OVERCOME JACK-UP RIG INSTALLATION PROBLEM IN DIFFICULT SOIL CONDITION IN EAST SEA – A CASE HISTORY

X. Li, P. Handidjaja, T.C. Teh, D.Q. Nhut

Braemar Technical Services (Offshore) Pte. Ltd

ABSTRACT

Thin and mobile loose Sand over very dense Sandy soil condition on the seabed can cause potential damage to the integrity of the jack up with partial spudcan embedment. Due to its strong current and sandy seabed in Nam Con Son Basin, Offshore Vietnam poses significant scouring risk for jack up installation and operation. A case study of a spudcan scouring problem at Dai Hung field is presented. Previously reported scouring incident had happened at the proposed jack up location. To mitigate the potential scouring risk, Mass Flow Excavator was utilised to create three cavities at the seabed to provide full embedment for the spudcan. The operation eventually resulted in a two year scour-free attack to jack up operation. This paper summarises the challenges and experience gained from this site preparation and installation.

KEYWORDS

Jack-up Rig, Scouring Risk, Loose Sand, Mass Flow Excavator, Spudcan Penetration, Site Preparation.

INTRODUCTION

Jack-ups are generally vulnerable to the seabed conditions, and a risk assessment should be undertaken for all locations to be sufficiently prepared for the expected leg penetration. Partially embedded leg penetration in the loose non-cohesive material, set in the relatively deep water with high airgap requirement under extreme weather exposure could be vulnerable during a long period of operation on-site. Geotechnical and Structural models should not be overly simplified, as this could jeopardize the accountability of the geotechnical and structural methods and leave an impression that the uncertainty and risks are much larger than they expected.

This paper presents the ground preparation in the vulnerable seabed conditions and shows the risk involved should the preparation of the site not be taken care of in advanced for the safe installation and operating condition of a jack up rig.

GEOLOGICAL SETTING, GROUND AND ENVIRONMENTAL CONDITIONS

The site is located in the Nam Con Son basin, near Vanguard Bank, where the end of the Gulf of Thailand meets the end of the East Sea, as presented in Figure 1. The soil conditions influencing the spudcan penetration at the site are characterized by sediments from the Quaternary period, namely Holocene shore face SAND and followed by weathered Stiff to very Stiff CLAYS. The site and to the southeast part is an area where surface soils are dominated by Holocene SAND forming mega-ripples and sand-waves with heights up to 2 metres. Unfortunately there is only one geotechnical borehole for the installation of the platform at this location. The soil boring log is presented in Figure 2.

Several Site Survey campaigns have been conducted in the area and noted that mega ripples and sand waves are observed on the seafloor in the region. There was not a geo-hazard issue in the early MODU installation, as

the wells were drilled by Semi-submersible units. Hence, it was not well understood how the sand-waves were formed and it was not a serious issue for a mooring type drilling MODU. The water depths in this basin vary from 98 metres to 120 metres. The site is facing directly to the outflow of the Mekong delta where high energy 9 river flows (Cuu Long river, the nine dragons) that carry sediments from China to the East Sea through the Mekong delta. The maximum surface and seabed currents are 4m/sec and 3m/sec, respectively. Seabed conditions as revealed by Sidescan sonar from one of the Site Survey campaigns is presented in Figure 3. Prevailing winds are distinctively seasonal depending on the monsoon period. October to March winds tend to be North Northeast to East Northeast, while June to September winds tend to be South Southwest to West. Waves reflect the seasonal directionality of the monsoonal winds. The waves associated with the monsoon are generally very high due to the stronger and more consistent winds.

BACKGROUND OF JACK UP RIG INSTALLATION

In 2009, the first Jack-up rig (Mitsui Modec 400C-35) installed on-site but was only operated in a short period of time during the Southwest monsoon. Then in July 2011, a Wellhead Platform was installed over the existing well and thereafter a Keppel Fels Mod V B installed with a rig heading of 128^{o}. Leg Penetrations were shallow with the unit operating at a high airgap over the platform and operation continued from July over the Northeast Monsoon period. A Tropical Depression approached the unit in December 2011; the unit "walked" and later on found structural failure on the legs. This was the first incident of this kind Offshore Vietnam. Investigation showed that high current and waves/wind had undermined the stability of the footing foundation. The unit was removed shortly thereafter. In August 2012, another Keppel Fels Mod V B (big foot) was installed during the Southwest monsoon however, operation was limited to the end of the Southwest monsoon. This time around ROV surveys were conducted regularly to see the movement of the Seabed SAND over a period of time during operation on-site. Found that the movement of loose SAND around the spudcan was erratic and high current was imminently present even in the Southwest monsoon. Figure 4 shows the spudcan embedment as surveyed by ROV. The unit was moved off the platform in October 2012, prior to the Northeast monsoon period. Based on the lessons learnt of previous Jack-up rig installations, the bottom current exists throughout the year. Operator planned for a solution as such to select a Jack up rig unit that is able to work safely over a long period of time including operating throughout the Northeast Monsoon and during any typhoon season. In 2013, a Friede & Goldman JU 2000E design was selected to drill over the platform. But this time, ground preparation was studied and considered for the installation to eliminate or minimize the scour potential problem.

LEARNING EXPERIENCE

Based on the geological setting of the area which is 150 Nm Southeast from the shore, widely exposed to harsh environmental conditions especially during the Northeast Monsoon, and at the centre axis of high energy outflow from the Mekong delta through Cuu Long river, a site specific and long term study on the characteristics of each parameters effecting the seabed conditions is required. After the incident in 2011, a current meter measurement was initiated to study the magnitude and direction of the current. Unfortunately, the study as initiated by the operator had limited budget and only a short period of Metocean measurement was taken onsite. It turns out that two different current magnitudes and directions found on seabed and at the surface. This provides the seabed sand movement. The trend, the periodic events and when they become an issue to create scouring on the spudcan are not fully understood and need further long investigation and study. The operator is therefore looking for quick alternative solution to install the rig safely without having any uncertainty of a possible scouring event if shallow spudcan

penetration or insufficient penetration is present. The Site Specific Assessment of Keppel Fels Mod VB with the installation configuration over the platform under the given Metocean environment condition for Northeast Monsoon is passed marginally for 5-year return period under normal condition (SNAME Criteria). However, the observed environmental condition during the Tropical Depression in December 2011 was surpassing the Metocean condition. Moreover, the uneven marginal minimum penetration originally achieved was altered due to the passing of the Tropical Depression and Storm.

This paper does not discuss the incident event but to look for the way-forward for future safe installation and operation with the conditions and constraints/limitations of the present seabed conditions. The key parameters to enable the solutions are:

1. The right Metocean Study to be applied as presented in Table 1
2. The Period that the unit is going to operate with specific rig configuration installed over the platform. Specific Operating Rig configuration, worst scenario is given in Table 2
3. To set the leg penetration such that scour potential is minimized or eliminated

Since the Operator does not have a complete set of long term metocean measurements on-site, therefore the Metocean is set based on the model study and utilizing the limited current meter measurement on-site. The operating period is set to be long term over the Southwest and Northeast monsoon period. Therefore, the selection of the future rig will be based on above 3 points. A Friede and Goldman JU-2000E design rig with 547.8 ft leg was selected to operate in September 2013.

MASS FLOW EXCAVATION

Introduction of Mass Flow Excavation (MFE) was considered to prepare the ground such that potential scour undermining the footing foundation can be minimized or eliminated. It is planned to bury the spudcan from the base until the widest section part. The tip height to widest section is 1.17 metre. Figure 5 shows the plan of buried part of the spudcan. However, the loose fine SAND that is moveable in all seasons is estimated to be about 2 metres in depth, as reported by ROV survey prior to the plan of rig installation. Due to numerous shallow footprints around the platform with various depths, it was planned to bury the spudcan between 3 and 5 metres below the existing seabed level. Figure 6 is proposed position of the JU 2000E rig over the numerous sets of Jack up footprints. The MFE is a tool of non-contact dredging operations, providing an efficient method of clearing sediment from subsea structures without damaging the structures themselves. Large hydraulic flow is generally powered directly from the surface. Loss of hydraulic power in the hoses was expected. The MFE scope of work was as follows:

- Set soil conditions with engineering properties, Table 3
- Run a debris survey clearance over the area that the unit will be emplaced. Remove the debris. Figure 7 shows the position of debris and removal of debris.
- Excavate the seabed at each proposed spudcan position of the Jack-up unit to a depth of 5 metres x 18 metres diameter at the base of excavation depth. Based on the anticipated soil condition, the surface hole diameter was approximately 40 metres, assuming a 1:2 slope. The excavation will be in the shape of a soup bowl. Figure 8 shows the excavation hole.
- Carry out a multibeam sonar that is attached to the tool while dredging. Survey was run again after completion of the excavation.
- 8-ins. Suction system is on standby, if there is a need to clear and move the displaced cuttings away from the area.

Following are the main items of equipment utilised:

- T8000 controlled flow excavator – it pushes a high volume, low pressure controlled column of

seawater to the seabed at a rate of up to 8,000 litres per second, as presented in Figure 9
- Diesel Hydraulic Power Pack
- Hose Reel with umbilical hose sets
- Multibeam sonar system
- Compact Work Class ROV
- Surface and Subsurface Positioning

Ground Preparation worked fairly smooth clearing the materials within the allotted time frame of 5 days. It is about 1.5 days for each hole plus half a day to touch-up side of the hole. Although there was an area or bottom hole which was not 18m, but generally they were sufficiently deep for the spudcan embedment. Figure 10 shows the multibeam images before and after the excavation. Figure 11 shows the 3-D excavation Model with accurate coordinates, which will be passed on to the positioning surveyor that will position the Rig. Due to the delay of the rig being still underway to the location, re-survey of the area with a multibeam after 8 days, still showed the same side-wall and slope inside the hole was fairly stable as depicted in Figure 12. Figure 13.1 to Figure 13.3 which shows the cross-section profiles from one spudcan to the others. It was noted that the depth required was not achieved completely to 5metres below the existing seafloor. As the seafloor condition is undulating and disturbed by previous footprints, a reference elevation had to be established throughout at -110.5 metres. The bottom of the holes was estimated at elevation -114 metres. Thus, at least a 3.5-meters cut was made at each spudcan position. The width of the hole was narrowing down from the surface to the bottom of the hole. At elevation -113 metres, this width was still acceptable to accommodate the spudcan width. This was however sufficient for the widest section to be embedded inside the hole under the present seafloor level. Another check is the centre to centre of spudcan distance and rig's heading. All appeared within a tolerable distance of one metre. Therefore, the ground preparation for installation was acceptable.

INSTALLATION OF JACK-UP RIG

The unit was soft-pinned and anchors run. The unit's final position was assisted by anchors. Initial penetrations at zero airgap and final penetrations at full preload are the same. It was recorded as Bow 4.85 metres, Port 4.75 metres, and Starboard 4.65 metres. Upon preloading and skidded out, ROV survey inspections were carried out and video clips are presented in Figure 14. The spudcan widest section seems to be embedded, though starboard leg penetration was marginally penetrated to the widest section.

CONCLUSION

Jack-up installation and operation with partially embedded spudcan penetration in non-cohesive soil under harsh environmental conditions may pose risk to structural integrity failure. There is a way to minimise or eliminate the risk by treating or altering the ground or to carry out ground preparation by mass flow excavation (MFE). As the environmental data is limited to desk study and the site is remote, a Jack-up installation plan cannot be made easily and quickly. A thorough study of the environmental conditions by in-situ measurement and monitoring and subsequently analyzing the data are required. This study will take time and funding. Therefore, a solution to the problem is required.

The introduction of MFE to solve the problem is very attractive as the short time taken to eliminate the soil results in a safe installation and operational requirements can be met. A decision by the Operator to take the challenge was made. The Operator engaged the MFE contractor who has a track record with pipeline installation, a tool for pipeline correction or remedial work. The challenge is to plan the process and to get the work with a highly accurate position and the amount of quantity of cutting/excavation. The next challenge is to ensure the cutting holes are still present and do not collapse. The advantages to employ the ground preparation method by using MFE are:

- Quick to clear the sediment
- Excavating the area can be seen in real-time, thus it has full control of the operation with high accuracy
- Improves the foundation and structural integrity

The disadvantages of MFE are :

- Once the holes are made, therefore the set of footprints is only applicable for that typical size of rig with a specific rig position
- A thorough soil information assessment must be carried out in order to know if the MFE is able to be carried out. There is a limitation to types of materials and strength that can be cut.

For future application, it is prudent to have a thorough technical assessment to evaluate the feasibility of the method and site support to ensure successful execution, because for each site the characteristics are varied.

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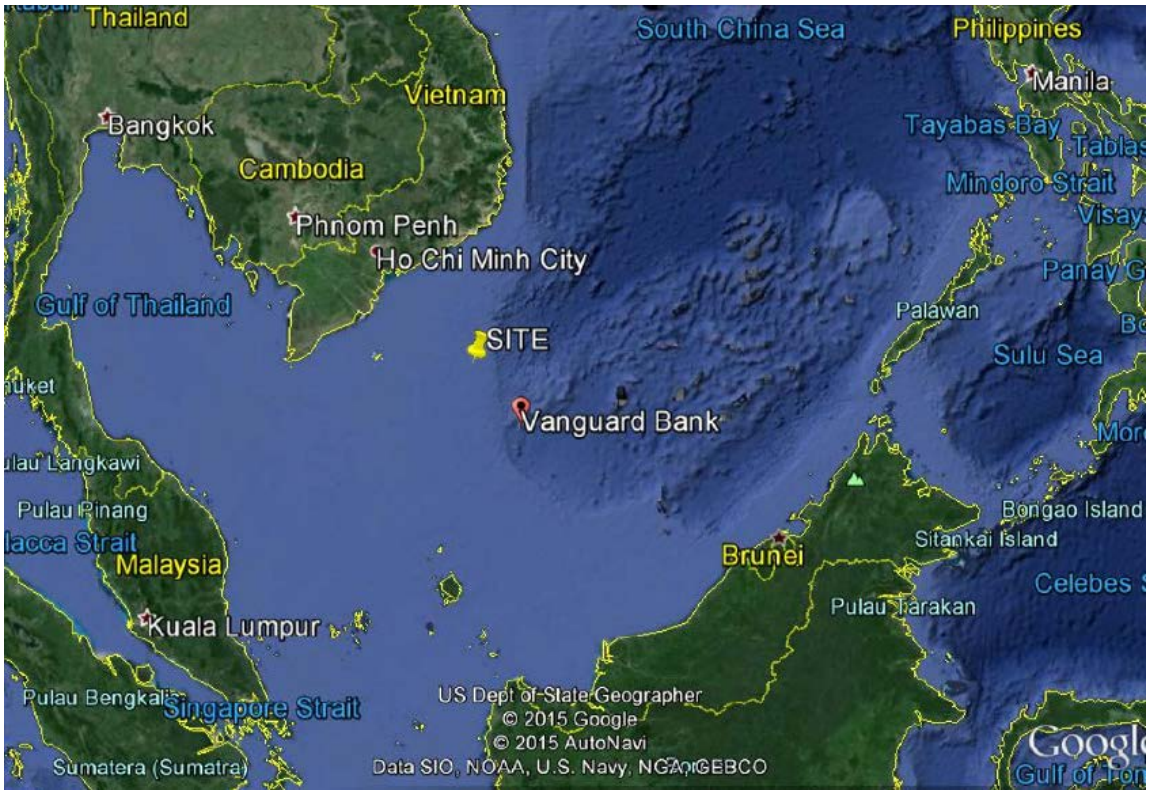


Figure 1 Site in the Nam Con Son Basin near Vanguard Bank

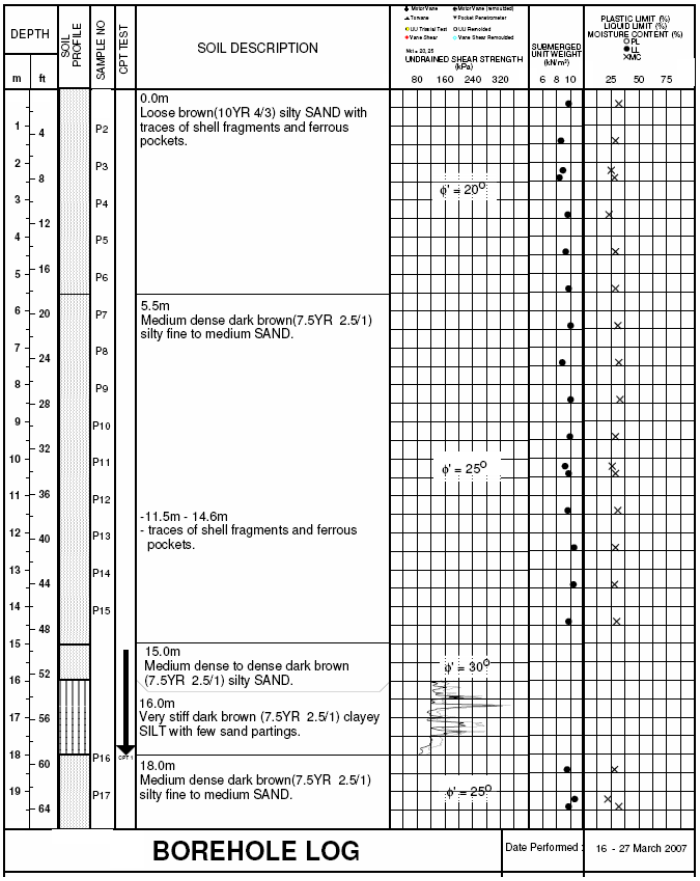


Figure 2 Boring Log at the Platform Location

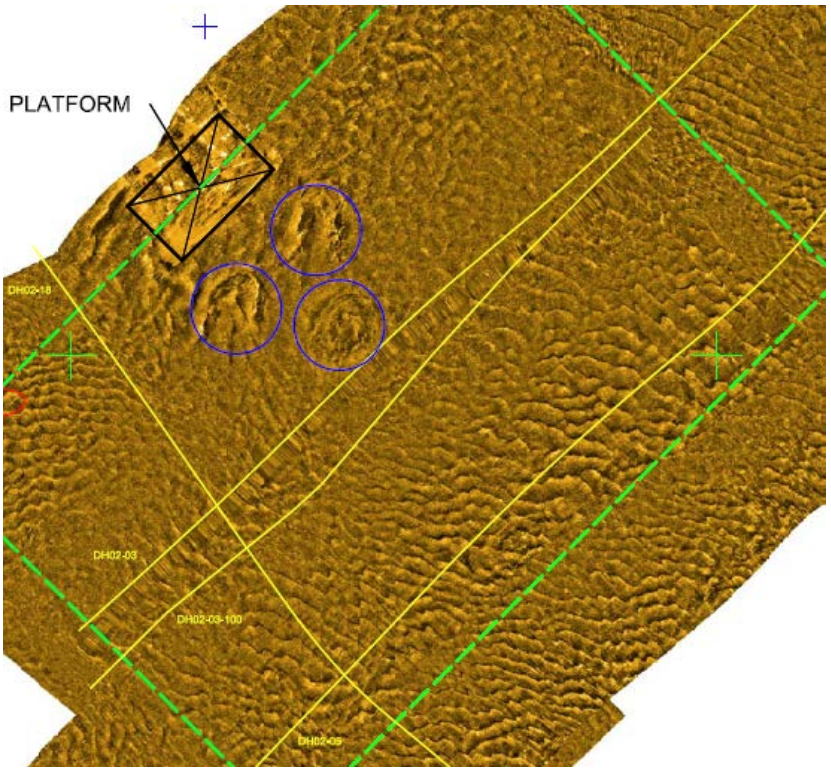


Figure 3 Extract of Side Scan Sonar showing the mega ripples and sand waves around the platform

Figure 4 Typical Spudcan along the AB-Chord as surveyed taken on 25 August and on 29 August 2012

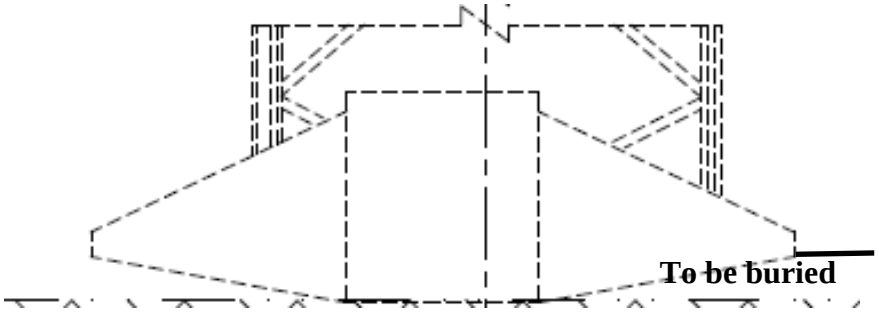


Figure 5 Typical Friede & Goldman JU 2000E Class Spudcan – Part to be embedded below widest section

Parameter	Unit	Normal Operating	Storm Survival
Return Period	year	*50*	*50*
Water Depth (LAT)	m	*107.3*	*107.3*
1-minute Mean Wind Speed	m/s	*26.2*	*26.8*
Maximum Wave Height, H_{max}	m	*12.5*	*13.0*
Most Probable Wave Period for H_{max}	sec	*10.8*	*11.0*
Significant Wave Height, H_s	m	*7.5*	*7.8*
Current Speed at Sea Surface	m/s	*2.51*	*2.61*
Current Speed at 25% depth	m/s	*2.28*	*2.37*
Current Speed at Mid-Depth	m/s	*1.99*	*2.07*
Current Speed 1m above seabed	m/s	*1.29*	*1.34*
Tidal Range	m	*2.36*	*2.36*
Storm Surge Height	m	*0.75*	*0.94*

Table 1 Metocean data at the Platform

Parameter	Units	Quantity	Remark
Air-gap	m (ft)	32.0 (105.0)	from LAT
Spudcan tip penetration	m (ft)	6.1 (20.0)	5m trench from virgin seabed
Water depth	m (ft)	107.3 (352.0)	from LAT to virgin seabed
Hull base to top of Jack house	m (ft)	19.5 (64.0)	fixed dimension
Leg Reserve	m (ft)	2.1 (6.8)	minimum 1.5 m

Table 2 Set of Operating Configuration, worst scenario

Location: WHP-1
Coordinates : E 791 050m
N 936 815m

Layer	Depth Below Seabed (m) From	To	Thickness (m)	Description
1.	0.0	5.5	5.5	Loose silty SAND
2.	5.5	15.0	9.5	Medium dense silty SAND

Stratum	Soil Description	Penetration From (m)	Penetration To (m)	Submerged Unit Weight (kN/m^3)	Design Shear Strength (kPa)
1	Loose silty SAND	0.0	5.5	9	20^0
2	Medium dense silty SAND	5.5	15.0	9.8	25^0

Table 3 Set of soil conditions and parameters

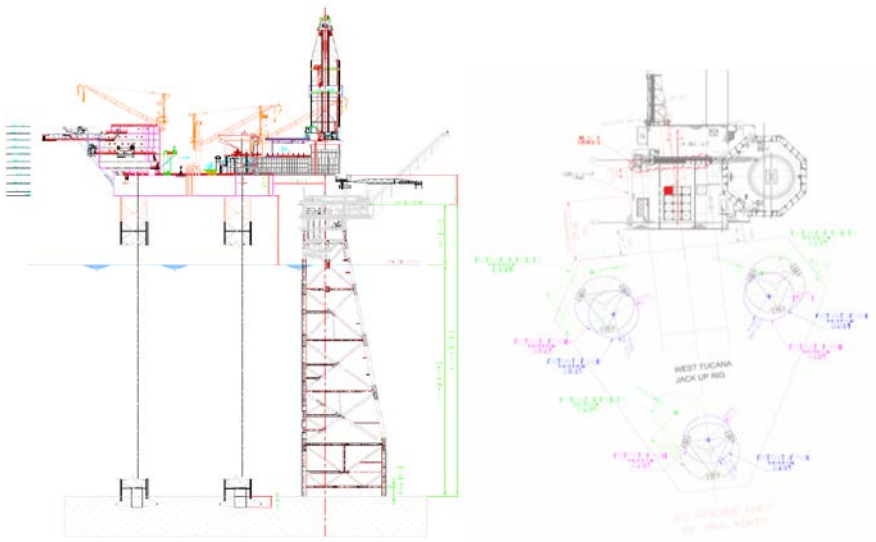
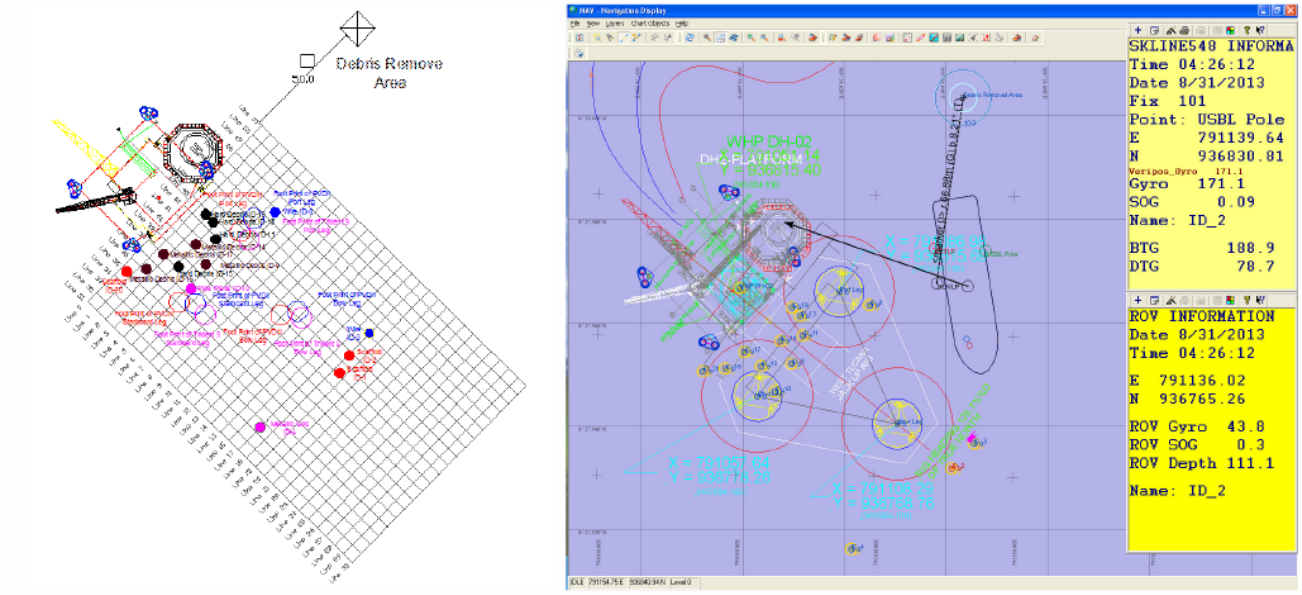


Figure 6 Three sets of Jack-up footprints recorded over the platform



15 items of debris(Previous inspection campaign 05/2013)

Layout of 15 items of debris on Navigation Screen

Figure 7 Debris were cleared prior to Mass Flow Excavation work

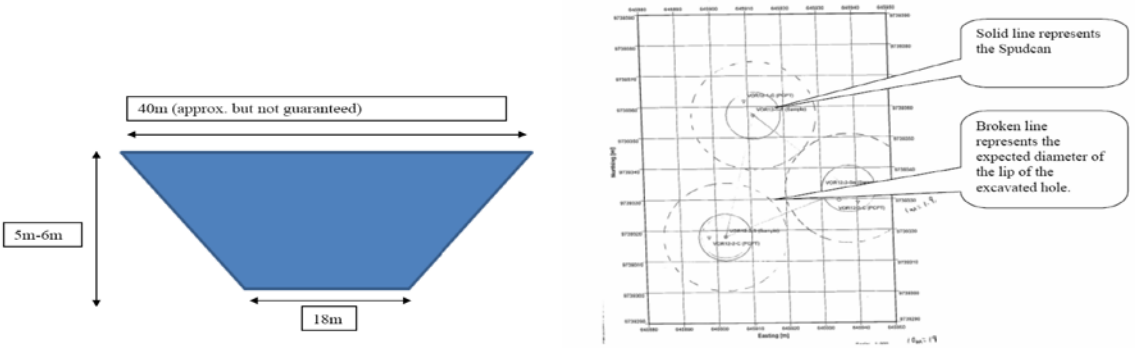


Figure 8 Proposed excavation shape and dimension

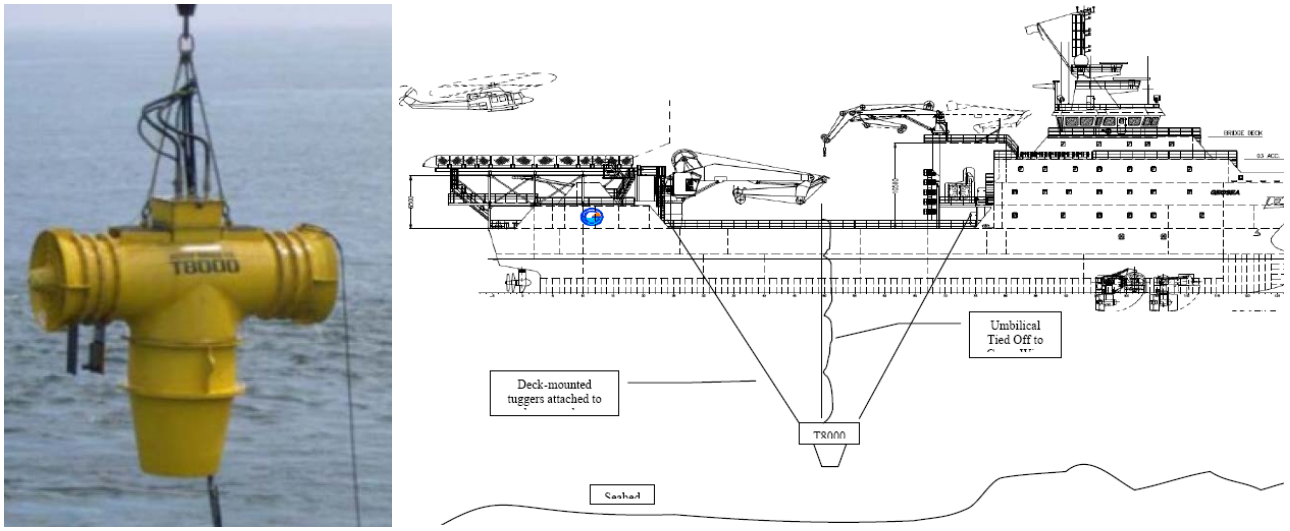


Figure 9 T8000 Controlled Mass Flow Excavator and method of launching the unit over the side of the DP Vessel

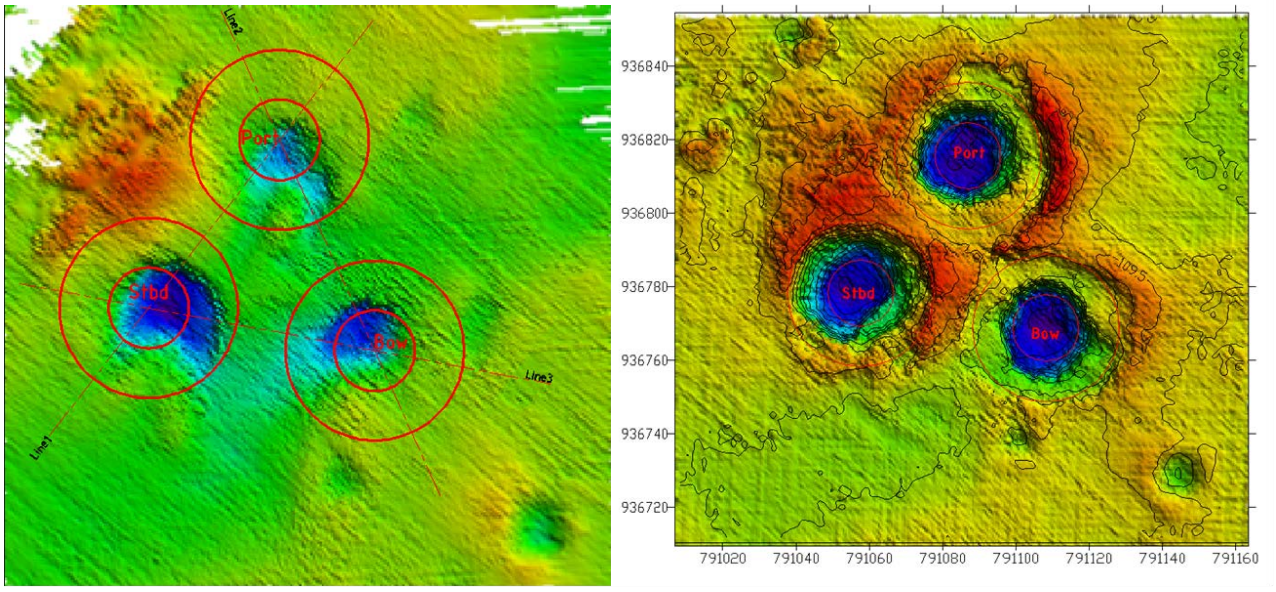


Figure 10 Multi-beam prior to excavation (left) and after the excavation (right)

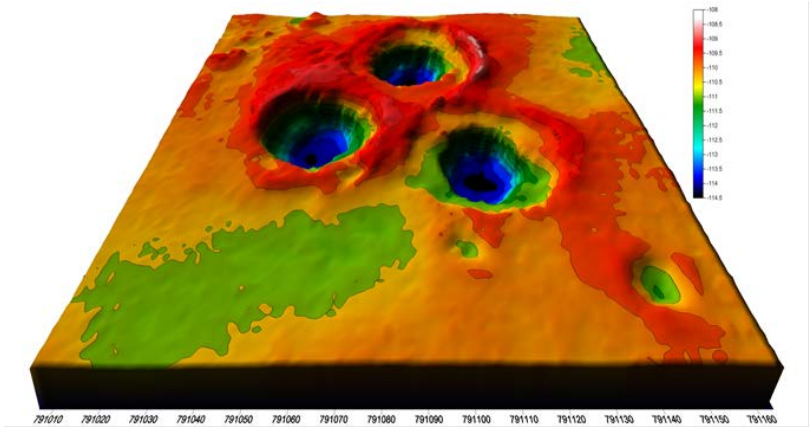
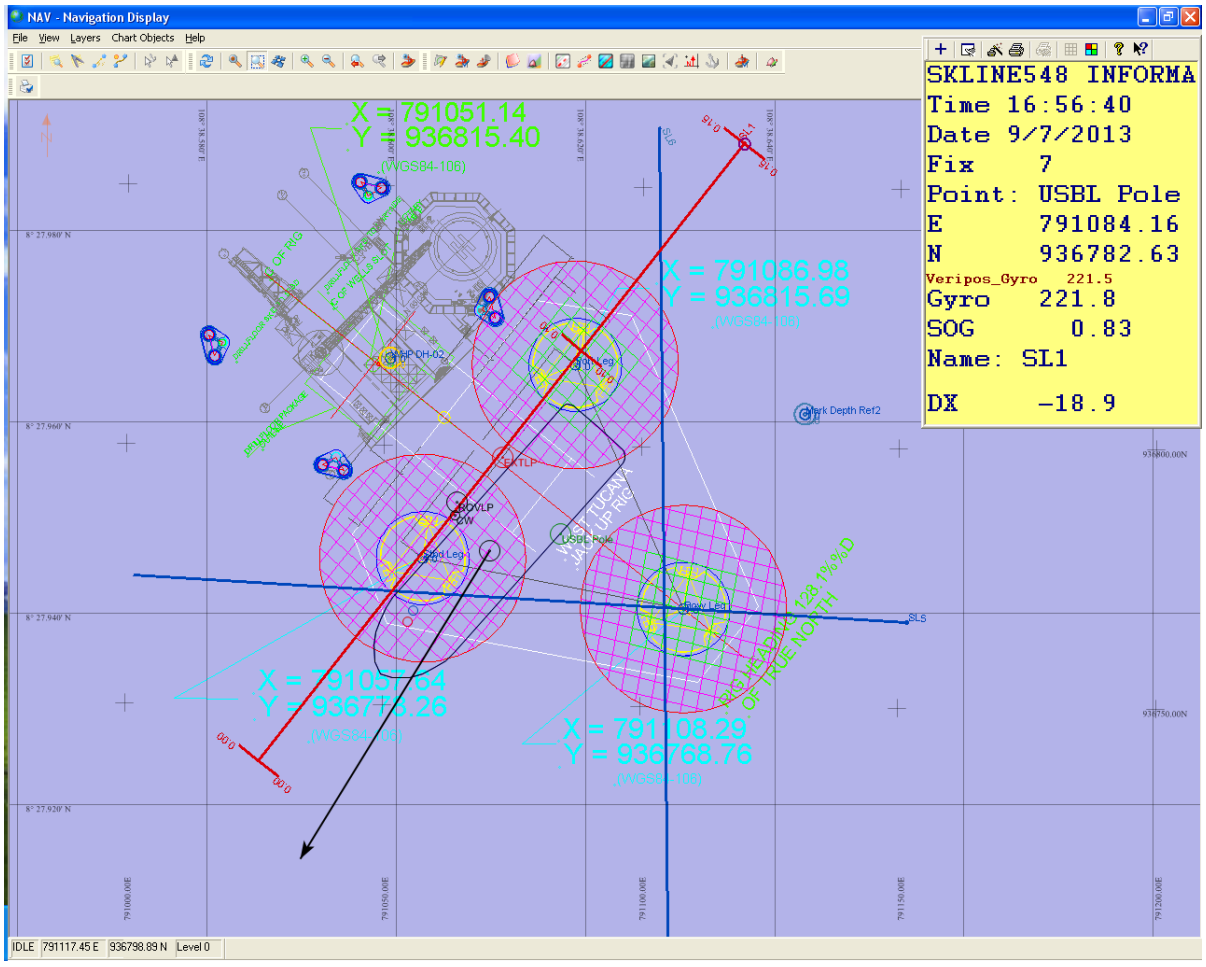


Figure 11 Terra model Map after excavation



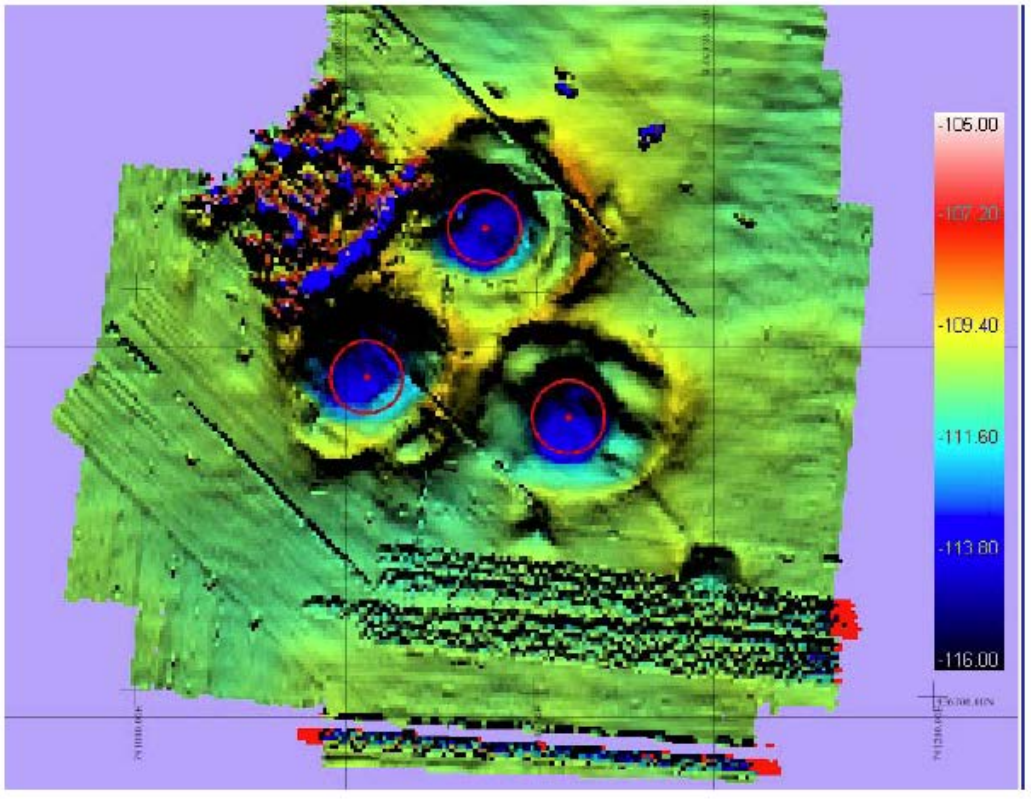


Figure 12 Re-run Multibeam after 8 days of excavation just prior to Rig Installation

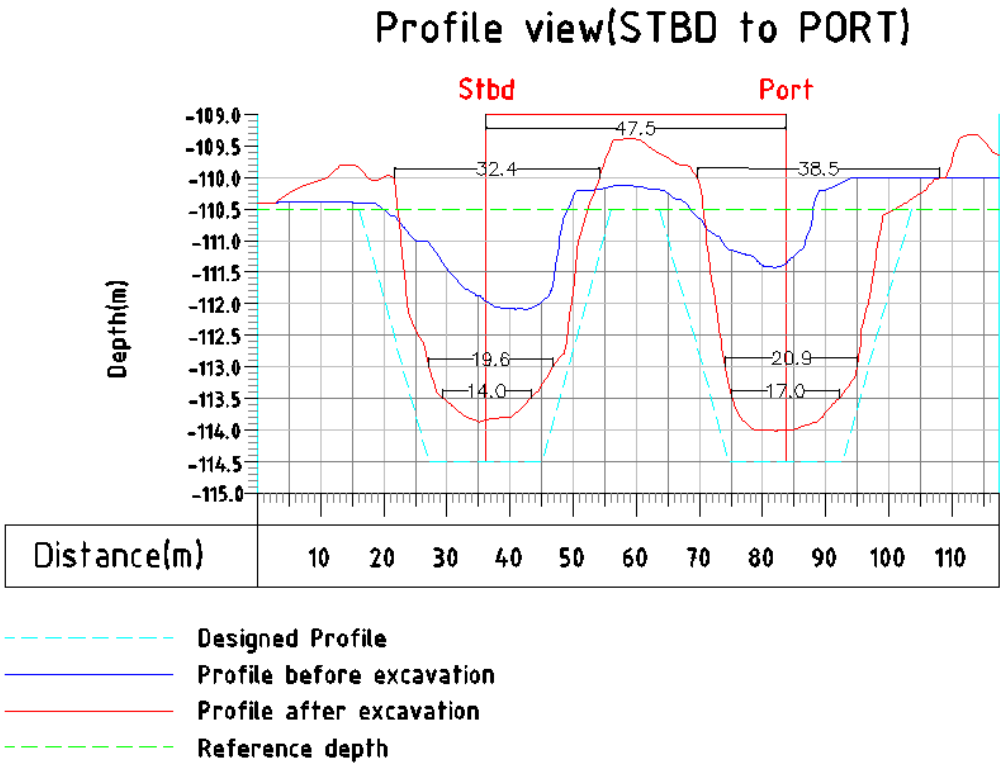


Figure 13.1 Cross Section Profile Starboard to Port before, designed and after excavation

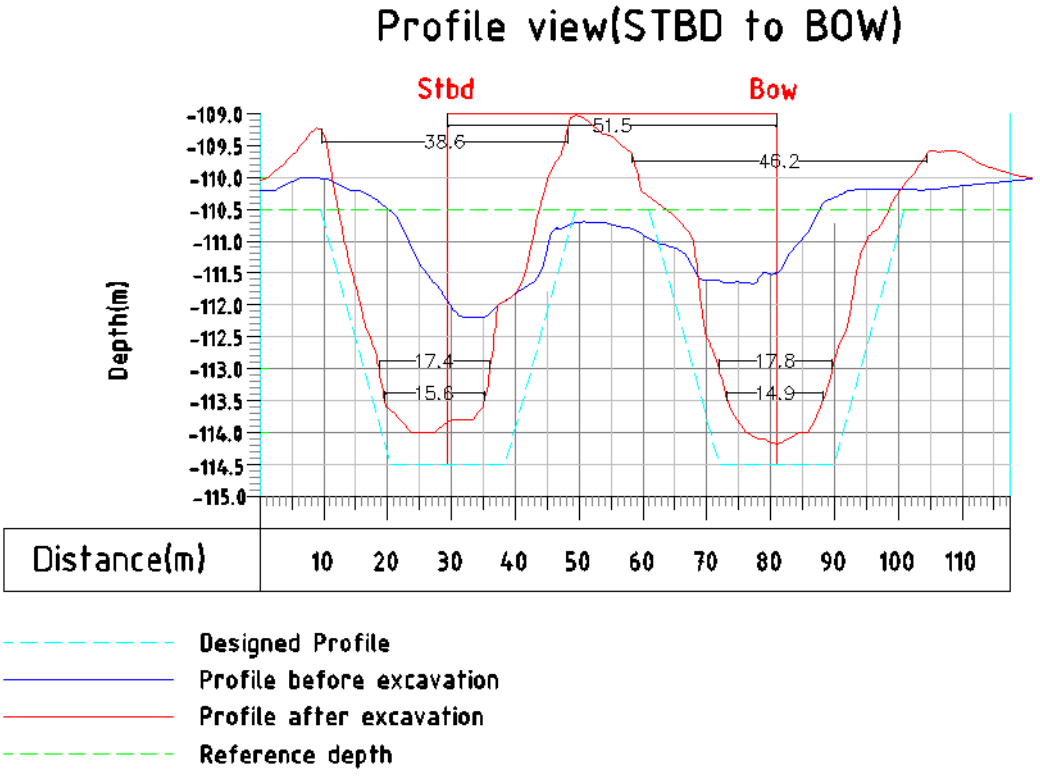


Figure 13.2 Cross Section Profile Starboard to Bow before, designed and after excavation

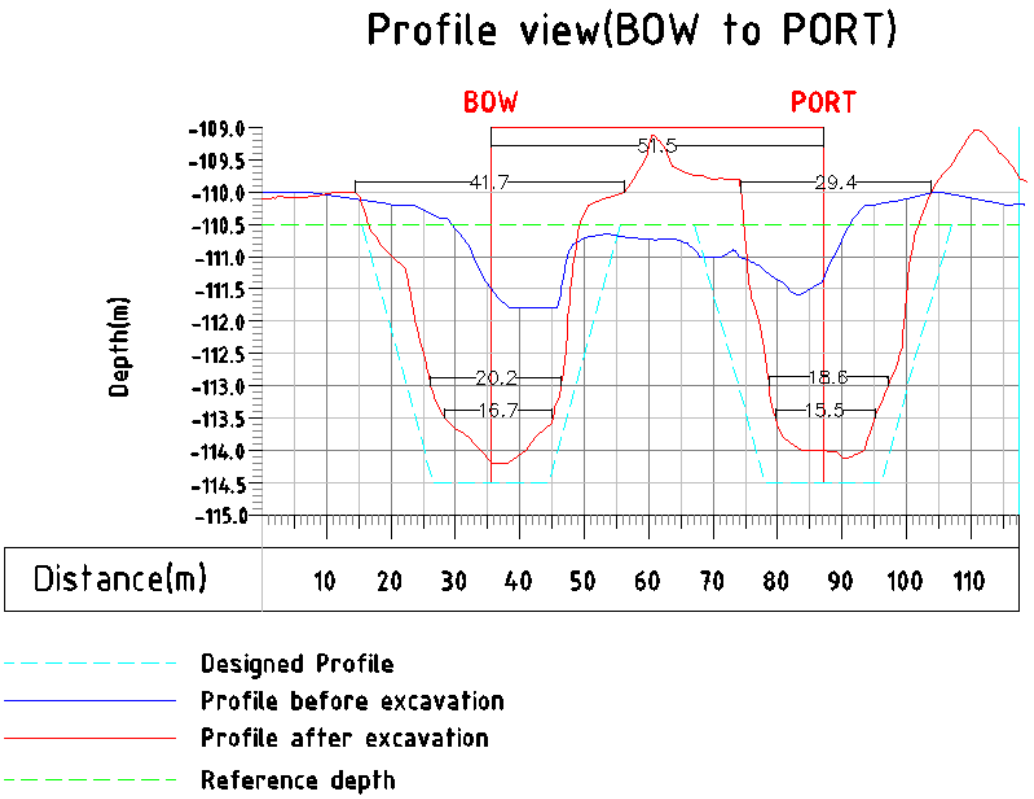


Figure 13.3 Cross Section Profile Bow to Port before, designed and after excavation

Figure 14.1 ROV survey inspections after installation – Bow Leg

Figure 14.2 ROV survey inspections after installation – Port Leg

Figure 14.3 ROV survey inspections after installation – Starboard Leg