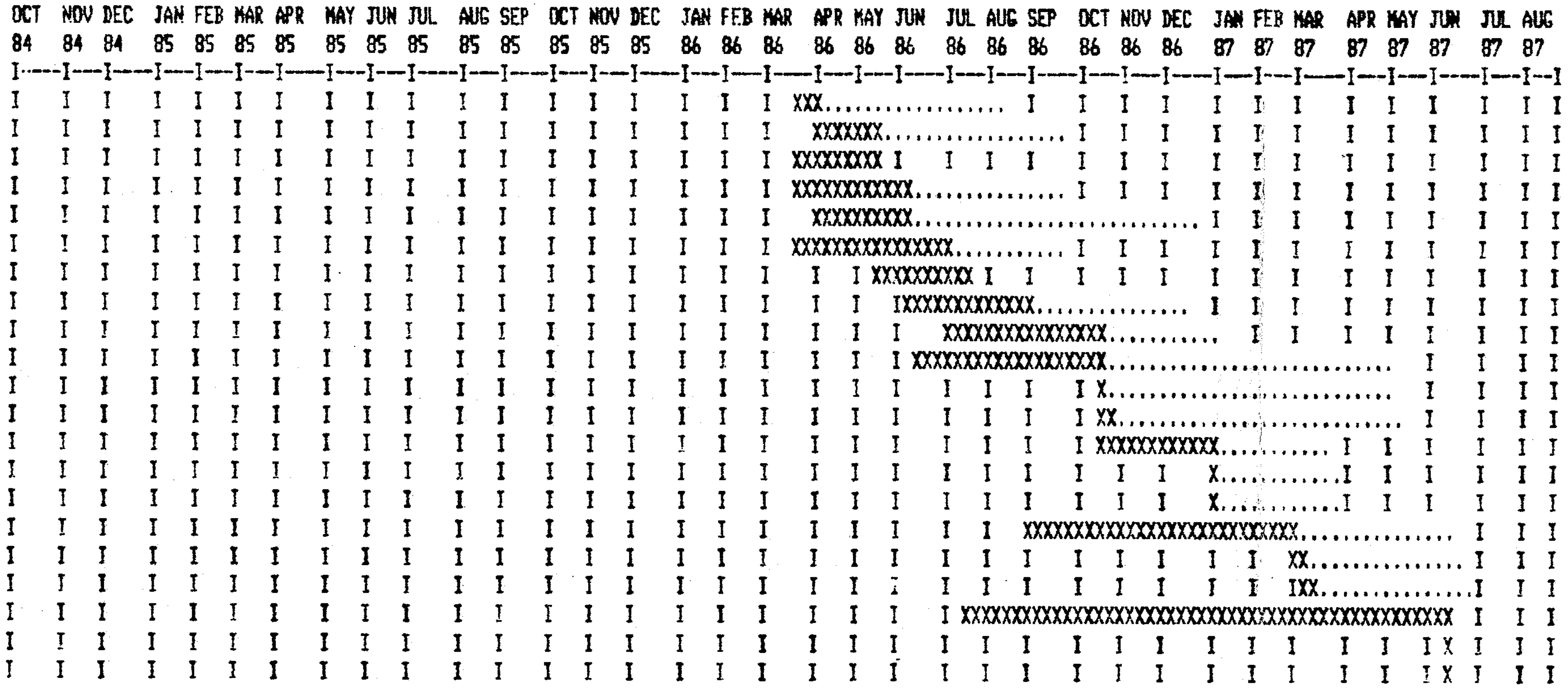
NORTON SOUND STUDY SCHEDULE
30 FOOT MLLW JACKET CONFIGURATION
(LEVEL-III CONTROL SCHEDULE)

CONTRACT: 411093
PROJECT MANAGER: JE LACY/BR PIER

STATUS DATE:16-MAR-82
DATE: 17-MAR-82

FABRICATION, LOADOUT, & SEAFASTENING

EACH SPACE REPRESENTS ONE WEEK



RN	DESCRIPTION	DURATION IN WEEKS	EARLY START	EARLY FINISH
31	ROLL LEG & PILE SLEEVES	2.8	9-APR-86	28-APR-86
35	FABRICATE LEG & PILE SLEEVES	5.7	29-APR-86	6-JUN-86
33	FABRICATE PRODUCTION TRUSSES	8.8	9-APR-86	9-JUN-86
34	FABRICATE DRILLING TRUSSES	11.7	9-APR-86	28-JUN-86
36	ROLL PILES & HAMMER ADDAPTERS	9.2	29-APR-86	1-JUL-86
32	FAB BOX BEAMS	15.2	9-APR-86	23-JUL-86
40	FABRICATE PRODUCTION MODULES	8.8	10-JUN-86	9-AUG-86
41	FAB DRILL MODULES & APPURT'S	11.7	30-JUN-86	18-SEP-86
37	ASSEMBLE TOWER	15.2	24-JUL-86	6-NOV-86
38	FABRICATE PILES & HAMMER ADDAPTERS	18.5	2-JUL-86	7-NOV-86
44	LOADOUT PILES & ADDAPTERS	0.3	8-NOV-86	10-NOV-86
46	SEAFASTEN PILING BARGE	0.3	11-NOV-86	12-NOV-86
39	OUTFIT TOWER	10.8	7-NOV-86	21-JAN-87
45	TOW TOWER OUT	0.7	22-JAN-87	26-JAN-87
49	SECURE TOWER FOR VOYAGE	0.2	27-JAN-87	27-JAN-87
43	OUTFIT DRILL MODULES & APPURT'S	25.8	19-SEP-86	18-MAR-87
60	LOADOUT DRILL MODULES & APPURT'S	1.0	19-MAR-87	25-MAR-87
61	SEAFASTEN DRILL MODULES & APPURT'S	1.0	26-MAR-87	1-APR-87
42	OUTFIT PRODUCTION MODULES	46.7	11-AUG-86	2-JUL-87
57	LOADOUT PRODUCTION MODULES	0.3	3-JUL-87	4-JUL-87
58	SEAFASTEN PROD. MODULE BARGES	0.3	6-JUL-87	7-JUL-87

NOTES:
(1) EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2) CALENDAR DURATIONS BASED ON:
(A) 8 HR. DAYS, 5 DAYS/WEEK FOR MANAGEMENT ENGINEERING & PROCUREMENT ACTIVITIES
(B) 8 HR. DAYS, 6 DAYS/WEEK FOR FABRICATION, LOADOUT, & SEAFASTENING ACTIVITIES
(C) 24 HR. DAYS, 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES

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CLIENT:
LOCATION: NORTON SOUND                                                                                                                      FLUOR OCEAN SERVICES
                                                       NORTON SOUND STUDY SCHEDULE                                                          REPORT RBAR3PAGE:    3
                                                30 FOOT MLLW JACKET CONFIGURATION
CONTRACT: 411093                                          (LEVEL-III CONTROL SCHEDULE)
PROJECT MANAGER: JE LACY/BR PIER                                                                                                            STATUS DATE:16-MAR-82
----------------------------------------------------------------------------------------------------------------------------------------------DATE: 17-MAR-82--------
TRANSPORTATION & INSTALLATION

RN         DESCRIPTION                                                     EACH SPACE REPRESENTS ONE WEEK                                              DURATION   EARLY     EARLY
                                                                                                                                                        IN WEEKS   START     FINISH
                                            OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG
                                            84  84  84  85  85  85  85  85  85  85  85  85  85  85  85  86  86  86  86  86  86  86  86  86  86  86  86  87  87  87  87  87  87  87  87
                                            I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I--I
 47 TOW PILING BARGE TO BRISTOL BAY         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXX.........................I   I   I   I     2.0     12-NOV-86 26-NOV-86
 51 MOB. DERRICK VESSELS TO BRISTOL         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXX................ I   I   I   I     2.0     27-JAN-87 10-FEB-87
    BAY
 55 MOB. SURVEY VESSELS TO BRISTOL BAY      I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXX:........... I   I   I   I   I     2.0     27-JAN-87 10-FEB-87
 50 MOB. GROUT/CONCRETE BARGE TO SITE       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXX...................     I   I   I     2.4     27-JAN-87 13-FEB-87
 53 TOW TOWER TO BRISTOL BAY                I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXX.............. I   I   I   I     3.3     27-JAN-87 19-FEB-87
 62 TOW DRILL MOD'S & APP'S TO SITE         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXX.............    I   I     2.4      1-APR-87 18-APR-87
 48 TOW PILING BARGE TO SITE                I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX......I   I   I   I     0.6      1-MAY-87  4-MAY-87
 52 DERRICK BARGES TO SITE                  I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX..... I   I   I   I     0.6      1-MAY-87  4-MAY-87
 54 TOW TOWER TO SITE                       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXX.... I   I   I   I     0.9      1-MAY-87  6-MAY-87
 56 SURVEY VESSEL TO SITE                   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXXXXX  I   I   I   I     4.1      1-MAY-87 29-MAY-87
 63 SURVEY/BUOY SITE                        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXX I   I   I   I     1.0     30-MAY-87  5-JUN-87
 64 ANCHOR DERRICK VESSEL                   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I   I   I   I     0.1      6-JUN-87  6-JUN-87
 65 RIG TOWER                               I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I   I   I   I     0.0      6-JUN-87  6-JUN-87
 66 POSITION TOWER                          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I   I   I   I     0.1      6-JUN-87  7-JUN-87
 67 BALLAST TOWER                           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I   I   I   I     0.1      7-JUN-87  7-JUN-87
 68 JET/LEVEL TOWER                         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I XXI   I   I   I     0.9      7-JUN-87 13-JUN-87
 69 PREP. DERRICK VESSELS FOR PILING        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI   I   I   I     0.1     13-JUN-87 14-JUN-87
 70 REMOVE 8X BUOYANCY CAPS                 I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI   I   I   I     0.1     14-JUN-87 15-JUN-87
 71 RUN/DRIVE 8X LEAD PILES                 I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI   I   I   I     0.1     15-JUN-87 16-JUN-87
 72 STAB/WELD/INSP 8X 1 ADDON PILES         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XX   I   I   I     0.7     16-JUN-87 21-JUN-87
 73 DRIVE 8X FIRST ADDON PILES              I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X   I   I   I     0.0     21-JUN-87 21-JUN-87
 74 STAB/WELD/INSPECT 8X 2 ADDON PILES      I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I    XX I   I   I     0.7     21-JUN-87 26-JUN-87
 75 DRIVE 8X 2 ADDON PILES                  I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX  I   I   I     0.1     26-JUN-87 27-JUN-87
 78 REANCHOR DV'S & REMOVE 8X RC'S          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX  I   I   I     0.1     27-JUN-87 28-JUN-87
 79 RUN/DRIVE 8X LEAD PILES                 I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX  I   I   I     0.1     28-JUN-87 29-JUN-87
 80 STAB/WELD/INSPECT 1ST ADDON PILES       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXX I   I   I     0.7     29-JUN-87  4-JUL-87
 81 DRIVE 8X 1ST ADDON PILES                I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I   I   I     0.0      4-JUL-87  4-JUL-87
 76 ANCHOR BARGE & GROUT 8X PILES           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXX I   I   I     1.1     27-JUN-87  4-JUL-87
 82 STAB/WELD/INSPECT 2ND ADDON PILES       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I XXI   I   I     0.7      4-JUL-87  9-JUL-87
 83 DRIVE 8X 2ND ADDON PILES                I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI   I   I     0.1      9-JUL-87 10-JUL-87
 77 FILL 2X LEGS                            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I XXI   I   I     0.9      5-JUL-87 10-JUL-87
 85 REANCHOR DV(S) & DRIVE CND'S            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XX.  I   I     0.8     11-JUL-87 16-JUL-87
 84 REANCHOR & GROUT 8X PILES               I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XXI  I   I     1.1     11-JUL-87 18-JUL-87
 59 TOW PROD. MODULE BARGES TO SITE         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I XXXX  I   I     2.4      7-JUL-87 24-JUL-87
 86 FILL 2X LEGS                            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I    XX I   I     0.9     18-JUL-87 24-JUL-87
NOTES:
(1)   EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2)   CALENDAR DURATIONS BASED ON:
      (A)   8 HR. DAYS, 5 DAYS/WEEK FOR MANAGEMENT, ENGINEERING & PROCUREMENT ACTIVITIES
      (B)   8 HR. DAYS, 6 DAYS/WEEK FOR FABRICATION, LOADOUT, & SEAFASTENING ACTIVITIES
      (C)   24 HR. DAYS, 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES
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CLIENT:
LOCATION: NORTON SOUND                                                                                                                                                          FLUOR OCEAN SERVICES
                                                                   NORTON SOUND STUDY SCHEDULE                                                                                  REPORT RBAP3PAGE:    4
                                                              30 FOOT MLLW JACKET CONFIGURATION
                                                                  (LEVEL-III'CONTROL SCHEDULE)
CONTRACT: 411093
PROJECT MANAGER: JE LACY/BR PIER                                                                                                                                                STATUS DATE:16-MAR-82
                                                                                                                                                                                DATE: 17-MAR-82
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ERECTION & COMMISSIONING
                                                                          EACH SPACE REPRESENTS ONE WEEK                                                                        DURATION    EARLY     EARLY
RN              DESCRIPTION                                                                                                                                                     IN WEEKS    START     FINISH
                                      OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG
                                      84  84  84  85  85  85  85  85  85  85  85  85  85  85  85  86  86  86  86  86  86  86  86  86  86  86  86  87  87  87  87  87  87  87  87
                                      I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I--I
87  PREPARE TOWER FOR MODULES         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X   I  I    0.0   24-JUL-87 24-JUL-87
88  SET PB                            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X   I  I    0.2   25-JUL-87 26-JUL-87
89  REANCHOR DERRICK VESSEL(S)        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X   I  I    0.1   26-JUL-87 26-JUL-87
90  SET PC                            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X   I  I    0.2   27-JUL-87 28-JUL-87
91  SKID PB & PC                      I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XX  I  I    0.2   28-JUL-87 29-JUL-87
92  SET WA                            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX  I  I    0.2   30-JUL-87 31-JUL-87
93  REANCHOR DERRICK VESSEL(S)        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX  I  I    0.1   31-JUL-87 31-JUL-87
94  SET PD                            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX  I  I    0.2    1-AUG-87  2-AUG-87
95  REANCHOR DERRICK VESSEL           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX  I  I    0.1    2-AUG-87  2-AUG-87
96  SET DB1.DC1.DD1.EL-1A. & ME-8A    I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX  I  I    0.1    2-AUG-87  3-AUG-87
97  REANCHOR DERRICK VESSEL           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX  I  I    0.0    3-AUG-87  3-AUG-87
98  SET DB2. DC2. DD2. EL-1B. & ME-8B I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX  I  I    0.1    3-AUG-87  4-AUG-87
99  REANCHOR DERRICK VESSEL           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX  I  I    0.0    4-AUG-87  4-AUG-87
100 SET CO-1B AND CO-1A               I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXX I  I    0.1    4-AUG-87  5-AUG-87
101 REANCHOR DERRICK VESSEL           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I    0.0    5-AUG-87  5-AUG-87
102 SET/SKID DA                       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I    0.1    5-AUG-87  6-AUG-87
103 SET RM-1A & FB-1A                 I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I    0.1    6-AUG-87  7-AUG-87
104 REANCHOR DERRICK VESSEL           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I    0.0    7-AUG-87  7-AUG-87
105 SET RM-1B & FB-1B                 I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I    0.1    7-AUG-87  8-AUG-87
106 PERFORM MISCELLANEOUS LIFTS       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I    0.1    8-AUG-87  9-AUG-87
107 COMMISSION CRANES & QTRS          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I XXI  I    0.9    9-AUG-87 15-AUG-87
108 COMMISSION DRILLING PLANT         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XXXXX    4.3   15-AUG-87 14-SEP-87
109 COMMISSION PRODUCTION PLANT       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  X    7.1   14-SEP-87  3-NOV-87

NOTES:
(1)   EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2)   CALENDAR DURATIONS BASED ON:
      (A)   8 HR. DAYS, 5 DAYS/WEEK FOR MANAGEMENT, ENGINEERING & PROCUREMENT ACTIVITIES
      (B)   8 HR. DAYS, 6 DAYS/WEEK FOR FABRICATION, LOADOUT, & SEAFASTENING ACTIVITIES
      (C)   24 HR. DAYS, 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES
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FACTOR TYPE COST ESTIMATE

FLUOR OCEAN SERVICES

CUSTOMER SOCAL
LOCATION ALASKA
PROJECT NORTON SOUND STUDY

DESCRIPTION BARGE CONCEPT
30' WATER DEPTH
(FOS + ABAM)
"MAIN SUMMARY"

PROP. NO. 82-110-02
W.O. NO.
CONT. NO. 411093
MADE BY MG
APPROVED

A/C NO.	ITEM & DESCRIPTION	QTY.	ESTIMATED COST / 1ST QUAR. '82 US $ x1000				
			LABOR	MAT'LS	EQUIPMENT	SUB-CONTRACTS	TOTALS
	ONSHORE WORK						
	SUPERSTRUCTURE YARD FABRICATION (417BT)			2,840		12,770	15,610
				—			
	MODULE ASSEMBLY AND OUTFITTING			78,275		17,705	95,980
*	BARGE CONSTRUCTION			7,880		5,445	13,325
	OFFSHORE WORK						
*	BARGE ASSEMBLY			4,630		3,270	7,900
	MODULE INSTALLATION					3,545	3,545
*	TRANSPORTATION			6,075		—	6,075
*	DEPLOYMENT			10,680		—	10,680
	HOOKUP / CHECKOUT START UP / COMM.					12,425	12,425
	DIRECT FIELD COSTS			110,380		55,160	165,540
	FOS INDIRECT COSTS			2,420		1,300	3,720
*	ABAM INDIRECT COSTS			13,535		2,630	16,165
	INDIRECT FIELD COSTS			15,955		3,930	19,885
	TOTAL FIELD COSTS			126,335		59,090	185,425
	FOS FIELD CONST. MGMT	3% OF DFC					4,965
92-000	HOME OFFICE CONSTRUCTION MGMT.						
93-000	PROJECT MANAGEMENT						
94-000	CENTRAL ENGINEERING	~ 10.0% OF FOS DFC					12,760
95-000	DRAFTING & TECH. SERVICES	(283,500 MHRS @ 45/MH)					
96-000	PURCHASING						
97-000	BUSINESS SERVICES					*	3,265
97-000	OFFICE EXPENSE						
98-000	OFFICE PAYROLL BURDEN						
99-500	INDIRECT OFFICE COSTS						
	TOTAL OFFICE COSTS						20,990
	TOTAL FIELD & OFFICE COSTS						206,415
99-100	ESCALATION						
99-200	CONTINGENCY (TOPSIDES) 19.4%						28,735
99-600	FEE						
99-300	SALES TAX						
	* DENOTES COSTS BY ABAM						235,150
	TOTAL						

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DATE 3/16/82 REVISION NO. 3 REVISION DATE 4/1/82 PAGE NO. 1 OF 9

FACTOR TYPE COST ESTIMATE

FLUOR OCEAN SERVICES

CUSTOMER Socal
LOCATION Alaska
PROJECT Norton Sound Study

DESCRIPTION Barge Concept
30' Water Depth
(FOS Costs Only)
"Main Summary"

PROP. NO. 82-110-02
W.O. NO. 411093
CONT. NO.
MADE BY MG
APPROVED

A/C NO.	ITEM & DESCRIPTION	QTY.	ESTIMATED COST 1st Qtr '82 US$ x 1000 LABOR	MAT'LS	EQUIPMENT	SUB-CONTRACTS	TOTALS
	<u>ONSHORE WORK</u>						
	PLATFORM FABRICATION IN YARD	4,178 T		2,840		13,790	16,630
	MODULE ASSEMBLY AND OUTFITTING			78,275		17,705	95,980
	<u>OFFSHORE WORK</u>						
	TRANSPORTATION			(IN INSTALLATION		COST	BELOW)
	INSTALLATION					3,545	3,545
	HOOKUP/CHECKOUT STARTUP/COMM.					11,405	11,405
	DIRECT FIELD COSTS			81,115		46,445	127,560
	INDIRECT FIELD COSTS			2,420		1,300	3,720
	TOTAL FIELD COSTS			83,535		47,745	131,280
	Field Const. Mgmt	3% OF D.F.C					3,830
92-000	HOME OFFICE CONSTRUCTION MGMT.						
93-000	PROJECT MANAGEMENT						
94-000	CENTRAL ENGINEERING						
95-000	DRAFTING & TECH. SERVICES						
96-000	PURCHASING	10.0% OF DFC					12,760
97-000	BUSINESS SERVICES	(283,500 MHRS. x $45/MHR)					
97-000	OFFICE EXPENSE						
98-000	OFFICE PAYROLL BURDEN						
99-500	INDIRECT OFFICE COSTS						
	TOTAL OFFICE COSTS						16,590
	TOTAL FIELD & OFFICE COSTS						147,870
99-100	ESCALATION						
99-200	CONTINGENCY 19.4 %						28,735
99-600	FEE						
99-300	SALES TAX						
	TOTAL						176,605

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ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study
DESCRIPTION Barge Concept - 30' water depth
Module Superstructure in Fabrication Yard
AREA Onshore
ACCOUNT

ESTIMATE NO 82-110-02
SHEET NO. 3 OF 9
PREPARED BY MG DATE 3/16/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ Qtr. '82 US $ LABOR (MH)	COST/ Qtr. '82 US $ MAT'LS	COST/ Qtr. '82 US $ EQUIPMENT	COST/ Qtr. '82 US $ SUB CONTR.	BASIS DWG/P.O.
	Framing Steel											
	Plate	Tons										
	A633-C	↓	809	675		3300			546 000		2,670 000	
	A537-Class I	↓	652	700		↓			456 000		2,152 000	
	A36	↓	15	510		↓			8 000		50 000	
	Shapes	Tons										
	A633-C/A633-Gr.C	↓	1549	675		3300			1,046 000		5,112 000	
	A588/A678-A	↓	1038	700		↓			727 000		3,425 000	
	A36	↓	115	510		↓			59 000		390 000	
	Subtotal	Tons	4178									

REMARKS Quotes from Kaiser Steel in Napa Calif. for material & S/C costs

SUB TOTALS		2,840 000		13,790 000	
ADJUSTMENTS					
RATES					

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study
DESCRIPTION Barge Concept / 30' Water Depth
Module Assembly & Equip. Outfitting in Fab. Yard
AREA Onshore
ACCOUNT

ESTIMATE NO 82-110-02
SHEET NO. 4 OF 9
PREPARED BY MG DATE 3/16/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS				COST / Quar. '82 US $				BASIS DWG/P.O.
				MAT'L	EQUIP.	S/C	MAN HR	LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	
				Factor		Factor						
	Module No A/1-2											
	Equip. Cost		—	—		—			—		—	
	Module No B/1-2											
	Equip. Cost	M$	741	1.43		.75			1,060 000		555 000	
	Module No C/1-2											
	Equip. Cost	M$	80	1.80		1.20			145 000		95 000	
	Drilling Rig	M$	18530	1.00		—			18530 000		—	
*	Module No D/1-2											
	Equip. Cost	M$	1537	1.76		.80			2,705 000		1230 000	
	Module No E/1-2											
	Equip. Cost	M$	358	1.92		.85			[illegible] 000		305 000	
	Module No A/3-4											
	Equip. Cost	M$	358	1.92		.85			685 000		305 000	
	Module No B/3-4											
	Equip. Cost	M$	1537	1.76		.80			2705 000		1230 000	
	Module No C/3-4											
	Equip. Cost	M$	18530	1.00		—			18,530 000		—	
	Module No D/3-4											
	Equip. Cost	M$	741	1.43		.75			1,060 000		555 000	
	Module No E/3-4											
	Equip. Cost	M$	1135	1.43		.75			1625 000		850 000	
*	Module No A/5-6											
	Equip. Cost	M$	5320	1.55		.83			8245 000		4440 000	

REMARKS Factors used are based on current modules being assembled & outfitted on the US West Coast. Equipment costs from procurement

SUB TOTALS				
ADJUSTMENTS		—		—
RATES				
TOTALS				

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study
DESCRIPTION Barge Concept
Module Assembly & Equip. Outfitting in Fab. Yard

AREA Onshore
ACCOUNT

ESTIMATE NO 82-110-02
SHEET NO. 5 OF 9
PREPARED BY MHg DATE 3/16/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ Qmr. '82 US $ LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	BASIS DWG/P.O.
	(Continued)			Factor		Factor						
#	Module No B/5-6											
	Equip. Cost	M$	404	2.79		1.86			1125 000		750 000	
#	Module No C/5-6											
	Equip. Cost	M$	447	1.65		.70			740 000		315 000	
	Module No D/5-6											
	Equip. Cost	M$	188	2.35		1.56			440 000		295 000	
#	Module No E/5-6											
	Equip. Cost	M$	4190	1.55		.83			6495 000		3480 000	
	Module No B/7-8											
	Equip. Cost	M$	735	2.23		1.40			1640 000		1230 000	
#	Module No C/7-8											
	Equip. Cost	M$	355	1.56		.73			555 000		360 000	
	Module No B/9-10											
	Equip. Cost	M$	2117	1.60		.95			3385 000		2010 000	
	Module No C/9-10	M$	3000	1.00		—			3,000 000		—	
	Module No D/9-10	M$	3000	1.00		—			3,000 000		—	
	Misc. Items	M$				—			1,020 000		—	
	Ped. Cranes, Survival Crafts, Logging Units, Mooring Systems, Nav-Aids, Flare Tips											
	Track Vehicle	EA.	1						250 000		—	

REMARKS

	LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.
SUB TOTALS		78275 000		17705 000
ADJUSTMENTS				
RATES				

ESTIMATE DETAIL SHEET

FLUOR OCEAN RVICES

PROJECT Norton Sound Study
DESCRIPTION Barge Concept
INSTALLATION OF MODULES & PACKAGES

AREA OFFSHORE
ACCOUNT

ESTIMATE NO 82-110-02
SHEET NO. 6 OF 9
PREPARED BY MG DATE 3/16/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ QUAR. '82 US $ LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	BASIS DWG/P.O.
	INSTALLATION											
	LOADOUT MODULES	DAYS	4.0									
	WEATHER 10%		.4									
	SUBTOTAL		4.4			$ 42,000/DAY					185 000	
	SEAFASTEN AND TOW	DAYS	4.25									
	MODULES TO CONC. BARGE		–									
	WEATHER 10%		.40									
			4.65			$ 42,000/DAY					195 000	
	SETUP & INSTALL MODULES	DAYS	16.45									
	WEATHER 10%		1.65									
	SUBTOTAL		18.10			$ 128,000/DAY					2,320 000	
	COMMISSIONING CRANES & QUARTERS	DAYS	6.0									
	WEATHER @ 10%		.6									
	SUBTOTAL		6.6			$ 128,000/DAY					845 000	

REMARKS ALL INSTALLATION PERFORMED NEAR PROX. TO FAB. YARD IN WEST COAST USA AREA.

SUB TOTALS 3,545 000
ADJUSTMENTS
RATES
TOTALS

ESTIMATE DETAIL SHEET

FLUOR OCEAN .RVICES

PROJECT Norton Sound Study
DESCRIPTION Barge Concept
Hookup & Checkout

AREA OFFSHORE
ACCOUNT

ESTIMATE NO 82-110-02
SHEET NO. 7 OF 9
PREPARED BY MG DATE 3/16/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ Quar. '82 US$ LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	BASIS DWG/P.O.
	Hookup/Checkout	DAYS	108			$100,000/DAY					10,800 000	
	Startup & Commissioning	DAYS	14			$31,000/DAY					435 000	
	10 MEN - 2 WKS.											
	Misc. Punch List Work	DAYS	14			$12,000/DAY					170 000	
	2 MEN - 2 WKS											
	2 SHIFTS OF 2 MEN PER											
	DAY = 48 MHRS/DAY x $80/MHR											
	IS $3840/DAY x 14 DAYS											
	IS $53,760											
	LABOR: 3840 /DAY											
	HELICOPTER 3000- /DAY											
	MISC. TOOLS 5000- /DAY											
	11,840 /DAY											
	SAY 12,000											

REMARKS

SUB TOTALS 11,405 000
ADJUSTMENTS
RATES
TOTALS

ESTIMATE WORK SHEET

FLUOR OCEAN SERVICES

CUSTOMER SOCAL
LOCATION US WEST COAST/ALASKA
PROJECT NORTON SOUND STUDY

DESCRIPTION FACTORED ESTIMATE FOR A DRILLING AND PRODUCTION FACILITY OUTFITTING & HOOKUP BARGE CONCEPT 30' WATER DEPTH

PROP. NO. 82-110-02
W.O. NO.
CONT. NO. 411093
MADE BY MG
APPROVED

A/C NO.		MHRS. USWC	ON SHORE %	OFF SHORE %	ONSHORE YARD MHRS.	OFFSHORE HOOKUP MHRS.
20	STRUCTURAL STEEL					
40	EQUIPMENT					
50	PIPING					
60	ELECTRICAL					
70	INSTRUMENTATION					
80	PAINTING					
85	INSULATION					
	TOTAL DFC MHRS.	520700	85	15	442 625	78,100
	ONSHORE MHRS. USWC				442 625	
	ALL-IN YARD RATE PER MHR.				#40	
	TOTAL SUBCONTRACT YARD COST				17705,000	
	OFFSHORE MHRS USWC					78,100
	OFFSHORE PRODUCTIVITY ADJ					1.5
	OFFSHORE ADJ'D MHRS.					117,165
	100 MAN WORK CREW FOR HOOKUP w/ 50 MEN PER 12 HOUR SHIFT = 1200 MHRS./DAY					98 DAYS
	10% WEATHER DOWNTIME					10 DAYS
						108' DAYS

ESTIMATE DETAIL SHEET

FLUOR OCEAN VICES

PROJECT Norton Sound Study
DESCRIPTION Barge Concept
Indirect Field Costs
AREA
ACCOUNT
ESTIMATE NO. 82-110-02
SHEET NO. 9 OF 9
PREPARED BY Mlg DATE 3/16/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/1st Quar. '83 US$ LABOR (MH)	COST/1st Quar. '83 US$ MAT'LS	COST/1st Quar. '83 US$ EQUIPMENT	COST/1st Quar. '83 US$ SUB CONTR.	BASIS DWG/P.O.
	Mob/Demob										600 000	
	Freight @ 2% of Mat. + Equip. Cost 81,115 (~~[illegible]~~ x .02)								1,620 000			
	Misc. Services & Exp.		Allow						300 000		700 000	
	Spare Parts								500 000			
	SUB TOTALS								2420 000		1300 000	
	ADJUSTMENTS											
	RATES											
	TOTALS											

REMARKS

FACTOR TYPE COST ESTIMATE

FLUOR OCEAN SERVICES

CUSTOMER Socal
LOCATION Alaska
PROJECT Norton Sound Study

DESCRIPTION Jacket Concept
50' Water Depth
"Main Summary"

PROP. NO. 82-110-02
W.O. NO. 411098
CONT. NO.
MADE BY MG
APPROVED

A/C NO.	ITEM & DESCRIPTION	QTY.	ESTIMATED COST/1ST QTR. '82 US $ K 1000				
			LABOR	MAT'LS	EQUIPMENT	SUB-CONTRACTS	TOTALS
	ONSHORE WORK						
	PLATFORM FABRICATION IN YARD	26,779 T		18,115		58,215	76,330
	MODULE ASSEMBLY AND OUTFITTING			75,725		16,545	92,270
	OFFSHORE WORK						
	TRANSPORTATION					10,930	10,930
	INSTALLATION					23,725	23,725
	HOOKUP/CHECKOUT STARTUP/COMM.					11,490	11,490
	DIRECT FIELD COSTS			93,840		120,705	214,745
	INDIRECT FIELD COSTS			2,675		4,375	7,050
	TOTAL FIELD COSTS			96,515		125,280	221,795
	FIELD CONST MGMT	3% OF D.F.C.					6,440
92-000	HOME OFFICE CONSTRUCTION MGMT.						
93-000	PROJECT MANAGEMENT						
94-000	CENTRAL ENGINEERING						
95-000	DRAFTING & TECH. SERVICES						
96-000	PURCHASING	7.0% OF DFC					15,300
97-000	BUSINESS SERVICES	(340,000 MHRS x $45/MH)					
97-000	OFFICE EXPENSE						
98-000	OFFICE PAYROLL BURDEN						
99-500	INDIRECT OFFICE COSTS						
	TOTAL OFFICE COSTS						21,740
	TOTAL FIELD & OFFICE COSTS						243,535
99-100	ESCALATION						
99-200	CONTINGENCY 16.4 %						39,765
99-600	FEE						
99-300	SALES TAX						
	TOTAL						283,300

F.O.S. 1917

DATE 3/12/82 REVISION NO. 3 REVISION DATE 4/1/82 PAGE NO. 1 OF 9

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study AREA ONSHORE
DESCRIPTION Jacket Concept For 50 Water Depth ACCOUNT
Platform Fabrication in Yard

ESTIMATE NO. 82-110-02
SHEET NO. 2 OF 9
PREPARED BY Mg DATE 3/15/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ Quar. '82 US $ LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	BASIS DWG/P.O.
	Jacket	Tons	7510	677			4300		5,085 000		32,293 000	
	Piles	Tons	13,635	675			700		9,204 000		9,545 000	
	Conductors	Tons	984	675			500		669 000		[illegible] 000	
	Module Superstructure	Tons	4470	680			3300		3,040 000		14,750 000	
	Flare Boom	Tons	180	675			6300		122 000		1,135 000	
	Subtotal		26,779									

REMARKS

SUB TOTALS		18,115 000		58,215 000	
ADJUSTMENTS					
RATES					
TOTALS					

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study,
DESCRIPTION Jacket Concept 50' water depth
Module Assembly & Outfitting in Fab. Yard

AREA Onshore
ACCOUNT

ESTIMATE NO. 82-110-02
SHEET NO. 3 OF 9
PREPARED BY ______ DATE 3/10/82
CHECKED BY ______ DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ Quar. '82 US $ LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	BASIS DWG/P.O.
				Factor		Factor						
	Module No DA 11											
	Equip. Cost	M$	1150	1.41		.60			1,622 000		690 000	
	Module No DB1 5											
	Equip. Cost	M$	1425	1.45		.87			2,066 000		1,240 000	
	Module No DB2 10											
	Equip. Cost	M$	1425	1.45		.87			2,066 000		1,240 000	
	Module No DC1 6											
	Equip. Cost	M$	643	2.09		.89			1,344 000		572 000	
	Module No DC2 11											
	Equip. Cost	M$	643	2.09		.89			1,344 000		572 000	
	Module No DD1 7											
	Equip. Cost	M$	585	1.37		.59			801 000		345 000	
	Module No DD2 12											
	Equip. Cost	M$	585	1.37		.59			801 000		345 000	
	Module No WA (2)											
	Equip. Cost	M$	531	2.38		1.39			1,264 000		739 000	
	Module No PB (1)											
	Equip. Cost	M$	1000	2.35		1.56			2,350 000		1,560 000	
	Module No PC											
	Equip. Cost	M$	6776	1.43		.77			7,718 000		5,233 000	
	Module No PD 4											
	Equip. Cost	M$	5493	1.35		.73			7,416 000		1,010 000	

REMARKS Factors used are based on current modules being assembled & outfitted on the US West Coast. Equipment costs from

SUB TOTALS		30,972 000		16,545 000	
ADJUSTMENTS					
RATES					

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study
DESCRIPTION Jacket Concept 50' Water Depth
Module Assembly & Outfitting in Fab. Yard
AREA Onshore
ACCOUNT
ESTIMATE NO. 82-110-02
SHEET NO. 4 OF 9
PREPARED BY MG DATE 3/10/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ 1st QUAR. US$ '82 LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	BASIS DWG/P.O.
	From Previous Page								30,972 000		16,545 000	
	Package No RM-1A 13											
	Equip. Cost	M$	18530				1.0		18530 000			
	Package No RM-1B 20											
	Equip. Cost	M$	18530				1.0		18530 000			
	Package No EL-1A 1											
	Equip. Cost	M$	78				1.0		78 000			
	Package No EL-1B 17											
	Equip. Cost	M$	78				1.0		78 000			
	Module No CQ-1A 12	M$	3000				1.0		3000 000			
	Module No CQ-1B 16	M$	3000				1.0		3000 000			
	Pedestal Cranes 9/11	EA	2	225,000			1.0		450 000			
	Survival Crafts	EA	4	150,000			1.0		600 000			
	Nav-Aids	Sets	4	25,000			1.0		100 000			
	Rucker Mooring System	EA.	2	80,000			1.0		160 000			
	Flare Tips 19/21	EA	2	10,000			1.0		155 000			
	Track Vehicle	EA.	1	250,000			1.0		250 000			
	Total Equip.	M$	65,200	1.16			.25					

REMARKS

	LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.
SUB TOTALS		75,725 000		16,545 000
ADJUSTMENTS				
RATES				
TOTALS				

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT NORTON SOUND STUDY
DESCRIPTION JACKET CONCEPT 50' WATER DEPTH
TRANSPORTATION

AREA OFFSHORE
ACCOUNT

ESTIMATE NO. 82-110-02
SHEET NO. 5 OF 9
PREPARED BY
DATE 3/12/82
CHECKED BY
DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS				COST/ 1st QTR. '82 US $				BASIS DWG/P.O.
				MAT'L	EQUIP.	S/C	MAN HR	LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	
	JACKET	DAYS	60			$20,000/DAY					1200 000	.165
	2 - 6000 HP TUGS @											
	$10,000/DAY EA. = $20,000/DAY											
	PILING & CONDUCTORS	DAYS	114 ~~119~~			$18,000/DAY					2,050 000 ~~2,142,000~~	.317
	1 - 400' x 105' x 25' BARGE											
	W/ 1 - 6000 HP TUG											
	@ 8,000/DAY + 10,000/DAY											
	RESPECTIVELY											
	WEATHER - 25% of 56 DAYS	DAYS	14			$18,000/DAY					250 000	
	MODULES & PACKAGES	DAYS	185			$18,000/DAY					3,330 000	.514
	5 - 400' x 105' x 25' BARGES											
	W/ 5 - 6000 HP TUGS											
	DURATION/SPREAD = 37											
	DAYS x 5 SPREADS =											
	185 TOTAL DAYS @											
	$18,000/DAY											
	WEATHER - 28% OF 12 DAYS	DAYS	3.5			18,000/DAY					65 000	
	NOTE: DURATIONS INCLUDE											
	TIME FOR STANDBY											
	WHILE UNLOADING											
	LOADOUT @ PORT (MODULES)	DAYS	20.			$18,000/DAY					360 000	
	INSURANCE FOR TOW		L.S								3,675 000	
	SUB TOTALS										10,930,000	
	ADJUSTMENTS											
	RATES											

REMARKS TOW INSURANCE BASED ON DIRECT QUOTATION

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT NORTON SOUND STUDY
DESCRIPTION JACKET CONCEPT / 50' WATER DEPTH
INSTALLATION
AREA OFFSHORE
ACCOUNT

ESTIMATE NO. 82-110-02
SHEET NO. 6 OF 7
PREPARED BY MG DATE 3/15/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ 1st QUAR. '82 US $ LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	BASIS DWG/P.O.
	JACKETS / PILES / CONDUCTORS											
	SURVEY & BUOY SITE	DAYS	7									
	WEATHER	DAYS	2									
	SUBTOTAL	DAYS	9			$10,000/DAY					90 000	
	SETUP & SINK TOWER	DAYS	1.5									
	JET-IN & LEVEL TOWER		5.0									
	SETUP FOR PILING & REMOVE BUOY CAPS		2.75									
	DRIVE 12' Ø PILES		53.0									
	DRIVE 2' Ø CONDUCTORS		10.25									
	SUBTOTAL		72.5									
	25% WEATHER		18.1									
	SUBTOTAL		90.6			$204,000/DAY					18,482 000	
	CONCRETE JACKET LEGS	DAYS	29.5									
	25% WEATHER		7.5									
	SUBTOTAL		37.0			$28,000/DAY					1,036 000	
	CONCRETE MATERIALS	CY	2880	41.00					118 000			
	SET MODULES / PACKAGES	DAYS	13.0									
	28% WEATHER		3.6									
	SUBTOTAL		16.6			$162,500/DAY					2,698 000	
	COMMISSION CRANES & QUARTERS	DAYS	6.0									
	33% WEATHER		2.0									
	SUBTOTAL		8.0			$162,500/DAY					1,300 000	

REMARKS

SUB TOTALS		118 000		23,606 000	
ADJUSTMENTS					
RATES					

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study, AREA OFFSHORE
DESCRIPTION Jacket Concept 50' Water Depth ACCOUNT
Hookup / Checkout / Startup / Commissioning

ESTIMATE NO. 82-110-02
SHEET NO. 7 OF 9
PREPARED BY MG DATE 3/12/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST / 1st Quar. 82 US $ LABOR (MH)	COST MAT'LS	COST EQUIPMENT	COST SUB CONTR.	BASIS DWG/P.O.
	Hookup / Checkout	Days	91			$119,600/Day					10,885 000	
	Startup / Commissioning	Days	14			$31,000/Day					435 000	
	2 Shifts of 10 Men											
	per Shift for 14 Days											
	is 240 MHRs/Day × $80											
	per MHR.											
	Labor:											
	268,000 ÷ 14 Days = 19,200/Day											
	Helicopter = 3,000/Day											
	Misc./Tools = 8,600/Day											
	30,800/Day											
	Say $31,000/Day											
	Misc. Punch List Work	Days	14			$12,000/Day					170 000	
	2 Men, 24 Hrs/Day											

REMARKS

SUB TOTALS 11,490 000
ADJUSTMENTS
RATES
TOTALS

ESTIMATE WORK SHEET

V OCEAN SERVICES

CUSTOMER SOCAL

LOCATION US WEST COAST/ALASKA

PROJECT NORTON SOUND STUDY

DESCRIPTION FACTORED ESTIMATE
FOR A DRILLING AND
PRODUCTION FACILITY
OUTFITTING & HOOKUP
JACKET CONCEPT
50' WATER DEPTH

PROP. NO. 82-110-02
W.O. NO.
CONT. NO. 411093
MADE BY MG
APPROVED

A/C NO.		MHRS. USWC	ON SHORE %	OFF SHORE %	ONSHORE YARD MHRS.	OFFSHORE HOOKUP MHRS.
20	STRUCTURAL STEEL					
40	EQUIPMENT					
50	PIPING					
60	ELECTRICAL					
70	INSTRUMENTATION					
80	PAINTING					
85	INSULATION					
	TOTAL DEC MHRS.	486,600	85	15	413,625	73,000
	ONSHORE MHRS. USWC				413,625	
	ALL-IN YARD RATE PER MHR.				$40.00	
	TOTAL SUBCONTRACT YARD COST				16,545,000	
	OFFSHORE MHRS USWC					73,000
	OFFSHORE PRODUCTIVITY ADJ					1.5
	OFFSHORE ADJ'D MHRS.					109,500

100 MAN WORK CREW FOR HOOKUP w/ 50 MEN
PER 12 HOUR SHIFT = 1200 MHRS./DAY

91 DAYS

WEATHER DOWNTIME —

F.O.S. 1918 V

DATE 3/12/82 REVISION NO. REVISION DATE PAGE NO. 8 OF 9

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study
DESCRIPTION Jacket Concept - 50' Water Depth
Indirect Costs

AREA
ACCOUNT

ESTIMATE NO. 82-110-02
SHEET NO. 9 OF 9
PREPARED BY MKG DATE
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ LABOR (MH)	COST/ MAT'LS	COST/ EQUIPMENT	COST/ SUB CONTR.	BASIS DWG/P.O.
	Mob/Demob											
	Derrick Barge w/Lab.										2,185 000	
	Survey Vessel w/ "										370 000	
	Conc. Barge w/Lab										1,120 000	
	Subtotal										3,675 000	
	Freight at 2% of Mat. + Equip Cost								1,875 000			
	(.02 × 93,840,000)											
	Const. Services & Expense		Allow						300 000		700 000	
	Spare Parts		Allow						500 000			
	SUB TOTALS								2,675 000		4,375 000	
	ADJUSTMENTS											
	RATES											
	TOTALS											

REMARKS

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CLIENT:
LOCATION: NORTON SOUND                                                                                                               FLUOR OCEAN SERVICES
                                                   NORTON SOUND STUDY SCHEDULE                                                       REPORT RBAR3PAGE:   1
                                            50 FOOT MLLW JACKET CONFIGURATION
CONTRACT: 411093                                            (LEVEL-III CONTROL SCHEDULE)
PROJECT MANAGER: JE LACY/BR PIER                                                                                                     STATUS DATE:16-MAR-82
                                                                                                                                     DATE: 17-MAR-82
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MANAGEMENT, ENGINEERING, & PROCUREMENT
                                                                            EACH SPACE REPRESENTS ONE WEEK
RN   DESCRIPTION                                                                                                                                                                               DURATION   EARLY     EARLY
                                        NOV  DEC JAN  FEB MAR APR MAY  JUN JUL AUG  SEP OCT  NOV DEC JAN  FEB MAR APR MAY  JUN JUL  AUG SEP OCT  NOV DEC JAN  FEB MAR APR  MAY JUN JUL  AUG SEP         IN WEEKS   START     FINISH
                                        84   84  85   85  85  85  85   85  85  85   85  85   85  85  86   86  86  86  86   86  86   86  86  86   86  86  87   87  87  87   87  87  87   87  87
                                        I----I---I----I---I---I---I----I---I---I----I---I----I---I---I----I---I---I---I----I---I----I---I---I----I---I---I----I---I---I----I---I---I----I---I--I
  1  SCOPE PROCESS                      IXXXXX   I    I   I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I
  2  REVIEW TECHNOLOGY                  IXXXXXXX....  I   I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     4.0    14-NOV-84 11-DEC-84
  3  SIZE DECKS                         I    XXX....  I   I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     6.0    14-NOV-84 25-DEC-84
  6  DEVELOP CONSTRUCTION PHILOSOPHY    I    I XXXXX.......   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     2.0    12-DEC-84 25-DEC-84
  4  SIZE MODULES                       I    I XXXXXXX....I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     4.0    26-DEC-84 22-JAN-85
  5  SIZE MAJOR EQUIPMENT               I    XXXXXXXXXXX  I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     6.0    26-DEC-84  5-FEB-85
  7  SIZE SKIDS                         I    I   I    IXXXI   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I    10.0    12-DEC-84 19-FEB-85
  8  SIZE SKID BEAMS                    I    I   I    I  XX   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     2.0    20-FEB-85  5-MAR-85
 11  LAYOUT EQUIPMENT                   I    I   I    IXXXXX  I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     1.0     6-MAR-85 12-MAR-85
 10  LAYOUT MODULES                     I    I   I    I  XXXX.I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     4.0    20-FEB-85 19-MAR-85
110  TAKEOFF SKIDS                      I    I   I    I   IXXXI   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     3.0     6-MAR-85 26-MAR-85
  9  OPTIMIZE TOWER                     I    I   I    I   XXXXX   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     2.0    20-MAR-85  2-APR-85
111  CALCULATE REACTIONS                I    I   I    I   I  XX   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     4.0    13-MAR-85  9-APR-85
 14  PREP. LONG LEAD EQUIP. SPECS       I    I   I    I   IXXXXXXXI    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     1.0     3-APR-85  9-APR-85
 15  SIZE ANCILLARY EQUIPMENT           I    I   I    I   I   I  XXXXX I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     6.0    20-MAR-85 30-APR-85
 12  SIZE TOWER/PILES                   I    I   I    I   I   XXXXXXXXXX   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     4.0     1-MAY-85 28-MAY-85
 13  SIZE MODULE FRAMING                I    I   I    I   I  XXXXXXXXXXX   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     9.0    10-APR-85 11-JUN-85
 17  FINALIZE EQUIPMENT LIST            I    I   I    I   I   I   I  XXX   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I    10.0     3-APR-85 11-JUN-85
 20  PREPARE ANCILLARY SPECS            I    I   I    I   I   I   I  XXXXXXXXXXXXX  I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     2.0    29-MAY-85 11-JUN-85
112  PROCURE BULK MAT'L & CONTRACT FAB. I    I   I    I   I   I   I    XXXXXXXXXXXXXX..................................    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I    12.0    29-MAY-85 20-AUG-85
 18  DETAIL TOWER                       I    I   I    I   I   I   I    XXXXXXXXXXXXXXXXXI    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I    13.0    12-JUN-85 10-SEP-85
 19  DETAIL MODULES                     I    I   I    I   I   I   I    XXXXXXXXXXXXXXXXXXXXXXXX  I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I    16.0    12-JUN-85  1-OCT-85
 24  DETAIL FACILITIES                  I    I   I    I   I   I   I    I   I   I XXXXXXXXXXXXXXX I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I    23.0    12-JUN-85 19-NOV-85
 21  DETAIL PILES                       I    I   I    I   I   I   I    I   I   I    I  XXXXXXXXXXXXX I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I    14.0    21-AUG-85 26-NOV-85
 28  PROCURE ANCILLARY EQUIPMENT        I    I   I    I   I   I   I    I   I   I XXXXXXXXXXXXXXXXXXXXX...................................   I    I   I   I    I   I   I    I   I   I    I   I  I    12.0     2-OCT-85 24-DEC-85
 29  PROCURE COMMODITIES                I    I   I    I   I   I   I    I   I   I    I   I    I XXXXXXX...................................   I    I   I   I    I   I   I    I   I   I    I   I  I    20.0    21-AUG-85  7-JAN-86
 23  DETAIL APPURTENANCES               I    I   I    I   I   I   I    I   I   I    I   I    IXXXXXXXXX   I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     6.0    27-NOV-85  7-JAN-86
 22  DETAIL INSTALLATION AIDS           I    I   I    I   I   I   I    I   I   I    I   I    I   I XXXXXXXXXX I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     8.0    20-NOV-85 14-JAN-86
 25  DETAIL ERECTION AIDS               I    I   I    I   I   I   I    I   I   I    I   I    I   I   IXXXXXXX I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     9.0    25-DEC-85 25-FEB-86
 26  PREPARE HOOK-UP PROCEDURES         I    I   I    I   I   I   I    I   I   I    I   I    I XXXXXXXXXXXXXX I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I     6.0    15-JAN-86 25-FEB-86
 30  CONTRACT INSTALLATION              I    I   I    I   I   I   I    I   I   I    I   I    I   I   I    I XXXXXXX....................................................    I   I   I    I   I  I    13.0    27-NOV-85 25-FEB-86
 16  PROCURE LONG LEAD EQUIPMENT        I    I   I    I   I   I  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX...................   I    I   I   I    I   I   I    I   I   I    I   I  I     6.0    26-FEB-86  8-APR-86
 27  PREP INSTALL. & OPER. MANUALS      I    I   I    I   I   I   I    I   I   I    I   I    I   I   I    I XXXXXXXXXXX    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I  I    52.0     1-MAY-85 29-APR-86
                                                                                                                                                                                                10.0    26-FEB-86  6-MAY-86
NOTES:
(1)   EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2)   CALENDAR DURATIONS BASED ON:
      (A)   8 HR. DAYS, 5 DAYS/WEEK FOR MANAGEMENT, ENGINEERING & PROCUREMENT ACTIVITIES
      (B)   8 HR. DAYS, 6 DAYS/WEEK FOR FABRICATION, LOADOUT, & SEAFASTENING ACTIVITIES
      (C)   24 HR. DAYS, 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES
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CLIENT:
LOCATION: NORTON SOUND                                                                             FLUOR OCEAN SERVICES
                                              NORTON SOUND STUDY SCHEDULE                          REPORT RBAR3PAGE:    2
                                         50 FOOT MLLW JACKET CONFIGURATION
CONTRACT: 411093                                (LEVEL-III CONTROL SCHEDULE)
PROJECT MANAGER: JE LACY/BR PIER
---------------------------------------------------------------------------------------------------  STATUS DATE:16-MAR-82
FABRICATION. LOADOUT. & SEAFASTENING                                                                 DATE: 17-MAR-82
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RN          DESCRIPTION                                                     EACH SPACE REPRESENTS ONE WEEK
                                                                                                                                                                    DURATION  EARLY     EARLY
                                        NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP   IN WEEKS  START     FINISH
                                        84  84  85  85  85  85  85  85  85  85  85  85  85  85  86  86  86  86  86  86  86  86  86  86  86  86  87  87  87  87  87  87  87  87  87
                                        I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I
31 ROLL LEG & PILE SLEEVES              I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I
33 FABRICATE PRODUCTION TRUSSES         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXX...........I   I   I   I   I   I   I   I   I   I   I   I   I   I      3.7    7-MAY-86 31-MAY-86
35 FABRICATE LEG & PILE SLEEVES         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXX  I   I   I   I   I   I   I   I   I   I   I   I   I   I   I      8.8    7-MAY-86  7-JUL-86
34 FABRICATE DRILLING TRUSSES           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXX........... I   I   I   I   I   I   I   I   I   I   I   I      7.3    2-JUN-86 22-JUL-86
32 FAB BOX BEAMS                        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXX...............I   I   I   I   I   I   I   I   I   I   I     11.7    7-MAY-86 26-JUL-86
36 ROLL PILES & HAMMER ADDAPTERS        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXXXXXX...... I   I   I   I   I   I   I   I   I   I   I   I     16.0    7-MAY-86 26-AUG-86
40 FABRICATE PRODUCTION MODULES         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXXX..........I   I   I   I   I   I   I   I   I   I   I     13.0    2-JUN-86 30-AUG-86
41 FAB DRILL MODULES & APPURT'S         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXX  I   I   I   I   I   I   I   I   I   I   I   I   I      8.8    8-JUL-86  6-SEP-86
37 ASSEMBLE TOWER                       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXX...........I   I   I   I   I   I   I   I   I     11.7   28-JUL-86 16-OCT-86
39 OUTFIT TOWER                         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXXXXXX...I   I   I   I   I   I   I   I   I     16.0   27-AUG-86 16-DEC-86
38 FABRICATE PILES & HAMMER ADDAPTERS   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXXXXXXXXXXXX...... I   I   I   I   I   I     10.8   17-DEC-86  2-MAR-87
44 LOADOUT PILES & ADDAPTERS            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXXXXXXXXXXXXXXX..........I   I   I   I   I     26.3    1-SEP-86  3-MAR-87
45 TOW TOWER OUT                        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XX..........    I   I   I   I   I      0.3    4-MAR-87  5-MAR-87
46 SEAFASTEN PILING BARGE               I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XX....      I   I   I   I   I   I      0.7    3-MAR-87  6-MAR-87
49 SECURE TOWER FOR VOYAGE              I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X..........     I   I   I   I   I      0.3    6-MAR-87  7-MAR-87
43 OUTFIT DRILL MODULES & APPURT'S      I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X.....      I   I   I   I   I   I      0.2    7-MAR-87  7-MAR-87
60 LOADOUT DRILL MODULES & APPURT'S     I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXXXXXXXXXXXXXX...........I   I   I     25.8   17-OCT-86 15-APR-87
61 SEAFASTEN DRILL MODULES & APPURT'S   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X...............I   I   I      1.0   16-APR-87 22-APR-87
42 OUTFIT PRODUCTION MODULES            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X...............    I   I      1.0   23-APR-87 29-APR-87
57 LOADOUT PRODUCTION MODULES           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXI   I   I     46.7    8-SEP-86 30-JUL-87
58 SEAFASTEN PROD. MODULE BARGES        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI   I   I      0.3   31-JUL-87  1-AUG-87
                                        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI   I   I      0.3    3-AUG-87  4-AUG-87
NOTES:
(1)  EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2)  CALENDAR DURATIONS BASED ON:
     (A)  8 HR. DAYS, 5 DAYS/WEEK FOR MANAGEMENT, ENGINEERING & PROCUREMENT ACTIVITIES
     (B)  8 HR. DAYS, 6 DAYS/WEEK FOR FABRICATION, LOADOUT, & SEAFASTENING ACTIVITIES
     (C)  24 HR. DAYS, 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES
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CLIENT:                                                                                              FLUOR OCEAN SERVICES
LOCATION: NORTON SOUND                                                                               REPORT RBAR3PAGE:   3
                                   NORTON SOUND STUDY SCHEDULE
                                50 FOOT MLLW JACKET CONFIGURATION
                                   (LEVEL-III,CONTROL SCHEDULE)
CONTRACT: 411093                                                                                     STATUS DATE:16-MAR-82
PROJECT MANAGER: JE LACY/BR PIER                                                                     DATE: 17-MAR-82
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TRANSPORTATION & INSTALLATION
                                                  EACH SPACE REPRESENTS ONE WEEK                                 DURATION  EARLY     EARLY
RN          DESCRIPTION                                                                                          IN WEEKS  START     FINISH
                                   NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
                                   84  84  85  85  85  85  85  85  85  85  85  85  85  85  86  86  86  86  86  86  86  86  86  86  86  86  87  87  87  87  87  87  87  87  87
                                   I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I--I
47 TOW PILING BARGE TO BRISTOL BAY I I I I I I I I I I I I I I I I I I I I I I I I I I I I XXX...........    I I I I    2.0   7-MAR-87 21-MAR-87
51 MOB. DERRICK VESSELS TO BRISTOL I I I I I I I I I I I I I I I I I I I I I I I I I I I I XXX..........I I I I I      2.0   7-MAR-87 21-MAR-87
   BAY
55 MOB. SURVEY VESSELS TO BRISTOL BAY I I I I I I I I I I I I I I I I I I I I I I I I I I I I XXX......I I I I I I  2.0   7-MAR-87 21-MAR-87
50 MOB. GROUT/CONCRETE BARGE TO SITE I I I I I I I I I I I I I I I I I I I I I I I I I I I I XXX................ I I I  2.4   7-MAR-87 24-MAR-87
53 TOW TOWER TO BRISTOL BAY        I I I I I I I I I I I I I I I I I I I I I I I I I I I I XXXX.........I I I I I     3.3   7-MAR-87 30-MAR-87
48 TOW PILING BARGE TO SITE        I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I X...... I I I I        0.6   1-MAY-87  4-MAY-87
52 DERRICK BARGES TO SITE          I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I X..... I I I I         0.6   1-MAY-87  4-MAY-87
54 TOW TOWER TO SITE               I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I X..... I I I I         0.9   1-MAY-87  6-MAY-87
62 TOW DRILL MOD'S & APP'S TO SITE I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I XXXX...............I I  2.4  29-APR-87 16-MAY-87
56 SURVEY VESSEL TO SITE           I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I XXXXXI I I I I          4.1   1-MAY-87 29-MAY-87
63 SURVEY/BUOY SITE                I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I XX I I I I            1.0  30-MAY-87  5-JUN-87
64 ANCHOR DERRICK VESSEL           I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I X I I I I             0.0   6-JUN-87  6-JUN-87
65 RIG TOWER                       I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I X I I I I             0.0   6-JUN-87  6-JUN-87
66 POSITION TOWER                  I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I X I I I I             0.1   6-JUN-87  6-JUN-87
67 BALLAST TOWER                   I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I X I I I I             0.1   7-JUN-87  7-JUN-87
68 JET/LEVEL TOWER                 I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I XX I I I I            0.7   7-JUN-87 12-JUN-87
69 PREP. DERRICK VESSELS FOR PILING I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I IX I I I I          0.1  12-JUN-87 13-JUN-87
70 REMOVE 8X BUOYANCY CAPS         I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I IX I I I I            0.1  13-JUN-87 14-JUN-87
71 RUN/DRIVE 8X LEAD PILES         I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I IX I I I I            0.3  14-JUN-87 16-JUN-87
72 STAB/WELD/INSP 8X 1 ADDON PILES I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I IXXXI I I I          1.6  16-JUN-87 27-JUN-87
73 DRIVE 8X FIRST ADDON PILES      I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I XI I I I            0.1  27-JUN-87 27-JUN-87
74 STAB/WELD/INSPECT 8X 2 ADDON PILES I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I XX I I I        1.6  29-JUN-87  8-JUL-87
75 DRIVE 8X 2 ADDON PILES          I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I IX I I I            0.3   9-JUL-87 10-JUL-87
78 REANCHOR DV'S & REMOVE 8X BC'S  I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I IX I I I            0.1  10-JUL-87 11-JUL-87
79 RUN/DRIVE 8X LEAD PILES         I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I IX I I I            0.3  11-JUL-87 13-JUL-87
76 ANCHOR BARGE & GROUT 8X PILES   I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I IXX..I I I          1.1  10-JUL-87 18-JUL-87
80 STAB/WELD/INSPECT 1ST ADDON PILES I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I IXXX I I I        1.6  13-JUL-87 24-JUL-87
77 FILL 2X LEGS                    I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I XX..  I I          1.0  18-JUL-87 25-JUL-87
81 DRIVE 8X 1ST ADDON PILES        I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I X I I I           0.1  24-JUL-87 25-JUL-87
82 STAB/WELD/INSPECT 2ND ADDON PILES I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I XXI I I        1.6  25-JUL-87  5-AUG-87
83 DRIVE 8X 2ND ADDON PILES        I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I  XX I I            0.3   5-AUG-87  7-AUG-87
84 REANCHOR & GROUT 8X PILES       I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I   XX I I           1.1   7-AUG-87 14-AUG-87
85 REANCHOR DV(S) & DRIVE CND'S    I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I   XX. I I          1.5   7-AUG-87 17-AUG-87
59 TOW PROD. MODULE BARGES TO SITE I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I  XXXX I I          2.4   4-AUG-87 21-AUG-87
86 FILL 2X LEGS                    I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I   IXX I I          1.0  15-AUG-87 21-AUG-87

NOTES:
(1)  EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2)  CALENDAR DURATIONS BASED ON:
     (A)  8 HR. DAYS, 5 DAYS/WEEK FOR MANAGEMENT, ENGINEERING & PROCUREMENT ACTIVITIES
     (B)  8 HR. DAYS, 6 DAYS/WEEK FOR FABRICATION, LOADOUT, & SEAFASTENING ACTIVITIES
     (C)  24 HR. DAYS, 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES
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CLIENT:
LOCATION: NORTON SOUND                                                                                                                        FLUOR OCEAN SERVICES
                                                        NORTON SOUND STUDY SCHEDULE                                                           REPORT RBAR3PAGE:    4
                                                50 FOOT MLLW JACKET CONFIGURATION
                                                         (LEVEL-III CONTROL SCHEDULE)
CONTRACT: 411093
PROJECT MANAGER: JE LACY/BR PIER                                                                                                              STATUS DATE:16-MAR-82
                                                                                                                                              DATE: 17-MAR-82
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ERECTION & COMMISSIONING
                                                                             EACH SPACE REPRESENTS ONE WEEK                                                   DURATION     EARLY     EARLY
RN          DESCRIPTION                                                                                                                                       IN WEEKS     START     FINISH
                                        NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
                                        84  84  85  85  85  85  85  85  85  85  85  85  85  85  86  86  86  86  86  86  86  86  86  86  86  86  87  87  87  87  87  87  87  87  87
                                        I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I--I
 87 PREPARE TOWER FOR MODULES           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I     0.0     22-AUG-87 22-AUG-87
 88 SET PB                              I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I     0.1     22-AUG-87 23-AUG-87
 89 REANCHOR DERRICK VESSEL(S)          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I     0.0     23-AUG-87 23-AUG-87
 90 SET PC                              I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I     0.1     23-AUG-87 24-AUG-87
 91 SKID PB & PC                        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I     0.2     24-AUG-87 25-AUG-87
 92 SET WA                              I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I     0.1     26-AUG-87 26-AUG-87
 93 REANCHOR DERRICK VESSEL(S)          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I     0.0     27-AUG-87 27-AUG-87
 94 SET PD                              I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I     0.1     27-AUG-87 28-AUG-87
 95 REANCHOR DERRICK VESSEL             I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I     0.0     28-AUG-87 28-AUG-87
 96 SET DB1.DC1.DD1.EL-1A, & ME-8A      I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I     0.1     28-AUG-87 28-AUG-87
 97 REANCHOR DERRICK VESSEL             I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I     0.0     29-AUG-87 29-AUG-87
 98 SET DB2, DC2, DD2, EL-1B, & ME-8B   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I     0.1     29-AUG-87 29-AUG-87
 99 REANCHOR DERRICK VESSEL             I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I     0.0     29-AUG-87 29-AUG-87
100 SET CQ-1B AND CQ-1A                 I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I     0.1     30-AUG-87 30-AUG-87
101 REANCHOR DERRICK VESSEL             I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I     0.0     31-AUG-87 31-AUG-87
102 SET/SKID DA                         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I     0.1     31-AUG-87 31-AUG-87
103 SET RM-1A & FB-1A                   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I     0.1     31-AUG-87  1-SEP-87
104 REANCHOR DERRICK VESSEL             I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I     0.0      1-SEP-87  1-SEP-87
105 SET RM-1B & FB-1B                   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I     0.1      2-SEP-87  2-SEP-87
106 PERFORM MISCELLANEOUS LIFTS         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X  I     0.1      3-SEP-87  3-SEP-87
107 COMMISSION CRANES & QTRS            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X  I     0.9      4-SEP-87  9-SEP-87
108 COMMISSION DRILLING PLANT           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXXX     4.3     10-SEP-87  9-OCT-87
109 COMMISSION PRODUCTION PLANT         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  I     7.1     10-OCT-87 28-NOV-87
NOTES:
(1)   EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2)   CALENDAR DURATIONS BASED ON:
      (A)   8 HR. DAYS, 5 DAYS/WEEK FOR MANAGEMENT, ENGINEERING & PROCUREMENT ACTIVITIES
      (B)   8 HR. DAYS, 6 DAYS/WEEK FOR FABRICATION, LOADOUT, & SEAFASTENING ACTIVITIES
      (C)   24 HR. DAYS, 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES
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FACTOR TYPE COST ESTIMATE

FLUOR OCEAN SERVICES

CUSTOMER Socal
LOCATION Alaska
PROJECT Norton Sound Study

DESCRIPTION Jacket Concept
70' water depth
"Main Summary"

PROP. NO. 82-110-02
W.O. NO. 411093
CONT. NO.
MADE BY MG
APPROVED

A/C NO.	ITEM & DESCRIPTION	QTY.	ESTIMATED COST 1st QUAR. '82 US $ × 1000				
			LABOR	MAT'LS	EQUIPMENT	SUB-CONTRACTS	TOTALS
	ONSHORE WORK						
	PLATFORM FABRICATION IN YARD	27,220 T		18,590		59,080	77,670
	MODULE ASSEMBLY AND OUTFITTING			75,725		16,545	92,270
	OFFSHORE WORK						
	TRANSPORTATION					11,115	11,115
	INSTALLATION					23,945	23,945
	HOOKUP/CHECKOUT STARTUP/COMM.					11,490	11,490
	DIRECT FIELD COSTS			94,315		122,175	216,490
	INDIRECT FIELD COSTS			2,685		4,375	7,060
	TOTAL FIELD COSTS			97,000		126,550	223,550
	FIELD CONST. MGMT.	3% OF D.F.C.					6,495
92-000	HOME OFFICE CONSTRUCTION MGMT.						
93-000	PROJECT MANAGEMENT						
94-000	CENTRAL ENGINEERING						
95-000	DRAFTING & TECH. SERVICES						
96-000	PURCHASING	7.0% OF D.F.C.					15,300
97-000	BUSINESS SERVICES	(340,000 MHRS × $45/MH)					
97-000	OFFICE EXPENSE						
98-000	OFFICE PAYROLL BURDEN						
99-500	INDIRECT OFFICE COSTS						
	TOTAL OFFICE COSTS						21,795
	TOTAL FIELD & OFFICE COSTS						245,345
99-100	ESCALATION						
99-200	CONTINGENCY 16.3%						39,985
99-600	FEE						
99-300	SALES TAX						
	TOTAL						285,330

F.O.S. 1917

DATE 3/12/82 REVISION NO. 3 REVISION DATE 4/1/82 PAGE NO. 1 OF 9

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study AREA Onshore
DESCRIPTION Jacket Concept for 70' water depth ACCOUNT
Platform Fabrication in Yard

ESTIMATE NO. 82-110-02
SHEET NO. 2 OF 7
PREPARED BY MG DATE 3/10/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS				COST / Quar. '82 US $				BASIS DWG/P.O.
				MAT'L	EQUIP.	S/C	MAN HR	LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	
	Jacket	TONS	7,619	677		4300			5,158 000		32760 000	
	Piles	TONS	14,145	675		700			9,376 000		9725 000	
	Conductors	TONS	1,070	675		500			722 000		535 000	
	Module Superstructure	TONS	4,470	680		3300			3,040 000		14750 000	
	Flare Booms		180	675		6300			122 000		1135 000	
	Subtotal		27,230									

REMARKS Quoted from Kaiser Steel, Napa
Calc for material & S/C costs

	LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.
SUB TOTALS		18,516 000		58905 000
ADJUSTMENTS				
RATES				
TOTALS				

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study,
DESCRIPTION Jacket Concept 70' Water Depth
Module Assembly & Outfitting in Fab. Yard
AREA Onshore
ACCOUNT
ESTIMATE NO. 82-110-02
SHEET NO. 3 OF 9
PREPARED BY ______ DATE 3/10/82
CHECKED BY ______ DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS				COST/ Quar. '82 US $				BASIS DWG/P.O.
				MAT'L	EQUIP.	S/C	MAN HR	LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	
				Factor		Factor						
	Module Nº DA											
	Equip. Cost	M$	1150	1.41		.60			1,622 000		690 000	
	Module Nº DB1											
	Equip. Cost	M$	1425	1.45		.87			2,066 000		1,240 000	
	Module Nº DB2											
	Equip. Cost	M$	1425	1.45		.87			2,066 000		1,240 000	
	Module Nº DC1											
	Equip. Cost	M$	643	2.09		.89			1,344 000		572 000	
	Module Nº DC2											
	Equip. Cost	M$	643	2.09		.89			1,344 000		572 000	
	Module Nº DD1											
	Equip. Cost	M$	585	1.37		.59			801 000		345 000	
	Module Nº DD2											
	Equip. Cost	M$	585	1.37		.59			801 000		345 000	
	Module Nº WA											
	Equip. Cost	M$	531	2.38		1.39			1,264 000		738 000	
	Module Nº PB											
	Equip. Cost	M$	1000	2.35		1.56			2,350 000		1,560 000	
	Module Nº PC											
	Equip. Cost	M$	6796	1.43		.77			9,718 000		5,233 000	
	Module Nº PD											
	Equip. Cost	M$	5493	1.35		.73			7,416 000		4,010 000	
	SUB TOTALS								30,792 000		16,545 000	
	ADJUSTMENTS											
	RATES											
	TOTALS											

REMARKS Factors used are based on current
Modules [illegible]
US [illegible]

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study
DESCRIPTION Jacket Concept 70' Water Depth
Module Assembly & Outfitting in Fab. Yard
AREA Onshore
ACCOUNT
ESTIMATE NO. 82-110-02
SHEET NO. 4 OF 9
PREPARED BY ____ DATE 3/10/82
CHECKED BY ____ DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS				COST/ 1st Quar. US $ '82				BASIS DWG/P.O.
				MAT'L	EQUIP.	S/C	MAN HR	LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	
	From Previous Page								30,192 000		16,545 000	
	Package Nº RM-1A											
	Equip. Cost	M$	18530				1.0		18530 000			
	Package Nº RM-1B											
	Equip. Cost	M$	18530				1.0		18530 000			
	Package Nº EL-1A											
	Equip. Cost	M$	78				1.0		78 000			
	Package Nº EL-1B											
	Equip. Cost	M$	78				1.0		78 000			
	Module Nº CQ-1A	M$	3000				1.0		3000 000			
	Module Nº CQ-1B	M$	3000				1.0		3000 000			
	Pedestal Cranes	EA	2	225,000			1.0		450 000			
	Survival Crafts	EA	4	150,000			1.0		600 000			
	Nav-Aids	SETS	4	25,000			1.0		100 000			
	Rucker Mooring System	EA.	2	80,000			1.0		160 000			
	Flare Tips	EA	2	77,500			1.0		155 000			
	Track Vehicle	EA	1	250,000			1.0		250 000			

REMARKS

	LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.
SUB TOTALS		15,725 000		16,545 000
ADJUSTMENTS				
RATES				
TOTALS				

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study

AREA Offshore

DESCRIPTION Jacket Concept 70' Water Depth

ACCOUNT

Transportation

ESTIMATE NO. 82-110-02

SHEET NO. 5 OF 9

PREPARED BY ____ DATE 3/12/82

CHECKED BY ____ DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ 1st Quar. '82 US $ LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	BASIS DWG/P.O.
	Jacket	Days	60			$20,000/Day					1200 000	
	2 - 6000 HP Tugs @											
	$10,000/Day EA. = $20,000/Day											
	Piling & Conductors	Days	119			$18,000/Day					2,140 000	
	1 - 400' x 105' x 25' Barge											
	w/ 1 - 6000 HP Tug											
	@ $8,000/Day + $10,000/Day											
	Respectfully											
	Weather 25% of 71 days	Days	18			$18,000/Day					325 000	
	Modules & Packages	Days	185			$18,000/Day					3,330 000	
	5 - 400' x 105' x 25' Barges											
	w/ 5 - 6000 HP Tugs											
	Duration/Spread = 37											
	Days x 5 Spreads =											
	185 Total Days @											
	$18,000/Day											
	Weather - 28% of 12 days	Days	3.5			18,000/Day					63 000	
	Note: Durations include											
	time for standby											
	while unloading											
	Loadout Modules & S.F.	Days	20			18,000/Day					360 000	
	(4 Days x 5 Spreads = 20 Days)											
	Tow Insurance (2.8%)		[illegible]								[illegible]	

REMARKS Tow insurance [illegible]

	LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.
SUB TOTALS				11,115 [illegible]
ADJUSTMENTS				
RATES				
TOTALS				

ESTIMATE DETAIL SHEET

FLUOR OCEAN SERVICES

PROJECT Norton Sound Study
DESCRIPTION JACKET CONCEPT 70' WATER DEPTH
INSTALLATION

AREA OFFSHORE
ACCOUNT

ESTIMATE NO. 82-110-02
SHEET NO. 6 OF 9
PREPARED BY DATE 3/12/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS				COST/ 1st QUAR. '82 US $				BASIS DWG/P.O.
				MAT'L	EQUIP.	S/C	MAN HR	LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.	
	JACKET/PILES/CONDUCTORS											
	SURVEY & BUOY SITE	DAYS	7									
	27% WEATHER	DAYS	2									
	TOTAL	DAYS	9			$10,000/DAY					90 000	
	SETUP & SINK TOWER	DAYS	1.5									
	JET-IN & LEVEL TOWER	DAYS	1									
	SETUP FOR PILING & REMOVE BUOY CAPS	DAYS	2.75									
	DRIVE 12' ϕ PILES	DAYS	57.5									
	DRIVE 2' ϕ CONDUCTORS	DAYS	10.25									
	SUBTOTAL	DAYS	73.0									
	25% WEATHER	DAYS	18.5									
	TOTAL	DAYS	91.5			$204,000/DAY					18,666 000	
	CONCRETE JACKET LEGS	DAYS	30.5									
	25% WEATHER	DAYS	7.5									
	TOTAL	DAYS	38.0			$28,000/DAY					1,064 000	
	CONCRETE MATERIAL	CY	2970	41^{00}					125 000			
	SET MODULES/PACKAGES	DAYS	13.0									
	28% WEATHER	DAYS	3.6									
	TOTAL	DAYS	16.6			$162,50/DAY					2,696 000	
	COMMISSION CRANES AND QUARTERS	DAYS	6.0									
	33% WEATHER	DAYS	2.0									
	TOTAL		8.0			$162,50/DAY					1,300 000	

REMARKS

SUB TOTALS		125		23,816 000
ADJUSTMENTS				
RATES				
TOTALS				

ESTIMATE DETAIL SHEET

FLUO OCE ERVICES

PROJECT Norton Sound Study, AREA OFFSHORE
DESCRIPTION Jacket Concept 70' Water Depth ACCOUNT
Hookup / Checkout / Startup / Commissioning

ESTIMATE NO. 82-110-02
SHEET NO. 7 OF 9
PREPARED BY DATE 3/12/82
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ 1st Quar. '82 US $ LABOR (MH)	COST MAT'LS	COST EQUIPMENT	COST SUB CONTR.	BASIS DWG/P.O.
	HOOKUP / CHECKOUT	DAYS	91			$119,600	/DAY				10,885 000	
	STARTUP / COMMISSIONING	DAYS	14			$31,000	/DAY				435 000	
	2 SHIFTS OF 10 MEN											
	PER SHIFT FOR 14 DAYS											
	IS 240 MHRS/DAY X $80											
	PER MHR.											
	$ LABOR:											
	268,000 ÷ 14 DAYS = 19,200/DAY											
	HELICOPTER = 3,000/DAY											
	MISC./TOOLS = 8,600/DAY											
	30,800/DAY											
	SAY $31,000/DAY											
	MISC. PUNCHLIST WORK	DAYS	14			$12,000	/DAY				170 000	
	2 MEN, 24 HRS, 2 WKS											

REMARKS

	LABOR (MH)	MAT'LS	EQUIPMENT	SUB CONTR.
SUB TOTALS				11,490 000
ADJUSTMENTS				
RATES				
TOTALS				

ESTIMATE WORK SHEET

FLUOR OCEAN SERVICES

CUSTOMER SOCAL

LOCATION US WEST COAST/ALASKA

PROJECT NORTON SOUND STUDY

DESCRIPTION FACTORED ESTIMATE FOR A DRILLING AND PRODUCTION FACILITY OUTFITTING & HOOKUP JACKET CONCEPT 70' WATER DEPTH

PROP. NO. 82-110-02

W.O. NO.

CONT. NO. 411093

MADE BY MG

APPROVED

A/C NO.		MHRS. USWC	ON SHORE %	OFF SHORE %	ONSHORE YARD MHRS.	OFFSHORE HOOKUP MHRS.
20	STRUCTURAL STEEL					
40	EQUIPMENT					
50	PIPING					
60	ELECTRICAL					
70	INSTRUMENTATION					
80	PAINTING					
85	INSULATION					
	TOTAL DFC MHRS.	486,600	85	15	413,625	73,000
	ONSHORE MHRS. USWC				413,625	
	ALL-IN YARD RATE PER MHR.				$40=	
	TOTAL SUBCONTRACT YARD COST				16,545,000	
	OFFSHORE MHRS USWC					73,000
	OFFSHORE PRODUCTIVITY ADJ					1.5
	OFFSHORE ADJ'D MHRS.					109,500

100 MAN WORK CREW FOR HOOKUP w/ 50 MEN PER 12 HOUR SHIFT = 1200 MHRS./DAY

91 DAYS

WEATHER DOWNTIME —

DATE 3/12/82 REVISION NO. 3 REVISION DATE 4/1/82 PAGE NO. 2 of 9

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ESTIMATE DETAIL SHEET

FLUOR OCEAN VICES

PROJECT Norton Sound Study
DESCRIPTION Jacket Concept - 70' water depth
Indirect Field Costs
AREA
ACCOUNT

ESTIMATE NO. 82-110-02
SHEET NO. 9 OF 9
PREPARED BY MG DATE
CHECKED BY DATE

ACCOUNT NO.	DESCRIPTION	WT.	QTY.	UNITS MAT'L	UNITS EQUIP.	UNITS S/C	UNITS MAN HR	COST/ 1st Quar. '82 US$ LABOR (MH)	COST/ 1st Quar. '82 US$ MAT'LS	COST/ 1st Quar. '82 US$ EQUIPMENT	COST/ 1st Quar. '82 US$ SUB CONTR.	BASIS DWG/P.O.
	MOB/DEMOB											
	Derrick Barge w/labor										2,185 000	
	Survey Vessel w/labor										370 000	
	Conc. Barge w/labor										1,120 000	
	Subtotal										3,675 000	
	Freight @ 2% of Mat. + Equip. Cost											
	(.02 × $94,315,000 = 1,885,000)								1,885 000			
	Misc. Services & Exp		Allow						300 000		700 000	
	Spare Parts		Allow						500 000			
	SUB TOTALS								2,685 000		4,375 000	
	ADJUSTMENTS											
	RATES											
	TOTALS											

REMARKS

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CLIENT:                                                                                                                                                                     FLUOR OCEAN SERVICES
LOCATION: NORTON SOUND                                                                                                                                                      REPORT RBAR3PAGE:    1
                                                              NORTON SOUND STUDY SCHEDULE
                                                       70 FOOT MLLW JACKET CONFIGURATION
                                                              (LEVEL-III CONTROL SCHEDULE)
CONTRACT: 411093                                                                                                                                                            STATUS DATE:16-MAR-82
PROJECT MANAGER: JE LACY/BR PIER                                                                                                                                            DATE: 17-MAR-82
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MANAGEMENT, ENGINEERING, & PROCUREMENT
                                                                          EACH SPACE REPRESENTS ONE WEEK                                                                              DURATION    FARLY     EARLY
RN          DESCRIPTION                                                                                                                                                               IN WEEKS    START     FINISH
                                       NOV  DEC JAN  FEB MAR APR MAY  JUN JUL AUG  SEP OCT  NOV DEC JAN  FEB MAR APR MAY  JUN JUL  AUG SEP OCT  NOV DEC JAN  FEB MAR APR  MAY JUN JUL  AUG SEP
                                       84   84  85   85  85  85  85   85  85  85   85  85   85  85  86   86  86  86  86   86  86   86  86  86   86  86  87   87  87  87   87  87  87   87  87
                                       I----I---I----I---I---I---I----I---I---I----I---I----I---I---I----I---I---I---I----I---I----I---I---I----I---I---I----I---I---I----I---I---I----I---I---I
  1 SCOPE PROCESS                      I XXXX   I    I   I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     4.0   15-NOV-84 12-DEC-84
  2 REVIEW TECHNOLOGY                  I XXXXXX....  I   I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     6.0   15-NOV-84 26-DEC-84
  3 SIZE DECKS                         I    IXX....  I   I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     2.0   13-DEC-84 26-DEC-84
  6 DEVELOP CONSTRUCTION PHILOSOPHY    I    I  XXXX.......   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     4.0   27-DEC-84 23-JAN-85
  4 SIZE MODULES                       I    I  XXXXXX....I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     6.0   27-DEC-84  6-FEB-85
  5 SIZE MAJOR EQUIPMENT               I    IXXXXXXXXXX  I   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    10.0   13-DEC-84 20-FEB-85
  7 SIZE SKIDS                         I    I   I    I XXI   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     2.0   21-FEB-85  6-MAR-85
  8 SIZE SKID BEAMS                    I    I   I    I   X   I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     1.0    7-MAR-85 13-MAR-85
 11 LAYOUT EQUIPMENT                   I    I   I    I XXXX  I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     4.0   21-FEB-85 20-MAR-85
 10 LAYOUT MODULES                     I    I   I    I   XXX.I   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     3.0    7-MAR-85 27-MAR-85
110 TAKEOFF SKIDS                      I    I   I    I   I XXI   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     2.0   21-MAR-85  3-APR-85
  9 OPTIMIZE TOWER                     I    I   I    I   IXXXX   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     4.0   14-MAR-85 10-APR-85
111 CALCULATE REACTIONS                I    I   I    I   I   X   I    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     1.0    4-APR-85 10-APR-85
 14 PREP. LONG LEAD EQUIP. SPECS       I    I   I    I   I XXXXXXI    I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     6.0   21-MAR-85  1-MAY-85
 15 SIZE ANCILLARY EQUIPMENT           I    I   I    I   I   I   XXXX I   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     4.0    2-MAY-85 29-MAY-85
 12 SIZE TOWER/PILES                   I    I   I    I   I   IXXXXXXXXX   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     9.0   11-APR-85 12-JUN-85
 13 SIZE MODULE FRAMING                I    I   I    I   I   XXXXXXXXXX   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    10.0    4-APR-85 12-JUN-85
 17 FINALIZE EQUIPMENT LIST            I    I   I    I   I   I   I   XX   I   I    I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     2.0   30-MAY-85 12-JUN-85
 20 PREPARE ANCILLARY SPECS            I    I   I    I   I   I   I   XXXXXXXXXXXX  I   I    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    12.0   30-MAY-85 21-AUG-85
112 PROCURE BULK MAT'L & CONTRACT FAB. I    I   I    I   I   I   I    IXXXXXXXXXXXXX....................................  I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    13.0   13-JUN-85 11-SEP-85
 18 DETAIL TOWER                       I    I   I    I   I   I   I    IXXXXXXXXXXXXXXXI    I   I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    16.0   13-JUN-85  2-OCT-85
 19 DETAIL MODULES                     I    I   I    I   I   I   I    IXXXXXXXXXXXXXXXXXXXXXX  I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    23.0   13-JUN-85 20-NOV-85
 24 DETAIL FACILITIES                  I    I   I    I   I   I   I    I   I   I  XXXXXXXXXXXXXX I   I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    14.0   22-AUG-85 27-NOV-85
 21 DETAIL PILES                       I    I   I    I   I   I   I    I   I   I    I   XXXXXXXXXXXX I    I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    12.0    3-OCT-85 25-DEC-85
 28 PROCURE ANCILLARY EQUIPMENT        I    I   I    I   I   I   I    I   I   I  XXXXXXXXXXXXXXXXXXXX....................................  I   I   I    I   I   I    I   I   I    I   I   I    20.0   22-AUG-85  8-JAN-86
 29 PROCURE COMMODITIES                I    I   I    I   I   I   I    I   I   I    I   I    I  XXXXXX....................................  I   I   I    I   I   I    I   I   I    I   I   I     6.0   28-NOV-85  8-JAN-86
 23 DETAIL APPURTENANCES               I    I   I    I   I   I   I    I   I   I    I   I    I XXXXXXXX   I   I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     8.0   21-NOV-85 15-JAN-86
 22 DETAIL INSTALLATION AIDS           I    I   I    I   I   I   I    I   I   I    I   I    I   I  XXXXXXXXX I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     9.0   26-DEC-85 26-FEB-86
 25 DETAIL ERECTION AIDS               I    I   I    I   I   I   I    I   I   I    I   I    I   I   I XXXXXX I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I     6.0   16-JAN-86 26-FEB-86
 26 PREPARE HOOK-UP PROCEDURES         I    I   I    I   I   I   I    I   I   I    I   I    I  XXXXXXXXXXXXX I   I   I    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    13.0   28-NOV-85 26-FEB-86
 30 CONTRACT INSTALLATION              I    I   I    I   I   I   I    I   I   I    I   I    I   I   I    I  XXXXXX......................................................  I   I   I    I   I   I     6.0   27-FEB-86  9-APR-86
 16 PROCURE LONG LEAD EQUIPMENT        I    I   I    I   I   I   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX....................  I   I   I    I   I   I    I   I   I    I   I   I    52.0    2-MAY-85 30-APR-86
 27 PREP INSTALL. & OPER. MANUALS      I    I   I    I   I   I   I    I   I   I    I   I    I   I   I    I  XXXXXXXXXX    I   I    I   I   I    I   I   I    I   I   I    I   I   I    I   I   I    10.0   27-FEB-86  7-MAY-86

NOTES:
(1)  EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2)  CALENDAR DURATIONS BASED ON:
     (A)  8 HR. DAYS, 5 DAYS/WEEK FOR MANAGEMENT, ENGINEERING & PROCUREMENT ACTIVITIES
     (B)  8 HR. DAYS, 6 DAYS/WEEK FOR FABRICATION, LOADOUT, & SEAFASTENING ACTIVITIES
     (C)  24 HR. DAYS, 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES
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                                                                                                                                                   FLUOR OCEAN SERVICES
CLIENT:                                                                                                                                            REPORT RBAR3PAGE:   2
LOCATION: NORTON SOUND
                                                  N O R T O N   S O U N D   S T U D Y   S C H E D U L E
                                            7 0   F O O T   M L L W   J A C K E T   C O N F I G U R A T I O N
                                                                 (LEVEL-III CONTROL SCHEDULE)
                                                                                                                                                   STATUS DATE:16-MAR-82
CONTRACT: 411093                                                                                                                                   DATE: 17-MAR-82
PROJECT MANAGER: JE LACY/BR PIER
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FABRICATION. LOADOUT. & SEAFASTENING
                                                                              EACH SPACE REPRESENTS ONE WEEK                                     DURATION     EARLY     EARLY
RN            DESCRIPTION                                                                                                                        IN WEEKS     START     FINISH
                                      NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
                                      84  84  85  85  85  85  85  85  85  85  85  85  85  85  86  86  86  86  86  86  86  86  86  86  86  86  87  87  87  87  87  87  87  87  87
                                      I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I--I
31 ROLL LEG & PILE SLEEVES            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXXXX.......I   I   I   I   I   I   I   I   I   I   I   I   I   I  I     3.8   8-MAY-86  3-JUN-86
33 FABRICATE PRODUCTION TRUSSES       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXXXXXXXXX  I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  I     8.8   8-MAY-86  8-JUL-86
35 FABRICATE LEG & PILE SLEEVES       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXX..........     I   I   I   I   I   I   I   I   I   I   I  I     7.7   4-JUN-86 26-JUL-86
34 FABRICATE DRILLING TRUSSES         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXXXXXXXXXXXX..............     I   I   I   I   I   I   I   I   I   I  I    11.7   8-MAY-86 28-JUL-86
32 FAB BOX BEAMS                      I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXXXXXXXXXXXXXXXX......     I   I   I   I   I   I   I   I   I   I   I  I    16.0   8-MAY-86 27-AUG-86
36 ROLL PILES & HAMMER ADDAPTERS      I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXXX.........     I   I   I   I   I   I   I   I   I   I  I    13.3   4-JUN-86  4-SEP-86
40 FABRICATE PRODUCTION MODULES       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXX  I   I   I   I   I   I   I   I   I   I   I   I   I  I     8.8   9-JUL-86  8-SEP-86
41 FAB DRILL MODULES & APPURT'S       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXX...........I   I   I   I   I   I   I   I   I  I    11.7  29-JUL-86 17-OCT-86
37 ASSEMBLE TOWER                     I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXXXXX....I   I   I   I   I   I   I   I   I  I    16.0  28-AUG-86 17-DEC-86
39 OUTFIT TOWER                       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I XXXXXXXXXXX......     I   I   I   I   I  I    10.8  18-DEC-86  3-MAR-87
45 TOW TOWER OUT                      I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XX.....     I   I   I   I   I  I     0.7   4-MAR-87  7-MAR-87
49 SECURE TOWER FOR VOYAGE            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X......     I   I   I   I   I  I     0.2   9-MAR-87  9-MAR-87
38 FABRICATE PILES & HAMMER ADDAPTERS I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXXXXXXXXXXXXXXXX.........I   I   I   I  I    27.3   5-SEP-86 14-MAR-87
44 LOADOUT PILES & ADDAPTERS          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX.........     I   I   I   I  I     0.3  16-MAR-87 17-MAR-87
46 SEAFASTEN PILING BARGE             I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXX.........I   I   I   I   I  I     0.3  18-MAR-87 19-MAR-87
43 OUTFIT DRILL MODULES & APPURT'S    I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXXXXXXXXXXXXXXX..........I   I  I    25.8  18-OCT-86 16-APR-87
60 LOADOUT DRILL MODULES & APPURT'S   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XX..........I   I  I     1.0  17-APR-87 23-APR-87
61 SEAFASTEN DRILL MODULES & APPURT'S I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XX.............I  I     1.0  24-APR-87 30-APR-87
42 OUTFIT PRODUCTION MODULES          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXI   I  I    46.7   9-SEP-86 31-JUL-87
57 LOADOUT PRODUCTION MODULES         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI   I  I     0.3   1-AUG-87  3-AUG-87
58 SEAFASTEN PROD. MODULE BARGES      I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI   I  I     0.3   4-AUG-87  5-AUG-87

NOTES:
(1)  EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2)  CALENDAR DURATIONS BASED ON:
     (A)  8 HR. DAYS. 5 DAYS/WEEK FOR MANAGEMENT. ENGINEERING & PROCUREMENT ACTIVITIES
     (B)  8 HR. DAYS. 6 DAYS/WEEK FOR FABRICATION. LOADOUT. & SEAFASTENING ACTIVITIES
     (C)  24 HR. DAYS. 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES
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CLIENT:                                                                                    FLUOR OCEAN SERVICES
LOCATION: NORTON SOUND                                                                     REPORT RBAR3PAGE:    3
                                      NORTON SOUND STUDY SCHEDULE
                                  70 FOOT MLLW JACKET CONFIGURATION
                                      (LEVEL-III CONTROL SCHEDULE)
CONTRACT: 411093                                                                           STATUS DATE:16-MAR-82
PROJECT MANAGER: JE LACY/BR PIER                                                           DATE: 17-MAR-82
-----------------------------------------------------------------------------------------------------------------
TRANSPORTATION & INSTALLATION
                                                                      EACH SPACE REPRESENTS ONE WEEK                                          DURATION    EARLY     EARLY
RN        DESCRIPTION                        NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP  IN WEEKS    START     FINISH
                                             84  84  85  85  85  85  85  85  85  85  85  85  85  85  86  86  86  86  86  86  86  86  86  86  86  86  87  87  87  87  87  87  87  87  87
                                             I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I
51  MOB. DERRICK VESSELS TO BRISTOL          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXX.........I   I   I   I   I      2.0     9-MAR-87 23-MAR-87
    BAY
55  MOB. SURVEY VESSELS TO BRISTOL BAY       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXX.....I   I   I   I   I   I      2.0     9-MAR-87 23-MAR-87
58  MOB. GROUT/CONCRETE BARGE TO SITE        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXX................I   I   I      2.4     9-MAR-87 26-MAR-87
53  TOW TOWER TO BRISTOL BAY                 I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXX........I   I   I   I   I      3.3     9-MAR-87  1-APR-87
47  TOW PILING BARGE TO BRISTOL BAY          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I XXX.......    I   I   I   I      2.0    19-MAR-87  2-APR-87
48  TOW PILING BARGE TO SITE                 I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X.......I   I   I   I      0.6     1-MAY-87  4-MAY-87
52  DERRICK BARGES TO SITE                   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X.......I   I   I   I      0.6     1-MAY-87  4-MAY-87
54  TOW TOWER TO SITE                        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X.......I   I   I   I      0.9     1-MAY-87  6-MAY-87
62  TOW DRILL MOD'S & APP'S TO SITE          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXX.............I   I      2.4    30-APR-87 17-MAY-87
56  SURVEY VESSEL TO SITE                    I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXXI  I   I   I   I      4.1     1-MAY-87 29-MAY-87
63  SURVEY/BUOY SITE                         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XX  I   I   I   I      1.0    30-MAY-87  5-JUN-87
64  ANCHOR DERRICK VESSEL                    I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X   I   I   I   I      0.0     6-JUN-87  6-JUN-87
65  RIG TOWER                                I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X   I   I   I   I      0.0     6-JUN-87  6-JUN-87
66  POSITION TOWER                           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X   I   I   I   I      0.1     6-JUN-87  6-JUN-87
67  BALLAST TOWER                            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X   I   I   I   I      0.1     7-JUN-87  7-JUN-87
68  JET/LEVEL TOWER                          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X   I   I   I   I      0.1     7-JUN-87  8-JUN-87
69  PREP. DERRICK VESSELS FOR PILING         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X   I   I   I   I      0.1     8-JUN-87  9-JUN-87
70  REMOVE 8X BUOYANCY CAPS                  I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X   I   I   I   I      0.1     9-JUN-87 10-JUN-87
71  RUN/DRIVE 8X LEAD PILES                  I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XX  I   I   I   I      0.3    10-JUN-87 12-JUN-87
72  STAB/WELD/INSP 8X 1 ADDON PILES          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXX I   I   I   I      1.7    12-JUN-87 24-JUN-87
73  DRIVE 8X FIRST ADDON PILES               I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I   I   I   I      0.1    24-JUN-87 24-JUN-87
74  STAB/WELD/INSPECT 8X 2 ADDON PILES       I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XX   I   I   I      1.7    25-JUN-87  6-JUL-87
75  DRIVE 8X 2 ADDON PILES                   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X   I   I   I      0.3     7-JUL-87  8-JUL-87
78  REANCHOR DV'S & REMOVE 8X BC'S           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX  I   I   I      0.1     9-JUL-87  9-JUL-87
79  RUN/DRIVE 8X LEAD PILES                  I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IX  I   I   I      0.3    10-JUL-87 11-JUL-87
76  ANCHOR BARGE & GROUT 8X PILES            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXX..I  I   I      1.1     9-JUL-87 16-JUL-87
80  STAB/WELD/INSPECT 1ST ADDON PILES        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXXX I  I   I      1.7    12-JUL-87 23-JUL-87
77  FILL 2X LEGS                             I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I XX..  I   I      1.1    16-JUL-87 24-JUL-87
81  DRIVE 8X 1ST ADDON PILES                 I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  X I  I   I      0.1    24-JUL-87 24-JUL-87
82  STAB/WELD/INSPECT 2ND ADDON PILES        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXI I   I      1.7    24-JUL-87  5-AUG-87
83  DRIVE 8X 2ND ADDON PILES                 I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XX  I   I      0.3     5-AUG-87  7-AUG-87
84  REANCHOR & GROUT 8X PILES                I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I    XX I   I      1.1     7-AUG-87 15-AUG-87
85  REANCHOR DV(S) & DRIVE CND'S             I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I    XX.I   I      1.5     7-AUG-87 17-AUG-87
59  TOW PROD. MODULE BARGES TO SITE          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XXXXI   I      2.4     5-AUG-87 22-AUG-87
86  FILL 2X LEGS                             I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXX I   I      1.1    15-AUG-87 20-AUG-87
NOTES:
(1)  EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2)  CALENDAR DURATIONS BASED ON:
     (A)  8 HR. DAYS, 5 DAYS/WEEK FOR MANAGEMENT, ENGINEERING & PROCUREMENT ACTIVITIES
     (B)  8 HR. DAYS, 6 DAYS/WEEK FOR FABRICATION, LOADOUT, & SEAFASTENING ACTIVITIES
     (C)  24 HR. DAYS, 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES
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CLIENT:                                                                                                                                                                FLUOR OCEAN SERVICES
LOCATION: NORTON SOUND                                                                                                                                                 REPORT NBAR3PAGE:
                                                               NORTON  SOUND  STUDY  SCHEDULE
                                                        70  FOOT  MLLW  JACKET  CONFIGURATION
                                                                 (LEVEL-III CONTROL SCHEDULE)
CONTRACT: 411093                                                                                                                                                       STATUS DATE:16-MAR-82
PROJECT MANAGER: JE LACY/BR PIER                                                                                                                                       DATE: 17-MAR-82
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
ERECTION & COMMISSIONING
                                                                           EACH SPACE REPRESENTS ONE WEEK                                                        DURATION     EARLY     EARLY
RN          DESCRIPTION                                                                                                                                          IN WEEKS     START     FINISH
                                        NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
                                        84  84  85  85  85  85  85  85  85  85  85  85  85  85  86  86  86  86  86  86  86  86  86  86  86  86  87  87  87  87  87  87  87  87  87
                                        I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I---I--I
87  PREPARE TOWER FOR MODULES           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I      0.0      23-AUG-87 23-AUG-87
88  SET PB                              I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I      0.1      23-AUG-87 24-AUG-87
89  REANCHOR DERRICK VESSEL(S)          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I      0.0      24-AUG-87 24-AUG-87
90  SET PC                              I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I      0.1      24-AUG-87 25-AUG-87
91  SKID PB & PC                        I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I X I  I      0.2      25-AUG-87 26-AUG-87
92  SET WA                              I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I      0.1      27-AUG-87 27-AUG-87
93  REANCHOR DERRICK VESSEL(S)          I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I      0.0      28-AUG-87 29-AUG-87
94  SET PD                              I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I      0.1      29-AUG-87 29-AUG-87
95  REANCHOR DERRICK VESSEL             I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I      0.0      29-AUG-87 29-AUG-87
96  SET DB1,DC1,DD1,EL-1A, & ME-8A      I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I      0.1      29-AUG-87 29-AUG-87
97  REANCHOR DERRICK VESSEL             I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I      0.0      30-AUG-87 30-AUG-87
98  SET DB2, DC2, DD2, EL-1B, & ME-8B   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I      0.1      30-AUG-87 30-AUG-87
99  REANCHOR DERRICK VESSEL             I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I      0.0      30-AUG-87 30-AUG-87
100 SET CQ-1B AND CQ-1A                 I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I      0.1      31-AUG-87 31-AUG-87
101 REANCHOR DERRICK VESSEL             I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I      0.0       1-SEP-87  1-SEP-87
102 SET/SKID DA                         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I      0.1       1-SEP-87  1-SEP-87
103 SET RM-1A & FB-1A                   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I      0.1       1-SEP-87  2-SEP-87
104 REANCHOR DERRICK VESSEL             I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  XI  I      0.0       2-SEP-87  2-SEP-87
105 SET RM-1B & FB-1B                   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X  I      0.1       3-SEP-87  3-SEP-87
106 PERFORM MISCELLANEOUS LIFTS         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   X  I      0.1       4-SEP-87  4-SEP-87
107 COMMISSION CRANES & QTRS            I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   XX I      0.9       5-SEP-87 10-SEP-87
108 COMMISSION DRILLING PLANT           I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   IXXX      4.3      11-SEP-87 10-OCT-87
109 COMMISSION PRODUCTION PLANT         I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I   I  I      7.1      11-OCT-87 29-NOV-87
NOTES:
(1)   EARLY ACTIVITY SHOWN 'XXX', ALLOWABLE FLOAT (SLACK) SHOWN'.....'
(2)   CALENDAR DURATIONS BASED ON:
      (A)   8 HR. DAYS, 5 DAYS/WEEK FOR MANAGEMENT, ENGINEERING & PROCUREMENT ACTIVITIES
      (B)   8 HR. DAYS, 6 DAYS/WEEK FOR FABRICATION, LOADOUT, & SEAFASTENING ACTIVITIES
      (C)   24 HR. DAYS, 7 DAYS/WEEK FOR TRANSPORTATION & INSTALLATION AND ERECTION & COMMISSIONING ACTIVITIES
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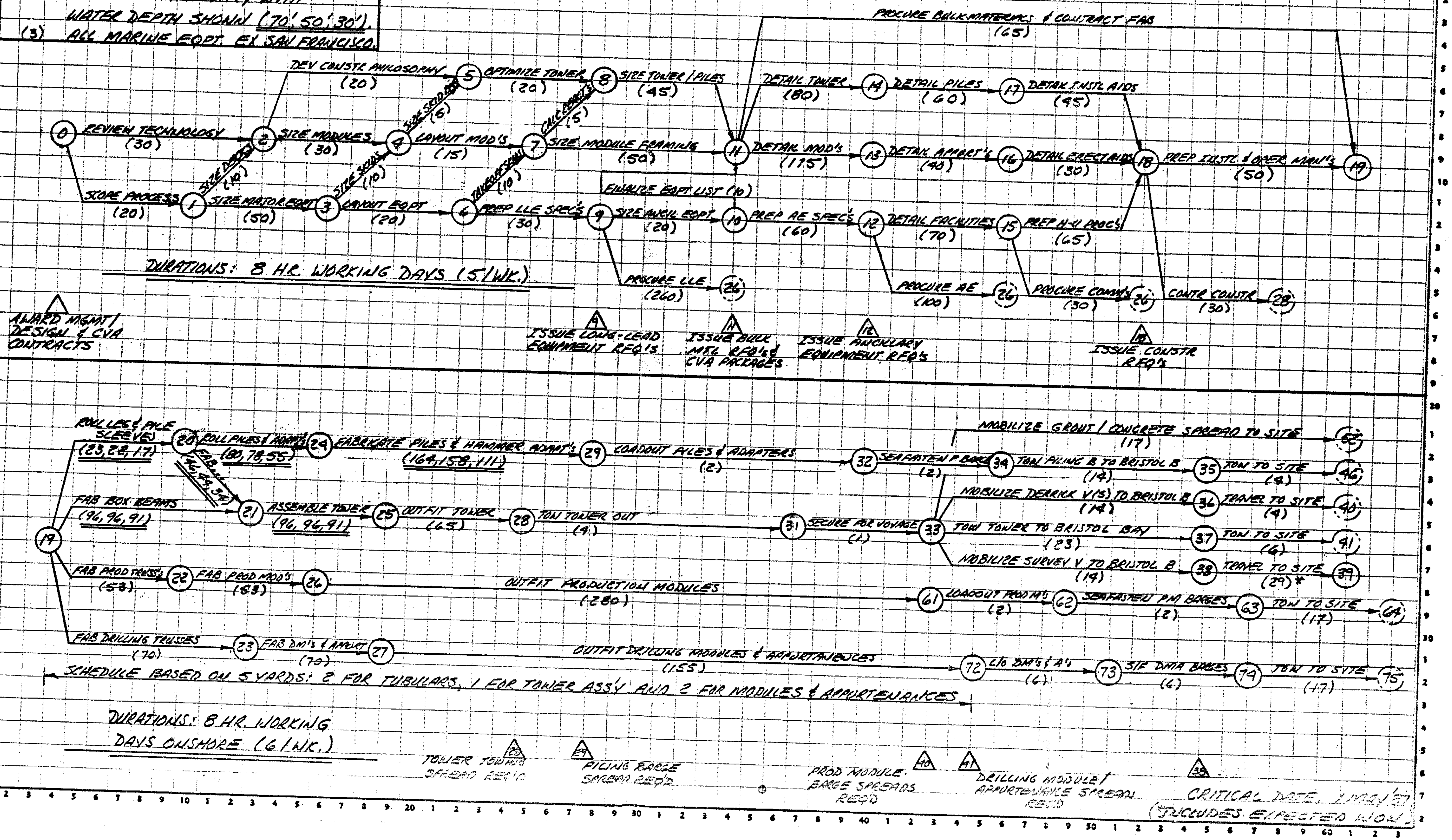
SOCAL/NORTON SOUND STUDY
PROJECT EXECUTION NETWORK/JACKET CONCEPT

FLUOR

MARCH 9, 1982
CONT. NO. 411093
BY BR PIER PE CHK'D
SHEET NO. 1 OF 2

NOTES:
(1) ALL DURATIONS 24 HR WORK DAYS U.N.
(2) DURATIONS THAT VARY WITH WATER DEPTH SHOWN (70', 50', 30').
(3) ALL MARINE EQPT. EX SAN FRANCISCO.

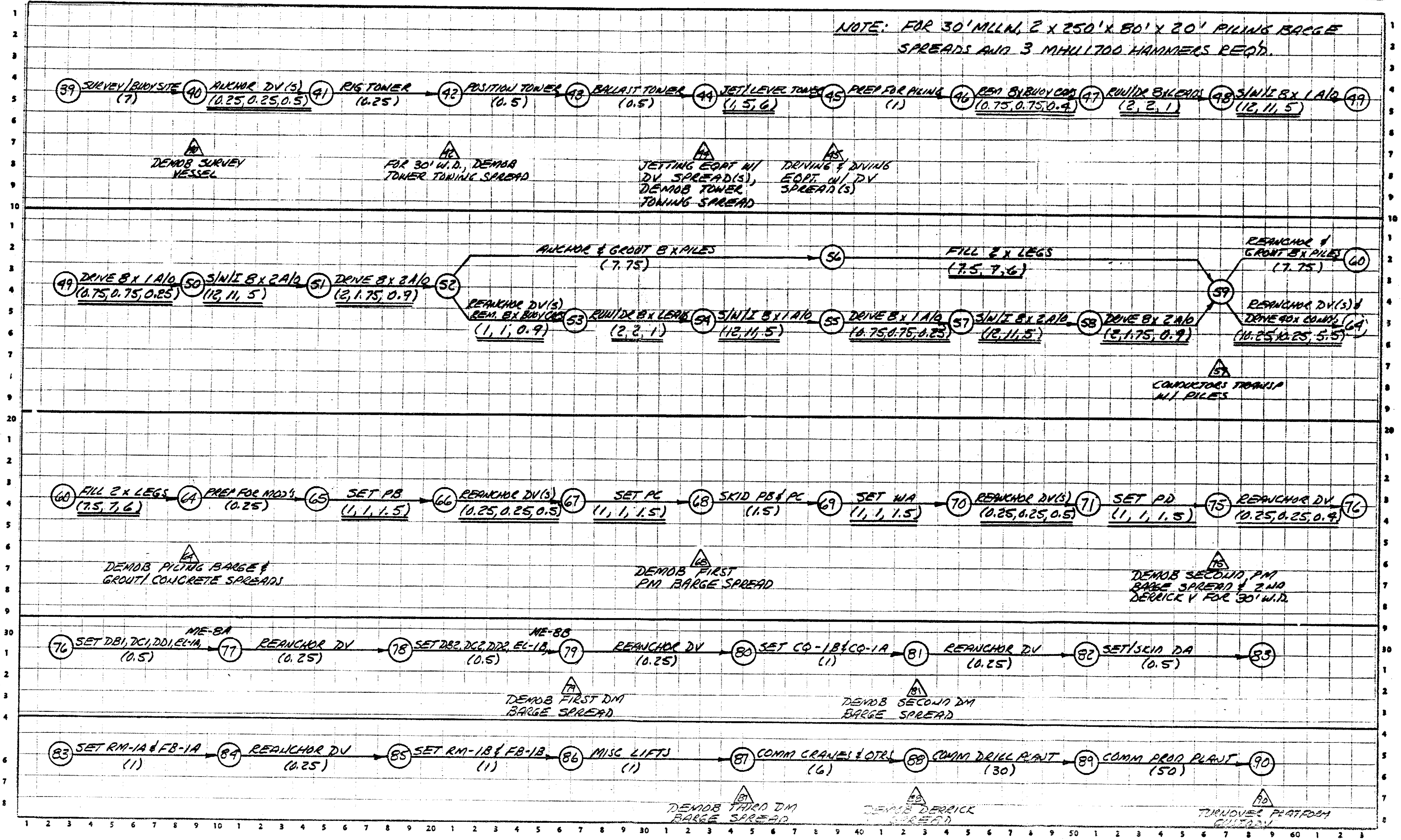


FORM E-082 R
PRINTED IN U.S.A.

FLUOR

MARCH 9, 1982
CONT. NO. 41093
BY BP Per PE CHK'D
SHEET NO. 2 OF 2

SOCAL/NORTON SOUND STUDY
PROJECT EXECUTION NETWORK/JACKET CONCEPT



ESTIMATE WORK SHEET

FLUOR OCEAN SERVICES

CUSTOMER SOCAL
LOCATION ALASKA
PROJECT NORTON SOUND STUDY

DESCRIPTION INSTALLATION SPREAD FOR JACKET, PILING AND CONDUCTORS
JACKET CONCEPT - 30' MWL

PROP. NO. 82-110-02
W.O. NO.
CONT. NO. 211093
MADE BY MKg
APPROVED

A/C NO.		
	JACKET CONCEPT : 30 FOOT MWL	($/DAY)
	2 - 800/1000 TON DERRICK VESSELS WITH TUGS, CREWBOATS AND OPERATION/ MAINTANENCE CREWS	75,000
	3 - 1.5 MILLION FOOT POUND PILE HAMMARS AND EQUIPMENT	45,000
	JETTING EQUIPMENT	6,500
	2 - AUTOMATIC WELDING MACHINES	600
	1 - ADDITIONAL AIR COMPRESSOR	700
	MISC. EQUIPMENT	3,000
	SMALL HAND TOOLS	3,600
	DIVING CREW	3,000
	LABOR - 70 MEN @ $60-/HR. X 12 HRS/DAY	50,400
	LABOR ROTATION COST @ 50% OF BASE LABOR	25,200
	TOTAL SPREAD DAILY RATE	238,000

F.O.S. 1918 V

DATE 3/12/82 REVISION NO. ______ REVISION DATE ______ PAGE NO. 1 OF 7

ESTIMATE WORK SHEET

FLUOR OCEAN SERVICES

CUSTOMER Socal
LOCATION Alaska
PROJECT Norton Sound Study

DESCRIPTION Installation Spread for Jacket, Piling and Conductors
Jacket Concept - 50' & 70' MWL

PROP. NO. 82-110-02
W.O. NO.
CONT. NO. 41393
MADE BY MG
APPROVED

A/C NO.		
	JACKET CONCEPT : 50' AND 70' MWL	($/DAY)
	1 - 1600/2000 TON DERRICK VESSEL WITH TUG, CREWBOAT AND OPERATION/MAINTANENCE CREW	76,000
	2 - 1.5 MILLION FOOT POUND PILE HAMMARS W/ EQUIPMENT	30,000
	JETTING EQUIPMENT	4,500
	2 - ADDITIONAL AUTOMATIC WELDING MACHINES	600
	1 - ADDITIONAL AIR COMPRESSOR	700
	MISC. EQUIPMENT	5,000
	SMALL HAND TOOLS	3,000
	LIVING CREW	2,000
	LABOR - 70 MEN @ $60/HR X 12 HRS/DAY	50,400
	LOCATION @ 50% OF LABOR COST	25,700
	TOTAL SPREAD DAILY RATE	204,000

DATE 3/12/82 REVISION NO. ____ REVISION DATE ____ PAGE NO. 2 of 7

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ESTIMATE WORK SHEET

FLUOR OCEAN SERVICES

CUSTOMER Socal

LOCATION Alaska

PROJECT Norton Sound Study

DESCRIPTION Installation Spread for Modules and Packages

Jacket Concept - 30' MWL

PROP. NO. 82-110-02

W.O. NO.

CONT. NO. 411093

MADE BY MG

APPROVED

A/C NO.		
	JACKET CONCEPT - 30' MWL	(#/DAY)
	2 - 800/1000 TON DERRICK VESSELS WITH TUGS, CREWBOATS, OPERATION AND MAINTANENCE CREWS	95,000
	2 - SKIDDING LUCKERS	4,000
	3 - ADDITIONAL WELDING MACHINES	[illegible]
	3 - " CUTTING RIGS	500
	2 - " AIR COMPRESSORS	[illegible]
	MISC. EQUIPMENT	5,000
	SMALL HAND TOOLS	3,600
	X-RAY EQUIPMENT	2,000
	PAINTING/SAND BLASTING EQUIPMENT	[illegible]
	WORKBOAT	[illegible]
	HELICOPTER SERVICE	2,000
	LABOR - 50 MEN @ $60/HR. x 12 HRS/DAY	36,000
	LABOR ROTATION COST @ 50% OF ABOVE LABOR	18,000
	TOTAL SPREAD DAILY RATE	182,000

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F.O.S. 1918 V

ESTIMATE WORK SHEET

FLUOR OCEAN SERVICES

CUSTOMER Sohio

LOCATION ALASKA

PROJECT NORTON SOUND STUDY

DESCRIPTION INSTALLATION SPREAD FOR MODULES AND PACKAGES

JACKET CONCEPT - 50' & 70' MWL

PROP. NO. 82-110-02

W.O. NO.

CONT. NO. [illegible]

MADE BY [illegible]

APPROVED

A/C NO.		
	JACKET CONCEPT - 50' AND 70' MWL	([illegible])
	1 - 1600/2000 TON DERRICK VESSEL WITH TUG & CREWBOAT AND OPERATION/ MAINTENANCE CREWS	75,500
	2 - SKIDDING JACKS	4,000
	8 - ADDITIONAL WELDING MACHINES	600
	6 - " CUTTING RIGS	500
	2 - " AIR COMPRESSORS	700
	SMALL HAND TOOLS	[illegible]
	X-RAY EQUIPMENT	[illegible]
	PAINTING/SANDBLASTING EQUIPMENT	[illegible]
	MISC. EQUIPMENT	5,000
	WORKBOAT	[illegible]
	HELICOPTER SERVICE	3,000
	LABOR - 50 MEN @ $50/HR. x12 HRS/DAY	[illegible]
	LABOR ROTATION COST @ 50% OF ABOVE LABOR	15,000
	TOTAL SPREAD DAILY RATE	162,500

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ESTIMATE WORK SHEET

FLUOR OCEAN SERVICES

CUSTOMER SOCAL

LOCATION ALASKA

PROJECT NORTON SOUND STUDY

DESCRIPTION HOOKUP/CHECKOUT SPREAD FOR JACKET CONCEPT IN 30', 50' AND 70' MWL

PROP. NO. 82-110-02

W.O. NO.

CONT. NO. [illegible]

MADE BY

APPROVED

A/C NO.		
	JACKET CONCEPT - 30', 50' AND 70' MWL	($/DAY)
	LABOR - 100 MEN @ $60/HR X 12 HRS/DAY	72,000
	LABOR ROTATION @ 50% OF LABOR	36,000
	HAND TOOLS	3,600
	MISC. EQUIPMENT	5,000
	HELICOPTER SERVICE	3,000
	TOTAL SPREAD DAILY RATE	119,600

F.O.S. 1918 V

DATE 3/12/82 REVISION NO. ______ REVISION DATE ______ PAGE NO. 5 OF 7

ESTIMATE WORK SHEET

FLUOR OCEAN SERVICES

CUSTOMER SOCAL
LOCATION ALASKA
PROJECT NORTON SOUND STUDY

DESCRIPTION INSTALLATION
SPREAD FOR MODULES
AND [illegible]

BARGE CONCEPT - 30' MWL

PROP. NO. 22-112-02
W.O. NO.
CONT. NO. [illegible]
MADE BY [illegible]
APPROVED

A/C NO.	SAN FRANCISCO BAY AREA	
	BARGE CONCEPT - 30' MWL	([illegible])
	1 - 800/1000 TON DERRICK VESSEL WITH TUG, CREWBOAT AND OPERATION/ MAINTENANCE CREW	50,000
	2 - SKIDDING LUCKERS	4,000
	3 - ADDITIONAL WELDING MACHINES	[illegible]
	5 - " CUTTING RIGS	500
	2 - " AIR COMPRESSORS	[illegible]
	SMALL HAND TOOLS	2,500
	X-RAY EQUIPMENT	3,000
	PAINTING/SANDBLASTING EQUIPMENT	[illegible]
	MISC. EQUIPMENT	5,000
	WORK BOAT	8,500
	LABOR - 100 MEN @ $40/HR. X 12 HRS/DAY	48,000
	TOTAL SPREAD DAILY RATE	128,000

F.O.S. 1918 V

DATE 3/12/82 REVISION NO. ______ REVISION DATE ______ PAGE NO. 6 OF 7

ESTIMATE WORK SHEET

FLUOR OCEAN SERVICES

CUSTOMER Socal

LOCATION Alaska

PROJECT Norton Sound Study

DESCRIPTION Hookup/Checkout Spread

Barge Concept - 30' MWL

PROP. NO. 82-110-02

W.O. NO.

CONT. NO. [illegible]

MADE BY [illegible]

APPROVED

A/C NO.	SAN FRANCISCO BAY AREA	
	BARGE CONCEPT - 30' MWL	[illegible]
	LABOR - 100 MEN @ $60/HR. x 12 HRS./DAY	72,000
	SMALL HAND TOOLS	4,700
	MISC. EQUIPMENT	5,700
	CREW BOAT	5,800
	WORK BOAT	[illegible]
	TOTAL SPREAD DAILY RATE	100,000

F.O.S. 1918 V

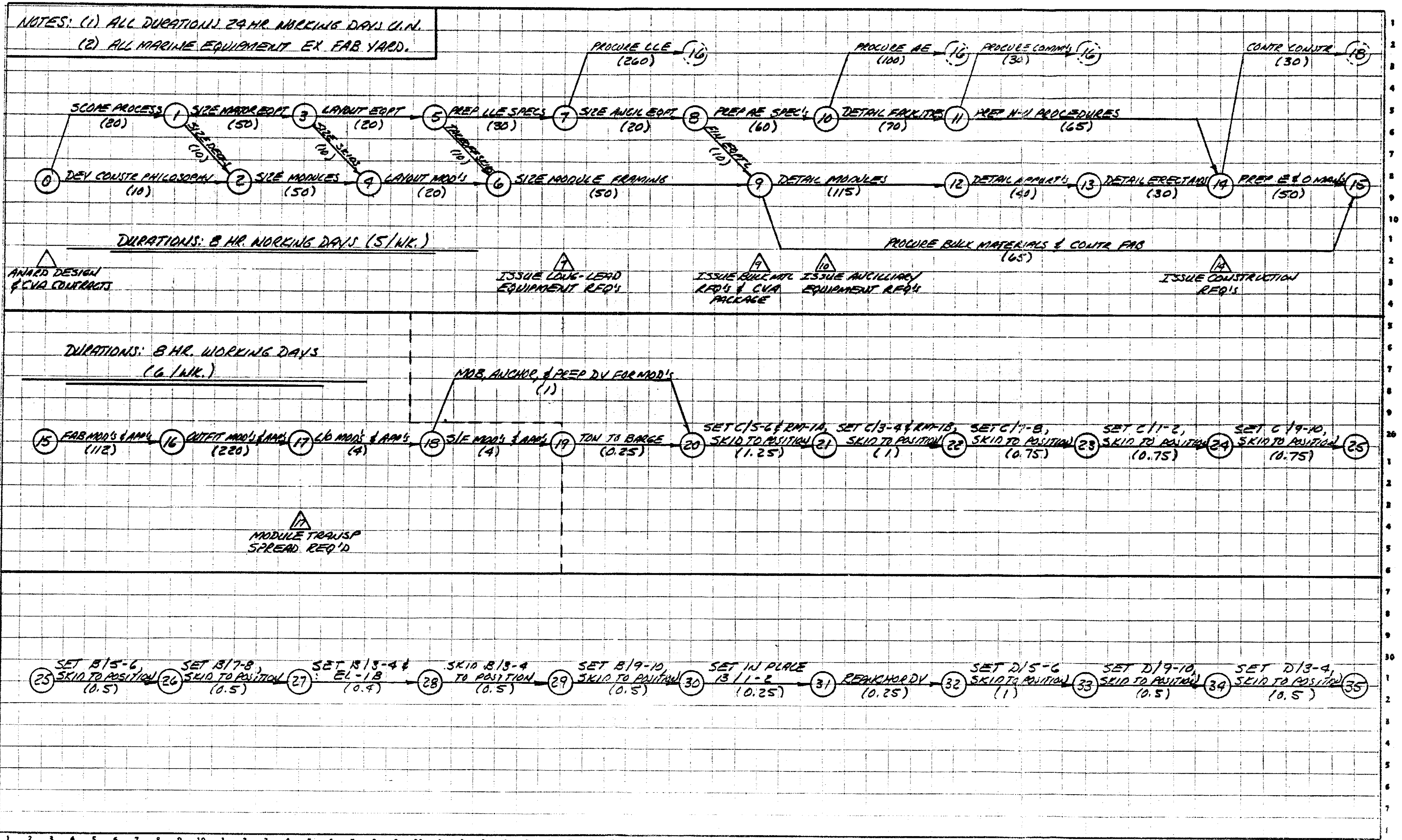
DATE 3/12/82 REVISION NO. ______ REVISION DATE ______ PAGE NO. 7 OF 7

FLUOR

MARCH 10, 1982
CONT. NO. 411095
BY RR PIER AE CHK'D
SHEET NO. 1 OF 2

SOCAL / NORTON SOUND STUDY
PROJECT EXECUTION NETWORK / BARGE CONCEPT

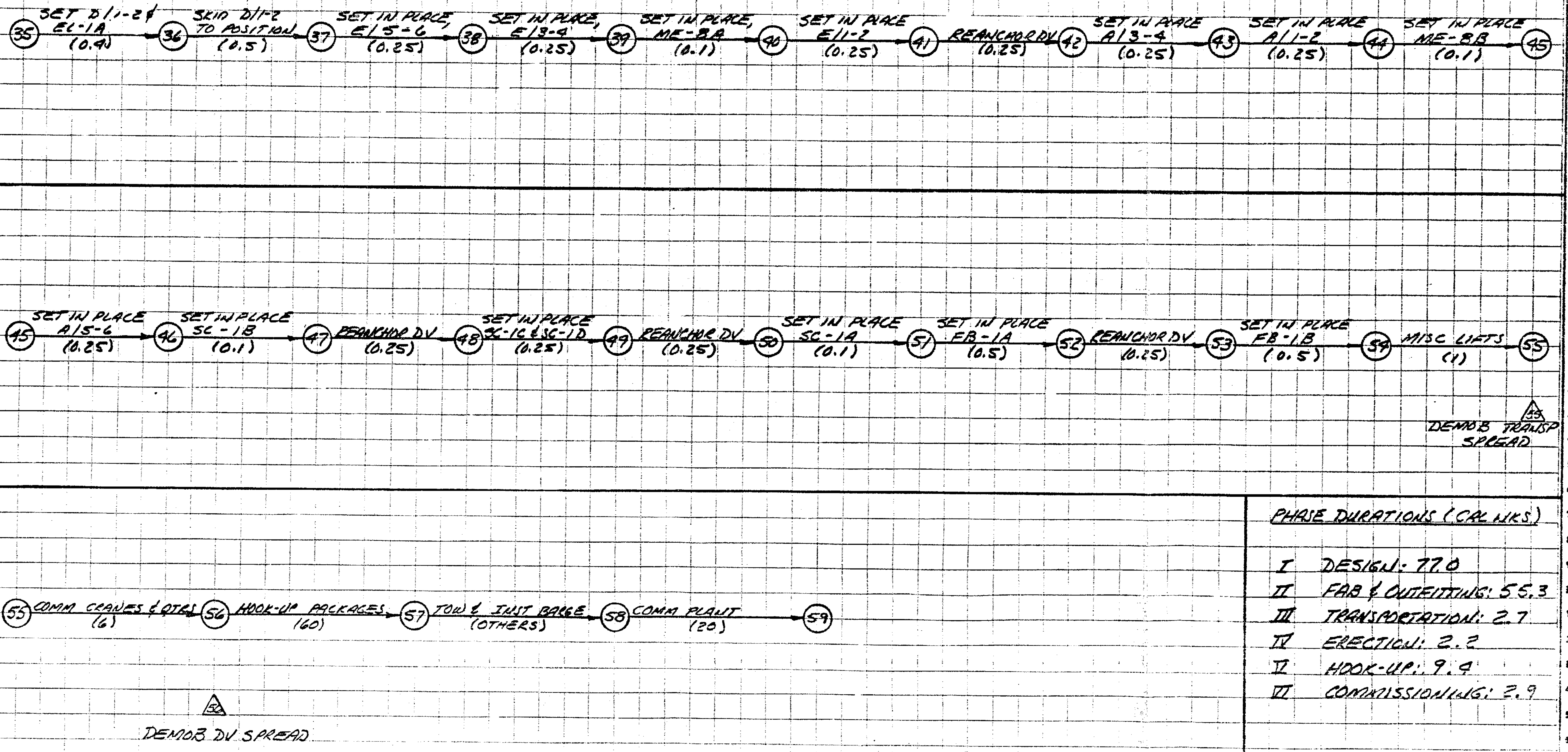
NOTES: (1) ALL DURATIONS 24 HR. WORKING DAYS U.N.
(2) ALL MARINE EQUIPMENT EX FAB YARD.



FLUOR

MARCH 10, 1982
CONT. NO. 911093
BY BRAER, PE CHK'D
SHEET NO. 2 OF 2

SOCAL / NORTON SOUND STUDY
PROJECT EXECUTION / BARGE CONCEPT



PHASE DURATIONS (CAL WKS)

I DESIGN: 77.0
II FAB & OUTFITTING: 55.3
III TRANSPORTATION: 2.7
IV ERECTION: 2.2
V HOOK-UP: 9.4
VI COMMISSIONING: 2.9

FORM F-052 R1
PRINTED IN U.S

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PROJECT NORTON SOUND PLATFORM
SUBJECT COST ESTIMATE
SUMMARY - CONCRETE STRUCTURE

SHEET NO. 1 OF 33
DES. EWO
JOB NO. A82001
DATE 12 MARCH 82

BARGE ASSEMBLY SUMMARY

	CONCRETE CY	$ x 10^3 EQUIPMENT & MATERIALS	$ x 10^3 LABOR
I. PONTOONS			
Precast Concrete			
Bulkheads	11,389	$ 2,652	$ 1,465
Deck Panels	2,249	$ 416	$ 173
Precast Panel Erection	-	-	$ 384
Cast-In-Place Concrete			
Pilasters & Closure Pours	2,804	$ 422	$ 1,037
Keel Slab	6,070	$ 1,494	$ 496
Exterior Bulkhead - Ice Zone	3,248	$ 1,077	$ 513
Deck Slab	3,044	$ 1,006	$ 306
Post Tensioning	-	$ 791	$ 148
Float - Out & Graving Dock Prep	-	$ 20	$ 15
Sub Total Pontoons	28,804	$ 7,878	$ 4,537
II JOINTING	374	$ 414	$ 185
III SUPERSTRUCTURE			
Precast Concrete (Skid Beam)	835	$ 236	$ 191
Skid Beam Erection	-	$ 86	$ 27
Cast-in-Place Concrete	6,725		
Wave Barrier	1,934	$ 1,799	$ 860
Shear Walls / Columns.	-	$ 481	$ 213
Steel	-	$ 1,613	$ 1,499
Subtotal - Superstructure	$ 9,494	$ 4,215	$ 2,790
Sub-Total Barge			
Lost-Time (20%) ON CONCRETE WORK (ITEMS I - III)			$ 1,202
TOTAL BARGE	38,672	12507	8,714

2/33

NO.	DESCRIPTION	MATERIAL				EQUIPMENT				LABOR				SUB CONTRACTS	TOTAL
		UNIT	QTY	UNIT PRICE	COST	UNIT	QTY	UNIT PRICE	COST	UNIT	QTY	UNIT PRICE	COST		
	CIP BARGE JOINTING														
1.	Special Embedments														
	Guide Pins & Allignment Hardware	lb.	9000	0^{25}	$2250					lb	9000	1^{75}	15750		$18,000
	Rubber Gaskets	LS			$230,000										$ 230,000
	Steel For Rubber Gaskets	lb	21000	0^{25}	$ 5250					lb	21000	0^{25}	$ 5250		$ 10,500
2.	Pontoon Launching & Meting														
	Tugs					LS		8,000							8,000
	Labor									MHR	280	22	6160		6 160
-2a	Surface Preparation- Waterblasting w/ Divers					LS		3000		MHR	384	2/3 divers 1/3 labor	115^{00} = 29,440 22^{00} = 2816		29,440 2,816
3.	Ballasting, Joining & Dewatering														
	Pumps					LS		4200							4200
	Winches					LS									
	Labor									MHR	360	22	7920		$ 7920
4.	Post-Tensioning														
	12 Strand Tendons	lb	103,459	$\$0^{90}$	93113										93,113
	Labor									MH	3667	$22	$30,674		$ 80,674
	Scaffold, etc.					LS		12,800							$ 12,800
5	Grout Joint														
	Superplasticized Concrete	cy	374	135	$ 50,490										$ 50,490
	Pump.					LS		4480							4480
	Labor									MH	448	x22	9856		9856
					301,103			32,480					$157,866		
	20% LOST TIME FOR FIELD LABOR.												27,373		$ 27373
						$413,583							$185,239		595,822

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ENGINEERING COST ESTIMATE
Project

File No. AB2001
Date 4 MAR 92
Des EWJ
Chk
Est No.
Sht of

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PROJECT Norton Sound
SUBJECT Cost Summary – Deployment
SHEET NO. 3 OF 33
DES. [illegible]
JOB NO.
DATE 2/24/82

DELIVERY VOYAGE

ITEM	UNIT	UNIT COST	QUANTITY	AMOUNT	SUB-TOTAL
DELIVERY VOYAGE:					
MOBILIZE TUGS	LS	$300,000		$300,000 ✓	
TOW (4 TUGS)	DAY	$60,000	38	2,280,000	
EST. DOWN TIME	DAY	36,000	7	250,000	
DEMOBILIZE TUGS	LS	$1,020,000		1,020,000 ✓	
TOW INSURANCE (1½%)	LS	$2,962,000		$2,962,000	
OVERHEAD				580,000	
					$7,392,000

PROJECT NORTON SOUND

SUBJECT DELIVERY VOYAGE - MOB/DE-MOB TUGS

SHEET NO. 4 OF 33
DES. JF
JOB NO.
DATE

ASSUME: → MOB - DEMOB POINTS
2 TUGS - PUGET SOUND
1 TUG - CALIF.
1 TUG - GULF OF MEXICO

→ SPEED = 12 KNOTS

DISTANCE:

PUGET SOUND - NORTON SOUND	2300	NAUTICAL MILES
S.F. - PUGET SOUND	900	" "
GULF - PUGET SOUND	5000	" "

MOB TUGS.

1 @ 900 NAUTICAL MILES
1 @ 5000 NAUTICAL MILES

$$\frac{5900 \text{ Naut. Miles}}{12 \text{ KNOTS}} = 492 \text{ hrs.} = 20.5 \text{ days.}$$

$$\text{Mob} = 20.5 \times \$15{,}000/\text{day} = \underline{\underline{\$307{,}000}}$$

DE-MOB TUGS

2 @ 2300 N.M.
1 @ 2300 + 900 = 3200 N.M.
1 @ 2300 + 5000 = 7300 N.M.

$$\frac{15{,}100 \text{ N.M.}}{12 \text{ KNOTS}} = 1258 \text{ hrs} = 52.4 \text{ days}$$

Say Down Time = 20% (52.4 + 20.5) = 15 days

$$\text{DeMob} = (53 + 15) \times \$15000/\text{day} = \underline{\underline{\$1{,}020{,}000}}$$

PROJECT Norton Sound
SUBJECT Deployment Costs
SHEET NO. 5 OF 33
DES.
JOB NO.
DATE

Delivery Voyage Tow

DISTANCE: Puget Sound → Norton Sound = 2300 N. Miles

Assume Avg. Tow Speed = 2.5 knots

$$\text{TIME} = \frac{2300\ \text{N.M.}}{2.5\ \text{K}} = 920\ \text{hrs} = 38\ \text{days.}$$

38 days @ $15,000/day x4 = **$2,280,000**

down time = 20% = 7 days @ $9,000/day x4 = **$252,000**
↖ less fuel

rate per Crowley $9000/day/tug

Fuel Say 6500 gallons/day x $0.95/gal = $6175/day

Say TOTAL **$15000/day**

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PROJECT 907.4 205
SUBJECT
SHEET NO. 6 OF 33
DES. EWO
JOB NO.
DATE

INSURANCE	7378	5444		
	4629	3270		X 10^3
Barge	12,507	8714	21,221	
mob	137		137	
Cnst. Fee.	4980		4330	
Field Staff		1151	1151	
			27339	
Profit			4,108	
			31,497	
Module Fabr & Erect			166,000	
			197,497 x 10^3	

Ins. 1½% x 197497 = 2,962,000

PROJECT Norton Sound
SUBJECT Cost Summary — Deployment
SHEET NO. 7 OF 33
DES. [illegible]
JOB NO.
DATE 2/24/82

Site Construction

ITEM	UNIT	UNIT COST	QUANTITY	AMOUNT	SUB-TOTAL
Mobilize	LS	$ 1,000,000		$ 1,000,000	
Position Barge	DAY				
Est. Down Time	DAY	$ 172,000	4	$ 640,000	
Ballast Operations	DAY	112,000	31	$ 3,470,000	
Est. Down Time	DAY	112,000	6	670,000	
Rip Rap!					
Material (F.O.B. Nome)	TON	$50*	8500	$ 430,000	
Transport & place	DAY	$ 112,000	18	2,020,000	
Est. Down Time	DAY	$ 112,000	4	450,000	
Dewatering System	LS	$ 690,000		$ 690,000	
Ballasting System	LS	$ 658,000		$ 658,000	
De Mobilization	LS	$ 1,000,000		$ 1,000,000	
Overhead				$ 1,650,000	$ 12,678,000

* Based upon escalation of 1978 price given in PMB study.

PROJECT Norton Sound
SUBJECT Deployment
SHEET NO. 8 OF 33
DES.
JOB NO.
DATE

MOB / DE-MOB : INSTALLATION SPREAD

1 tug	$15,390/day
1 barge	$2,000/day
Dredge Unit	$14,085/day
Cranes	$1605/day
Crew: 10 men x 8 hrs x $55/hr	$4400/day
10 men x 4 hrs x $55/hr x 2	$4400/day
	$41,880/day

Say Mob from Puget Sound, 5 knot Avg. Speed

$$\frac{2300 \text{ Nautical Miles}}{5 \text{ knots}} = 460 \text{ hrs} = 19 \text{ days}$$

Allow 20% down time

Mob = 19 days x 1.20 x $41,880/day = $955,000

SAY $1,000,000

ASSUME LOCAL AVAILABILITY OF FLATDEC BARGES.

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PROJECT Norton Sound
SUBJECT Deployment

SHEET NO. 9 OF 33
DES.
JOB NO.
DATE

PLACE Rip·Rap

→ Assume Site 70 Nautical Miles from Nome

→ Assume Speed = 10 knots Empty
= 5 knots Loaded

$$\text{Round Trip} = \frac{70\ \text{N.M.}}{10\ \text{knots}} + \frac{70\ \text{N.M.}}{5\ \text{knots}} = 21\ \text{hrs.}$$

Load = 8 hrs

Unload = 8 hrs

37 hrs.

For 7000 CY Material, 2×300 CY = 600 CY/trip

$$\#\ \text{Trips} = \frac{7000}{300 \times 2} = 12$$

Duration = 12 trips × 37 hrs = 444 hrs = 18.5 days

Rip Rap Material Costs

Per PMB Study Cost = \$35/ton (1978)

Escalate By 15%, 15%, 10%

∴ Cost = \$35/ton × 1.15 × 1.15 × 1.10 = \$50/ton Say

PROJECT NORTON SOUND
SHEET NO. 10 OF 33
DES.
SUBJECT DEPLOYMENT COSTS
JOB NO.
DATE

DEWATERING SYSTEM
(SEE ENCLOSED SKETCHES)

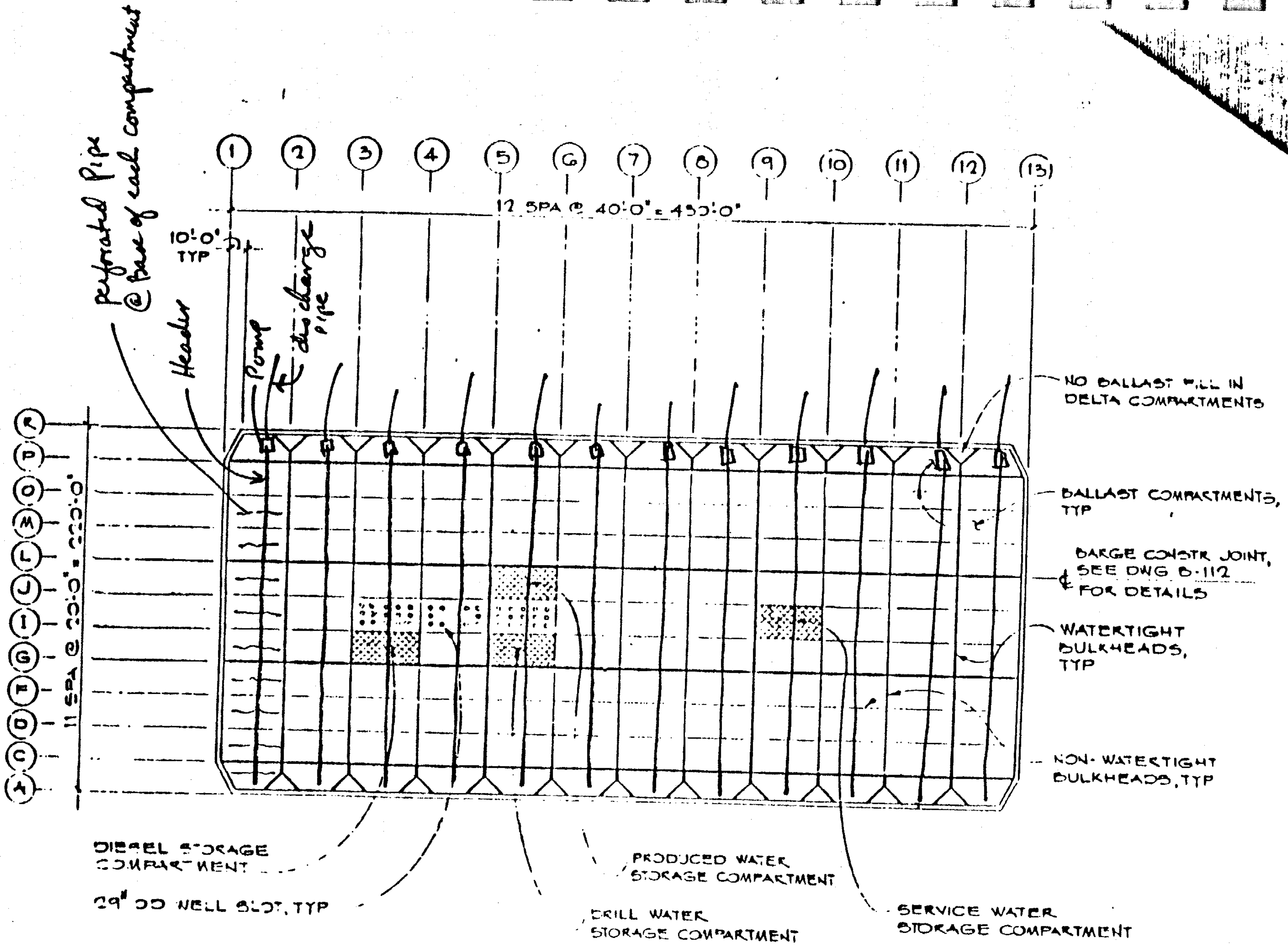
SAY 8" ϕ PERF. PIPE 480 LF x 11 = 5280 LF
5280 LF x 43.4#/1 = 230,000#
8" ϕ RISERS 60 LF x 132 = 7920 LF
8" ϕ HEADERS 220 LF x 12 = 2640 LF
DISCHARGE PIPE 100 LF x 12 = 1200 LF
Σ = 11760 LF
11760 LF x 43.4#/1 = 510,400#

PURCHASE PRICE $0.60/# PIPE (PER MEANS)
$0.70/# PERF. PIPE

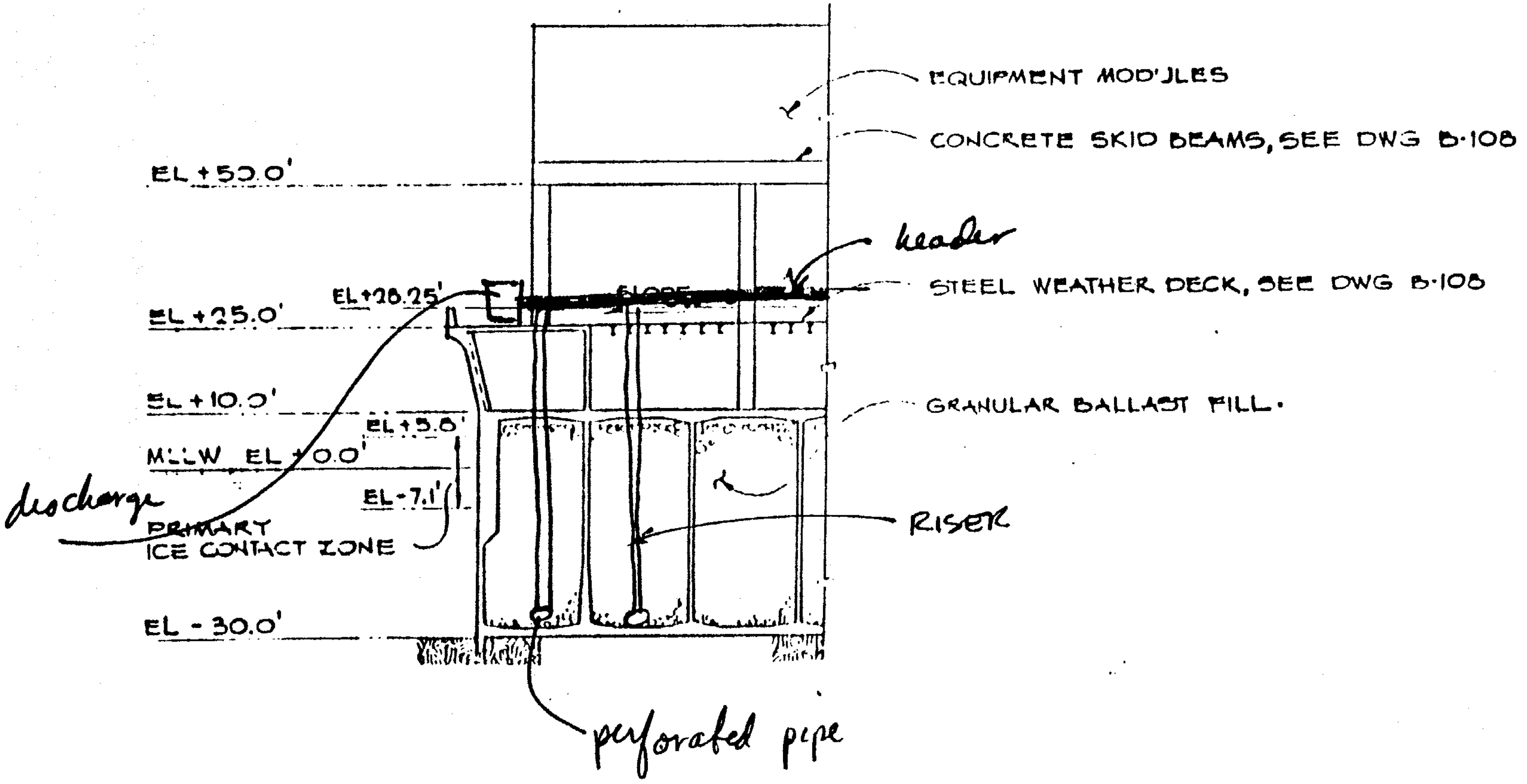
PIPE COSTS $0.60 x 510,400# = $306,200
PERF PIPE $0.70 x 230,000# = $161,000

INSTALL SAY $0.05/lb. x 740,400# = $37,000

RENT PUMPS: 12 + 3 STANDBY x $2000/MO x 4 MO = $120,000
Σ = $624,200
10% CONTINGENCY = 62,400
TOTAL = $686,600
SAY $690,000


perforated Pipe
@ base of each compartment
Header
Pump
discharge pipe
10'-0" TYP
12 SPA @ 40'-0" = 480'-0"
11 SPA @ 20'-0" = 220'-0"
1
2
3
4
5
6
7
8
9
10
11
12
13
R
P
O
M
L
J
I
G
F
D
C
A
NO BALLAST FILL IN DELTA COMPARTMENTS
BALLAST COMPARTMENTS, TYP
BARGE CONSTR JOINT, SEE DWG B-112 FOR DETAILS
WATERTIGHT BULKHEADS, TYP
NON-WATERTIGHT BULKHEADS, TYP
DIESEL STORAGE COMPARTMENT
29" OD WELL SLOT, TYP
PRODUCED WATER STORAGE COMPARTMENT
DRILL WATER STORAGE COMPARTMENT
SERVICE WATER STORAGE COMPARTMENT

12/33


EQUIPMENT MODULES
CONCRETE SKID BEAMS, SEE DWG B-108
header
STEEL WEATHER DECK, SEE DWG B-108
SLOPE
GRANULAR BALLAST FILL.
RISER
perforated pipe
EL +50.0'
EL +28.25'
EL +25.0'
EL +10.0'
EL +5.0'
MLLW EL +0.0'
EL -7.1'
PRIMARY
ICE CONTACT ZONE
EL - 30.0'
discharge

PROJECT Norton Sound

SUBJECT Deployment Costs

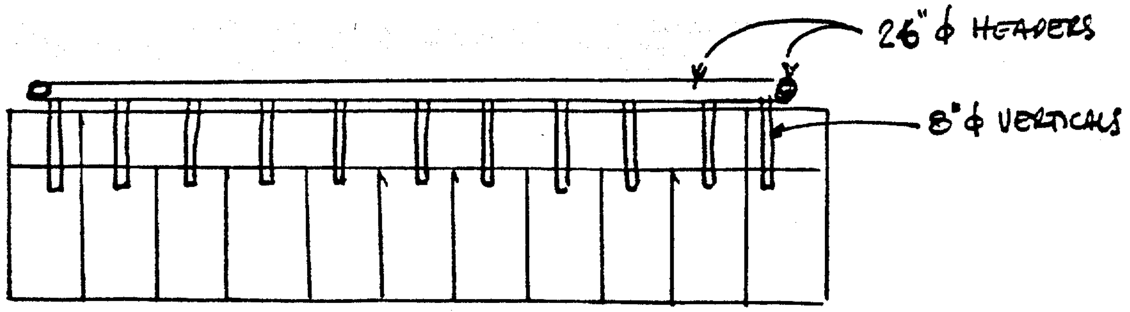
SHEET NO. 13 OF 23

DES.

JOB NO.

DATE

BALLASTING SYSTEM



26" ϕ HEADERS

2 × 480 LF + 12 × 200 = 3360 LF

SAY 26" OD , 24" ID A = 78.5 in² W = 267 #/'

TOTAL W = 897,100#

8" ϕ VERTICALS

11 × 20' × 12 = 2640 LF

W = 2640 LF × 43.4 #/' = 114,600#

PIPE COST = $0.60/lb × (897,100# + 114,600#) = $607,020

INSTALL $0.05/lb × (897,100# + 114,600#) = $50,600

$657,620

SAY $658,000

14/33

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ENGINEERING COST ESTIMATE
Project
File No. 182001
Date 12 MARCH 82
Des
Chk
Est No.
Sht of

NO.	DESCRIPTION	MATERIAL UNIT	MATERIAL QTY	MATERIAL UNIT PRICE	MATERIAL COST	EQUIPMENT UNIT	EQUIPMENT QTY	EQUIPMENT UNIT PRICE	EQUIPMENT COST	LABOR UNIT	LABOR QTY	LABOR UNIT PRICE	LABOR COST	SUB CONTRACTS	TOTAL
	SITE FACILITIES & EQUIPMENT														
1.	GRAVING DOCK														
	(30 x 2500/day = 75,000/Mo x 12 Mo														
															$900,000
2.	CASTING & MATERIALS STORAGE SITE														
	1450/ACRE/Mo x 5 acres x 11 mos														$ 79,750
3.	DOCKSIDE MOORAGE - Assume 10 acres														
	w/ 500' of frontage														
	Landside $1450 x 10 x 14 mos														$ 203,000
	Waterside $725 x $\frac{500 \times 300}{43560}$ x 14 mos														$ 34,952
	MAJOR EQUIPMENT														1,217,702
1.	200 TON CRANE	OPERATING COSTS												MONTHLY	
	1 Shift w/ 2 operators	HR	5x22	53.45	9400/mo	Mo		14000/		HR	16x22	25	8800/mo	32200/mo	
	2 shifts w/ 2 operators (2@ 10 mos)	HR	16x22	53.45	18,800/mo	Mo		21,000		HR	32x22	25	17600/mo	57,400/mo	20 1,148,000
2.	70 TON CRANE (At Storage Site & Dockside) 1 YR	HR	8x22	21	3700	Mo		8200		HR	16x22	25	8800/mo	20700/mo	x 5 $103,500
	1 shift w/ 2 operator (5 mos)	HR	16x22	21	7900	Mo		12300		HR	32x22	25	17600/mo	37,300/mo	x 8 $298,400
	2 Shift w/ 2 operator (8 mos)														
3	20 TON CRANE														
	1 shift w/ 1 operator (@ 47 mos)	HR	8x22	13	2300	Mo		3000		HR	8x22	25	4400	9700/mo	x 47 455,900
	2 Shift w/ 1 operator (@ 8 mos)	HR	16x22	13	4600	Mo		4500		HR	16x22	25	8800	17900/mo	x 8 143,200
4.	2 TOWER CRANES (6 mos.)					Mo.	2	16950	$33,900	HR	16x22	25	4600	40,500 x 6	243,000
	ERECTION													20,000	20,000
															2,412,000
	MISC. EQUIP & MATERIALS														
	10% OF GROSS EQUIP & MATERIALS COSTS.	0.10 x	12,507,000												
															1,250,700
														TOTAL	4,880,402

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PROJECT NORTON SOUND PLATFORM
SUBJECT MOBILIZATION SUMMARY
SHEET NO. 15 OF 33
DES. EWO
JOB NO. A82001
DATE 16 MAR 82

FIELD STAFF			$83000
CRANES			
200 T	$10,000 ea/ea way	40,000	
70 T	3,000 ea/ea way	6,000	
20 T	1,000 ea/ea way	8,000	
		54,000	
DELIVERY VOYAGE	300,000 + 1,020,000 =		1,320,000
DEPLOYMENT			2000,000
			$ 3,457,000

16/22

NO.	DESCRIPTION	MATERIAL				EQUIPMENT				LABOR				SUB CONTRACTS	TOTAL
		UNIT	QTY	UNIT PRICE	COST	UNIT	QTY	UNIT PRICE	COST	UNIT	QTY	UNIT PRICE	COST		
	FIELD STAFF														
1	Construction Manager - (Mid range Project Mngr - VP x 1.3									Mo.	1	$6000	6000	x 21 mos	$126,000
2	Project Engineers (Mid Range - RE X1.3									Mo.	2	$4300	8600	x 21 mos	180,600
3.	Office Manager									Mo.	1	$2600	2600	x 21	54,600
4	Office Personell														
	Receptionist/Secretary									Mo	1	$1100	1100	x 21	23,100
	Purchasing Agent									Mo	1	$2500	2500	x 21	52,500
	Accounting									Mo	4	1600	6400	x 21	134,400
	Field Engineers - (Incl. Surveying)									Mo	4	3100	12,400	x 21	260,400
	Quality Assurance -									Mo	1	2500	2500	x 21	52,500
	Drafting (Shop Drawings)									Mo	4	2000	8000	x 15	120,000
5	Maintenance & Clean-up									Mo		1000	1000	x 21	21,000
6	Security Guards (3 shift/day + 1 extra for weekends)									Mo.	4	$1500	6000	x 21	126,000
															1,151,100
	FIELD STAFF MOBILIZATION														
	Office Trailer 2 (Double Wides.) 12x56 + Operating Costs									Mo	2	1000	2000	x 21	42,000
	Xerox Machine & Supplies									Mo		500	500 x	21 mos	10,500
	Outfit Work Stations									Per Employee	20	1000	20,000		20,000
	Telephones									Mo		500	500 x	x 21 mos	10,500
															$83,000

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ENGINEERING COST ESTIMATE

Project

File No. AB2001
Date 3 MAR 82
Des Ewo
Chk
Est No.
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PROJECT NORTON SOUND PLATFORM
SHEET NO. 17 OF 32
DES. EWD
SUBJECT COST ESTIMATE - SUMMARIES
CONCRETE UNIT PRICE & ENGR FEES
JOB NO. A82001
DATE 16 MARCH 82

Check Unit Costs - Concrete Barge Construction
x $1000

	MAT.	LABOR	TOTAL
Barge Construction	12,507	8714	21,221
Construction Facilities	4,880		
Mobil.	137		
Field Staff		1,151	
Subtotal	17,524	9,865	27,389
Profit 15%	2629	1480	4109
TOTAL CONSTRUCTION PRICE	20,153	11,345	31,498

UNIT PRICE $\frac{31,498,000}{38672} = \$815$

$\boxed{= \$815/cy}$

DESIGN FEE $31,498 x 0.04 = $1,260 x 10^3

INSPECTION $54,134 x 0.007 = $379 x 10^3

CONST MGMNT $54,134 x 0.03 = $1624 x 10^3

PROJECT NORTON SOUND PLATFORM
SUBJECT CONCRETE SUMMARY
SHEET NO. 18 OF 33
DES. EWO
JOB NO. A82001
DATE 8 MARCH 82

CONCRETE & OTHER WEIGHT SUMMARY

Precast Panels	368,225 cf
Pilasters & Closure Pours	75,720 cf
Keel Slab CIP	163,897 cf
Exterior CIP Blkd	87,698 cf
Deck Slab CIP	82,188 cf
Wave Barrier CIP	181,583 cf
Superstructure CIP	52,209 cf
Precast	22 547 cf
Construction Joint	10,098 cf
	1,044,164 cf => 38,673 cy

MATERIAL	UNIT	AMOUNT	UNIT WT	TOTAL WT (KIPS)
REBAR	KIPS	5449	-	5449
THREAD BAR	KIPS	1285	-	1285
MESH (WWF)	KIPS	857	-	857
1/2"ϕ STRAND	FT	310,667	0.525 lb/ft	163
4 STRAND TENDON	FT	33,904	2.10 lb/ft	71
6 " "	FT	70,392	3.15 lb/ft	222
10 " "	FT	5808	5.25 lb/ft	30
12 " "	FT	410,177	6.30 lb/ft	2,584
18 " "	FT	42,372	9.45 lb/ft	400
1"ϕ DYWIDAG BAR	FT	335,838	3.01	1,011
1 1/4"ϕ " "	FT	3,204	4.39	14
1 3/8ϕ " "	FT	44,545	5.56	248
TOTAL				12,334

$$\text{UNIT WEIGHT} = \frac{12,334,000}{1,044,164} = 12 \text{ lb/cf}$$

CONCRETE UNIT WEIGHT = 130 - 12 = 118 lb/c

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PROJECT NORTON SOUND PLATFORM
SUBJECT COST ESTIMATE PRECAST BLKD PANELS
SHEET NO. 19 OF 33
DES. EWO
JOB NO. 482001
DATE 10 MARCH 92

BULKHEAD PANELS

FORMWORK			# 54,620
MATERIALS			
	Concrete	$\frac{307510}{27}$ = 11389cy × $120/cy =	1,366,711
	Reber	1,520,559# × $0.22/lb =	334,523
	Mesh	275,865# × $0.30/lb =	82,760
P/T	1" DYWIDAG		
	DUCT	332,934 ft × $0.28/ft =	$ 93,222
	BAR	332,934 ft × $1.80 =	$ 599,281
	Dead End Anchor	4722 × 12 =	56,664
	Plate Anchor	4722 × 13.50 =	63,747
	1 3/8" DYWIDAG		
	Duct & Bar	35932 ft × 3.53 =	126 840
	Anchors	3100 × 26.25 =	81,375
		724 × 24.75	17,913
			2,596,708
LABOR			
	Concrete	5.5 hr/cy × 11389 × 22	1,378,069
	P/T	5910 Bars × 0.67 hr/Bar × 22	87,113
			$ 1,465,182
	TOTAL		4,116,710
			($361/cy)

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~~SUBJECT~~	NORTON SOUND PLATFORM	SHEET NO.	20 OF 33
		DES.	EWO
SUBJECT	COST ESTIMATE PRECAST PANELS	JOB NO.	A82001
		DATE	10 March 82

Deck Panels

FORMWORK		$32100
MATERIALS		
Concrete	$\frac{60,715}{27}$: 2,249 cy x $120/cy =	269,844
Rebar	107,441 # x $0.22/lb =	23,637
Mesh	96,838 # x $0.30/lb =	29,051
Strand.	310,666 ft x $0.20/ft	62,133
Subtotal Materials		$383,665
LABOR	3.5 hr/cy x 2249 x $22/hr	173,173
TOTAL		$588,938

PROJECT NORTON SOUND PLATFORM	SHEET NO. 21 OF 33
	DES. EWO
SUBJECT COST ESTIMATE PANEL ERECTION.	JOB NO. A52001
	DATE 10 MARCH 82

PANEL ERECTION

BULKHEADS

21 hrs/panel × 629 × 22 = 290,598

DECK PANELS

5.45 hrs/panel × 782 × 22 = 93,762

TOTAL $384,360

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PROJECT NORTON SOUND PLATFORM
SUBJECT COST ESTIMATE CIP PILASTERS

SHEET NO. 22 OF 33
DES. EWO
JOB NO. A82001
DATE 10 March 82

FORMS (ASSUME COVERED BY MISC. PROD. COSTS) 0

MATERIALS

Concrete	75,720/27 = 2804 cy × $120/cy	336,533
Rebar	378,685# × $0.22/#	83,311
Mesh	9023# × $0.30/#	2,707
		422,551
LABOR	16.8 hrs/yard × 2804/cy × $22	1,036,523
TOTAL		1,459,074
		$535 cy
		$520/cy

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SUBJECT NORTON SOUND
PLATFORM
SUBJECT POST TENSIONING
COSTS

SHEET NO. 23 OF 33
DES. EWO
JOB NO. A82001
DATE 10 MARCH 82

MATERIAL

Longitudinal Strand.

12 Strand 207 × 480' × 6.3 #/' × $^{\$}0^{\underline{35}}$/16 => 532,073
4 Strand 66 × 480' × 21 #/' × $1^{\underline{00}}$/16 => 66,52

Transverse

12 Strand 154 × 140 × 6.3 × $^{\$}0^{\underline{20}}$ => $122,245
12 Strand 154 × 80 × 6.3 × $0^{\underline{20}}$ => 69,854

$790,700

LABOR

Long 12 Str 207 (1.5 + 2.6 + 4.5) × $22 = $39164
Long 4 Str. 66 (1.5 + 2.6 + 3.0) × 22 = 10,309
Transv 12 Str. 2×154 (1.5 + 2.6 + 2.0) × 22 = 41,334
Dywidag $\left(\underset{\text{Vertical}}{\frac{4722 + 724}{2}} + \underset{\text{Horiz.}}{\frac{2376}{2}} \right) \times 0.67\ ^{hr}/\text{bar} \times 22$ 57,361.

$148,168

938,868

SUBJECT NORTON SOUND PLATFORM

SHEET NO. 24 OF 33

DES. SWO

SUBJECT COST ESTIMATE
CIP KEEL SLAB

JOB NO. A82001

DATE 9 MARCH 92

CIP KEEL SLAB SUMMARY

FORMS

MATERIALS

Concrete		163,897 cf => 6,070 cy x $120/cy	= $728,43
Threadbar		293,608 # x 0.31	91,018
Couplers		10,924 x $4.41/coupler	48,175
Mesh		295,970 # x $0.20/#	= $88,791
P/T	Long 12 Strand	11 x 10 (110) x 490' x 6.3 #/' x $0.85/#	= 282,749
	Trans 12 Strand	17 x 12 (204) x 140 x 6.3 x 0.90	161,935
	Transv 12 Strand	17 x 12 (204) x 80 x 6.3 x 0.90	92,534
SUBTOTAL MATERIALS			$1,493,628

LABOR

Concrete	6,070 cy x 3.15 hr/cy x 22	= $420,651
P/T	110 x (1.5 + 2.6 + 4.5) x 22	= 20,812
	2 x 204 x (1.5 + 2.6 + 2.0) x 22	- 54,754
Subtotal Labor		$496,217

TOTAL $1,989,845

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PROJECT NORTON SOUND PLATFORM
SUBJECT COST ESTIMATE
CIP EXTERIOR BULKHEAD
SHEET NO. 25 OF 33
DES. EWB
JOB NO. A92001
DATE 9 MARCH 92

Man hours

Place Steel, Concrete, Strip Forms (19:16) 484 hrs = 16,940 h

Post Tension 230 horizontal Strands (1.5 + 2.6 + 4.5) = 1978

724 vertical Strands (1.5 + 2.6 + 2.0) = 4416 hr

FORMS	L.S.	$ 144,000
LABOR	23,334 hrs @ 22 7.18 cy/hr	$ 513 348
MATERIALS		
CONCRETE	87693 cf = 3248 cy $60	$ 194,884
REBAR	1,315 960 @ 0.22	$ 289,511
P/T 18 STRAND	42 273 × 9.45 × 0.80	$ 319,584
P/T 6 STRAND	724 × 38 × 3.15 × 0.95	$ 82,330
	724 × 21.5 × 3.15 × 0.95	46,581
		$ 932,890

TOTAL $ 1,590,238

$ 490/cy

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PROJECT NORTON SOUND PLATFORM
SUBJECT COST ESTIMATE CIP DECK SLAB
SHEET NO. 26 OF 33
DES. EWO
JOB NO. A82001
DATE 10 MARCH 92

CIP DECK SLAB

FORMS (Assume covered by misc prod. costs 0

MATERIALS

Concrete		$\frac{82188}{27}$ = 3044 cy x $120 /cy =	$ 365 280
Rebar		78585# x 0.22 =	$ 17,289
Mesh		140,705 x $0.30 =	$ 42,212
P/T	Long.	110 x 480' x 6.3#/lf x 0.85 =	$ 282,744
	Transv.	239 x 140 x 6.3 x 0.90 =	$ 189,718
		239 x 80 x 6.3 x 0.90	$ 108 410
			$ 1,005,653

LABOR

Concrete Work		3.3 Hr/cy x 3044 cy x $22/hr	$ 220,994
P/T	Long.	110 (1.5 + 2.6 + 4.5) x $22	20,812
	Transv.	239 (1.5 x 2.6 + 2.0) x $22	32,074
		239 (1.5 x 2.6 + 2.0) x $22	32,074
			305,954

TOTAL $1,311,607

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PROJECT NORTON SOUND PLATFORM
SUBJECT COST ESTIMATE
C/P WAVE BARRIER

SHEET NO. 27 OF 33
DES. EWO
JOB NO. A82001
DATE 9 MARCH 82

Manhours

		+ Bulwark form
Vertical Walls.	796 × 35	27,860
Roof Slab		4633
Bulwark		1266
Post-Tension	107 × (1.5 + 2.6 + 4.5)	920
	724 × (1.5 + 2.6 + 2.0)	4416
		39,095 hrs.

SUMMARY

30,130

FORMS L.S	293,454 + 75,052	$ 368,506
LABOR HRS	39095 × 22	$ 860,090
MATERIALS		
Concrete	$\frac{181,552}{27}$ (6725 cy) × $120/cy	$ 807,036
Rebar	1,518,963 × $0.22/lb	$ 334,172
Mesh	40,596 × $0.30	$ 12,179
P/T 12 Strand	51642 × 6.3 × $0.85/lb	$ 276,543
		$ 1,429,930

TOTAL $ 2,658,526
($395/cy)

PROJECT NORTON SOUND PLATFORM
SUBJECT COST ESTIMATE CIP SHEAR WALLS & COLUMNS

SHEET NO. 28 OF 33
DES. EWD
JOB NO. A82031
DATE 10 March 82

SHEAR WALLS & COLUMNS

FORMS $143,600

MATERIALS

Concrete $\frac{52203}{27}$ = 1934 cy $ $120 = $232,036

Rebar 397,138 # × 0.22 = $87,370

1 DYWIDAG

Bar & Duct 2904' × 2.08 = $6,040

Anchors 66 × 13^{50} $891

1¼" DYWIDAG

Bar & Duct 3204' × 2^{81} $8987

Anchors 132 × 19^{88} 2624

337,948

LABOR

Concrete 5 hr/cy × 1934 × 22 = $212,740

TOTAL $694,288

($359/cy)

PROJECT NORTON SOUND
PLATFORM
SUBJECT PRECAST SKID BEAM

SHEET NO. 29 OF 33
DES. Elwo
JOB NO. A82001
DATE 10 MARCH 82

PRECAST

FORMS $ 33,000

MATERIALS

Concrete 22,547/27 = 835 cy x 120 = $100,209
Rebar 131,081# x 0.22/# = $28,838
P/T Assume All 1/2 strand
9650' x 6.2 x 0.35 = $51,836
Styrofoam 1025 x 10 x $1.60/cf = $16,400
$ 197,283

LABOR

Concrete 10 hr/cy x 835 x 22.00 $183,700
P/T 40 (15 + 7.6 + 4.5) x 22.00 7568
$ 191,268

TOTAL $ 426,551
$ 511/cy.

ERECTION

Erect 5 x 10 = 50 pieces
Assume 4/day => 50/4 = 12.5 Use 13 days
Labor 5 men on derrick barge
4 on platform
3 on tug & barge
12 x 8 x 13 = 1248 manhours
x 22
$ 27456

Note: Material & Labor for CIP Joints included above

Incl. mobil
Derrick 15 days x $5000/day => 75,000
Barge 2 wks @ 3000/wk => 6,000
Tug 2 days @ 2500/day 5,000
$ 86

PROJECT NORTON SOUND PLATFORM
SUBJECT STEEL QUANTITIES
SHEET NO. 30 OF 33
DES. EWO
JOB NO. A82001
DATE 11 March 82

STEEL FABRICATION

				MATERIAL	LABOR
A633	Wave Deflector	0.35	85,000 lb	Shipping 5270 29750	$ 24,225
A441	Weatherdeck		2,612,000 lb	$ 1,436,600	$ 1,175,400
A323	Pipe 12 x 40 x 49.56 #/l		23,789 lb x $1.00	23800	$ 3,000
API 5L	Well Slots 40 x 40 x 147 #/l 28"⌀ x ½"		235,182 lb x $0.50	117,592	23,918
			2,755,972 #	$ 1,613,012	$ 1,226,143

STEEL ERECTION

1 Seismic Pipe 3 men @ 4 hrs ea x 12 x 22 = $3168
2 Well Slots 2 men @ 2 hrs ea x 40 x 22 = $3520
3 Wave Deflector 3 men @ 1 wk = $ 2640
4 Weatherdeck Use $200/Ton = $0.10/lb x 2,612,000 = 261,200
20% Lost Time - Items 1 to 3 1866

$ 272,394

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PROJECT NORTON SOUND PLATFORM
SUBJECT
SHEET NO. 31 OF 33
DES. EWO
JOB NO. A82001
DATE

CIP FORMWORK

high concrete pressures

Exterior Bulkhead 3 x 80 x 20 x $30 = $144,000

Closure Pours 2 x 2 x 38 x $30 = $4560

Pilasters 2 [4 x 1.41 x 38 x 30] = 12,900

$17,460

Wave Barrier

Curved 40 x 15 x $50 = $30,000

Inside Module 3[(825 + 20) x 2 x 15] x 20 = 50,850

Outside Modules 2 [(4.13 x 2 + 20) x 15] x 20 = 16956

Outside Wall 40 x 15 x 20 . 12000

$ 97,818 / form

TOTAL 3 x 97818 = 293,454

Shear Walls 2 [40 x 40 x 2 x $20] = $128,000

Columns 2 [(4.0 + 2.5) 2 x 40 x $15] = $15,600

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PROJECT NORTON SOUND PLATFORM
SUBJECT FORM COSTS.

SHEET NO. 32 OF 33
DES. EWO
JOB NO. A92001
DATE 9 MARCH 82

FORM DECK - WAVE BARRIER ROOF SLAB

$w = 0.130 \times 12 = 130$ psf + 20 psf Const. + 10 psf DL = 160 psf

$$M = \frac{w\ell^2}{8} = \frac{160 \times 8.25^2}{8} = 1361 \text{ ft-lbs.}$$

$$S_{req'd} = \frac{1361 \times 12}{30{,}000} = 0.54 \text{ in}^3/\text{ft}$$

$$\Delta = \frac{\ell}{240} = \frac{825 \times 12}{240} = 0.413 \text{ in}$$

$$\Delta = \frac{5 w \ell^4}{384 EI} \qquad I = \frac{5 \times \frac{160}{144} \times 99^4}{384 \times 29 \times 10^6 \times 0.413}$$

$$I_{req'd} = 0.116 \text{ in}^4/\text{ft}$$

Use Bethlehem Super Slab Form SS16

TOTAL AREA OF SLAB FORM 37,905 sf

Per. John Pruszk of Bethlehem Steel (215) 694-7614

\$1.98/per sq ft FOB Seattle

Scott Whitmore
Steve Knight

TOTAL $37905 \times 1^{\underline{98}} = 75052$

PROJECT NORTON SOUND PLATFORM
SUBJECT PONTOON FLOAT-OUT & DRYDOCK RECYCLING
SHEET NO. 33 OF 33
DES. FLWO
JOB NO. A82001
DATE 12 MARCH

1. Clean Drydock & Make Ready For 1st Pontoon

5 men crew @ 5 days = 200 hrs.

2. Prepare For First Floatout

5 man crew @ 2 days = 80 hrs

3. First Float-out

15 man crew @ 1 day = 120 hrs

2 tugs @ 8 hrs × $310/hr = $5000

Remove Graving Dock Gates,
Replace Gates & Dewater => $5000

4 Prepare Drydock For 2nd Pontoon

5 Man crew @ 2 days = 80 hrs

5 Prepare For 2nd Float-Out 50 hrs

6 Second Float-out

Labor	120
Tugs	$5000
Graving Dock Work	$5000

TOTALS

LABOR	680 hrs × 22	= 14,960
Tugs		$10,000
Graving Dock Prep		10,000

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PROJECT NORTON SOUND PLATFORM	SHEET NO. 1 OF 8
	DES. Ewo
SUBJECT 70' WATER DEPTH	JOB NO. A82001
COST ESTIMATE	DATE 18 MARCH 82

SUMMARY (Ea category has overhead & profit already included)

CONCRETE PLATFORM			
Barge	$29,295 \times 10^3$		
Towers	$5,959 \times 10^3$		
~~Erect Skid Beams & Equip Modules~~	~~$1,658 \times 10^3$~~		(COVERED BY F.O.S.)
Steel weather deck	$2,797 \times 10^3$		
TOW TO SITE	$9,044 \times 10^3$		
DEPLOYMENT	~~$17,079 \times 10^3$~~	$19,010 \times 10^3$	Add Granu Backf
	~~$65,832 \times 10^3$~~		
	$66,105 \times 10^3$		

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PROJECT NORTON SOUND PLATFORM
SUBJECT 70' WATER DEPTH
COST ESTIMATE
SHEET NO. 2 OF 8
DES. EWO
JOB NO. A32001
DATE 17 MARCH 92

DEVELOP UNIT COST PRECAST BARGE STRUCTURE BASED ON 30' WATER DEPTH CONCEPT

Costs up to & thru jointing

Concrete = 29178 cy vs total 38,672 cy

Equipment & Material = $8292 x10^3
Labor = 4,722 x10^3
13,014 x10^3

Field Staff = $\frac{29178}{38672}$ x 1,151,100 = 868 x10^3

Graving Dock & Storage	980 x10^3
Waterside Facilities	17 x10^3
Cranes	2,052 x10^3
10% General Overhead	829 x10^3
Profit	2,664 x10^3
	$20,424 x10^3

Unit Price = $\frac{20,424}{29178}$ = $700 /cy

COST OF BASIC BARGE = 40,472 x 700 = $28,330 x10^3
includes 15% of towers

Precast Skid Beams $\frac{37,230}{27}$ x 700 = $965 x10^3

Σ = $29,295 x10^3

Steel Weather Deck

Subcontract - Fabricate & Erect	2,432 x10^3
Profit	365 x10^3
	2,797 x10^3

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PROJECT ______

SHEET NO. 3 OF 8

DES. ______

SUBJECT 70' WATER DEPTH - COST ESTIMATE

JOB NO. ______

DATE ______

CONSTRUCT TOWERS

Assume Jump Forms are used. 12' per lift

EL -40 to +97 => 137'

Assume 12 set-ups w/ 5 days / set-up

Use ? sets of Forms @ $30/SF per discussion w/ Norm Flodean of Cantilev

Forms = 157 x 12 (outer) + 137 x 12 (inner) = 3468 sf

$ = 3468 x 30 = 104,050 / Form

Based on 2 Forms $ 208,099
4 Forms $ 416,198

CONSTRUCT TOWERS

	Forms	$ 208,099 ←
Based on Ext Blkd	Materials & Labor 500 x 7069 cy =	$ 3,534,444 ←
	Facilities	
	Shoreside $17000/mo x 11 mos =	$ 187,000 ←
	Misc Overhead = $\left(3,534,444 \times \frac{932}{932+513} + 208099\right) \times 0.10$ (64%)	= 250,000 ←
	2 - TOWER CRANES 2 x 16950 x 11 + 26500 (means pg 23)	399,400
	Field Staff $\frac{1,151,100}{21} \times 11$	= 603,000 ←
	Profit	777,291 ←
		$ 5,959,000

Erecting & Dismantling
Mismantling
125 - (-40) 145'
14,300 + 45(90) = 18,350
10,100 + 45(70) = 13,250
x 2 = 26,500

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PROJECT NORTON SOUND PLATFORM

SUBJECT CAISSON STRUCTURE · 70' WATER

SHEET NO. 4 OF 8
DES. EWO
JOB NO. A82001
DATE 18 MARCH 82

TOW TO SITE: Use Same Estimate as for 30 ft waterdepth structure, assume deeper displacement slows tugs to 2 knot

Delivery voyage 2300 nautical miles

Tow Time $\frac{2300}{2}$ = 1150 hrs = 48 days

Down Time 0.20 × 48 = 10 days

SUMMARY COSTS

Mobilize		$300,000
Tow	$60,000/day × 48 days =	2,880,000
Down time	$60,000 × 10 =	600,000
Demobilize		1,020,000 / 4,800,000
Tow Insurance	0.015 × (36,912 + 166,000) =	3,044,000
Overhead	15%	720,000
Profit	10%	480,000
		$9,044,000

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PROJECT NORTON SOUND PLATFORM
SUBJECT 70' WATER DEPTH - CAISSON

SHEET NO. 5 OF 8
DES. EWD
JOB NO. A82001
DATE 18 MARCH 82

SUMMARY DEPLOYMENT COSTS

Materials - Rip-Rap	$\frac{12169\text{ cy}}{7000} \times 430{,}000$ =	748×10^3
Grounding Downtime		640×10^3
Work Barge	67 days × $112,000/day	$7{,}504 \times 10^3$
Tugs	$60,000 × 31	$1{,}860 \times 10^3$
* Dewatering System.		650×10^3
Overhead	15%	$1{,}710 \times 10^3$
Profit	15%	$1{,}967 \times 10^3$
Mobilization		$2{,}000 \times 10^3$
		$ $17{,}077 \times 10^3$

* COST FROM BASIC CONCEPT. COVERS COST OF VIBRO COMPACTOR.

ADD COST TO REPLACE WATER BALLAST W/ GRANULAR	$ $1{,}460 \times 10^3$
OVERHEAD (15%)	219×10^3
PROFIT (15%)	252×10^3
SUBTOTAL	$ $1{,}931 \times 10^3$
DEPLOYMENT TOTAL	$19{,}010 \times 10^3$

PROJECT NORTON SOUND PLATFORM
SUBJECT
SHEET NO. 6 OF 8
DES. EWO
JOB NO. A92001
DATE 18 MAR 92

DEPLOYMENT COSTS

SITE EXCAVATION

$(400+100) \times (280+100) \times 10' = 1.9 \times 10^6$ cf
$= 70,370$ cy

Suction Dredge 15% solids

Total Volume $\frac{1.9 \times 10^6}{0.15} = 12.67 \times 10^6$

Rate 2000 cf/min

Time $= \frac{12.67 \times 10^6}{2000} = 6333.33$ min
$= 105.56$ hrs

Work Time @ 2 shifts @ 12 hrs/day

no of days $= \frac{105.56}{24} = 4.40$

Use 5 days.

Down time $= 20\% \times 5 = 1$ day

BALLASTING SAND

$\frac{24,954 \text{ cy}}{\frac{118,900}{31}} = 6.5$ days $= 7$ days

30' water depth.

Down time $= 0.20 \times 7 = 1.4$ days

RIP-RAP

$\frac{5823 \text{ cy}}{\frac{7000}{18}} = 15$ days

Down time $= 0.2 \times 15 = 3$ days

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PROJECT NORTON SOUND PLATFORM
SUBJECT
SHEET NO. 7 OF 8
DES. Ecco
JOB NO. A32001
DATE 18 MAR 92

Sand Backfill

$1.9 \times 10^6 - 1.12 \times 10^6 = 780{,}000$ cf

$= 28{,}889$ cy

Days $= \dfrac{28{,}889}{\frac{\cancel{115{,}500}}{31}} = 7\frac{1}{2}$ days

Downtime $= 0.20 \times 7.5 = 1\frac{1}{2}$ days

Place Rip Rap $\dfrac{126 \text{ cf/ft} \times 2(400+230)}{27} = 6346$ CY

Days $= \dfrac{6346}{\frac{1000}{13}} = 16$ Days

Down time $0.2 \times 16 = 3.3$ Days

Water Ballast $277{,}809 \times 10^3$ lb $= \dfrac{33.8 \times 10^6 \text{ gallons}}{35{,}000 \text{ gpm}} = 907.5$ mi

$= 0.6$ da

Down time $= 0.2$ da

SUMMARY

Site Excavation	4.4	days
Down time	0.9	days
Sand Ballast	6.5	days
Downtime	1.3	days
Place Rip Rap	15	days
Downtime	3	days
Sand Backfill	7.5	days
Downtime	1.5	days
Place Rip Rap	16.3	days
Down time	3.2	days
Water Ballasting	0.6	days
Down time	0.2	days
	60.5	days ⟹ 61 days
Remove Steel Weather Deck	5	days
Down time	1	day

4 delivery tugs. 31 days.

Structure Grounded

→ 67 days

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PROJECT Norton Sound
SUBJECT 70' WATER DEPTH - DEPLOYMENT COST

SHEET NO. 8 OF 8
DES. GT
JOB NO.
DATE 4/27/82

FIND ADDITIONAL COSTS DUE TO REPLACING SEAWATER BALLAST w/ GRANULAR MATERIAL.

NEED 145,700 CY GRANULAR BALLAST

145,700 CY = 3,933,900 CF

SLURRY @ 15% SOLIDS ∴ $\frac{3,933,900 CF}{0.15}$ = 26,226,000 CF Slu

SLURRY FLOW RATE = 2000 CF/MIN

∴ 13,113 MIN. = 218.5 HR = 9.11 DAYS

ALLOW 20% SET UP TIME = 1.8 DAYS

ALLOW 20% DOWN TIME = 1.8 DAYS

Σ = 12.7 DAYS Say 13

13 DAYS @ $112,000 = $1.46 Million

15% OVERHEAD 0.22 Million

15% PROFIT 0.25 Million

$1.93 Million

REFERENCES

ADDENDUM G

REFERENCES

1. Maattanen, Marui, "Ice Forces on Fixed. Flexible Structures," Working Group on Ice Forces on Structures, Special Report 80-26, Part III, June, 1980, p. 112.

2. Iten, R. M.; Gable, W. L., "Behavior of Missile Silo Closures Designed to Resist High Overpressures," Department of Civil Engineering, University of Illinois, March, 1978.

3. PMB Systems Engineering, Inc., "Norton Sound Production Structure Study," Submitted to Standard Oil Company of California, August, 1981.

4. Liv, Tony C., "Abrasion Resistance of Concrete," ACI Journal, Proceedings Vol. 77, No. 5, September-October, 1981, pp. 341-350.

5. Weigler, H. and Karl, S., "Salt Scaling Resistance and Abrasion Resistance of Lightweight Concretes," Betonstein-Zeitung 34, 1968, No. 5, pp. 225-240, No. 11, pp. 581-583.

6. "Measurement of Properties of Fiber Reinforced Concrete," ACI 544-2, R-78.

7. "Applications of Concrete Polymers in Hydrotechnic Construction," ACI SP 69-3.

8. Klieger, P. and Hanson, J. A., "Freezing and Thawing Tests of Lightweight Aggregate Concrete," ACI Journal, Proceedings, Vol. 57, No. 1, Jan, 1961, pp. 779-796. Also, PCA Research Department Bulletin No. 121.

9. Reading, Thomas J., "Combating Sulfate Attack in Corps of Engineers Concrete Construction," ACI Publication SP 47-16, 1975.

10. Short, A., "The Use of Lightweight Concrete for Reinforced Concrete Construction," Reinforced Concrete Review, 5(3).

11. "Lightweight Aggregate Concrete," CEB/FIB, 1977.

12. Spiess, F. N., "Seawater Absorption by Precast Portland Cement Concrete Containig Lightweight Aggregates," Report by Scripps Institution of Oceanography, University of California, San Diego, November 1973.

13. Khan, Fazlur R., "Lightweight Concrete for Total Design of One Shell Plaza," ACI Publication SP 29-1, 1971.

14. "Recommendations for Estimating Prestress Losses," by PCI Committee on Prestress Losses.

15. Furr, Howard L., et al, "Creep in Prestressed Lightweight Concrete," Texas Transportation Institute College Station, Texas, October, 1967.

16. Ractliffe, Alan T., "An Experimental Study of the Parameters Affecting the Drag of Barges in Current and Waves," OTC 4166.

17. Roark, Raymond J., "Formulas for Stress and Strain," Fourth Edition.

18. "Shore Protection Manual," U.S. Army, Corps of Engineers, U.S. Army Coastal Engineering Research Center, Volume II, 1973.

19. "Guide for the Design and Construction of Fixed Offshore Concrete Structures," ACI 357, ACI Journal, December, 1978.

20. "Rental Rate Blue Book," Equipment Guide Book Company.

21. "Building Construction Cost Data," Robert Snow Means, Co., Inc., 1982.

22. ASCE Manual 45 "Consulting Engineering, A Guide for the Engagement of Engineering Services," American Society of Civil Engineers, 1975.

23. "A Design Manual On the Buckling Strength of Metal Structures", Dr. Friedrich Bleich and Commander Lyle B. Ramsey, Fourth Printing, December 1965.

GLOSTEN ASSOCIATES REPORT

characteristics were claimed for it [van Lammeren, W. P. A., RPSS, 1948, p. 97].

The flare angle of the bow sections may increase with height above the designed waterline, as at C in Fig. 26.B. The principle of this curvature is to impart a sensibly constant outward acceleration to the water when the ship pitches down, again corresponding to the slowly increasing curvature in a railway track carrying a fast-moving train. Under certain conditions this flare imparts a high outward velocity to the water, with no abrupt changes in acceleration, while the free surface of a wave is rising to the forecastle deck, or while that deck is dropping to the wave level. This increasing flare is advantageous if the ship is running at an angle of encounter of 180 deg, head into the sea, approximately at right angles to the wave crests. However, it presents a most vulnerable surface for water impact if the waves meet the bow in a direction roughly parallel to any flaring portion of the side.

It is frequently desirable to gain increased deck space forward. It may even be necessary, for reasons not directly related to hydrodynamics, to work an excessive degree of flare into the abovewater bow sections, as at D in Fig. 26.B, much greater than would normally be considered suitable. Severe slamming under some sea conditions is certain to follow, often necessitating a reduction of speed far in excess of what would be required with a bow of more moderate form. Furthermore, the idea that a widely flaring bow prevents spray from reaching the deck and the upper works may be a disappointing delusion, especially if the vessel operates with high relative winds blowing from the bow or from the forward quarterpoints.

A *double* or *compound flare*, indicated at E in the figure, was developed by British naval constructors for their men-of-war many years ago. It is one successful method of imparting relatively high outward velocity to the water when the bow is plunging into waves, and of avoiding the undesirable impact features of excessive bow-section flare. Above the designed waterline and up to a height equal to two-thirds, three-quarters, or possibly a greater fraction of the freeboard, the bow sections are curved outward with a slowly increasing flare angle. At this level there is a sharp longitudinal knuckle, conveniently located to suit the structural design, above which the sides are sensibly straight with a constant flare angle of small or moderate amount. This compound-flare section is characterized by a reasonably high rate of increase in buoyancy moment with forward trim, an adequate outward velocity imparted to the water when the bow is plunging, and a reasonably spacious deck and forecastle. It does not have the disadvantages of water impact throughout the rather wide range of operating conditions which would obtain if the curving

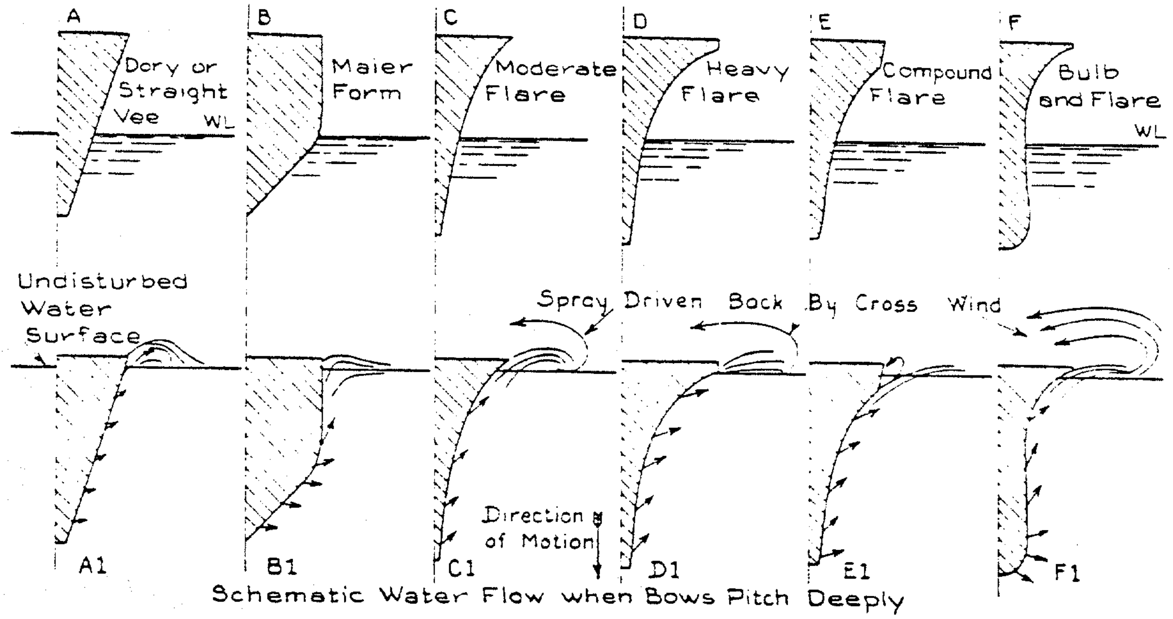


FIG. 26.B VARIOUS SHAPES OF ABOVEWATER BOW SECTION

angle of heel, the greater part of the water on a wide ship spills over the top of the bulwarks.

To require that a deckload of water, up to the top of the bulwarks, should run off completely within the interval of one pitching cycle would practically require taking away the bulwarks altogether. It is therefore necessary to assume that some roll angle or pitch angle, or both, will unload most of the water over the bulwark rail. To get rid of the rest of the water in one pitching or rolling period it appears that the freeing-port area should be more nearly 0.2 the bulwark area. Furthermore, this freeing-port area should be provided *abreast* the volume which needs to be emptied if the vessel ships a deckload of solid water.

Bulwarks at the extreme bow can serve as an effective increase in freeboard in that region, over and above that provided by the intact hull. If not extended too far aft, say to not farther than the point where the local beam exceeds $0.5B_X$, it should be possible to leave them solid, without freeing ports or slots.

Breakwaters require positioning and shaping so that the maximum water is deflected for the minimum of splash or spray over the top. This calls for a deflecting surface which is never—or rarely ever—normal to the onrushing water and which does not form an objectionable spray-thrower for water in quantities greater than the breakwater is designed to handle. The water deflected from the forward side should have no upward component, and as great an outward component as possible, to throw it toward the gunwale and get it off the deck. Fig. 68.E illustrates, at 3 and 4, two alternative methods of accomplishing this. The function of the horizontal lip along the top of the barrier is to throw moderate quantities of water back forward but to permit large quantities to pass over the breakwater without too violent obstruction.

The breakwater on a forecastle is usually of V-shape in plan, with its vertex forward and with diagonal sides extending practically to the deck edges. The planform angles may vary from 45 to 60 deg with the centerline, indicated at 1 and 2 on Fig. 68.E. The height at the center, where the water can not run off the deck freely, should be higher than at the sides. A breakwater having an elliptic or parabolic planform, with the sharp curvature forward, is shown for an early German "schnellboote" (high-speed boat) in Schiffbau [26 Oct-2 Nov 1921, Fig. 4, p. 114]. There may be two breakwaters in tandem, separated by an appreciable fore-and-aft distance, so that the water spilling over one is trapped by the second. A set of tandem breakwaters of concave section is fitted on the French battleship *Jean Bart* [The Ill. London News, 9 Apr 1955, p. 661].

A breakwater of any type requires adequate bracing against the hydrodynamic forces. These are not accurately or even roughly known but their order of magnitude may be estimated by assuming a dynamic load imposed by solid water striking the breakwater at a certain velocity. For a head sea, or an angle of encounter α(alpha) of 180 deg, this is compounded of (1) the speed V which it is estimated the ship can make in heavy weather and (2) the orbital velocity U_{Orb} of the crest of a wave which breaks over the forecastle and strikes the breakwater. While, strictly speaking, the dynamic pressure is that due to the component of $(V + U_{Orb})$ normal to the breakwater, there is little assurance that the deck load of water sliding aft on the forecastle will strike the breakwater from ahead. The blow may just as well come from the side, striking against one face for

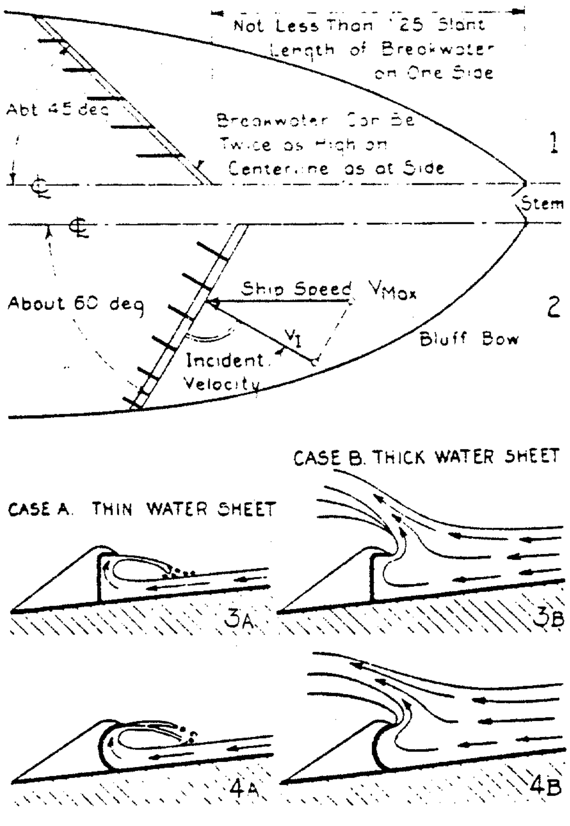


FIG. 68.E DESIGN SKETCHES FOR FORECASTLE BREAKWATERS

Report on a Brief Investigation of the Motions and Deck Wetness for the Norton Sound Caisson Delivery Voyage

Prepared for

ABAM ENGINEERS, INC.
Federal Way, Washington

BRUCE L. HUTCHISON

THE GLOSTEN ASSOCIATES, INC.
Naval Architects - Marine Engineers - Ocean Engineers
610 Colman Building - 811 First Avenue
Seattle, Washington 98104

File No. 8195

December 1981

Freeboard requirements were judged against the criteria established in an earlier report to ABAM ENGINEERS from THE GLOSTEN ASSOCIATES, titled "Review of Rational Freeboard Determination for an OTEC Platform", (report dated May 1979). In that report the following criteria were established for a structure similar to the Norton Sound caisson laboring in extreme sea conditions.

CRITERIA FOR FREEBOARD

Location	Probability of Shipping Water
F.P.	0.40
M.P.	0.00
A.P.	0.50

The criteria above were conservatively set by comparison to the deck wetness computed using similar techniques for a Victory ship and a T-2 tanker.

Using the criteria stated above the required freeboard for the Norton Sound caisson in head seas is no greater than 18 feet during the delivery voyage. The actual freeboard at the [illegible] delivery voyage draft of 26 feet is 29 feet. This is adequate freeboard to satisfy the stated criteria even at a heading of 135 degrees (bow quartering seas). The freeboard available and required for other reasons (ice rubble and shipping of green water when on station in Norton Sound), is therefor considered adequate for the delivery voyage.

The enclosed figure 1 shows the mean squared values for the relative motion (relative to the local sea surface) displacement and relative velocity processes for the Norton Sound caisson. These motion statistics are given for the F.P., M.P. and A.P. in head seas. Also presented in figure 1 is the probability of shipping green water for each of these locations given the 29 foot delivery voyage freeboard.

The enclosed figure 2 shows the probability of shipping green water for each of the subject locations as a function of freeboard. And, figures 3 and 4 show the number of cycles per hour exceeding the 29 foot freeboard by various amounts.

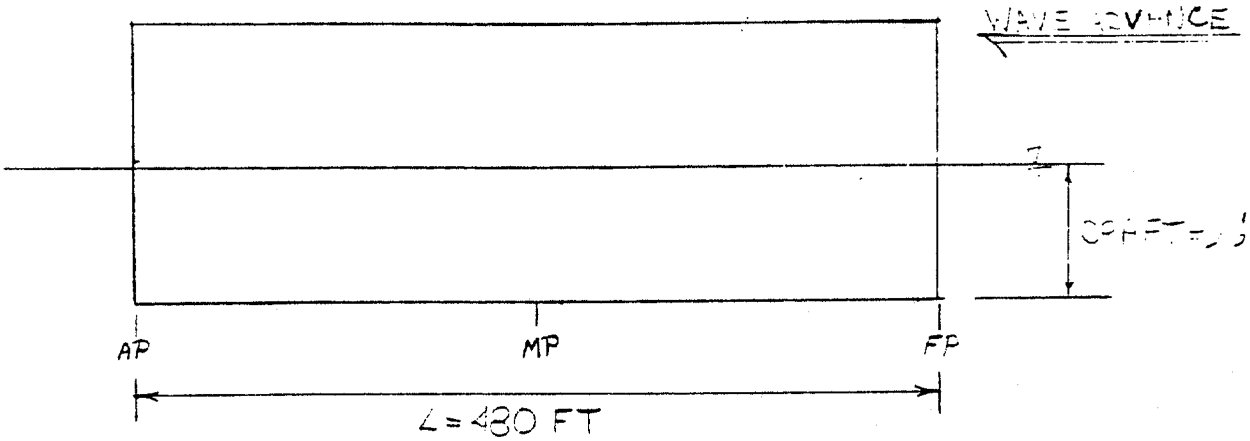
LOCATION	CRITERION P(z>f)	$H_{1/3}$ = 25 ft. T_m = 12 s Required f	$H_{1/3}$ = 28 ft T_m = 13 s Required f	Heading χ, deg.
Bow Stbd	0.4	16.41	18.00	180°
Bow Cntr.	0.4	16.41	18.00	↓
Bow Port	0.4	16.41	18.00	↓
Mid - Stbd	0.001	14.19	14.10	↓
Mid - Port	0.001	14.19	14.10	↓
A.P. - Cntr	0.5	14.01	15.59	180°
Bow Stbd.	0.4	8.91	9.26	135°
Bow Cntr	0.4	14.35	15.38	↓
Bow Port	0.4	20.43	22.05	↓
Mid-Stbd	0.001	26.43	27.86	↓
Mid - Port	0.001	20.29	21.56	↓
A.P. - Cntr	0.5	13.01	14.01	135°
Bow Stbd.	0.4	12.19	12.98	90°
Bow Cntr.	0.4	3.19	3.11	↓
Bow Port	0.4	12.83	13.55	↓
Mid-Stbd	0.001	33.48	35.65	↓
Mid-Port	0.001	35.22	37.21	↓
A.P.-Cntr	0.5	2.78	2.70	90°

SUBJECT [illegible] Freeboard Study

THE GLOSTEN ASSOCIATES, inc.
Naval Architects · Marine Engineers · Ocean Engineers
610 Colman Building · 811 First Avenue · Seattle, Washington 98104

BY ALH
DATE Dec. 1981
JOB NO.
SHEET OF

NORTON SOUND CONCRETE CAISSON



χ = 180° $\tilde{H}_{1/3}$ = 25.0 FT T_1 = 12.0 sec

LOCATION	FREEBOARD	MN SQ (z)	MN SQ ($\dot{z}$)	PROB. SUBMERGENCE
FF	29.0 FT	146.20	36.06	0.06
MP	29.0 FT	14.57	7.56	0.00
AP	29.0 FT	141.60	32.58	0.05

χ = 180° $\tilde{H}_{1/3}$ = 28.0 FT T_1 = 13.0 sec

LOCATION	FREEBOARD	MN. SQ. (z)	MN. SQ ($\dot{z}$)	PROB. SUBMERGENCE
FP	29.0 FT	176.0	40.03	0.09
MP	29.0 FT	14.40	7.22	0.00
AP	29.0 FT	175.30	37.17	0.09

SUBJECT
480 FT NORTON SOUND CONCRETE CAISSON

FIG. 1

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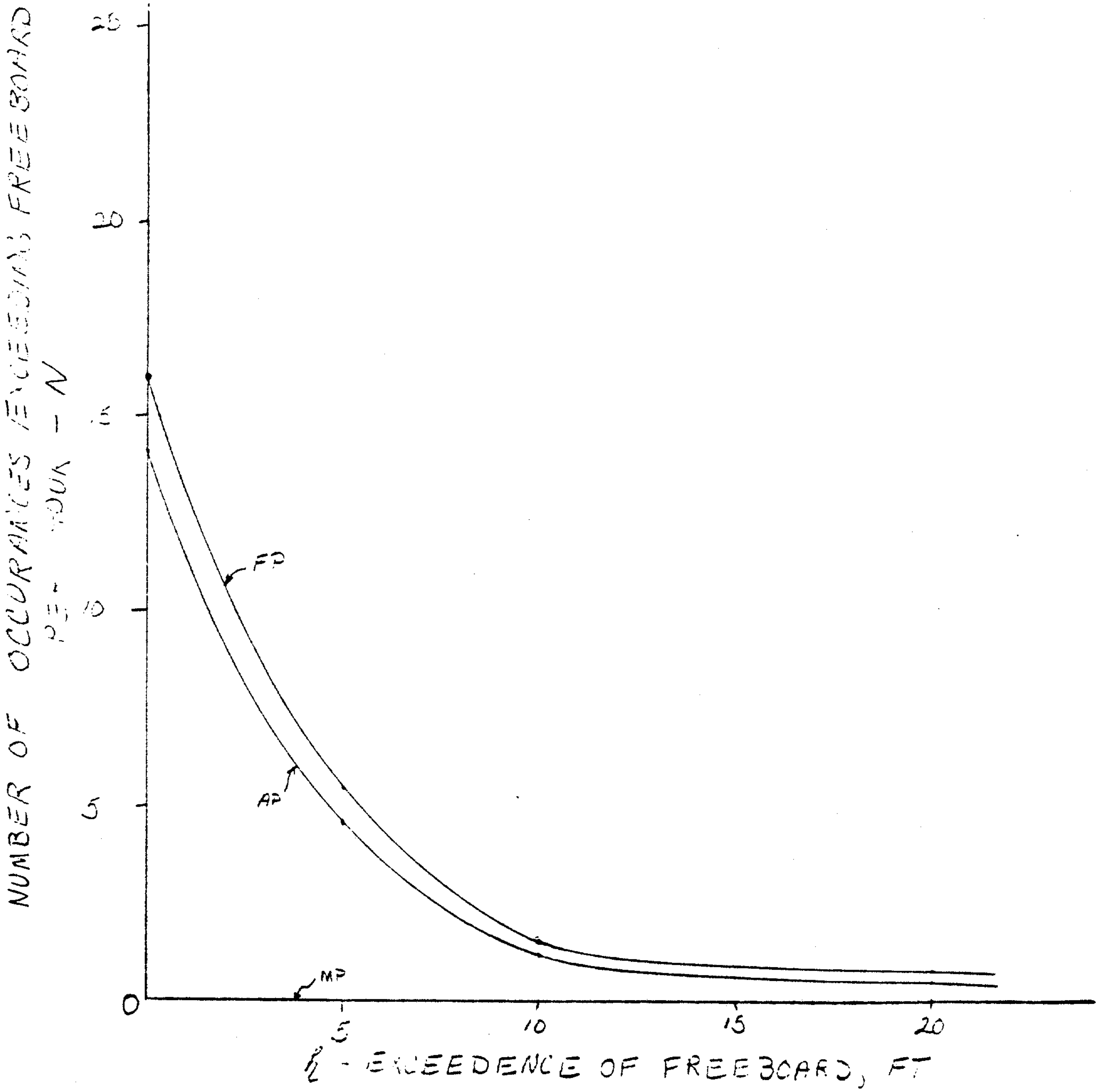

SUBJECT

HEAD SEAS $\tilde{H}_{1/3} = 25.0$ FT $T_1 = 12.0$ sec

FIG. 3

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BY EAG

JOB NO. 8195

DATE 11-27-81

SHEET 7 OF 10

W.J. Cichanski

Review of Rational Freeboard Determination for an OTEC Platform

Prepared for

ABAM ENGINEERS, INC.
Tacoma, Washington

BRUCE L. HUTCHISON

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May 1979
File No. 7915

INTRODUCTION

The OTEC platform represents an unusual oceangoing vessel for which there is not a body of suitable experience and proven practice on which to base many key design decisions. One such design decision is the selection of the appropriate freeboard for both operability and survivability in the chosen environment. The unique combination of deep draft and short length associated with the OTEC set it apart from any previous marine experience. The freeboard problem is further aggrevated by the stationary role the OTEC is to assume which prevents it from avoiding severe storm conditions in the manner of normal shipping.

The unique aspects of this situation recommended that freeboard requirements be assessed on some rational basis in addition to the normal appeal to conventional wisdom. The rational approach selected was to study the deck wetness using standard linear ship motions prediction techniques. This led to a selection of what seemed to be a reasonable amount of freeboard for a tropical operating site with a 100 year survival sea state of 29 foot significant wave height and an 18 foot significant wave height for the limit of operability.

When this approach was applied to an island operating site, such as found near Puerto Rico, the severe 100 year survival sea state associated with tropical hurricanes (H_{SIG} = 44.2 feet in this case) led to recommendation of a much larger freeboard. This much larger freeboard was excessive when compared to freeboard assignments for normal shipping, though it was reasonable when compared to fixed offshore structures and motion stable platforms placed in a similar environment. The additional freeboard required represented an undesirable economic burden on the OTEC design and this design area was, therefore, made subject to further critical review.

THE KINEMATIC MODEL OF SHIPPING WATER

The work herein reported represents a strictly kinematic approach to the problem of a vessel shipping water. In this approach the absolute temporal motion displacements of the ship at any specified location are compared with the instantaneous ambient wave elevation to determine if the wave has overtopped the freeboard. Hydrodynamic effects are ignored except insofar as they were applied to determine the ship motions. What is meant by this statement is that the unaltered ambient wave is used in this analysis, that being the wave that would be present in the absence of the ship. In fact, there are modifications of the wave imposed by the precense of the motionless ship, and further modifications due to the ship's motions. These modifications to the incident wave are not insignificant if one is attemtping to make a quantitatively accurate estimate of the actual incidence of shipping green water, but there is some justification for arguing that these effects can be neglected in a strictly comparative study such as currently at hand.

Another hydrodynamic effect ignored in the kinematic model is the favorable influence of flare or flam, and spray rails. While not included in this study's quantitative estimates, the effect of these features is almost always favorable, at least up to some fairly severe sea condition, and virtually all ships have these features to some extent. The OTEC, too, should include some or all of these features to the extent practicable.

The kinematic model of the deck wetness phenomenae leads to a Poisson process in the probability domain. The following formulae for the probability of shipping water and for the number of occurrences per hour are pertinent to the later discussions in this report.

Probability of Shipping Water

$$\text{Prob. } (\text{ƶ} > f) = \exp - \left\{ \frac{f^2}{2\,[\text{mn.sq.}(\text{ƶ})]} \right\}$$

where: f = freeboard

mn.sq.(ƶ) = the mean squared amplitude of the relative motion displacement process.

than one occurence per hour of shipping six or more feet of water, the conventional ships are seen to experience over 100 events per hour of that severity.

The plots seem also to indicate that the conventional ships experience shipping of water events of extreme severity (for purposes of discussion this may be considered to refer to events where the freeboard is exceeded by 30 feet or more). It is our opinion that such extreme events are considerably less common than implied by these figures. If such an extreme event were to occur, these ships would likely sustain substantial structural damage which might even jeopardize the safety of the ship. Such damage as might occur (stove in bridge fronts, caved in focsle decks and set down bows) does in fact occur, but rarely. In our judgement the relatively frequent predicated occurences of these extreme shipping of water events is a result of pushing the linear kinematic model beyond the range of validity. Significant higher order and nonlinear effects are at play, in these extreme sea states and responses, which tend to ameliorate the situation with respect to shipping water.

It is observed in Tables 1 and 2 that the forward perpendicular is not the wettest point on these ships. In fact, the after perpendicular is the wettest point examined by virtue of a lesser freeboard (not by virtue of greater relative motion). We have observed a similar behavior in model tests of some modified Victory ships in severe head seas. The wetness at the after perpendicular and at the forward waist (just behind the focsle) is probably not as objectionable as wetness over the F.P. or at amidships. At the F.P. the wave can board without any significant alteration of the fluid momentum which increases the volume and impact that potentially could result. At the forward waist the wave has been first sheared away from the ship by the bow, and then must curl over the side behind the focsle where it can ultimately do less damage. A wave boarding amidship must also curl over the side, but there it has the possibility of driving against the relatively light structure of the bridge. Stability issues are a concern also if waves can board too easily over a significant portion of the ship's length. Waves boarding at the A.P. can be considered in a similar vein as those boarding just abaft the focsle.

CRITERIA FOR SHIPS

Before considering what criteria for acceptable deck wetness should be applied to an OTEC platform, it is instructive to extract from the tables and figures just presented the criteria that might properly apply to conventional ships of the size considered. If this is done, the following simple criteria might result:

APPLICATION OF WETNESS CRITERIA TO OTEC

The OTEC platforms experience relative motions and related probability of wetness as indicated in Tables 3 and 4, applying respectively to the 354 and 378 foot OTEC plants. Application of the criteria stated in the previous section to OTEC results in a minimum freeboard of about 25 feet at the forward perpendicular and 26 feet at the after perpendicular. About 23 feet of freeboard amiship would be required.

The OTEC is currently designed with 29 feet of freeboard throughout its length in the survival condition.

In the operating condition the draft is 5 feet greater and the freeboard is, therefore, only 24 feet. In the 18 foot sea state designated for the limit of operability, 24 feet of freeboard is seen to result in about 3 occurrences per hour of shipping water at the forward perpendicular, well within permissable levels.

COMPARISON WITH OTHER SHIP MOTION PROGRAMS

Comparison of predictions of relative bow motion and deck wetness were made between results obtained using SCORES-CARGO, the MIT program as executed by APL, and certain results obtained using Dr. Paulling's program which includes the influence on the motions of the cold water pipe. In general, there was substantial and good agreement between the programs.

Table 5 shows the predicted relative motion statistics obtained using programs SCORES-CARGO and using the MIT program for a 378 foot long OTEC in head seas at a 60 foot draft. Comparisons are shown in sea states of three different severities using the ISSC (1967) two parameter wave spectrum. Figure 4 shows a comparison of the center of gravity heave and pitch motion frequency response functions as obtained from the two programs. Both modulus and phase of the response functions are shown and are seen to agree almost identically except for a slight resonance in pitch indicated by the MIT program at about $\omega = 0.5$. Figure 5 shows a comparison of the relative bow motion response modulus as a function of frequency as obtained from each program. These relative bow motion response moduli are the direct result of the response functions shown in figure 4. Again, there is seen to be excellent agreement at the higher frequencies. For frequencies corresponding to $\omega < 0.6$ there is some divergence of results with the MIT program predicting a more peaked response operator and a sharper low frequency cut-off. In general program SCORES-CARGO seems to be indicating a more highly damped pitch response at low frequencies then is the MIT program.

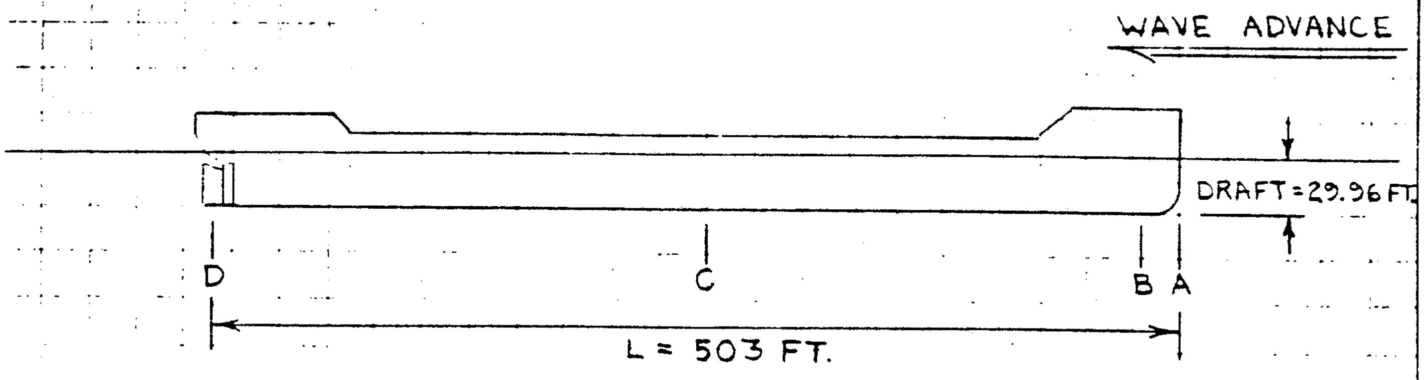
Table 6 shows the predicted relative motion statistics obtained using SCORES-CARGO, the MIT program, and using motion operators

CONCLUSIONS AND RECOMMENDATIONS

The less restrictive deck wetness criteria developed in this report result in the conclusion that as little as 26 feet of freeboard might be adequate for the OTEC platform in the H_{SIG} = 44.2 foot survival sea state. The 29 feet of freeboard provided in the current design increases the confidence that the freeboard is adequate.

The criteria developed in this report corresponds to a condition that is very wet (i.e. on the order of 140 wetness events per hour). There are indications that the linear kinematic model may be overextended in this application. While the comparative method of analysis has led to the finding that the current design freeboard may be adequate, this result should be confirmed and the consequences evaluated in a model testing program. A proper model testing program should engender more confidence at less cost and effort than attempting to further refine the analytical model.

T-2 TANKER



$\chi = 180°$ $\tilde{H}_{1/3} = 44.2$ FT. $T_1 = 13.0$ SEC.

LOCATION	FREEBOARD	MN. SQ. (z)	MN. SQ. ($\dot{z}$)	PROB. SUBMERGENCE
A	27 FT.	564.3	135.6	0.524
B	27 FT.	506.5	124.5	0.487
C	10.5 FT.	27.6	16.2	0.136
D	20.4 FT.	505.5	113.5	0.662

THE FOLLOWING F.P. RELATIVE BOW MOTION RESPONSES WERE CALCULATED USING FREQUENCY RESPONSE OPERATORS GENERATED BY PROF. WEBSTER USING THE NSRDC PROGRAM FOR A T-2 TANKER AT A 24 FT. DRAFT.

$\chi = 180°$ $\tilde{H}_{1/3} = 44.2$ FT. $T_1 = 13.0$ SEC.

LOCATION	FREEBOARD	MN. SQ. (z)	MN. SQ. ($\dot{z}$)	PROB. SUBMERGENCE
A	32.96	515.45	116.48	0.349

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SUBJECT
TABLE 2
T-2 TANKER IN HEAD SEAS
$\tilde{H}_{1/3} = 44.2$ FT. $T_1 = 13.0$ SEC.

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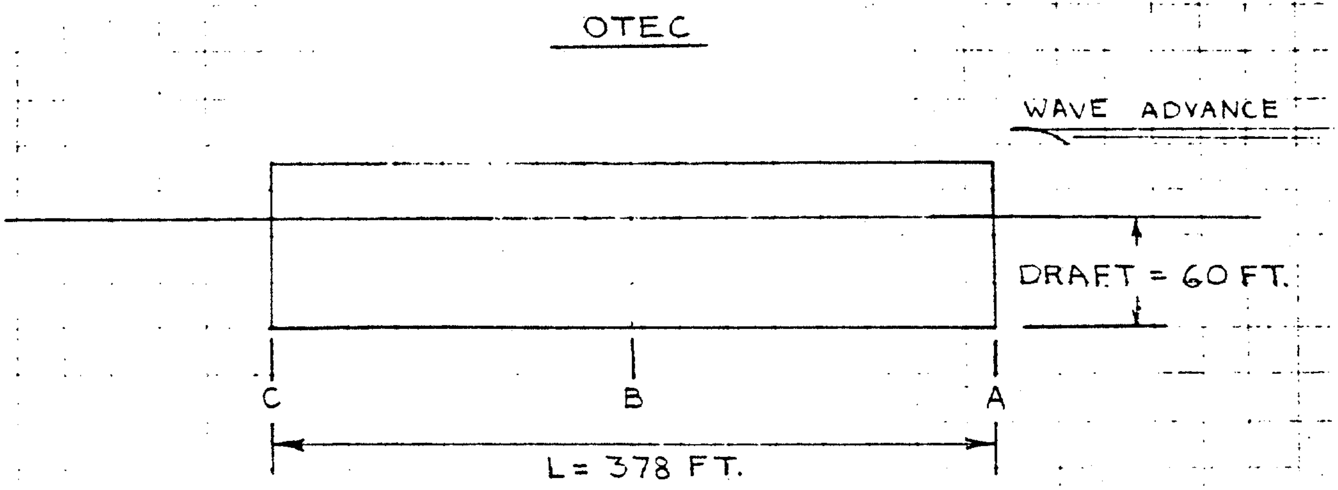
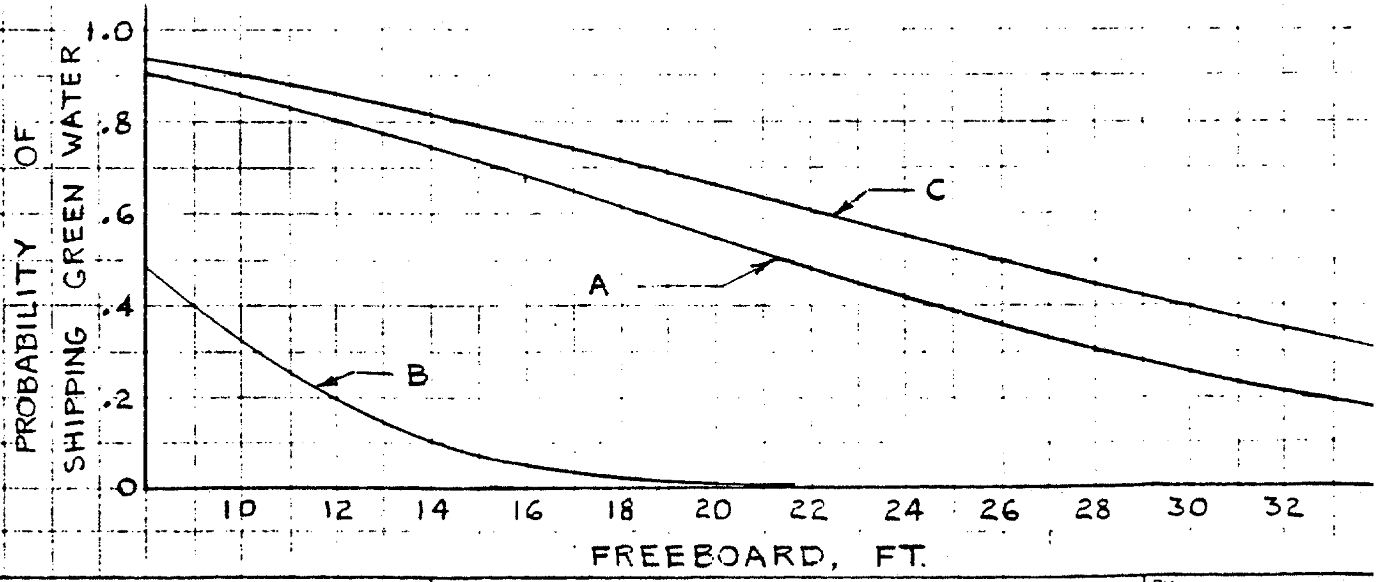


$\chi = 180°$ $\tilde{H}_{1/3} = 44.2$ FT. $T_1 = 13.0$ SEC.

LOCATION	FREEBOARD	MN. SQ. (z)	MN. SQ. ($\dot{z}$)	PROB. SUBMERGENCE
A	29 FT.	330.4	83.7	0.280
B	29 FT.	44.8	21.3	0.000+
C	29 FT.	484.4	117.8	0.420



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SUBJECT TABLE 4

378 FT. OTEC IN HEAD SEAS
$\tilde{H}_{1/3} = 44.2$ FT. $T_1 = 13.0$ SEC.

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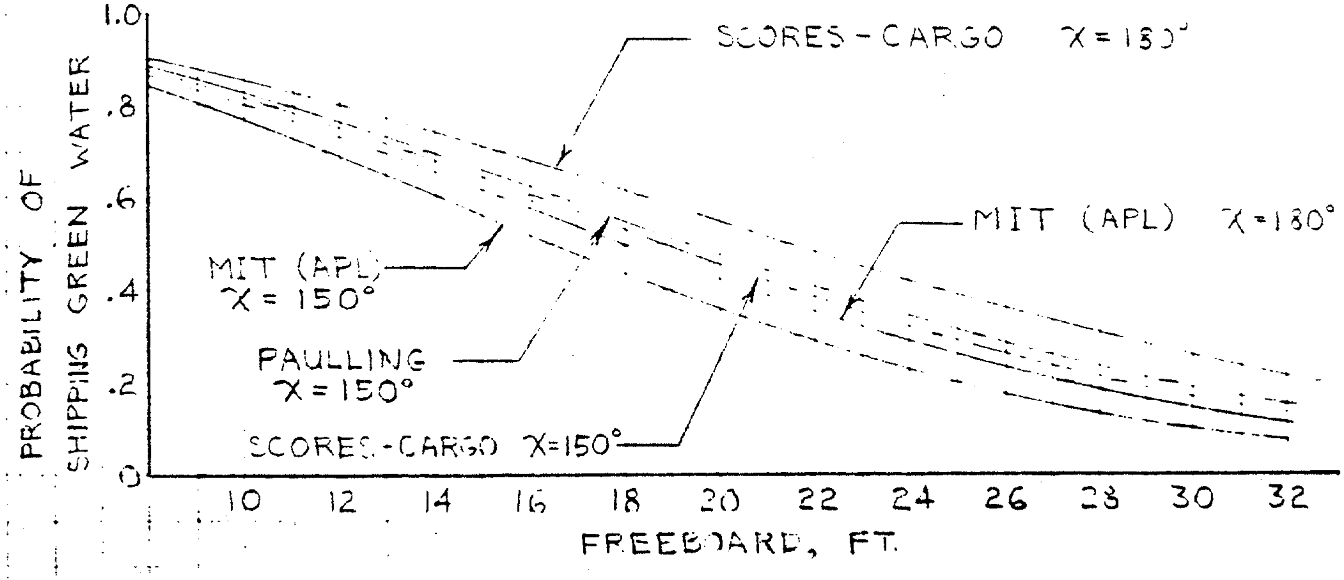
$\chi = 150°$ $\tilde{H}_{1/3} = 44.2$ FT. $T_1 = 13.0$ SEC.

PROGRAM	FREEBOARD	MN. SQ. $\underline{Z}$	MN. SQ. $\dot{Z}$	PROBABILITY OF SUBMERGENCE
MIT (APL)	29.0	193.8	65.1	0.114
Dr. K. PAULLING	29.0	268.7	82.4	0.209
SCORES - CARGO	29.0	252.5	65.4	0.189



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378 FT. OTEC IN QTRNG SEAS

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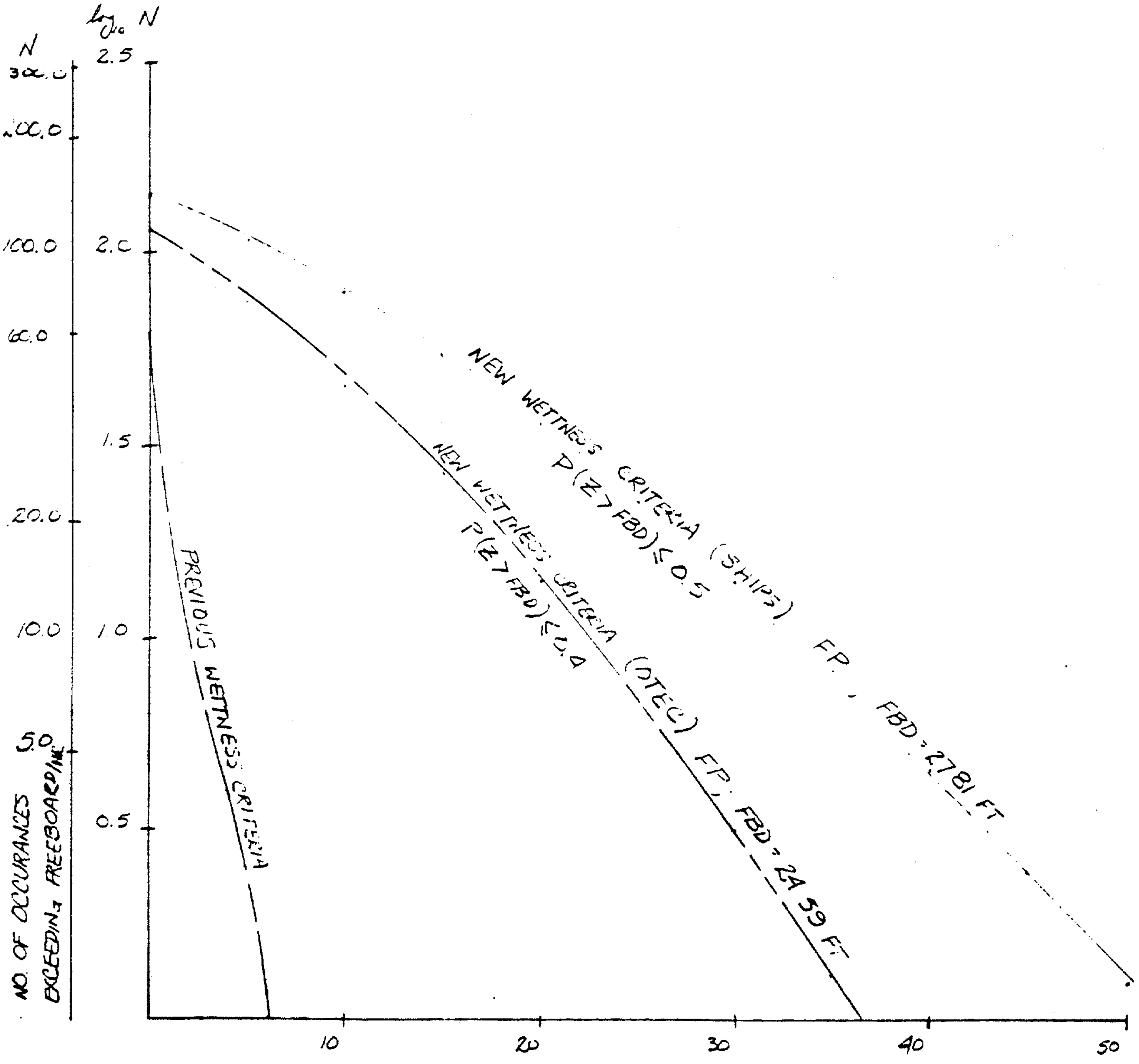

FIG 2

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SUBJECT
COMPARISON OF WETTNESS
CRITERIA @ FP

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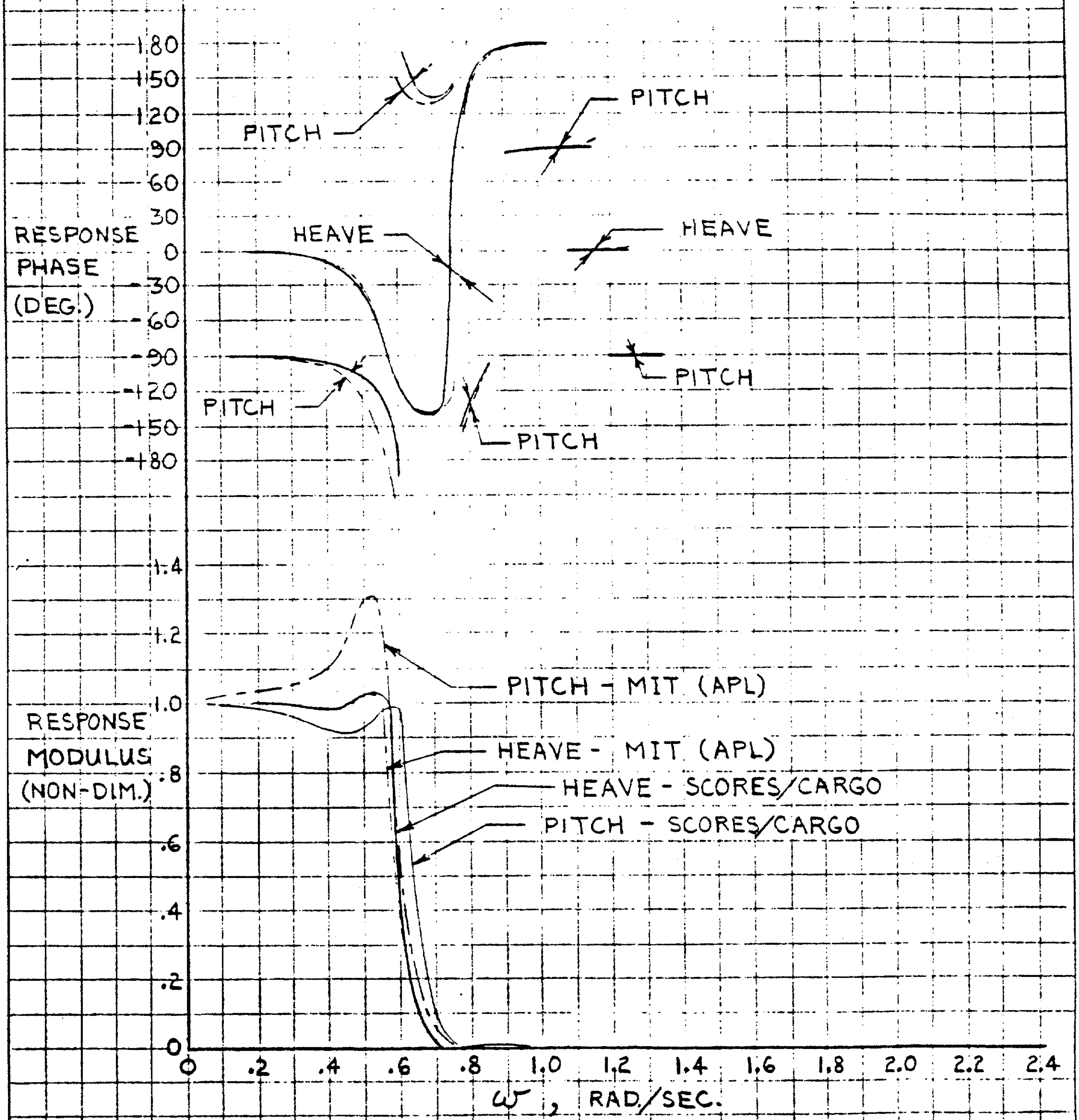

FIGURE 4

L.R. Glosten & Associates, Inc. **Naval Architects** **Marine Engineers** **Ocean Engineers**	SUBJECT COMPARISON OF HEAD SEA C.G. RESPONSE FUNCTIONS FOR 378 FT. × 60 FT. DRAFT OTEC	BY BLH DATE 22 APR. '79 JOB NO. 7915
Colman Building 811 First Avenue	Seattle, Washington 98104 (206) 624-7850	SHEET 1 OF 1

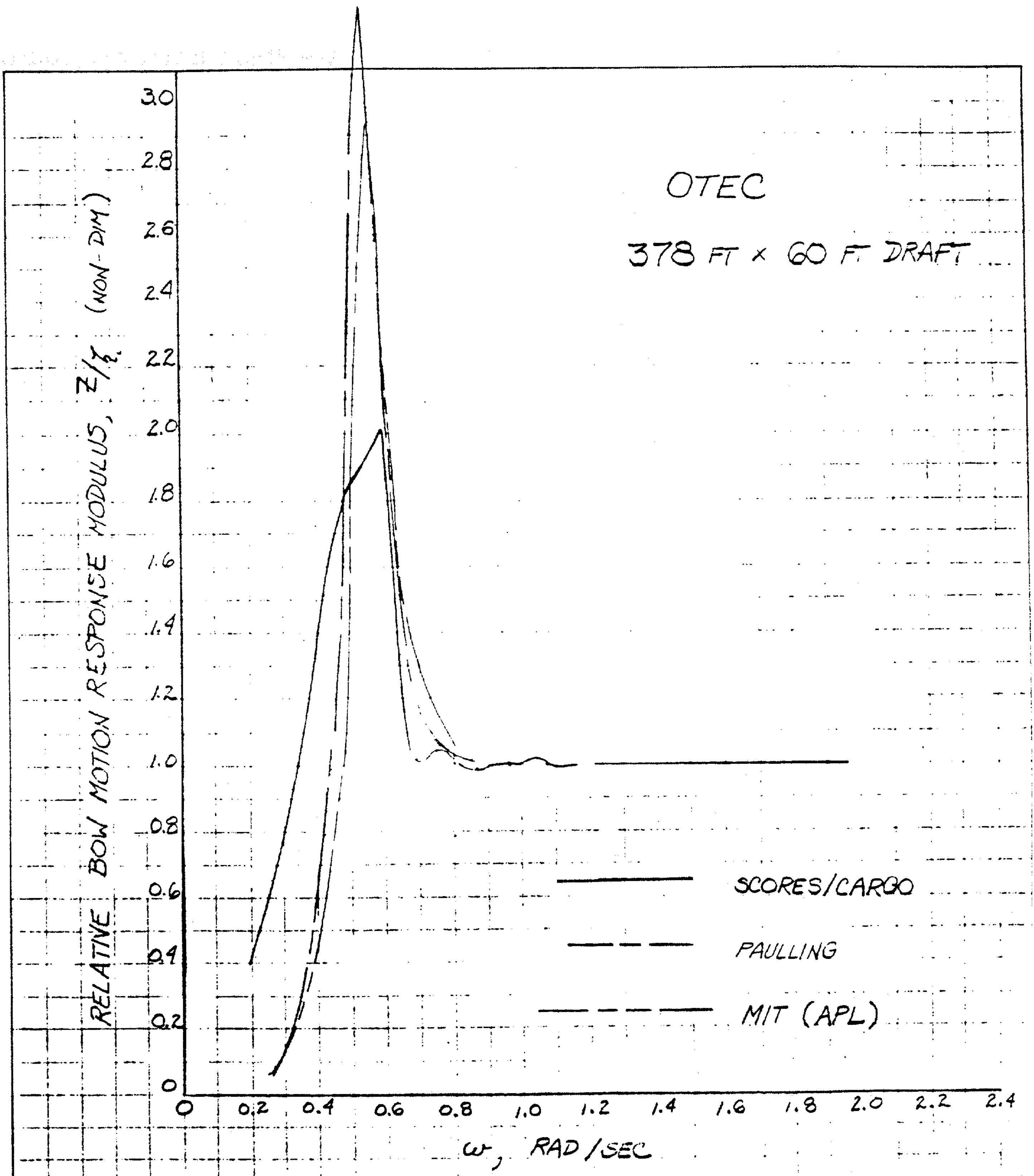

FIGURE 6

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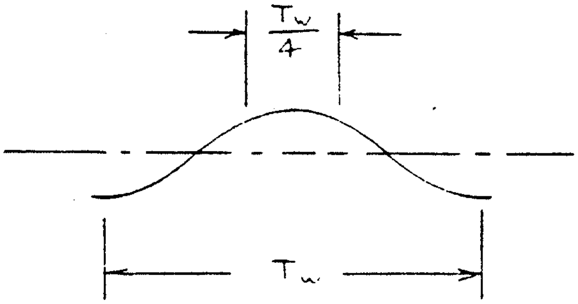
SUBJECT
COMPARISON OF FWD QTR SEAS
R.B.M. RESPONSE FUNCTIONS

BY EWF
DATE 4/23/79
JOB NO. 7915
SHEET OF

Colman Building 811 First Avenue Seattle, Washington 98104 (206) 624-7850

Assume that all water boards during $\frac{1}{4}$ of wave period (see sketch):



$T =$ 10 ; 11 ; 14 seconds

$\bar{\zeta} = \frac{4\ \bar{Q}}{5.12\ T}$ avg. depth of boarding water

$\bar{\zeta} =$ 1.02 ; 1.41 ; 1.70 ft.

$\zeta_{0.005} =$ 3.65 ; 4.58 ; 4.67 ft.

$V \approx$ 51.2 ; 56.3 ; 71.7 fps

$\frac{V^2}{2g} \simeq$ 40.7 ; 49.3 ; 79.89 ft.

SUBJECT Rate of Shipping Water

BY BLH	JOB NO. 8195
DATE 7 Dec '81	SHEET 3 OF 3

Ref.: Shore Protection Manual, Vol. II; Sect. 7.22

$H_o' = 26 \; ; \; 28 \; ; \; 32$ (ABAM 10/27/81)

$h = 55$ ft.

$d_s = 30$ ft.

$R = 69.78 \; ; \; 75.15 \; ; \; 89.79$ (ABAM 10/27/81)

$H_o'/gT^2 = 0.0081 \; ; \; 0.0072 \; ; \; 0.0051$ (ABAM 10/27/81)

$d_s/H_o' = 1.38 \; ; \; 1.39 \; ; \; 1.34$ (ABAM 10/27/81)

$\alpha = 0.069 \; ; \; 0.069 \; ; \; 0.069$ Fig. 7-24

$Q_o^* = 0.0067 \; ; \; 0.0066 \; ; \; 0.0066$ Fig. 7-24

$$Q = \left(g\, Q_o^*\, H_o'^{\,3} \right)^{1/2} \exp\left\{ - \left[\frac{0.1085}{\alpha} \log_e \left(\frac{R+h-d_s}{R-h+d_s} \right) \right] \right\}$$

$Q = 18.93 \; ; \; 23.01 \; ; \; 33.94$ $\text{ft}^3/\text{sec-ft}$

$V_w = 45 \; ; \; 60 \; ; \; 75$ knots

$W_f = 1.25 \; ; \; 2.0 \; ; \; 2.0$

SUBJECT Rate of Shipping Water

THE GLOSTEN ASSOCIATES, inc.
Naval Architects · Marine Engineers · Ocean Engineers
610 Colman Building · 811 First Avenue · Seattle, Washington 98104

BY BLH	JOB NO. 8135
DATE 7 Dec '81	SHEET 1 OF 3

$\theta = 90°$

$$k' = 1 + W_f \left(\frac{h - d_s}{R} + 0.1 \right)$$

$k' = 1.57 \quad ; \quad 1.87 \quad ; \quad 1.76$

$Q_c = 29.72 \ ; \ 43.03 \ ; \ 59.73$ $\quad$ ft^3/sec-ft

<u>Irregular Waves</u>

$\alpha = 0.069 \quad ; \quad 0.069 \quad ; \quad 0.069$

$\frac{h-d_s}{R} = 0.358 \quad ; \quad 0.333 \quad ; \quad 0.278$

$Q_{0.005}/Q = 1.57 \quad ; \quad 1.50 \quad ; \quad 1.40$

$\overline{Q}/Q = 0.44 \quad ; \quad 0.46 \quad ; \quad 0.51$

$Q_{0.005} = 46.66 \quad ; \quad 64.55 \quad ; \quad 83.62$ $\quad$ ft^3/sec-ft

$\overline{Q} = 13.08 \quad ; \quad 19.79 \quad ; \quad 30.46$ $\quad$ ft^3/sec-ft.

SUBJECT Rate of Shipping Water

THE GLOSTEN ASSOCIATES, inc.
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610 Colman Building · 811 First Avenue · Seattle, Washington 98104

BY BLH	JOB NO. 8195
DATE 7 Dec '81	SHEET 2 OF 3

ADDENDUM E

Wave Run-up and Boarding Seas Study-Concrete Barge Concept, Glosten Associates Inc., 9 December 1981.

THE GLOSTEN ASSOCIATES, inc.
Naval Architects · Marine Engineers · Ocean Engineers

610 Colman Building · 811 First Avenue
Seattle, Washington 98104

Phone 206·624·7850
Telex 32·1226

9 December 1981
File No. 8195

Mr. Bill Cichanski
ABAM Engineers, Inc.
500 South 226th Street
Federal Way, Washington 98003

Dear Bill:

Enclosed are two copies each of sketches of suggested bow flare and upper deck breakwater configurations for the Norton Sound Caisson. Also enclosed is one set of calculations pertaining to the possible rate of shipping water. These calculations were used to set a conservative breakwater height. For your information I have also included a couple of pages from H. Saunders Hydrodynamics in Ship Design that discuss flare and breakwaters.

I believe that the ideas contained in the enclosed sketches, if implemented, should provide substantial protection from wave run-up and boarding seas in the design wave conditions you provided to me.

With best regards.

Yours very truly,

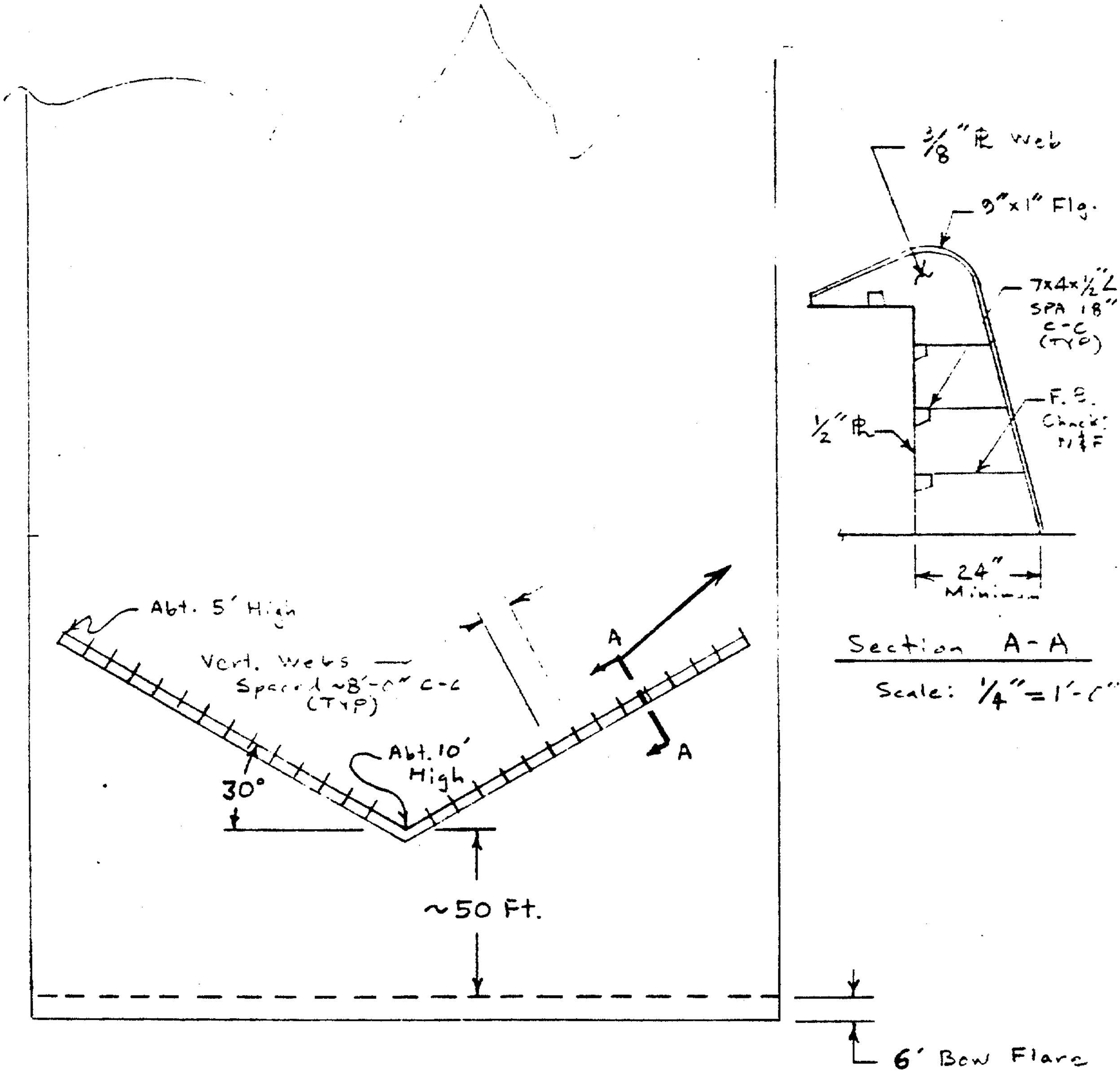
THE GLOSTEN ASSOCIATES, INC.

Bruce L. Hutchison

BRUCE L. HUTCHISON

BLH:ap

Enclosures



Section A-A

Scale: ¼"=1'-0"

Scale: 1" = 50'-0"

SUBJECT BREAKWATER FOR NORTON SOUND CAISSON

THE GLOSTEN ASSOCIATES, inc.
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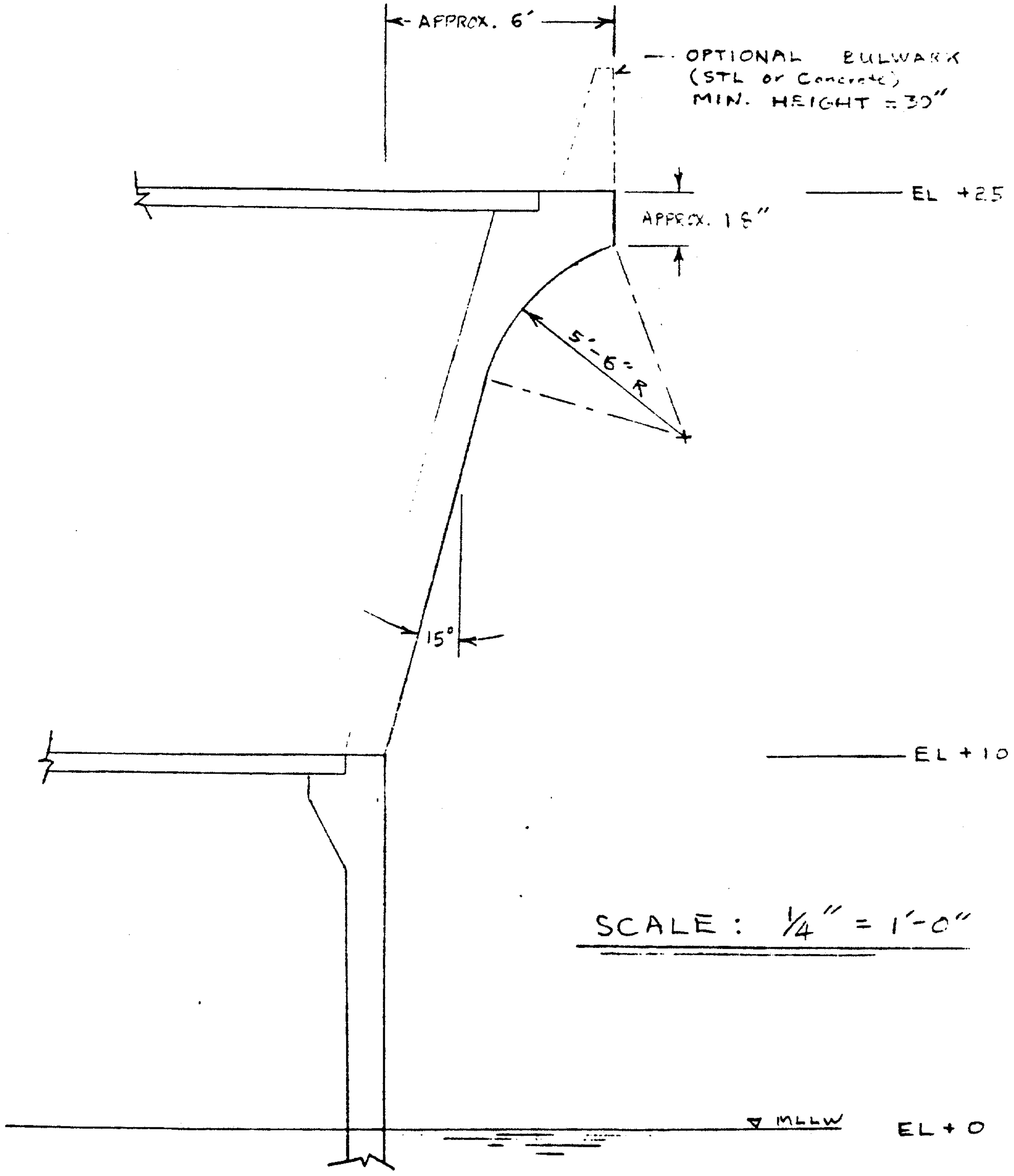
BY ELH	JOB NO. 8195
DATE 9 Dec '81	SHEET OF



SCALE: 1/4" = 1'-0"

SUBJECT BOW FLARE FOR NORTON SOUND CAISSON

THE GLOSTEN ASSOCIATES, inc.
Naval Architects · Marine Engineers · Ocean Engineers
610 Colman Building · 811 First Avenue · Seattle, Washington 98104

BY GLH	JOB NO. 8195
DATE 9 DEC '81	SHEET OF

LIGHTWEIGHT CONCRETE EVALUATION

ADDENDUM F

LIGHTWEIGHT CONCRETE EVALUATION

1.0 INTRODUCTION

The feasibility of the use of concrete gravity structures for oil production platforms in Norton Sound is dependent upon the ability to tow these structures into 30 foot water depths after outfitting with drilling and production modules. Additionally, the cost effectiveness of these structures can be significantly improved if they are constructable in existing construction facilities. For these reasons, the design of the concrete barge substructures has considered extensive use of lightweight concrete.

While material costs for lightweight concrete are somewhat greater than those of normal weight concrete, these costs are a small percentage of the in-place cost of concrete. Additionally, the use of lightweight concrete results in the requirement of a smaller waterplane area to achieve a given draft. This results in a reduction in the net concrete volume required in the structure.

While there has been considerable experience with lightweight concrete structures, including structures in the marine environment, unique environmental conditions in Arctic and Subarctic climates warranted an investigation of the behavior of lightweight concrete materials for applications in Norton Sound. Of particular concern was the freeze-thaw durability of the material and its resistance to abrasion resulting from ice movement along the structure.

Additional objectives of this investigation have been to investigate availability of lightweight aggregates, to identify appropriate properties to use in the design of the barge structures and to identify any constraints to construction with lightweight concretes. Areas which require further definition prior to proceeding with final design have been identified.

2.0 DEFINITION

As with higher density concretes, lightweight concrete is made by mixing cement, coarse aggregate, fine aggregate and chemical admixtures which are designed to impart various properties to the wet and/or hardened concrete. The density reduction in structural lightweight concrete, as compared to normal weight concrete, is achieved by replacing a portion of the natural aggregates with lower density aggregates.

According to the American Concrete Institute, structural lightweight concretes are defined as having a 28 day air dry density not exceeding 115 pcf and 28 day compressive strengths exceeding 2500 psi. For cost-effective design of the concrete barge structure, compressive strengths of 6000 psi or greater are required. Thus, this investigation has focused on high strength lightweight concretes.

Lightweight aggregates can be subdivided into the following groups:

- Naturally occurring materials, such as pumice, foamed lava, scoria, volcanic tuff, porous limestone.
- Naturally occurring materials which require further processing, such as expanded clay, shale and slate.
- Industrial by-products, such as sintered pulverized-fuel ash (fly ash), sintered slate and colliery waste, and foamed or expanded blast-furnace slag.

Lack of commercial availability of certain lightweight aggregate types has limited the scope of this investigation to lightweight concretes made from expanded clay, slate or shale. Potential sources for lightweight aggregate from volcanic materials exist in Western North America, however these materials require developmental testing to identify their capabilities.

The manufacture of expanded shale, clay or slate involves the application of heat to the highly siliceous raw material. The heating causes expansion of the gases which are trapped within the raw material. The release and entrapment of gases cause the raw material to expand, thus producing an aggregate with a considerably lower specific gravity. This is accomplished by two manufacturing processes: the rotary kiln or the sintering process.

In the rotary kiln process, the raw material is crushed and introduced at the upper end of a kiln similar to the type used in the Portland cement industry. Hot air or gases are passed in the opposite direction and the raw material is heated to about 2000°F. In the sintering process, crushed raw material is mixed with pulverized fuel and burnt over travelling grates.

Crushing of the manufactured aggregate produces a course surface texture and more permeable aggregate. These conditions adversely effect the workability and strength of the lightweight concrete. Therefore, crushing of aggregate after manufacture should be minimized.

Lightweight aggregates should conform with ASTM C330, "Specification for Lightweight Aggregates for Structural Concrete."

3.0 APPLICATIONS

Among the earliest applications of lightweight concrete was the construction of reinforced concrete ships and barges for use in World Wars I and II. Expanded shale aggregates were used to produce lightweight concrete for these ships.

Concrete densities of 119 pcf and 28 day compressive strengths exceeding 5000 psi were achieved by the concrete used in the construction of the U.S.S. Selma in 1919. After three years of service transporting crude oil, the Selma, a reinforced, non-prestressed vessel, ran aground in Galveston Bay, resulting in a large crack near the bow. Since no one would guarantee a repair of the crack, she was intentionally sunk to act as a breakwater in Galveston Bay.

The hull of the Selma was inspected in 1953. Testing of core samples showed the compressive strength of the hull exceeded 8000 psi. There was no evidence of concrete deterioration in the hull. While the concrete cover on the reinforcing steel was only 5/8 inch, no evidence of pitting of the bars was evident, even in the splash zone. The concrete mix used in the construction of the Selma had a water-cement ratio of 0.49, although the quantity of cement was very high at 1034 pounds per cubic yard.

Among other examples of marine applications of lightweight concrete are the San Francisco-Oakland Bay Bridge, built in the 1930's, a floating drydock built recently in Genoa, Italy, and caissons for Dome Petroleum's Tarsiut project in the Canadian Beaufort Sea, which was completed in 1981. This project will provide valuable epxerience regarding the behavior of lightweight concrete in the Arctic.

Lightweight concrete has also been used in the construction of many bridges and high-rise buildings.

4.0 PROPERTIES

4.1 ABRASION RESISTANCE

The abrasion resistance of any concrete is not only dependent upon the hardness properties of the aggregate, but also upon the quality and strength of the hardened cement paste and the bond between the cement paste and the aggregate. Lightweight concrete, like normal weight concrete, exhibits a strong correlation between abrasion resistance and compressive strength or water-cement ratio (4). Abrasion resistance may also be a function of the degree of saturation of the concrete and its freeze-thaw history.

The surface of concrete consists of a layer of hardened cement paste. Hence, concrete exhibits two distinct abrasion behaviors. Initially the abrasion resistance is independent of the type of aggregate and no difference in abrasion resistance exists between lightweight and normal weight concrete. After the cement paste layer has been abraded, the type of aggregate will influence the abrasion resistance of the concrete. Tests made on German standard abrasion equipment showed that wear, due to abrasion, was two to five times greater in the case of lightweight concrete containing expanded clays and shales than for ordinary sand gravel concrete (5). These tests were made on concretes with compressive strengths between 3500 and 8000 psi.

It should be noted that most abrasion tests have been designed to simulate abrasion occurring in commercial and industrial facilities, highway pavements, or that due to high velocity water flow and debris as in dam spillways.

The primary source of abrasion for the Norton Sound barge structure will be that due to moving ice. While test data from available standard tests will provide relative abrasion resistance provided by different concrete surfaces, these tests do not simulate the actual wear mechanism expected in Norton Sound. It would be desirable to develop an abrasion test which is representative of the environment and thus determine material wear rates which can be accommodated in design.

Due to an inability to quantify the ice abrasion resistance of lightweight concretes, several methods which may be used to improve the abrasion resistance of the exterior bulkheads have been identified:

- Provide normal weight concrete with natural sand and gravel aggregate in the ice abrasion zone.
- Provide a steel armour plate at the external surface of the bulkhead.

- Provide fiber reinforced concrete in the ice abrasion zone.
- Impregnate the surface of the cured concrete with a monomer and polymerise by external heat.
- Use polymer concrete in the ice abrasion zone.
- Use epoxy or latex modified concrete in the ice abrasion zone.

By far the most economical method to improve abrasion resistance is to utilize normal weight concrete using natural aggregates exhibiting good hardness properties. As mentioned above, one reference indicates that wear rates with ordinary sand/gravel concrete can be from one-half to one-fifth those for concrete with expanded clay and shale aggregates.

Fiber reinforced concrete is constructed by incorporating fibers of steel or other materials as an aggregate. These fibers can be incorporated in the concrete mix or by sprayed-on application with a gunite process. Fiber reinforced concretes have been used in highway and hydroelectric applications. Tests have shown that slabs of fiber reinforced concrete abraded to a depth 27 percent less than plain concrete with gravel (6). In the event that fiber reinforced concretes were used, further research into its durability and corrosion behavior would be necessary.

Various applications of polymers in concretes appear to provide relatively slower abrasion rates than those of conventional concrete mixes. However, in order to justify the use of these materials, it is felt that further investigation would be necessary to identify appropriate construction techniques in order to effectively and economically incorporate these materials into the exterior bulkheads. Additionally, further investigation of the properties of these materials, including the application in low temperature environments, would be necessary.

In polymer-impregnated concrete (PIC), a monomer in liquid form is used to impregnate a concrete surface. The monomer is then polymerized through the application of heat. Since the exterior bulkhead is constructed of cast-in-place concrete, the application of the monomer to a vertical surface is not economical. Significant additional expenses result from the requirement for dry surfaces and the application of heat for polymerization. Based upon an abrasion test procedure developed to simulate erosion in hydroelectric applications, PIC wear rates were one-third those of conventional concrete (7).

In polymer concrete (PC), a polymer is used to replace portland cement as a binder in a concrete mix. This process has been used in patching and overlay repairs of bridge decks. An important benefit of the material in repair applications is its quick curing property which allows traffic resumption in a short time. This property may prove undesirable in terms of construction of the exterior bulkhead. In abrasion testing developed to simulate erosion in hydroelectric applications, polymer concretes are shown to exhibit wear rates that are one-sixth to one-ninth those of conventional concretes.

Epoxy or latex modified concretes are made by adding an epoxy or latex material as a partial replacement for mixing water in a concrete mix. These concretes have been used in bridge deck repairs, parking structures and industrial plants where the concretes are subject to corrosive environments. Epoxy or latex modified concretes appear to be adaptable to conventional construction techniques and thus result in the smallest cost penalty with respect to conventional concrete construction. The abrasion testing discussed above has shown that an epoxy modified concrete exhibited wear rates that were two-thirds those of conventional concrete.

Due to it's superior abrasion resistance properties, the use of normal weight concrete utilizing natural sand and gravel aggregates is recommended for the ice abrasion zone of the exterior bulkhead. In order to provide sufficient design data for the exterior bulkhead plating, it is also recommended that testing methods which simulate ice abrasion be developed. These testing methods could be used to provide the following design information:

- Concrete cover requirements which account for expected ice abrasion wear rates.
- Relative wear rates of various exterior bulkhead materials, thus allowing meaningful cost-benefit studies.
- The relative benefits of concrete surface treatments and coatings.
- Production techniques regarding aggregate stockpiling, batching, mixing and placing which may effect the abrasion resistance of the finished structure.

4.2 DURABILITY

The durability of concrete can be defined as its ability to resist adverse external influences such as climatic conditions, fire, chemical attack and mechanical damage. The Norton Sound barge structures will be subjected to the influences of repeated cycles of freezing and thawing, chemical deterioration of the concrete due to chemicals in the seawater and corrosion of the steel reinforcement.

Deterioration due to freezing and thawing results when water in the concrete matrix freezes. The resulting volume increase of water creates high stresses which cause cracking and spalling. In the thaw cycle, cracks allow further water penetration and hence the deterioration is progressive. The stategy in combatting freeze-thaw deterioration is to create a situation where freezing cannot produce these high stresses. This is achieved by providing voids within the concrete into which the freezing water can expand. These voids are typically provided by air entrainment of the concrete. Additionally, by provision of a dense, strong cement paste the permeability of the concrete is minimized, thus limiting availability of water within the concrete.

Experience and testing with lightweight concrete have shown that the freeze-thaw durability of the material can equal or exceed that of normal weight concrete. This can result from the porosity of the aggregate which, in effect, adds air voids to the concrete matrix. In essence, lightweight concrete may outperform normal weight concrete with regard to freeze-thaw.

Testing has also shown a relationship between the moisture content of the aggregate and the durability of lightweight concrete (8). Lightweight concrete made with air-dried aggregate exhibited superior freeze-thaw durability to aggregate which had been soaked for 18-24 hours. Thus, aggregate stockpiling methods which control the moisture content of the aggregate are recommended.

It may be cost-effective to place lightweight concretes by pumping. In this event, pre-soaking of the aggregate will be required. The consequences of the pre-saturated aggregate upon the freeze-thaw durability of the concrete must be determined and acceptable remedies taken.

The frost resistance of some lightweight aggregates is not adequate even when embedded in the concrete matrix, and they may damage the concrete due to disintegration of the aggregate. Prior to construction, concrete samples made with the specific lightweight aggregate should be subjected to accelerated freeze-thaw testing.

Chemical replacement in the concrete by chloride, sulfate and magnesium ions contained in seawater adversely effect the durability of concrete in the marine environment. Although the mechanism is not entirely clear, investigations agree that the chemical reaction is between tri-calcium aluminate (C_3A) contained in the cement and the substituted ions from the environment; the chemical reaction is accompanied by a volume increase which causes the distress in the concrete (9). Specific aggregates can also be prone to this phenomena. Unsound and reactive aggregates have swollen after prolonged immersion in seawater, producing cracking and general disintegration. The chemical inertness of the aggregates is essential and should be verified using standard tests, prior to their use.

The mechanism that causes distress in concrete due to corrosion of reinforcement is similar to that of the chemical replacement in cement. In both instances, the product of the chemical reaction occupy a greater volume than the combined volume of the reactants. In the case of corrosion of reinforcement, the oxidation products occupy twice the volume of the original steel. This increase in volume exerts tension in the concrete surrounding the reinforcement, resulting in cracking and eventual spalling of the concrete. However, the cement paste can provide an alkaline environment which will inhibit the oxidation of the reinforcement. It has been shown by tests that the concretes with a high cement content can provide an adequate protection against corrosion (10). To insure this protection, dense, impervious cement paste in the concrete is essential because the alkaline materials can be lost to the environment through leaching and carbonization. The rate at which carbonization of the alkaline materials in concrete and the rate at which carbonization spreads inwards from the surface depends, to a much greater extent, on the quality of the concrete; i.e., its grading, compaction and cement content, than on the type of aggregate used.

In order to minimize the chemical replacement in the cement paste and also to ensure adequate protection to the reinforcement, a high cement content (7-8 sacks per cubic yard) is recommended. Cement should have a moderate quantity (5-6 percent) of calcium trialuminate (C_3A).

In conclusion, with proper concrete mix design and placing techniques, the durability of lightweight concrete can equal or exceed that of normal weight concrete. The same parameters are important to assure the durability of both lightweight concrete and normal weight concrete: an air void system, a dense, impervious concrete utilizing a low water-cement ratio (0.40 maximum) and sufficient cement content (650-750 pounds per cubic yard). The moisture content of the lightweight aggregate and its effects upon freeze-thaw durability is the one parameter which requires more critical consideration for lightweight concrete.

4.3 ABSORPTION

The amount of moisture absorbed by lightweight concrete when submerged in seawater is an important consideration in the determination of the effective draft of the barge structure. According to the FIP (11), water absorption in lightweight concretes can range from 12% to 22% by volume. Similar values have been found in Navy testing of seawater absorption of lightweight concrete (12).

In-place compaction and the quality of the cement paste are important parameters in limiting water absorption in any concrete.

4.4 COMPRESSIVE STRENGTH

In order to provide a cost-effective barge structure, the maximum compressive strength practically obtainable should be used. Based upon discussions with lightweight aggregate suppliers and observations of concrete strengths used in previous applications of lightweight concrete, a 28 day compressive strength of 6000 psi is recommended for the lightweight concrete. Indications are that proper mix proportioning and material selection may allow higher strengths to be achieved.

4.5 DENSITY

The density of lightweight concrete and the compressive strength of the concrete are generally related. In order to achieve higher compressive strengths, the concrete densities will be in the upper range of lightweight concrete density.

In compacted lightweight concretes approximately 70% of the volume is taken up by the aggregates. Thus the particle density of the aggregate is the primary factor influencing concrete density. In lightweight aggregates the particle density is dependent upon the particle size. For lightweight concrete a reduction in the maximum coarse aggregate particle size will generally result in an increase in concrete strength while increasing density.

In structural lightweight concrete, natural sand is often used as a fine aggregate in the mix. This results in a more economical mix design due to the reduced water demand for a given workability; however, the resulting density is greater than that possible with a concrete with lightweight fines.

At the early stages of a project, various lightweight concrete mix designs should be tested in order to select the optimum mix proportions which result in the desired concrete density and strength. This testing must also consider the need for constructability with the material in order to assure that the desired properties are achieved in field conditions.

Based upon test results obtained from lightweight aggregate suppliers and documentation of projects which have used high strength lightweight concrete, lightweight concretes with a fresh unit weight between 110 and 125 pcf should be capable of producing compressive strengths of 6000 psi. This should provide concrete with a 28 day air-dry unit weight between 105 and 120 pcf. The design density of the Norton

Sound concrete structures has been based upon a density of 130 pcf. This density includes an allowance for steel reinforcement of 10 pcf. An allowance of 5 to 10 pcf should be used for water absorption in plating elements subject to hydrostatic pressures.

4.6 TENSILE/SHEAR STRENGTH

The tensile strength of lightweight concretes is typically less than that of normal weight concrete. Concrete shear capacity is determined primarily by the diagonal tension capacity of the concrete. In lieu of specific test data, ACI 318-77 requires a reduction factor for lightweight concrete shear capacities and modulus of rupture. This reduction factor is 0.85 for sand-lightweight concrete and 0.75 for all lightweight concrete. ACI 318-77 also requires increased development lengths for reinforcement in lightweight concretes. Development lengths calculated for normal weight concrete must be increased 18 percent for sand-lightweight concrete and 33 percent for all lightweight concrete.

It should be noted that ACI 318 allows the use of test data for a specific concrete in lieu of these capacity reductions. Considerable design economy may result through testing of proposed materials.

4.7 MODULES OF ELASTICITY

It has been shown that modulus of elasticity of concrete is a function of the unit weight and compressive strength. The formula, $E_c = W_c^{1.5} 33 f'^{0.5}_c$ presented in the 318-77 ACI Code, defines this relationship. For high strength concrete, this formula over estimates the modulus of elasticity, and a better estimate can be made by modifying the formula ($E_c = W_c^{1.5} C f'^{0.5}_c$ where $C = 31$ when $f'_c = 5000$ psi and $C = 29$ when $f'_c = 6000$ psi). Based on the modified formula, $E_C = 2600$ ksi should be used for concrete having $f'_c = 6000$ psi and $W_C = 110$ pcf. The modulus of elasticity can and should be accurately determined by testing.

4.8 POISSON'S RATIO

Concrete gravity structures are subjected to biaxial stress states due to the combined effects of prestressing and externally applied loadings. For this reason, testing should identify Poisson's ratio of potential lightweight concretes. For preliminary design, Poisson's ratio can be taken as 0.2.

4.9 CREEP

Creep is the time dependent deformation of concrete due to a load and can occur with or without the exchange of moisture between the concrete and the environment. Creep occurs in addition to the initial elastic deformations under a load and in addition to shrinkage and swelling deformations.

Creep resulting from moisture exchange is termed as wetting or drying creep and is essentially thought to be a modification of shrinkage due to an applied load. The creep associated without moisture exchange is called basic creep. Basic creep consists of two parts: the delayed elastic deformation and the viscous flow. Hydrated cement is a colloidal mass or gel, with a partly crystalline and partly amorphous structure. The viscous flow occurs in the amorphous structure and results in a permanent plastic deformation. The delayed elastic deformation is due to the gradual transfer of stress to the crystalline components of the gel which reacts in an elastic manner. The time dependent deformation is a result of the potential energy stored in the aggregate particles; its magnitude depends on the elastic properties of the aggregate. Since lightweight aggregates are porous and have a lower modulus of elasticity, the time dependent elastic deformations in lightweight concrete is expected to be less than in normal weight concrete with aggregates having a high modulus of elasticity.

Other aggregate properties which can effect creep are the size, shape and surface texture of lightweight aggregate. Good aggregate and a compact particle shape, the particle having rounded edges and a closed surface, are favorable factors. Creep is also a function of the cement paste, creep decreases with decreasing porosity of the cement paste.

As for normal weight concrete, the method of curing and the maturity of the concrete at the time of loading are important factors affecting creep.

As evidenced by testing of lightweight concretes for use in One Shell Plaza in Houston, with proper mix design, creep deformations can be very close to those with normal weight concrete (13).

4.10 PRESTRESS LOSSES

Prestress loss mechanisms in lightweight concrete are similar to those in normal weight concrete. Losses are a function of creep, shrinkage and elastic shortening of the concrete as well as relaxation of the prestressing steel. Testing has shown that prestress losses in lightweight concrete can be greater than those for normal weight concrete.

For preliminary design purposes, losses for both pretensioning and post-tensioning have been calculated in accordance with recommendations by the PCI Committee on Prestress Losses (14). These calculations gave 50 ksi losses for pretensioned concrete.

More accurate testing of a specific lightweight concrete may offer economy by allowing a reduction in the magnitude of prestress losses. Testing on pretensioned concrete bridge girders has shown prestress losses of 23 percent of initial prestress force for lightweight concrete and 14 percent of initial force for normal weight concrete (15). This translates into losses of 40 ksi for pretensioned lightweight concrete.

4.11 SHRINKAGE

Shrinkage is the shortening of an unloaded concrete member due to the withdrawal of water from the cement gel. A part of this shrinkage is not recoverable on subsequent wetting and is thought to be linked with an irreversible modification of the cement gel which apparently occurs during this first drying. Shrinkage is mainly affected by:

- quantity of cement paste in the concrete,
- the quality and water-cement ratio of the cement paste, and
- the type of aggregate used.

The type of aggregate affects the quantity and quality of cement paste required for a given strength and workability. Additionally, depending on their rigidity, aggregate particles tend to restrain shrinkage of the hardened cement paste. In general, where the lightweight aggregate does not require the inclusion of considerably more cement paste than would be required by normal weight aggregates, shrinkage of the lightweight concrete is of the same magnitude as that of the normal weight concrete.

For the preliminary design, it appears that a value of 600×10^{-6} should be used for the final shrinkage of lightweight concrete.

5.0 AVAILABILITY

The manufacture of lightweight aggregate is energy intensive. The escalating energy cost in the last decade as well as the recent downturn in the economy has forced many manufacturers of lightweight aggregate out of business. Our search has revealed three sources of lightweight aggregate supply in western North America:

o	Port Costa Materials, Inc., Port Costa, Calif.	90,000 CY/year
o	Utelite Corporation, Coalville, Utah	80,000 CY/year
o	Consolidated Concrete Limited, Edmonton, Alberta	90,000 CY/year

All three of these sources produce expanded shale aggregates by the rotary kiln process. Port Costa has furnished test data showing 28 day compressive strengths exceeding 6500 psi for concrete with a 28 day air-dry unit weight of 105 pcf. Consolidated concrete has furnished lightweight concrete with a 28 day compressive strength of 5800 psi for caissons used on the Dome Petroleum Tarsuit project.

The annual production of these three producers is 260,000 cubic yards. Current indications are that a project of this magnitude could be accommodated by any of these three suppliers. With the probable upturn in the construction industry, a deficit in supply could result; particularly in the event of a significant demand for concrete gravity structures in Alaska. Therefore, it is necessary to plan in advance for an uninterrupted supply of lightweight aggregates.

One potential way to increase the supply of lightweight aggregate is to reactivate a lightweight aggregate plant. A lightweight aggregate plant which formerly manufactured Literock aggregate is located 30 miles west of Portland, Oregon. This plant went out of business several years ago. Indications are that this facility could potentially be reactivated with an approximate lead time of 18 to 20 months and a capital investment of 3 to 4 million dollars. It is possible, however, that environmental restrictions may significantly affect future use of this plant.

Additionally, both Utelite Corporation and Consolidated Concrete Limited have indicated a desire to expand their capacity if the demand warrants an increased supply of lightweight aggregate.

Prior to proceeding with final design of a concrete barge structure, current sources for lightweight aggregate and the suitability of the properties of concretes manufactured with these aggregates should be assessed. In the event that aggregate supply is limited, advance commitments may be required in order to assure a sufficient supply for construction. Approximate quantities of lightweight aggregate, based upon preliminary design quantities of lightweight concrete and a Port Costa mix design, are 12000 cubic yards of course aggregate and 6000 cubic yards of fine aggregate.

6.0 DESIGN CONSIDERATIONS

Recommendations for lightweight concrete properties for use in preliminary design are included in Section 3.4.8-d. Design codes which are applicable to the design of structural lightweight concretes are ACI 318-77, Building Code Requirements for Reinforced Concrete and ACI 357, Guide for the Design and Construction of Fixed Offshore Structures. ACI 318 Code sections which specifically apply to lightweight concrete are sections regarding materials, concrete quality, reduction factors for modulus of rupture and concrete shear capacities, deflections and calculation of reinforcement development lengths.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 MIX PROPORTIONING

The development of concrete mix proportions is a crucial operation. Approximate mix proportions can be determined from relationships established by previous experience. Final proportions will be based upon trial mixes. The objectives of the total mixes will be:

- to assure that the concrete properties used in design can be achieved reliably;

- to provide a workable, fresh concrete that can be economically placed and compacted into its proper location; and

- to obtain the most economical combination of concrete components.

Not all of these objectives can be mutually optimized, and concrete specifications must indicate acceptable ranges for the critical properties.

A consideration which is unique to proportioning of lightweight concretes is the absorptive property of lightweight aggregates. During the time between mixing and placing concrete, lightweight aggregate will absorb some of the water from the mix, resulting in a slump loss. Trial mixes must determine the required mixing water to provide sufficient workability of the concrete at the time it is to be placed. Procedures must be established to minimize the variability of the absorption properties and the initial moisture content of the aggregate. This can include quality control in the manufacture of the aggregate and covering or sprinkling of aggregate stockpiles to provide consistent material supply. Where pre-wetting of aggregate is used to limit absorption of mix water, the consequences of aggregate saturation on freeze-thaw durability must be considered.

7.2 PLACING AND CURING

There is little or no difference in the techniques required to place and cure lightweight concrete from those used for normal weight concrete. Lightweight concretes tend to require more thorough vibration. Segregation caused by over-vibration is unlikely to occur. In any case, excessive vibration is normally less damaging than inadequate vibration. Whenever possible external form vibration should be utilized.

Lightweight concrete can be pumped; however, special procedures will be required to assure consistent pumpability. Prior to pumping, the aggregate must be presaturated, thus minimizing the aggregates ability to absorb water from the mix under the pumping pressures. The pumping system should be designed to minimize pumping pressures.

If pumping of the concrete mix is to be considered, field trials should be run with the mix design and pumping system intended for the project. Additionally, it must be assured that the moisture in the aggregate is reduced to acceptable levels prior to the time the concrete experiences freeze-thaw cycles.

7.3 QUALITY CONTROL

Quality control procedures for lightweight concrete are the same as those for normal weight concrete, and conform to ASTM standards. Special attention should be paid to fresh concrete density as this test will indicate variations in aggregate gradation, specific gravity and/or moisture content.