RPSEA 1402

Ultra Deepwater Dry Tree System for Drilling and Production

Stage 1 Final Report

H08130-G-RPT-GN-15002

Rev	Date	Document Status	Originator	Checked	Approved
A	11/3/09	Issued for information	P. Poll		

Table of Contents

1 Introduction

RPSEA has funded work to develop a dry tree semisubmersible (DTS) that can be cost competitive with a Spar through their program "Ultra-Deepwater Dry Tree System for Drilling and Production in the Gulf of Mexico". The RPSEA program consists of 3 stages:

1) Develop preliminary hull, riser, and mooring designs and cost estimates for 3 hull forms and 2 payloads and select options for further study.
2) Further develop the options selected from Stage 1 and refine cost estimates. Select one configuration for model testing.
3) Perform model testing.

This document summarizes Stage 1 work performed by Houston Offshore Engineering (HOE) using the Paired-Column Semisubmersible concept. The scope of work for Stage 1 included the following:

1) Technical coordination and project management
2) Develop basis of design, including
   a) Design criteria from RPSEA Working Committee
   b) High-level topsides arrangements and payload
   c) High-level drilling rig arrangement and payload
   d) High-level top-tensioned riser system arrangement and payload
   e) High-level umbilicals, risers and flowlines arrangement and payload
   f) Wellbay layout
3) Develop hull and mooring configuration
4) Perform high-level global performance analysis for critical cases to compute motions and offsets
5) Perform high-level top-tensioned riser analysis to estimate stroke, strength and tensioner stiffness requirements
6) Perform high-level constructability review for hull structure and topsides integration
7) Compare calculation results to design criteria
8) Prepare cost estimates
9) Summarize Stage 1 results in a summary report, workshop and presentation

2 Abbreviations and Definitions

ABS	-	American Bureau of Shipping
API	-	American Petroleum Institute
ASME	-	American Society of Mechanical Engineers
BOP	-	Blow Out Preventer
CG	-	Center of Gravity
DB	-	Design Basis
DTS	-	Dry Tree Semisubmersible
FPI	-	Floating Production Installation
ft	-	Feet
GOR	-	Gas to Oil Ratio
HOE	-	Houston Offshore Engineering
HP	-	High Pressure
HIPPS	-	High Integrity Pressure Protection System
ksi	-	Kips (kilopounds) per square inch
mbopd	-	Thousand barrels oil per day
mbpd	-	Thousand barrels per day
mbwpd	-	Thousand barrels water per day
mmscfd	-	Million standard cubic feet per day
MMS	-	Minerals Management Service
MODU	-	Mobile Offshore Drilling Unit
psi	-	Pounds per square inch
RAO	-	Response Amplitude Operator
ROV	-	Remotely Operated Vehicle
RPSEA	-	Research Partnership to Secure Energy for America
SCR	-	Steel Catenary Riser
SEMI	-	Semisubmersible
st	-	Short tons
TBD	-	To Be Determined
TOC	-	Top of Column
TTR	-	Top Tension Riser
tvdss	-	Total vertical depth sub surface
UCF	-	Upper Column Frame
USCG	-	United States Coast Guard
VIM	-	Vortex-induced motion
VIV	-	Vortex-induced vibration

3 Paired Column Semisubmersible Concept Description

The semisubmersible hull form used for this work is the Paired-Column Semisubmersible developed by HOE. The hull form uses traditional semisubmersible hull components (i.e. columns and pontoons) with the columns arranged in pairs. Figure 3.0-1 compares the traditional semisubmersible hull to the Paired-Column Semisubmersible hull.

Arranging the columns in pairs de-couples traditional semisubmersible dependences such as:

- Wide column spacing for stability and narrow column spacing for deck support
- Heave natural period and pontoon width
- Pre-service draft constraints and preferred final installation draft

The hull configuration can be optimized because of the flexibility of the column arrangement, which results in

- Improved heave motions
- Improved deck structure efficiency
- Improved hull-deck interface
- Improved motions at SCR hang-off locations

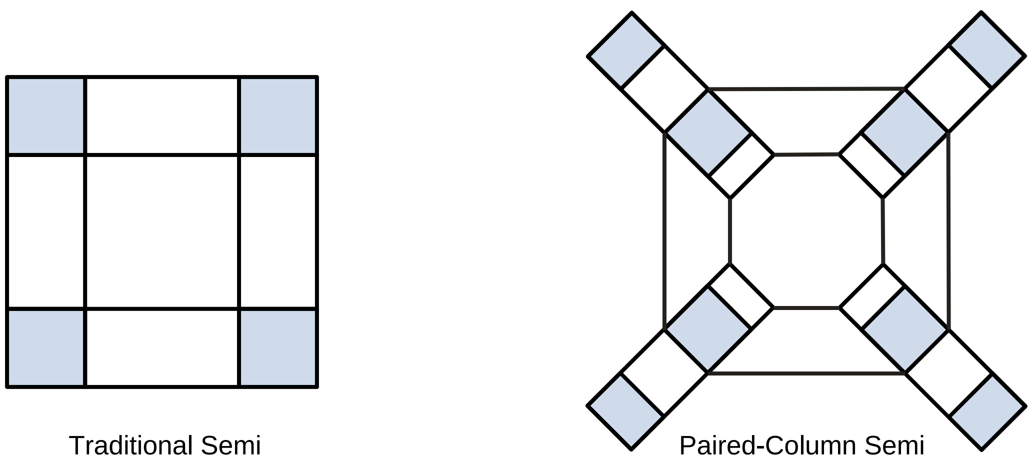


Figure 3.0-1 Comparison of Traditional Semisubmersible and Paired-Column Semisubmersible Hull Arrangement

4 Design Basis

The design basis, included as Appendix A, was developed by RPSEA in conjunction with HOE and other Stage 1 participants. The design basis is summarized in Table 4.0-1.

Table 4.0-1 Summary of Design Basis Data and Criteria

	Data or Criteria		**Comments**
	Base Case	**Sensitivity Case**	
Water Depth	8,000 ft	8,000 ft	
Throughput	Oil: 100 mbopd Gas: 50 mmscfd Total Fluids:120 mbpd	Oil: 75 mbopd Gas: 38 mmscfd Total Fluids: 90 mbpd	
Water Injection	80 mbwpd	60 mbwpd	At 5,000 psi
Reservoir Depth	27,000 ft	27,000 ft	tvdss
Production TTR	12	9	Dual casing, 9,000 psi shut-in pressure.
Wellbay Slots	16	12	One dedicated slot for drilling riser.
Export Risers	1 oil, 1 gas, 1 spare	1 oil, 1 gas	
Satellite Well Risers	6 x 8" 5,000 psi	4 x 8" 5,000 psi	Satellite production using HIPPS
Water Injection Risers	2 x 10" 5,000 psi	1 x 10" 5,000 psi	Manifold at seafloor to serve injector wells
Umbilicals	6 x 6"	4 x 6"	
Topsides Payload	7,000 st facilities 10,000 st drilling 2,275 st tensioners	5,600 st facilities 8,000 st drilling 1,750 st tensioners	Operating weights, excludes deck steel, includes drilling fluids.
TTR Tension	11,000 st	8,400 st	Production + drilling
SCR & Umbilicals	6,000 st	3,600 st	
Dead Oil	500 st	400 st	

Other key assumptions and criteria from the design basis include the following:

- Hull is classed and must satisfy USCG and MMS requirements.
- Air gap requirement is based on a minimum air gap of 5 ft to bottom of deck steel in 100-yr hurricane conditions.
- The platform must satisfy global response criteria given in Table 4.0-2.
- The mooring system will be designed according to API RP-2SK and API RP-2SM for polyester systems. In addition, a 10% safety margin is applied for the polyester rope.

- Metocean conditions include hurricane, loop current, combined hurricane and loop current, winter storm and fatigue sea states. Hurricane conditions are based on API RP 2INT-MET Central Gulf criteria.

Table 4.0-2 Global Response Criteria

Response	Conditions with Safety Criteria B	Conditions with Safety Criteria A
Combined Pitch & Roll (single amplitude)	10 degrees (intact)	4 degrees (intact)
Horizontal Acceleration (at top deck, single amplitude, includes gravitational component due to pitch & roll)	0.35 g	0.15 g
Max. Offset – Intact	5% of water depth	
Max. Offset – Damaged	7% of water depth	

5 Configuration Description

The design basis was used to develop a complete platform configuration including topsides, drilling, top-tensioned risers, SCRs, umbilicals, hull and mooring. A high-level summary of these major components is presented in this section. Full details are provided for the base case and a tabular comparison summary is provided for the sensitivity case at the end of this section.

5.1 Topsides

The topsides developed for this study provide realistic layouts using data provided in the design basis. The realistic layouts are used for accurate input to global analysis in the form of wind area, wind center of pressure, deck structural weight and overall topsides weight and center of gravity.

General arrangements of the topsides layouts are provided for the base case in Appendix B and the drawing numbers are shown in Table 5.1-1. Final dimensions and weights of the topsides are summarized in Table 5.1-2.

Table 5.1-1 General Arrangement Drawing Numbers

	Drawing Number
Upper Deck - Plan	H08130-G-0021-01
Mezzanine Deck – Plan	H08130-G-0022-01
Lower Deck – Plan	H08130-G-0023-01
Top of Columns - Plan	H08130-G-0024-01
Looking East – Elevation	H08130-G-0025-01
Looking South – Elevation	H08130-G-0026-01

The general design philosophy for the topsides is based on providing adequate deck area for safe, maintainable, and operator-friendly facilities. The Paired-Column Semi concept provides excellent opportunities for good topsides layouts with open, 2-level decks and plenty of deck area for efficient arrangement of the drilling rig on the upper deck level.

It is not uncommon for conceptual design projects to develop initial estimates of topsides facilities and deck area that are aggressively small, which has a negative impact on project execution when design changes are required to accommodate increases in payload. The layouts developed in this study are sufficiently conservative (based on the square footages given by RPSEA) to minimize the impact of normal design development during future project phases.

In addition to deck area requirements for equipment, access and maintenance, additional area is required to accommodate top-tensioned risers. Riser spacing is determined based on surface tree spacing and riser clashing. Once the minimum riser spacing is estimated, the wellbay layout is determined based on the number of risers specified by RPSEA.

Table 5.1-2 Summary of Topsides Facility Weight Data

Item	Equipment and Bulks	
	Dry (st)	Operating (st)
Base Case		
Drilling(1)(2)	4,000	7,000
Facilities and Utilities(1)	5,120	7,168
Deck Structure(3)	5,400	5,400
Tensioners(4)	2,275	2,275
Total	**16,795**	**21,843**
Sensitivity Case		
Drilling(1)(2)	3,200	6,000
Facilities and Utilities(1)	4,120	5,768
Deck Structure(3)	4,640	4,640
Tensioners(5)	1,750	1,750
Total	**13,710**	**18,158**

Notes:

(1) Weights for drilling rig have been provided by RPSEA. A ROV has also been added to Facilities and Utilities.
(2) Drilling bulks and reserve mud on the topsides are included under equipment and bulks. Drilling does not include fluids stored in the hull.
(3) Steel weight estimated by HOE includes 15% contingency. Includes helideck weight (200 st). Does not include upper column frame.
(4) Tensioners weight includes (11) production and (1) drilling tensioners.
(5) Tensioners weight includes (9) production and (1) drilling tensioners.
(6) Weight of future topside equipment, associated deck structure and future flowline loads are assumed to be included in RPSEA payload requirement.

The general arrangement of the equipment was established based on considerations such as operability and functional requirements, environmental conditions, and safety and hazards prevention concerns. The prevailing wind direction is assumed generally from the southeast towards the northeast. The flare boom is positioned at the north side of the platform, while the living quarters and helideck are located at the south side. In general, the process equipment or hazardous equipment is located on the lower deck toward the flare-boom (north side), and the utility or non-hazardous equipment is located toward the living quarter area (south side).

The drilling rig is located on the upper most deck level in order to facilitate easy installation. Drilling support equipment (power generation, mud pumps, drilling utilities, etc.) are located in a designated location on the production deck to reduce the overall platform vertical center of gravity. The drilling crew quarters are assumed to be included in the permanent quarters. The deck layout provides space for the temporary rig crew quarters building in the laydown areas, which can be removed when not in use. The wellheads in the center well-bay area are housed between the upper and lower decks, and are to be supported with a riser tensioner system supported from the upper column frame.

The open drain system is located below the lower deck on the north side of the wellbay. The hull pontoons will store the following fluids: drill water, brine completion fluid, diesel fuel and potable water. Methanol storage is located in the hull at the top of the northwest column.

5.1.1 Base Case Layout Description

The layout incorporates a rectangular shaped deck that has 2 levels: an upper deck (approx. 245 ft (E/W) X 217.5 ft (N/S)) with the top of deck steel at 116 ft above mean water level; and the lower deck (approx. 245 ft (E/W) X 217.5 ft (N/S)) with the top of deck steel at 66 ft above mean water level. A mezzanine area (approx. 97.5 ft (E/W) x 120 ft (N/S)) is located on the southwest side of the platform between the upper and lower decks at elevation 91 ft above mean water level. The total deck area for the platform including the mezzanine is approximately 118,275 ft^2. The separation distance between the decks is 50 ft. The production deck top of steel is equal to the top of outer hull column and 6 ft above the inner column hull.

The layout includes a 3 x 6 wellbay that provides 18 slots for 12 top-tensioned risers and 1 dedicated drilling slot. This arrangement allows a single deployment of the drilling riser to drill 12 wells for top-tensioned risers.

5.1.2 Sensitivity Case Layout Description

The layout incorporates a square shaped deck that has 2 levels, each (approx. 210 ft (E/W) X 210 ft (N/S)). The top-of-steel upper deck is at 116 ft above mean water level and the top-of-steel lower deck is at 66 ft above mean water level. A mezzanine area is not required for this case. The total deck area for the platform is approximately 88,200 ft^2. The separation distance between the decks is 50 ft. The production deck top of steel is equal to the top of steel of outer hull column and 6 ft above the inner column hull.

The layout includes a 3 x 4 wellbay that provides 12 slots for 9 top-tensioned risers and 1 dedicated drilling slot. The arrangement still allows a single deployment of the drilling riser to drill 9 wells for top-tensioned risers.

5.1.3 Topsides Structure

For a semisubmersible, the primary structure supporting the topsides is part of the global structural system including the hull and deck. Global loads on the hull are resisted by the hull structure and deck structure as a system.

For a large dry tree facility, it is common to provide an upper column support frame (UCF) as part of the basic structural system. The UCF is designed to take squeeze/pry loads from the hull.

However, the execution plan must also be considered when developing the overall conceptual design. Topsides integration by lifting multiple modules can benefit from the UCF, which provides temporary support as the modules are set.

The proposed structural system includes a large, single-piece open-truss deck structure supported by deck posts on the hull columns. The deck structure is conservatively designed to take all hull squeeze pry loads in addition to the topsides loads and riser tensions. This assumption will result in a conservative estimate of structural weight, but provides a deck with the flexibility to work with several integration options, including a quayside lift.

Basic truss row locations are indicated on the arrangement drawings (see drawing list in Table 5.1-1). These truss locations have been coordinated between various disciplines to satisfy structural framing requirements, hull column spacing, and equipment layout.

The deck structural weight is a critical component of the overall hull sizing basis. In addition, the deck structure represents an important cost item when estimating overall platform costs. A conceptual estimate was developed using in-house tools and previous project benchmarks. The important feature of these estimating tools is that the evaluation takes into account the function of the deck steel rather than applying a uniform weight per unit area to the entire deck area. In addition, the deck structural estimate takes into consideration the column span for large semisubmersibles. The span between column supports is an important and nonlinear factor when sizing truss members.

The deck structural weight estimates are shown in Table 5.1-2. This weight estimate includes primary, secondary and tertiary steel, including typical local reinforcements at lift points in the primary structure.

5.2 Riser Configuration and Payload

The top-tensioned riser configuration is shown in Figure 5.2-1. The riser top tension for 8,000 ft water depth is 921.5 st for each production riser, based on a specified tension factor of 1.3. The drilling riser is a 21” outside diameter casing and has a specified top tension of 1,000 st, which assumes that buoyancy elements are included to reduce the tension supported by the platform.

The total riser payload for the base case is based on 11 production risers plus 1 drilling riser and equals 11,137 st. Details regarding TTR spacing in the wellbay and at the seafloor are discussed in Section 6.3.

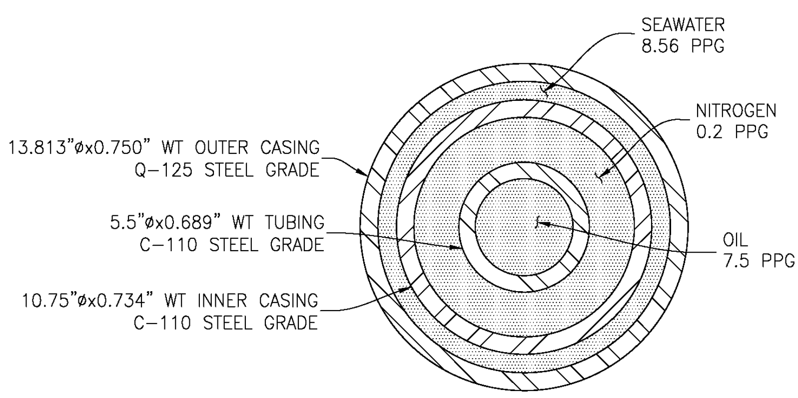


Figure 5.2-1 Top-Tension Production Riser Configuration

5.3 SCR and Umbilical Payload

The SCR and umbilical payload for the base case is summarized as follows:

- Tieback SCR: 8.625” x 0.812”, Six at 310 st each
- Water Injection SCR: 10.75” x 1.0”, Two at 490 st each
- Oil Export SCR: 18” x 1.1”, Two at 910 st each
- Gas Export SCR: 18” x 1.1”, One at 530 st each
- Umbilicals: 6.0”, Six at 120 st each
- Total Vertical Payload: 5,910 st

SCRs are hung off of riser porches attached to the pontoons. Risers carrying hydrocarbons are primarily located on the north and west pontoons and water injection risers on the east pontoon.

Umbilicals are pulled through pull tubes and the vertical tension is supported at the top of the pull tube. The pull tubes are located near inboard columns.

In general, the Paired-Column Semi concept provides ample locations to support a large number of SCRs and umbilicals and the preferred SCR hang-off location on the pontoon structure is relatively close to the center of platform pitch and roll rotation compared to traditional semisubmersible hull arrangements.

5.4 Overall Payload Summary

Table 5.4-1 gives an overall payload summary for the base case including topsides, drilling, TTRs, SCRs, umbilicals and stored fluids. Figure 5.4-1 presents the overall payload in graphical form. The total base case payload is approximately 39,000 st.

Table 5.4-1 Base Case Payload Summary (Sizing Basis)

Items		Base Case Payload	
Design Life	yrs	20	
Integration		Quayside	
Water Depth	ft	8,000	
Design Oil Production Rate	KBP	100	
Peak Gas Processing Rate @500 GOR	MCFD	50	
Max. Produced Water rate	KPD	40	
Max. total fluids processing rate	KPD	120	
Peak Water Injection Rate @ 5,000 PSI	KPD	80	
Number of TTRs + DR		12 + 1	
Number of SCRS: Production + Water Injection		6 + 2	
Number of Export Risers		3	
Number of Umbilicals		6	
DR Drilling Riser tension (vert. each) x O.D	DR 1	1,000 st 21" O.D.	
TTR Top Tension Riser tension (vert. each) x O.D x WT	TTR 1 thru 12	921.5 st 13.813" O.D. x .75" WT outer 10.75" O.D. x .734" WT inner 5.5" O.D. x .689" WT tubing	
Deck Dimension (estimate)	Upper Deck	245' (E/W) x 217.5' (N/S)	
	Lower Deck	245' (E/W) x 217.5' (N/S)	
Wellbay Slots		18	
Deck Height (BOS subcellar deck to TOS main deck)	ft	55'	
Deck primary+secondary steel weight	st	5,400	
		Operating Wt	Dry Weight
Facility & quarters weights	st	7,168	5,120
Drilling Weight	st	7,000	4,000
Tensioners	st	2,275	2,275
Total Topside Weight (facility+quarters+ deck+company reserve)	st	21,843	16,795
DR + TTR Vertical Loads(initial+ future)	st	11,137	
SCR+Umbilicals at Pontoon Vertical Loads(initial+ future)	st	5,910	
Dead oil storage in hull (not incl. in total system payload)	st	500	
Hull storage (not incl. in total system payload)	st	3,000	
Total System Payload (Facility+deck+Reserve+SCR's+Umbillicals, initial+future)	st	**38,890**	

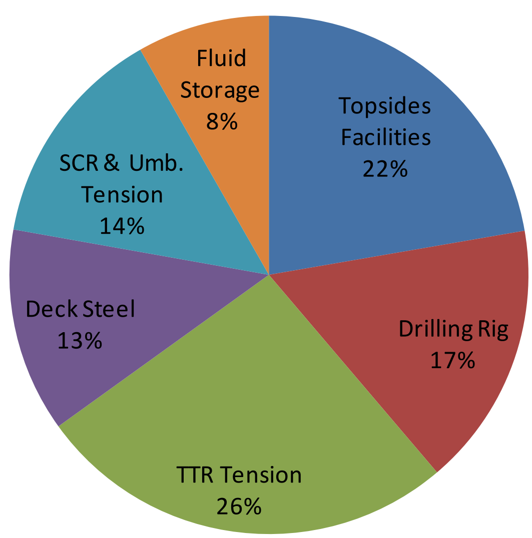


Figure 5.4-1 Base Case Payload Summary in Graphical Form

5.5 Hull Configuration

A tabular summary of the base case hull configuration is provided in Table 5.5-1. Figures 5.5-1 and 5.5-2 provide a sketch of the base case hull configuration.

The arrangement of the columns in pairs is readily apparent in the plan view in Figure 5.5-1. All of the topsides payload and TTR payload are efficiently supported off of the inner columns with minimal span (165 ft center to center). The other significant payload components are also efficiently supported by the hull: fluid storage in hull compartments and SCRs on riser porches on the pontoons. The outer columns are spaced further apart as required to meet stability requirements and to improve platform motions.

Table 5.5-1 Base Case Hull Configuration Summary

Water Depth	(ft)	8,000
Draft	(ft)	175.0
Displacement	(st)	98,579
Inner Column Span (center to center)	(ft)	165
Inner Column Size (length x width)	(ft)	44 x 32
Outer Column Size (length x width)	(ft)	44 x 42
Outer Column Height	(ft)	241.0
Pontoon width (molded)	(ft)	37.0
Pontoon height (molded)	(ft)	26.0
Deck Dimension	(ft)	245' (E/W) x 217.5' (N/S)
Deck height (BOS to TOS)	(ft)	50.0
Deck clearance from MWL	(ft)	66.0
Facilities, utilities, and drilling	(st)	15,443
Prod. Riser tension @ upper column frame	(st)	11,137
Total topsides payload	(st)	26,580
Total weight (excludes riser tension)	(st)	77,386
Vertical C.O.G from keel	(ft)	110.8
Mooring vertical load	(st)	4,143
SCR and Umbilical Vertical Load	(st)	5,910
PR and DR tensioner stiffness	(kips/ft)	20.0
Total vertical stiffness (11 PR + 1 DR)	(kips/ft)	240.0
Heave period (No Risers / All Risers)	(sec)	22.5 / 18.5
Roll period (No Risers / All Risers)	(sec)	32.5 / 35.6
Pitch period (No Risers / All Risers)	(sec)	32.3 / 35.4

Note: Total weight includes facilities, utilities, drilling, deck steel, hull steel, marine systems, stored fluids and water ballast.

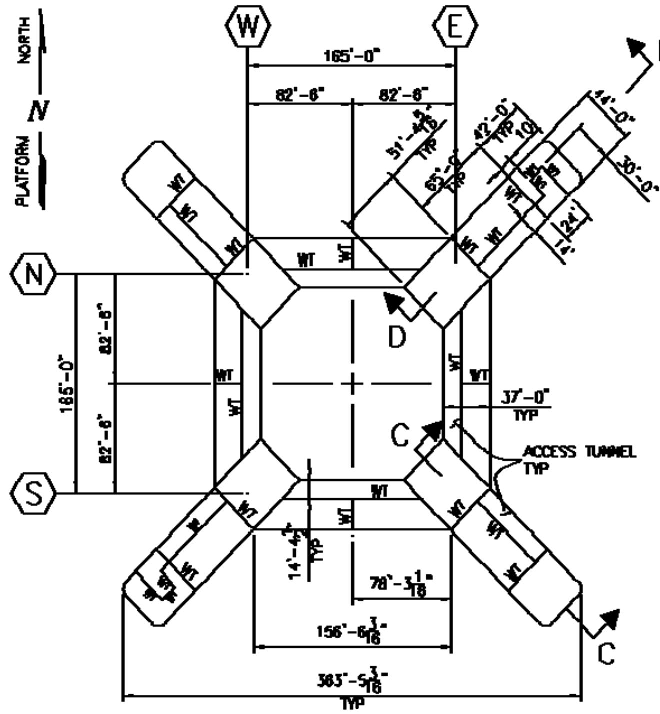


Figure 5.5-1 Base Case Hull Configuration – Plan

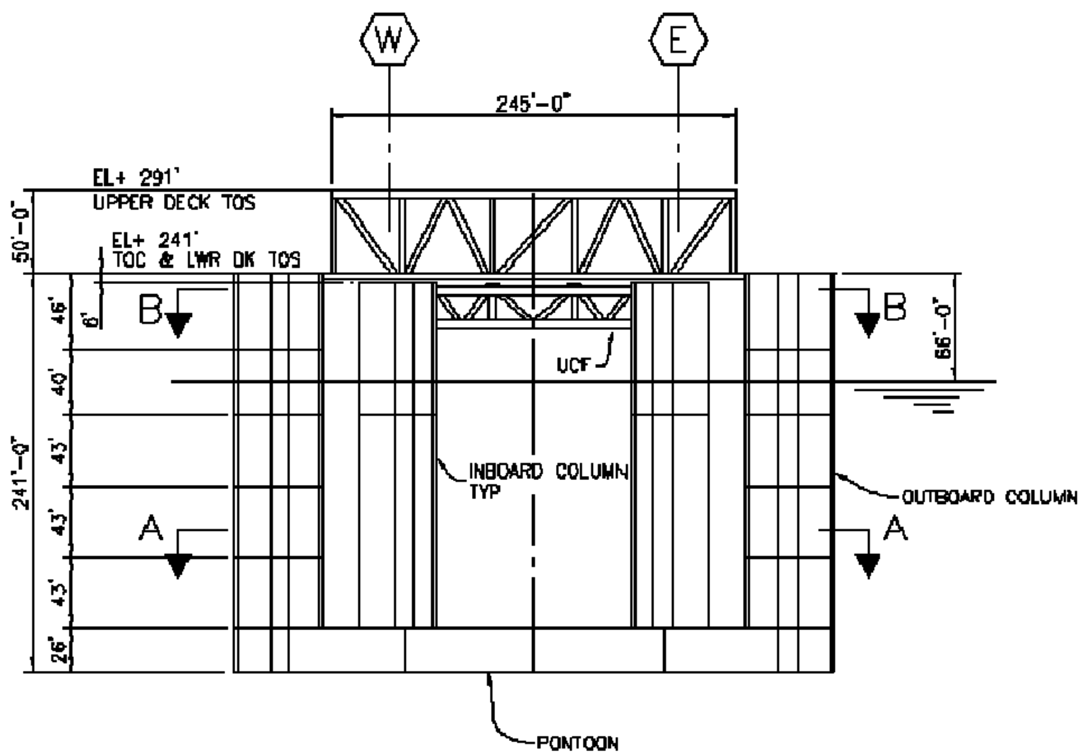


Figure 5.5-2 Base Case Hull Configuration - Elevation

5.6 Mooring Configuration

The mooring configuration is comprised of 14 mooring lines, each utilizing a chain-polyester-chain arrangement. The mooring configuration is not symmetric because of the unbalanced loads from the SCRs and umbilicals. The total unbalanced load is 440 st west and 100 st north. The unbalanced load also results in two basic mooring line sizes as summarized in Table 5.6-1. The component sizes are within the range of sizes previously delivered for Gulf of Mexico projects. In particular, the polyester rope size of 10-5/8" is the same size used for the Mad Dog spar.

Table 5.6-1 Base Case Mooring Configuration Summary

	East Lines	West Lines
Platform Chain (Chain size includes 3/8" corrosion allowance. Length is outboard of fairlead)	6-1/8" 150 ft	5-7/8" 150 ft
Polyester Rope	10-5/8" 11,800 ft	10-1/4" 11,800 ft
Ground Chain (Chain size includes 3/8" corrosion allowance.)	6-1/8" 300 ft	5-7/8" 300 ft

5.7 Sensitivity Case Configuration

A hull configuration was also developed for a sensitivity case with reduced throughput, drilling payload and riser payload. Table 5.7-1 shows the sizing basis for the sensitivity case presented in comparison to the base case. The total system payload is 30,180 st compared to the base case amount of 38,890 st.

Table 5.7-2 summarizes the sensitivity case hull configuration in comparison to the base case. The displacement reduces from 98,579 st (base case) to 89,834 st (sensitivity case). The reduced displacement is primarily achieved through reductions in column dimensions and pontoon width.

Table 5.7-2 summarizes the sensitivity case mooring configuration in comparison to the base case.

Table 5.7-1 Sensitivity Case Payload Summary (Sizing Basis)

Items		Base Case Payload		Sensitivity Case (if different)
Design Life	yrs	20		
Integration		Quayside		
Water Depth	ft	8,000		
Design Oil Production Rate	KBP	100		75
Peak Gas Processing Rate @500 GOR	MCFD	50		38
Max. Produced Water rate	KPD	40		30
Max. total fluids processing rate	KPD	120		90
Peak Water Injection Rate @ 5,000 PSI	KPD	80		60
Number of TTRs + DR		12 + 1		9 + 1
Number of SCRS: Production + Water Injection		6 + 2		4 + 1
Number of Export Risers		3		2
Number of Umbilicals		6		4
DR Drilling Riser tension (vert. each) x O.D	DR 1	1,000 st 21" O.D.		
TTR Top Tension Riser tension (vert. each) x O.D x WT	TTR 1 thru 12	921.5 st 13.813" O.D. x .75" WT outer 10.75" O.D. x .734" WT inner 5.5" O.D. x .689" WT tubing		
Deck Dimension (estimate)	Upper Deck	245' (E/W) x 217.5' (N/S)		210' (E/W) x 210' (N/S)
	Lower Deck	245' (E/W) x 217.5' (N/S)		210' (E/W) x 210' (N/S)
Wellbay Slots		18		12
Deck Height (BOS subcellar deck to TOS main deck)	ft	55'		
Deck primary+secondary steel weight	st	5,400		4,500
		Operating Wt	Dry Weight	Operating Wt
Facility & quarters weights	st	7,168	5,120	5,768
Drilling Weight	st	7,000	4,000	6,000
Tensioners	st	2,275	2,275	1,750
Total Topside Weight (facility+quarters+ deck+company reserve)	st	21,843	16,795	18,158
DR + TTR Vertical Loads(initial+ future)	st	11,137		8,372
SCR+Umbilicals at Pontoon Vertical Loads(initial+ future)	st	5,910		3,650
Dead oil storage in hull (not incl. in total system payload)	st	500		400
Hull storage (not incl. in total system payload)	st	3,000		2,000
Total System Payload (Facility+deck+Reserve+SCR's+Umbillicals, initial+future)	st	**38,890**		**30,180**

Table 5.7-2 Sensitivity Case Hull Configuration Summary

		Base Case	Sensitivity Case (If Different)
Water Depth	(ft)	8,000	
Draft	(ft)	175.0	175.0
Displacement	(st)	98,579	89,834
Inner Column Span (center to center)	(ft)	165	
Inner Column Size (length x width)	(ft)	44 x 32	42 x 30
Outer Column Size (length x width)	(ft)	44 x 42	42 x 40
Outer Column Height	(ft)	241.0	
Pontoon width (molded)	(ft)	37.0	34.0
Pontoon height (molded)	(ft)	26.0	
Deck Dimension	(ft)	245' (E/W) x 217.5' (N/S)	210' x 210'
Deck height (BOS to TOS)	(ft)	50.0	
Deck clearance from MWL	(ft)	66.0	
Facilities, utilities, and drilling	(st)	15,443	13,518
Prod. Riser tension @ upper column frame	(st)	11,137	8,372
Total topsides payload	(st)	26,580	21,890
Deck steel weight (primary + secondary)	(st)	5,400	4,500
Upper column frame weight	(st)	3,100	2,600
Hull primary steel weight	(st)	21,350	20,496
Hull appurtenance, outfitting, mooring equip.	(st)	3,619	3,139
Hull marine systems	(st)	674	607
Hull fluids including dead oil	(st)	3,500	2,400
Water Ballast (trim plus reserve)	(st)	24,300	26,850
Total weight (excludes riser tension)	(st)	77,386	74,110
Mooring vertical load	(st)	4,143	3,698
SCR and Umbilical Vertical Load	(st)	5,910	3,650
PR and DR tensioner stiffness	(kips/ft)	20.0	20.0
Total vertical stiffness	(kips/ft)	240.0	180.0
Heave period (No Risers / All Risers)	(sec)	22.5 / 18.5	21.8 / 19.1
Roll period (No Risers / All Risers)	(sec)	32.5 / 35.6	33.6 / 36.7
Pitch period (No Risers / All Risers)	(sec)	32.3 / 35.4	33.4 / 36.5

Table 5.7-3 Base Case Mooring Configuration Summary

	Base Case		Sensitivity Case	
	East Lines	**West Lines**	**SE Lines**	**NE, NW, SW Lines**
Platform Chain (Chain size includes 3/8" corrosion allowance. Length is outboard of fairlead)	6-1/8" 150 ft	5-7/8" 150 ft	5-3/4" 150 ft	5-1/2" 150 ft
Polyester Rope	10-5/8" 11,800 ft	10-1/4" 11,800 ft	10-1/4" 11,800 ft	9-3/4" 11,800 ft
Ground Chain (Chain size includes 3/8" corrosion allowance.)	6-1/8" 300 ft	5-7/8" 300 ft	5-3/4" 300 ft	5-1/2" 300 ft

6 Verification Analysis

The platform configuration described in Section 5 was verified through analysis as described in this section. In particular, the following analysis was completed:

- Stability analysis to verify compartmentation
- Global performance analysis to verify platform motions and offsets
- Riser strength and stroke analysis to verify TTR compatibility

The analysis was preliminary as required by the Stage 1 scope of work and concentrated on critical cases as required to verify the design.

6.1 Stability Analysis

Stability analysis was performed using the GHS software to verify hull compartmentation. Figure 6.1-1 shows a plot of the GHS model. Preliminary analysis was completed for both intact and damage stability for in-place and pre-service conditions. A more detailed report on the stability analysis and results will be provided in the next Stage for this project. However, the preliminary analysis confirmed that the final compartmentation used for hull structural weight estimation will satisfy class and regulatory requirements for platform stability.

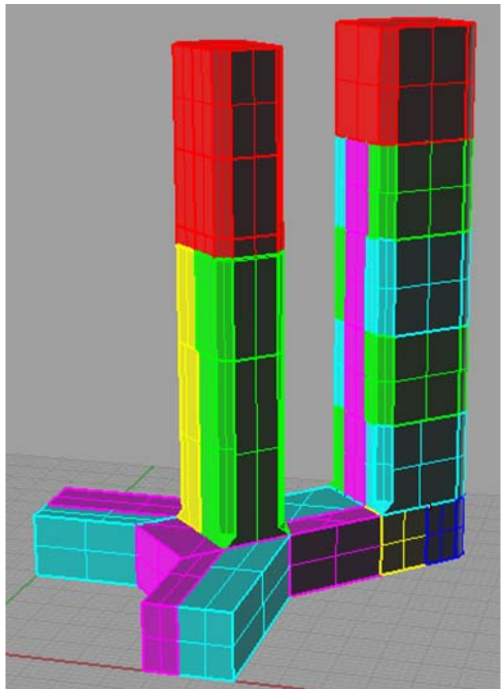


Figure 6.1-1 GHS Model for Stability Analysis

6.2 Global Performance and Mooring Analysis

Global performance analysis was performed to compute platform motions and offsets. The analysis used the WAMIT software to compute hydrodynamic coefficients and in-house software to calculate platform response. A plot of the typical panel model used for hydrodynamic analysis is shown in Figure 6.2-1.

Surge, heave and pitch motion response amplitude operators (RAOs) are presented in Figures 6.2-2 through 6.2-4. The platform response is compared to a traditional Gulf of Mexico production semisubmersible to highlight the benefits of the Paired-Column Semisubmersible concept. The RAOs were generated for the no riser condition and the full riser condition because the stiffness of the riser system impacts the platform motion.

The surge motion RAO shows a clear benefit compared to a traditional semisubmersible. The peak surge response is significantly lower and the overall response is lower throughout most of the wave period range. The heave motion RAO similarly shows a benefit compared to the traditional semisubmersible in the form of a lower heave response. The heave RAO also clearly shows the impact of the TTR system stiffness on the platform response. When the TTRs are excluded from the analysis, the heave RAO approaches unity for long wave periods because the semisubmersible essentially rides the long-period waves up and down from peak to trough. With the TTRs included, the heave RAO approaches a value less than unity because of the system stiffness. The pitch motion RAO highlights the optimization available with the paired column arrangement. The configuration includes several principal dimensions (inner column spacing and size, outer column spacing and size, etc.) that can be optimized for a particular design basis. In this case, the minimum pitch response occurs at the same period as the peak wave energy for the 100-yr sea state.

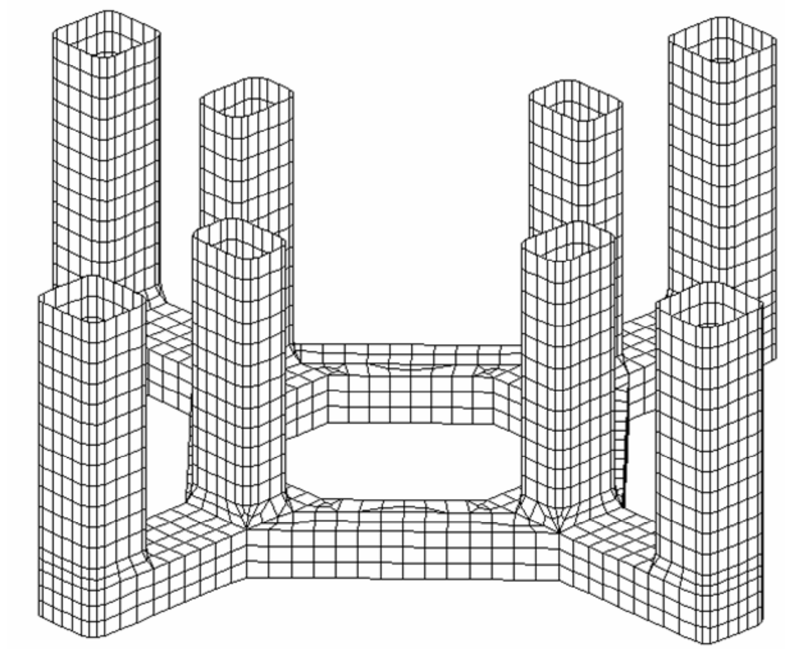


Figure 6.2-1 Panel Model for Hydrodynamic Analysis

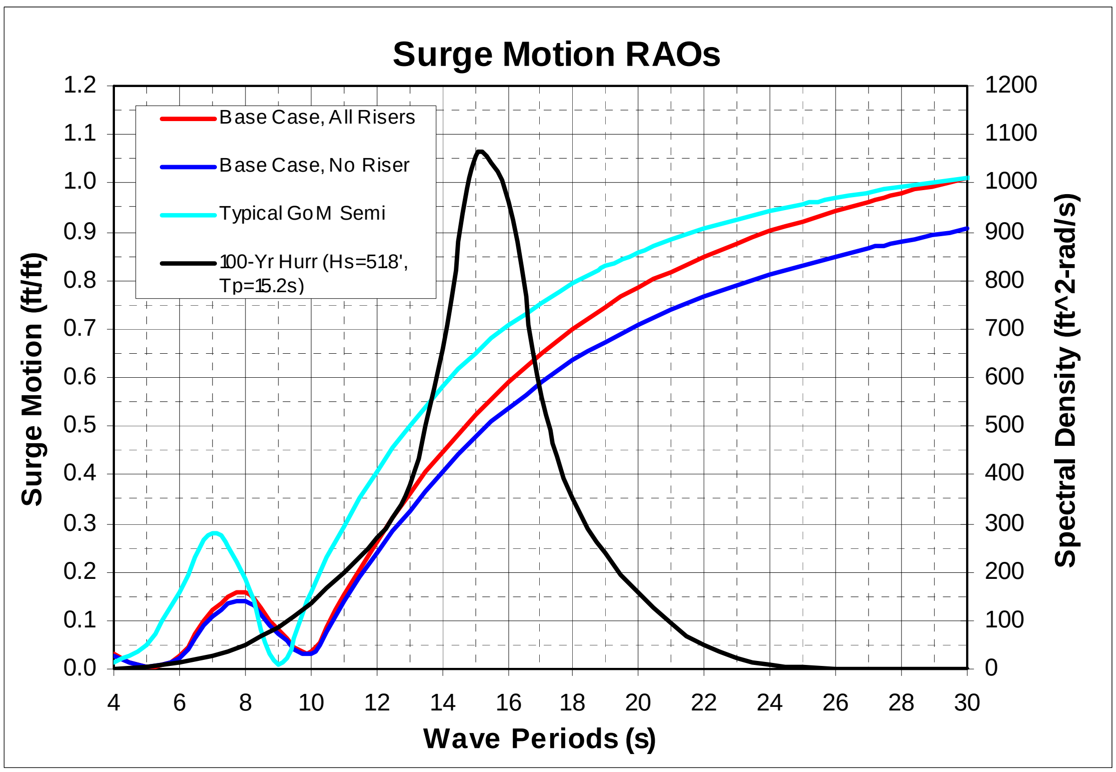


Figure 6.2-2 Surge Motion RAO for Base Case

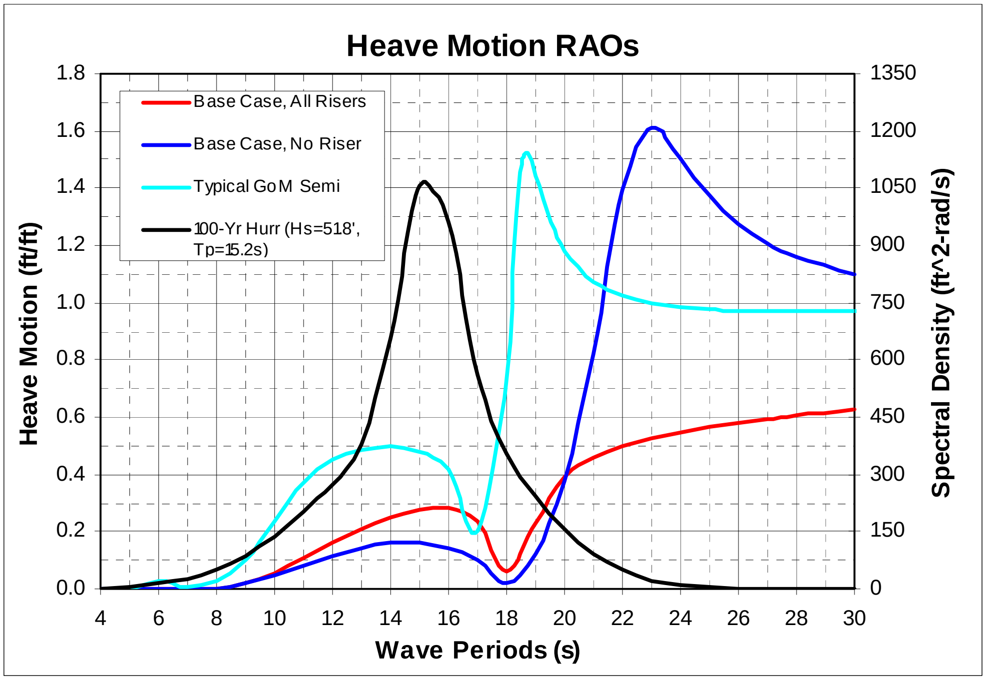


Figure 6.2-3 Heave Motion RAO for Base Case

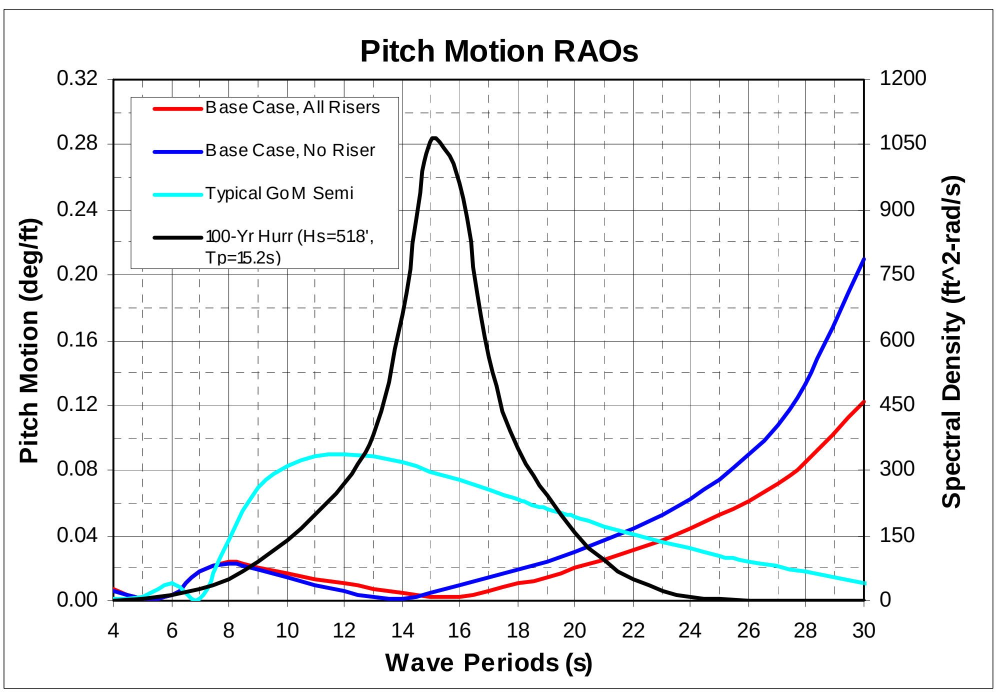


Figure 6.2-4 Pitch Motion RAO for Base Case

Wind force and moment coefficients were developed using WINDOS and a model of the specific hull and topsides configuration developed for this study. Typical force and moment coefficient plots are shown in Figures 6.2-5 and 6.2-6. The critical direction for maximum wind forces and moments is 135 degrees and the center of pressure for this direction is 130 ft above the mean water level. The WINDOS results were used in the global performance analysis for offsets, motions, etc.

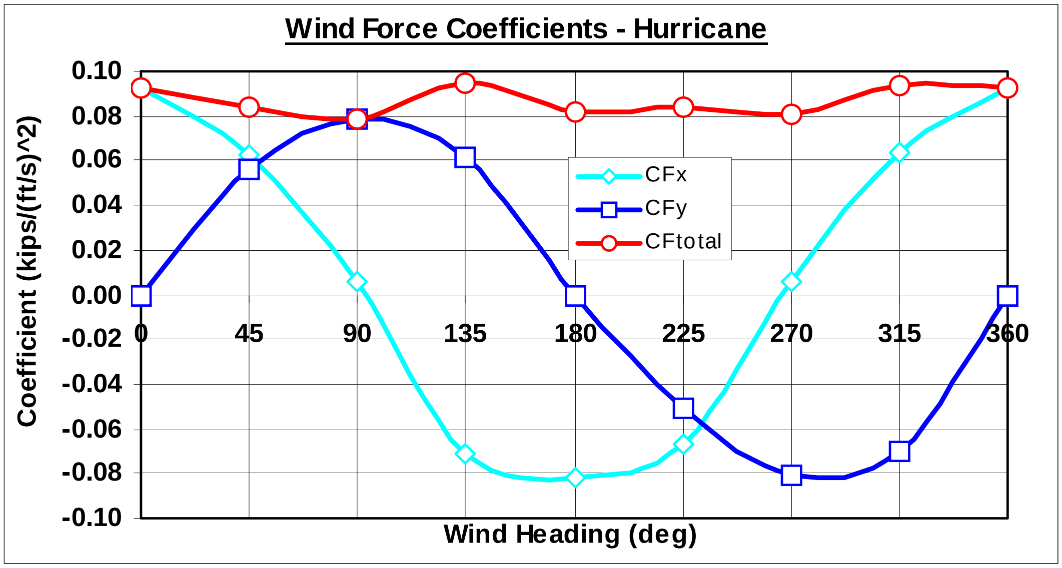


Figure 6.2-5 Wind Force Coefficients for Base Case

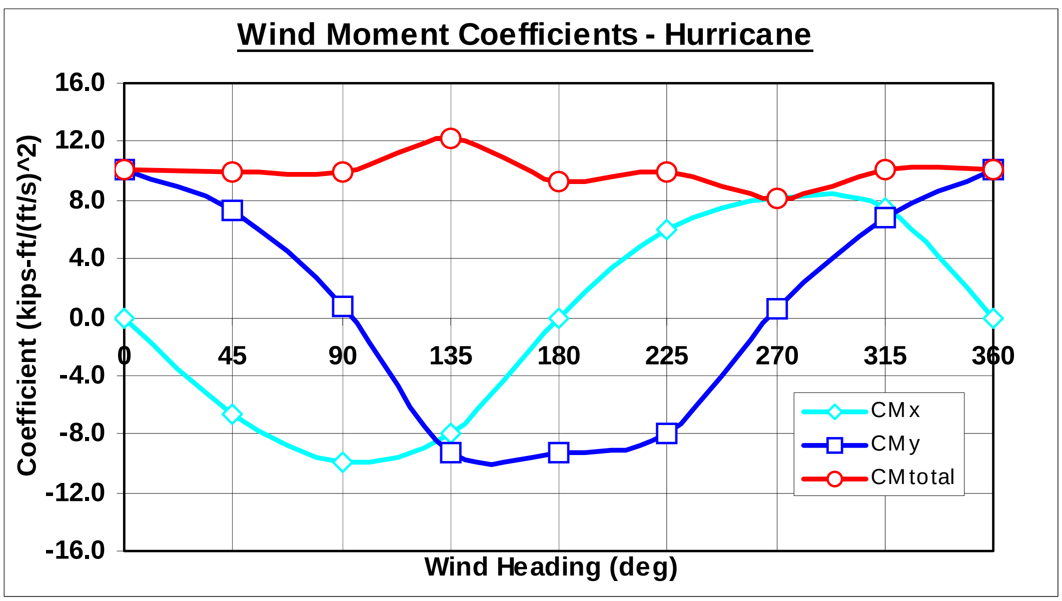


Figure 6.2-6 Wind Moment Coefficients for Base Case

Global performance results including offsets, motions, air gap and accelerations are presented in Figure 6.2-7. Analysis was performed for intact and one-mooring-line-damaged conditions for hurricane, loop current and winter storm sea states as given in the design basis. Five critical headings were screened to identify extreme responses due to the unsymmetrical riser and mooring configuration. The results reported in Table 6.2-1 include mean plus dynamic responses. In all cases, the reported results satisfy required design criteria.

Table 6.2-1 Summary Global Performance Results for Base Case

Performance Characteristic	100-yr Hurricane	10-yr Winter Storm
Offset (Intact)	3.2% water depth	0.5% water depth
Offset (Damaged)	4.3% water depth	1.0% water depth
Combined Roll/Pitch	5.7 degrees	2.3 degrees
Downward Heave	12.5 ft	2.1 ft
Air Gap	7.7 ft	39.8 ft
Horizontal Acceleration	0.24 g	0.08 g

Mooring analysis was performed to confirm mooring sizes given in Section 5.6. Maximum offsets are listed in Table 6.2-1.

6.3 Top-Tensioned Riser Analysis

6.3.1 Configuration

The top-tensioned riser configuration from the mud line to the wellbay is shown in Figure 6.3-1. The riser consists of a tieback connector and stress joint at the connection to the wellhead and a tensioner with tension joint at the connection to the platform. All components of the TTR are within the range of equipment sizes and configurations previously delivered on existing floating platforms. The casing material was specified in the design basis as Q125 (yield strength = 125 ksi) which has not previously been used on existing TTRs but is currently being qualified through another technology program. More details regarding assumptions and criteria used to develop the TTR configuration are contained in the design basis which is included as Appendix A.

The tensioner stroke (25 ft), minimum stiffness (20 kips/ft) and weight (350 kips) were specified in the design basis. Other details regarding the tensioner equipment were not specified but the design is based on existing tensioner equipment. The conceptual layout of the tensioner is shown in Figure 6.3-2. The tensioner is supported at two elevations within the upper column frame spaced approximately 33 feet apart. The tensioner includes a conductor that interfaces with the rollers and hydro-pneumatic cylinders and moves with the riser. The riser tension joint interfaces with the conductor through centralizers and an interface structure for the primary tension load. This arrangement keeps the riser stroke vertical relative to the platform and takes both tension and bending within the tensioner equipment. A keel joint is not required.

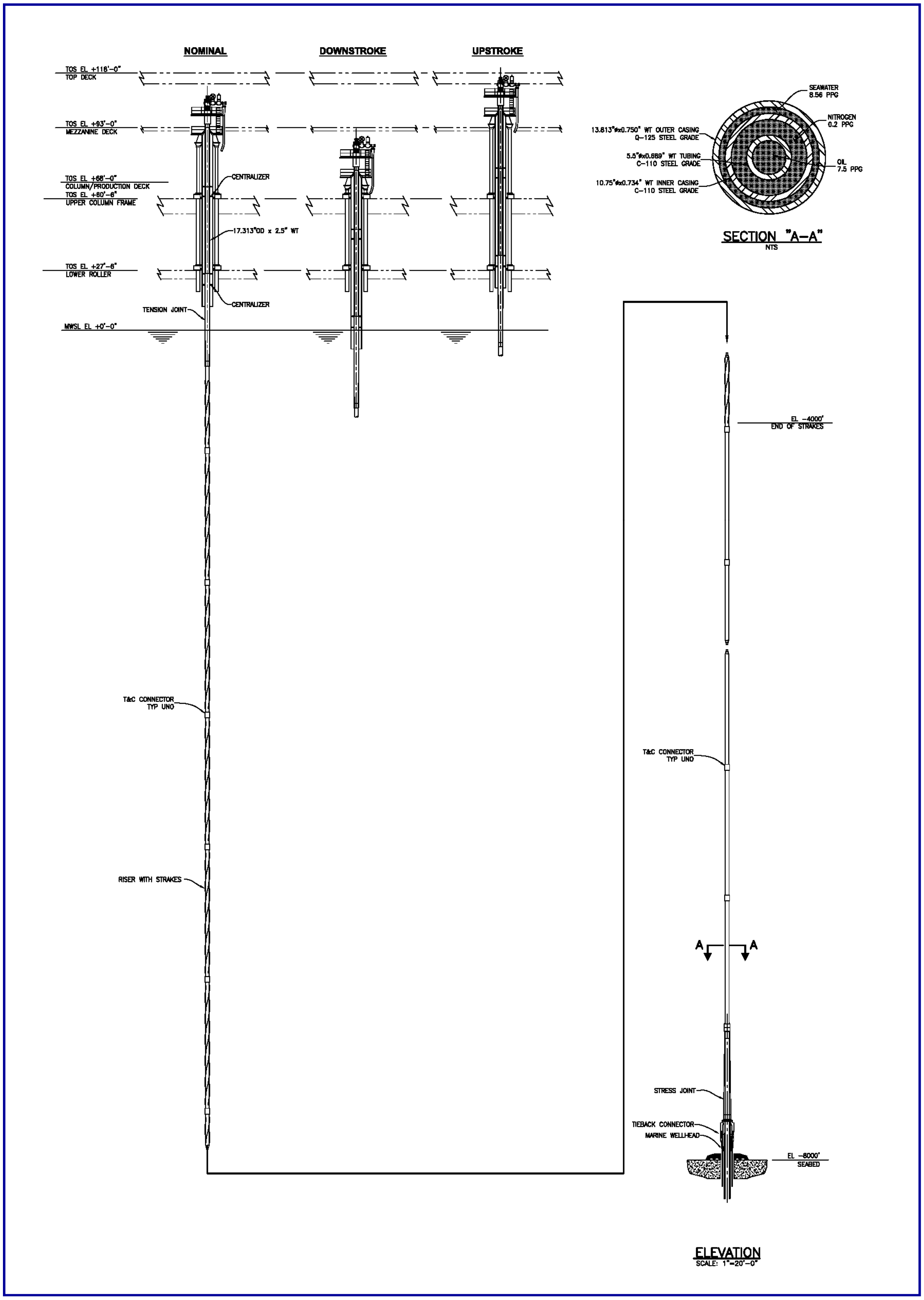


Figure 6.3-1 Top-Tensioned Riser Configuration

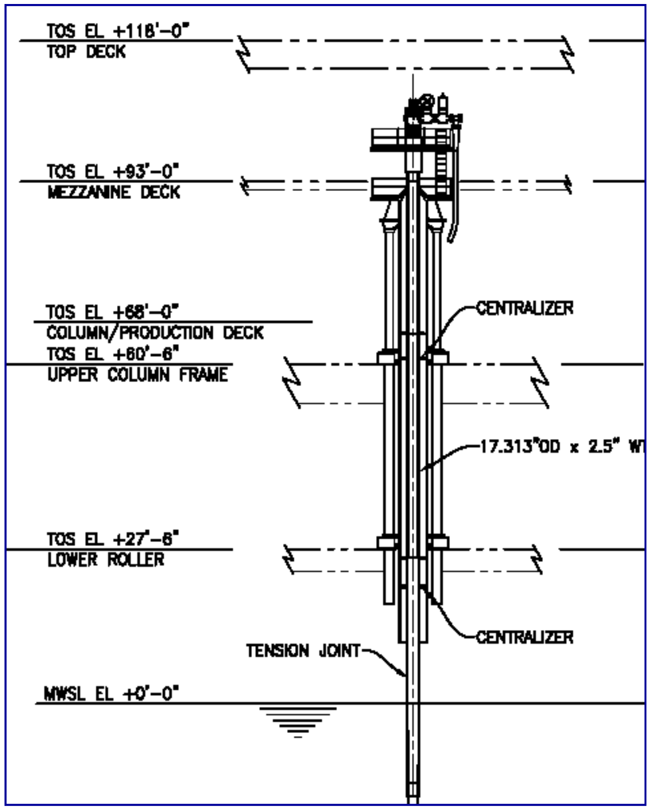


Figure 6.3-2 Conceptual Tensioner Arrangement

A conceptual study for the TTR system considered arrangements with and without the keel guide. Although the keel guide reduces the bending loads on the TTR at the tension joint, the results of the conceptual study indicated that the better arrangement in terms of functionality and cost was an arrangement without the keel guide. This arrangement eliminates the keel joint and tapered stress joint at the keel guide location. In addition, this arrangement eliminates the structures required to take the keel loads into the hull primary structure (i.e. a keel guide support frame). Another benefit is that with the proposed arrangement, there is open water between the tensioner support location above the waterline all the way down to the wellhead at the mud line. Compared to a truss spar that requires heave plates, a keel tank and multiple guides along the length of the spar hull, operations to run and retrieve risers or to move equipment through the water column will be much less complicated for the proposed semisubmersible configuration.

6.3.2 Well Pattern

TTR stroke and clashing analyses are dependent on the well pattern in the well bay and at the sea floor. Two different arrangements for TTR spacing were considered as shown in Figure 6.3-3. The design basis value for minimum seafloor spacing is 25 ft. A second arrangement with 35-ft spacing was also considered to confirm adequate flexibility at the seafloor.

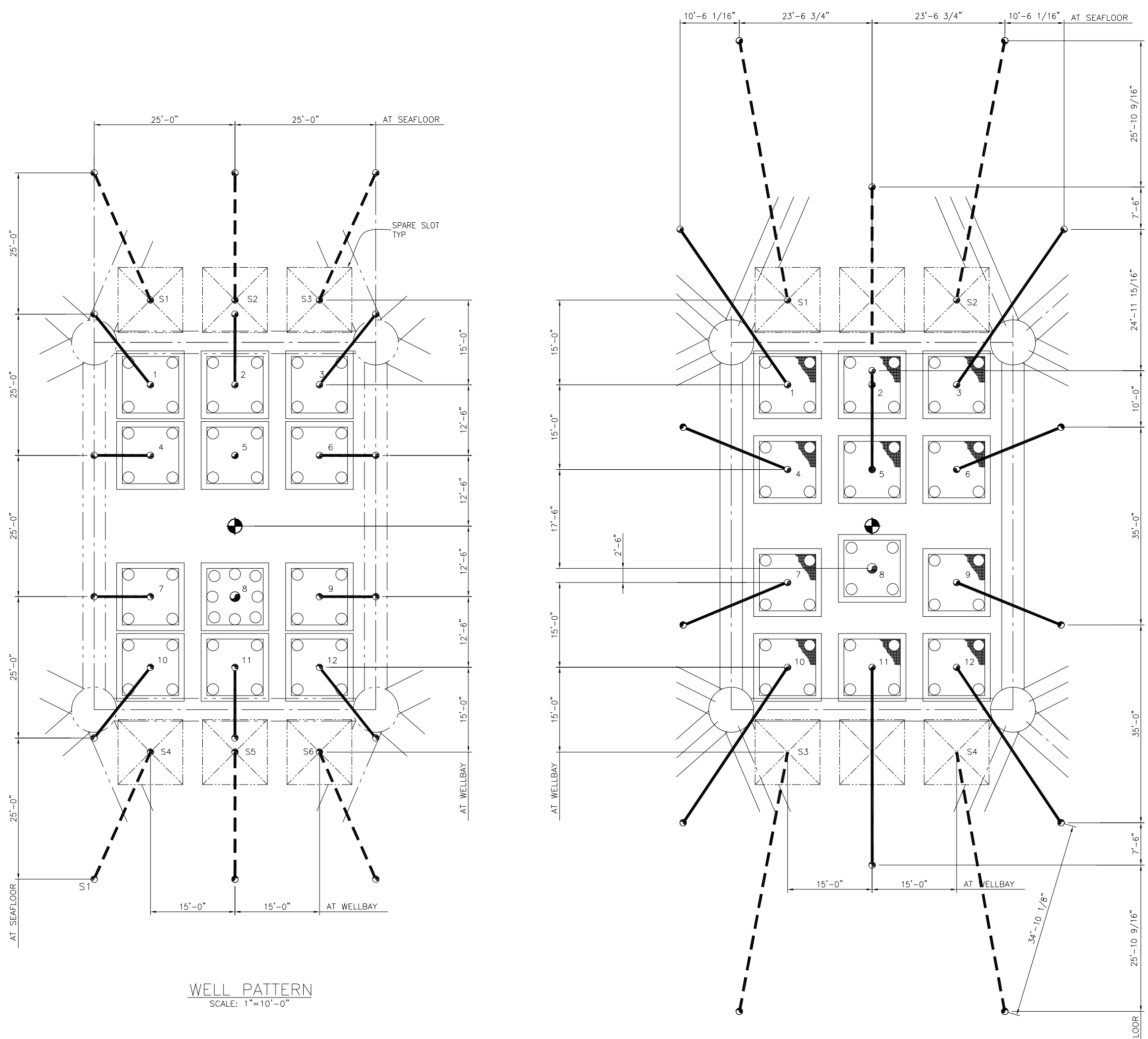


Figure 6.3-3 Well Pattern at Wellbay and Seafloor

6.3.3 TTR Stroke Analysis

The riser system was analyzed using the riser dynamic finite element program Flexcom. Flexcom is the leading three-dimensional nonlinear time domain finite element program for the analysis of a wide range of compliant and rigid offshore structures. Platform motion time series were generated through global performance analysis of the coupled platform, mooring and riser system. These motions were applied to the Flexcom riser model along with the corresponding wave and current loads. The Flexcom analysis computed the dynamic motion and stress of the riser induced by the platform motions and associated wave and current loads on the riser. A typical stroke time series is shown in Figure 6.3-4.

The results of the stoke analysis indicated that a total stroke of 23 ft is required from the tensioner system (up stroke = 8.4 ft, down stroke = 14.6 ft). This stroke analysis includes the effects of thermal growth, pressure growth, tide, motions, tension variation, analysis allowance, design allowance, etc. The total stroke is within the required limit of 25 ft.

Other cases were also considered, including mooring damage, TTR shut-in with leak, and the alternate seafloor spacing shown in Figure 6.3-3 where the wellheads at the seafloor are spaced 35 ft apart.

It is important to note that the 23-ft stroke reported above was for an extreme sea state (100-yr hurricane). For the most severe operating condition, the total stroke is less than 7 ft, of which only 3.4 ft is due to platform motion. Not only does the proposed semisubmersible meet the TTR stroke limit requirements, but also the stroke during normal operating conditions is small.

For survival conditions (e.g. mooring damage), the tensioner system is designed to limit riser stroke with a hard stop. Two conditions are expected to result in contact with the hard stop: 1) 100-yr hurricane plus 1 mooring line broken (down stroke), and 2) temporary conditions during shut-in with a tubing leak resulting in excess thermal and pressure grown (up stroke). In both cases, the integrity of the riser is maintained. More detailed analysis in future project stages will examine intact and damage conditions of the TTR in more detail.

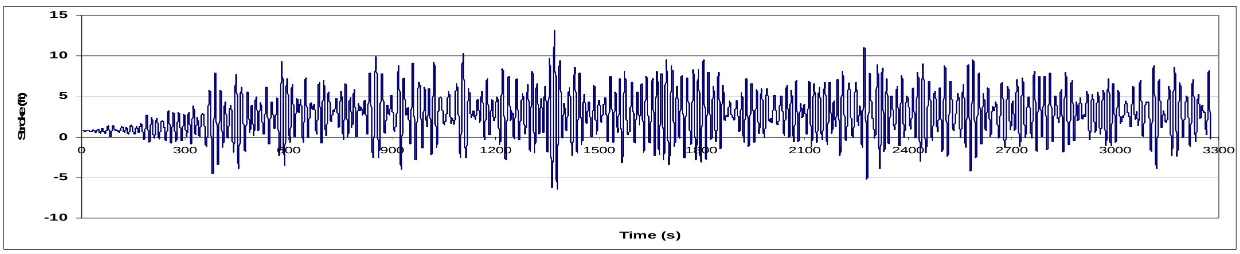


Figure 6.3-3 Typical Stroke Time Series, 100-yr Hurricane

6.3.4 TTR Strength Analysis

The strength of the TTR was confirmed using the same Flexcom analysis described in Section 6.3.3 for riser stroke. The 100-yr hurricane condition was analyzed for both an intact condition and a one-mooring-line-damaged condition. Maximum stress in the riser casing was 70-ksi and the maximum strength utilization was 0.7. A typical plot of stress along the length of the TTR is shown in Figure 6.3-4. More detailed strength and fatigue analysis will be performed in future project stages.

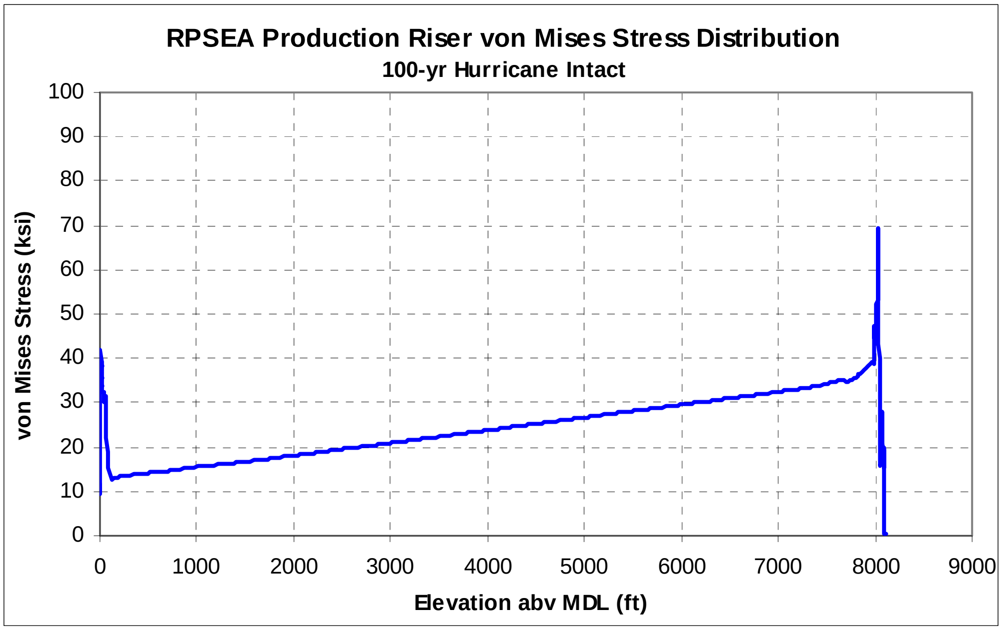


Figure 6.3-4 Typical TTR Stress Envelope

7 Constructability

7.1 Hull Structure

The hull structure is comprised of traditional stiffened plate panels common in many different floating systems. The hull configuration presented in this report consists mainly of flat panels for simplified fabrication. The flat panels are especially beneficial for fabrication yards with existing panel-line assembly equipment that can efficiently assemble stiffeners to plate panels prior to subsequent assembly steps.

The hull scantlings (plate thickness, stiffener sizes and girder sizes) were developed assuming conventional hull materials with specified minimum yield strength equal to 50 ksi. Plate thicknesses are designed in standard sizes and most of the plating is less than 2” thick with the exception being localized insert plates and intersections of major structural components or concentrated load foundations. Stiffener sizes are also selected from commonly available shapes. Girders are fabricated “T” sections and the girder spans are very reasonable because of the arrangement of the structural panels. In particular, the paired-column arrangement results in column sizes that are relatively small (e.g. 44’ x 42’ for base case outboard column) compared to other column/pontoon based floating hull systems with similar displacement (e.g. semisubmersibles and tension leg platforms).

The typical construction sequence for the hull includes the following steps:

1) Stiffeners are assembled to plate to form basic stiffened panels
2) Girders are installed to complete the basic subassembly
3) Subassemblies are assembled into blocks based on the lift capacity of the fabrication yard
4) Blocks are assembled into the complete hull either in a dry dock or on land nearby a skid way for offloading the hull onto a transport vessel

A typical block fabrication and assembly sequence is shown in Figure 7.1-1. In general, the block sizes, material usage, plate and shape sizes and overall structural arrangements are well suited to fabrication at many worldwide locations. Any fabrication yard or shipyard with experience assembling medium to large hulls for floating production facilities would be capable of building the proposed semisubmersible configuration.

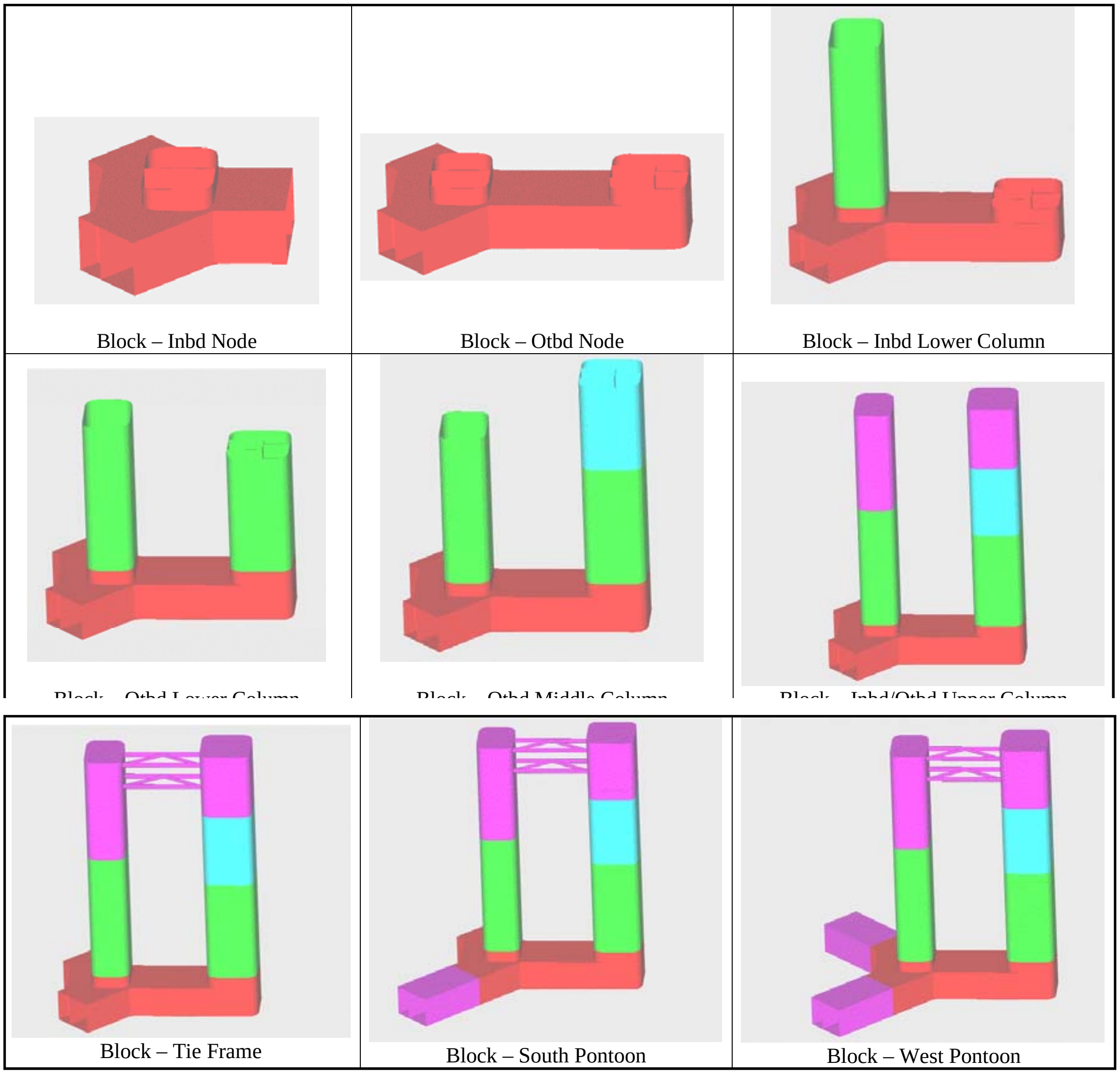


Figure 7.1-1 Typical Block Fabrication and Assembly

7.2 Topsides Integration

Multiple options were considered for topsides integration including quayside lifting, offshore lifting and float over. For this report, the feasibility of quayside lifting was confirmed conceptually using the geometry, hook height, capacity and reach of the Kiewit Special Lifting Device. Figures 7.2-1 and 7.2-2 show the results of the preliminary investigation and confirm feasibility.

The deck is assembled using two primary lifts. The drilling rig, quarters and flare would typically be assembled as separated lifts. In the topsides arrangements developed for this study, the quarters and drilling support equipment would be included in the two primary deck lifts and the drilling skid base and derrick would be a separate lift.

Although the hull columns are not shown in the plan view in Figure 7.2-2, it should be noted that the main structure of the SLD fits between the outboard columns, which improves the minimum clearance between the crane booms and the hull structure.

The primary purpose of the preliminary integration study was to confirm that quayside integration is feasible. Future stages will review the topsides integration in more detail.

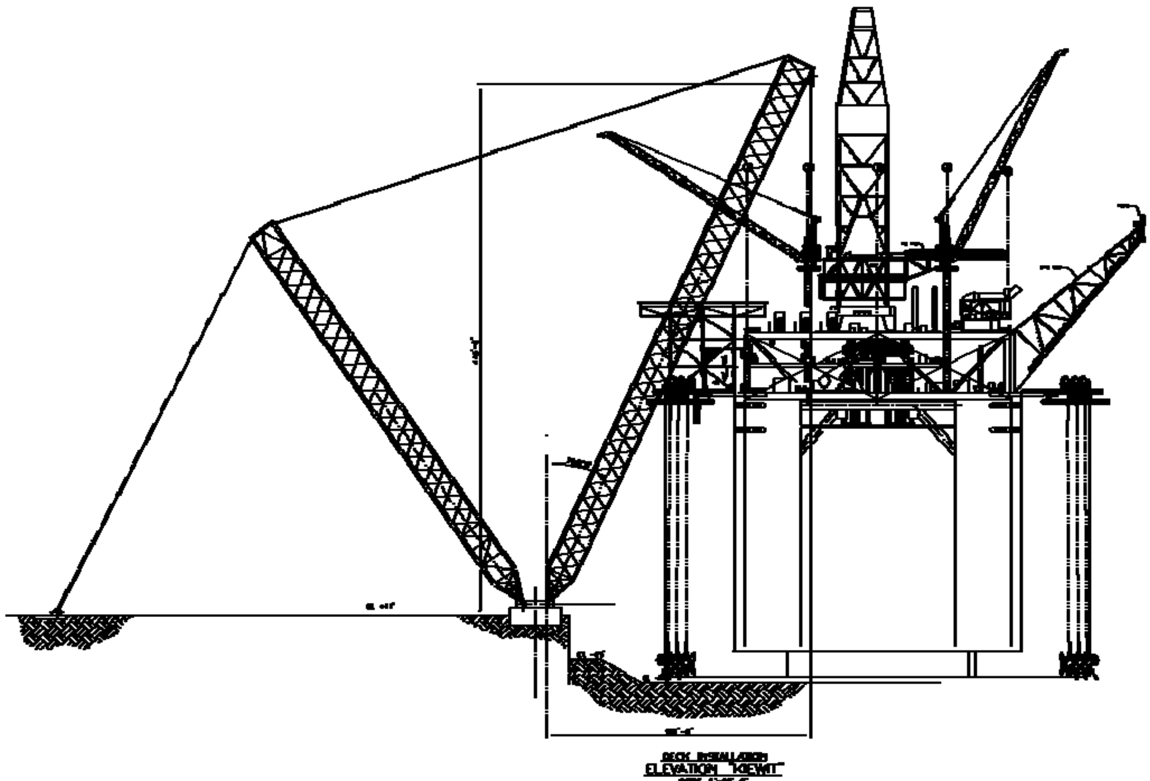


Figure 7.2-1 Quayside Topsides Integration Using Kiewit SLD - Elevation View

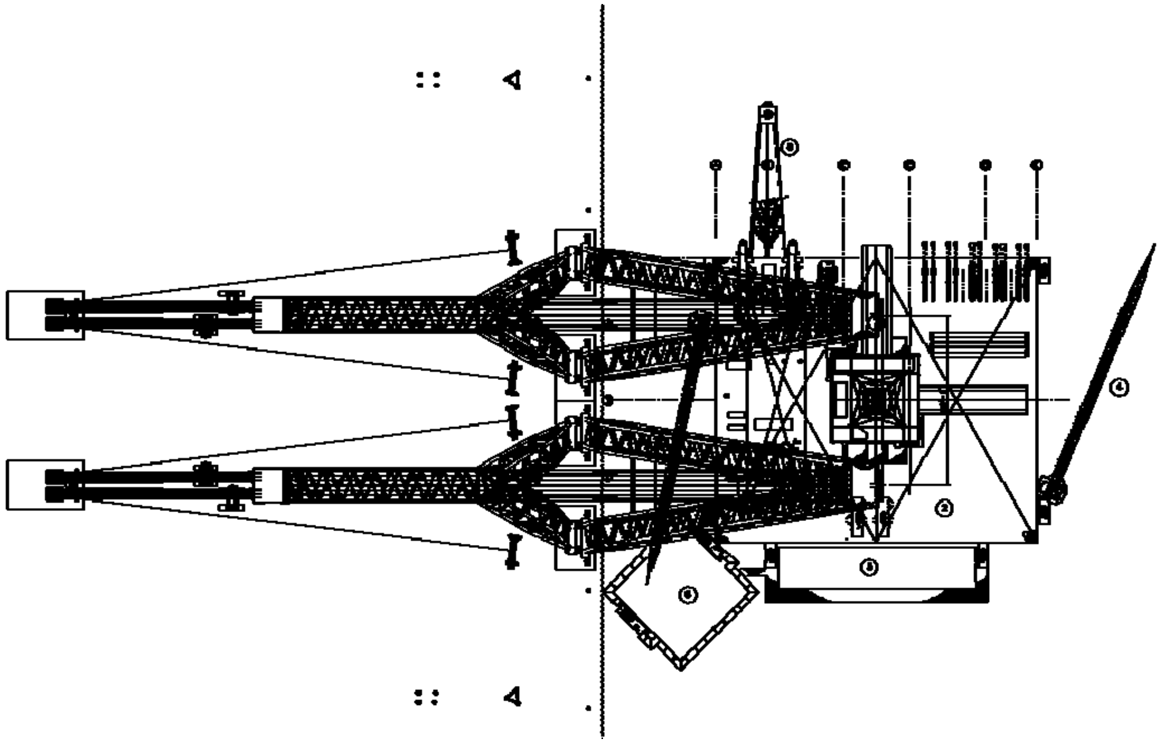


Figure 7.2-2 Quayside Topsides Integration Using Kiewit SLD – Plan View

8 Conclusions and Recommendations

Hull configurations for a dry tree semisubmersible have been developed and confirmed for Central GoM metocean conditions in 8,000 ft water depth. The hull concept utilized is the Paired Column Semisubmersible. The hull configuration consists of conventional stiffened plate structures without any moving structural components or novel structural connections. Similarly, the mooring system is conventional and utilizes chain and polyester rope sizes within the range of what has been previously delivered for existing platforms.

Global performance and riser analysis have confirmed that the configuration has suitable motions for dry tree support and drilling operations. Maximum riser stroke requirements for the 100-yr hurricane conditions is less than 25 feet, which is compatible with existing field-proven riser tensioning technology. The riser system does not require a keel joint so there is open water between the wellbay and the seafloor. The arrangement of the risers provides flexibility in the riser spacing at the wellbay and at the seafloor. In addition to compatibility with top-tensioned risers, the hull concept provides excellent support for steel catenary risers due to low surge motion, low roll/pitch motion and hang-off locations close to the center of the platform.

The paired-column arrangement allows for an efficient deck structural design because of the structural support from the inner columns. The topsides can be integrated through several methods, including quayside integration with the Kiewit Special Lifting Device. The option of quayside integration significantly reduces the scope of offshore installation and hook-up. The fully integrated platform can be towed offshore to the installation site and hooked up to mooring and risers using conventional methods.

Feasibility of the dry tree semisubmersible has been demonstrated. Future work should improve definition of the configuration through more detailed analysis and testing. The following activities are recommended in the next stage of work:

1) More detailed global performance in preparation for model test correlation and to support riser and structural analysis.
2) More detailed stability analysis to confirm final compartmentation.
3) Global hull structural analysis to confirm structural scantlings and the hull structural weight estimate.
4) Local structural analysis for the column to pontoon connections to size the necessary reinforcements.
5) More detailed TTR analysis for more definition of riser system components (e.g. tension joint, stress joint, etc.) based on strength and fatigue performance.
6) High-level TTR clashing analysis to confirm riser spacing.
7) Confirm expected improvement in SCR compatibility using high-level strength and fatigue analysis for a representative SCR.
8) Perform model testing to confirm global performance predictions.
9) Get feedback from industry on hull constructability and topsides integration.
10) Perform a technology readiness review.

Appendix A

RPSEA Design Basis

RPSEA CTR 1402

ULTRA DEEPWATER DRY TREE SYSTEM FOR DRILLING AND PRODUCTION IN THE GULF OF MEXICO

DESIGN BASIS

Table of Contents

1 INTRODUCTION

This document provides the design basis for RPSEA CTR 1402 "Ultra-Deepwater Dry Tree System for Drilling and Production in the Gulf of Mexico". The RPSEA program consists of 3 stages, and this document is mainly for Stage 1.

Stage 1

Develop preliminary hull, riser, and mooring design and cost estimates for 3 hull forms and 2 payloads and select 2 options out of the 6 for further study. The hull forms are:

- FloaTEC Truss Semi (T-Semi)
- FloaTEC ESEMI II (ESEMI)
- Houston Offshore Paired-Colum Semisubmersible

The payload options are:

- Base case (25,000 st)
- Sensitivity case (20,000 st)

The payloads stated here are nominal values consisting of topside facilities, drilling rig and fluids, and deck steel. The actual payloads are defined in Section 4.

Stage 2

Further develop the 2 options selected from Stage 1 and refine cost estimates. Select one option out of the 2 for model testing.

Stage 3

Perform model testing for the option selected from Stage 2.

2 OVERALL FIELD ARCHITECTURE

The field architecture defines platform north relative to true north and gives departure headings for SCRs and umbilicals, as shown in Figure 1 (Base Case Payload) and Figure 2 (Sensitivity Case Payload).

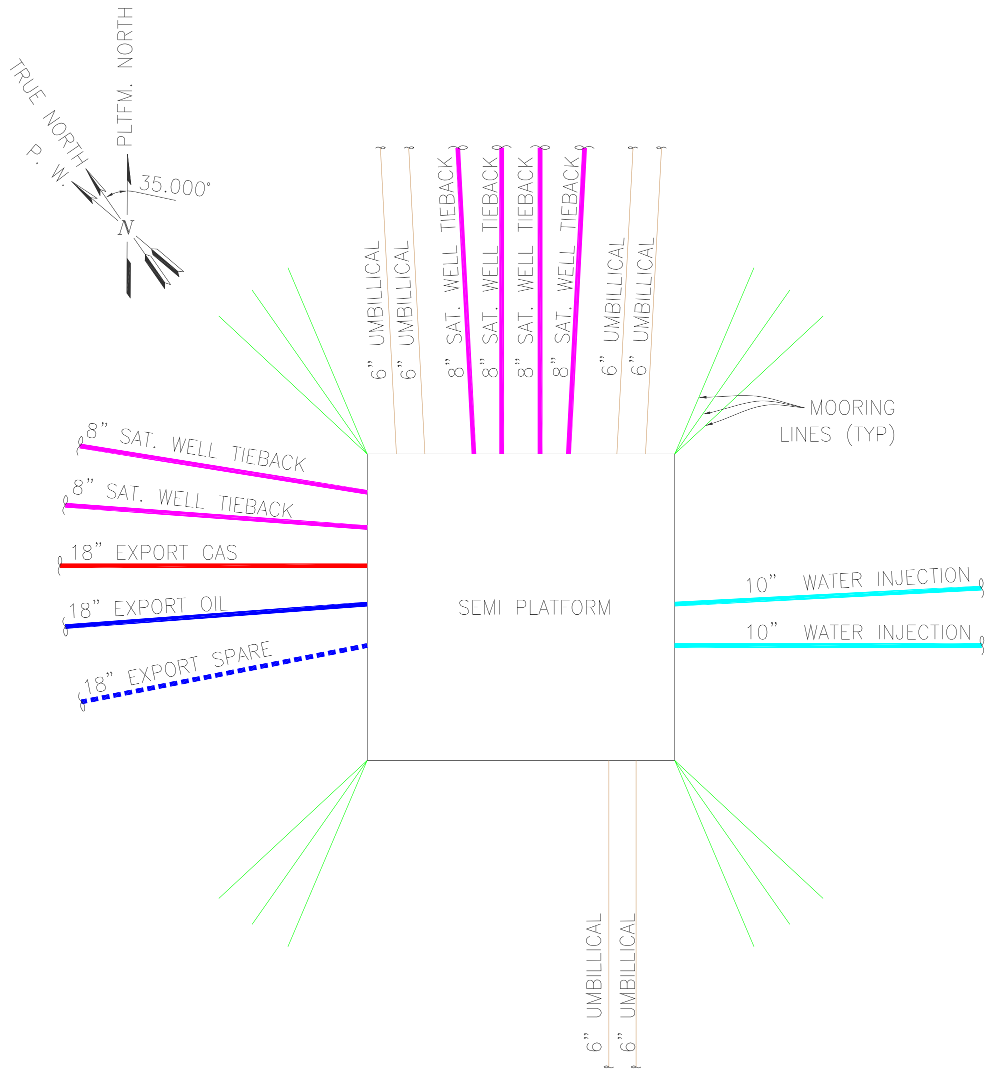


Figure 1 Field Layout for Base Case Payload

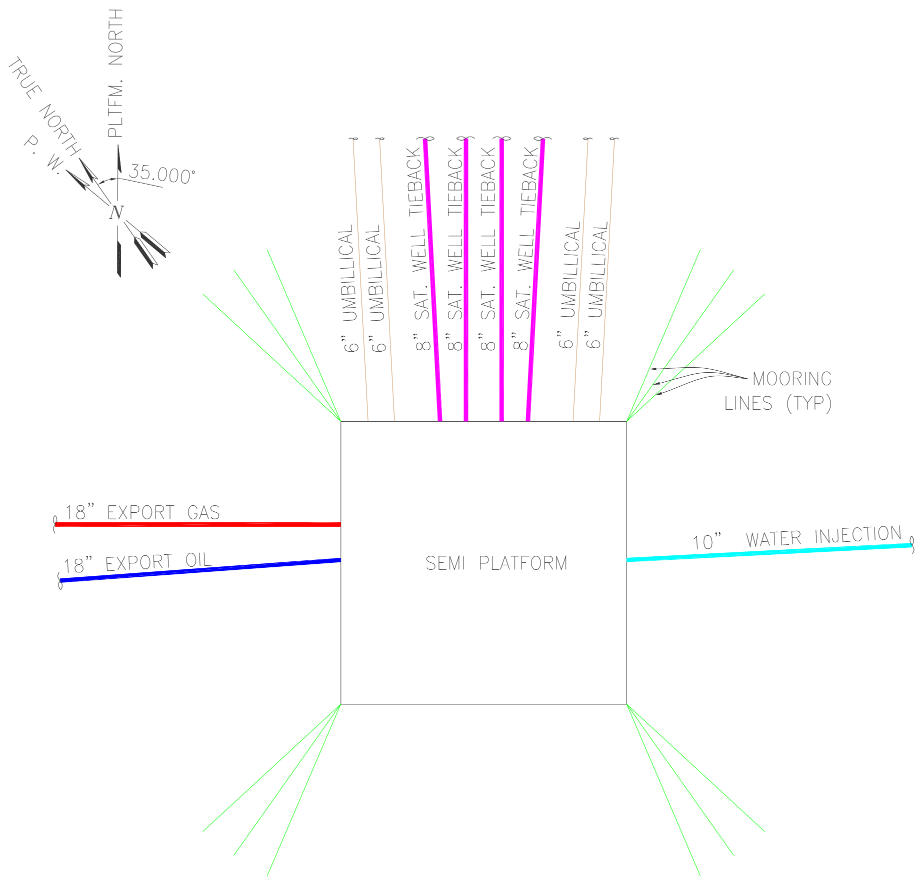


Figure 2 Field Layout for Sensitivity Case Payload

3 FUNCTIONAL CRITERIA AND DESIGN REQUIREMENTS

The functional criteria and design requirements based on GOM Palogene Reservoir is provided in Table 1. The specified system throughput is based on the assumption that future satellite well tie-backs will increase the overall process system throughput and weight to the original requirements. This will ensure an efficient design of a robust and capable hull so topside weight management will not be a major issue in a real project.

Table 1 Functional Criteria and Design Requirements

Item	Base Case Payload 25,000 ton	Sensitivity Case Payload 20,000 ton	Comment
Water depth (ft)	8,000	8,000	
Design life (years)	20	20	
Process Requirements			
Oil process production rate (KBD)	100	75	
Max process produced water rate (KBD)	40	30	
Max. total fluids processing rate (KBD)	120	90	
Peak gas processing rate @500 GOR (MCFD)	50	38	
Peak water injection rate (KBD)	80	60	
Maximum water injection pressure (psi)	5,000	5,000	
Dead oil storage (S. ton)	500	400	
Reservoir Information			
Reservoir depth (tvdss, ft)	27,000	27,000	
Max. (initial) reservoir pressure (psi)	16,000	16,000	
Max. temperature (deg. F) at wellhead	190	190	
API gravity (deg)	30	30	

Dry Tree Wells			
Shut-in Tubing Pressure (psi)	9,000	9,000	
Max. per well oil rate (KBD)	16	16	
Production TTRs	12	9	Dual casing well conductors
Wellbay Slots	16	12	One slot sized for HP drilling riser service
Risers and TieBacks			
Export riser pressure rating (psi)	2,500	2,500	
Number of Export Risers	1 oil, 1 gas, 1 spare	1 oil, 1 gas	Sized for rates
Satellite Well Tieback Risers	6 x 8" x 5,000 psi wp	4 x 8" x 5,000 psi wp	Satellite Production Wells with HIPPS
Water Injection Riser	2 x 10" x 5,000 psi wp	1 x 10" x 5,000 psi wp	Daisy Chain Injector Wells
Satellite Well Umbilicals	6 x 6"	4 x 6"	
Drilling riser	1-21"	1-21"	

4 TOPSIDES

4.1 General Requirements

The hull must provide adequate payload capacity to support the topsides weight and adequate trim ballast capacity to allow a topsides center of gravity envelope of +/-10 ft horizontal and +/-5 ft vertical.

Topside weights include dry and operating values. Dry values will be used for all pre-service conditions and operating values will be used for in-place conditions. There will be no topsides facilities located in the hull except for optional Dead Oil Storage and Drilling Bulks.

The deck structural weight shall be estimated based on total operating weight and area requirements. The deck structural estimate shall be based on using 60-ksi specified minimum yield strength material. Both open truss and deck box structural configurations are acceptable.

4.2 Weight and Deck Area Estimates

4.2.1 OGM Output

Topside weight and deck area requirements for the Base Case shall be based on output from the software OGM (Oil and Gas Manager) provided to the contractors by a separate file. Following are some clarifications:

1. The primary deck support structural steel is included as a nominal load. Each contractor will need to size the topside primary structural steel and adjust this nominal value for their respective structures.

2. Since the OGM model is a SPAR, the risers and trees are assumed to be supported by riser buoyancy cans. Thus, tensioner weight and riser loads on the structure are not included in this summary.

3. The equipment sizes (L x W) and weights are given. However, the VCG for the equipment skids are not given. For the Stage 1 study, the VCG for a module can be taken 3 ft above the equipment baseline as an estimated VCG. This means, each contractor will have to decide on an equipment and deck layout to be able to calculate a topside total weight and CG. The SPAR OGM model used a 3 level deck design, which may not be the case for the contractors' deck.

4. Each contractor will need to estimate a projected wind surface area, based upon the deck design they develop.

4.2.2 Summary of Topside Weight and Deck Area for Base Case Payload

Table 2 reconciles the topsides data provided by OGM with the data that should be used for this study. The OGM drilling rig, deck steel, and wellbay area are removed, and the RPSEA drilling rig, an ROV, riser tensioners, etc. are added back. The table also indicates which items are concept specific and must be added by the contractor (e.g. deck steel).

Table 2 Adjustments of OGM Topside Weight and Deck Area for Base Case Payload

Component	Weight (st)		Area	Comments
	Dry	Operating	(sq ft)	
Total Topsides per OGM data	**18,136**	**25,390**	**95,741**	includes drill rig, deck steel, process equipment buildings and conginencies.
Exclusions (items subtracted out from OGM data)				
Drill rig	6,634	9,287	29,500	dry weight includes 25% contingency in OGM data. Operating weight scaled from dry weight as in OGM data. Area is without maintenance factor.
Deck steel	6,533	9,146		dry weight includes 25% contingency in OGM data. Operating weight scaled from dry weight as in OGM data.
Well bay area			4,356	OGM data appears to be wellbay area for single level. No maintenance area included.
Subtotal	**4,970**	**6,958**	**61,885**	
Additions required (items to be added to OGM data)				
Drill rig from RPSEA design basis	4,000	7,000	37,194	Drilling operating load includes hook load and setback but excludes drilling fluid storage. Area includes derrick/substructure footprint envelop for all wellbay slots, drilling module area. Pipe storage is assumed to be on top of drilling modules. Note that footpring envelop includes wellbay area for top deck.
ROV	150	210	3,500	Includes area for ROV, control shed, maintenance and access area, etc.
Riser tensioners	2,275	2,275		12 production riser tensioners plus 1 drilling riser tensioner, each assumed to be 175 st.
Subtotal	**11,395**	**16,443**	**102,579**	
Concept-specific additions required to be added by Contractor				
Deck steel	TBD	TBD		Primary, secondary and tertiary steel, excluding steel for skidded equipment or components and buildings. Contractor to add 200 st for helideck (from OGM's deck steel data) to the estimated deck structural weight.
Wellbay area			TBD	Contractor to add area for each deck level excluding top deck level. For top deck level, area is already included in derrick/substructure footprint envelop.

Notes:

1. Other payload items to be considered by Contractor include drilling fluid storage (3,000 st located either in hull or topsides), TTR tensions, SCR tensions, umbilical tensions and dead oil storage (500 st located either in hull or topsides).
2. Contractor to add pipe rack area if top of drilling module is not accessible for pipe storage.
3. Quarters is assumed to be 3 levels and 36 feet high.

The total operating payload for the Base Case is approximately 37,000 st (excluding deck steel), broken down as follows. These weights are rough estimates only, and the contractors should develop more accurate weight estimates for their respective designs.

1. 7,000 st for topsides facilities
2. 10,000 st for drilling, including rig and fluids
3. 2275 st for riser tensioners
4. 11,000 st for riser tension (1,000 st for drilling riser + 11 x 921.5 st for production risers)
5. 6,000 st for umbilicals and SCRs
6. 500 st for dead oil storage

4.2.3 Summary of Topside Weight and Deck Area for Sensitivity Case Payload

The sensitivity case is roughly derived from the base case to achieve a high-level objective of approximately 10,000 st less total operating payload. The topsides facilities shall be modified by reducing the facilities dry and operating weights by 1,000 st and 1,400 st, respectively. The total deck area requirement shall be reduced by 12,500 ft^2. Steel weight and wind area adjustments shall be estimated by Contractor.

The total operating payload for the Sensitivity Case is approximately 27,800 st (excluding deck steel), broken down as follows. These weights are rough estimates only, and the contractors should develop more accurate weight estimates for their respective designs.

1. 5,600 st for topsides facilities
2. 8,000 st for drilling, including rig and fluids
3. 1,750 st for riser tensioners
4. 8,400 st for riser tension (1,000 st for drilling riser + 8 x 921.5 st for production risers)
5. 3,600 st for umbilicals and SCRs
6. 400 st for dead oil storage

5 RISER SYSTEMS

5.1 Top-Tensioned Production Riser System

5.1.1 General Description

The dry tree top tensioned riser system includes production and drilling risers. The riser system extends from the seabed elevation at the subsea wellhead, through the water column, splash zone, air gap and terminates in the wellbay at the surface tree. The data for production riser configuration and sizing is listed in Table 3. Additional assumptions follow in Sections 5.1.4. Drilling riser assumptions are provided in Section 5.2.

5.1.2 Codes and Standards

The top tensioned riser system shall be designed in accordance with the following codes, and standards, as applicable.

General criteria:

- *Recommended Practice for Design, Selection, Operation and Maintenance of Marine Drilling Riser Systems* (API RP 16Q), 1993.
- *Recommended Practice for Design of Risers for Floating Production Systems (FPSs) and Tension-Leg Platforms (TLPs)* (API RP 2RD), 1998.
- *Specification for Design of Marine Drilling Riser Equipment* (API Specification 16F), 2004.
- *Specification for Wellhead and Christmas Tree Equipment* (API Specification 6A), latest edition.
- *Rules for the Construction of Pressure Vessels* (ASME VIII, Section 1 and 2), 2008.
- ASME Section II, ASME Material Specification.
- ASME Section V, ASME Nondestructive Examination.
- ASME Section IX, ASME Welding and Brazing Qualifications.
- ASME Section X, ASME Fiberglass-Reinforced Plastic Pressure Vessels.
- *Specification for Subsea Wellhead and Christmas Tree Equipment* (API Specification 17D), 1992.
- *Design Rules for Steel Structures, Curve* B (NS 3472), 2004.

- *Recommended Practice for Design and Operation of Completion / Workover Riser Systems* (API Specification 17G), 2005.
- *Offshore Riser Systems* (DNV-OSS-302), Det Norske Veritas, 2003
- *Riser Interference* (DNV-RP-F203), Det Norske Veritas
- *Riser Collision* (DNV-RP-F205), Det Norske Veritas, 2004

Tension, Collapse and Burst

- *Bulletin on Formulas and Calculations for Casing, Tubing, Drill Pipe, and Line Pipe Properties-Sixth Edition* (API Bulletin 5C3), 1999.

Allowable Stress Limits

- API RP 2RD, latest edition.

Fatigue

- *Fatigue Design of Offshore Steel Structures* (DNV RP-C203), Det Norske Veritas, 2008
- *Riser Fatigue* (DNV-RP-F204), Det Norske Veritas, 2005

5.1.3 Production Riser Parameters

Production Riser Parameters are given in Table 3.

Table 3 Production Riser Parameters

Data	Production Riser	
	Base Case	Sensitivity Case
Pipe Geometry and Material		
Inner casing OD (in.)	10.750	
Outer casing OD (in.)	13.813	
Steel Grade (ksi)	Q125 KSI for casings / Q110 KSI for tubing	
Wall thickness mill tolerance	-10% / +10%	
Corrosion Allowance (in.)	0.125	

Data	Production Riser	
	Base Case	Sensitivity Case
Maximum Pressures on Top of the Riser		
Pressure Test (psi)	9000	9000
Shut-In Pressure (psi)	9000	9000
Gas Kick Pressure (psi)	9000	9000
Operating Production Pressure (psi)	2500	2500
Fluid Weights		
Sea Water (ppg)	8.56	
Nitrogen (ppg)	0.2	
Completion Fluid (ppg)	15.0	
Oil (ppg)	7.5	
Service Life		
Service Life	20	
Fatigue Safety Factor	10	
Internal Tubing		
External Diameter (in.)	5.50	
Weight (lbf/ft)	35.4	35.4
Wall Thickness (in.)	0.689	0.689
Top-tension Calculation		
Min. top tension factor	1.3	

Table 4 Production Riser Steel Properties

Minimum Yield Stress (ksi)	Material Orientation	UTS (ksi)	Elongation (%)
110	Longitudinal	120	23
125	Longitudinal	140	21

5.1.4 Production Riser System Assumptions

The top tensioned production riser system design parameters and assumptions are as follows:

- Subsea connector: Hydraulic subsea wellhead system. Wellhead elevation for tie-back connector is 10 ft above mud line.
- Stress joint: Tapered pipe section with hydraulic connector upper body profile on bottom and threaded connection on top
- Production Riser: Dual barrier production riser (Dual casing plus production tubing).
- Production riser joints with no integrated buoyancy. .
- The temperature of the product in the tubing above the mud line is:
    - Medium: 68ºF minimum, 190ºF maximum
    - High: 68ºF minimum, 275ºF maximum
- Tubing hanger at mud line level
- Keel guide interface to production riser, as required.
- Surface tree: 15 st total weight including jumpers, miscellaneous items, and margin.
- Strake: 50% of riser covered by strakes. For riser without strakes, C_d = 1.0. For riser with strakes, the following will apply:

  Equivalent OD = 1.125 x base pipe OD

  Drag C_d = 1.35 (based on equivalent OD)
  Added mass C_m = 1.2 (based on equivalent OD)
- Fatigue analyses will assume DNV "E" S-N curve, SCF 1.3 and factor of safety 10.
- Total riser tensioner stroke is limited to 25 ft. Tensioner stiffness is minimum 20 kips/ft, and tensioner weight is 350 kips each.
- Riser analysis is performed for intact condition only.

The workover riser system is the same as the production riser system except that surface tree is removed and a workover spool is installed to connect the riser to the surface BOP stack and equipment. The workover BOP is rated for 10,000 psi and weighs 60 st.

Nitrogen shall be used in the production riser annulus between the riser outer casing and tubing.

Top tension calculation is based on seawater in the outer annulus (i.e. between the outer casing and inner casing) and nitrogen in the inner annulus (i.e. between the inner casing and the tubing).

5.2 Drilling Riser System

The drilling riser system consists of a single high-pressure barrier for containing well bore fluids and pressures between the subsea wellhead and the surface BOP. Top tension is 2,000 kips, and tensioner stiffness is 20 kips/ft. Riser dry weight is 4,800 kips, and wet weight is 800 kips. For global analysis, the drilling riser is assumed to be at its designated slot. The seafloor base is assumed to be 25 ft by 25 ft.

5.3 Subsea Interfaces

As an interface to the subsea systems, the hull will support umbilicals, flowlines, injection lines and export lines. The SCR and umbilical configuration includes provisions for future expansion and/or additional tie-backs. No additional payload capacity shall be added.

Vertical payload and departure angles, and other key data, are given in Table 5. The horizontal departure angle is governed by the riser layout given in Figure 1 and Figure 2. SCR's shall be supported on porches and shall utilize a stress joint or flex element at the connection to the hull. Umbilicals shall be supported at the top of pull tubes that extend to the keel of the hull.

Table 5 Subsea and Export Interface Summary

	Unit	Base Case	Sensitivity Case
Satellite Well Tieback (SCR)			
Quantity	#	6	4
Diameter	in.	8.625	8.625
Thickness	in.	0.812	0.812
Pressure	psi	5,000	5,000
Departure Angle	deg.	12	12
Vertical Payload	st	310	310
Water Injection (SCR)			
Quantity	#	2	1
Oil Export (SCR)			
Quantity	#	2	1

Diameter	in.	18	18
Thickness	in.	1.1	1.1
Pressure	psi	2,500	2,500
Departure Angle	deg.	14	14
Vertical Payload	st	910	910
Gas Export (SCR)			
Quantity	#	1	1
Diameter	in.	18	18
Thickness	in.	1.1	1.1
Pressure	psi	2,500	2,500
Departure Angle	deg.	14	14
Vertical Payload	st	530	530
Umbilicals			
Quantity	#	6	4
Diameter	in.	6.0	6.0
Vertical payload	st	120	120
Departure Angle	deg.	8	8

Notes:
(1) Quantities shown include all future or reserve lines.
(2) Satellite well tieback SCR pressure assumes pipeline is protected by HIPPS.

6 HULL STRUCTURE

6.1 Regulatory requirements

The semi-submersible will be flagged as an American vessel. Therefore, compliance with Gulf of Mexico local coastal authority regulations will be required. Compliance with the applicable US Coast Guard (USCG) and the Minerals Management Service (MMS) regulations will be required, as defined in the US Code of Federal Regulations. In addition, the semi-submersible will be classed with the American Bureau of Shipping (ABS) as an ✠A1 Floating Offshore Installation (FOI).

6.2 Stability

The stability will be in accordance with the ABS Guide for Building and Classing Floating Offshore Production Installations 2000. The unit must maintain a positive metacentric height in calm water equilibrium for all conditions. Mooring vertical loads are included in the loading conditions, however mooring restraints are excluded for the purpose of determining stability compliance, except when the mooring system may be detrimental for stability, e.g. in damage mooring line conditions.

6.3 Air-gap

Air-gap requirements will be based a safety margin of 5 ft during 100 year event.

6.4 Structural Design

6.4.1 General

The hull structural design shall be carried out according to ABS "Guide for Building and Classing Floating Production Installations" For sizing purposes a simplified damaged heel condition is used based on DnV-RP-C103. A damaged heel of 17 degrees is combined with a 1 yr operating condition for scantling checks of the pontoons and columns.

Buckling design is based on DnV C201 and C201 (for Stage 2 study only).

6.4.2 Codes and Standards

The hull design should satisfy government regulations, industry codes and recommended practices, including:

- *Recommended Practice for Planning, Designing, and Constructing Floating Production Systems* (API RP 2FPS), First Edition, American Petroleum Institute, 2001.
- *Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms – Working Stress Design* (API RP 2A - WSD), Twenty First Edition, American Petroleum Institute, 2000.
- *Guide for Building and Classing Floating Production Installations*, American Bureau of Shipping, 2004. (ABS FPI Guide)
- *Rules for Building and Classing Mobile Offshore Drilling Units*, American Bureau of Shipping, 2006. (ABS MODU Rules)

6.4.3 Design Criteria

The semi-submersible shall be designed for the conditions provided in Table 6 and meet the design criteria given in Table 7.

The hull safety criteria are defined as follows, based on the ABS FPI Guide:

- Category A: Factor of safety = 1.67 (1.43 for von Mises stresses)
- Category B: Factor of safety = 1.25 (1.11 for von Mises stresses)
- Category C: Fatigue factor of safety = 3.0 to 10.0 depending on criticality and inspectability
- Category D: Factor of safety = 1.0

Table 6 Global Load Case Matrix

Phase	Condition		Environment	Hull Safety Criteria(1)	Mooring Safety Criteria(1)
Fabrication	Hull Loadout		Calm	A	–
Transport & Installation	Dry Transport		10-yr Route-Specific Wind/Wave/Current	B, C	–
	Float-off		Calm	A	–
	Wet Tow		10-yr Wind/Wave/Current	B, C	–
	Topside Installation		Calm	A	–
In-place	Intact	Operating	1-yr Winter Storm	A	A
	Intact	Operating	Long-term Wind/Wave/Current	C	C
	Intact	Evacuated	100-yr Hurricane	B	B
	Intact	Manned	100-yr Loop Current	B	B
	Damaged	One Mooring Line Missing	100-yr Hurricane	B	B
	Damaged	One Mooring Line Missing	100-yr Loop Current	B	B
	Damaged	One Compartment Flooded	10-yr Hurricane	B	B
	Intact	Evacuated	1000-yr Hurricane	D	D
	Damaged	Two Compartments Flooded	Calm	D	D

Notes:

(1) Hull Safety Criteria and Mooring Safety Criteria are defined in API RP 2FPS, except for Category D. Category A criteria are intended for conditions which exist on a day-to-day basis. Category B criteria are intended for rarely occurring conditions, Category C criteria are intended for the design of the structure against fatigue failure. Category D criteria are intended for survival conditions.

(2) Environmental conditions are provided in the metocean data.

(3) Both minimum and maximum riser configurations shall be considered for intact Category B cases. The minimum riser configuration shall include one production TTR, one drilling TTR and all export risers. The maximum riser configuration shall include the maximum TTR payload configuration and all SCRs and umbilicals.

Table 7 Global Response Criteria

Response	Conditions with Safety Criteria B	Conditions with Safety Criteria A
Semisubmersible In Place		
Combined Pitch & Roll (single amplitude)	10 degrees (intact)	4 degrees (intact)
Horizontal Acceleration (at top deck, single amplitude)	0.35 g	0.15 g
Max. Offset – Intact	5% of water depth	
Max. Offset – Damaged	7% of water depth	
Minimum Air gap	5 ft	

Notes:

(1) Horizontal acceleration includes the gravitational component due to pitch and roll.

(2) Air gap estimates shall account for wave enhancement, hull drawdown, phasing of motions and wave surface elevations and second order effects.

6.4.4 Global Performance Analysis

Heave damping shall include hydrodynamic damping, keel damping and tensioner damping. Hydrodynamic damping shall be calculated according to usual design practice. Keel damping and tensioner damping shall be …*(values to be specified by Shell)*

6.4.5 Hull Material

The hull structure shall be based on 50-ksi specified minimum yield strength material.

6.4.6 Fluid Storage in the Hull

Fluid storage in the hull is acceptable.

6.4.7 Corrosion Protection

Corrosion protection shall include coatings, cathodic protection, and corrosion allowances as required for the design service life. Hull external plating in the splash zone shall include 0.375 in. corrosion allowance.

6.4.8 Marine Growth

Marine growth will not be considered at this stage of the work.

7 MOORING

The mooring system will be designed according to API RP-2SK and API RP-2SM for polyester systems. In addition, a 10% safety margin is applied for the Polyester rope. Minimum safety factors for chain, wire rope, and polyester are shown in Table 6.

Table 8 Required minimum safety factor

Condition	**Minimum safety factor**	
	Chain/wire rope segments	Polyester segments
Intact	1.67	1.84
Damage (on mooring line)	1.25	1.38

In addition the mooring system will comply with the following requirements:

- The mooring system design shall take into account any asymmetric loads imparted by the riser systems.
- The mooring system shall be capable of being installed prior to the installation of the floating facility.
- Maximum design conditions shall be based on the 100 year return period events.
- The mooring system shall be designed to provide extreme offsets within the values outlined in Table 5.

<u>Polyester Rope Stiffness</u>

The mooring system design and analyses will be carried out assuming the following stiffness of polyester ropes:

Static stiffness	12 x MBL
Dynamic stiffness	28 x MBL

where MBL stand for Minimum Breaking Load.

8 METOCEAN CRITERIA

8.1 Maximum Design Condition

Maximum environmental criteria are provided in Table 9.

Table 9 Maximum Design Conditions

Events	100 Yr Hurricane	Max Loop Current	Hurricane Plus Loop Current
Waves			
γ - Jonswap	2.6	1.0	2.6
Hs (ft)	51.8	4.0	36.3
Tp (sec)	15.4	6.0	13.5
Hmax (ft)	91.5	8.8	64.3
Tmax (sec)	13.9	5.2	12.2
Max Crest Elevation (ft)	61.0	5.5	42.8
Wind			
1-hour Mean Wind (ft/sec)	150	20.3	110.3
Current			
Depth below Surface (ft)	Vc (ft/sec)	Vc (ft/sec)	Vc (ft/sec)
0	5.9	8.9	7.9
164	4.4	8.9	5.9
328	0	8.9	0
656		5.6	
984		3.5	
1,968		0.5	
2296		0.4	
8,000	0	0	0
.			
Water Level			
Storm Surge (ft)	1.8	0.7	1.8
Tidal Amplitude (ft)	1.4	1.4	1.4

The above data is considered omni-directional with collinear wind, waves and current. Maximum crest elevation includes associated surge and tide.

8.2 10-Year Operating Condition

Table 10 Ten-Year Winter Storm Criteria

Parameter	
H_s (ft)	18
T_p (s)	10.7
Wind Speed (ft/s), 1 hr @ 10 m	59
Current	
Depth (ft)	Current Speed (ft/s)
0	1.6
100	1.2
200	0.6
300	0.3
>300	0.3

Spectral Shape: JONSWAP with γ = 2.0

8.3 1-year Operating Condition

Table 11 One-Year Winter Storm Criteria

Parameter	
H_s (ft)	12
T_p (s)	9.1
Wind Speed (ft/s) 1 hr @ 10 m	46
Current	
Depth (ft)	Current Speed (ft/s)
0	1.3
100	1.0
200	0.5
300	0.3

>300	0.3

Spectral Shape: JONSWAP with γ = 2.0

8.4 Fatigue Seastates

JONSWAP spectrum with a gamma value of 1.0 should be used for the fatigue sea states presented below.

Table 12 Fatigue Seastates

Fatigue Bin	H_s (ft)	T_p (s)	V_w (ft/s)	*V_c (ft/s)	Probability of Occurrence
1	0.75	4.5	16	0.5	0.18038
2	2.5	5.5	20	0.65	0.3925
3	4.5	5.5	24	0.75	0.11887
4	4.5	7.5	24	0.75	0.12406
5	6.5	6.5	28	0.9	0.05908
6	6.5	8.5	28	0.9	0.05082
7	8.5	8.5	34	1.1	0.04211
8	11.0	9.5	38	1.3	0.02162
9	13.75	9.5	46	1.5	0.00518
10	17.5	11.5	56	1.8	0.00473
11	22.5	12.5	72	3.1	0.00068
12	27.5	12.5	88	3.8	0.00014
13	32.5	14.5	104	4.4	0.00003
14	37.5	14.5	116	5.2	0.00003

*Surface $V_{c,}$, which decreases to zero at 300 ft below surface

The directional distribution is as follows:

Table 13 Directional Distribution of Fatigue Seastates

*Wave Direction (deg.)	Probability of Occurrence
0	0.076
30	0.081

60	0.113
90	0.160
120	0.160
150	0.135
180	0.068
210	0.027
240	0.025
270	0.037
300	0.050
330	0.068

*Heading from (0 deg. is from true North, 90 deg. is from East, etc.)

9 SOIL DATA

- Submerged Unit Weight: 25 pounds per cubic foot (pcf) at the surface and linearly increasing to 40 pcf at a depth of 50 ft; constant for the remaining of the profile.

- Undrained shear strength: 30 psf at the seafloor and linearly increasing with depth at a rate of 8 psf/ft of depth.

- Strain @ 50% of Maximum Shear Stress (ε_{50}): 0.02 in the top 40 ft, 0.015 below 40 ft.

10 DRILLING RIG SPECIFICATION

Dry Tree Drilling Rig located on Structure using HP drilling riser through dedicated moonpool. Rig specifics for Base Case payload can be found in Appendix A. A drilling rig summary is provided in Table 14, and the wind area parameters are provided in Table 15.

Table 14 Drilling Rig Summary

Rig Component/Parameter		Base Case	Sensitivity Case
Total rig operating payload	st	10,000	8000
Dry weight – Derrick/Substructure	st	2,040	1700
Dry weight – Drilling Modules	st	1,960	1412
Variable load – Derrick/Substructure	st	720	680
Variable load – Drilling Modules	st	2280	2208
Hull storage	st	3,000	2000

Vertical CG above skid beams			
Derrick/Substructure Dry weight	ft	60	60
Derrick/Substructure Variable load	ft	95	95
Vertical CG from bottom of module			
Drilling Modules Dry weight	ft	16	16
Drilling Modules Variable load	ft	22	22
Hook Load (included in variable load)	lbs	2,000,000	2,000,000
Set Back (included in variable load)	lbs	1,000,000	1,000,000
Total vertical depth capacity	ft	27,000	27,000
Total engine horsepower (drilling rig power separate from topsides main power generation)	hp	8,600	8,600
Draw works	Hp	4,200	4,200
Top Drive	ft-lbs	63,000	63,000
Mud System	qty	4	4
Pressure	psi	7,500	7,500
Pump horsepower (each)	hp	2,200	2,200
capacity	bbls	8,000	8,000
density	ppg	15	15
Bulks - cement	ft^3	8,800	8,800
Bulks – barite and other	ft^3	10,000	10,000
BOP weight	st	150	150

Note: Total operating payload includes hook load and setback.

Table 15 Wind Area Parameters

Rig Component/Parameter		Base Case		Sensitivity Case	
		Operating	Hurricane	Operating	Hurricane
Wind Area					
Modules					
E-W	**ft**2**	3335	3335	3335	3335
N-S	**ft**2**	4292	4292	4292	4292
Substructure, Skidbase, derrick					
E-W	**ft**2**	9261	6842	9261	6842
N-S	**ft**2**	8334	5929	8334	5929
Wind Center of Pressure (elevation above skid beams)					
Modules					
E-W	**ft**	18.8	18.8	18.8	18.8
N-S	**ft**	18.8	18.8	18.8	18.8

Substructure, Skidbase, derrick					
E-W	**ft**	96.8	78.4	96.8	78.4
N-S	**ft**	100.5	85.4	100.5	85.4

Notes:
1. Setback is considered for Operating condition.
2. E-W wind area is the area facing the wind from North to South.
3. N-S wind area is the area facing the wind from West to East.
4. E-W CoP is the pressure center of area facing the wind from north to south.
5. N-S CoP is the pressure center of area facing the wind from west to east.
6. Substructure shading effect is considered for calculating Modules N-S wind area.
7. Pipe rack on top of DSM is not considered for calculation of wind area and CoP of Modules.

Appendix A

Base Case Drilling Rig – Miocene Capability

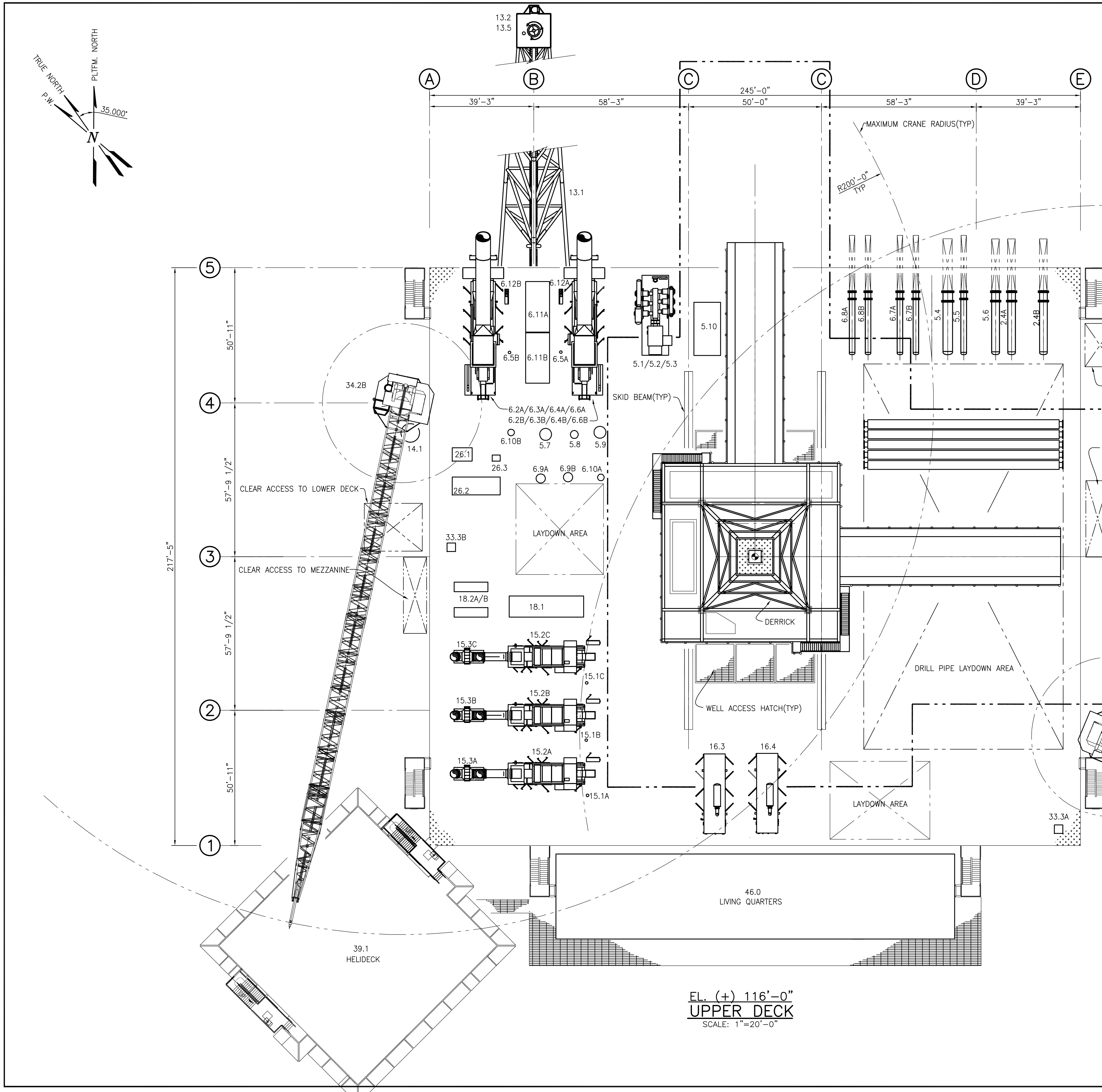
Capable of drilling and completing dry tree wells inside 9 7/8” casing in reservoirs up to 28,000 feet below sea level in up to 8,000 feet of water.

Rig Payload Live	**About 10,000 short tons - includes dead and live loads**
Derrick	165’ clear height with about 2,500,000$^{\#}$’s static hook load capacity 13 $^{5/8}$” casing load 1,700,000$^{\#}$’s
Substructure	2,000,000$^{\#}$’s hook load in addition to about 1,000,000# setback load
Setback	33,000’
Engines	Four each with total about 8,600 hp
Drawworks	Varco 4,200 hp. 1 ¾” drill-line or similar
Top Drive	Varco TDS 1000 & PH-100. 1,150 hp. Drilling torque 63,000$^{\#}$’s continuous
Work String	5 $^{7/8}$” 27.9$^{\#}$ S-135, XTM 57. TJ ID 4.25” + 6 $^{5/8}$” 34# 4$^{1/2”}$ 16.6#
Landing String	6 5/8” plus or minus 50 ft
Mud Pumps	Four each 7,500 psi triplex pumps – 2,200 hp each
Mud & Completion Fluid Capacity	About 8,000 bbls at 15 ppg. Scalable to 12,000 bbls as a function of topsides loads.
Well Kick Fluid	Client to specify ppg, quantity and pit volume philosophy
Riser Liquid Capacity	1,700 bbls without pipe in the 14” ID riser about 9,000 feet water depth
Cased Hole Capacity	2,000 bbls without production tubing in 9 7/8” C110, 62.8# casing about 26,000 feet below mud line
Shale Shakers	Six each Brandt LCM-2D or similar
P Tanks	Four each about 2.200 ft^3 each. Total 15,000 ft^3 plus 10,000 ft^3 barite & gel
Production Tubing	As specified by client. Assume 5 ½”
Completion Fluids	Filters, centrifuges etc as specified in the completion program

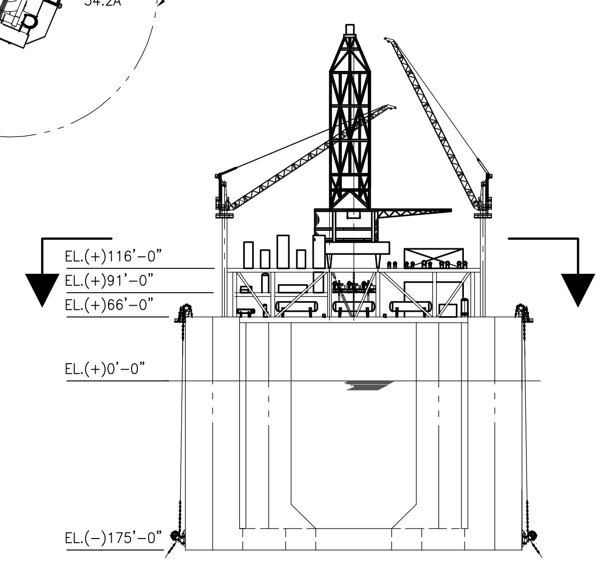
Shut-in Tubing Press	10,000 psi oil and 12,000 psi dry gas.
BOP Rams	13 5/8" Four each at 15,000 psi. Surface stack. Other BOPs: 11", 18 ¾" x 15ksi four rams, as specified by client.
BOP Annular	13 5/8" One each at 5,000 psi, 18 ¾" x 10 ksi
Coiled Tubing Operations	Client to specify unit including system, frame and support equipment

Appendix B

Topsides General Arrangement Drawings



EL. (+) 116'-0"
UPPER DECK
SCALE: 1"=20'-0"



KEY PLAN

ANSI D - 22 x 34

EQUIPMENT LIST	
EQUIPMENT TAG NO.	DESCRIPTION
2.4A/B	PRODUCTION HEAT EXCHANGER STAGE 3
5.1	SKID 1 BASE
5.2	COMPRESSOR (LOW PRESSURE)
5.3	DRIVER
5.4	INTERSTAGE COOLER STAGE 1
5.5	INTERSTAGE COOLER STAGE 2
5.6	INTERSTAGE COOLER STAGE 3
5.7	INTERSTAGE SCRUBBER STAGE 1
5.8	INTERSTAGE SCRUBBER STAGE 2
5.9	INTERSTAGE SCRUBBER STAGE 3
5.10	LUBE OIL CONSOLE
6.2A/B	SKID 1 BASE
6.3A/B	COMPRESSOR (EXPORT GAS)
6.4A/B	DRIVER
6.5A/B	FUEL GAS FILTER SEPARATOR
6.6A/B	GEARBOX
6.7A/B	INTERSTAGE COOLER STAGE 1
6.8A/B	INTERSTAGE COOLER STAGE 2
6.9A/B	INTERSTAGE SCRUBBER STAGE 1
6.10A/B	INTERSTAGE SCRUBBER STAGE 2
6.11A/B	LUBE OIL CONSOLE
6.12A/B	TURBINE PANEL
13.1	FLARE BOOM
13.2	HIGH PRESSURE FLARE TIP
13.5	LOW PRESSURE FLARE TIP
14.1	DEAERATOR
15.1A/B/C	FUEL GAS FILTER SEPARATOR
15.2A/B/C	POWER GENERATOR
15.3A/B/C	WASTE HEAT RECOVERY UNIT
16.3	EMERGENCY GENERATOR
16.4	ESSENTIAL GENERATORS
18.1	EXPANSION TANK
18.2A/B	HEATING MEDIUM CIRCULATION PUMP
26.1	COMPRESSOR AND AFTERCOOLER SKID
26.2	INERT GAS GENERATOR
26.3	NITROGEN BOTTLES QUAD
33.3A/B	FIRE MONITORS
34.2A/B	NON-COUNTERWEIGHTED PEDESTAL CRANE
39.1	HELIDECK
46.0	LIVING QUARTERS

REV	DESCRIPTION	BY	DATE
C	HULL CONFIGURATION UPDATE	CEB	05/04/09
B	HULL CONFIGURATION UPDATE	CEB	04/16/09
A	PRELIMINARY	CEB	04/07/09

RELEASE FOR:	DEPT ENGR	PROJ ENGR	DESIGN ENGR	DESIGN LEAD	DATE
PRELIMINARY					
BIDDING					
MATL ORDER					
FABRICATION					

RPSEA Research Partnership to Secure Energy for America

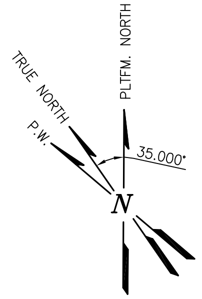
Houston Offshore ENGINEERING

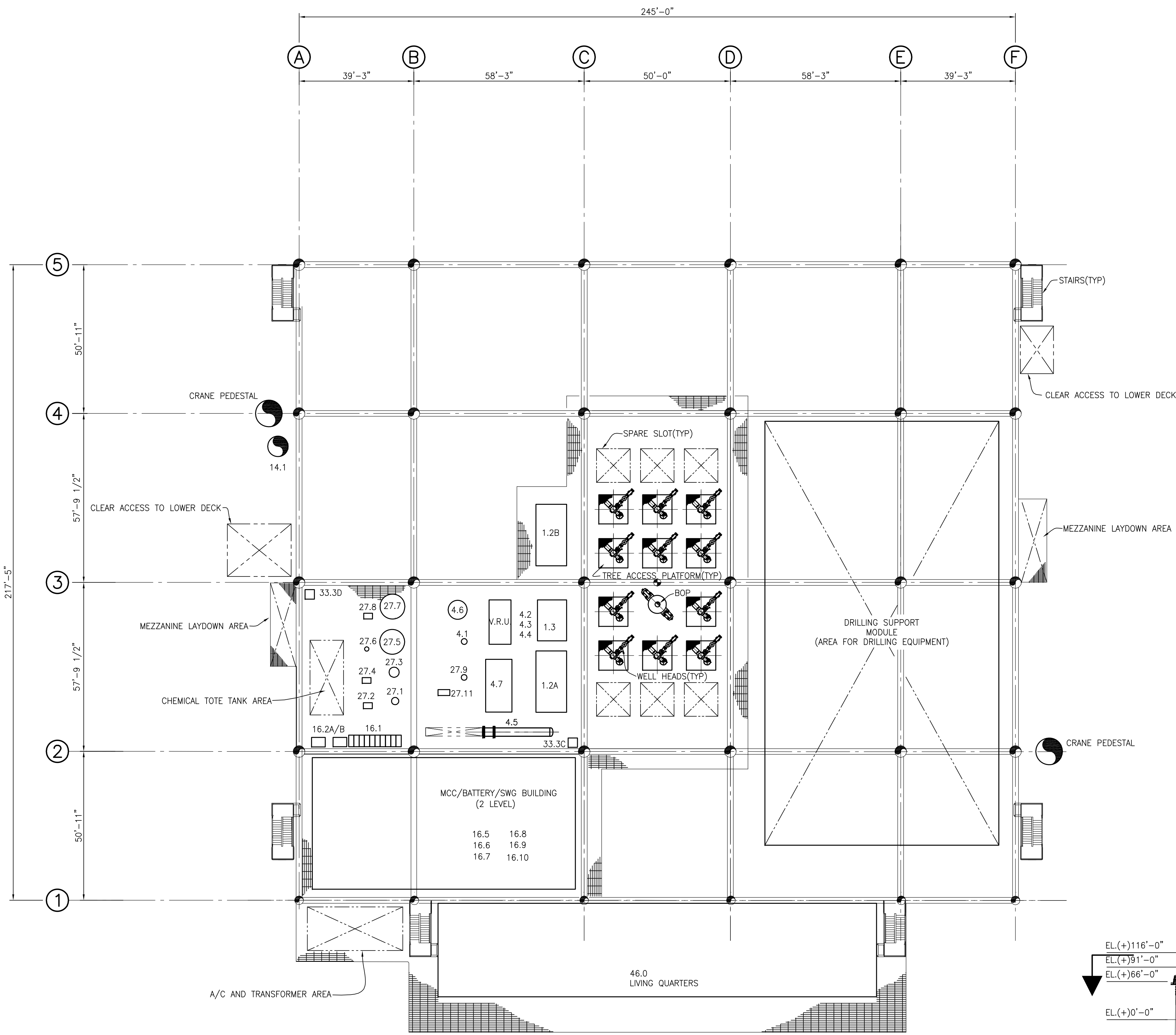
RPSEA 1402

GENERAL ARRANGEMENT
MEDIUM PAYLOAD
UPPER DECK
PLAN

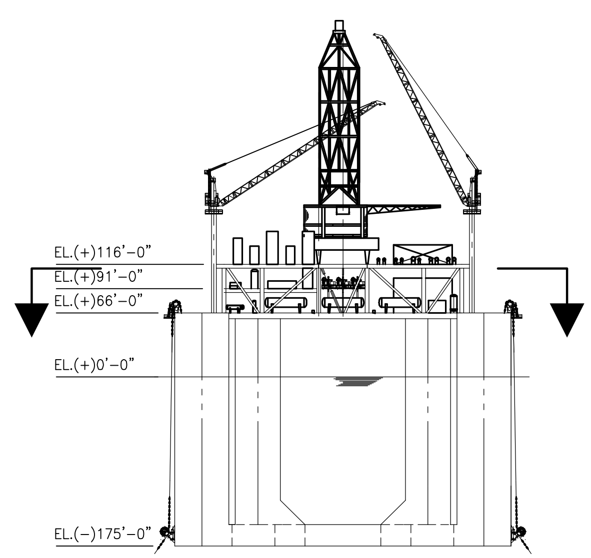
PROJ NO.	SCALE	DRAWN	DATE	CHECKED
H08130	1"=20'-0"	OWM	02/20/09	

DWG NO.	SHT	REV
H08130-G-0021	01	C





EL. (+) 91'-0"
MEZZANINE DECK
SCALE: 1"=20'-0"



KEY PLAN

EQUIPMENT LIST

EQUIPMENT TAG NO.	DESCRIPTION
1.2A/B	PROD MANIFOLDS
1.3	WATER INJ MANIFOLDS
4.1	INLET SCRUBBER
4.2	SKID 1 BASE
4.3	COMPRESSOR(VRU)
4.4	DRIVER
4.5	INTERSTAGE COOLER(VRU)
4.6	INTERSTAGE SCRUBBER STAGE 1
4.7	LUBE OIL CONSOLE
14.1	DEAERATOR
16.1	BATTERY BANK
16.2A/B	BATTERY CHARGER
16.5	LOW VOLTAGE SWITCHGEAR
16.6	LOW VOLTAGE TRANSFORMER
16.7	MEDIUM VOLTAGE SWITCHGEAR
16.8	MOTOR CONTROL CENTER
16.9	VSD LOW PRESSURE GAS
16.10	VSD VAPOR RECOVERY UNIT
27.1	ANTIFOAM STORAGE TANK
27.2	ANTIFOAM TRANSFER PUMP
27.3	ANTISCALE STORAGE TANK
27.4	ANTISCALE TRANSFER PUMP
27.5	GLYCOL STORAGE TANK
27.6	GLYCOL TRANSFER PUMP
27.7	METHANOL STORAGE TANK
27.8	METHANOL TRANSFER PUMP
27.9	OXYGEN SCAVENGER MIXING TANK
27.10	OXYGEN SCAVENGER SOLID STORAGE
27.11	OXYGEN SCAVENGER TRANSFER PUMP
33.3C/D	FIRE MONITORS
34.2A/B	NON-COUNTERWEIGHTED PEDESTAL CRANE
46.0	LIVING QUARTERS

REV	DESCRIPTION	BY	DATE
C	HULL CONFIGURATION UPDATE	CEB	05/04/09
B	HULL CONFIGURATION UPDATE	CEB	04/16/09
A	PRELIMINARY	CEB	04/07/09

RELEASE FOR:	DEPT ENGR	PROJ ENGR	DESIGN ENGR	DESIGN LEAD	DATE
PRELIMINARY					
BIDDING					
MATL ORDER					
FABRICATION					

RPSEA Research Partnership to Secure Energy for America

Houston Offshore ENGINEERING

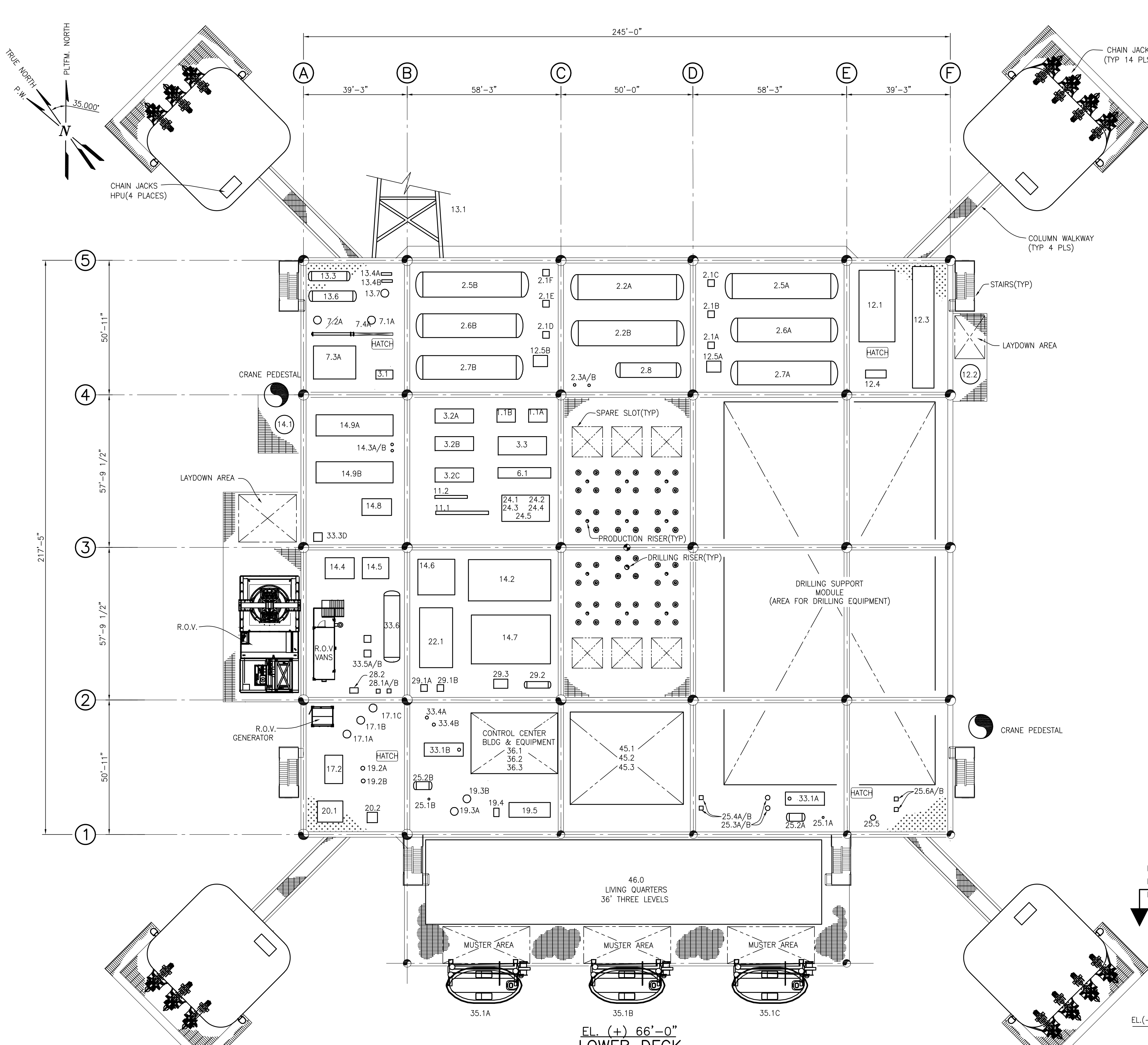
RPSEA 1402

GENERAL ARRANGEMENT
MEDIUM PAYLOAD
MEZZNINE DECK
PLAN

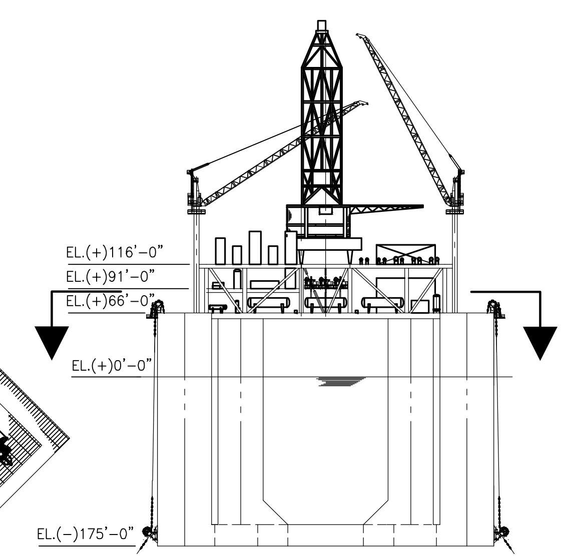
PROJ NO.	SCALE	DRAWN	DATE	CHECKED
H08130	1"=20'-0"	OWM	02/20/09	

DWG NO.	SHT	REV
H08130-G-0022	01	C

ANSI D - 22 x 34



EL. (+) 66'-0"
LOWER DECK
SCALE: 1"=20'-0"



KEY PLAN

EQUIPMENT LIST

TAG NO.	DESCRIPTION
1.1A/B	HYDRAULIC SKID
2.1A/B/C/D/E/F	CRUDE BOOSTER PUMP
2.2A/B	DESALTER
2.3A/B	PRE-FLASH SEPARATOR
2.5A/B	PRODUCTION SEPARATOR STAGE 1
2.6A/B	PRODUCTION SEPARATOR STAGE 2
2.7A/B	PRODUCTION SEPARATOR STAGE 3
2.8	TEST SEPARATOR
3.1	CRUDE COOLER
3.2A/B/C	CRUDE EXPORT PUMPS
3.3	CRUDE METERING SKID
6.1	GAS METERING SKID
7.1A	DEHYDRATION SCRUBBER
7.2A	GLYCOL CONTACTOR
7.3A	GLYCOL REGENERATION SKID-S.G.
7.4A	LEAN GLYCOL/DRY GAS EXCHANGER
11.1	CRUDE EXPORT PIG LAUNCHER
11.2	EXPORT GAS SPHERE LAUNCHER
12.1	DUAL MEDIUM DOWNFLOW FILTER
12.2	FLASH TANK
12.3	FLOTATION UNIT
12.4	HYDROCYCLONE UNIT
12.5A/B	SEPARATED OIL PUMP
13.1	FLARE BOOM
13.3	HIGH PRESSURE RELIEF DRUM
13.4A/B	IGNITION PANEL
13.6	LOW PRESSURE RELIEF DRUM
13.7	OPEN VENT SCRUBBER
14.1	DEAERATOR
14.2	DUAL MEDIUM DOWNFLOW FILTER
14.3A/B	FUEL GAS FILTER SEPARATOR
14.4	SULFATE ION REMOVAL CARTRIDGE FLTR. PKG.
14.5	SULFATE ION REMOVAL CLEAN-UP PACKAGE
14.6	SULFATE ION REMOVAL FEED PUMP PACKAGE
14.7	SULFATE ION REMOVAL MEMBRANE PACKAGE
14.8	VACUUM UNIT

EQUIPMENT LIST

TAG NO.	DESCRIPTION
14.9A/B	WATER INJECTION PUMP AND DRIVER
17.1A/B/C	SEAWATER LIFT PUMPS
17.2	SEAWATER STRAINER
19.2A/B	FRESH WATER TRANSFER PUMPS
19.3A/B	SEAWATER LIFT PUMP
19.4	SEAWATER STRAINER
19.5	WATER-MAKER
20.1	CHLORINATOR
20.2	DEGASSING TANK
22.1	INSTR. & UTILITY AIR COMP. SKID
24.1	FUEL GAS HEATER
24.2	FUEL GAS PACKAGE BULKS
24.3	FUEL GAS PRE-HEATER
24.4	FUEL GAS SCRUBBER
24.5	FUEL GAS SKID BASE
25.1A/B	DIESEL FILTER COALESCER
25.2A/B	FIRE PUMP DAY TANK
25.3A/B	INLET FILTER COALESCER
25.4A/B	TREATED DIESEL TRANSFER PUMP
25.5	UNTREATED DIESEL LIFT PUMP
25.6A/B	UNTREATED DIESEL TRANSFER PUMP
28.1A/B	SEAWATER DISTRIBUTION PUMPS
28.2	SEAWATER STRAINER
29.1A/B	COOLING MEDIUM CIRCULATION PUMP
29.2	EXPANSION TANK
29.3	PLATE HEAT EXCHANGER
33.1A/B	DIESEL FIREWATER PUMP AND DRIVER
33.3E	FIRE MONITORS
33.4A/B	FIREWATER JOCKEY PUMP
33.5A/B	FOAM PUMP
33.6	FOAM TANK
35.1A/B/C	LIFEBOATS CAPSULES
36.1	CONTROL ROOM
36.2	FIELDBUS CONTROL PANEL
36.3	FIELDBUS SAFETY PANEL
45.1	CONTROL CENTER HOUSING
45.2	LAB AND WORKSHOPS
45.3	POWER DISTRIBUTION EQUIPMENT HOUSING
46.0	LIVING QUARTERS

REV	DESCRIPTION	BY	DATE
C	HULL CONFIGURATION UPDATE	CEB	05/04/09
B	HULL CONFIGURATION UPDATE	CEB	04/16/09
A	PRELIMINARY	CEB	04/07/09

RELEASE FOR:	DEPT ENGR	PROJ ENGR	DESIGN ENGR	DESIGN LEAD	DATE
PRELIMINARY					
BIDDING					
MATL ORDER					
FABRICATION					

RPSEA Research Partnership to Secure Energy for America

Houston Offshore ENGINEERING

RPSEA 1402

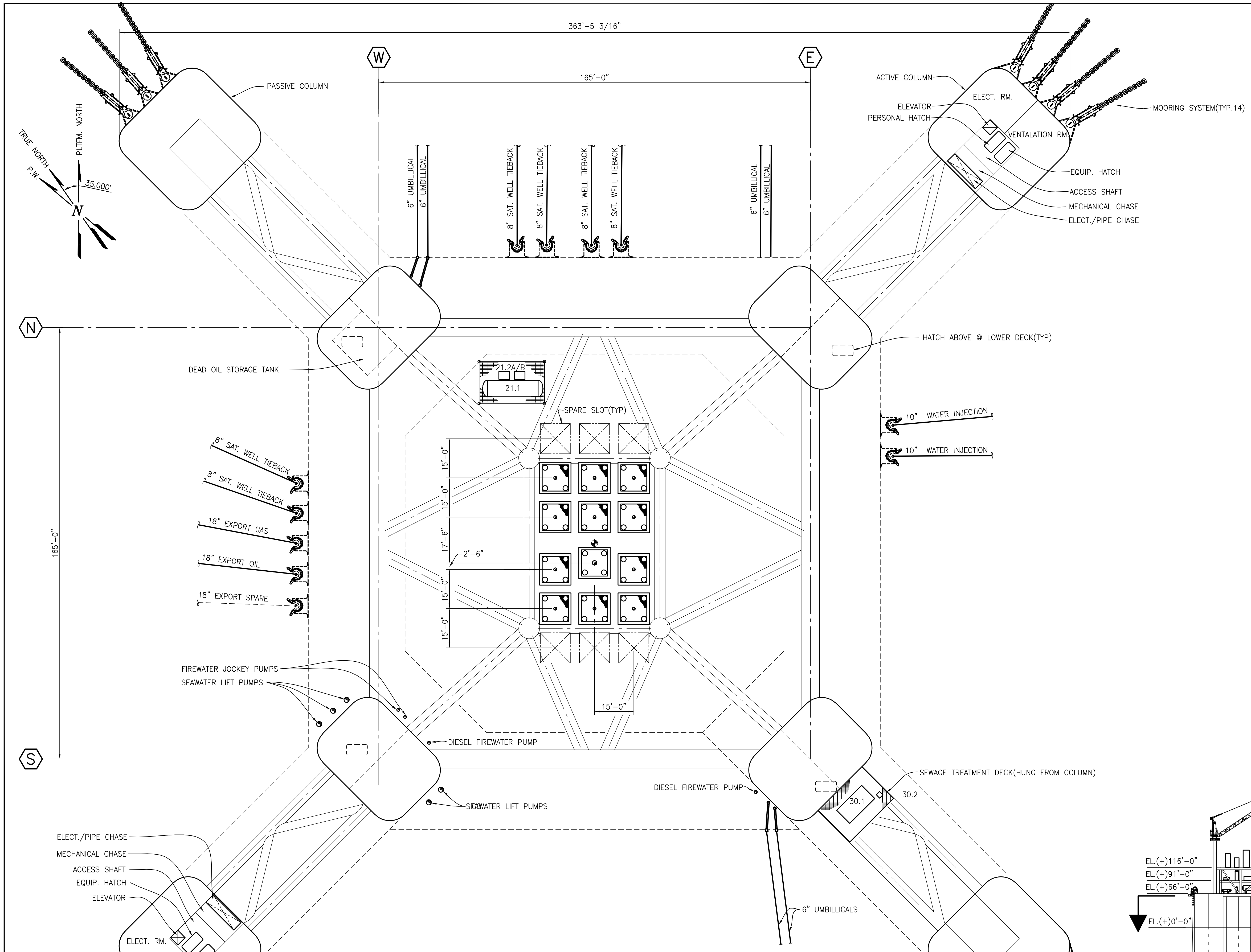
GENERAL ARRANGEMENT MEDIUM PAYLOAD LOWER DECK PLAN

PROJ NO.	SCALE	DRAWN	DATE	CHECKED
H08130	1"=20'-0"	OWM	02/19/09	

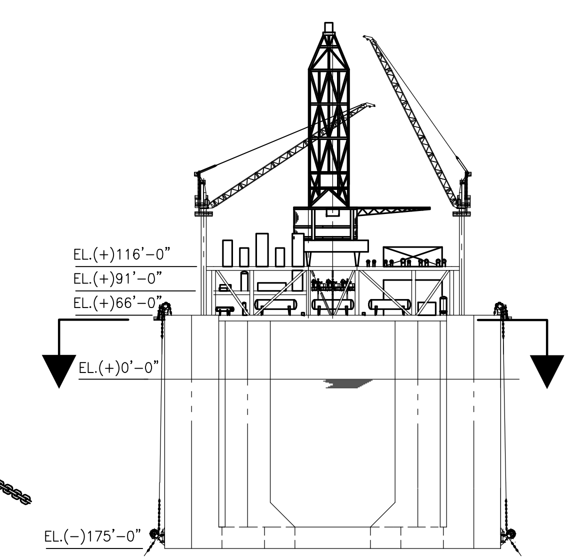
DWG NO.	SHT	REV
H08130-G-0023	01	C

ANSI D - 22 x 34

EQUIPMENT LIST	
TAG NO.	DESCRIPTION
21.1	DRAIN SEPARATOR
21.2A/B	DRAIN SEPARATOR PUMP
30.1	AEROBIC UNIT
30.2	HOLDING TANK



EL. (+) 60'-0"
TOP OF COLUMN
SCALE: 1"=20'-0"



KEY PLAN

REV	DESCRIPTION	BY	DATE
C	HULL CONFIGURATION UPDATE	CEB	05/04/09
B	HULL CONFIGURATION UPDATE	CEB	04/16/09
A	PRELIMINARY	CEB	04/07/09

RELEASE FOR:	DEPT ENGR	PROJ ENGR	DESIGN ENGR	DESIGN LEAD	DATE
PRELIMINARY					
BIDDING					
MATL ORDER					
FABRICATION					

RPSEA Research Partnership to Secure Energy for America

Houston Offshore ENGINEERING

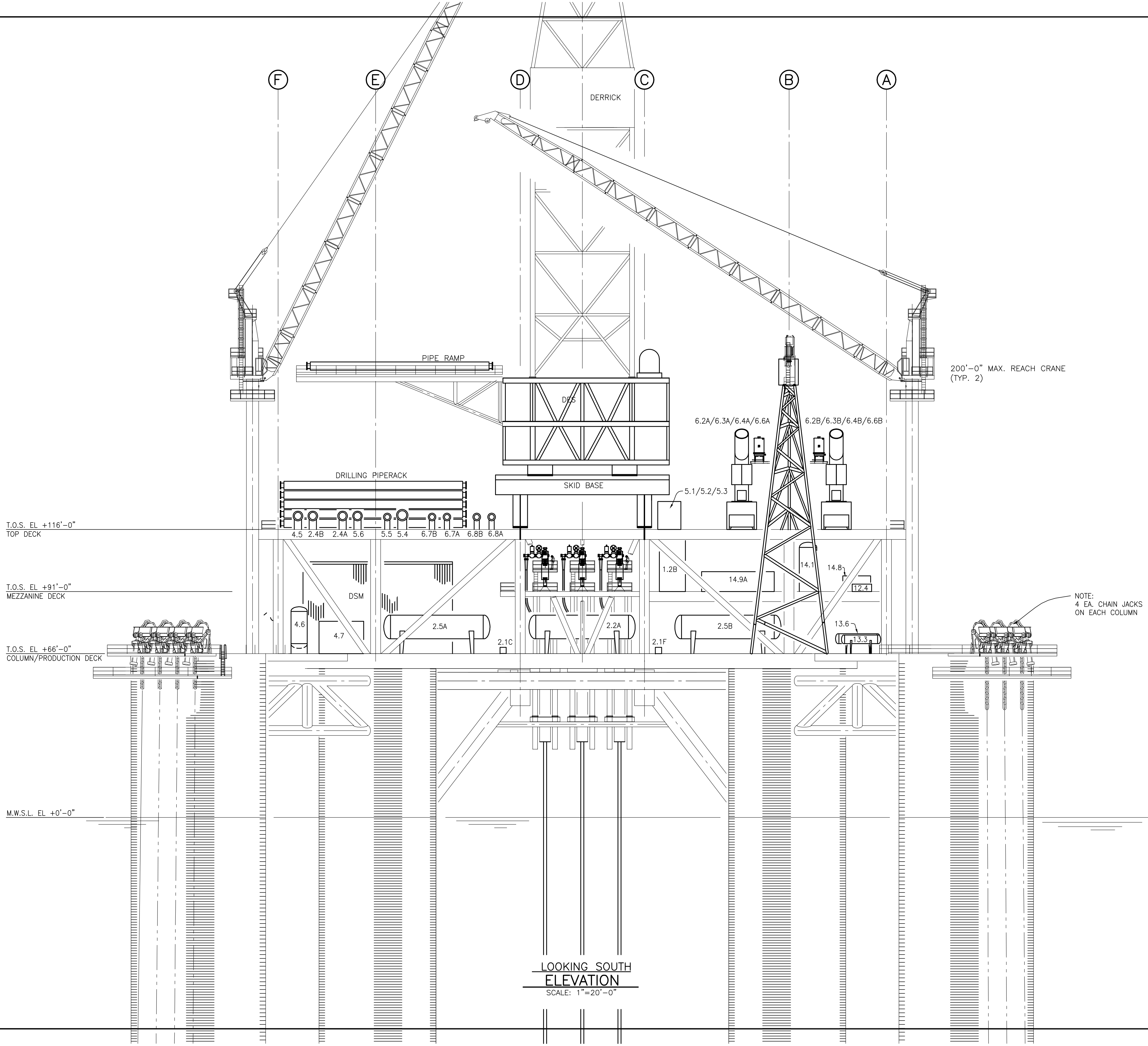
RPSEA 1402

GENERAL ARRANGEMENT BASE CASE PAYLOAD TOP OF COLUMN PLAN

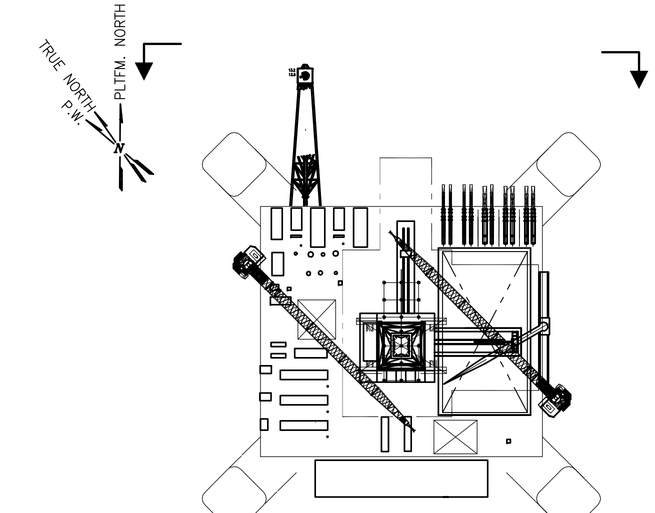
PROJ NO.	SCALE	DRAWN	DATE	CHECKED
H08130	1"=20'-0"	OWM	02/20/09	

DWG NO.	SHT	REV
H08130-G-0024	01	C

ANSI D - 22 x 34



LOOKING SOUTH
ELEVATION
SCALE: 1"=20'-0"



KEY PLAN

NOTES:

1. SEE PLAN SHEETS FOR EQUIPMENT LIST AND LOCATIONS.

REV	DESCRIPTION	BY	DATE
C	HULL CONFIGURATION UPDATE	CEB	05/06/09
B	HULL CONFIGURATION UPDATE	CEB	04/16/09
A	PRELIMINARY	CEB	04/07/09

RELEASE FOR:	DEPT ENGR	PROJ ENGR	DESIGN ENGR	DESIGN LEAD	DATE
PRELIMINARY					
BIDDING					
MATL ORDER					
FABRICATION					

RPSEA Research Partnership to Secure Energy for America

Houston Offshore ENGINEERING

RPSEA 1402

GENERAL ARRANGEMENT
MEDIUM PAYLOAD
LOOKING SOUTH
ELEVATION

PROJ NO.	SCALE	DRAWN	DATE	CHECKED
H08130	1"=20'-0"	OWM	02/20/09	

DWG NO.	SHT	REV
H08130-G-0026	01	C

ANSI D - 22 x 34