FINAL REPORT

Implementation Plan for the BEAM" – "Borehole into the Earth's Mantle" Program

Prepared For:

Yoshi Kawamura
Integrated Ocean Drilling Program – Management International

Nobu Eguchi
Japan Agency for Marine Earth Science and Technology

Purpose:

Develop an implementation plan for the BEAM Project that moves the project from its current feasibility phase towards a project execution phase that could be used by the various project stakeholders as the basis for internal operational planning and decision making.

Version:	**Date:**
001	14 July 2013

Project Number:
IOD-I212-003
JAM-I213-001

BLADE ENERGY PARTNERS

2600 Network Boulevard, Suite 550
Frisco, Texas 75034

+1 972-712-8407 (phone)
+1 972-712-8408 (fax)

www.blade-energy.com

Version Record

Version No.	Issue Date	Issued As / Nature of Revision	Author	Checked By	Project
000	7 July, 2013	Initial Draft	WSW/NP	BP	BP
001	14 July, 2013	Revised Draft	WSW/NP	BP	BP

Table of Contents

1 Executive Summary

In September 2012, IODP-MI requested that Blade develop an Implementation Plan for IODP's "Borehole into the Earth's Mantle Program" - "BEAM". The goal was to develop a conceptual roadmap that moves BEAM from the current feasibility phase, towards a project execution phase that could be used by IODP, JAMSTEC/CDEX and the scientific community as the basis for their internal operational planning and decision making process.

The objectives of this BEAM Implementation Plan are to provide a detailed roadmap covering all the key technical steps that need to be completed to provide high success probability for BEAM operations.

More specifically, this Implementation Plan addresses the following:

1. Updated wellbore design that incorporates the results of the current 2012 bit and coring systems study, and reduction of the risks associated with down hole problems.

2. Updated operational time and cost estimates based on the results of the current 2012 bit and coring systems study.

3. Identification of long lead time tangible items (marine drilling riser, down hole tubulars).

4. Identification of necessary pre-operations technical improvement studies, and their impact on overall project time and cost (ultra-deep water drilling riser design, drilling string design, met-ocean and current surveys, geo-hazard surveys, high-temperature down hole tool specifications, high-temperature drilling fluid system and measurement design).

5. Identification of the key project decision points, how those key decisions fit in the BEAM critical path, and their overall impact on BEAM time and cost (i.e. site selection, science plan, pre-operations studies).

6. Development of an integrated BEAM Program timeline - showing these key tasks, milestones, and operations implementation.

7. Specifically for marine riser system, conduct detail study for individual drilling candidate sites (water depth, 3,650m, 4,050m, and 4,300m).

Because this effort builds on the previous two studies that Blade has conducted, a summary of the key aspects of the Initial Feasibility Study and the High Impact Systems study are included in this report. Three different wellbore configurations are provided that attempt to account for the uncertainties in the down hole conditions. Revised estimates for the operational time and cost were prepared for the different wellbore configuration options and two different scientific drilling options for each of the candidate locations. This effort included a probabilistic evaluation to gain an understanding of the possible range of time and cost given the uncertainty with drill/core bit performance and rate of penetration. The operational time and cost estimates are substantially lower than what was initially developed for the feasibility study. The issues around the marine drilling riser were evaluated again and an updated riser analysis is provided as well as a summary of the pros and cons of the different material options. Finally, a project implementation timeline was developed that is based around the well planning approach used for complex deepwater projects in the oil and gas industry and assuming that the BEAM project would begin in January 2018.

Again, the results of this project show that scientific drilling to the mantle is feasible. While there are no shortage of technical issues that will need to be resolved, there are existing solutions to most of them based on current practices in the deepwater drilling industry and the continued evolution of technology as the industry pushes into deeper water and more complex and harsh down hole environments.

2 Project Background

This project builds on previous work done by Blade Energy Partners in 2011 and 2012 which in turn builds on work that IODP had already done in a series of workshops that investigated the technical issues associated with scientific drilling to the mantle. In 2011 Blade conducted a high-level study to look at the overall feasibility of drilling to the mantle. In 2012 Blade conducted an additional study to identify and investigate equipment and services that could substantially decrease drilling time and risk drilling to mantle. An overview of the results of these first two studies is provided below because some familiarity with these studies will be useful for understanding the results of this project.

For reference, the titles of the initial studies are as follows:

1. *Project Mohole Initial Feasibility Study For 2017 Drillin*g; Revision 4, 11 June, 2012
2. *High Impact Systems (Rock Bits, Coring & More) Technical Review & Risk Reduction Study for the BEAM - Borehole into Earth's Mantle, Mantle Quest Drilling Project*; Revision 3, 4 February, 2013

2.1 Feasibility Study Overview - 2011

IODP requested that Blade conduct a high-level study investigating the feasibility of the MoHole Drilling Project.

The objectives of this study were as follows.

- New technologies which need to be implemented on the IODP drillship Chikyu that are expected to be available now or with enough time before 2017 to prepare for their use.
- Investigate the sensitivity to success and cost relative to the primary operational variables at IODP's three candidate sites.
- Investigate the primary scientific coring methods (whole 'full' coring vs. spot coring vs. no coring).
- Provide a recommendation of the most efficient and most viable first order operational implementation plan for (various levels of scientific) success.
- Provide an estimate of the total cost of the complete project scoping and well design study following feedback from IODP on the results of this Initial Feasibility Study.

The study focused on what would be required for planning, drilling and coring a mantle hole from one of three candidate locations in Pacific Ocean and to identify some of the critical issues since, to date, no wells have been drilled with the combined extreme conditions of deep water (±4000 meters) and high temperature formations (±200-250°C). The main challenges discussed in the study were as follows:

- Drilling with riser in ultra-deepwater environments with water depths around 4000 meters, which will set a new world record.

- Drilling and coring in very high temperature igneous rocks with bottom-hole temperatures that are estimated to be as high as 250°C, which will also set a new world record.

- Drilling and coring a very deep hole with a total drilled and/or cored interval around 6000 meters in the oceanic crust below the Pacific Ocean seafloor in order to reach the upper mantle.

The key constraints for this project versus ‘normal’ offshore operations are the extreme water depths where drilling and coring operations need to be conducted, the extreme high temperatures present in very hard igneous rocks that push the limit of all the drilling and coring tools, and special procedures that are routinely used in less demanding environments.

The study reviewed and compared different marine drilling riser options and subsea equipment that are currently available in the ultra-deepwater industry and showed that the Chikyu could conduct drilling and coring operations through the deep seawater column with some component upgrades or modifications. The study also investigated the current state-of-the-art drilling and coring methods and instruments for high temperature igneous rocks, and current limitations and design efforts that would be needed to reach the mantle. Finally, a base case wellbore configuration was developed and preliminary estimates were made of the amount of time it would take to drill/core to the mantle and how much it would cost.

The study concluded that offshore drilling and coring are mature technologies and many commercial tools are currently available from several industries (oil and gas, mining, and aerospace). However, to reach extreme depths in the oceanic crust, while drilling and coring in very hard hot rocks and operating in ultra-deep water, require the use of the most recent tools and techniques. In addition, technologies and techniques are continuously advancing and can be expected to continue to close the gap between what is required for the ‘Mohole Project’ and what is currently possible.

The results of the study showed that drilling/coring a scientific hole into the upper mantle is certainly feasible, and there are existing solutions to many of the technological challenges based on work being done in the oilfield and geothermal industries. In fact, a hole could be drilled "today" at the Hawaii location because it has the lowest bottom-hole temperature of the three candidate locations.

The key conclusions from the study were:

1. There are existing solutions to the riser design issues.

2. There are existing solutions to the drill-string design issues.

3. A key issue would be the development of down hole tools capable of withstanding the extreme down hole temperatures.

4. A key issue would be the development of bits with improved bit life since this will have a huge impact on the operational cost and also improved core techniques that could result in faster coring rate.

The following sections summarize of some of the key topics that were addressed in the study.

2.1.1 Candidate Locations

Three potential well-site locations are being considered as shown in the following map.

- Location A - Cocos Plate: this area encompasses a region of the Cocos Plate off Central America from Guatemala to northern Costa Rica and is the location of the 1256D site.

- Location B – Baja: this area encompasses a region of the eastern Pacific plate located off Baja / Southern California.

- Location C - Hawaii: this area is located off the northeastern cost of Oahu.

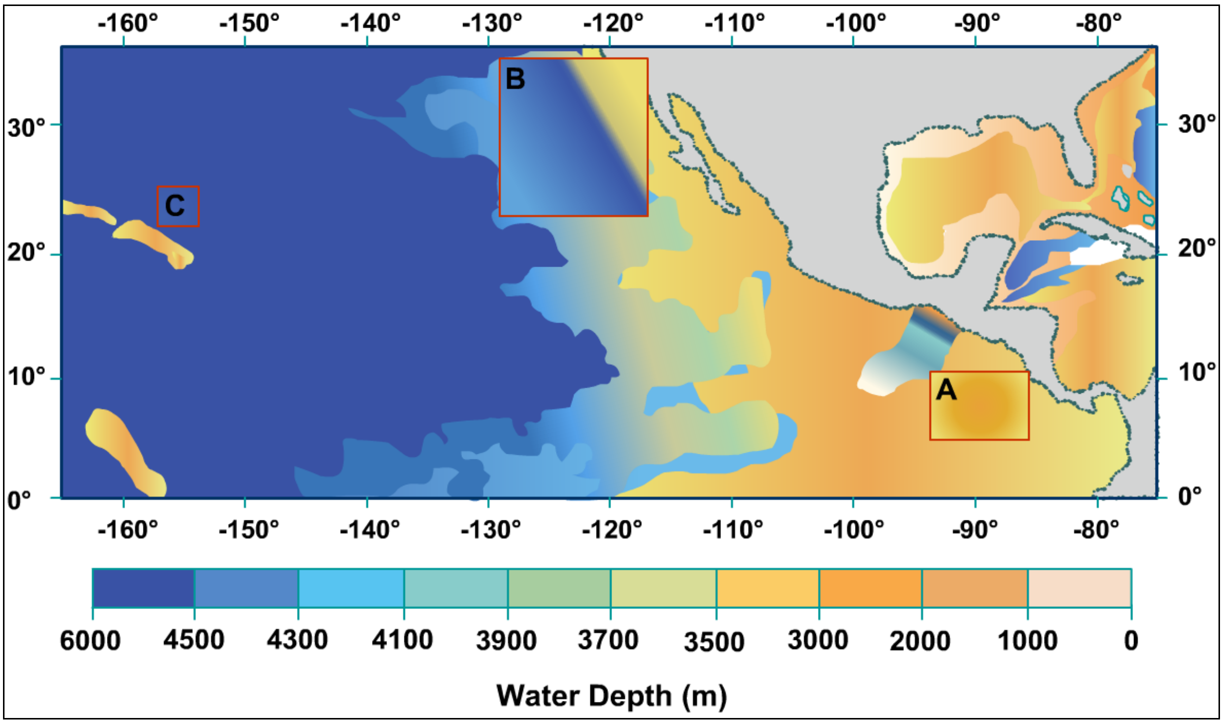


Figure 1. Bathymetric Map of Candidate Well Site Locations

	Location A: Cocos Plate		Location B: Baja California		Location C: Hawaii	
	This Area Encompasses a region of the Cocos Plate off Central America from Guatemala to Northern Costa Rica.		This Area Encompasses a region of the Eastern Pacific Plate Located off Baja/ Southen California.		This Area is Located off the Northeastern Cost of Oahu.	
Water Depth :	3,650m	11,975ft	4,300m	14,108 ft	4,050m	13,287ft
Penetration(bsf) :	6,250m	20,505ft	6,100m	20,013 ft	6,700m	21,982 ft
Total Depth (brf) :	9,900m	32,480ft	10,400m	34,121 ft	10,750m	35,269 ft
Crustal Age :	15 - 19 Ma	32,480ft	20 - 30 Ma		78 - 81 Ma	
Est. Moho Temperature:	≥ 250°C	482°F	200 - 250°C	392 - 482°F	±150°C	302°F
Sediment Thickness :	250-300m	820-984 ft	80 - 130°m	262-427 ft	±200m	392 ft
Latitude :	67-87°N		25 - 33°N		229 - 239°N	
Longitude :	89.5-91.9°W		120 - 127°W		154.5 - 155.8°W	
Analog Holes :	1256D		None		None	
Nearest Port :	Puerto de Caldera, Costa Rica, Port of Corinto, Nicaragua	±644 km (400 miles)	Long Beach, San Diego, Puerto de Ensenada Mexico	±800 - 1000km (500-620 miles)	Honolulu Harbor, Oahu	±400km (250m)

Advantages	shallowest Water Depth	Wide Water Depth Range	Lowest Moho Temperature
	Well Known Tectonics	Moderate Moho Temperature	Nearby Port Facilities
	Previous Expedition Experience		
Disadvantages	Highest Moho Temperature	Few Data Available	Deepest Total Depth
		Off Ridge Volcanism	Near Large Hotspot
		Deepest Water Depth	Arch Volcanism

Figure 2. Candidate Location Comparison

2.1.2 Marine Drilling Riser Analysis

Several different types of analysis were performed to assess the current limitations of the steel marine drilling riser which is onboard the Chikyu drilling vessel, and to investigate different riser design options, configurations and materials that could be viable options for operating in the expected ultra-deep water depths. For this preliminary analysis, the work was mainly focused on determining the required tension set by the drilling rig tensioning system and the loads seen by the marine drilling riser over the full column of seawater (between 3650 and 4300 meters) while the drilling riser is in a 'connected' mode (marine drilling riser is connected to the BOP with the LMRP). The different options that were investigated are listed below.

- Current Chikyu marine drilling riser
- Current Chikyu marine drilling riser bare joints with lighter buoyancy modules
- Titanium marine drilling riser
- Slim marine drilling riser
- Hybrid marine drilling riser
- Current Chikyu marine drilling riser with 2 more tensioners

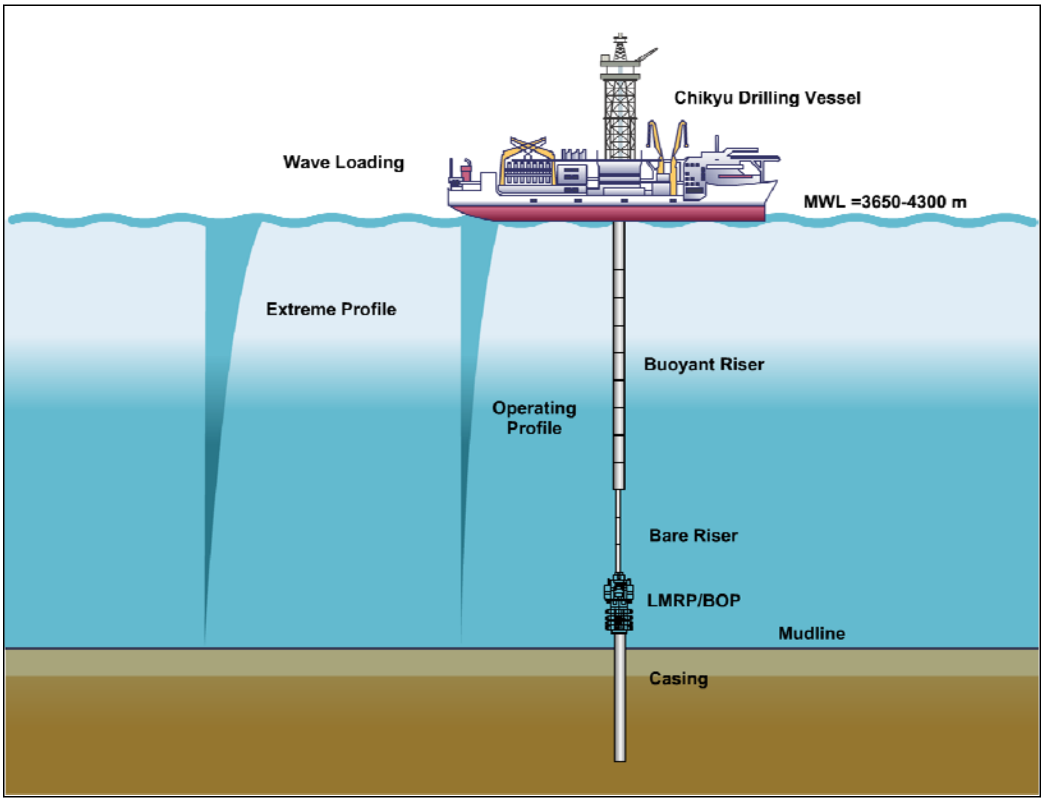


Figure 3. Marine Drilling Riser Configuration

The results of this work are summarized in the following below lists the limitations and benefits for each of the six drilling riser configurations that were analyzed. Mud weight value limits in specific gravity (S.G.) are provided, and "OK" means that a mud weight greater than 1.7 S.G. can be used with the drilling riser configuration at the noted location.

Water Depth	Maximum Fluid S.G.	Current Chiyu Drilling Riser	Steel Riser With Lighter Buoyency Modules	Titanium Riser	Slim Riser (16" OD)	Hybrid Riser (Steel + Titanium)	Current Chikyu Drilling Riser with 8 Tensioners
Water Depth (3650 m)-Cocos Plate	Maximum Drilling Fluid (S.G.) in Riser if 1 Tensioner is lost=	OK up to 1.3 SG	OK up to 1.45 SG	OK	OK	OK up to 1.55	OK
	Maximum Drilling Fluid (S.G.) in Riser if API Maximum Allowable (90%)=	OK up to 1.55 SG	OK	OK	OK	OK	OK
Water Depth (4050 m)- Hawaii	Maximum Drilling Fluid (S.G.) in Riser if 1 Tensioner is lost=	OK up to 1.2 SG	OK up to 1.35 SG	OK up to 1.65 SG	OK	OK up to 1.43	OK
	Maximum Drilling Fluid (S.G.) in Riser if API Maximum Allowable (90%)=	OK up to 1.45 SG	OK up to 1.65 SG	OK	OK	OK	OK
Water Depth (4300 m)- Baja California	Maximum Drilling Fluid (S.G.) in Riser if 1 Tensioner is lost=	Not OK	OK up to 1.2 SG	OK up to 1.55 SG	OK	OK up to 1.35	OK up to 1.55 SG
	Maximum Drilling Fluid (S.G.) in Riser if API Maximum Allowable (90%)=	Not OK	OK up to 1.45 SG	OK	OK	OK	OK

Figure 4. Summary of 6 Riser Options Analyzed for the 3 Locations

As is illustrated, existing technologies, components and materials available in the ultra-deepwater industry should enable the Chikyu drilling vessel to conduct offshore operations in water depths ranging between 3650 and 4300 meters off Baja, Cocos and Hawaii.

Note that some drilling riser options such as aluminum drilling riser and composite materials drilling riser were not analyzed because of their technology maturity and relative low interest for specific drilling riser applications. Therefore, at the time, reliable data could not be found to run detailed analyses.

To help comparing and ranking the different drilling riser options, three independent criteria were identified:

- Technology maturity ranging from "emerging" to "very mature"
- Capital cost ranging from "low" to "high"
- Easiness to design, construct and maintain the riser system option ranging from "easy/flexible" to "difficult"

In order to rank the marine drilling riser options, a Boston Square Matrix (BSM) which allows consistent ranking with the several criteria can be used. For this application, it includes capital cost on the "x" axis, easiness to design, construct, and maintain on the "y" axis, and technology maturity using four different circle sizes ranging from small for "emerging" to large for "very mature". The figure shown below ranks the different marine drilling riser options as of mid-2011. Current research and development programs and oil and gas operations field trials may cause these ranking to change in the future.

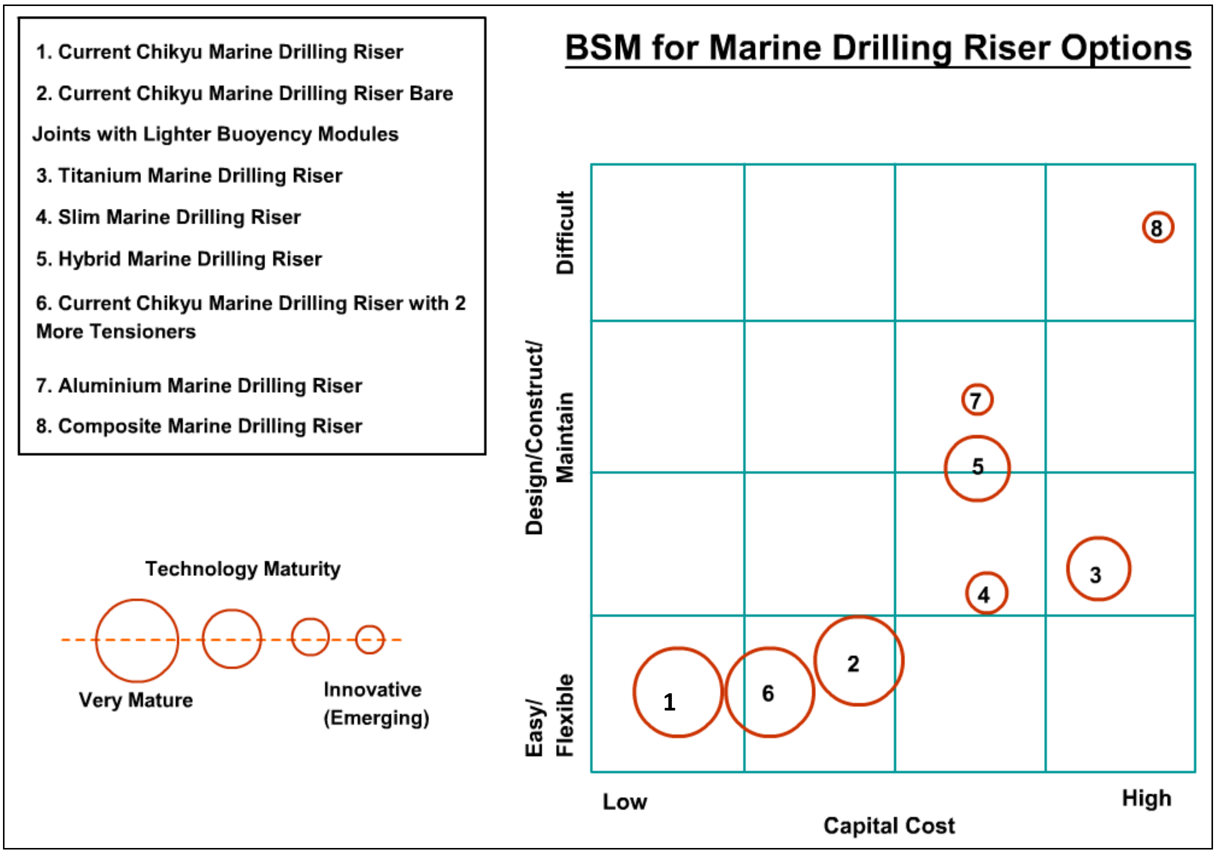


Figure 5. Boston Square Matrix Ranking of Riser Options

2.1.3 Well Design Assumptions

A key objective of this study was to investigate the operational time and cost implications of the main scientific coring methods being considered by the IODP such as continuous coring of the entire hole, long core intervals of key sections, or spot coring, as described in their 2011 Mohole workshop report. In order to do this, some assumptions had to be made about the fundamental down-hole conditions that impact the design of a well. It was recognized that most of the information about the down hole conditions is presently unknown. However, after discussions with the IODP, it was agreed that the assumptions discussed below are reasonable, or at least not unreasonable for the feasibility study work.

A cross-section showing the general stratigraphy / lithology that can be expected is shown below in Figure 6 which is based on information published by the IODP from their 2010 Mohole workshop report. The three main scientific coring methods (A, B and C) being considered are also shown. Note that a method D option was added which consists of drilling to the Moho and then just coring the Mantle to provide a comparison with method A.

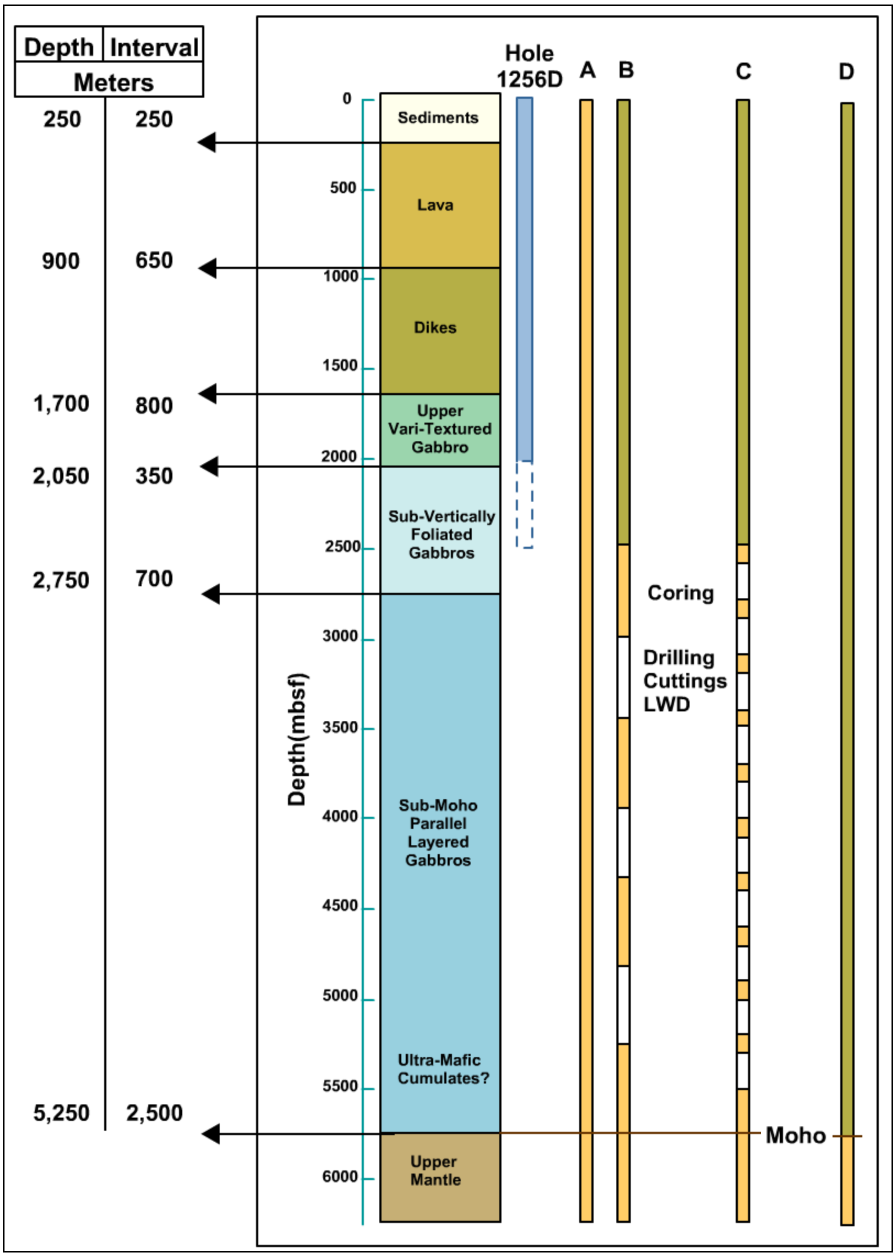


Figure 6. Assumed General Stratigraphy for the 3 Well Locations

From this, an assumed stratigraphic / lithologic column was developed for the three candidate locations as shown below.

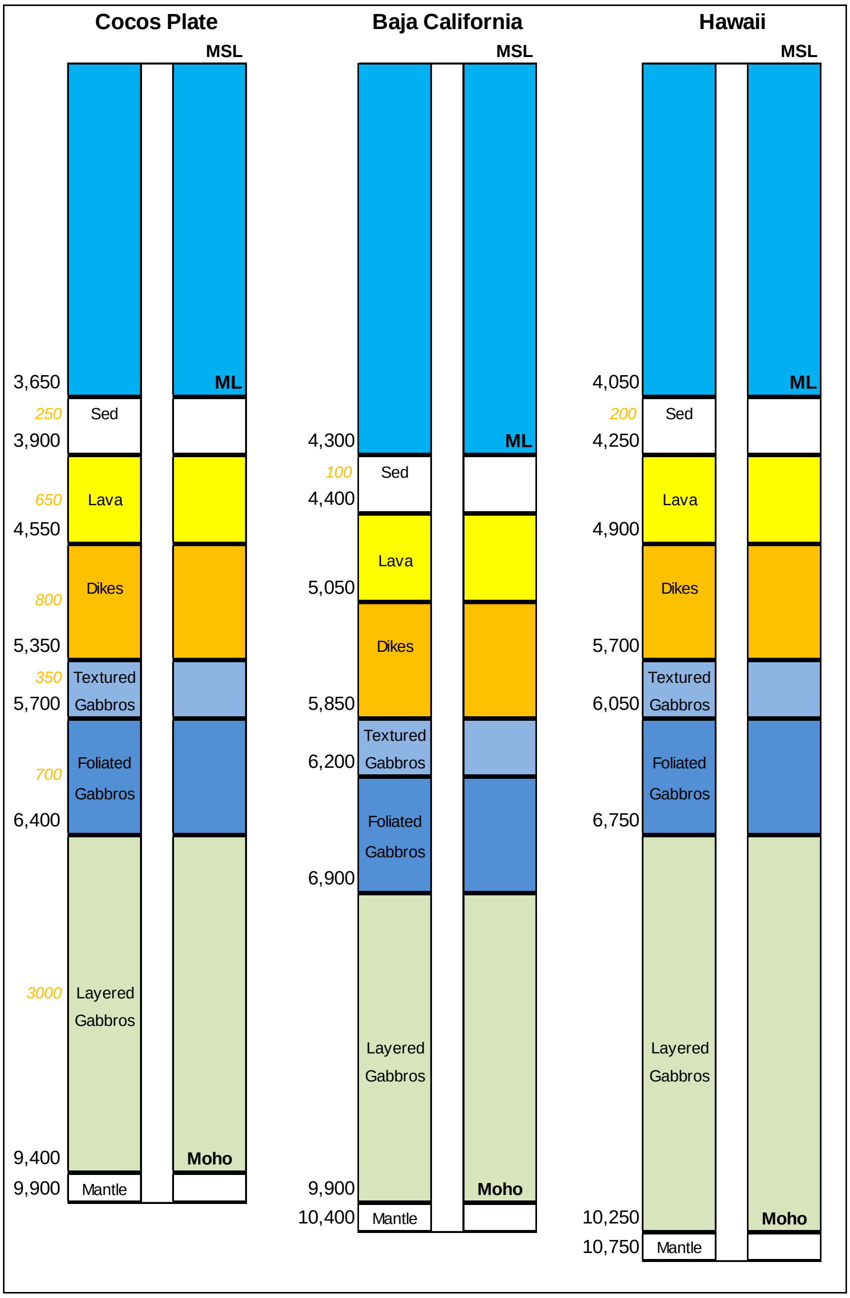


Figure 7. Assumed Lithological Column for Each Location

The assumed down hole temperature profiles for the candidate locations are shown below. The maximum bottom hole temperature (BHT) estimate is based on previous models of formation burial depth and age as provided by the IODP. The profiles are based on the water depth, available temperature measurements made during operations at the 1256D site, and the estimated BHT. The uncertainly in the BHT estimate is believed to be ±50°C. Therefore, a maximum expected temperature of 300°C was used for design and planning purposes.

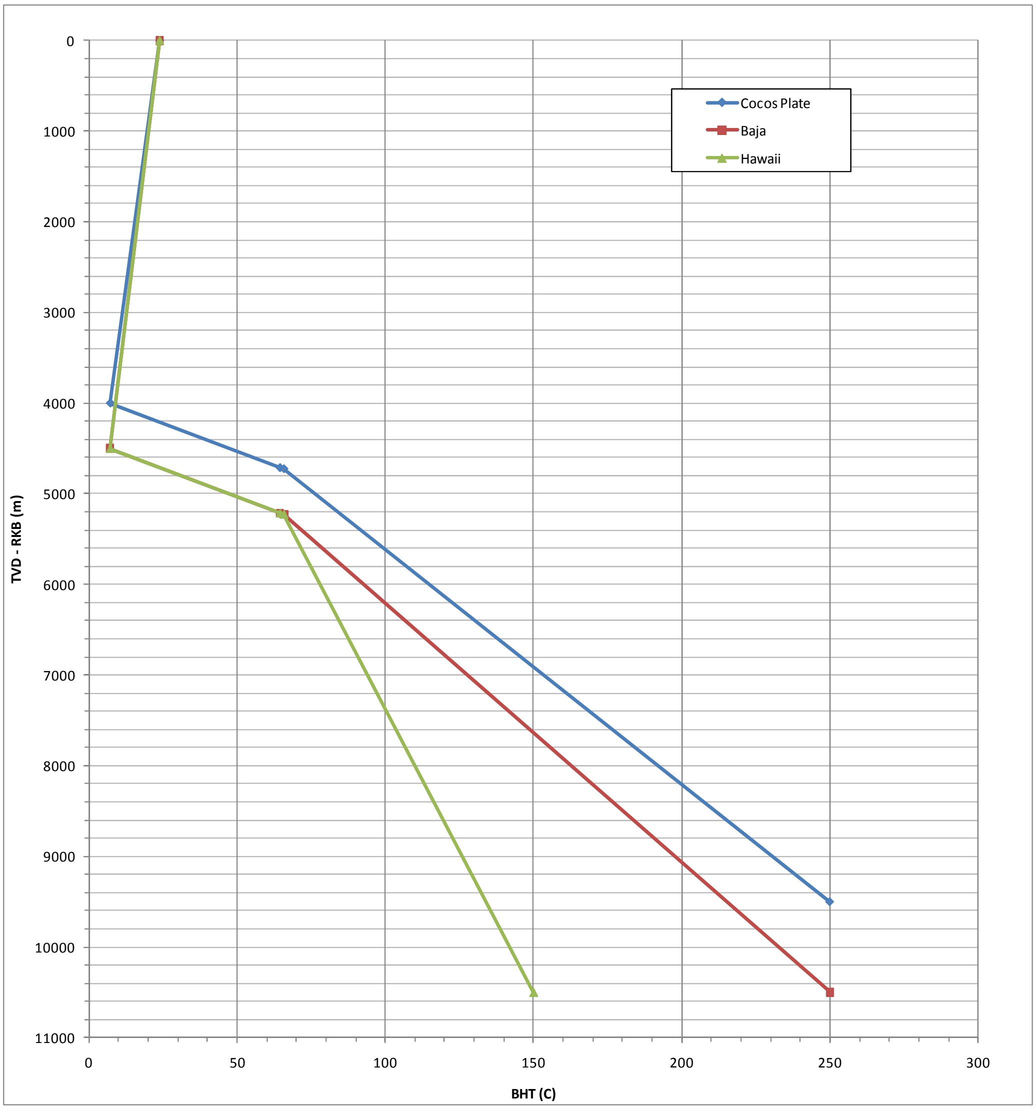


Figure 8. Assumed Geothermal Temperature Profiles

The wellbore is "unequivocally" expected to be normally pressured (1.03 SG / 8.66 ppge in oilfield units) to total depth. As such, the presence of abnormally pressured intervals, which is typically a critical design consideration, will not be an issue. Therefore, casing point selection will be done on the basis of wellbore stability. The figure below shows the assumed pore pressure (Pform), formation fracture (FG), and overburden gradients that were used for this study. The overburden gradient (OBG) is assumed to be 22.6 kPa/m (1.0 psi/ft) which is a common oilfield assumption for sedimentary basins and represents a conservative minimum case since the OBG in igneous rocks will be higher. The FG was then assumed to be 95% of the OBG.

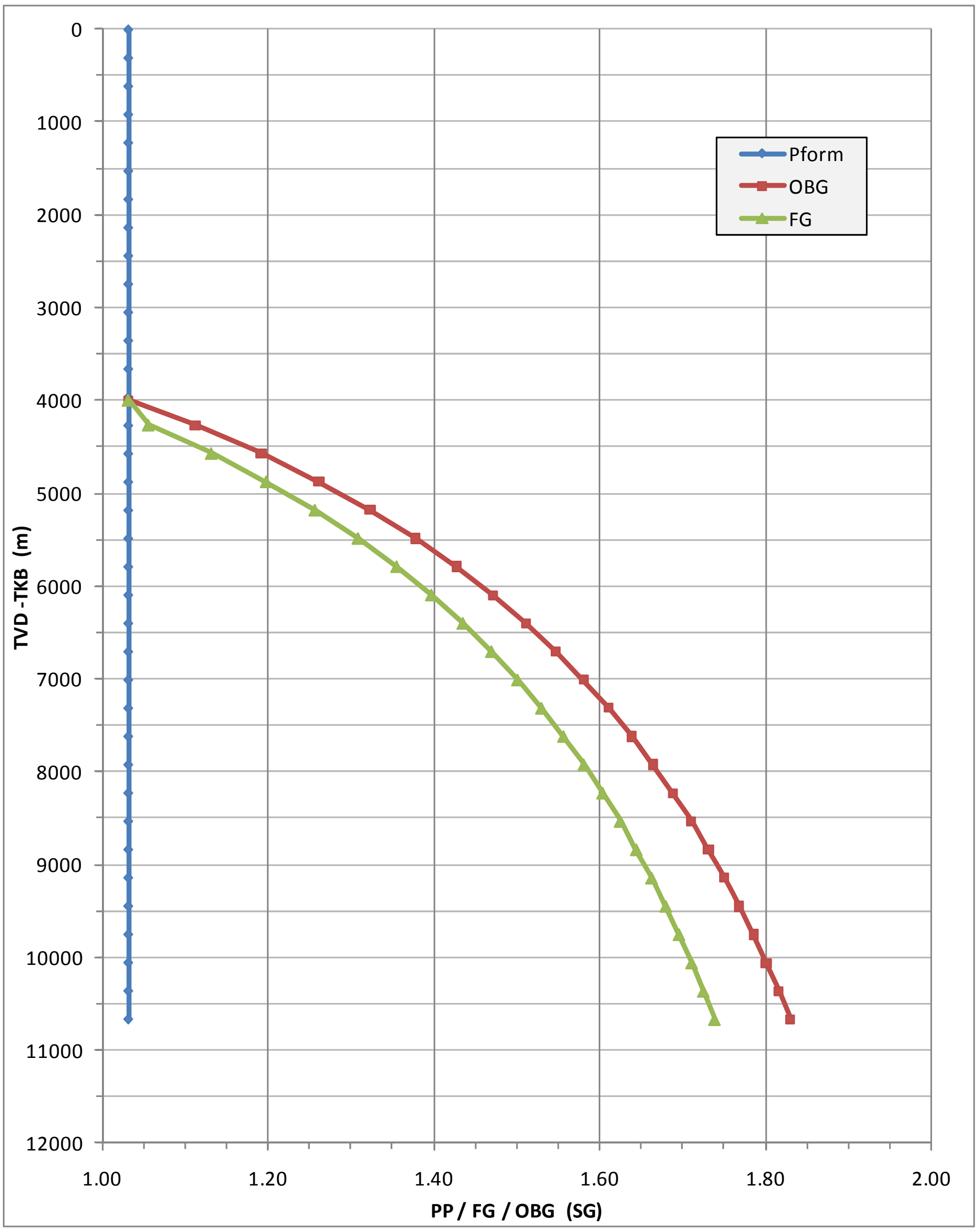


Figure 9. Assumed Down Hole Formation Pressure Profile

The other key assumptions that were used in developing the operational time and costs estimates are shown below.

- Coring and drilling rate of penetration (ROP) assumptions which were based largely on the experience at the 1256D site.

Stratigraphy	Coring	Drilling	
Sediments	3.0	15.2	m/hr
Lava	1.5	3.0	m/hr
Dikes	1.5	3.0	m/hr
Textured Gabbros	1.2	2.4	m/hr
Foliated Gabbros	1.2	2.4	m/hr
Layered Gabbros	0.9	1.5	m/hr
Mantle	0.9	0.0	m/hr

- An average bit life is 50 hours in the "upper" part of the well and 35 hours in the "lower" part of well was assumed.

- The bit trip time was assumed to be 305 m/hr (1,000 ft/hr) which is an oilfield rule of thumb and probably somewhat conservative for the Chikyu.

- The RCB wire-line trip time was estimated using the following historical data provided by IODP.

Depth (mBRT)	W/L Ops Time for One Core Barrel (hr)
4000	2.45
5000	3.05
6000	3.65
7000	4.25
8000	4.85
9000	5.45
10000	6.05

- Based on previous IODP experience, an average of 5% non-productive time (NPT) or trouble time is assumed to account for unexpected down-hole related problems when developing operational time estimates. This excludes weather or rig equipment related NPT.

2.1.4 Base Case Well Design Development

In most deepwater wells the presence of abnormal pressure is a fundamental criteria for determining casing points and the drilling mud density required to reach total depth (TD). Because abnormal pressure is not an issue for a Mantle well, the selection of casing points and mud weights will be based on wellbore stability considerations. In other words, a safe operating mud weight window needs to be defined that will offset the stress concentrations that are generated in the surrounding rock as it is drilled which can cause mechanical instability of the rock. If the mud weight is too low, the hole will essentially collapse due to a compressive shear failure in the rock. Too high a mud weight will cause lost circulation due to a tensile fracturing of the rock. The formation pressure estimate previously discussed was be used to provide some initial insight around possible mud weights that could be used and the selection of casing points.

In general, higher mud weights are needed to prevent the hole from collapsing so casing points need to be selected that maximize the fracture pressure of the formation allowing higher mud weights to be used. However a trade-off must be made between the allowable mud weights and the number of casing strings that are used. There are only so many casing strings that can fit in a well, and running multiple strings is time consuming, costly, and complicates the geometry of the well.

The casing points assumed for this study are shown in Figure 10. The basic logic is that the surface casing needs to be set near the base of the sediments in order to help provide structural support for the well. Furthermore, experience from IODP's operations on the 1256D hole has shown that the lava and dikes interval can be successfully drilled / cored with seawater so arguably, there is no need to set casing in this interval. Therefore, setting the second string of casing at the base of the dikes would allow the subsequent interval to be drilled with a higher mud weight. The depth needed for the next casing string is speculative, but arguably, at least a third string would be need to be set into the Layered Gabbros section in order to case off and protect the upper part of the hole, and to allow a higher mud weight to be used to reach the total depth (TD) of the hole.

Note that the point where the horizontal dashed lines intersect the FG curve represents the maximum allowable mud weight for the subsequent borehole interval. Exceeding this maximum would result in a risk of lost circulation, so the actual mud weight used to drill/core with would be somewhat less than the maximum.

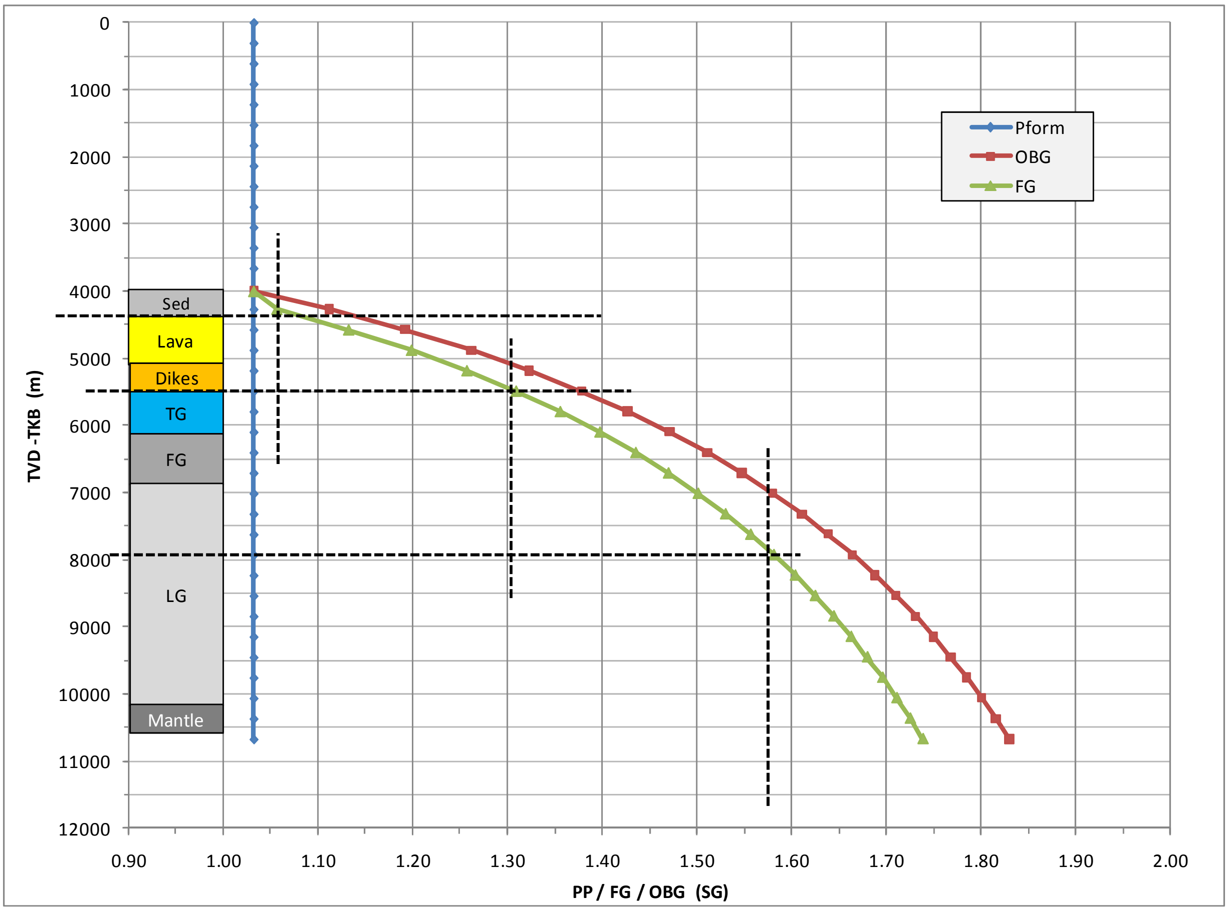


Figure 10. Casing Point Selection Assumption for the Base Case

While the casing points selected seemed reasonable at this stage, there are any number of permutations of casing points and mud weights. As such, the mud weight requirements are probably the single most important variable impacting the well design. Mud weight also has a significant impact on the riser design as was discussed previously

After selecting the casing points, a base case wellbore configuration was developed as shown below. Standard size casing diameters are used and the well is "TD'd" with a 9-7/8" hole size.

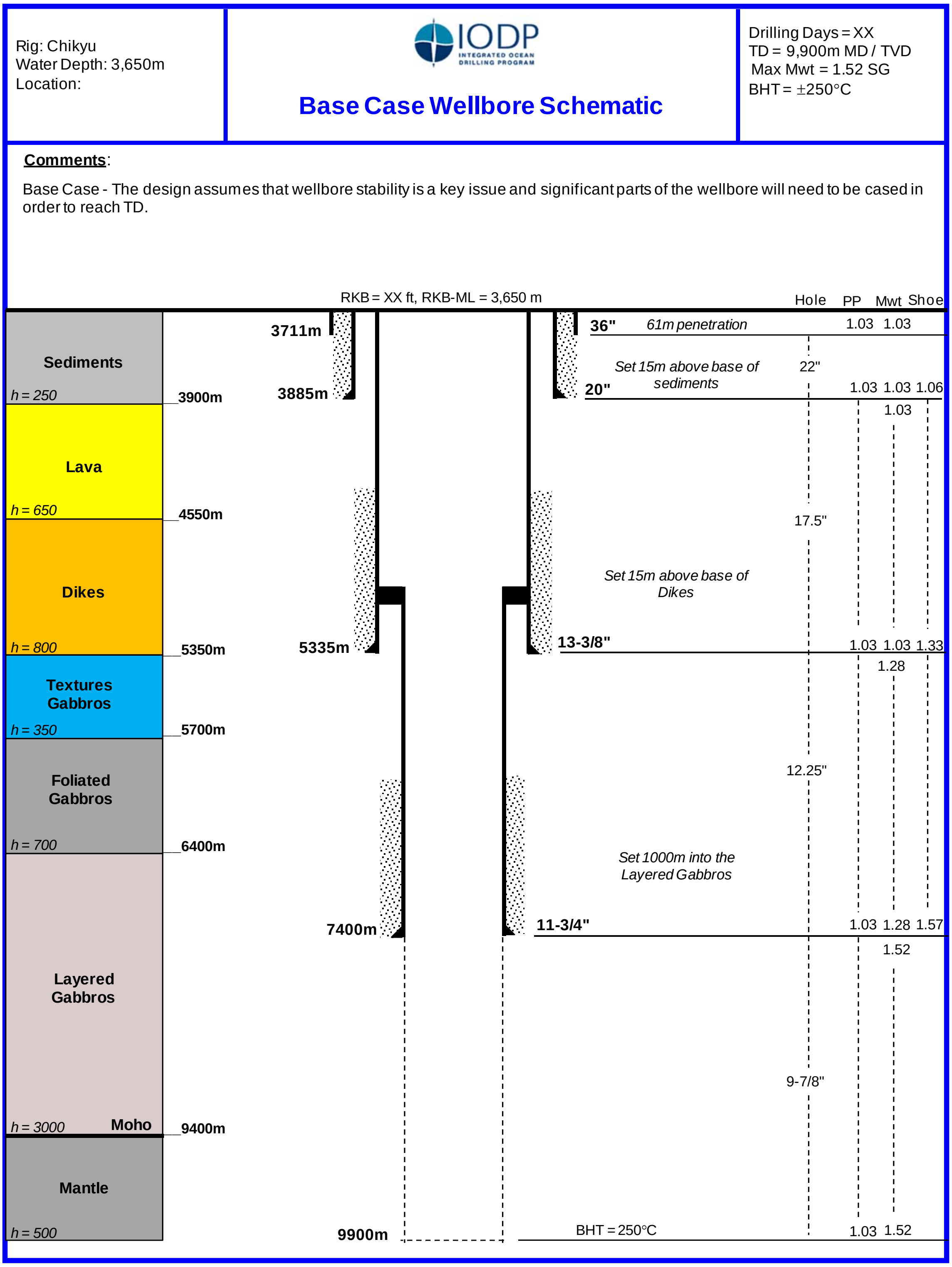


Figure 11. Base Case Wellbore Configuration

2.1.5 Operations Time and Cost Estimate

Operational time estimates for four different scientific drilling cases were developed for each of the candidate locations. The cases are similar to the IODP's options A, B and C as described in their 2011 Mohole workshop report.

- Case 1: Assumes that the hole is continuously cored to TD. This would be the ideal situation as it would maximize the amount of scientific information obtained from the hole. It is also the most expensive.

- Case 2: Assumes that long sections of continuous core are taken across the major lithologic and geophysical transition intervals of key sections. For the time estimate it was assumed that the upper third of each main stratigraphic interval was cored, the middle third was drilled and the lower third was cored.

- Case 3: Assumes that only spot coring is done during the last 10m of hole before each bit trip.

- Case 4: Assumes that the hole is drilled to the Moho and that the mantle is cored. This was done as a comparison to Case 1 since it represents the least expensive case.

The following table shows a summary of the operational time estimates for each of the 12 cases that were prepared.

Candidate Location	Water Depth	Total Depth	TD BSF	Operational Time (days)					Ops Time	Project Time
				Core/Drill	Bit Trip	W/L	Flat	NPT		
Cocos Location										
Case 1	3650	9900	6250	216	261	186	33	34	696	756
Case 2	3650	9900	6250	184	234	112	34	28	564	617
Case 3	3650	9900	6250	155	187	51	40	21	433	480
Case 4	3650	9900	6250	144	172	26	33	18	374	418
Baja Location										
Case 1	4300	10400	6100	236	300	238	33	40	807	866
Case 2	4300	10400	6100	197	259	147	38	32	642	693
Case 3	4300	10400	6100	157	160	58	31	20	405	445
Case 4	4300	10400	6100	143	183	27	33	19	386	425
Hawaii Location										
Case 1	4050	10750	6700	260	319	264	33	43	876	934
Case 2	4050	10750	6700	214	285	155	34	34	688	737
Case 3	4050	10750	6700	172	177	63	36	22	448	485
Case 4	4050	10750	6700	157	204	28	33	21	422	443

Figure 12. Initial Operational Time Estimates Summary for the 3 Locations

The order of magnitude costs for the various cases that were evaluated for the three candidate locations are shown in the table below. It was assumed that the intangible daily operating cost for a typical commercial drill-ship are $1 million/day. An estimate of the tangible cost which range between $7 to $10 million for a high-pressure deepwater well in the Gulf of Mexico requiring multiple casing strings were not considered for this study.

Candidate Location	Water Depth	Total Depth	TD BSF	Ops Time	Project Time	Project Cost
Cocos Location						
Case 1	3650	9900	6250	696	756	$756,000,000
Case 2	3650	9900	6250	564	617	$617,000,000
Case 3	3650	9900	6250	433	480	$480,000,000
Case 4	3650	9900	6250	374	418	$418,000,000
Baja Location						
Case 1	4300	10400	6100	807	866	$866,000,000
Case 2	4300	10400	6100	642	693	$693,000,000
Case 3	4300	10400	6100	405	445	$445,000,000
Case 4	4300	10400	6100	386	425	$425,000,000
Hawaii Location						
Case 1	4050	10750	6700	876	934	$934,000,000
Case 2	4050	10750	6700	688	737	$737,000,000
Case 3	4050	10750	6700	448	485	$485,000,000
Case 4	4050	10750	6700	422	443	$443,000,000

Figure 13. Project Cost for Each Case and Each Location

Note: For accounting purposes (depreciation and taxes), the cost for oil and gas wells are classified as being either intangible or tangible. Intangible costs are basically for non-salvageable items such as labor, drilling rig time, drilling fluids, services, etc. These costs, which are typically charged on a daily basis, account for some 70 to 80% of the total well cost. Tangible costs are basically salvageable items such as the wellhead and tubulars.

2.2 High Impact Systems Study Overview - 2012

In February 2012, IODP-MI requested that Blade conduct a study to identify and investigate equipment and services that could substantially decrease drilling time and risk when drilling to earth's mantle. The objectives of this study were to identify the original equipment manufacturers and service companies that provide rock drill bits and coring, and investigate the status of their technologies today, what technological improvements they may reveal for mantle quest application by 2017, and what suggestions they offer to accelerate technological development between now and 2017.

More specifically, the goals of study were to address the following:

- Review the mechanics of hard rock drilling.
- Identify current rock drill bit equipment and services.
- Investigate potential technological gaps and improvements that will enable rock drill bits to stay on-bottom longer, decreasing drilling time and risk.
- Identify current rock coring systems and services.
- Investigate possible development of new rock coring systems to improve the quality and quantity of cores recovered in order to satisfy the scientific objectives.
- Provide a recommendation of the most efficient and most viable drill bits and rock coring systems for a possible mantle drilling project start date in 2017-2018.
- Provide an estimate of how the designers, manufacturers, and service companies of such equipment and services may accelerate their technological offerings, including an estimate of the technological improvement costs to IODP and the scientific community.
- Identify additional high-impact equipment and services where technological improvements will also reduce project time and risks.

Blade had extensive discussions with 19 different service companies that provide a wide range of services to the oil and gas industry. The study investigated hard rock drilling failure mechanisms, and how hard rock drilling performance is optimized in the oil and gas business. This included discussions with the major oil and gas provider of bits, coring services, and down hole tools to evaluate the hard rock drilling and coring technology that currently exists within the oil and gas industry and to understand where and how the technology will be trending in the future. Discussions were also held with the various marine raiser manufacturers to investigate the various riser options in more detail.

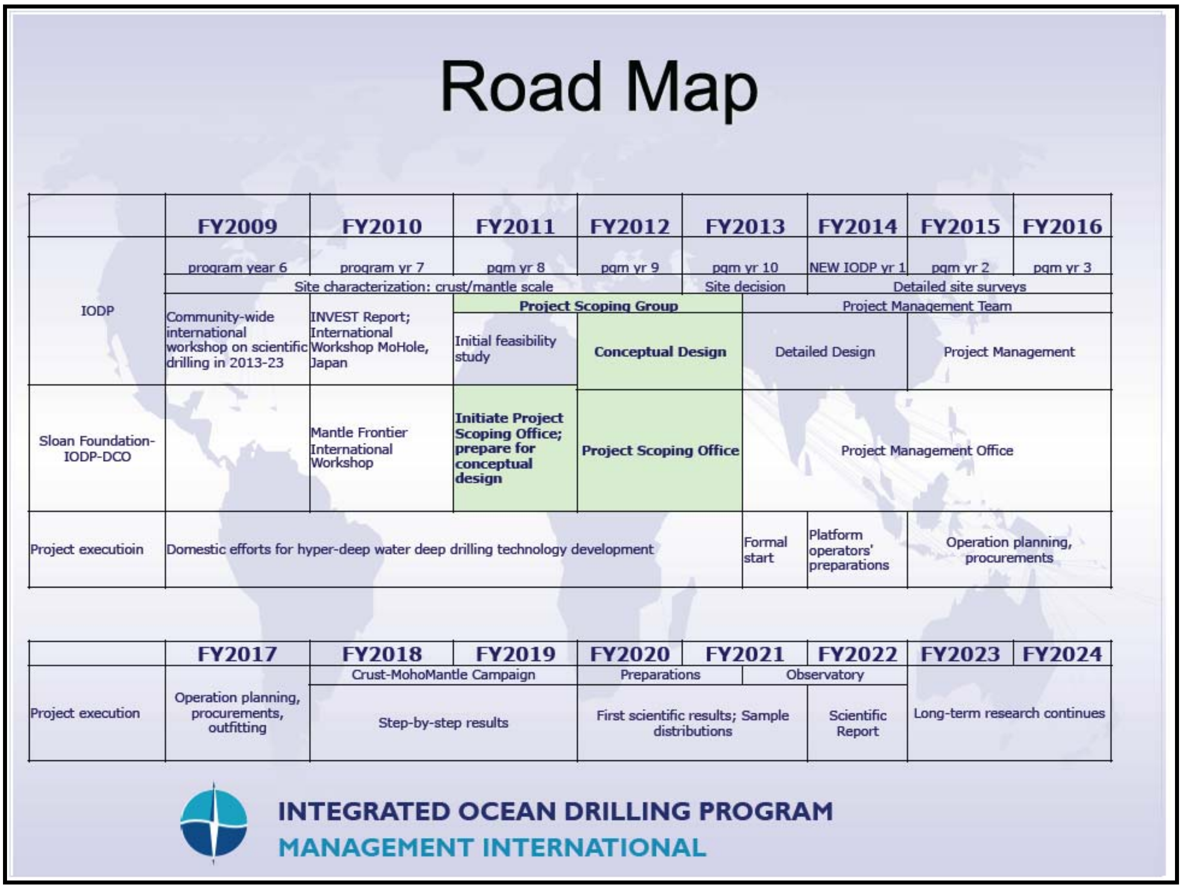


Figure 14. Mantle Project Road Map

The key conclusions and recommendations from this study were as follows.

- The major bit and coring system service providers have a great deal of experience with difficult hard rock drilling environments in the oil and gas industry. They currently all have products that could improve current IODP drilling performance. Perhaps more importantly, they all have the design, testing, manufacturing, analysis, and technical support capabilities needed to develop optimized solutions for difficult drilling conditions.

- It was not practical to recommend a specific bit type or coring system for a mantle hole mainly because optimizing performance is more than just selecting a bit. Optimizing performance requires a systems level approach that considers bit design, drill string mechanics, bottom hole assembly and drill string design, hydraulics, drilling fluids and so on. In addition, there are a variety of potentially viable options that need to be considered that, for example, range from conventional drilling, to using a bit and a down hole motor, to using a diamond impreg bit and a down hole turbine, and so on.

- Achieving success on a mantle hole will involve more than just selecting a promising looking bit and running it. It was felt that IODP should partner with 1 or 2 of these service companies in order to take advantage of the full range of experience and services they can provide during both the planning and operational phases of the project.

Blade further recommends that NOV be one the companies because they have the most familiarity and understanding of the technical issues and have expressed the most interest in the project.

- Working closely with a service company to develop an optimized solution to the mantle hole challenges can significantly reduce both the operational time and risk associated with the project.

The following sections summarize some of the key topics that were addressed in the study.

2.2.1 Review of Hard Rock O&G Drilling Services

The main focus of Blade's work for this project was to evaluate the hard rock drilling and coring technology that currently exists within the oil and gas industry and to understand where and how the technology will be trending in the future. Meetings were held with the major oil and gas service providers to introduce the BEAM project, get information about their current product offerings and their technical development efforts, and to identify their ability and willingness to provide technical support to the BEAM project. Meetings were held with the following service companies:

- National Oilwell Varco (NOV) who provides Reed and Hycalog bits
- Baker Hughes provides Hughes Christensen bits
- Halliburton who provides Security and DBS bits
- Schlumberger who provides Smith bits
- Ulterra who provides their own Ulterra bit product line

The key highlights from these meetings are as follows:

- All the companies were generally interested in the BEAM project, NOV and Ulterra in particular.
- Not surprisingly, each company also expressed concerns over "what's in it for me" to some degree.
- All the companies believe that they have current products that would improve performance by 30 to 50% compared to current scientific drilling practices and results.
- All the companies have active ongoing technology development programs that will result in new products on the market well before the nominal 2018 start date for the BEAM project.
- All the companies have extensive experience with hard rock, and high temperature drilling and coring applications within the oil and gas industry – including basalt.

A summary of the products and services that each of these service companies can provide is provided in the following table.

Capabilities	NOV	Baker Hughes	Halliburton	Schlumberger	Ulterra
Roller Cone Bits	Yes	Yes	Yes	Yes	No
Fixed Cutter Bits	Yes	Yes	Yes	Yes	Yes
Conventional Coring	Yes	Yes	Yes	Yes	No
Wireline Retrievable Coring	Yes	Yes	Yes	Yes	No
Down-Hole Tools	Yes	Yes	Yes	Yes	No
High-Temperature Tools	Yes	Yes	Yes	Yes	No
Hard Rock Drilling Experience	Yes	Yes	Yes	Yes	Yes
Hard Rock Coring Experience	Yes	Yes	Yes	Yes	No
Performance Modeling Software	Yes	Yes	Yes	Yes	Yes
Bit Testing/Development Facility	Yes	Yes	Yes	Yes	No

Figure 15 - Service Company Capability Summary

The overall results of Blade's investigations show that the major oil and gas industry bit and coring service providers have extensive hard rock experience that includes drilling in basalt. In addition, they currently offer products and services that would provide an improvement in bit and coring performance compared to current scientific drilling practices and results. It is also important to remember that drilling performance is more than just bit selection. Optimizing performance involves a systems view approach that includes the bit, the bottom hole assembly and drill string design, drilling parameters selection, drilling fluids system and so on. As such, these companies also have the technical expertise and support capabilities to develop custom drilling systems solutions to optimize drilling and coring performance.

Bit performance is characterized by the interaction between the bit design and the associated rock failure mechanism, type of rock being drilled, the bottom hole assembly (BHA) design, and the drilling practices being used (i.e. weight on bit, rotational speed, hydraulics, etc…). If one assumes that the optimum drilling practices are being utilized, then drilling efficiency becomes a function of the following bit performance characteristics.

- Durability – defined as the bit's ability to resist abrasive wear, teeth or cutter wear, body erosion, and thermal damage. Improving durability typically tends to reduce the bit's performance or rate of penetration.

- Stability – defined as the bit's ability to either resist or initiate BHA initiated lateral, torsional, and axial vibrations which can cause severe damage to the bit.

- Steerability – defined as the bit's tendency to drill in the desired direction, or conversely, the bit's tendency not to "walk" or deviate the direction of the wellbore in an undesired lateral direction, or cause an undesired deviation of the hole angle.

- Aggressivity – is defined as the rate of penetration (ROP) or how fast the bit drills based on the bit's response to an externally applied axial force, or the weight on bit (WOB).

Each of the parameters can be adjusted through modifications to the bit design. For example, stability and durability in a PDC bit can be improved with the addition of more blades. Vibration can be reduced by adjusting the number of cutters that are in contact with the formation at any one time. However, maximizing the effectiveness of one parameter can adversely impact the other parameters. For example, increasing the number of blades complicates the positioning of the nozzles which is critical for keeping the blades clean. Also, maximizing the bit's durability will usually reduce its performance or ROP.

The parameters are therefore interdependent from the standpoint that changing one parameter will impact the others sometimes unfavorably. The key to optimizing bit performance is the to determine which parameter(s) is the most important to achieve the goals of the hole interval to be drilled, and then to adjust the bit design to maximize that effectiveness of that parameter, while at the same time, minimizing the potential adverse effects on the other parameters.

As has been noted, the types of bits used today to drill hard rock formations are roller cone bits, diamond impregnated bit and PDC bits. Roller cone bits fail the rock through compression and generally have good steerability and aggressivity. However, high bit weights are needed to overcome the high compressive strengths found in hard rock formations. High bit weights and the rotation of the bit's cones can severely limit the life of the bearings, cause brittle fracture of the cutters, and result in an overall decrease in durability.

Diamond impregnated bits fail the rock by shearing a very fine layer of the formation which is known as "plowing", and generally have good steerability, durability, and stability. However, because only a fine layer of formation is cut at one time, these bits have a significantly lower ROP than the other two types. These bits are typically run with high RPM down-hole turbines in order to compensate for the low efficiency of the cutting elements and increase the ROP. However the inclusion of a turbine in the BHA increases the risk of an unplanned trip in the event of a failure of the turbine.

PDC bits fail the rock through shearing relatively large sections of the rock. This is the most efficient method of mechanically failing rock because the shear strength of the rock is roughly half of its compressive strength. However, PDC bits can have poor stability and be very susceptible to brittle fracture under high loads as well as thermal fatigue at high temperature when instability is present. In addition, their performance is sensitive to improper drilling practices. Conversely, the very nature of these bits allows a great deal of flexibility for adjusting or modifying the performance characteristics parameters so that the above limitations can be designed out of a particular PDC bit used for a particular application. With proper cutter selection, cutting structure design, torque control component design, and hydraulic design, PDC bits can provide the optimum balance between durability, stability, steerability and aggressivity thereby maximizing bit performance. It can be argued that roller cone and diamond impregnated bits need to be used only when a PDC cannot be properly designed.

2.2.2 Revised Operational Time Estimate

Based on the results of these discussions, which included NOV's unconfined compressive strength (UCS) testing on a core sample from 1256D, Blade was able to revise the mantle hole drilling time estimates that were initially provided in 2011 feasibility study to reflect what is possible using the technology currently available in the oil and gas industry.

From the UCS testing results and NOV's experience in drilling basalts and hard carbonate formations with UCS values greater than 50,000 ksi, NOV provided the following estimates of drilling penetration rates and bit life that would be ideally achievable for a mantle hole using a fixed cutter PDC bit and a PDC bit run on a down hole motor.

Hole Section	Rate of Penetration (ft/hr)		Rate of Penetration (m/hr)		Bit Life
	Ideal Bit	Ideal Bit/Motor	Ideal Bit	Ideal Bit/Motor	(hours)
Upper part of the hole :	70.0	100.0	21.3	30.5	110
Lower part of the hole :	50.0	70.0	15.2	21.3	70

Figure 16: Estimated Ideal ROP's Based on Current Technology

NOV further estimated that the coring penetration rates assumed in the 2011 feasibility study could be improved by around 30%. Note that these values are broadly consistent with the statements made by the other service companies.

In order to account for the uncertainties that remain about the drilling conditions in a mantle hole and the fact that more detailed work on the bit designs will be needed, Blade has used ROP values that are more conservative than the "ideal bit" values noted above. Despite this, the revised operational time estimates still demonstrate the significant improvement even relatively modest increases in ROP can have on the overall operational time. The bit life estimates provided by NOV were still used because there is less uncertainty around the durability of today's bits than what the actual ROP might be. A comparison between the revised ROP's used for this project compared to the ones used for the 2011 feasibility study is shown below.

Stratigraphy	2011 Feasibilty Study		2012 BEAM Project		
	Coring	Drilling	Coring	Drilling	
Sediments	3.0	15.2	4.0	21.3	m/hr
Lava	1.5	3.0	2.1	9.1	m/hr
Dikes	1.5	3.0	2.1	9.1	m/hr
Textured Gabbros	1.2	2.4	1.5	9.1	m/hr
Foliated Gabbros	1.2	2.4	1.5	3.0	m/hr
Layered Gabbros	0.9	1.5	1.2	3.0	m/hr
Mantle	0.9	0.0	1.2	0.0	m/hr
Upper Hole Bit Life	50 hours		110 hours		
Lower Hole Bit Life	35 hours		70 hours		

Figure 17: 2012 Operational ROP's Assumptions

Revised operational time estimate were done for Cases 2 and 4 for the Hawaii location since this location will require the most drilling/coring time. Cases 2 and 4 adequately illustrate the philosophical differences between the amounts of time spent coring versus time spent drilling.

The following table compares the operational time estimates from the two studies. The overall project includes the mobilization and demobilization to and from the location. Note the significant reduction in time using the revised estimates of ROP.

Location	Case	2011 Feasibity Study		2012 High Impact Study		Difference	
		Core/Drill	Project	Core/Drill	Project	Core/Drill	Project
Hawaii	2	688	737	460	497	228	240
	4	422	458	224	234	198	224

Figure 18. Operational Time Comparison 2011 vs. 2012 Study Results (days)

This difference is further illustrated in the following drilling curve comparison for the Case 4 example.

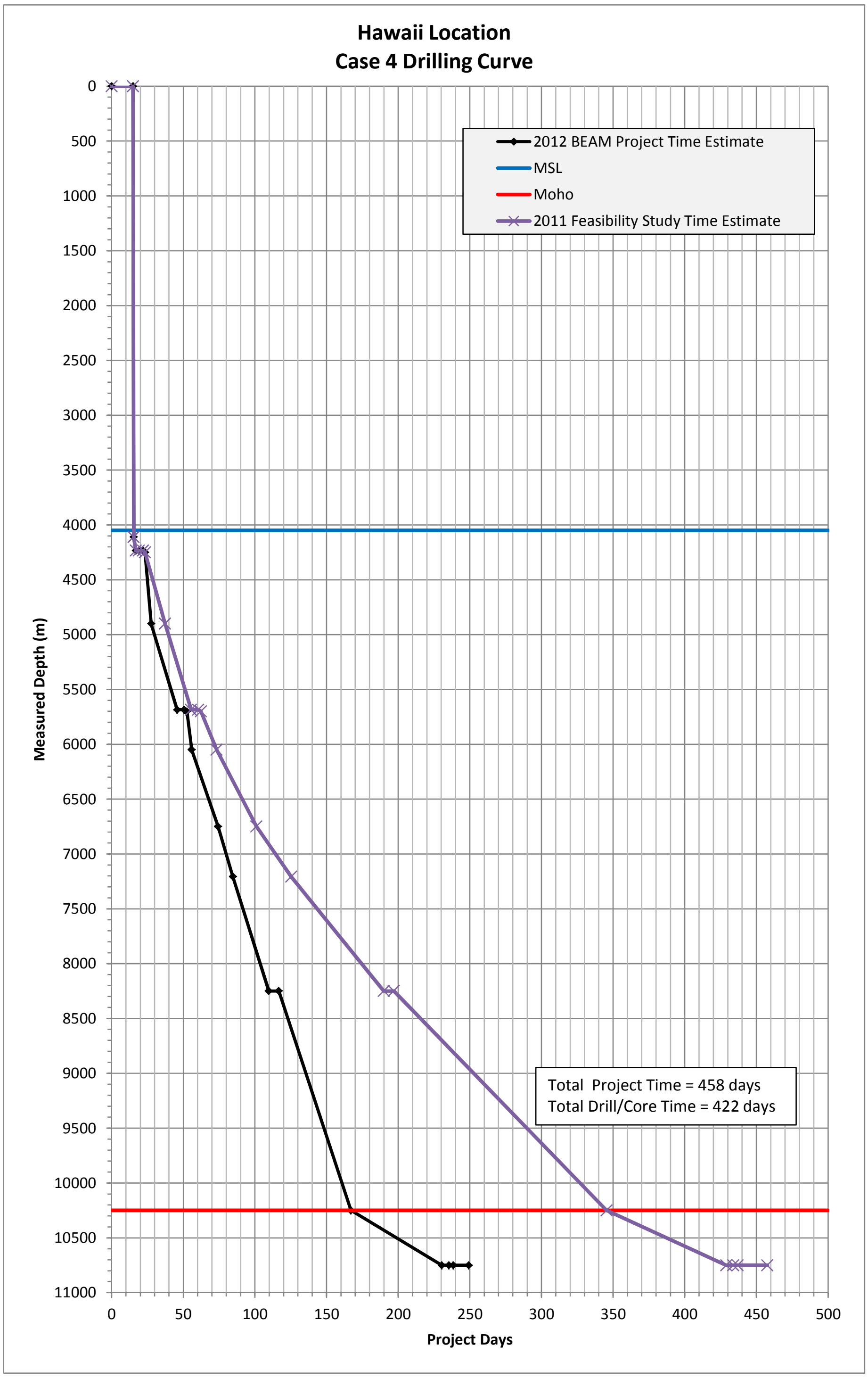


Figure 19. Case 4 Drilling Curve Comparison 2011 vs. 2012 Study Results

2.2.3 High Temperature Downhole Tools

Currently, the temperature rating for high temperature MWD and LWD tools is around 180°C (300°F). The bottom-hole temperature for Hawaii location is estimated to be around 150°C (300°F). The temperature at the other two locations are expected to be as high as 250°C (480°F). This exceeds the temperature ratings of most of the down hole tools that are presently commercially available. The industry is, however, focusing on developing tools with higher operating temperatures in response to trends towards drilling in higher temperature environments. The rate of improvement in down hole component temperature rating in the next 3-4 years may see a next generation of tools that are capable of operating in temperatures as high as 250°C.

Figure 20 shows Weatherford and Halliburton's current selection of high temperature tools. Figure 21 shows a list of high temperature tools that are currently under development.

.

	HIGH PRESSURE / TEMPERATURE TOOLS							
TOOL	9-1/2"		8-1/4"		6-3/4"		4-3/4"	
	Pressure (psi)	Temp (°F / °C)	Pressure (psi)	Temp (°F / °C)	Pressure (psi)	Temp (°F / °C)	Pressure (psi)	Temp (°F / °C)
RSS Systems	25,000	350°F 180°C	25,000	350°F 180°C	30,000	350°F 180°C	30,000	350°F 180°C
MWD / Pulser	25,000	350°F 180°C	25,000	350°F 180°C	30,000	350°F 180°C	30,000	350°F 180°C
Bore / Annular Pressure	25,000	350°F 180°C	25,000	350°F 180°C	30,000	350°F 180°C	30,000	350°F 180°C
Spectral Azimuthal Gamma Ray					20,000	330°F 165°C	20,000	330°F 165°C
Azimuthal Gamma Ray	25,000	350°F 180°C	25,000	330°F 165°C	30,000	350°F 180°C	30,000	350°F 180°C
Multi Frequency Resistivity	25,000	350°F 180°C	25,000	350°F 180°C	30,000	350°F 180°C	30,000	350°F 180°C
Azimuthal Density			25,000	330°F 165°C	30,000	330°F 165°C	30,000	330°F 165°C
Thermal Neutron Porosity			25,000	330°F 165°C	30,000	330°F 165°C	30,000	330°F 165°C
Sonic	25,000	330°F 165°C	25,000	330°F 165°C	30,000	330°F 165°C	30,000	330°F 165°C
Formation Pressure Tester			25,000	330°F 165°C	30,000	330°F 165°C	30,000	330°F 165°C

Figure 20. Current High Pressure / Temperature Down-hole Tool Ratings

TOOL	XHIGH PRESSURE / TEMPERATURE TOOLS			
	6-3/4"		4-3/4"	
	Pressure (psi)	Temp (°F / °C)	Pressure (psi)	Temp (°F / °C)
RSS Systems				
MWD / Pulser	30,000	375°F 190°C	30,000	440°F 230°C
Bore / Annular Pressure	30,000	375°F 190°C	30,000	375°F 190°C
Spectral Azimuthal Gamma Ray				
Azimuthal Gamma Ray	30,000	375°F 190°C	30,000	440°F 230°C
Multi Frequency Resistivity	30,000	390°F 200°C	25,000	390°F 200°C
Azimuthal Density	30,000	390°F 200°C	25,000	390°F 200°C
Thermal Neutron Porosity	30,000	390°F 200°C	25,000	390°F 200°C
Sonic				
Formation Pressure Tester				
True Vibration Monitor	30,000	375°F 190°C	30,000	375°F 190°C

Figure 21. High Temperature Tools Under Development

2.2.4 Marine Drilling Riser

High strength steel (i.e. 80 ksi) is currently the most widely used material for deepwater drilling and drilling riser systems. However, when drilling in water depths around 3,000m with relatively high drilling fluid densities (i.e. 1.7 to 2.1 SG), the technical limit of existing high strength riser systems commonly manufactured with 80 ksi steel material for the riser tube, auxiliary lines, and connectors is reached.

As water depths increase beyond 3,000m and the true vertical depth of borehole below the mudline increase beyond 4500m, the external pressure due to seawater and the internal pressure due to the mud weight required to balance the deep formation pressure that are acting on the marine drilling riser may become too large. Therefore stronger materials such as X-100 steel, or titanium or composite materials may be required. Also, since stronger drilling risers will often produce heavier risers (i.e. because of the increase in the main tube wall thickness), aluminum may also be considered as an alternative to be used for the design of auxiliary lines such as hydraulic, booster, choke, and kill lines thus reduce the overall weight of the drilling riser.

Nevertheless, even though both aluminum and titanium drilling risers have been already been developed and tested, they have rarely been applied but still show great potential. Moreover, as of today, composite materials have still not been tested or field deployed for deepwater drilling riser but has already had success for smaller diameter (i.e. 5.0 to 8.0 inches) production risers in the North Sea. Therefore, it is believed that, at least, for auxiliary lines, and because of high strength and weight saving associated with carbon fiber or carbon epoxy, composite materials may be a cost-effective solution for ultra-deepwater marine drilling riser systems. The following figure shows the different riser configurations that may be suitable for ultra-deepwater operations.

	MATERIALS THAT MAY BE USED FOR MARINE DRILLING RISERS			
CONFIG	RISER MAIN TUBE	CHOKE AND KILL LINES	BOOSTER LINE	HYDRAULIC LINE
Config #1	Steel	Steel	Steel	Steel
Config #2	Aluminum	Aluminum	Aluminum	Aluminum
Config #3	Titanium	Titanium	Titanium	Titanium
Config #4	Steel	Aluminum	Aluminum	Aluminum
Config #5	Steel	Steel	Aluminum	Aluminum
Config #6	Steel	Titanium	Titanium	Titanium
Config #7	Steel	Titanium	Steel	Steel
Config #8	Steel	Carbon Fiber	Carbon Fiber	Carbon Fiber
Config #9	Steel / Carbon Fiber	Steel	Steel	Steel

Figure 22. Possible Riser Configurations for Ultra-Deepwater Operations

Figure 23 shows the advantages and drawbacks of all the riser options that are either currently available to the ultra-deepwater drilling industry or at a conceptual stage development within service companies or material science department in universities.

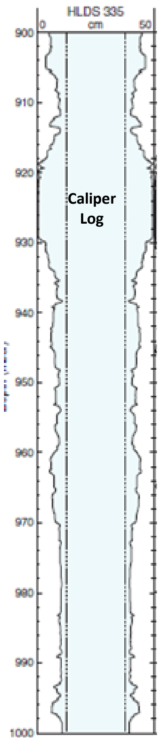
	MATERIALS THAT MAY BE USED FOR MARINE DRILLING RISERS	
CONFIG	PROS	CONS
Config #1	Easy to Design and Construct	Limited to about 10,000 feet Water Depth
	Technology is Very Mature	
	Relatively Low Capital Cost	
Config #2	Can Drilled Through Ultra-deep Waters	Medium Capital Cost
		Potential Corrosion and Strength Issues
		More Difficult to Design and Construct
		Technology is Just Mature
Config #3	Can Significantly Push the Limits (> 15,000 feet)	High Capital Cost
	Can Withstand High Loads and Rough Environments	More Difficult to Design and Construct
		Technology is Emerging
Config #4	Lower Capital Cost Than Full Aluminum Riser	More Difficult to Design and Construct
	Can Push the Limits (> 12,000 feet)	Technology is at a Conceptual Level
Config #5	Lower Capital Cost Than Full Aluminum Riser	More Difficult to Design and Construct
	Can Push the Limits (> 12,000 feet)	Technology is at a Conceptual Level
Config #6	Lower Capital Cost Than Full Titanium Riser	More Difficult to Design and Construct
	Can Significantly Push the Limits (> 12,000 feet)	Technology is also at a Conceptual Level
Config #7	Lower Capital Cost Than Full Titanium Riser	More Difficult to Design and Construct
	Can Significantly Push the Limits (> 12,000 feet)	Technology is also at a Conceptual Level
Config #8	Lower Capital Cost Than Other Hybrid Solutions	Very Difficult to Design and Construct
	Can Significantly Push the Limits (> 12,000 feet)	Technology is also at a Conceptual Level
Config #9	Lowest Capital Cost Than Other Hybrid Solutions	Very Difficult to Design and Construct
	Can Significantly Push the Limits (> 12,000 feet)	Technology is also at a Conceptual Level

Figure 23. Riser Configuration Options Pros and Cons

3 Wellbore Design Revisited

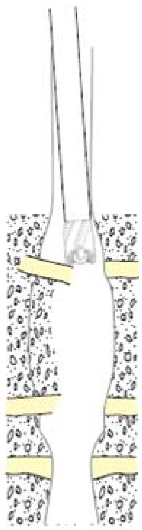
In retrospect, it would seem that the Base Case wellbore configuration developed during the Feasibility Study may be overly optimistic in terms of the number of casing strings that may be needed to get to TD.

In April 2011, Expedition 335 at the 1256D Cocos Plate site had problems reentering the hole due to a washed out interval and associated ledges at around 920 mbsf. The problems included excessive drag, high torque, and 3 incidents of stuck pipe. A cement plug had to be set across the washed out section to stabilize the hole. It took 16 days to resolve the problems before being able to get back to bottom at 1,507 mbsf which took up a significant part of the time allocated for the expedition. A summary of these events is provided below.



Expedition 335 Operations — 12 Apr to 1 June, 2011

Report Date	Days	Depth mbrf	Depth mbsf	MW (ppg)	m per Day	Hrs Drlg	Avg ROP	Hole Size	Expedition 335 Operations Summary
19-Apr-11	1	4,570.4	925.0	8.6	0	-	-	9-7/8"	Arrive location. Position rig. PU bit (Smith F9) and BHA. TIH, Re-enter hole. TIH, tag at 925 mbsf. Work pipe f/920-925 mbsf
20-Apr-11	2	4,568.4	923.0	8.6	0	-	-	9-7/8"	Cont work pipe on ledge. Erratic torque. W&R f/891.5-923.0 mbsf. Work stuck pipe. Pump 600 bbls total of hi-vis pills
21-Apr-11	3	4,568.7	923.3	8.6	0	-	-	9-7/8"	Cont work pipe to 923.3 mbsf. Unable to get deeper. Pump 150 bbl hi-vis pill. POOH for more aggressive bit. PU new bit (Reed 517) and 2 JB, and TIH
22-Apr-11	4	4,565.4	920.0	8.6	0	-	-	9-7/8"	Cont TIH. W&R from 892.1. Att to work past bridge at ~920 mbsf. Work stuck pipe. Pump 150 bbl hi-vis pill. POOH
23-Apr-11	5	4,567.4	922.0	8.6	0	-	-	9-7/8"	Fin POOH. Exp 312 logs show washed out section f/920-935 mbsf. TIH w/ cementing BHA to 922 mbsf. M&P 5 bbls 16# cmt. POOH
24-Apr-11	6	4,567.4	922.0	8.6	0	-	-	9-7/8"	Fin POOH. PU bit (Atlas HP61) and BHA and TIH. Tag bridge at 922 mbsf - no cmt. Att to W&R thru bridge. POOH
25-Apr-11	7	4,567.4	922.0	8.6	0	-	-	9-7/8"	Fin POOH. PU cementing BHA. TIH to 922 mbsf. M&P 50 bbls of 15 ppg cmt. POOH
26-Apr-11	8	4,567.4	922.0	8.6	0	-	-	9-7/8"	Fin POOH. PU bit (Atlas HP61) and BHA with 2 JB and TIH. Tag cmt at 882 mbsf. Drill cmt to 922 mbsf. Pumping hi-vis sweeps.
27-Apr-11	9	4,567.4	922.0	8.6	0	-	-	9-7/8"	Cont to W&R at 922 mbsf. Work stuck pipe. Cont W&R, pumping hi-vis pills
28-Apr-11	10	4,567.4	922.0	8.6	0	-	-	9-7/8"	Cont W&R at 922 mbsf. POOH. PU new bit (Smith Q7JS-735) and TIH.
29-Apr-11	11	4,586.9	941.5	8.6	0	-	-	9-7/8"	Fin TIH to 861.4. W&R to 921.9 mbsf. Tag obstruction. Cont W&R to 941.5 mbsf. Pump 100 bbl hi-vis sweep
30-Apr-11	12	5,009.3	1,363.9	8.6	0	-	-	9-7/8"	Cont W&R to 1143.2 mbsf. Had hi-torq and pump press increase. PU to 1113.6 mbsf, pump 50 bbl hi-vis pill. W&R to 1162.4 mbsf. Work stuck pipe. W&R to 1363.9 mbsg.
1-May-11	13	5,152.8	1,507.4	8.6	0	-	-	9-7/8"	Cont to W&R to bottom at 1507.1 mbsf. Had 6m of hard fill. Pump 100 bbl hi-vis sweep. POOH to 890.5 mbsf. RIH to 967.3 mbsf with no drag. Spot 60 bbls 10.5 ppg mud. POOH.
2-May-11	14	5,152.8	1,507.4	8.6	0	-	-	9-7/8"	Fin POOH. PU cementing BHA. TIH to 960.5 mbsf. M&P 60 bbls 15# cement. POOH
3-May-11	15	4,587.9	942.5	8.6	0	-	-	9-7/8"	Fin POOH. PU RCB assy (C-9 CB). TIH and tag at 924.0 mbsf. Cut cement cores to 942.5 mbsf
4-May-11	16	5,152.5	1,507.1	8.6	0	-	-	9-7/8"	Cont coring cement to 980.9 mbsf. Drop wash barrel and wash to bottom at 1507.1 mbsf. Hole tight from 1499.6 to 1501.1. Pump 50 bbl hi-vis sweep.
5-May-11	17	5,163.6	1,518.2	8.6	10.8	11.4	0.95	9-7/8"	Cont coring from 1507.1 to 1518.2 mbsf (new formation)



Affect of Ledges

Figure 24. Expedition 335: Summary of Reentry Problems

This type of hole stability problem suggests that the wellbore configuration needs to be able to accommodate additional contingency casing strings to allow for unexpected wellbore stability problems. The 1256D hole has been deepened to 1,522 mbsf, so if the kind of problems noted above can occur in the upper part of the hole, one must assume that they can also occur deeper in the hole. Additional strings may therefore be needed to case off problematic hole sections, and it would likely be prudent to be able to case off and protect sections of the hole that have been successfully cored/drilled in order to prevent the occurrence of stability problems that may evolve over time. The objective of incorporating additional casing strings into the wellbore configuration would therefore be to reduce the risk of not getting to TD by providing the means to react to wellbore stability problems or by preventing their occurrence.

The original Base Case wellbore configuration consisted of three casing strings: 20" set at the base of the sediments, 13-3/8" set at the base of the Dikes, and 11-3/4" set at about a third of the way into the layered gabbros. As such, only one casing string is set in the roughly 5,000m interval between the base of the dikes and the mantle. If, for example, the 11-3/4" string has to be set high because of down hole problems the risk of not getting to the mantle is higher because the length of the open hole below the 11-3/4" is larger. There are also a limited number of contingency casing options available to fit inside the 11-3/4" in the event that there are additional problems later in the hole and another casing string (or strings) is required.

3.1 Wellbore Configuration Options

As discussed above, it is clear that a mantle wellbore configuration should include a robust contingency design. However, at this stage, it is still difficult to define the exact number of casing strings that would be needed and where they should be set. Nevertheless, there are oilfield wells that require 6-8 casing strings to reach TD that can be used as a guide. Two examples are provided below that are intended to serve as a basis for further discussion.

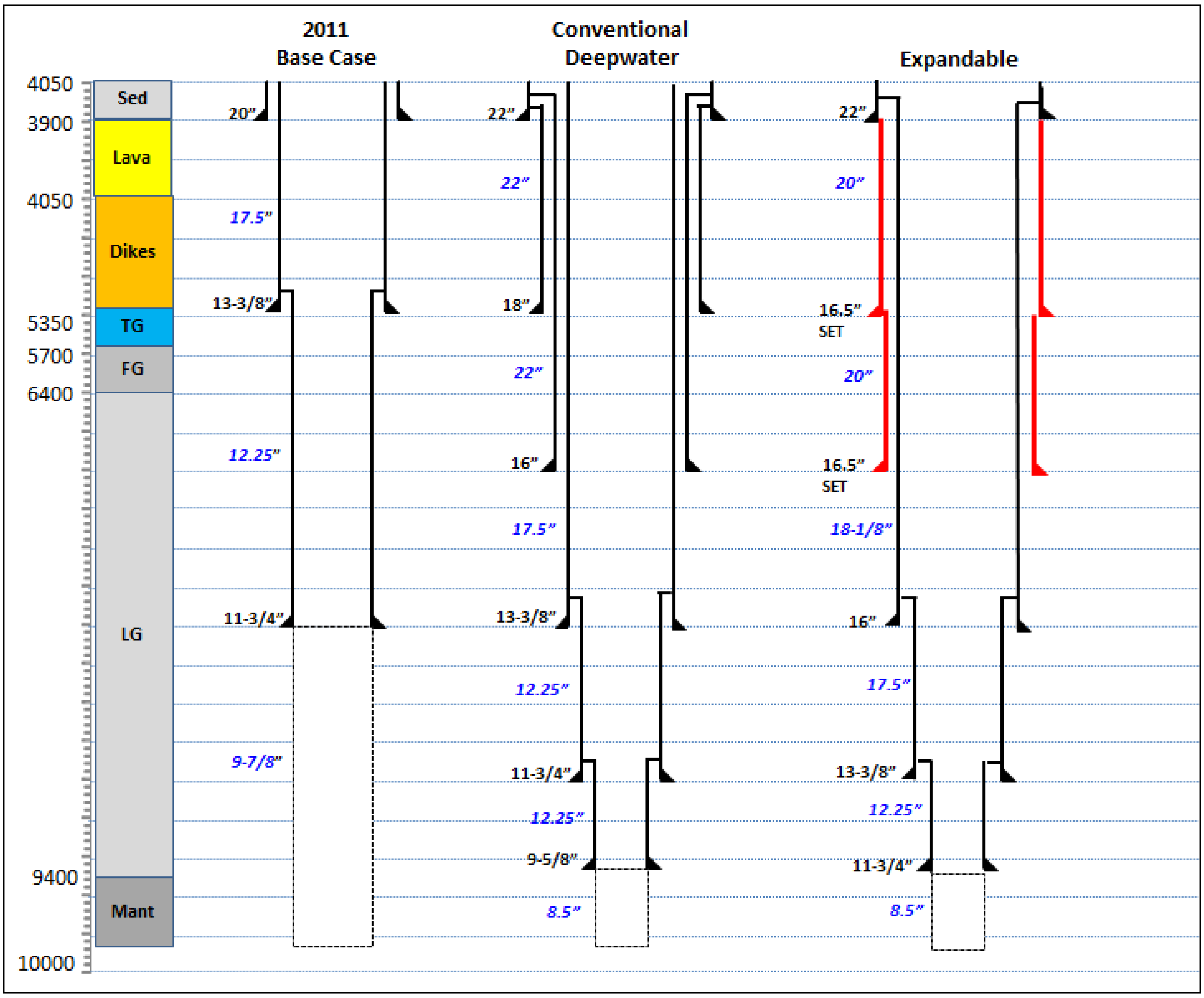


Figure 25. Multi-String Wellbore Configuration Options

Because of the telescoping nature of well designs, planning a well for multiple casing strings means that the large diameter strings run at the top of the hole must be set deeper than is normally the case. This allows the subsequent intermediate strings also to be set progressively deeper in the hole as is illustrated in the "Conventional Deepwater" and "Expandable" options in Figure 25.

The Conventional Deepwater option has a 6 string casing program that is commonly used today in deepwater Gulf of Mexico oil and gas wells. Note that running the 22", 18" and 16" strings in the upper part of the hole allows the 13-3/8" to be pushed to the 11-3/4" casing point in the Base Case design, which in turn allows the 11-3/4" to be set deeper in the layered gabbros interval. Note also that this configuration allows large portion of the hole to be cased off.

The Expandable option is a variation of the Deepwater option except that it uses solid expandable tubulars (SET) in the upper part of the hole to allow even larger hole sizes deeper in the hole which in turn allows larger diameter casing strings to be run deeper in the hole. Note, for example, that this option uses "nested" 16.5" diameter expandables which allows the 13-3/8" to be set where the 11-3/4" is set on the Deepwater option.

Expandable casing has been used in the oil and gas industry since late 1999 to mitigate the impact of unexpected hole problems. It involves running a special type of casing in the hole and cementing it conventionally, after which the internal diameter (ID) is expanded out to almost the internal diameter of the previous casing string. This allows a larger hole to be drilled below the expandable than would otherwise be the case if a conventional string had been run. For example, when the first 16.5" SET from Figure 25 is run in the hole it has a OD of 16" and an ID of 15.010". After expansion, the ID is increased to 17.125" and the OD to 18.188".

New developments in expandables have improved the reliability, and increased the applicable uses of this technology. For example, large diameter tubulars have been developed for applications higher in the wellbore (as shown above), and expandables are now being developed in diameters ranging from 3.5” to 20”. The three major companies currently providing this technology are Baker Hughes, Weatherford, and particularly Enventure.

The most prevalent expansion process involves running an expansion cone and launcher at the bottom of the casing. After the string is run and cemented, a plug is pumped down the casing, past the cone, and latches in the launcher. The volume below the cone, within the casing, and sealed by the plug is then pressurized. The pressure drives the cone upward, expanding the casing. The cone is also pulled axially; this steadies the process, enables extra force to be applied in case of a stuck cone, and allows mechanical expansion in the rare event that pressure is lost due to the casing splitting or connection failure. The seal between the expandable casing and the previous casing is provided by a series of elastomeric seals that isolate the annular space between the two strings. Enventure's elastomers are currently rated at 224°C (435°F) and they are currently developing ones rated to 232°C (450°F).

Another expandable technology that is currently available is the "Open Hole Clad System". This system is designed to isolate and seal off specific problematic sections of the wellbore. This involves drilling through the problem section and then running a length of expandable casing that covers just the problem area. Anchor joints are run on either end of the casing which is then expanded against the sides of the open hole with the anchor joints providing the seal. The clad system is another contingency option that may be beneficial for the mantle hole because it isolates a particular problem interval and does not require the entire open hole section to be cased off.

Revised wellbore schematics were developed for each of the 3 configuration cases for each of the 3 locations. As with the feasibility study, it was assumed that casing would be set at the base of the sediments and at the base of the dikes. Since the deeper casing points are speculative at this point, the distance between the Moho and the dikes was divided into equal intervals based on the number of casing strings that are available, and it was assumed that a casing string would be set at the base of each interval. These revised wellbore schematics are provided in Sections 3.3 to 3.5.

3.1.1 Wellbore Configuration Pros and Cons

The main pros and cons of each of the options shown in Figure 25 are as follows:

<u>Base Case</u>

- Pros:
  - It is a simple 3 string design using standard casing sizes and hole sizes.
  - It is the least expensive option.
  - It is the ideal option if the chances of having wellbore stability problems can somehow be ruled out.
- Cons:
  - It provides the least flexibility for reacting to unexpected hole problems
  - It allows for only two contingency strings. For example, if another casing string is needed below the 11-3/4", or the 11-3/4" has to be set high and another casing string(s) is required deeper in the hole, the contingency options are 9-5/8" and 7.0" casing.
  - The risk of not being able to get to TD is higher.

<u>Conventional Deepwater Case</u>

- Pros:
  - It allows for significant parts of the hole to be cased off since it involves running 6 strings instead of 3.
  - It provides increased flexibility in the event of unexpected hole problems.
  - A 7.0" contingency option is still available below the 9-5/8".
  - The risk of not being able to get to TD is reduced.
- Cons:
  - It requires non-standard casing sizes and non-standard hole sizes. Bit selection will be more complicated and hole opening tools (concentric reamers, hole openers) will be needed. Note, for example, the 13-3/8" casing is typically run in a 17.5" hole which is larger than the 16" casing previously run. Therefore the 13-3/8" interval would be drilled with a bit that fits inside the 16", but that another hole opening tool would need to be run to open the hole below the 16" out to 17.5". However, although the casing and bits are non-standard, wells having this kind of configuration are routinely drilled in the Gulf of Mexico, and the required tools and techniques have been developed to become de facto standards. So while the design issues are more complicated, they are not insurmountable.

  - Clearances are tighter and casing strings are heavier. Again these are not insurmountable problems or ones that exceed the capabilities of the Chikyu.
  - The costs will be higher in terms of the higher tangible costs and the time required to run all of the casing strings.

<u>Expandable Case</u>

- Pros:
  - The pros are basically the same as those for the Deepwater Case.
  - 9-5/8" and 7.0" contingency strings are still available below the 11-3/4" and therefore this case offers the maximum amount of flexibility in the event of unexpected problems by allowing 8 strings of casing to be run compared to 7 or 5.
- Cons:
  - Likewise, the cons are basically the same as this for the Deepwater Case.
  - The cost of the expandable casing is higher than that of conventional casing.
  - Expandable casing has a low collapse rating which can be problematic in an oil and gas well, but should be less of an issue in a mantle hole because the design loads will be much lower.
  - There is an added risk dealing with the expandables. The installation process is more complicated and although the chance of failure is relatively low, there still is a chance which doesn't exist with conventional casing.

3.2 Risk Discussion

It is important to realize that the wellbore configuration options discussed above are not necessarily the only options. They do however represent the extremes. The Base Case represents the most simple configuration and arguably most risky in terms of being able to get to TD and accomplish the goals of the project. The Expandable Case represents the most complex/expensive but least risky option in terms of being able to get to TD. As was the case with the initial feasibility study, the intent here is to show that there are existing solutions to the technical issues associated with a mantle hole, and to provide a foundation for further discussion and design work.

Although there are a multitude of technical issues and their associated risks that will need to be studied and addressed, there are arguably two main risks that impact the entire project. The first is the overall uncertainty with respect to the down hole conditions which impacts the ability to actually get to the mantle. The second involves time and cost which impacts the ability to accomplish the objectives within a reasonable cost and within a reasonable amount of time.

- <u>Down hole conditions uncertainty</u>:
  Developing an effective well design involves accounting for and designing around the expected down hole conditions such as stratigraphy, lithology, formation pressure, temperature, the existence of unstable zones or zones prone to lost circulation, etc., and then building in a degree of flexibility to deal with unexpected problems. These issues dictate the mud weight requirements, the number of casing strings needed, what size the casing needs to be, and where they need to be set. Setting casing in the wrong places or not being able to set them in the right places will severely jeopardize the ability to

accomplish the objectives of any well. The obvious problem here is that no one has ever drilled a hole to the mantle, and the down hole conditions won't be known until it is done. For example, discussions with Geomechanical International (GMI) identified some of the risks which will need to be addressed in order to develop the final wellbore configuration:

- No Overpressure Assumption – Are we Sure?
  - *Could fluids trapped in fractures or cavities in mafic igneous rocks be over pressured due to stress or other thermal processes?*

- Wellbore Instability Risk
  - *Shear failure if stress concentration exceeds rock strength*
  - *Failure of naturally fractured rock*
  - *Failure of induced fractures due to cooling*

- Lost Circulation Risk
  - *Hydraulic Fracturing if Mud Weight exceeds Fracture Gradient*
  - *Losses into natural and/or induced fractures*

- Creeping Risk
  - *Hole closure due to creeping rocks under high temperature and pressure*

- Fault Reactivation Risk
  - *Hole deformation due to reactivation of pre-existing faults*

This does not, however, mean that the risks cannot be mitigated and managed. Mitigating these risks will require a concerted joint effort between the science community, industry subject matter experts, and the well design engineers to define the most likely down hole conditions that can be expected, and which aspects have the most uncertainty. The results of this effort can then serve as the basis for developing an appropriate wellbore configuration.

- Time and cost uncertainty:
  The time required to drill a mantle hole must fall within the limits of the Chikyu's yearly scientific drilling vs. commercial endeavor schedule, and the cost of the project must be "reasonable". Preliminary estimates of the time and cost for a Mantle hole were developed during the feasibility study and were based largely on data from the 1256D location expeditions. The estimated time ranged from 400 to 900 days at a cost between $400 to $900 million, which are arguably not reasonable. The High Impact System study in 2012 looked at current and trending bit technology to determine if the drilling time could be reduced. It was concluded that the major oilfield bit and coring system service providers have a great deal of experience with difficult hard rock drilling environments, and the time required to drill a mantle hole could be significantly reduced by incorporating the bit selection and design practices currently being used in oil and gas industry.

  As will be discussed in Section 5, the number of days needed to drill the hole has the biggest impact on the cost of the mantle hole, and the other cost components are almost insignificant by comparison. The number of days is in turn effected by uncertainties around bit performance and rate of penetration. These uncertainties can be reduced by partnering with 1 or 2 of these service companies in order to take advantage of the full range of experience and services they can provide during both the planning and operational phases of the project in order to optimize the bit selection and drilling practices.

3.3 Cocos Location Wellbore Diagrams

3.3.1 Base Case Wellbore Configuration:

Below is the Base Case wellbore schematic for a hole drilled at the Cocos location.

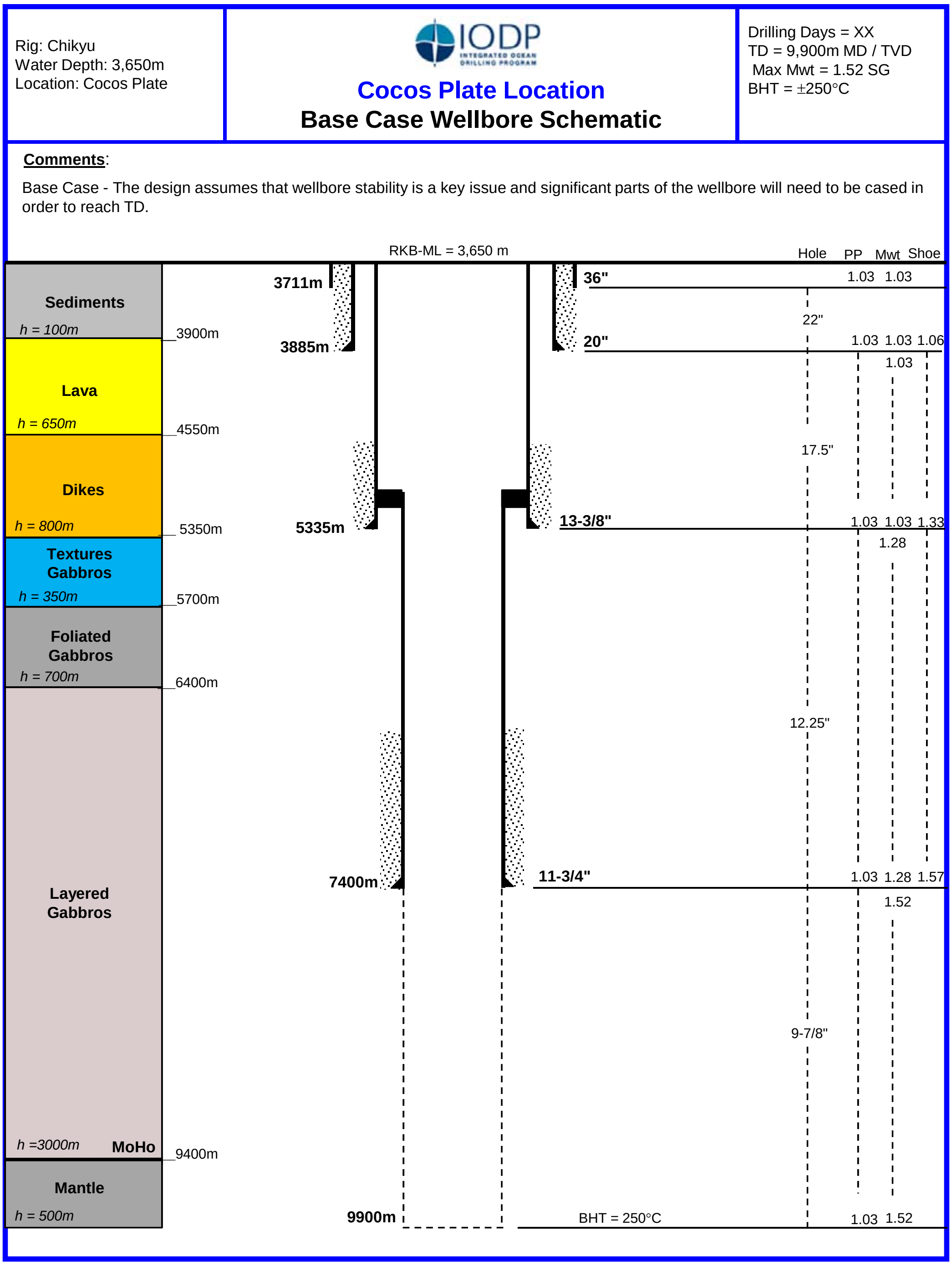


Figure 26 - Cocos Location Well Configuration – Base Case

3.3.2 *Deepwater Wellbore Configuration:*

Below is the Deepwater Case wellbore schematic for a hole drilled at the Cocos location.

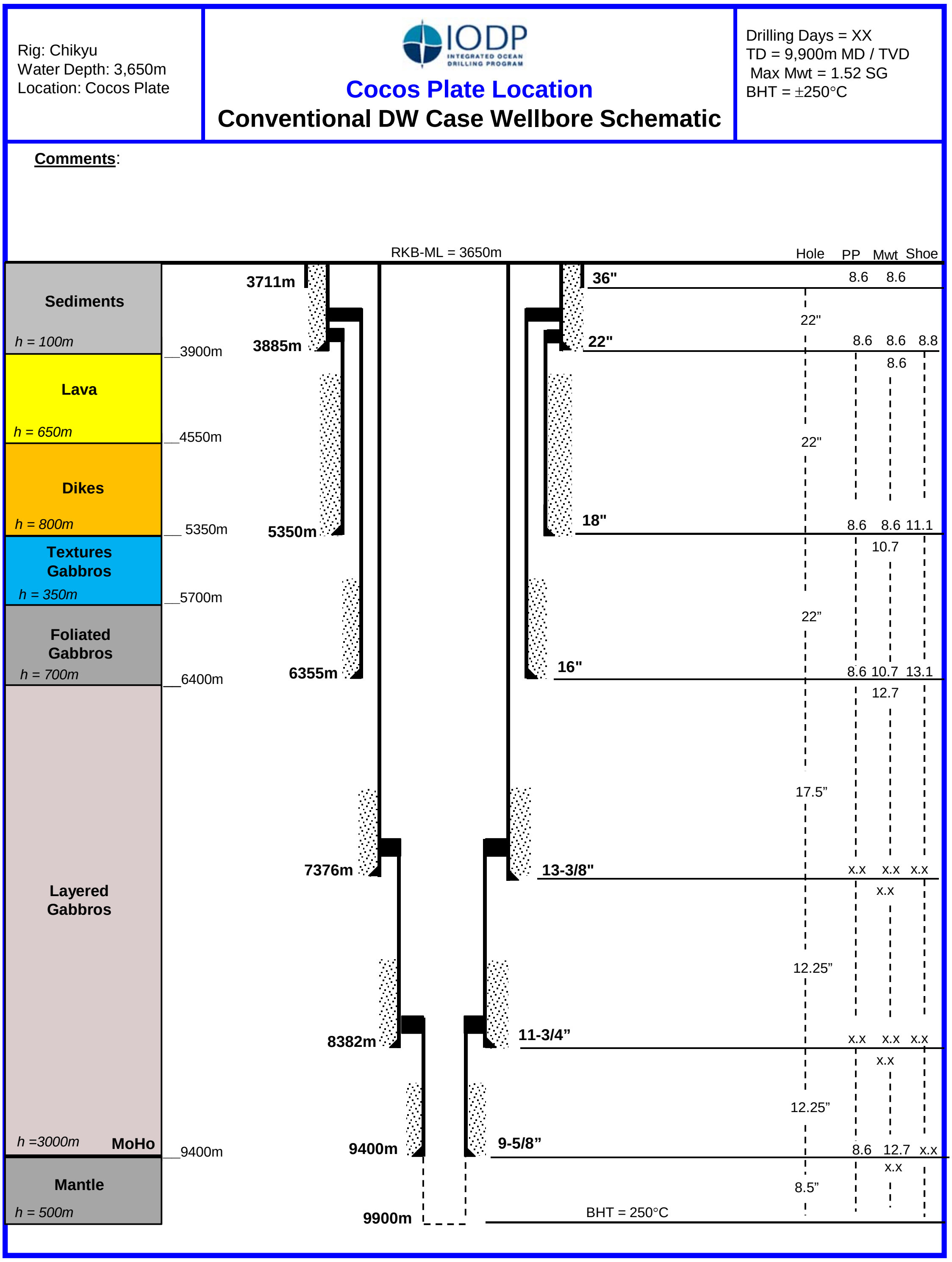


Figure 27. Cocos Location Well Configuration – Deepwater Case

3.3.3 Expandable Wellbore Configuration:

Below is the Expandable Case wellbore schematic for a hole drilled at the Cocos location.

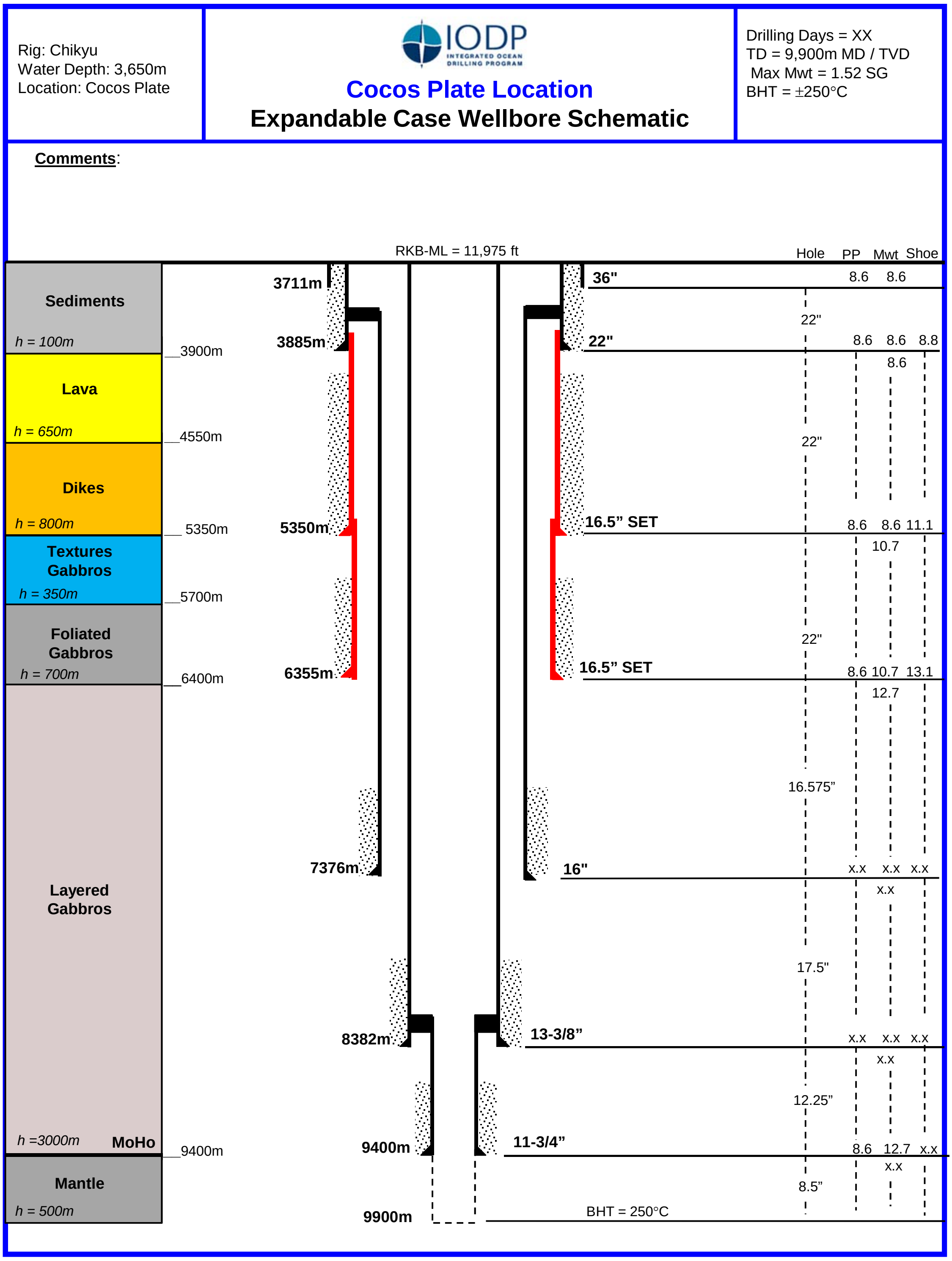


Figure 28. Cocos Location Well Configuration – Expandable Case

3.4 Hawaii Location Wellbore Diagrams

3.4.1 Base Case Wellbore Configuration:

Below is the Base Case wellbore schematic for a hole drilled at the Hawaii location.

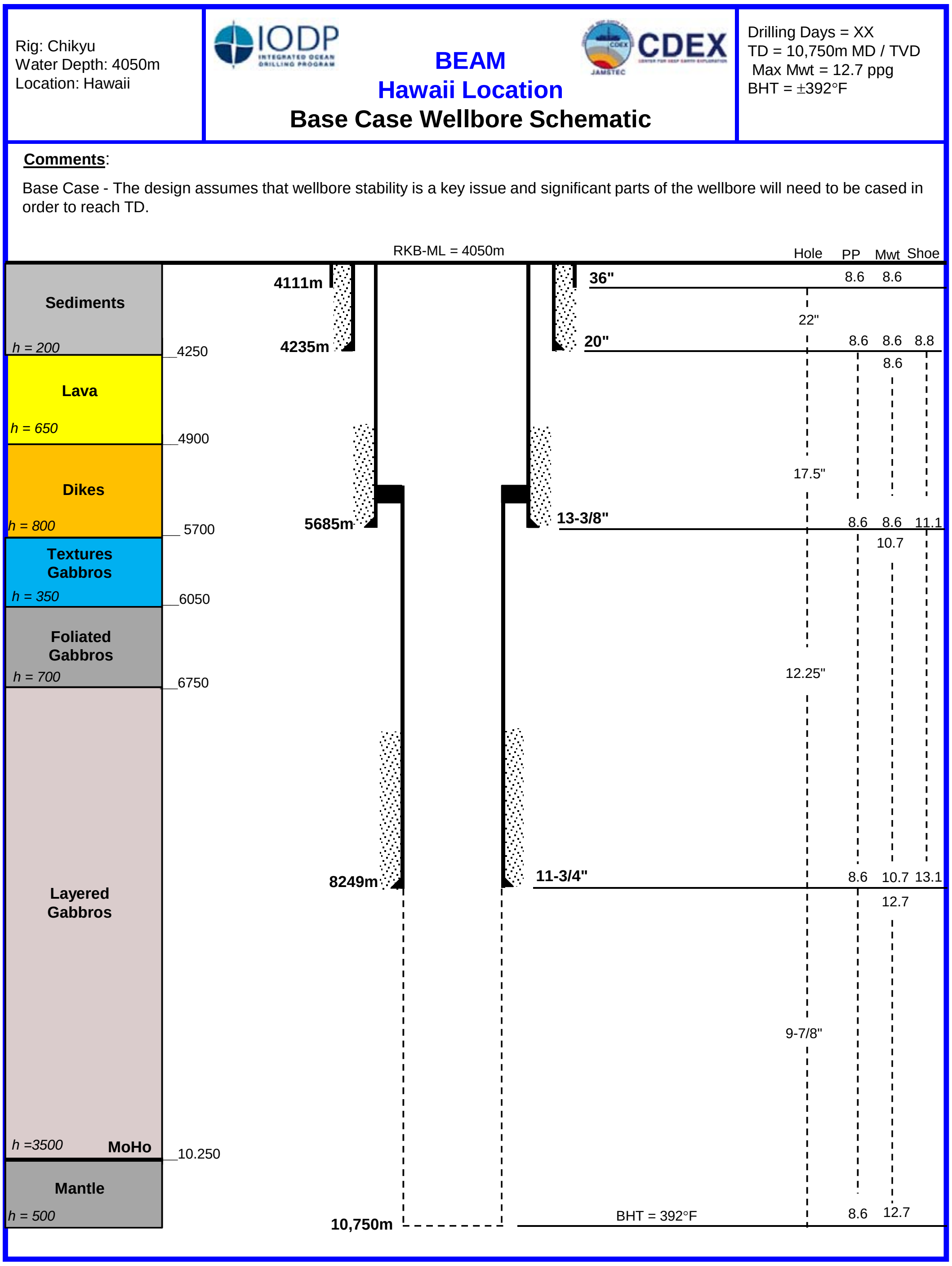


Figure 29 - Hawaii Location Well Configuration – Base Case

3.4.2 Deepwater Wellbore Configuration:

Below is the Deepwater Case wellbore schematic for a hole drilled at the Hawaii location.

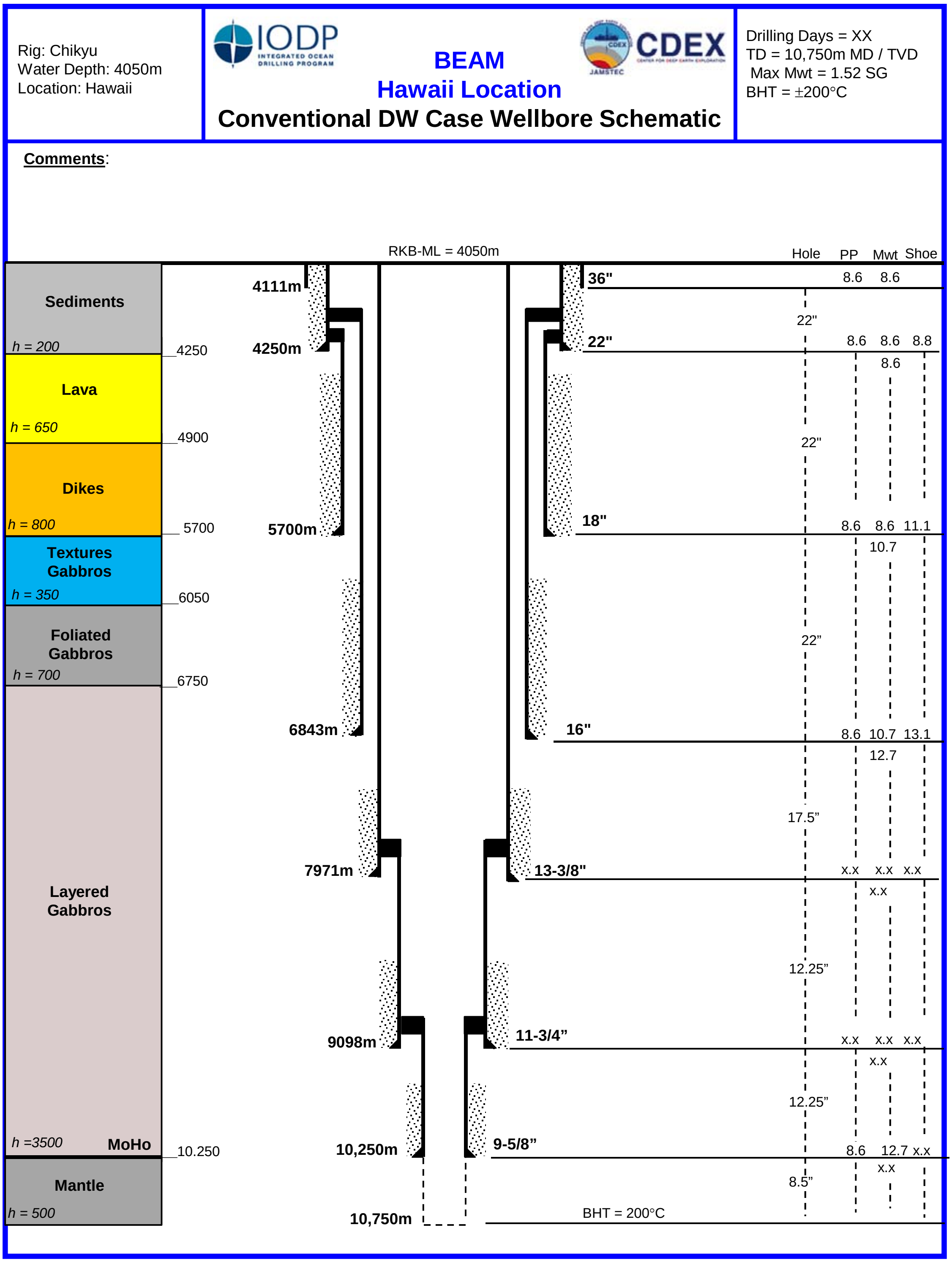


Figure 30 - Hawaii Location Well Configuration – Deepwater Case

3.4.3 Expandable Wellbore Configuration:

Below is the Expandable Case wellbore schematic for a hole drilled at the Hawaii location.

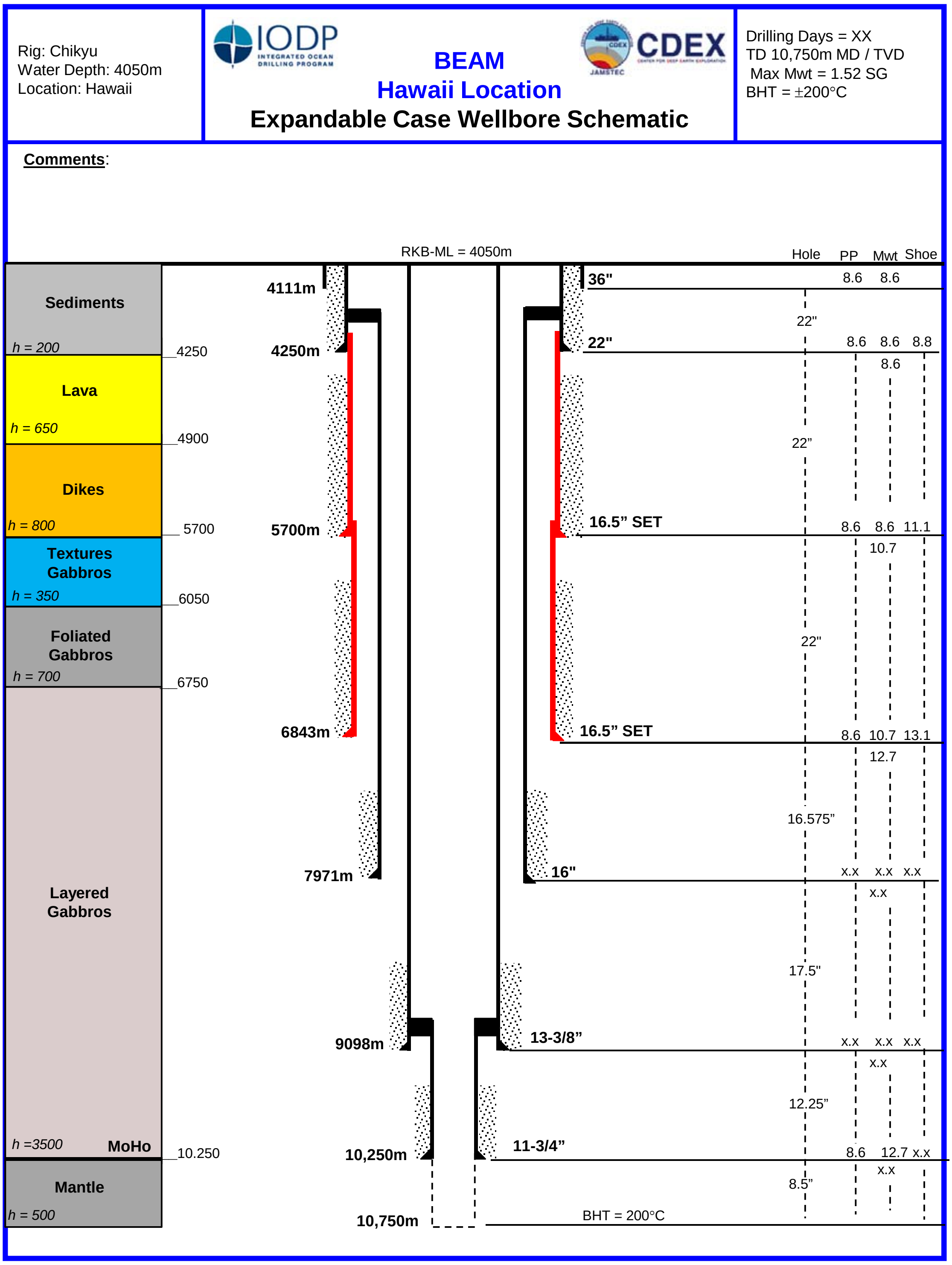


Figure 31 - Hawaii Location Well Configuration – Expandable Case

3.5 Baja Location Wellbore Diagrams

3.5.1 Base Case Wellbore Configuration:

Below is the Base Case wellbore schematic for a hole drilled at the Baja location.

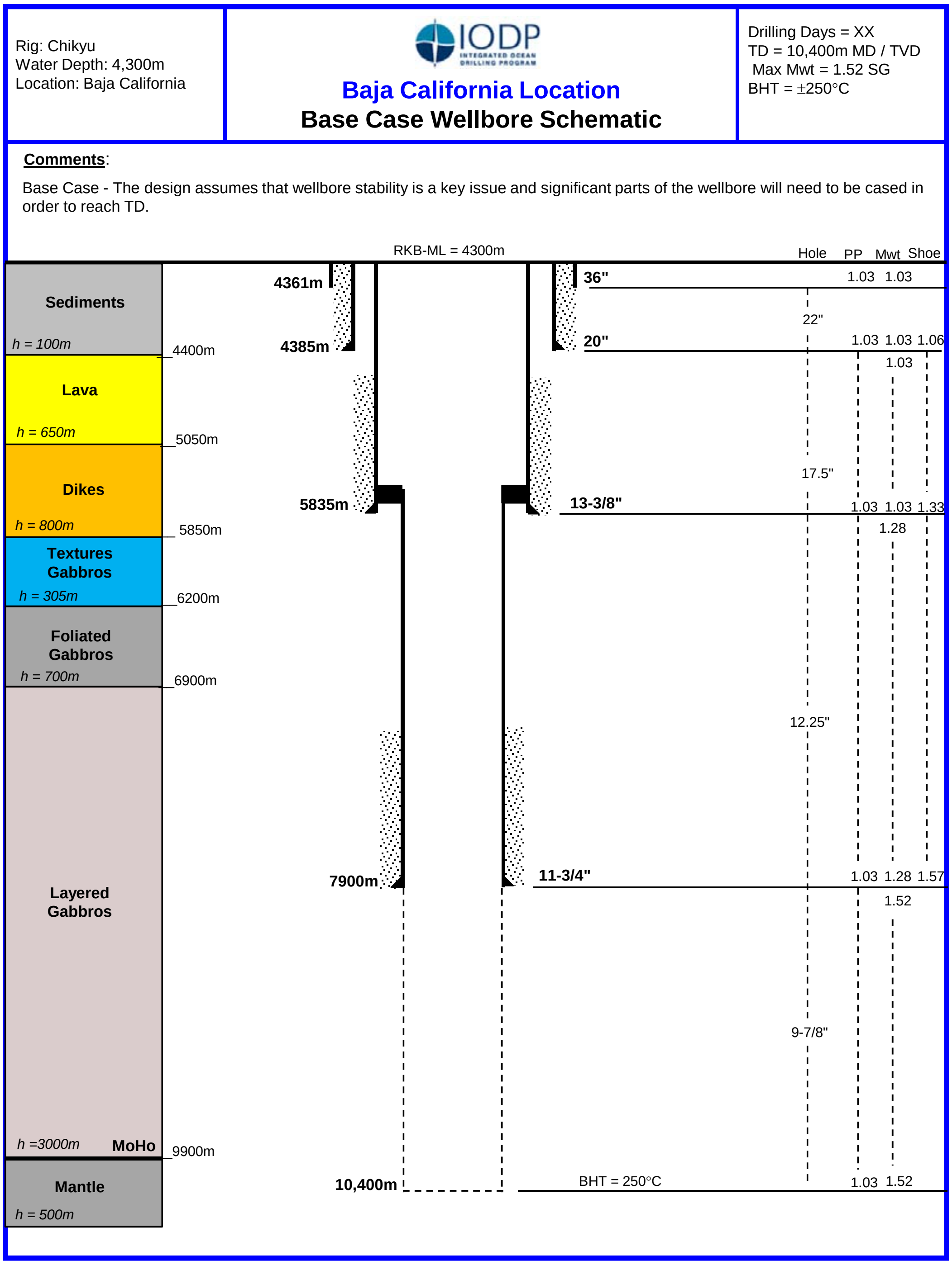


Figure 32 - Baja Location Well Configuration – Base Case

3.5.2 Deepwater Wellbore Configuration:

Below is the Deepwater Case wellbore schematic for a hole drilled at the Baja location.

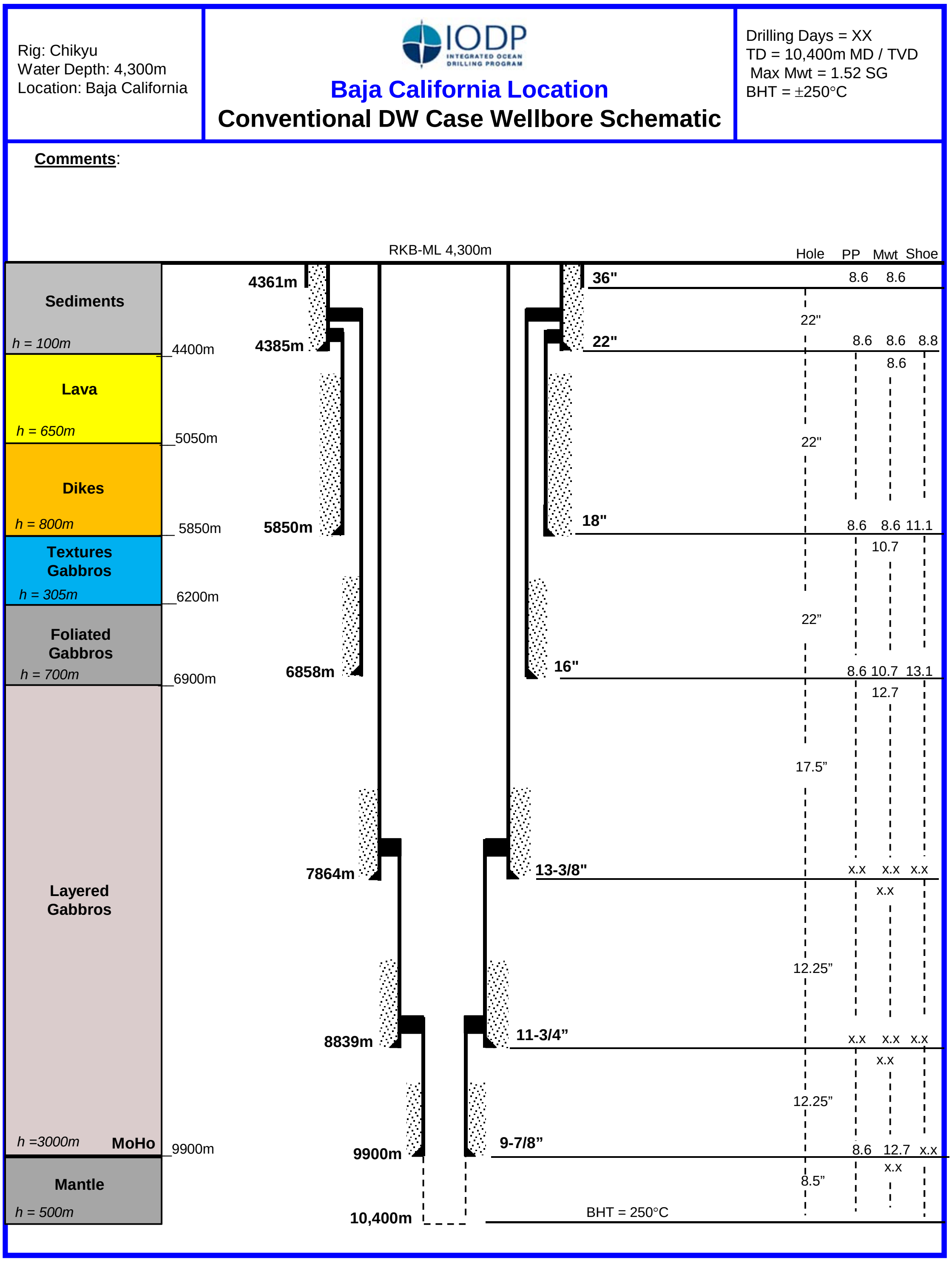


Figure 33 - Baja Location Well Configuration – Deepwater Case

3.5.3 Expandable Wellbore Configuration:

Below is the Expandable Case wellbore schematic for a hole drilled at the Baja location.

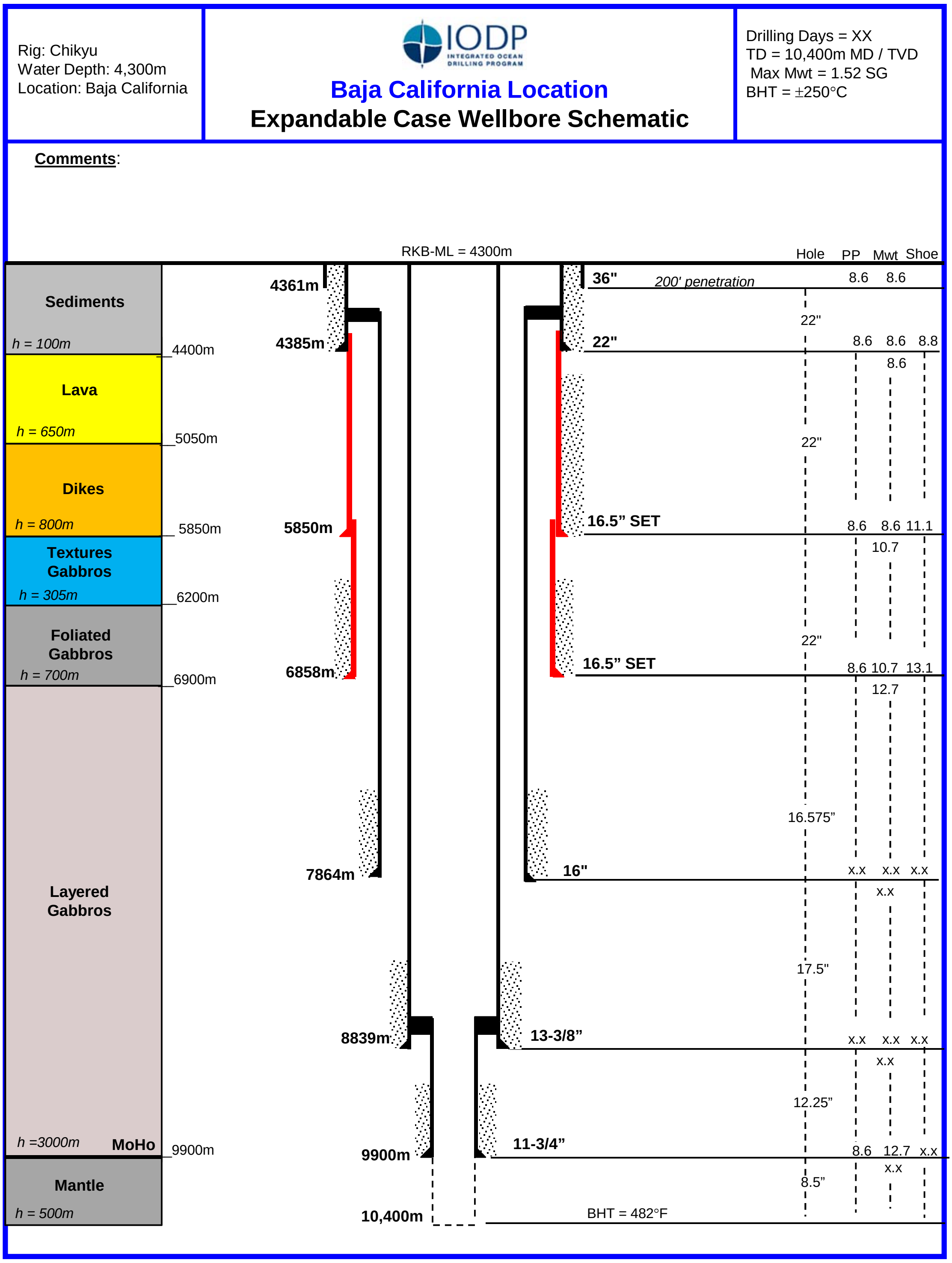


Figure 34 - Baja Location Well Configuration – Expandable Case

4 Marine Riser Design Discussion

This section details the main results for marine drilling riser feasibility analyses. The design premise for this analysis has been obtained from CDEX (i.e. Chikyu vessel and drilling riser specifications, subsea equipment, etc.).

The design process for the marine drilling riser analysis has been divided in the following sub-sections:

- Static analysis (i.e. Chikyu connected and disconnected at the LMRP connector);
- Dynamic analysis (i.e. Chikyu connected and disconnected at the LMRP connector);
  - Frequency domain analysis
  - Time domain analysis
- Chikyu operability analysis while on location in the Pacific Ocean;
- Riser hang-off analysis (i.e. soft and hard hang-off);
- Riser modal analysis;
- Vortex Induced Vibrations (VIV) screening and riser fatigue assessment.

Each of these analyses is investigated in detail with the pertinent response characteristics plotted in this chapter.

4.1 Introduction and Data

Figure 35 provides a picture from the Chikyu drill-ship vessel and Figure 36 illustrates the marine drilling riser configuration with slick and buoyed joints and with the main tube plus the auxiliary lines (i.e. choke and kill, booster and 2 hydraulic lines). Note that the maximum tensioning capacity of the Chikyu is 6 x 363 tons = 6 x 800 kips = 4,800,000 lbs.

The ability for the Chikyu to drill an ultra-deepwater well in the Pacific Ocean is mainly dependent on the riser drilling capacity of the vessel and the specifications of the riser components (i.e. riser tensioning system, buoyed and slick riser joints). In order to achieve this goal, several options or configurations can be considered and are discussed in the following sections.

Figure 35. Chikyu Drill-ship

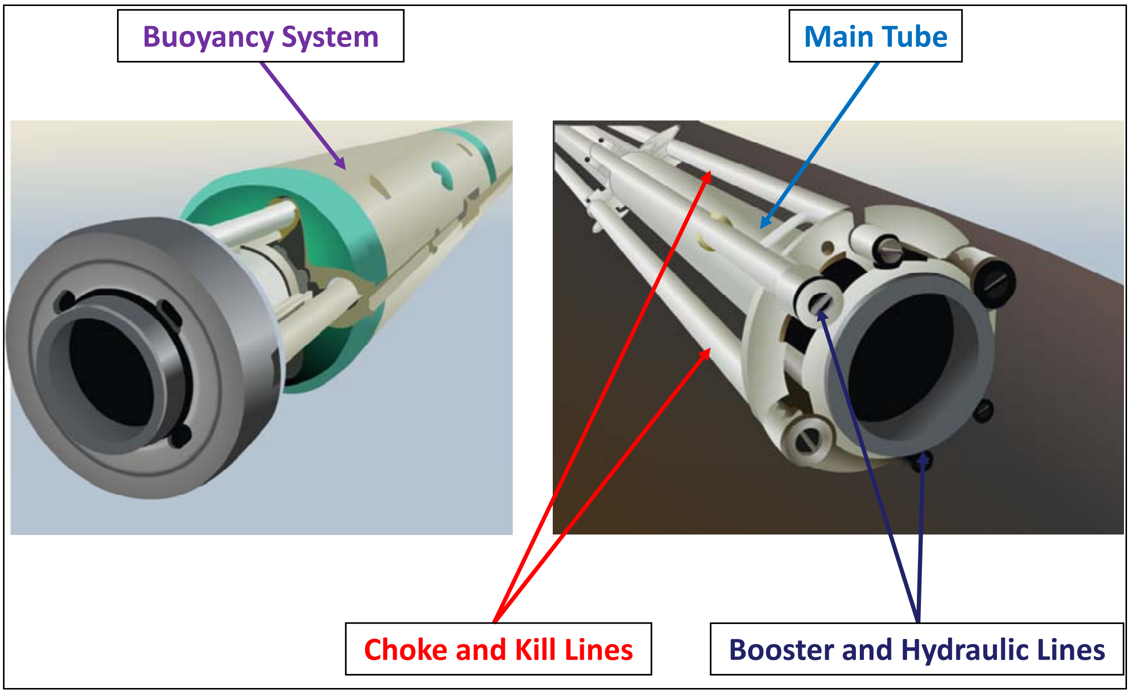


Figure 36. Marine Drilling Riser Schematic

4.2 Marine Drilling Riser Options

1. ***High strength steel: X-100*** (i.e. 100,000 psi yield strength) material line pipe is now available to manufacture the drilling riser main tube. Until recently, the highest steel grade that was available to manufacture riser joints was X-80 (i.e. 80,000 psi) but the impact of this technical improvement could be rather important on the design and application for ultra-deepwater riser drilling. X-100 material enables a thinner wall (i.e. weight reduction per riser joint) in order to achieve the same performance for a given field application. As a result, a thinner walled drilling riser would allow deploying greater lengths of riser joints for the same floating drilling structure tensioning system (i.e. 4,800 kips on the Chikyu). Note also that since the maximum VME in the drilling riser tubes cannot exceed 67% of the minimum yield strength, X-100 material will enable higher stresses in the riser tubes which implies that either higher mud weight could be used or greater water depths could be drilled using riser drilling technology.

2. ***Titanium:*** because of the drastic weight reduction associated with titanium (i.e. 40% lighter than steel) and much higher yield strength (i.e. 120-130 ksi), titanium drilling risers can be used for weight reduction for the entire drilling riser (i.e. main tube and/or auxiliary lines). Thus, similarly to X-100 material, titanium drilling risers could be used to drill through ultra-deepwater depths that have never been reached before with steel material and could also be utilized for harsh environments with high pressure reservoirs (high mud weight). Note that two grades of titanium: ASTM 23 and ASTM 29 would be readily suitable for deepwater titanium drilling risers. An additional benefit is titanium's high resistance to fatigue damage, which could be used for high current environment and very long drilling campaigns such as the one planned for the mantle hole. Obviously, the main disadvantage of titanium products is their relatively high cost in comparison to steel, which therefore make the concept of hybrid risers (i.e. the main tube made of steel and the auxiliary lines made of advanced materials) more attractive.

3. ***Aluminum:*** because of the large weight reduction associated with aluminum material (i.e. 60% lighter than steel) but generally lower yield strength (i.e. 40-60 ksi), aluminum drilling risers can be used for weight reduction for the entire drilling riser (i.e. main tube and/or auxiliary lines) but would be better suited for auxiliary lines keeping the riser main tube with a high yield strength material (X-80, X-100 or titanium); hence, illustrating the concept of hybrid drilling risers. Thus, aluminum drilling risers could be used to drill through ultra-deepwater depths with existing floaters. However, active work and studies are currently conducted to investigate the potential corrosion issues that are associated with using aluminum in seawater (i.e. chloride content) and the fatigue behavior of aluminum joints and the welding process for 75-foot and 90-foot long riser tubes.

4. ***Composite materials:*** the oil and gas industry (i.e. Aker Solutions, Lincoln Composite) is also currently investigating composite materials (i.e. carbon fiber) or hybrid risers that would use a coating layer on a thin matrix made of high strength steel. Again, because of the drastic weight reduction associated with composite materials (i.e. up to 75% lighter than steel) and much higher yield strength (i.e. 250-500 ksi), composite drilling risers can be used for weight reduction for the entire drilling riser (i.e. main tube and/or auxiliary lines). Thus, similarly to X-100 material and titanium, drilling risers made of composite materials could be used to drill through ultra-deepwater depths that have never been reached before with steel material and also utilized for harsh environments with high pressure reservoirs (high mud

weight). However, the main disadvantage of composite products for the offshore industry is that neither their performance nor their reliability have been field tested, and they have never been deployed for deepwater applications. Also, great challenges need to be overcome for welds and connectors when manufacturing 75-ft or 90-ft long riser joints.

5. ***Buoyancy systems:*** currently capable of equipping riser joints in up to 4572m (15,000 ft) of water. Note that the greater the water depth, the larger the buoyancy systems become because of the increased density of foam per volume that need to be employed to provide a good uplift force to the riser joint. Recent progress has enabled the buoyancy systems to provide a much reduced buoyed weight in comparison with the riser joint's dry weight. The foam material performance properties have improved also, and therefore do not always require a larger diameter.

Keep in mind that high strength steel (i.e. 80 ksi) is currently the most widely used material for deepwater drilling and drilling riser systems and is the material equipping the Chikyu riser joints and riser systems. However, because the target would be to drill with a marine drilling riser in water depths averaging greater than 3658m (12,000 ft) with drilling fluids up to 1.68 SG (14.0 ppg), the technical limit of existing riser systems may be reached and therefore other configurations have to be considered.

Figure 37 through Figure 40 shown below provide detailed calculations for the drilling riser weight for four different configurations:

1. Current Cameron LoadKing drilling riser with 4,000,000 lbf tension capacity made of steel with X-80 material;
2. Hydrid riser with aluminum auxiliary lines;
3. Hybrid riser with titanium auxiliary lines;
4. Hybrid riser with composite auxiliary lines.

Note that the dry weight of the Cameron LoadKing 4.0 drilling riser in 4267m (14,000 ft) of water is slightly greater than 4,500,000 lbs and that the five auxiliary lines account for almost half of the total weight of the drilling riser. In addition, advanced materials such as aluminum, titanium and composite can significantly reduce the dry weight of the drilling riser by changing the material on the auxiliary lines from steel to aluminum, titanium or composite. In 4267m (14,000 ft) of water, the aluminum hybrid configuration has a dry weight of slightly greater than 3,000,000 lbs, the titanium hybrid configuration has a dry weight of water slightly greater than 3,500,000 lbs, and the composite hybrid configuration has a dry weight of slightly greater than 2,800,000 lbs

Cameron LoadKing 4.0

RISER MAIN TUBE			CHOKE AND KILL LINES		
P_{API} (with 1.25 Factor of Safety) =	5000.0	psi	P_{API} (with 1.25 Factor of Safety) =	16961.5	psi
σ_y =	80	ksi	σ_y =	56	ksi
t =	0.75	in	t =	1.125	in
OD =	21	in	OD =	6.5	in
OD =	1.750	ft	OD =	0.542	ft
ID =	19.5	in	ID =	4.25	in
ID =	1.63	ft	ID =	0.354167	ft
Water Column =	14,000	ft	Water Column =	14,000	ft
$A_{s,fluid}$ =	2.07	ft^2	$A_{s,fluid}$ =	0.10	ft^2
V_{fluid} =	29035.2	ft^3	V_{fluid} =	1379.2	ft^3
V_{fluid} =	217198.3	gallons	V_{fluid} =	10317.3	gallons
V_{fluid} =	5171.4	bbl	V_{fluid} =	245.6	bbl
Fluid Weight =	8.6	ppg	Fluid Weight =	0	ppg
Total Weight of Mud in 14,000 ft =	1,867,905.2	lbs	Total Weight of Mud in 14,000 ft =	0.0	lbs
$A_{s,steel}$ =	0.33	ft^2	$A_{s,steel}$ =	0.13	ft^2
V_{steel} =	4638.8	ft^3	V_{steel} =	1846.9	ft^3
Steel Weight =	490	lb/ft^3	Steel Weight =	490	lb/ft^3
Total Weight of Steel in 14,000 ft =	2,272,991.4	lbs	Total Weight of Steel in 14,000 ft =	904,987.3	lbs
TOTAL WEIGHT =	4,140,896.6	lbs	TOTAL WEIGHT =	904,987.3	lbs

BOOSTER LINE			HYDRAULIC LINE		
P_{API} (with 1.25 Factor of Safety) =	9800.0	psi	P_{API} (with 1.25 Factor of Safety) =	8448.3	psi
σ_y =	56	ksi	σ_y =	56	ksi
t =	0.5	in	t =	0.3125	in
OD =	5	in	OD =	3.625	in
OD =	0.417	ft	OD =	0.302	ft
ID =	4.0	in	ID =	3	in
ID =	0.333333333	ft	ID =	0.25	ft
Water Column =	14,000	ft	Water Column =	14,000	ft
$A_{s,fluid}$ =	0.09	ft^2	$A_{s,fluid}$ =	0.05	ft^2
V_{fluid} =	1221.7	ft^3	V_{fluid} =	687.2	ft^3
V_{fluid} =	9139.2	gallons	V_{fluid} =	5140.8	gallons
V_{fluid} =	217.6	bbl	V_{fluid} =	122.4	bbl
Fluid Weight =	0	ppg	Fluid Weight =	0	ppg
Total Weight of Mud in 14,000 ft =	0.0	lbs	Total Weight of Mud in 14,000 ft =	0.0	lbs
$A_{s,steel}$ =	0.05	ft^2	$A_{s,steel}$ =	0.02	ft^2
V_{steel} =	687.2	ft^3	V_{steel} =	316.2	ft^3
Steel Weight =	490	lb/ft^3	Steel Weight =	490	lb/ft^3
Total Weight of Steel in 14,000 ft =	336,739.5	lbs	Total Weight of Steel in 14,000 ft =	154,923.5	lbs
TOTAL WEIGHT =	336,739.5	lbs	TOTAL WEIGHT =	154,923.5	lbs

TOTAL WEIGHT = RISER + AUXILIARY LINES		
Total Weight of Steel in 14,000 ft =	4,574,629.0	lbs
Ratio Lines / Total Weight =	50.31%	

Figure 37. Cameron LoadKing Drilling Riser Dry Weight in 4267m of Water

Cameron LoadKing 4.0 with Aluminum Auxiliary Lines					
RISER MAIN TUBE			**CHOKE AND KILL LINES**		
σ_y =	80	ksi	σ_y =	70	ksi
Steel Weight =	490	lb/ft^3	Aluminum Weight =	170	lb/ft^3
Total Weight of Steel in 14,000 ft =	2,272,991.4	lbs	Total Weight of Aluminum in 14,00	313,975.2	lbs
TOTAL WEIGHT =	4,140,896.6	lbs	TOTAL WEIGHT =	313,975.2	lbs
BOOSTER LINE			**HYDRAULIC LINE**		
σ_y =	70	ksi	σ_y =	70	ksi
Aluminum Weight =	170	lb/ft^3	Aluminum Weight =	170	lb/ft^3
Total Weight of Aluminum in 14,00	116,828.0	lbs	Total Weight of Aluminum in 14,00	53,749.0	lbs
TOTAL WEIGHT =	116,828.0	lbs	TOTAL WEIGHT =	53,749.0	lbs
TOTAL WEIGHT = RISER + AUXILIARY LINES					
Total Weight of Metal in 14,000 ft =	3,071,518.7	lbs			
Ratio Lines / Total Weight =	26.00%				

Figure 38. Cameron LoadKing and Aluminum Lines Drilling Riser Dry Weight in 4267m of Water

Cameron LoadKing 4.0 with Titanium Auxiliary Lines					
RISER MAIN TUBE			**CHOKE AND KILL LINES**		
σ_y =	80	ksi	σ_y =	130	ksi
Steel Weight =	490	lb/ft^3	Titanium Weight =	280	lb/ft^3
Total Weight of Steel in 14,000 ft =	2,272,991.4	lbs	Total Weight of Titanium in 14,000	517,135.6	lbs
TOTAL WEIGHT =	4,140,896.6	lbs	TOTAL WEIGHT =	517,135.6	lbs
BOOSTER LINE			**HYDRAULIC LINE**		
σ_y =	130	ksi	σ_y =	130	ksi
Titanium Weight =	280	lb/ft^3	Titanium Weight =	280	lb/ft^3
Total Weight of Titanium in 14,000	192,422.6	lbs	Total Weight of Titanium in 14,000	88,527.7	lbs
TOTAL WEIGHT =	192,422.6	lbs	TOTAL WEIGHT =	88,527.7	lbs
TOTAL WEIGHT = RISER + AUXILIARY LINES					
Total Weight of Metal in 14,000 ft =	3,588,212.9	lbs			
Ratio Lines / Total Weight =	36.65%				

Figure 39. Cameron LoadKing and Titanium Lines Drilling Riser Dry Weight in 4267m of Water

Cameron LoadKing 4.0 with Composite Auxiliary Lines					
RISER MAIN TUBE			**CHOKE AND KILL LINES**		
σ_y =	80	ksi	σ_y =	580	ksi
Steel Weight =	490	lb/ft^3	Composite Weight =	115	lb/ft^3
Total Weight of Steel in 14,000 ft =	2,272,991.4	lbs	Total Weight of Composite in 14,00	212,395.0	lbs
TOTAL WEIGHT =	4,140,896.6	lbs	TOTAL WEIGHT =	212,395.0	lbs
BOOSTER LINE			**HYDRAULIC LINE**		
σ_y =	580	ksi	σ_y =	580	ksi
Composite Weight =	115	lb/ft^3	Composite Weight =	115	lb/ft^3
Total Weight of Composite in 14,00	79,030.7	lbs	Total Weight of Composite in 14,00	36,359.6	lbs
TOTAL WEIGHT =	79,030.7	lbs	TOTAL WEIGHT =	36,359.6	lbs
TOTAL WEIGHT = RISER + AUXILIARY LINES					
Total Weight of Material in 14,000 f	2,813,171.6	lbs			
Ratio Lines / Total Weight =	19.20%				

Figure 40. Cameron LoadKing and Composite Lines Drilling Riser Dry Weight in 4267m of Water

The figure below is a screenshot from *DeepRiser* software showing the input and specifications for drilling riser joints with buoyancy foam that have been used to run the drilling riser analysis.

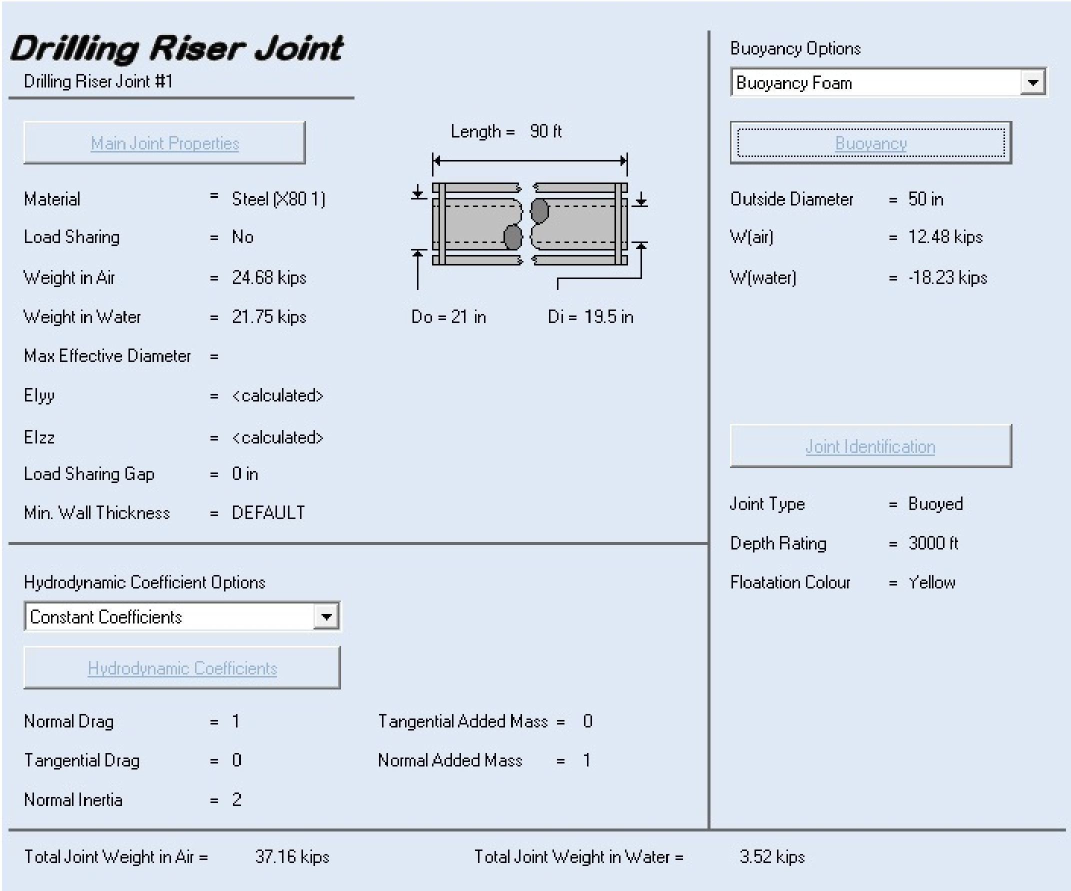


Figure 41. Example of a Typical 90-ft Long Drilling Riser Joint with Buoyancy Modules Input

4.3 Hydrodynamics in Ultra-deepwater

Wave and currents moving past the marine drilling riser place forces upon the riser causing it to displace, rotate, and stress. The force loadings are calculated using the industry standard Morison's equation. This equation calculates the force per unit length along a cylindrical member. Note that Morrison's Equation is nonlinear. The marine drilling riser is a drag-dominated structure (riser diameter is very small as compared to the wave length); therefore, the first half of Morison's equation will dominate the load calculation. The second half of the equation will govern inertia-dominated structures, i.e., gravity base structures, whereby the base structure is large as compared to the wavelength. Since a marine drilling riser is drag dominated, the velocity variable is the dominant term because the force is proportional to velocity squared.

Environmental Criteria

The significant wave height and period used in the analyses and tied to the return period are summarized in Figure 42 and Figure 43 below. Significant wave height is the average of the highest one-third of the waves and is an industry used value. Since the drilling campaign should last for about 6-12 months, the 10 year return period is sufficient to assess the maximum loads that the vessel will most likely experience during the duration of the drilling campaign.

WAVE DATA (NMRI : 1974-1988)			
LOCATION	Significant Wave Height (m)	Maximum Wave Height (m)	Peak Period (s)
Cocos Plate	1.0	1.7	7.0
Hawaii	4.0	6.8	9.0
Baja California	3.0	5.1	8.0

Figure 42. Wave Data for the 10 Year Return Period

LOCATION											
Cocos Plate				Hawaii				Baja California			
Depth (meters)											
1	500	1,000	3,650	1	500	1,000	4,000	1	500	1,000	4,300
2.5	1.00	0.50	0.25	2	0.75	0.50	0.25	3	1.25	0.60	0.25

Figure 43. Current Data for the 10 Year Return Period

Note that the current profile is not uniform and has a triangular or parabolic shape. This is of importance because experience and field studies have shown that usually, the more linear the current profile is, the more prone to severe vortex-induced vibrations (VIV)0 the structural members are (i.e. drilling riser for instance). Additionally, the wave spectrum that has been used to model more complex random seas for the dynamic analysis has been chosen to be Pierson-Moskowitz, which is usually a good choice for fully developed seas.

Drilling Riser Models

The connected and disconnected analyses (i.e. static and dynamic) are illustrated respectively in Figure 44 and Figure 45. Figure 44 covers the scenario when the marine drilling riser is installed and connected to the BOP system in 3,650 - 4,300 meters of water (i.e. 12,000 - 14,000 feet). The Chikyu vessel and marine drilling riser are exposed from rather benign to more extreme (i.e. 10 Year Return) environmental loadings.

The most critical variables in the analyses are waves, current, top tension, mud weight and vessel offset. Vessel offset is expressed as a percentage of water depth and says if the vessel is upstream or downstream of the well. A value of -10% offset in 4267m (14,000 ft) of water signifies the vessel is upstream 427m (1,400 ft) from the well. A value of +10% signifies the vessel is downstream 427m.

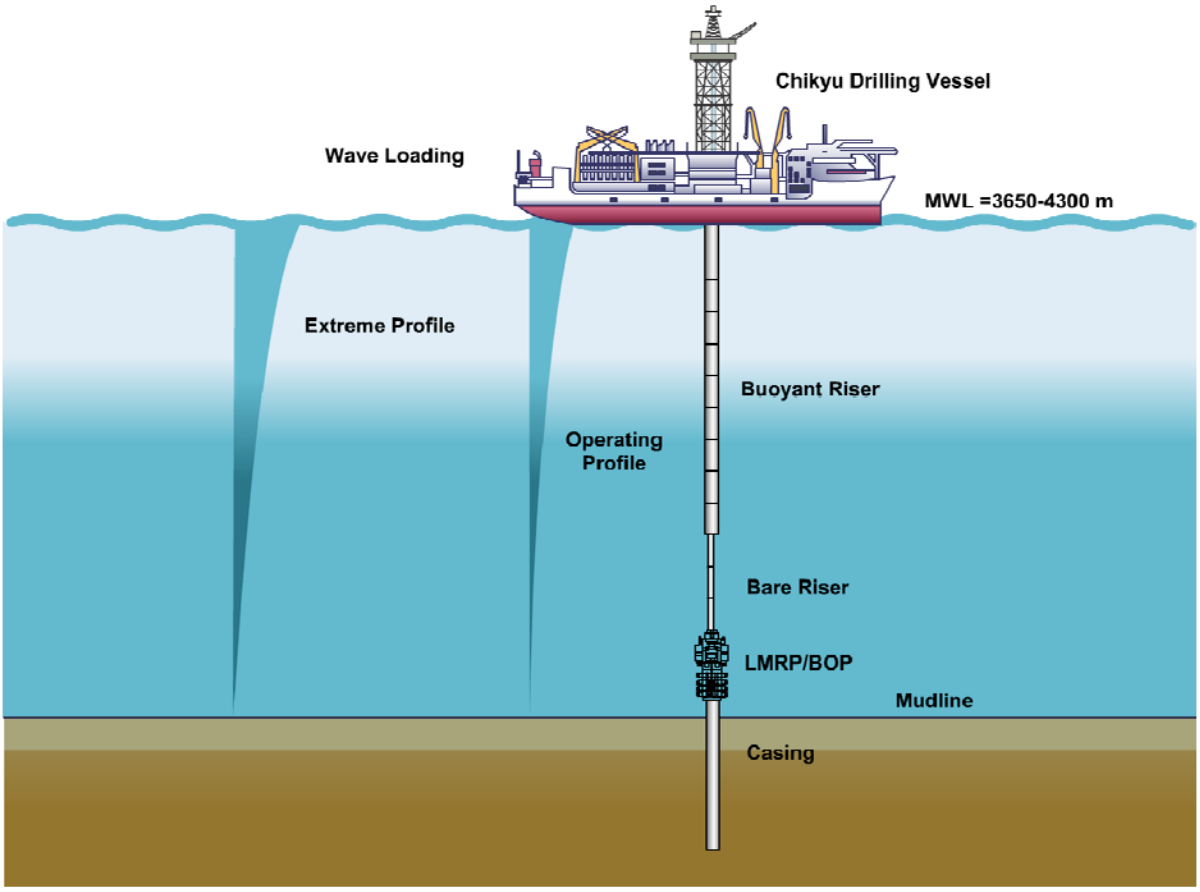


Figure 44. Schematic of Connected Riser Analysis Model

Figure 45 below illustrates two different disconnected scenarios:

- Soft hang-off analysis which covers the scenario when the drilling riser is still connected to (i.e. hanging on) the tensioning system and where the telescopic joint supports the weight of the drilling riser;

- Hard hang-off analysis which covers the case when the drilling riser is locked in the riser spider and gimbal components at the rig floor with the tensioning system being disconnected and also where the telescopic joint is collapsed.

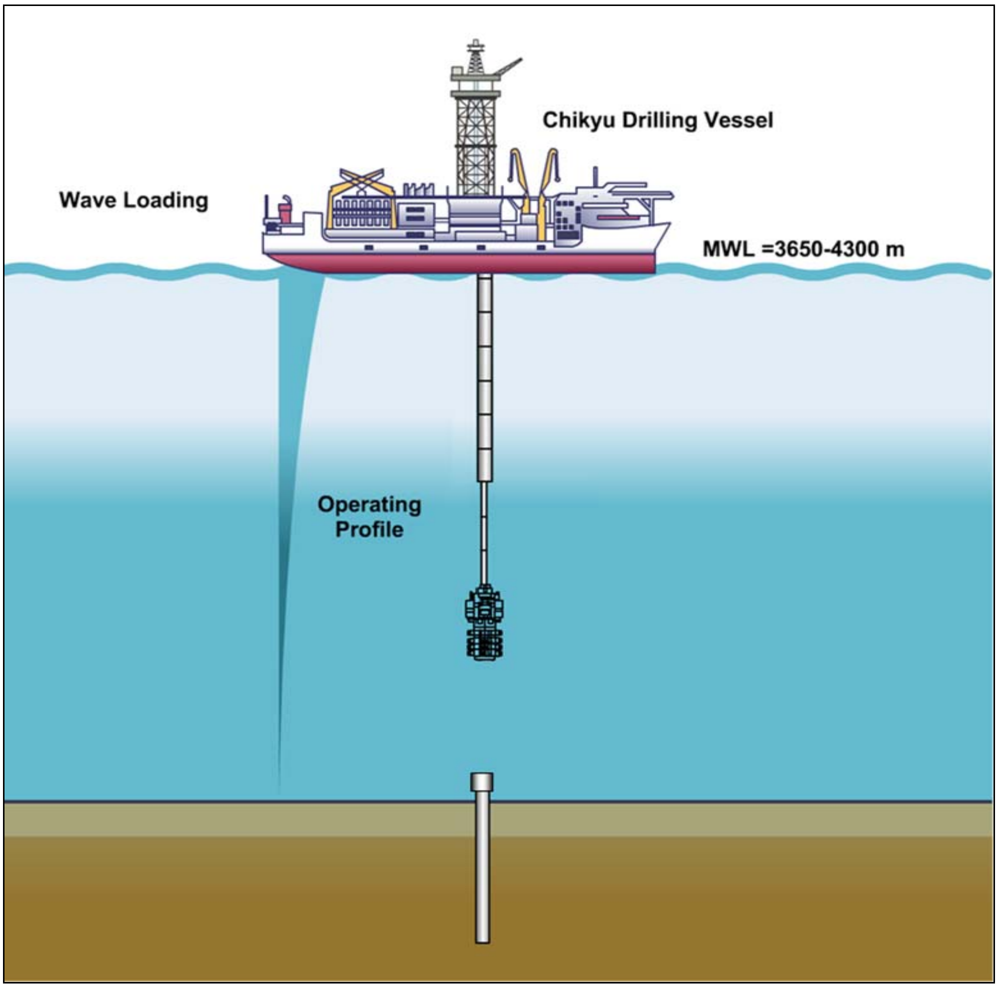


Figure 45. Schematic of Disconnected Riser Analysis Model

Figure 46 and Figure 46 illustrate the finite element models created to model the complex Chikyu drilling vessel and its riser components interaction, the drilling riser joints (i.e. pup joints, slick joint and buoyed joints), the subsea components (LMRP, BOP and wellhead), and the non-linear soil interaction.

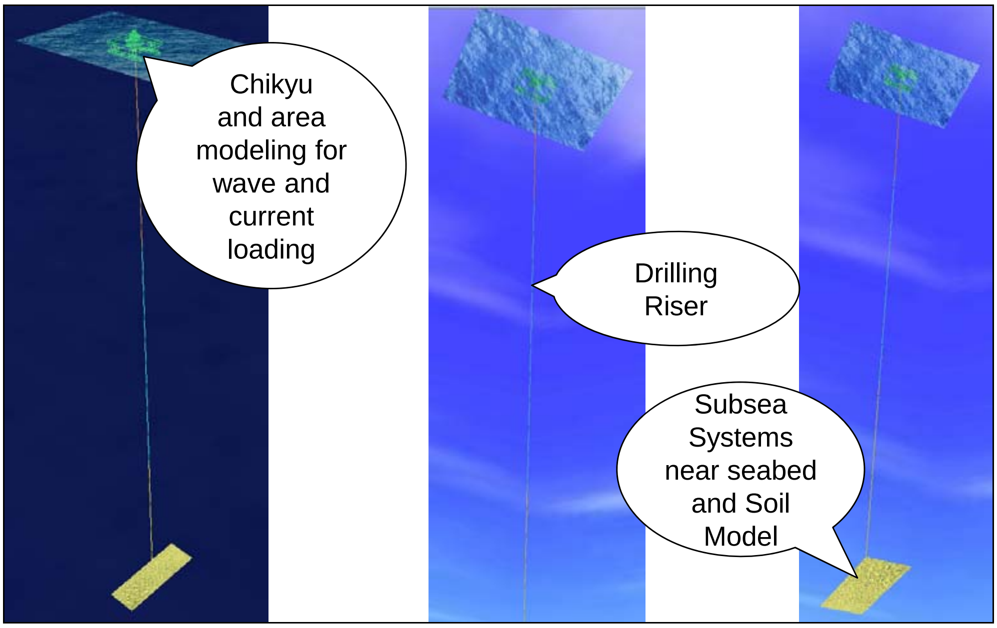
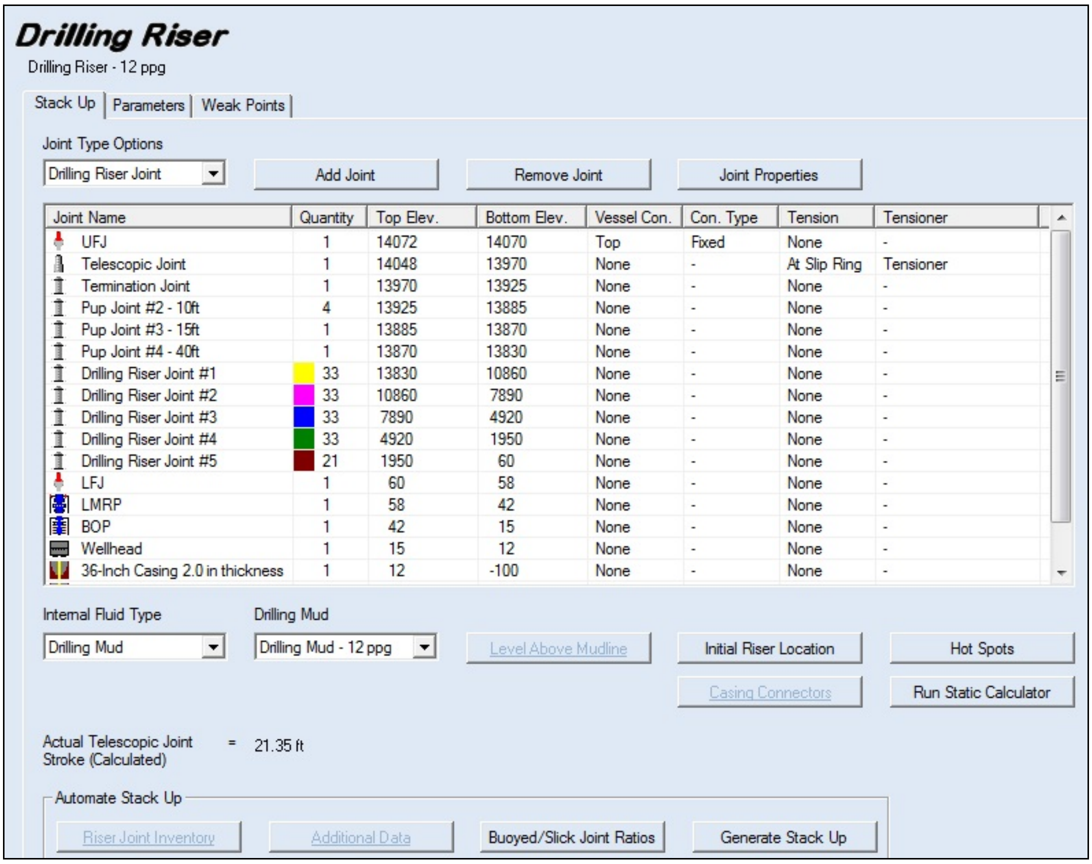


Figure 46. Finite Element Software Models



Joint Name	Quantity	Top Elev.	Bottom Elev.	Vessel Con.	Con. Type	Tension	Tensioner
UFJ	1	14072	14070	Top	Fixed	None	-
Telescopic Joint	1	14048	13970	None	-	At Slip Ring	Tensioner
Termination Joint	1	13970	13925	None	-	None	-
Pup Joint #2 - 10ft	4	13925	13885	None	-	None	-
Pup Joint #3 - 15ft	1	13885	13870	None	-	None	-
Pup Joint #4 - 40ft	1	13870	13830	None	-	None	-
Drilling Riser Joint #1	33	13830	10860	None	-	None	-
Drilling Riser Joint #2	33	10860	7890	None	-	None	-
Drilling Riser Joint #3	33	7890	4920	None	-	None	-
Drilling Riser Joint #4	33	4920	1950	None	-	None	-
Drilling Riser Joint #5	21	1950	60	None	-	None	-
LFJ	1	60	58	None	-	None	-
LMRP	1	58	42	None	-	None	-
BOP	1	42	15	None	-	None	-
Wellhead	1	15	12	None	-	None	-
36-Inch Casing 2.0 in thickness	1	12	-100	None	-	None	-

Figure 47. Example of Riser Stack-up in 4267m of Water for the Baja Location

Effective Tension And Minimum Tension Required For Drilling Operations

One very important characteristic of a marine drilling riser is the fact that the riser can buckle even when the vessel is pulling on the riser with a force greater than the weight of the riser (i.e. total buoyed riser weight). Because of internal pressure, it is effective tension and not actual or real tension that controls buckling of a marine drilling riser.

Effective tension is a mathematically derived expression contained in the equation of motion for a marine drilling riser. Effective tension must always be a positive value to keep the riser from buckling. The effective tension is a function of real tension (as calculated by statics), riser ID (i.e. internal diameter) and OD (i.e. outside diameter), internal pressure, and external pressure. Note that internal pressure multiplied by the internal riser ID area decreases the effective tension value, while external pressure multiplied by the external riser OD area increases the effective tension value. The problem is that the external pressure on a marine drilling riser is fixed (i.e. seawater = 1.03 SG / 8.6 ppg) while the internal pressure is variable based on drilling conditions (i.e. mud weight = 1.03 - 1.68 SG). Thus, the Chikyu tension must support not only the marine drilling riser weight but also must support the weight of the riser contents (i.e. mud). Based on the maximum mud density of about 1.44 SG (12.0 ppg), water depth ranging between 3658m and 4267m (12,000 - 14,000 ft), and the connected riser configuration, the minimum tension for stability per API RP 16Q has been calculated using *DeepRiser* built-for-purpose finite element analysis riser program. Note that the minimum tension calculated assumes one tensioner failure and 95% tensioner efficiency.

Figure 48 through Figure 50 shown below illustrate the static analysis results for a range of mud weight (0.9 SG to over 2.4 SG) with the 4,800,000 lbs tensioning system located on top of the Chikyu moon-pool (i.e. red line). Both the minimum tensioner setting for stability when connected per API RP 16Q (i.e. blue line) and the minimum tensioner setting for a disconnect scenario (i.e. black line) are displayed. Even though applying API 90% of maximum capacity which yields a total tensioning capability of 4,320,000 lbs, static analysis show that even steel riser can be used to drill in 4267m (14,000 ft) of water. Thus, from a buckling and minimum tension required standpoint the Chikyu tension capacity and drilling riser tension capacity are sufficient enough to prevent any type of buckling during the drilling operations. Note that the minimum tension required to drill in 3657m (12,000 ft) of water (i.e. Cocos Plate) ranges between 1,000 kips when drilling with seawater to 2,800 kips when drilling with 1.92 SG (16.0 ppg) mud. Also, the minimum tension required to drill in 3962m (13,000 ft) of water (i.e. Hawaii) ranges between 1,100 kips when drilling with seawater to 3,200 kips when drilling with 1.92 SG (16.0 ppg) mud. In addition, the minimum tension required to drill in 4267m (14,000 ft) of water (i.e. Baja) ranges between 1,200 kips when drilling with seawater to 3,400 kips when drilling with 1.92 SG mud.

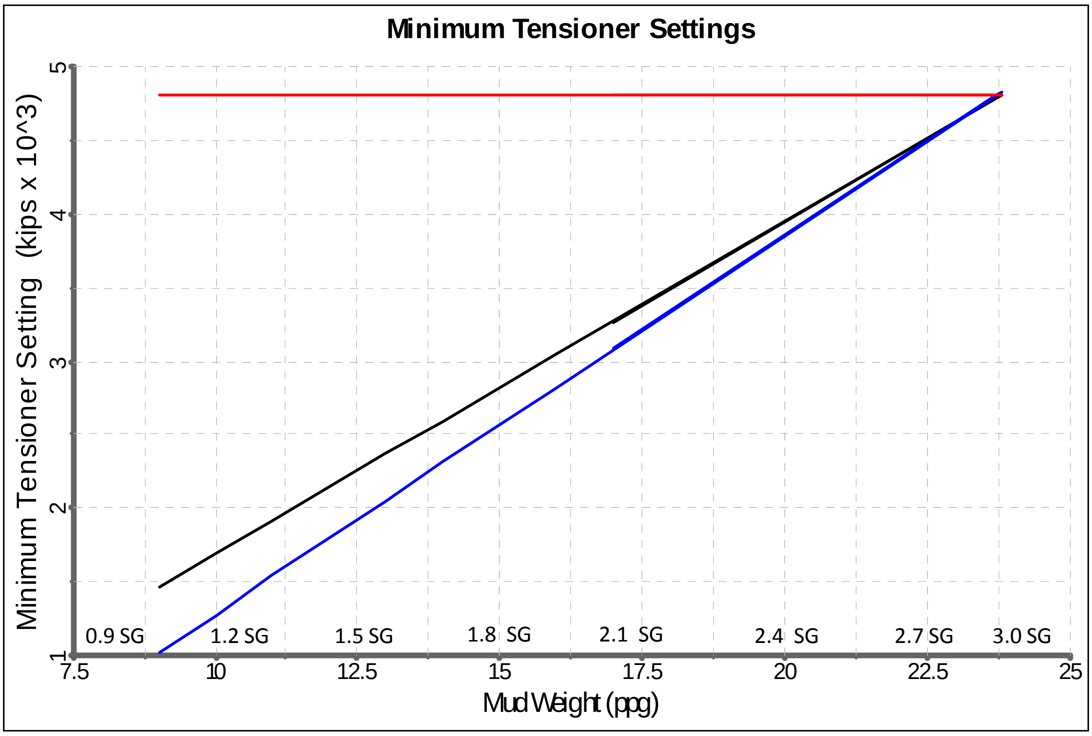


Figure 48. Minimum Tensioner Settings for 3,657 meters (12,000 feet) – Cocos Plate

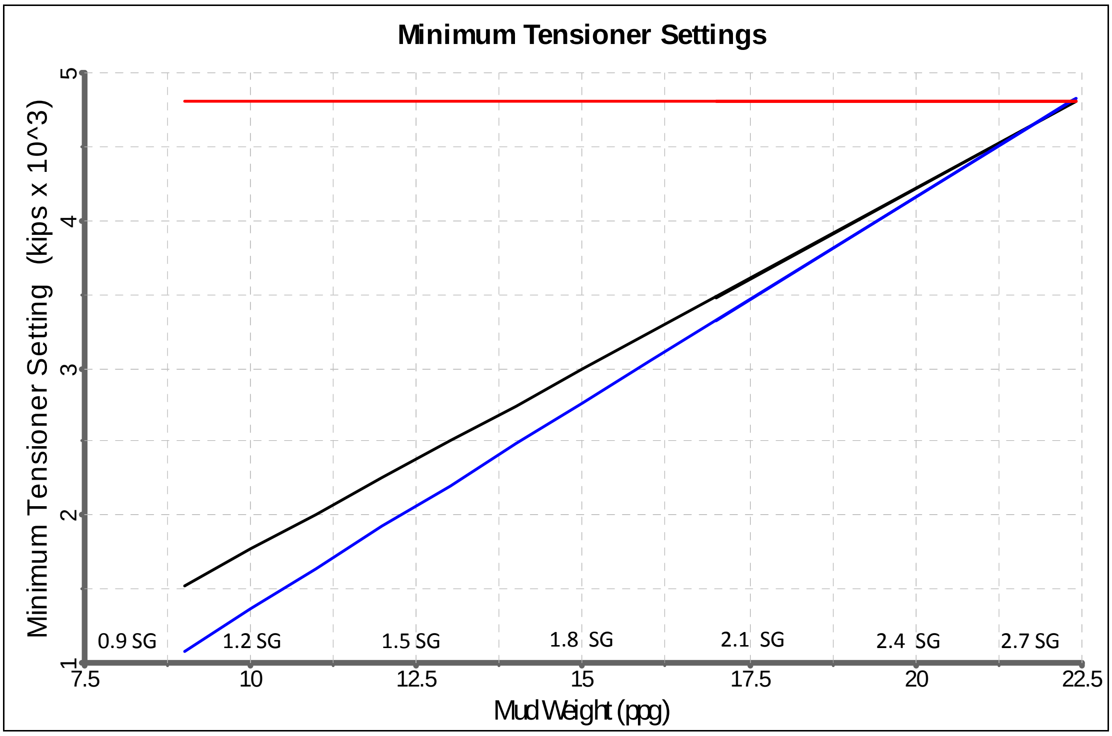


Figure 49. Minimum Tensioner Settings for 3962 meters (13,000 feet) – Hawaii

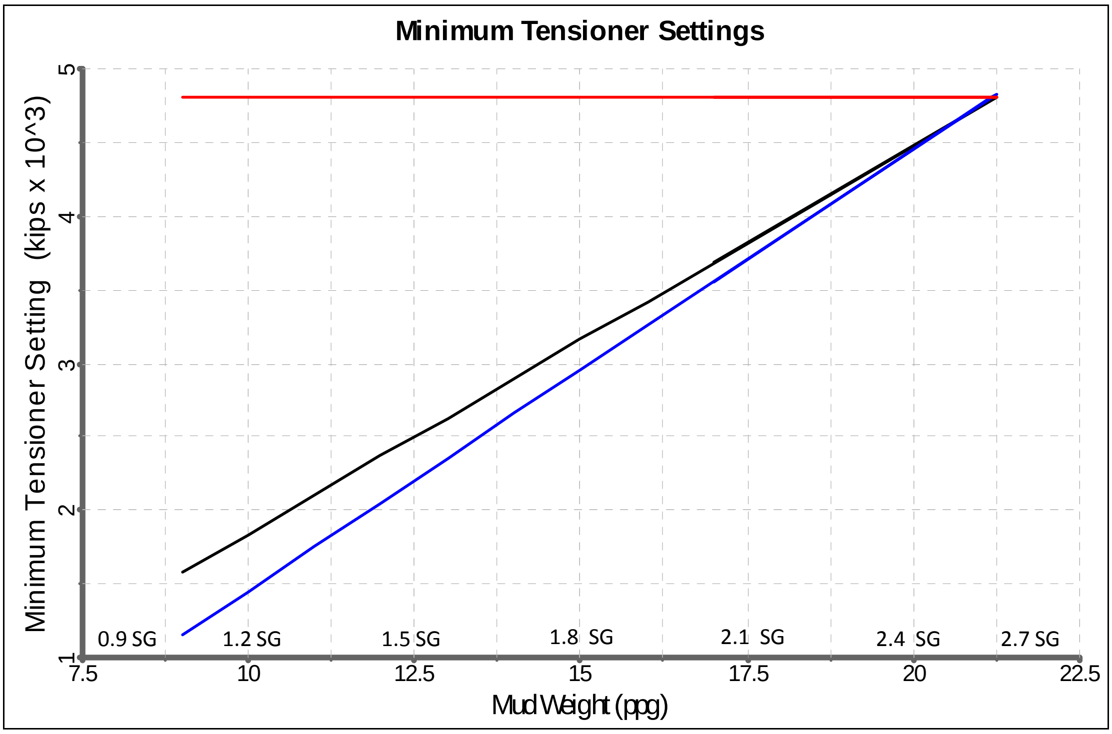


Figure 50. Minimum Tensioner Settings for 4,267 meters (14,000 feet) – Baja

However, the limitations of steel drilling riser and ultra-deepwater drilling capability are controlled by the different operating limits of critical riser drilling components. Indeed, API 16Q - *Recommended Practice for Design, Selection, Operation and Maintenance of Marine Drilling Riser Systems* details the operating limits for a given marine drilling riser and for deepwater locations. The following figures summarize these limits as a function of materials used for the riser joints. The critical parameters are notably the amount of flex/ball joint rotation, maximum stress and vessel tension. Note that the operating limits are divided between the riser connected and riser disconnected configurations, and furthermore the riser connected configuration can also be divided between the drilling mode and the non-drilling mode.

DRILLING RISER - STEEL - X-80 MATERIAL			
DESIGN PARAMETER	RISER CONNECTED		RISER DISCONNECTED
	DRILLING	NON-DRILLING	
Mean Flex / Ball Joint Angle	Mean **2.0 degrees**	N/A	N/A
Maximum Flex / Ball Joint Angle	Max **4.0 degrees**	90% available (**9.0 degrees**)	90% available (**9.0 degrees**)
Maximum VME Stress (METH "B") Deepwater Well	0.67*minimum yield point (**53.6 ksi**)	0.67*minimum yield point (**53.6 ksi**)	0.67*minimum yield point (**53.6 ksi**)
Maximum Tension Setting	90% of capacity (**4,320 kips**)	90% of capacity (**4,320 kips**)	N/A

Figure 51. Design and Operating Limits for Marine Drilling Risers – Steel – X-80

DRILLING RISER - STEEL - X-100 MATERIAL			
DESIGN PARAMETER	RISER CONNECTED		RISER DISCONNECTED
	DRILLING	NON-DRILLING	
Maximum VME Stress (METH "B") Deepwater Well	0.67*minimum yield point (**67 ksi**)	0.67*minimum yield point (**67 ksi**)	0.67*minimum yield point (**67 ksi**)

Figure 52. Design and Operating Limits for Marine Drilling Risers – Steel – X-100

DRILLING RISER - ALUMINUM AUXILIARY LINES			
DESIGN PARAMETER	RISER CONNECTED		RISER DISCONNECTED
	DRILLING	NON-DRILLING	
Maximum VME Stress (METH "B") Deepwater Well	0.67*minimum yield point (**46.9 ksi**)	0.67*minimum yield point (**46.9 ksi**)	0.67*minimum yield point (**46.9 ksi**)

Figure 53. Design and Operating Limits for Marine Drilling Risers – Aluminum

DRILLING RISER - TITANIUM AUXILIARY LINES			
DESIGN PARAMETER	RISER CONNECTED		RISER DISCONNECTED
	DRILLING	NON-DRILLING	
Maximum VME Stress (METH "B") Deepwater Well	0.67*minimum yield point (**87.1 ksi**)	0.67*minimum yield point **(87.1 ksi)**	0.67*minimum yield point (**87.1 ksi**)

Figure 54. Design and Operating Limits for Marine Drilling Risers – Titanium

DRILLING RISER - COMPOSITE AUXILIARY LINES			
DESIGN PARAMETER	RISER CONNECTED		RISER DISCONNECTED
	DRILLING	NON-DRILLING	
Maximum VME Stress (METH "B") Deepwater Well	0.67*minimum yield point (**388.6 ksi**)	0.67*minimum yield point **(388.6 ksi)**	0.67*minimum yield point (**388.6 ksi**)

Figure 55. Design and Operating Limits for Marine Drilling Risers – Composite Materials

4.4 Dynamic Analyses – Frequency and Time Domain

Maximum VME Stress in Drilling Riser

As with most marine structures the maximum Von Mises (VME) stress must be controlled. Depending on the material being used, the marine drilling riser has a minimum yield point of 70 ksi for aluminum, 80 ksi for steel, 130 ksi for titanium and 550 ksi for composite materials.

The maximum VME stresses are summarized in figures 56 to 58. The maximum allowable stress depends on the material being used. Note that the non-drilling mode covers operations such as circulating and tripping the drill-pipe. However, rotating the drill-pipe is covered by the drilling mode. These figures plot the VME stress as a function of the Chikyu vessel offset for the following cases:

- Drilling with seawater (1.03 SG/8.6 ppg) and mud (1.44 SG/12.0 ppg) at Cocos Plate;
- Drilling with seawater (1.03 SG/8.6 ppg) and mud (1.44 SG/12.0 ppg) at Hawaii;
- Drilling with seawater (1.03 SG/8.6 ppg) and mud (1.44 SG/12.0 ppg) at Baja

One can note that when drilling with seawater, the stresses in the riser are just below the maximum allowable. However, when using a fluid to drill that is heavier than seawater, the Chikyu operating envelope is greatly reduced for the Cocos Plate (i.e. 3657m of water) and shows the limits of steel riser in water depths greater than 3657m where API maximum allowable stresses criteria in the drilling riser cannot be satisfied. However, when using titanium or composite materials, this criteria is satisfied for a wide range of vessel offset.

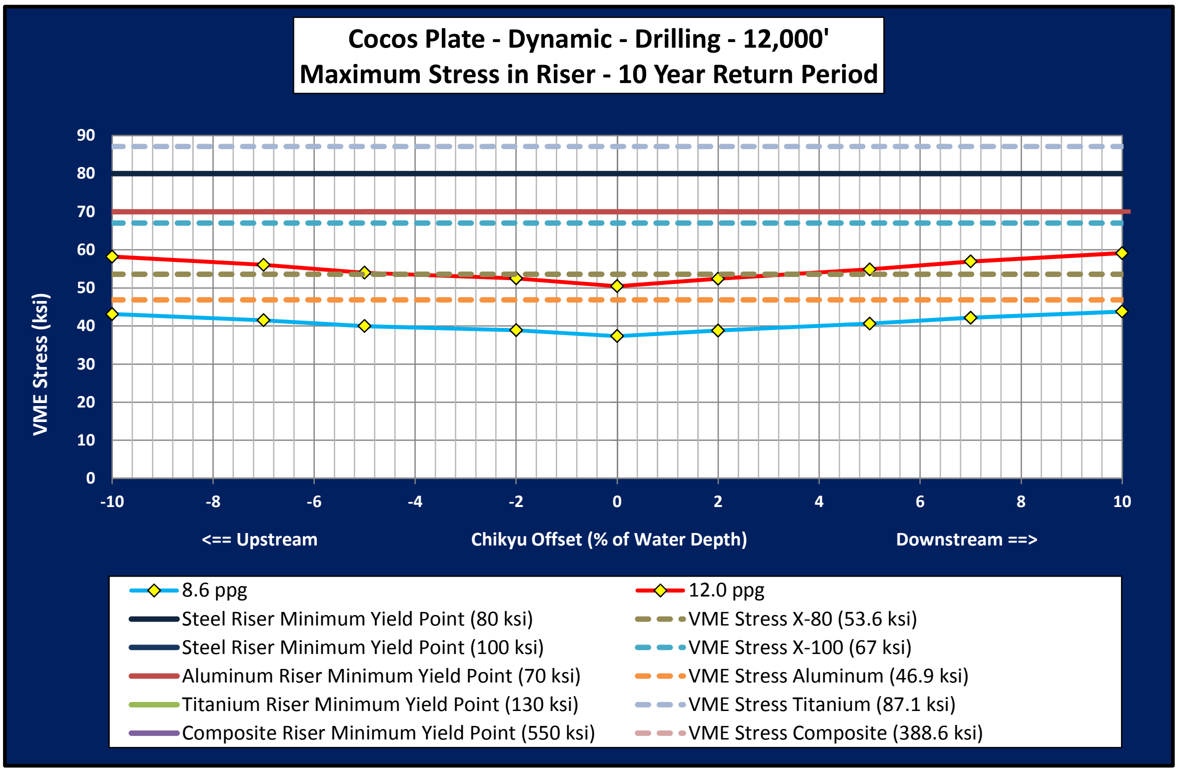


Figure 56. VME Stress – Cocos Plate – 10 Year Return

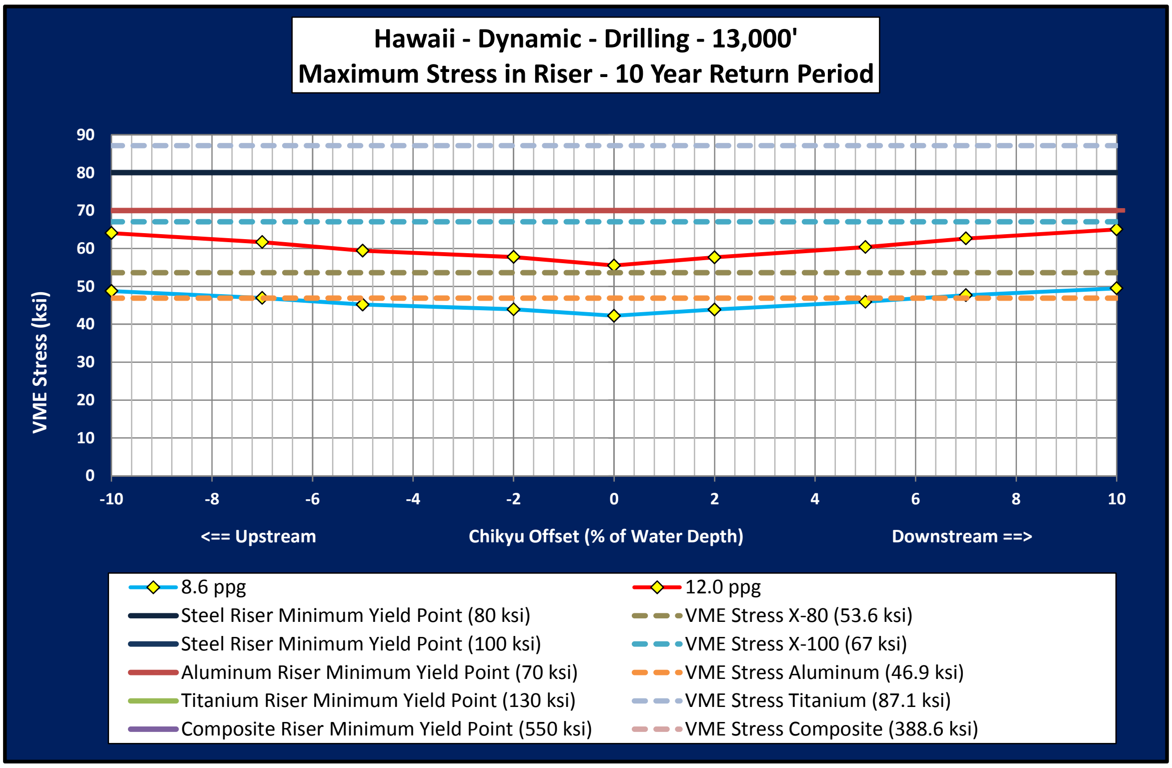


Figure 57. VME Stress – Hawaii – 10 Year Return

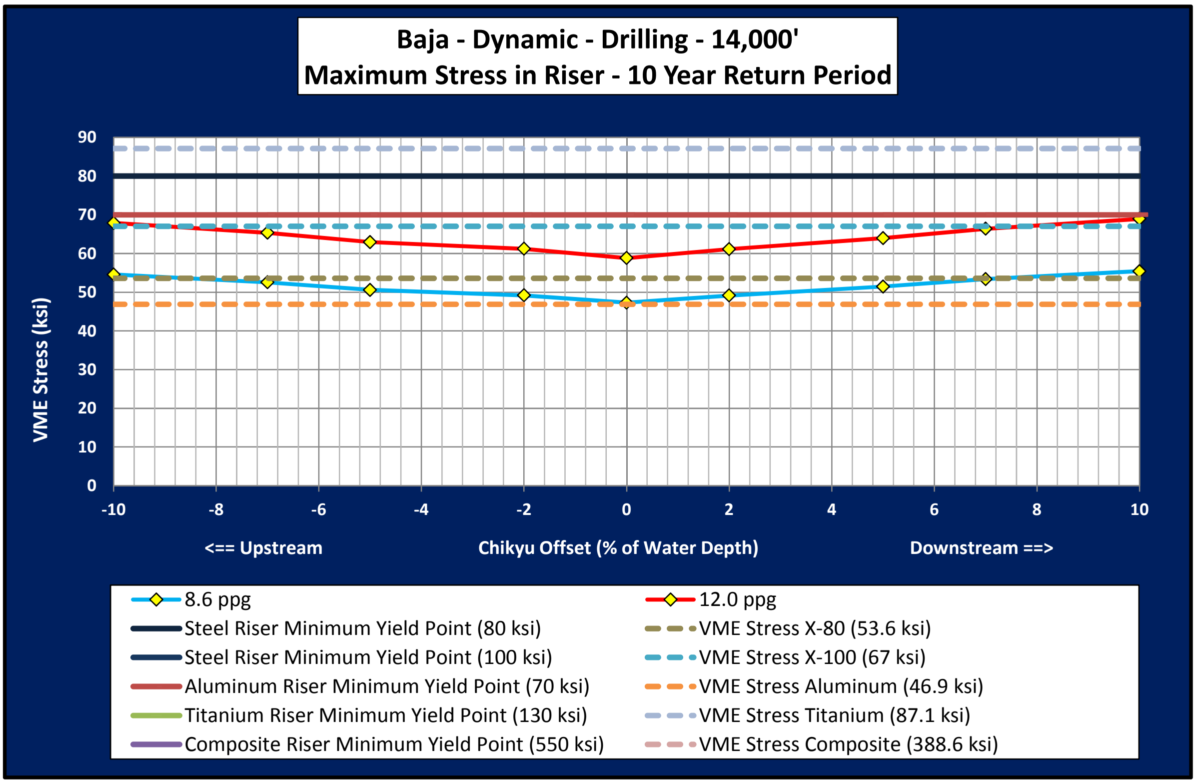


Figure 58. VME Stress – Time Domain – 10 Year Return

Maximum Slip Joint Stroke

As the vessel heaves and moves off location the slip joint (i.e. telescopic joint) strokes in and out to maintain a connection with the marine drilling riser and the Chikyu while keeping the tension constant at the top of the riser. The slip joint on the Chikyu has a limitation of about 60-foot stroke.

Figure 59 plots the telescopic joint stroke as a function of vessel offset for the following cases:

- Drilling with seawater (1.03 SG/8.6 ppg) and mud (1.44 SG/12.0 ppg) at Cocos Plate;
- Drilling with seawater (1.03 SG/8.6 ppg) and mud (1.44 SG/12.0 ppg) at Hawaii;
- Drilling with seawater (1.03 SG/8.6 ppg) and mud (1.44 SG/12.0 ppg) at Baja

One can note that for the different dynamic analyses, the maximum stroke of the telescopic joint remains below the maximum allowable stroke of the slip joint present onboard the Chikyu vessel when the vessel offset is ranging between -9% to -7% and +7% to +9% depending on the water depths (i.e. 3657m – 4267m) and drilling fluid (i.e. 1.03-1.44 SG).

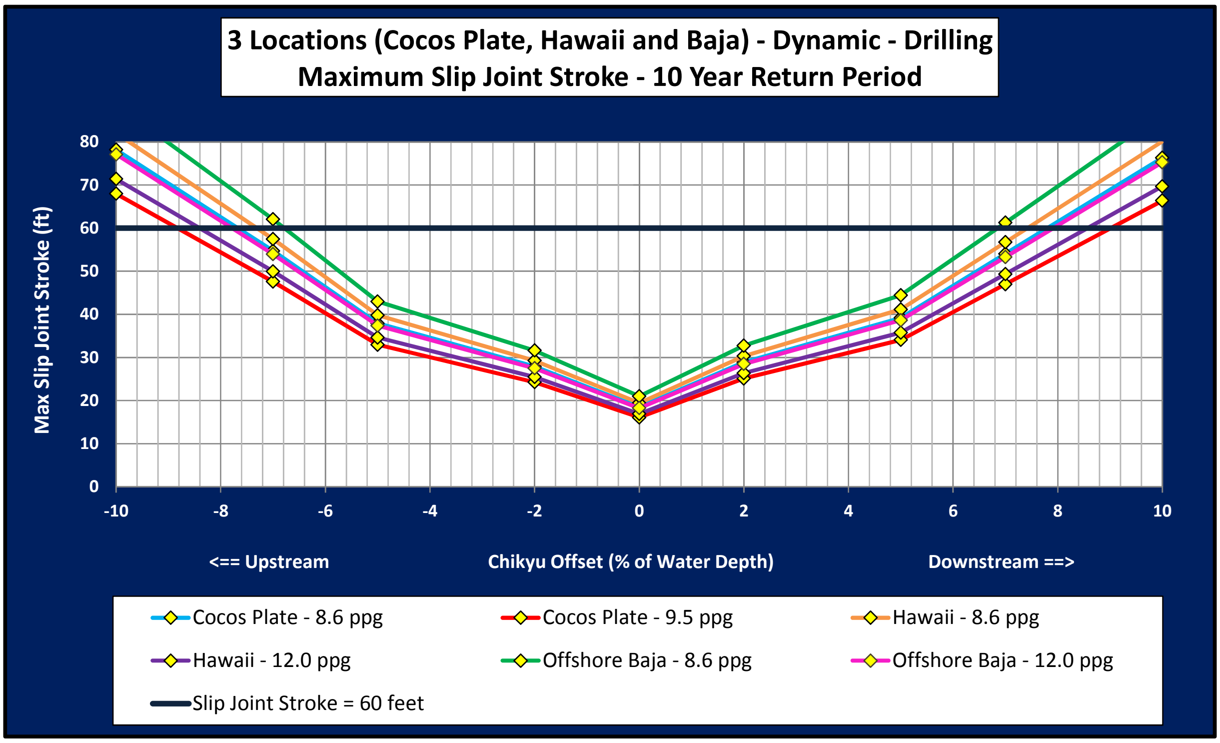


Figure 59. Maximum Slip Joint Stroke – 3 Offshore Locations – 10 Year Return

Rotation at Top of Riser (Upper Flex Joint)

This is the rotation which occurs at the top of the marine drilling riser. During the non-drilling period of 10 year return, the maximum riser angle should not exceed 9 degrees and the mean angle should not exceed 4 degrees to prevent the flex / ball joint from severe damage. Figure 60 summarizes respectively the mean rotation at the top of the riser for the following cases:

- Drilling with seawater (1.03 SG/8.6 ppg) and mud (1.44 SG/12.0 ppg) at Cocos Plate;
- Drilling with seawater (1.03 SG/8.6 ppg) and mud (1.44 SG/12.0 ppg) at Hawaii;
- Drilling with seawater (1.03 SG/8.6 ppg) and mud (1.44 SG/12.0 ppg) at Baja

As one can see, because of the maximum allowable rotation at the upper flex joint, the vessel operating window is comprised between -3.5% and +2%.

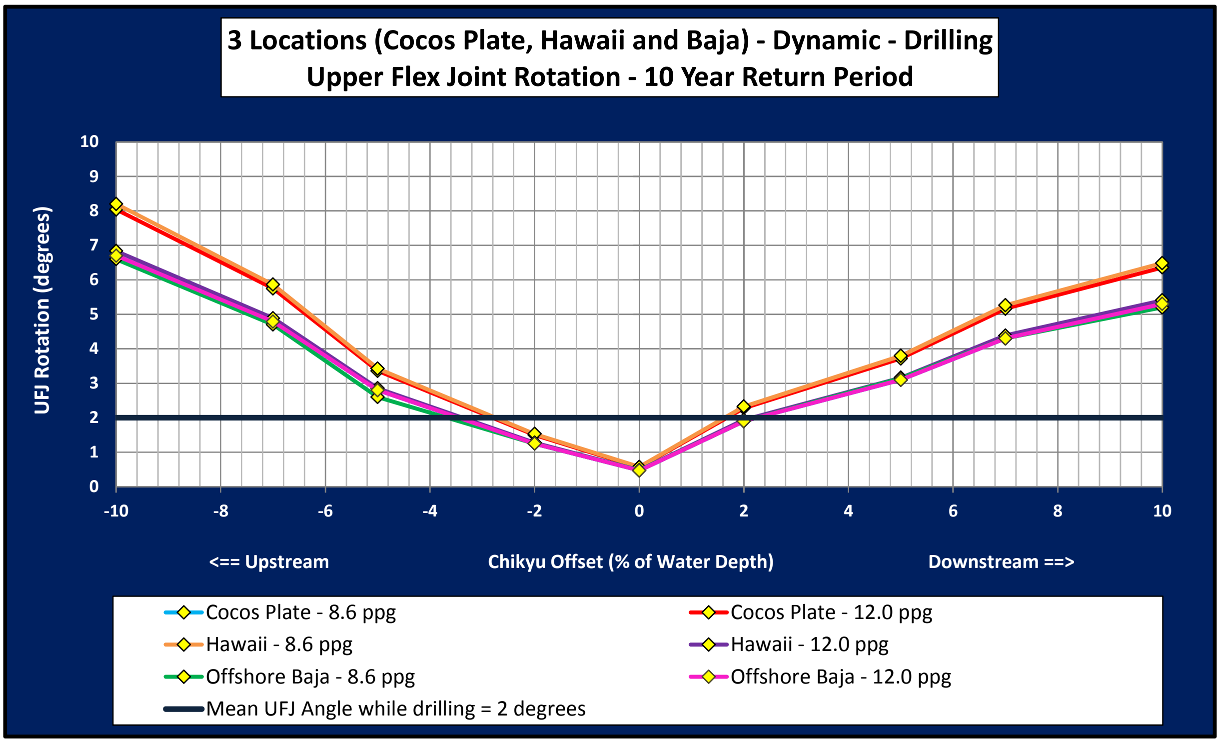


Figure 60. Mean Upper Flex Joint Rotation – 3 Offshore Locations – 10 Year Return

Rotation at BOP Flex Joint (Lower Flex Joint)

This is the rotation which occurs at the top of the BOP (flex joint). Figure 61 summarizes respectively the mean rotation at the top of the BOP for the following cases:

- Drilling with seawater (1.03 SG/8.6 ppg) and mud (1.44 SG/12.0 ppg) at Cocos Plate;
- Drilling with seawater (1.03 SG/8.6 ppg) and mud (1.44 SG/12.0 ppg) at Hawaii;
- Drilling with seawater (1.03 SG/8.6 ppg) and mud (1.44 SG/12.0 ppg) at Baja

As one can see, because of the maximum allowable rotation at the upper flex joint, the vessel operating window is comprised between -7% and +5%.

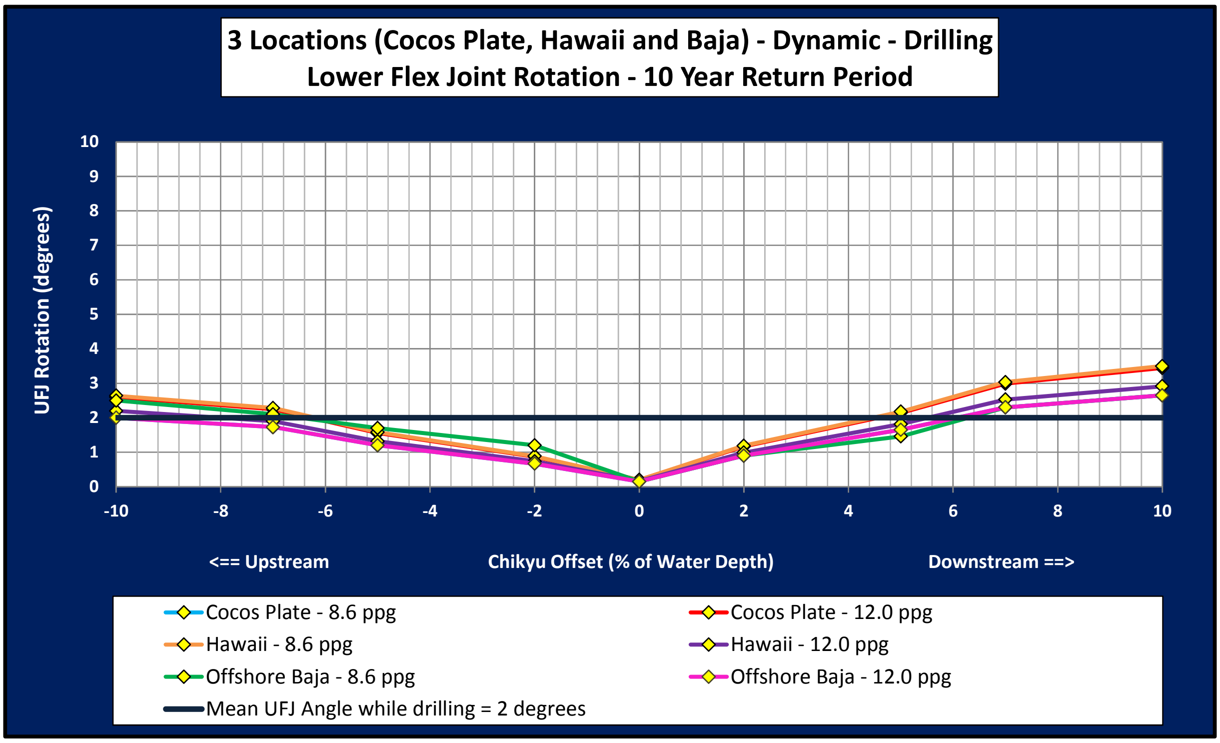


Figure 61. Mean Lower Flex Joint Rotation – 3 Offshore Locations – 10 Year Return

Hang-Off Analysis Results

Hang-off analysis can be divided into two sub-analysis:

- Drilling riser soft hang-off;
- Drilling riser hard hang-off

Soft hang-off analysis covers the scenario when the drilling riser is still connected to (i.e. hanging on) the tensioning system and where the telescopic joint supports the weight of the drilling riser.

Hard hang-off analysis covers the case when the drilling riser is locked in the riser spider and gimbal components at the rig floor with the tensioning system being disconnected and also where the telescopic joint is collapsed.

From both frequency domain and time domain dynamic analyses, the rotation of the upper flex joint for either soft hang-off or hard hang-off (0.5 degrees) remains well below the allowable mean upper flex joint rotation (2.0 degrees). In addition, the minimum moon-pool clearance has been calculated at about 3.57m (11.7 ft) which is also well within the Chikyu moon-pool usable opening.

In conclusion, during the disconnected mode, riser hang-off will not be an issue even during the 10 year return period for wave and current.

Chikyu Operating Window

Figure 62 summarizes the operating window for the Chikyu drill-ship following API RP 16Q operating envelope. Note that the operating window is mainly limited by the VME stress. However, the rotation of the flex joints and telescopic joint stroke while drifting off location are somehow a limiting factor as well.

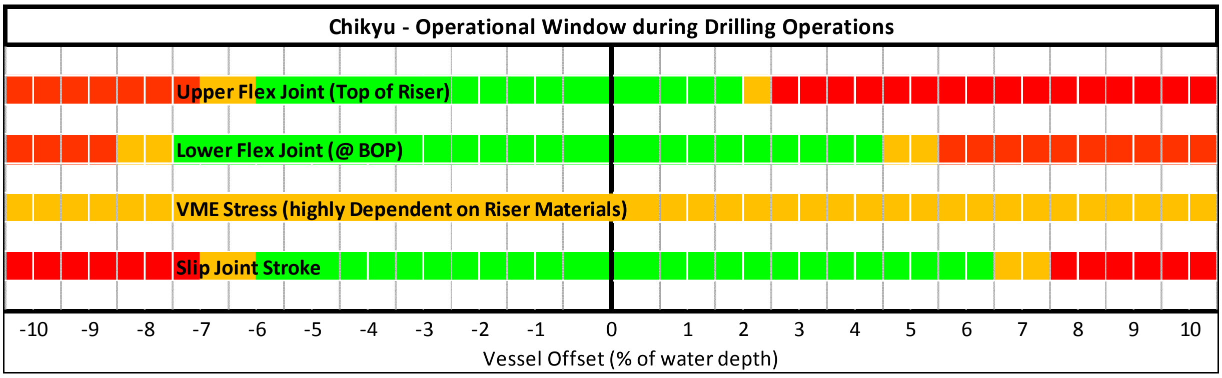


Figure 62. Chikyu Operating Window – Drilling Mode

Modal Analysis

Modal analysis is run to identify the dynamic behavior of a structural member when submitted to a given loading condition. Periodic loadings usually are of the most interest for the structural dynamic engineer and therefore are often a mandatory check for drilling risers that are submitted to periodic loadings such as wave and current. The main responses from a modal analysis are the natural frequencies associated to the Eigenvalues and also the deformed shaped of the Eigen modes (i.e. mode shapes).

Theoretically, an infinite number of modes for a vibrating structural member such as a drilling riser are possible. The contribution of higher modes towards the response is usually considered to be more negligible than the first modes. Note that in computation and for this VIV study, the first 50 modes have been calculated and are listed in Figure 63

Eigenpair No.	Period (s)	Frequency (Hz)	Eigenpair No.	Period (s)	Frequency (Hz)
1	157.5926	0.0063	26	11.6622	0.0857
2	157.565	0.0063	27	10.8248	0.0924
3	75.8509	0.0132	28	10.8179	0.0924
4	75.7952	0.0132	29	10.1071	0.0989
5	50.934	0.0196	30	10.1005	0.099
6	50.8989	0.0196	31	9.4675	0.1056
7	37.939	0.0264	32	9.4617	0.1057
8	37.9114	0.0264	33	8.909	0.1122
9	30.4521	0.0328	34	8.9032	0.1123
10	30.4307	0.0329	35	8.4126	0.1189
11	25.286	0.0395	36	8.4075	0.1189
12	25.2678	0.0396	37	7.966	0.1255
13	21.7361	0.046	38	7.961	0.1256
14	21.7209	0.046	39	7.568	0.1321
15	18.9602	0.0527	40	7.5634	0.1322
16	18.9471	0.0528	41	7.2018	0.1389
17	16.8851	0.0592	42	7.1973	0.1389
18	16.8734	0.0593	43	6.8781	0.1454
19	15.1648	0.0659	44	6.874	0.1455
20	15.1545	0.066	45	6.5738	0.1521
21	13.807	0.0724	46	6.5697	0.1522
22	13.7976	0.0725	47	6.3041	0.1586
23	12.6327	0.0792	48	6.3003	0.1587
24	12.6245	0.0792	49	6.0481	0.1653
25	11.6701	0.0857	50	6.0444	0.1654

Figure 63. Modal Analysis – Modes from 1 to 50 – 8.6 ppg mud – 14,000 feet Water Depth

The figure shown above lists the first 50 Eigenvalues and their associated periods and frequencies. Note that for the 1st mode, the Eigen period is about 157 seconds and thus the Eigen frequency is 0.006 Hertz.

4.5 Vortex Induced Vibrations Screening

Introduction

When any fluid flow passes through a structural member such as a drilling riser, it may cause an unsteady flow pattern due to vortex shedding. The current state of laboratory work is mainly focused on the interaction of a circular cylinder with only one degree of freedom (i.e. transverse motion) under a two or three dimensional flow.

Vortex Induced Oscillations

When the vortex shedding frequency $f_{shedding}$ of the drilling riser coincides with one of the natural frequencies f_n of the structural member (i.e. drilling riser) for a given critical current velocity, resonance vibrations occur (i.e. VIV). The phenomenon of lock-in mechanism takes place when the vortex shedding frequency approaches the natural frequency of the drilling riser. As discussed previously, the vortex shedding frequency follows the Strouhal number and current velocity relationship. Lock-in to one of the casing Eigen frequencies can be divided into two types of VIV:

1. In-line VIV which is a vibration mode where the casing vibrates in a pattern parallel with the incident current flow.
2. Cross-flow VIV which is a vibration mode where the casing moves perpendicularly to the fluid flow.

The results of the VIV analysis using *SHEAR7* are shown below.

VIV Analysis - Response Parameters - Generic Case - 14,000 Feet
Fundamental natural frequency = 0.00635 (Hz)
Maximum flow velocity = 3.000 ft/s
Minimum flow velocity = 0.2500 ft/s
The highest Strouhal frequency is: 0.18758 (Hz)
The lowest Strouhal frequency is: 0.01066 (Hz)
Minimum wavelength corresponding to the maximum flow velocity = 800 (ft)

Figure 64. VIV Analysis – Main Parameters Calculations

Riser Fatigue Assessment

Figure 65 below presents the fatigue damage and fatigue life in years for the drilling riser calculated at eleven different locations along the entire water column (i.e. 4267m). It appears that the fatigue life (i.e. unfactored without any factor if safety) ranges from 22 years to infinite (i.e. greater than a thousand years).

VIV Analysis - Fatigue Damage Calculations							
x/L	Depth below MSL (ft)	Displacement	A/D	Acceleration	Stress	Damage (1/years)	Fatigue (years)
0	Mean Sea Level	0.032	0.01	2.89E-02	3.86E-02	1.50E-07	6.67E+06
0.1	1,400	0.34	0.107	2.55E-01	1.92E-01	8.62E-05	1.16E+04
0.2	280	0.428	0.135	2.95E-01	2.18E-01	1.04E-04	9.62E+03
0.3	420	0.507	0.16	3.46E-01	2.49E-01	1.63E-04	6.13E+03
0.4	5,600	0.598	0.189	4.03E-01	2.86E-01	2.60E-04	3.85E+03
0.5	7,000	0.722	0.228	4.93E-01	3.42E-01	4.82E-04	2.07E+03
0.6	8,400	0.861	0.272	6.02E-01	3.94E-01	8.34E-04	1.20E+03
0.7	9,800	1.041	0.329	7.49E-01	5.56E-01	3.01E-03	3.32E+02
0.8	11,200	1.303	0.412	9.58E-01	8.20E-01	1.31E-02	7.63E+01
0.9	12,600	1.3081	0.436	1.11E+00	1.10E+00	4.51E-02	2.22E+01
1	Seabed	N/A	N/A	N/A	N/A	N/A	N/A

Figure 65. VIV Analysis – Fatigue Damage Calculations

4.6 Conclusions for the Drilling Riser Analysis

A detailed riser analysis using the most recent industry standards and software (*DeepRiser* and *SHEAR7*) has been carried out on the Chikyu drilling riser with extended buoyed joints to cover the ultra-deepwater depths of Cocos Plate, Hawaii or Baja locations. In addition, calculations and analyses were performed for hybrid configurations with aluminum, titanium and composite materials in order to show the limitations and benefits of advanced materials.

From this new set of analyses and sensitivity studies, it appears that steel riser can be used without changing current industry practices to a maximum of 3657m (12,000 ft) water depth and for certain drilling conditions (i.e. mud weight and metocean data). Beyond this water depth, some critical response from the drilling riser (i.e. VME stress) and riser components (i.e. rotation of the upper and lower joints) are violated per API 16Q criteria if steel riser is employed to drill an ultra-deepwater well. In order to push the envelope using steel material, the maximum allowable VME will have to be increased from 67% of minimum yield to a higher ratio. Note that API 16Q currently does not address riser response criteria for ultra-deepwater wells with water depth greater than 3048m (10,000 ft), and note also that the VME criteria is limited to 67% of minimum yield to avoid accounting for and tracking riser joint fatigue during the life of the riser. To push the envelope, and to be able to use steel riser for water depth greater than 3657m, a new set of riser response criteria will have to be develop internal and a design/operational risk assessment will have to be conducted. Regarding the VME maximum limit, this could very well be increased from 67% to 80% or 90% but the fatigue damage of the riser joints will also have to be monitored during the entire life of the drilling riser. This is feasible for drilling operations conducted with the Chikyu since it currently uses a riser monitoring system which is capable of tracking stress and fatigue in the drilling riser. Also, tests to increase the mean rotation angle that can be allowed at the two flex joints will have be performed. Again, this does not constitute a real problem and can be achieved when working closely with the riser component manufacturer and a testing facility.

However, the technical solution that would follow current API 16Q riser response criteria and that will enable to drill in water depths up to 4267m (i.e. Hawaii and Baja) will be to use hybrid riser joints or riser joints with advanced materials such as titanium or composite. The high minimum yield and strength to weight ratio of titanium and composite materials relative to steel would not require any adjustment to API 16Q recommended practices criteria, or a need for riser component limits, or even risk assessments. Nonetheless, the high cost associated with titanium and lack of experience with composite materials for ultra-deepwater offshore applications can be seen as a different technical limitation for conducting drilling operations in water depths greater than 3657m (12,000 ft). Composite materials seem very attractive, but composite materials have not been tested or field deployed for deepwater drilling riser systems. Indeed, the ability to keep the same weight and strength for a given riser joint made of composite material as well as maintaining the structural integrity of the drilling riser connectors remain a great challenge to be resolved.

5 Revised Operational Time Estimates

The High Impact System study included a revised operational time estimate for the Base Case wellbore configuration at the Hawaii location to demonstrate how the overall operational time can be reduced using the technology currently available in the oil and gas industry. This report expands on that work to include nominal time estimates for the three wellbore configuration options discussed in Section 3.1 at all three candidate locations. In addition, a probabilistic methodology for estimating operational time was also used to gain a better understanding of the effect of the uncertainty around bit performance. As shown in the following table (and detailed in Appendix 1), Minimum, Most Likely, and Maximum values of ROP and bit life were assigned, and the operational time for each of the 18 cases was calculated using a Monte Carlo simulator to provide P10, P50, and P90 values in addition to the nominal time estimate. Finally, the operations options were expanded from RCB Core and Drill to include Conventional Coring and Underreaming or Hole Opening.

Rate of Penetration	RCB Core			Drill			Conv Core			UR/HO		
by Formation (m/hr)	Low	ML	High	Low	ML	High	Low	ML	High	Low	ML	High
Sediments	2.4	4.0	15.2	9.1	21.3	30.5	3.0	12.2	15.2	9.1	12.2	24.4
Lava	1.2	2.1	6.1	3.0	9.1	21.3	1.5	4.6	6.1	3.0	7.6	9.1
Dikes	1.2	2.1	6.1	3.0	9.1	21.3	1.5	4.6	6.1	3.0	7.6	9.1
Textured Gabbros	1.2	2.1	6.1	3.0	9.1	21.3	1.5	4.6	6.1	3.0	7.6	9.1
Foliated Gabbros	0.9	1.5	2.4	1.5	3.0	9.1	1.5	2.4	4.6	1.5	2.4	6.1
Layered Gabbros	0.9	1.5	2.4	1.5	3.0	9.1	1.5	2.4	4.6	1.5	2.4	6.1
Mantle	0.9	1.2	2.1	1.5	1.8	6.1	0.9	1.5	3.0	0.9	1.5	4.6

Bit Life (hrs)	Bit Life		
	Low	ML	High
<= 6706m	30	110	150
> 6706m	20	70	110

Figure 66. Stochastic ROP Variable Ranges

Note that the operational estimates were done only for drill/core options B and D as previously described in Section 2.1.3 since these adequately illustrate the philosophical differences between the amount of time spent coring versus time spent drilling.

<u>Key Assumptions</u>

- The assumptions used to develop the operational sequences for each case are consistent with what was done during the Feasibility Study in order to allow a meaningful comparison between the two. As such, they are not necessarily optimized. For example, a hole opening run after a core run could be done while drilling the next section, but for this exercise, they are considered to be separate operations.

- Operational time is defined as the time spent on location drilling/coring to the mantle. The overall project time includes the operational time and the time required to mobilize the Chikyu to and from the location.

- It is assumed that the Chikyu would be mobilized from Japan to the site and then be de-mobilized back to Japan at the conclusion of the project. Note that this transit time is considered to be a set number of days and is not considered in the probabilistic calculations.

Location	Mobilization		De-Mobilization		Total
	Distance (km)	Time (days)	Distance (km)	Time (days)	Time
Cocos	10,622	23.9	10,622	23.9	47.8
Hawaii	5,955	13.4	5,955	13.4	26.8
Baja	8,047	18.1	8,047	18.1	36.2

Figure 67. Mob / De-Mob Assumptions

- To simplify the calculations, it is assumed that a bit trip is made at each stratigraphic transition. This will tend to slightly overestimate the number of bit trips that are required. In addition, conventional core barrel runs are treated like bit runs. This will tend to slightly underestimate the number of trips required since the length of the core barrel is not considered over the cored interval.

- It is assumed that the largest hole size that can be conventionally cored without having to open the hole after coring is 14-3/4". The maximum hole size that can be rotary cored with having to open the hole is 9-7/8".

- It is assumed that 2 days are spent running wireline logs at each casing point, and 3 days at TD.

- The RCB wireline trip time and bit trip time assumptions are the same as what was used during the Feasibility Study.

- The nominal time is determined using the most likely values of ROP and bit life. The P10, P50, and P90 values are determined only for the operational time estimate using the full range of possible ROP's using the Monte Carlo simulator.

- 5% non-productive time (NPT) is assumed to account for down-hole related problems based on previous IODP experience. This does not include weather or rig equipment related NPT.

5.1 Results Summary

A summary of the revised operational time estimates for all three locations is provided below. Figure 68 is a tabular listing of results for all 18 cases. Figures 69 through 71 graphically compare the results of each case by location, and Figures 72 through 74 compare the drilling curves for each case by location. The detailed results for each case are provided in the subsequent sections.

Recall that:

- Case 2: Assumes that long sections of continuous core are taken across the major lithologic and geophysical transition intervals of key sections. For the time estimate it was assumed that the upper third of each main stratigraphic interval was cored, the middle third was drilled and the lower third was cored.

- Case 4: Assumes that the hole is drilled to the Moho and that just the mantle is cored.
- Subcategory "a" is the Base Case wellbore configuration.
- Subcategory "b' is the Deepwater wellbore configuration
- Subcategory "c' is the Expandable wellbore configuration.

Location	Water Depth (m)	Total Depth (m)	Case	Revised Operational Time (days)					Feasibility Study	
				Nominal	Project	P10	P50	P90	Nominal	Project
Cocos	3,650	9,900	2a	228	276	188	212	251	564	617
			2b	272	320	231	257	298	---	---
			2c	289	337	247	273	314	---	---
			4a	202	250	152	180	220	374	418
			4b	220	269	185	217	268	---	---
			4c	223	271	175	204	248	---	---
Hawaii	4,050	10,750	2a	271	298	232	260	303	688	737
			2b	319	346	280	310	362	---	---
			2c	341	368	294	324	375	---	---
			4a	221	248	165	198	252	422	443
			4b	242	239	185	217	268	---	---
			4c	244	271	188	223	275	---	---
Baja	4,300	10,400	2a	251	287	221	247	284	807	866
			2b	308	345	269	299	342	---	---
			2c	327	363	283	313	364	---	---
			4a	208	244	158	188	232	386	425
			4b	229	265	179	207	257	---	---
			4c	231	267	178	207	259	---	---

Figure 68. Operations Time Results for all Cases

Note that there has been a significant decrease in the latest time estimates compared to those of the original feasibility study. The average time for all the cases is 258 days. The lowest estimate is 152 days and the highest is 375 days.

- **Case comparison by location**

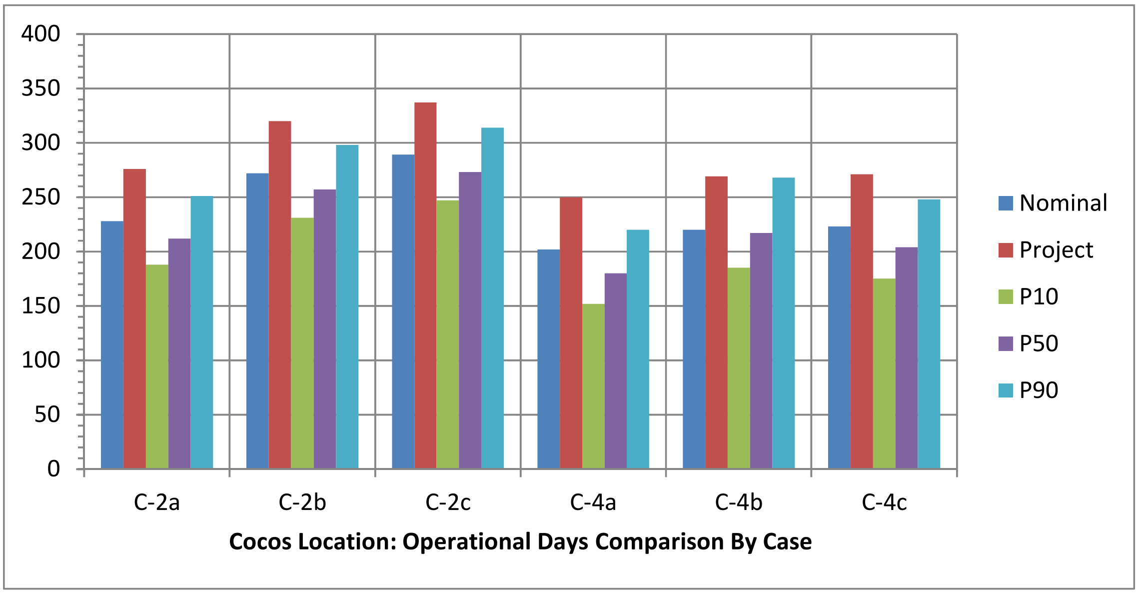


Figure 69.Cocos Location – Ops Time Comparison

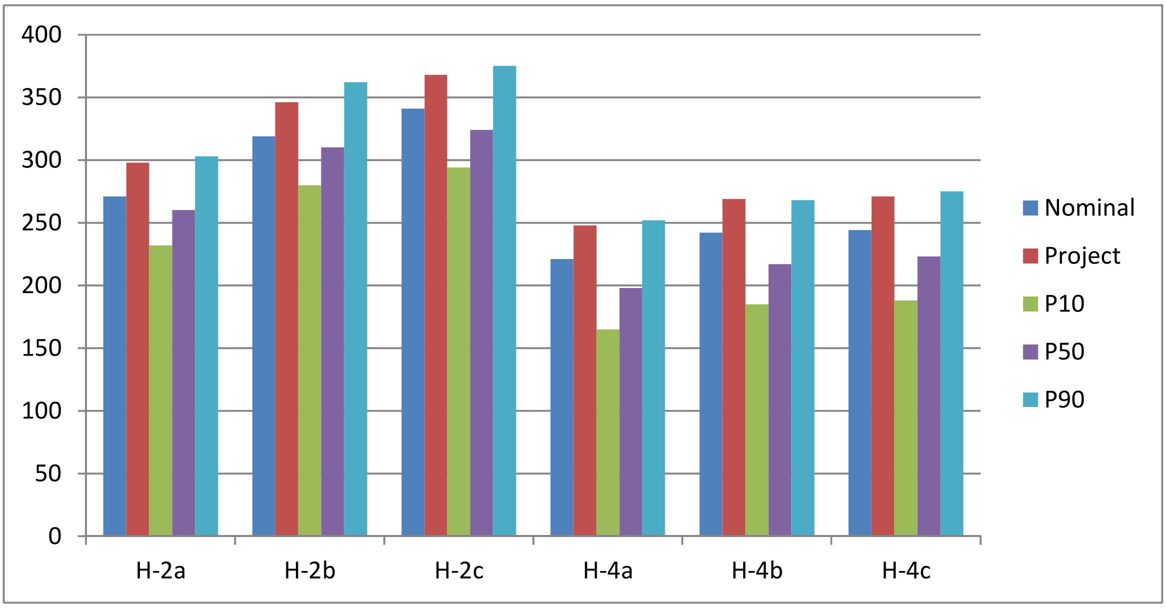


Figure 70. Hawaii Location – Ops Time Comparison

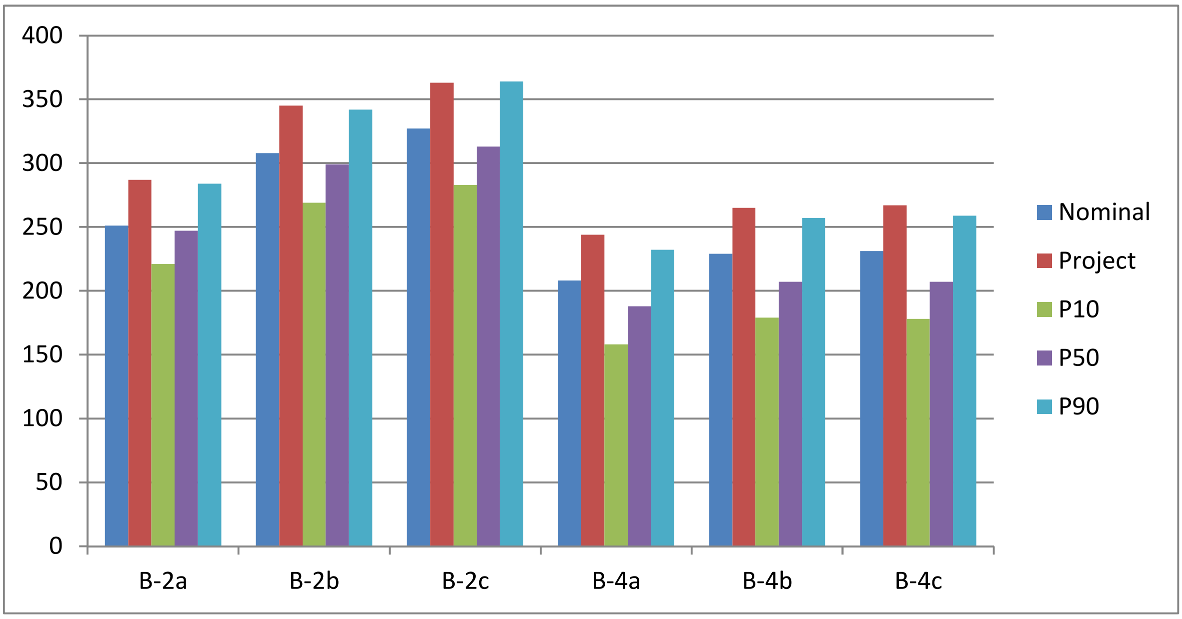


Figure 71. Baja Location – Ops Time Comparison

- **<u>Drilling curve comparison by location</u>**

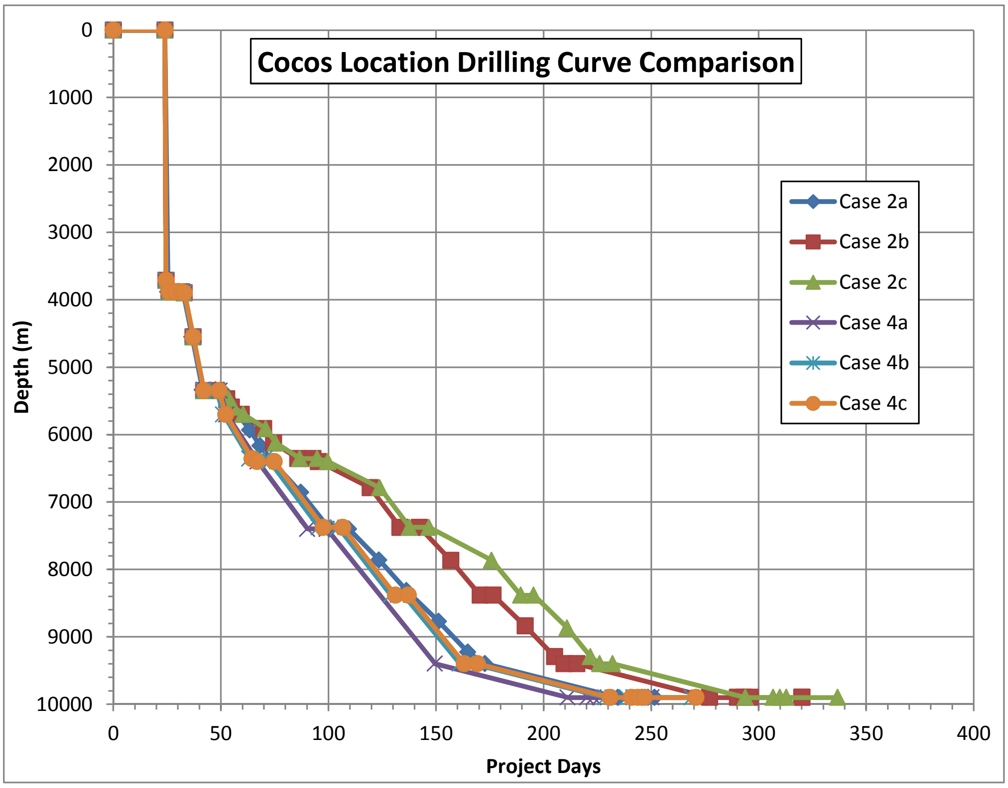


Figure 72. Cocos Location Drilling Curve Comparison

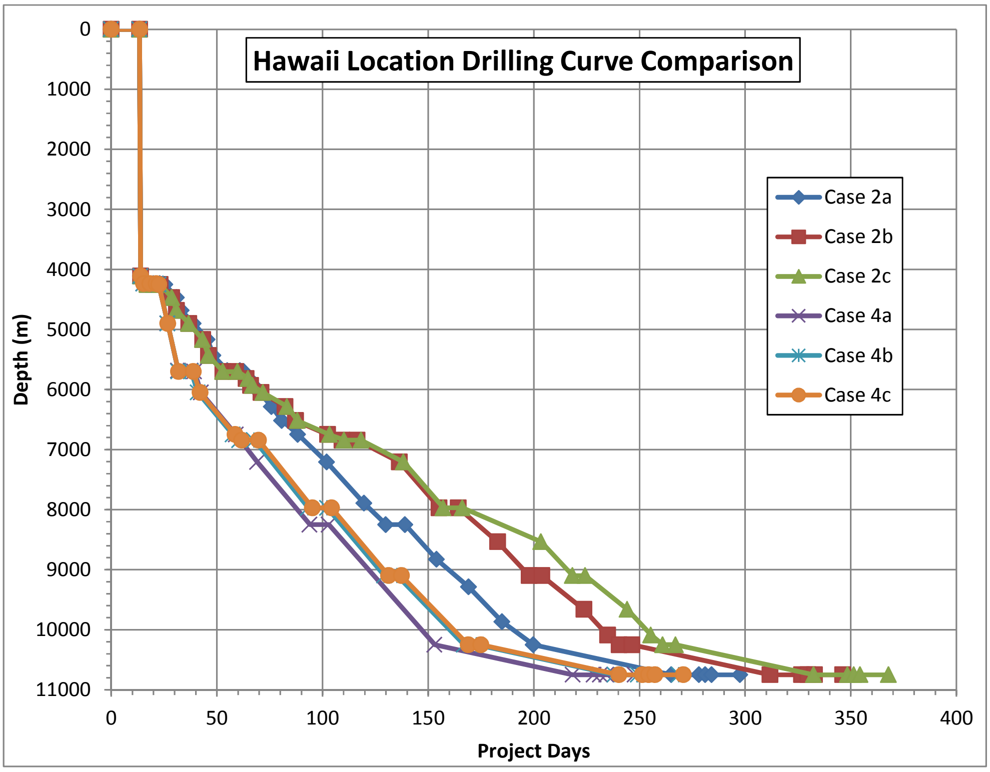


Figure 73. Hawaii Location Drilling Curve Comparison

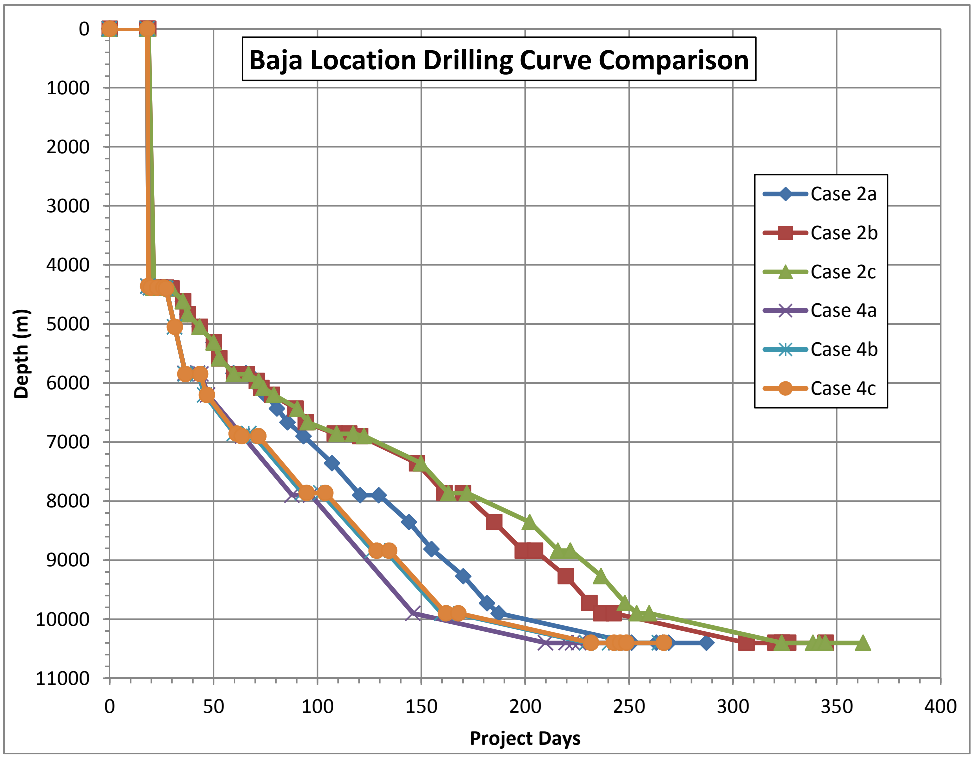


Figure 74. Baja Location Drilling Curve Comparison

5.2 Cocos Location Operational Time Estimates

5.2.1 Case 2a Operations Time:

This case assumes the original Base Case wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. However for the Cocos location it is assumed that the sediments, lava and dike intervals do not need to be cored because of previous IODP experience on the 1256D hole. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Move in rig	24.0					
Jet 30"	0.5	0.5	3,650	3,711	61	121.92
DRill Sediments	1.4	1.9	3,711	3,885	174	124
Set 20" casing	3.0	4.9				
Run BOP & Riser	3.0	7.9				
Drill Sediments	1.1	9.0	3,885	3,900	15	14
Drill Lava	4.1	13.1	3,900	4,550	650	159
Drill Dikes	4.9	18.0	4,550	5,335	785	160
Set 13-3/8" Casing	6.0	24.0				
Core/UR Dikes	3.2	27.2	5,335	5,350	15	5
Core Textured Gabbros	2.6	29.8	5,350	5,467	117	45
Drill Textured Gabbros	2.0	31.8	5,467	5,583	117	58
Core Textured Gabbros	2.6	34.4	5,583	5,700	117	45
Core Foliated Gabbros	5.6	40.0	5,700	5,933	233	42
Drill Foliated Gabbros	4.8	44.8	5,933	6,166	233	49
Core Foliated Gabbros	5.7	50.5	6,166	6,400	233	41
Core Layered Gabbros	13.2	63.7	6,400	6,857	457	35
Drill Layered Gabbros	13.3	77.0	6,857	7,400	543	41
Run 11-3/4" Liner	9.0	86.0				
Core Layered Gabbros	14.1	100.1	7,400	7,860	460	33
Drill Layered Gabbros	12.8	112.9	7,860	8,314	454	35
Core Layered Gabbros	14.9	127.8	8,314	8,772	457	31
Drill Layered Gabbros	13.6	141.4	8,772	9,229	457	34
Core Layered Gabbros	8.0	149.4	9,229	9,400	171	21
Core Mantle	61.8	211.2	9,400	9,900	500	8
5% Operational NPT	11.0	222.2				
TA hole	3.0	225.2				
Pull BOP/Riser	3.0	**228.2**				
De-Mobilize Rig	24.0					
Total Core/Drill Days =	**228**					
Total Project Days =	**276**					

Figure 75. Cocos Location - Case 2a: Operational Phase Summary

44% of the hole is cored, and 56% is drilled as shown below.

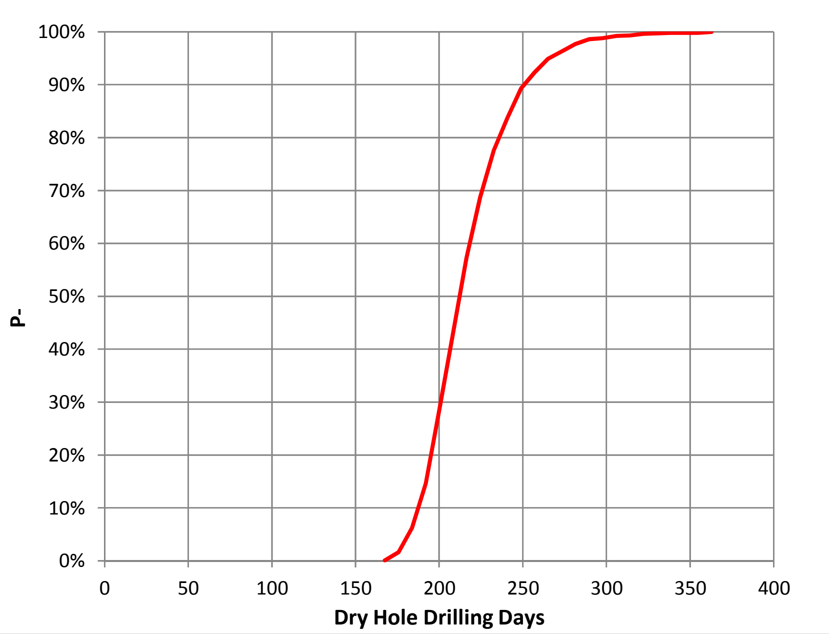
	Interval	%	Days
Coring =	2,761	44.2%	54
Drilling =	3,489	55.8%	31
	6,250	100%	85

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	3650	3711	61	Jetting	---	0.5	0	0	0	0.5	0.5
1	Sediments	3711	3885	174	Drill	21.3	0.3	1.0	0.0	6.0	7.4	7.9
2	Sediments	3885	3900	15	Drill	21.3	0.0	1.1	0.0	0.0	1.1	9.0
3	Lava	3900	4550	650	Drill	9.1	3.0	1.2	0.0	0.0	4.1	13.1
4	Dikes	4550	5335	785	Drill	9.1	3.6	1.4	0.0	6.0	10.9	24.0
5	Dikes	5335	5350	15	Conv Core	4.6	0.1	1.5	0.0	0.0	1.6	25.6
6	Dikes	5335	5350	15	UR	7.6	0.1	1.5	0.0	0.0	1.5	27.2
7	Textured Gabbros	5350	5467	117	Conv Core	4.6	1.1	1.5	0.0	0.0	2.5	29.7
8	Textured Gabbros	5467	5583	117	Drill	9.1	0.5	1.5	0.0	0.0	2.0	31.7
9	Textured Gabbros	5583	5700	117	Conv Core	4.6	1.1	1.5	0.0	0.0	2.6	34.4
10	Foliated Gabbros	5700	5933	233	Conv Core	2.4	4.0	1.6	0.0	0.0	5.6	39.9
11	Foliated Gabbros	5933	6166	233	Drill	3.0	3.2	1.7	0.0	0.0	4.8	44.8
12	Foliated Gabbros	6166	6400	233	Conv Core	2.4	4.0	1.7	0.0	0.0	5.7	50.5
13	Layered Gabbros	6400	6857	457	Conv Core	2.4	7.8	5.4	0.0	0.0	13.2	63.7
14	Layered Gabbros	6857	7400	543	Drill	3.0	7.4	5.8	0.0	9.0	22.3	86.0
15	Layered Gabbros	7400	7860	460	Conv Core	2.4	7.9	6.3	0.0	0.0	14.1	100.1
16	Layered Gabbros	7860	8314	454	Drill	3.0	6.2	6.6	0.0	0.0	12.8	113.0
17	Layered Gabbros	8314	8772	457	Conv Core	2.4	7.8	7.0	0.0	0.0	14.8	127.8
18	Layered Gabbros	8772	9229	457	Drill	3.0	6.3	7.4	0.0	0.0	13.6	141.4
19	Layered Gabbros	9229	9400	171	Conv Core	2.4	2.9	5.1	0.0	0.0	8.0	149.4
20	Mantle	9400	9900	500	RCB Core	1.2	17.1	15.8	25.8	3.0	61.7	211.2
						Sub-Total days =	**85**	**77**	**26**	**24**	**211**	
						Sub-Total % =	**40%**	**36%**	**12%**	**11%**	**100%**	

Figure 76. Cocos Location - Case 2a: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	168
P-10	**188**
P-50	**212**
P-90	**251**
Observed Maximum	363

Figure 77. Cocos Location - Case 2a: Probabilistic Time

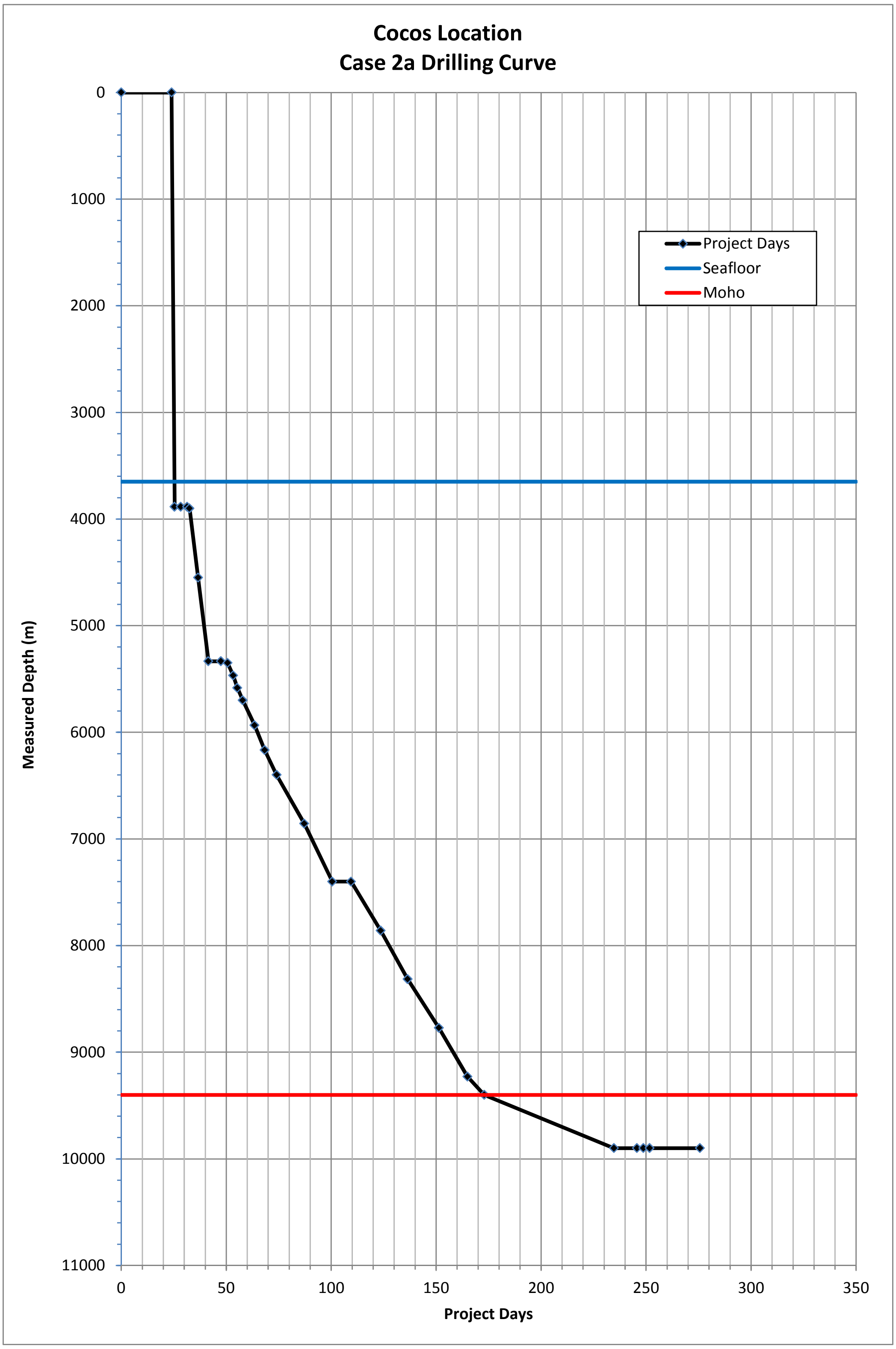


Figure 78. Cocos Location – Case 2a Drilling Curve

5.2.2 Case 2b Operations Time:

This case assumes the Deepwater case wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. However for the Cocos location it is assumed that the sediments, lava and dike intervals do not need to be cored because of previous IODP experience on the 1256D hole. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Move in rig	24.0					
Jet 36"	0.5	0.5	3,650	3,711	61	122
Drill Sediments	1.4	1.9	3,711	3,885	174	124
Set 20" casing	3.0	4.9	0	0	0	0
Run BOP & Riser	3.0	7.9	0	0	0	0
Drill Sediments	1.1	9.0	3,885	3,900	15	14
Drill Lava	4.1	13.1	3,900	4,550	650	159
Drill Dikes	5.0	18.1	4,550	5,350	800	160
Set 18" Casing	6.0	24.1				
Core/UR Textured Gabbros	4.7	28.8	5,350	5,471	121	26
Drill Textured Gabbros	2.1	30.9	5,471	5,593	122	58
Core/UR Textured Gabbros	4.6	35.5	5,593	5,700	107	23
Core/UR Foliated Gabbros	10.5	46.0	5,700	5,913	213	20
Drill Foliated Gabbros	4.6	50.6	5,913	6,127	213	46
Core/UR Foliated Gabbros	11.2	61.8	6,127	6,355	229	20
Set 16" Casing	7.0	68.8				
Core/UR Foliated Gabbros	2.5	71.3	6,355	6,400	45	18
Core/UR Layered Gabbros	24.2	95.5	6,400	6,790	390	16
Drill Layered Gabbros	13.8	109.3	6,790	7,376	586	42
Run 13-3/8" Casing	9.0	118.3				
Core Layered Gabbros	14.6	132.9	7,376	7,864	488	33
Drill Layered Gabbros	13.7	146.6	7,864	8,382	518	38
Run 11-3/4" Liner	6.0	152.6				
Core Layered Gabbros	14.9	167.5	8,382	8,839	457	31
Drill Layered Gabbros	13.7	181.2	8,839	9,297	457	33
Core Layered Gabbros	4.3	185.5	9,297	9,400	104	24
Run 9-5/8" Liner	6.0	191.5				
Core Mantle	61.7	253.2	9,400	9,900	500	8
5% Operational NPT	13.0	266.2				
TA hole	3.0	269.2				
Pull BOP/Riser	3.0	**272.2**				
De-Mobilize Rig	24.0					

Total Core/Drill Days =	**272**
Total Project Days =	**320**

Figure 79. Cocos Location - Case 2b: Operational Phase Summary

43% of the hole is cored, and 56% is drilled as shown below.

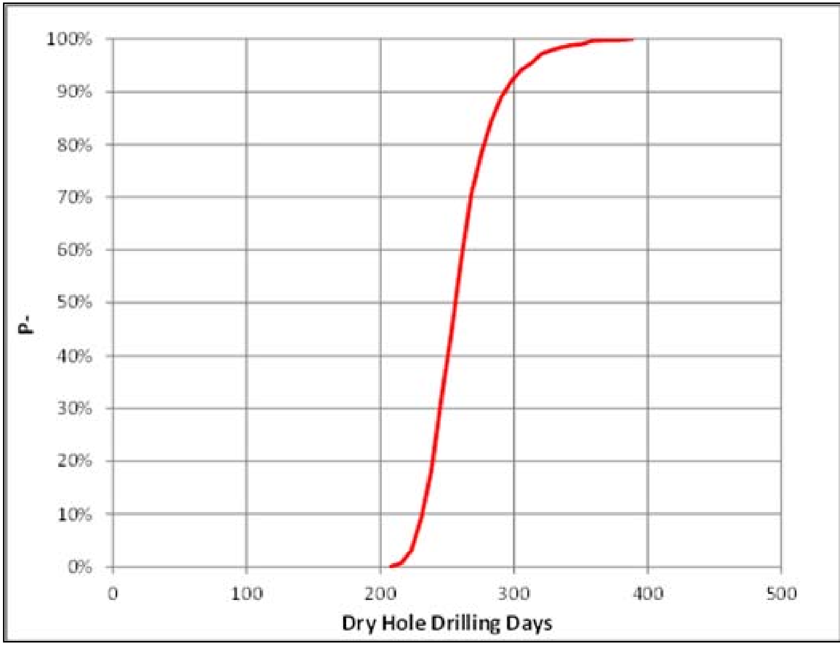
	Interval	%	Days
Coring =	2,654	42.5%	68
Drilling =	3,596	57.5%	32
	6,250	100%	100

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	3650	3711	61	Jetting	---	0.5	0	0	0	0.5	0.5
1	Sediments	3711	3885	174	Drill	17.4	0.4	1.0	0.0	0.0	1.5	2.0
2	Sediments	3885	3900	15	Drill	17.4	0.0	1.1	0.0	6.0	7.1	9.1
3	Lava	3900	4550	650	Drill	11.7	2.3	1.2	0.0	0.0	3.5	12.5
4	Dikes	4550	5350	800	Drill	15.4	2.2	1.4	0.0	6.0	9.5	22.0
5	Textured Gabbros	5350	5471	121	Conv Core	4.2	1.2	1.5	0.0	0.0	2.7	24.7
6	Textured Gabbros	5350	5471	121	UR	5.7	0.9	1.5	0.0	0.0	2.4	27.1
7	Textured Gabbros	5471	5593	122	Drill	18.3	0.3	1.5	0.0	0.0	1.8	28.9
8	Textured Gabbros	5593	5700	107	Conv Core	4.2	1.1	1.5	0.0	0.0	2.6	31.5
9	Textured Gabbros	5593	5700	107	UR	5.7	0.8	1.5	0.0	0.0	2.3	33.8
10	Foliated Gabbros	5700	5913	213	Conv Core	2.9	3.1	1.6	0.0	0.0	4.6	38.5
11	Foliated Gabbros	5700	5913	213	UR	1.9	4.7	3.2	0.0	0.0	7.8	46.3
12	Foliated Gabbros	5913	6127	213	Drill	3.4	2.6	1.6	0.0	0.0	4.2	50.5
13	Foliated Gabbros	6127	6355	229	Conv Core	2.9	3.3	1.7	0.0	0.0	5.0	55.5
14	Foliated Gabbros	6127	6355	229	UR	1.9	5.0	3.4	0.0	7.0	15.4	70.9
15	Foliated Gabbros	6355	6400	45	Conv Core	2.9	0.6	1.7	0.0	0.0	2.4	73.3
16	Layered Gabbros	6400	6790	390	Conv Core	3.4	4.7	3.6	0.0	0.0	8.3	81.7
17	Layered Gabbros	6400	6790	390	UR	4.1	4.0	3.6	0.0	0.0	7.6	89.2
18	Layered Gabbros	6790	7376	586	Drill	4.0	6.1	3.9	0.0	9.0	19.0	108.2
19	Layered Gabbros	7376	7864	488	Conv Core	3.4	5.9	4.2	0.0	0.0	10.1	118.3
20	Layered Gabbros	7864	8382	518	Drill	4.0	5.4	4.4	0.0	6.0	15.8	134.1
21	Layered Gabbros	8382	8839	457	Conv Core	3.4	5.6	4.7	0.0	0.0	10.3	144.4
22	Layered Gabbros	8839	9297	457	Drill	4.0	4.8	5.0	0.0	0.0	9.7	154.1
23	Layered Gabbros	9297	9400	104	Conv Core	3.4	1.3	2.6	0.0	6.0	9.8	163.9
24	Mantle	9400	9900	500	RCB Core	1.7	12.1	10.6	25.8	3.0	51.5	215.4
						Sub-Total days =	**79**	**68**	**26**	**43**	**215**	
						Sub-Total % =	**37%**	**32%**	**12%**	**20%**	**100%**	

Figure 80. Cocos Location - Case 2b: Operations Time Breakkdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	208
P-10	**231**
P-50	**256**
P-90	**293**
Observed Maximum	388

Figure 81. Cocos Location - Case 2b: Probabilistic Time

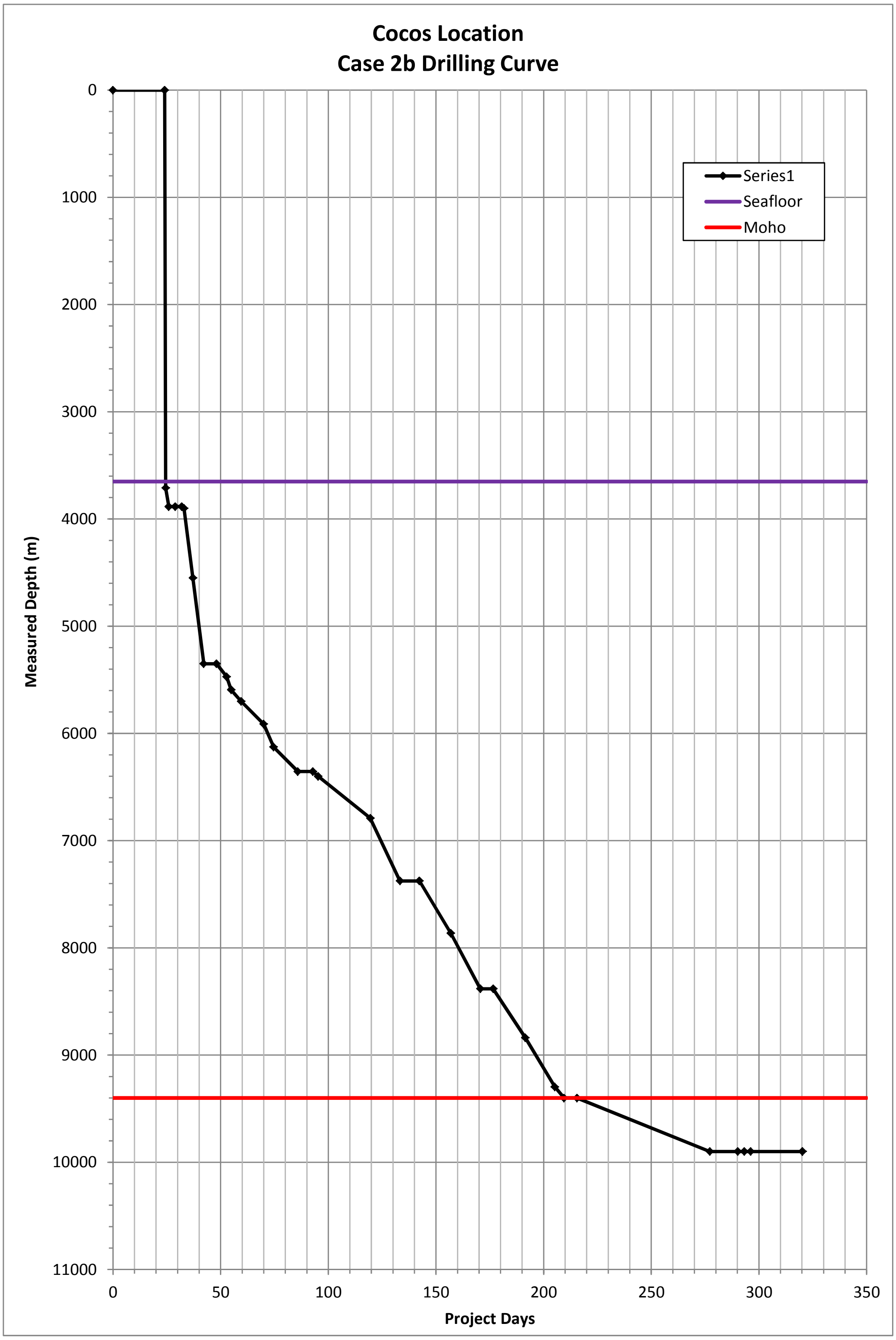


Figure 82. Cocos Location – Case 2b Drilling Curve

5.2.3 Case 2c Operations Time:

This case assumes the Expandable Case wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. However for the Cocos location it is assumed that the sediments, lava and dike intervals do not need to be cored because of previous IODP experience on the 1256D hole. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Move in rig	24.0					
Jet 36"	0.5	0.5	3,650	3,711	61	122
Drill Sediments	1.4	1.9	3,711	3,885	174	124
Set 20" casing	3.0	4.9				
Run BOP & Riser	3.0	7.9				
Drill Sediments	1.1	9.0	3,885	3,900	15	14
Drill Lava	4.1	13.1	3,900	4,550	650	159
Drill Dikes	5.0	18.1	4,550	5,350	800	160
Run 16.5" SET Casing	7.0	25.1				
Core/UR Textured Gabbros	4.7	29.8	5,350	5,471	121	26
Drill Textured Gabbros	2.1	31.9	5,471	5,593	122	58
Core/UR Textured Gabbros	4.6	36.5	5,593	5,700	107	23
Core/UR Foliated Gabbros	10.5	47.0	5,700	5,913	213	20
Drill Foliated Gabbros	4.6	51.6	5,913	6,127	213	46
Core/UR Foliated Gabbros	11.2	62.8	6,127	6,355	229	20
Run 16.5" SET Casing	8.0	70.8				
Core/UR Foliated Gabbros	5.0	75.8	6,355	6,400	45	9
Core/UR Layered Gabbros	24.2	100.0	6,400	6,790	390	16
Drill Layered Gabbros	13.8	113.8	6,790	7,376	586	42
Run 16" Casing	9.0	122.8				
Core/UR Layered Gabbros	29.1	151.9	7,376	7,864	488	17
Drill Layered Gabbros	13.6	165.5	7,864	8,382	518	38
Run 13-3/8" Liner	6.0	171.5				0
Core Layered Gabbros	15.6	187.1				31
Drill Layered Gabbros	10.8	197.9	8,870	9,297	427	40
Core Layered Gabbros	4.3	202.2	9,297	9,400	104	24
Run 11-3/4" Liner	6.0	208.2				
Core Mantle	61.7	269.9	9,400	9,900	500	8
5% Operational NPT	13.0	282.9				
TA hole	3.0	285.9				
Pull BOP/Riser	3.0	**288.9**				
De-Mobilize Rig	24.0					
Total Core/Drill Days =	**289**					
Total Project Days =	**337**					

Figure 83. Cocos Location - Case 2c: Project Time to Reach TD

43% of the hole is cored, and 57% is drilled as shown below.

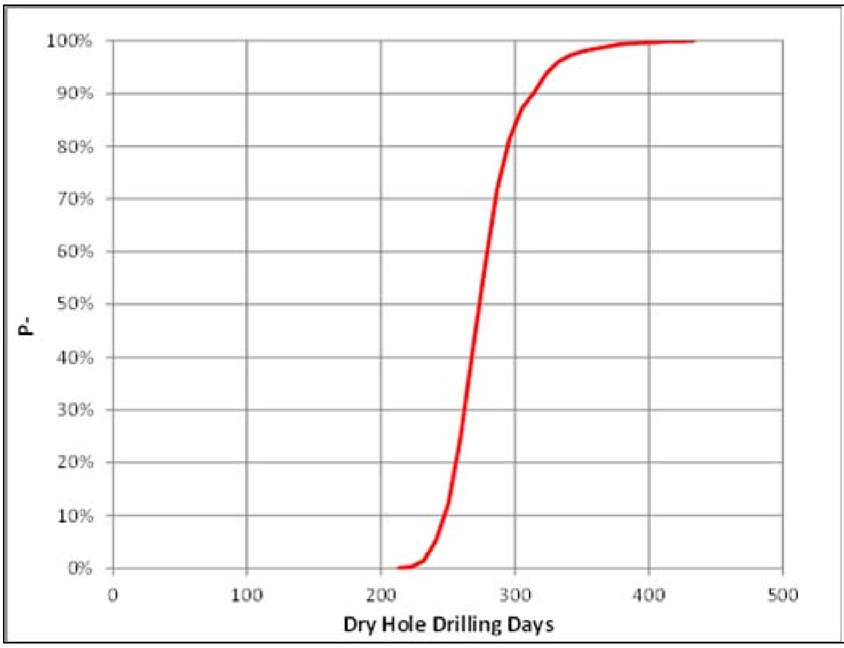
	Interval	%	Days
Coring =	2,684	42.9%	77
Drilling =	3,566	57.1%	32
	6,250	100%	109

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							**Section Time (days)**				**Section**	**Cum**
Section	**Stratigraphy**	**From**	**To**	**Interval**	**Operation**	**ROP**	**Ops Time**	**Bit Trip**	**W/L**	**Flat**	**Days**	**Days**
0.1	Sediments	3650	3711	61	Jetting	---	0.5	0	0	0	0.5	0.5
1	Sediments	3711	3885	174	Drill	21.3	0.3	1.0	0.0	6.0	7.4	7.9
2	Sediments	3885	3900	15	Drill	21.3	0.0	1.1	0.0	0.0	1.1	9.0
3	Lava	3900	4550	650	Drill	9.1	3.0	1.2	0.0	0.0	4.1	13.1
4	Dikes	4550	5350	800	Drill	9.1	3.6	1.4	0.0	7.0	12.0	25.1
5	Textured Gabbros	5350	5471	121	Conv Core	4.6	1.1	1.5	0.0	0.0	2.6	27.7
6	Textured Gabbros	5350	5471	121	UR	7.6	0.7	1.5	0.0	0.0	2.1	29.8
7	Textured Gabbros	5471	5593	122	Drill	9.1	0.6	1.5	0.0	0.0	2.1	31.9
8	Textured Gabbros	5593	5700	107	Conv Core	4.6	1.0	1.5	0.0	0.0	2.5	34.4
9	Textured Gabbros	5593	5700	107	UR	7.6	0.6	1.5	0.0	0.0	2.1	36.5
10	Foliated Gabbros	5700	5913	213	Conv Core	2.4	3.6	1.6	0.0	0.0	5.2	41.8
11	Foliated Gabbros	5700	5913	213	UR	2.4	3.6	1.6	0.0	0.0	5.2	47.0
12	Foliated Gabbros	5913	6127	213	Drill	3.0	2.9	1.6	0.0	0.0	4.6	51.5
13	Foliated Gabbros	6127	6355	229	Conv Core	2.4	3.9	1.7	0.0	0.0	5.6	57.2
14	Foliated Gabbros	6127	6355	229	UR	2.4	3.9	1.7	0.0	8.0	13.6	70.8
15	Foliated Gabbros	6355	6400	45	Conv Core	2.4	0.8	1.7	0.0	0.0	2.5	73.3
16	Foliated Gabbros	6355	6400	45	UR	2.4	0.8	1.7	0.0	0.0	2.5	75.8
17	Layered Gabbros	6400	6790	390	Conv Core	2.4	6.7	5.4	0.0	0.0	12.1	87.9
18	Layered Gabbros	6400	6790	390	UR	2.4	6.7	5.4	0.0	0.0	12.1	100.0
19	Layered Gabbros	6790	7376	586	Drill	3.0	8.0	5.8	0.0	9.0	22.8	122.8
20	Layered Gabbros	7376	7864	488	Conv Core	2.4	8.3	6.3	0.0	0.0	14.6	137.4
21	Layered Gabbros	7376	7864	488	UR	2.4	8.3	6.3	0.0	0.0	14.6	151.9
22	Layered Gabbros	7864	8382	518	Drill	3.0	7.1	6.7	0.0	6.0	19.7	171.7
23	Layered Gabbros	8382	8870	488	Conv Core	2.4	8.3	7.1	0.0	0.0	15.4	187.1
24	Layered Gabbros	8870	9297	427	Drill	3.0	5.8	5.0	0.0	0.0	10.8	197.9
25	Layered Gabbros	9297	9400	104	Conv Core	2.4	1.8	2.6	0.0	6.0	10.3	208.2
26	Mantle	9400	9900	500	RCB Core	1.2	17.1	15.8	25.8	3.0	61.7	269.9
						Sub-Total days =	**109**	**90**	**26**	**45**	**270**	
						Sub-Total % =	**40%**	**33%**	**10%**	**17%**	**100%**	

Figure 84. Cocos Location - Case 2c: Operations Time Breakkdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	214
P-10	**247**
P-50	**273**
P-90	**314**
Observed Maximum	433

Figure 85. Cocos Location - Case 2c: Probabilistic Time

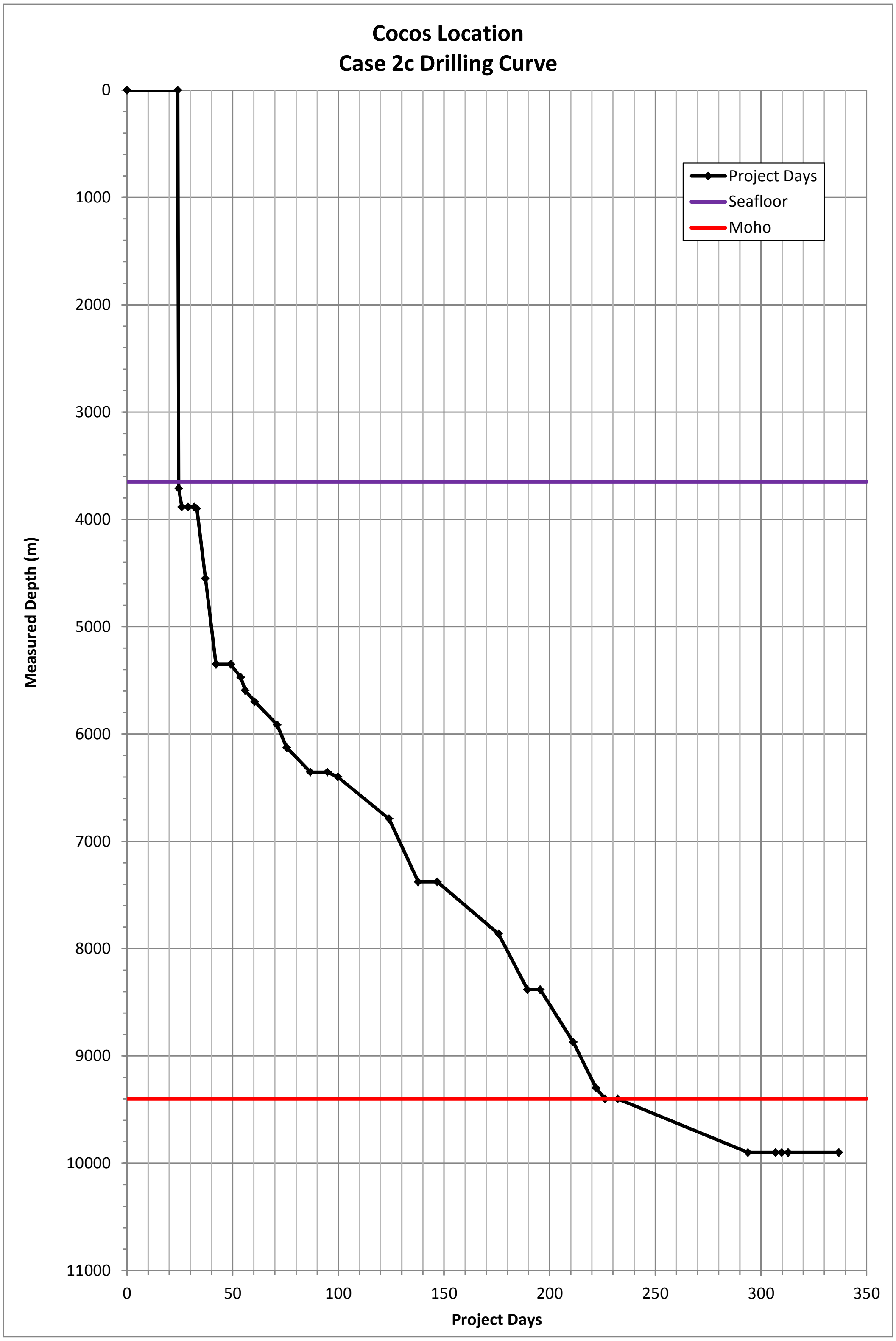


Figure 86. Cocos Location – Case 2c Drilling Curve

5.2.4 *Case 4a Operations Time:*

This case assumes the original Base Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Mobilize Rig	24.0					
Jet 36"	0.5	0.5	3,650	3,711	61	0
Drill Sediments	1.4	1.9	3,711	3,885	174	126
Set 20" casing	3.0	4.9				
Run BOP & Riser	3.0	7.9				
Drill Sediments	1.1	9.0	3,885	3,900	15	14
Drill Lava	4.1	13.1	3,900	4,550	650	158
Drill Dikes	4.9	18.0	4,550	5,335	785	159
Set 13-3/8" Casing	6.0	24.0				
Drill Dikes	1.5	25.5	5,335	5,350	15	10
Drill Textured Gabbros	3.1	28.7	5,350	5,700	350	113
Drill Foliated Gabbros	14.5	43.2	5,700	6,400	700	48
Drill Layered Gabbros	23.1	66.3	6,400	7,400	1,000	43
Run 11-3/4" Liner	9.0	75.3				
Drill Layered Gabbros	50.3	125.6	7,400	9,400	2,000	40
Core Mantle	61.7	187.3	9,400	9,900	500	8
5% Operational NPT	9.0	196.3				
TA hole	3.0	199.3				
Pull BOP/Riser	3.0	202.3				
De-Mobilize Rig	24.0					
Total Operational Days =	**202**					
Total Project Days =	**250**					

Figure 87. Cocos Location - Case 4a: Operational Phase Summary

8% of the hole is cored, and 92% is drilled as shown below.

	Interval	%	Days
Coring =	500	8.0%	17
Drilling =	5,750	92.0%	60
	6,250	100%	77

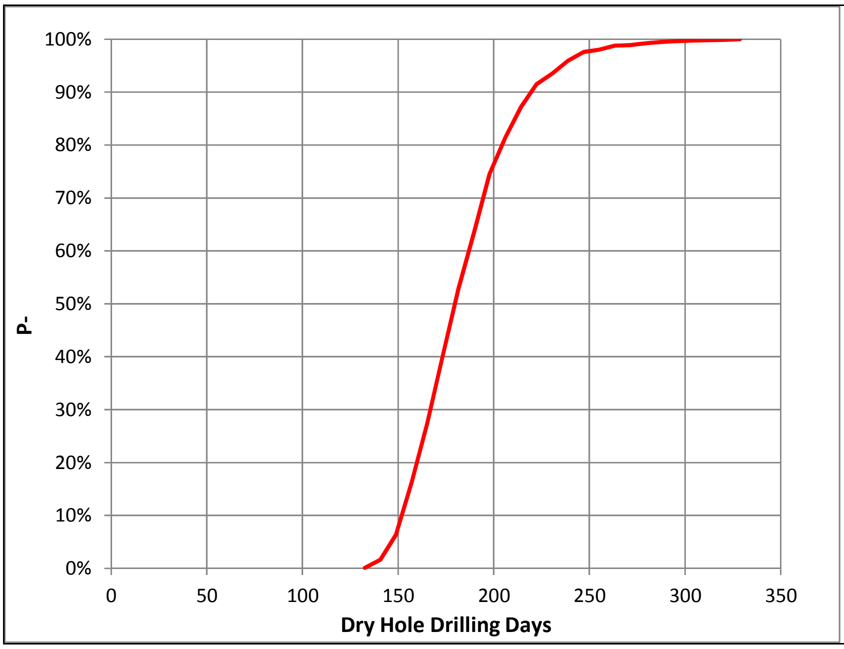
The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L"

time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	3,650	3,711	61	Jetting	---	0.5	0.0	0.0	0.0	0.5	0.5
1	Sediments	3,711	3,885	174	Drill	21.3	0.3	1.0	0.0	6.0	7.4	7.9
2	Sediments	3,885	3,900	15	Drill	21.3	0.0	1.06	0.0	0.0	1.1	9.0
3	Lava	3,900	4,550	650	Drill	9.1	3.0	1.2	0.0	0.0	4.1	13.1
4	Dikes	4,550	5,335	785	Drill	9.1	3.6	1.4	0.0	6.0	10.9	24.0
5	Dikes	5,335	5,350	15	Drill	9.1	0.07	1.46	0.00	0.00	1.53	25.5
6	Textured Gabbros	5,350	5,700	350	Drill	9.1	1.60	1.51	0.00	0.00	3.11	28.7
7	Foliated Gabbros	5,700	6,400	700	Drill	3.0	9.6	5.0	0.0	0.0	14.53	43.2
8	Layered Gabbros	6,400	7,400	1000	Drill	3.0	13.7	9.4	0.0	9.0	32.1	75.3
9	Layered Gabbros	7,400	9,400	2000	Drill	3.0	27.3	23.0	0.0	0.0	50.3	125.6
10	Mantle	9,400	9,900	500	RCB Core	1.2	17.1	15.8	25.8	3.0	61.7	187.3
						Sub-Total Days =	77	61	26	24	187	
						Sub-Total % =	41%	32%	14%	13%	100%	

Figure 88. Cocos Location - Case 4a: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	133
P-10	**152**
P-50	**180**
P-90	**220**
Observed Maximum	329

Figure 89. Cocos Location - Case 4a: Probabilistic Time

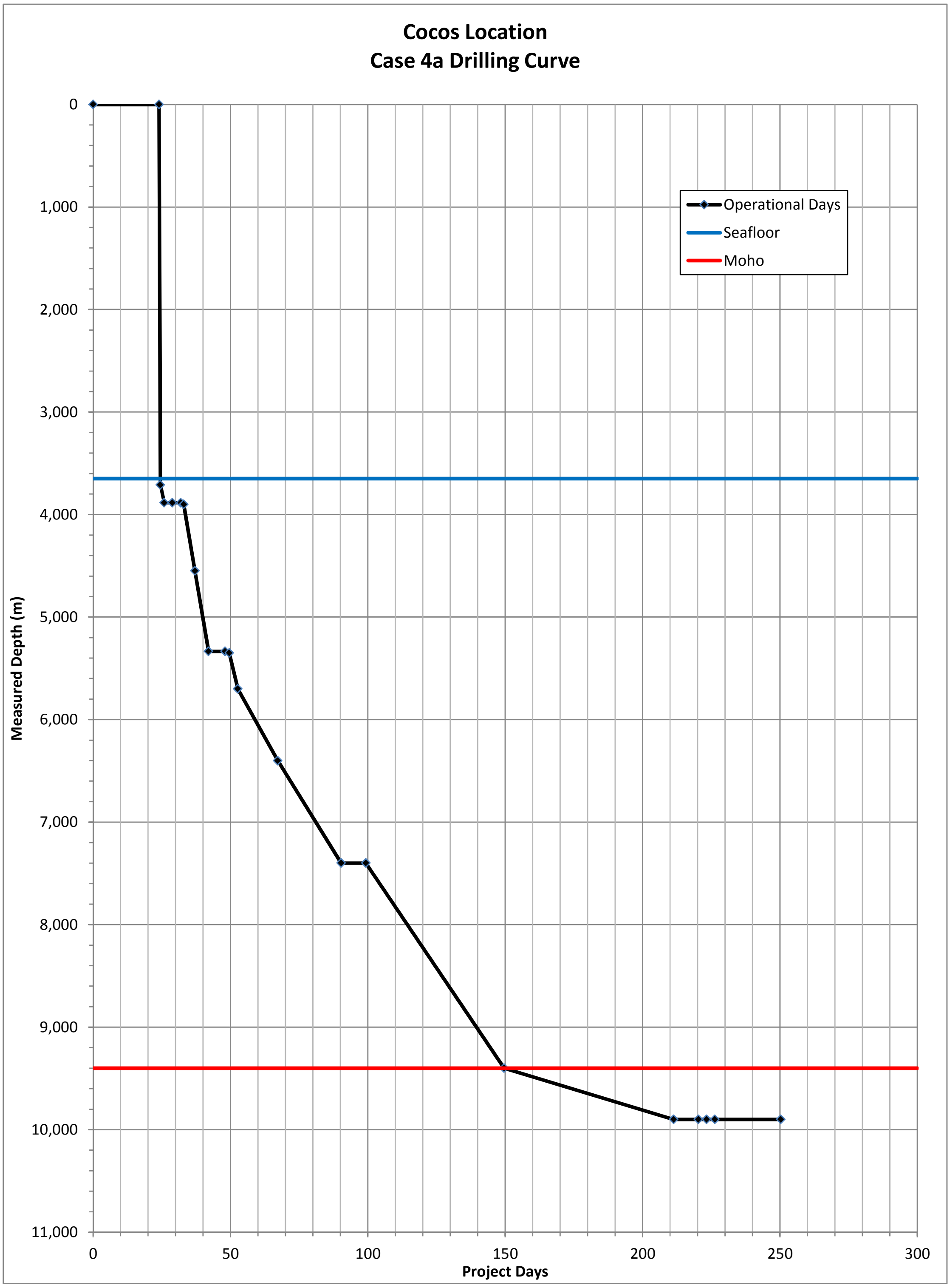


Figure 90. Cocos Location: Case 4a Drilling Curve

5.2.5 Case 4b Operations Time:

This case assumes the Deepwater Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Mobilize Rig	23.9					
Jet 36"	0.5	0.5	3,650	3,711	61	121.9215
Drill Sediments	1.3	1.8	3,711	3,885	174	130
Set 22" casing	3.0	4.9				
Run BOP & Riser	3.0	7.9				
Drill Sediments	1.1	9.0	3,885	3,900	15	13.9
Drill Lava	4.1	13.1	3,900	4,550	650	158.6
Drill Dikes	5.0	18.1	4,550	5,350	800	
Set 18" Casing	6.0	24.1				
Drill Textured Gabbros	3.1	27.2	5,350	5,700	350	113.0
Drill Foliated Gabbros	12.2	39.4	5,700	6,355	655	53.7
Set 16" Casing	7.0	46.4				
Drill Foliated Gabbros	2.4	48.8	6,355	6,400	45	18.7
Drill Layered Gabbros	22.8	71.6	6,400	7,376	976	42.8
Run 13-3/8" Liner	9.0	80.6				
Drill Layered Gabbros	24.5	105.1	7,376	8,382		
Run 11-3/4" Liner	6.0	111.1				
Drill Layered Gabbros	26.1	137.2	8,382	9,400		
Run 9-5/8" Liner	6.0	143.2				
Core Mantle	61.7	204.9	9,400	9,900	500	8.1
5% Operational NPT	10.0	214.9				
TA hole	3.0	217.9				
Pull BOP/Riser	3.0	**220.9**				
De-Mobilize Rig	23.9					
Total Operational Days =	**221**					
Total Project Days =	**269**					

Figure 91. Cocos Location - Case 4b: Operational Phase Summary

8% of the hole is cored, and 92% is drilled as shown below.

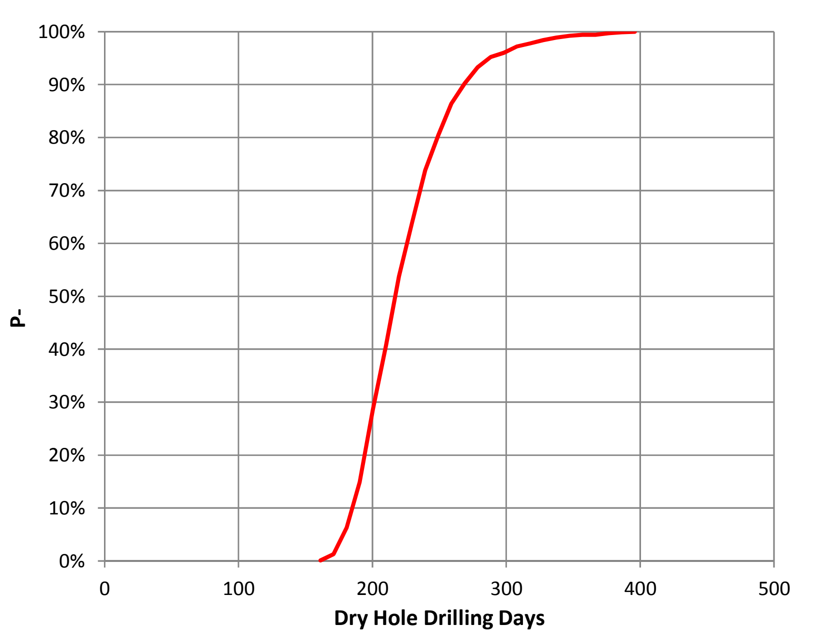
	Interval	%	Days
Coring =	500	8.0%	17
Drilling =	5,750	92.0%	60
	6,250	100%	77

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	3650	3711	61	Jetting	---	0.5	0.0	0.0	0.0	0.5	0.5
1	Sediments	3711	3885	174	Drill	21.3	0.3	1.0	0.0	6.0	7.4	7.9
2	Sediments	3885	3900	15	Drill	21.3	0.0	1.1	0.0	0.0	1.1	9.0
3	Lava	3900	4550	650	Drill	9.1	3.0	1.2	0.0	0.0	4.1	13.1
4	Dikes	4550	5350	800	Drill	9.1	3.6	1.4	0.0	6.0	11.0	24.1
5	Textured Gabbros	5350	5700	350	Drill	9.1	1.6	1.5	0.0	0.0	3.1	27.2
6	Foliated Gabbros	5700	6355	655	Drill	3.0	9.0	3.3	0.0	7.0	19.3	46.4
7	Foliated Gabbros	6355	6400	45	Drill	3.0	0.6	1.7	0.0	0.0	2.4	48.8
8	Layered Gabbros	6400	7376	976	Drill	3.0	13.3	9.4	0.0	9.0	31.8	80.6
9	Layered Gabbros	7376	8382	1006	Drill	3.0	13.8	10.8	0.0	6.0	30.5	111.1
10	Layered Gabbros	8382	9400	1018	Drill	3.0	13.9	12.2	0.0	6.0	32.1	143.2
11	Mantle	9400	9900	500	RCB Core	1.2	17.1	15.8	25.8	3.0	61.7	204.9
						Sub-Total Days =	**77**	**59**	**26**	**43**	**205**	
						Sub-Total % =	37%	29%	13%	21%	100%	

Figure 92. Cocos Location - Case 4a: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	161
P-10	**185**
P-50	**217**
P-90	**268**
Observed Maximum	396

Figure 93. Cocos Location - Case 4b: Probabilistic Time

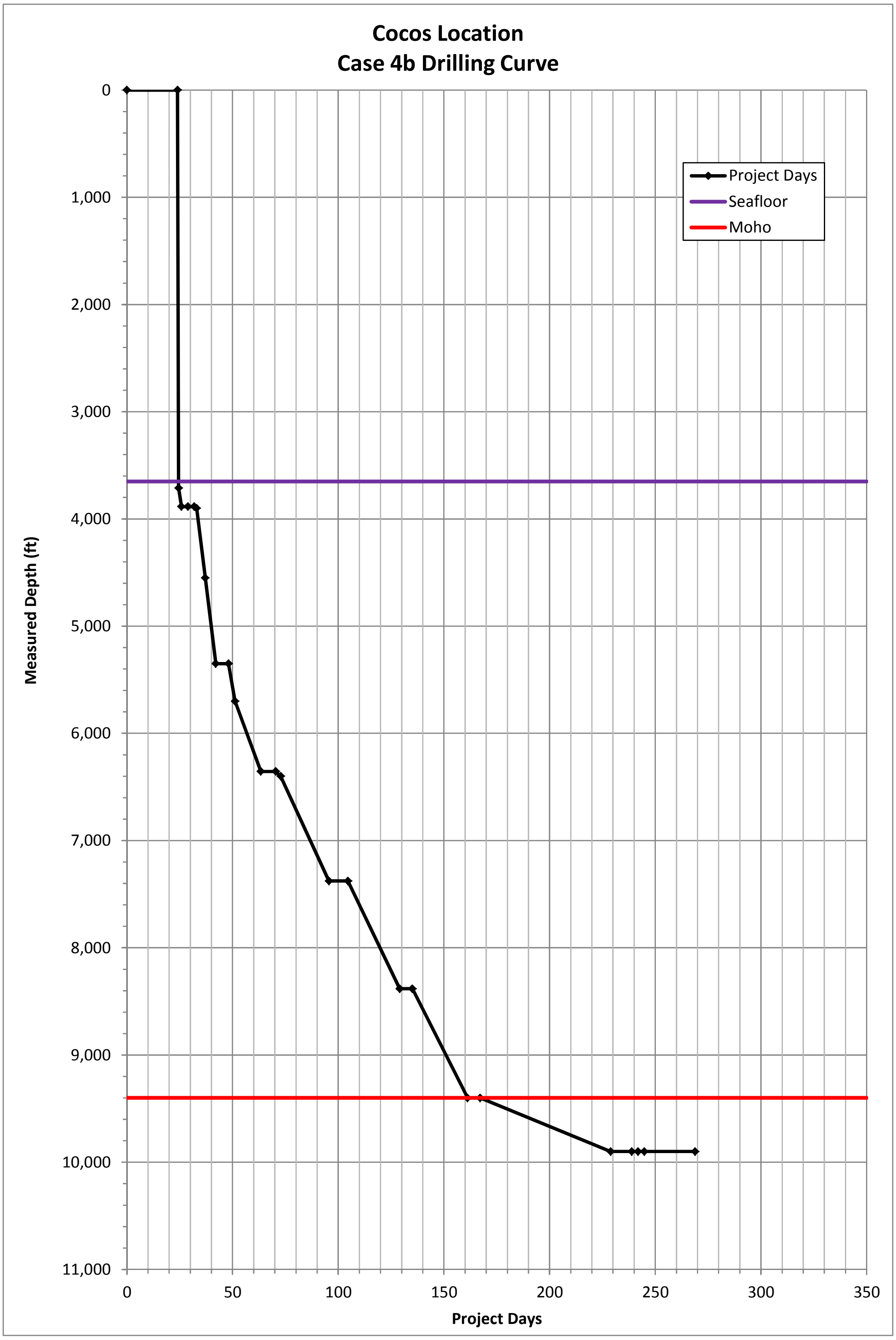


Figure 94. Cocos Location: Case 4b Drilling Curve

5.2.6 Case 4c Operations Time:

This case assumes the Expandable Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Mobilize Rig	24.0					
Jet 36"	0.5	0.5	3,650	3,711	61	121.9
Drill Sediments	1.4	1.9	3,711	3,885	174	126
Set 22" casing	3.0	4.9				
Run BOP & Riser	3.0	7.9				
Drill Sediments	1.1	9.0	3,885	3,900	15	13.9
Drill Lava	4.1	13.1	3,900	4,550	650	157.9
Drill Dikes	5.0	18.1	4,550	5,350	800	0.0
Set 16.5" SET Casing	7.0	25.1				
Drill Textured Gabbros	3.1	28.2	5,350	5,700	350	112.7
Drill Foliated Gabbros	12.3	40.5	5,700	6,355	655	53.5
Drill Foliated Gabbros	2.4	42.8	6,355	6,400	45	19.0
Set 16.5 SET" Casing	8.0	50.8				
Drill Layered Gabbros	22.8	73.6	6,400	7,376	976	42.9
Run 16" Liner	9.0	82.6				
Drill Layered Gabbros	24.5	107.1	7,376	8,382		
Run 13-3/8" Liner	6.0	113.1				
Drill Layered Gabbros	26.1	139.2	8,382	9,400		
Run 11-3/4" Liner	6.0	145.2				
Core Mantle	61.7	206.9	9,400	9,900	500	8.1
5% Operational NPT	10.0	216.9				
TA hole	3.0	219.9				
Pull BOP/Riser	3.0	222.9				
De-Mobilize Rig	24.0					

Total Operational Days =	**223**
Total Project Days =	**271**

Figure 95. Cocos Location - Case 4b: Operational Phase Summary

8% of the hole is cored, and 92% is drilled as shown below.

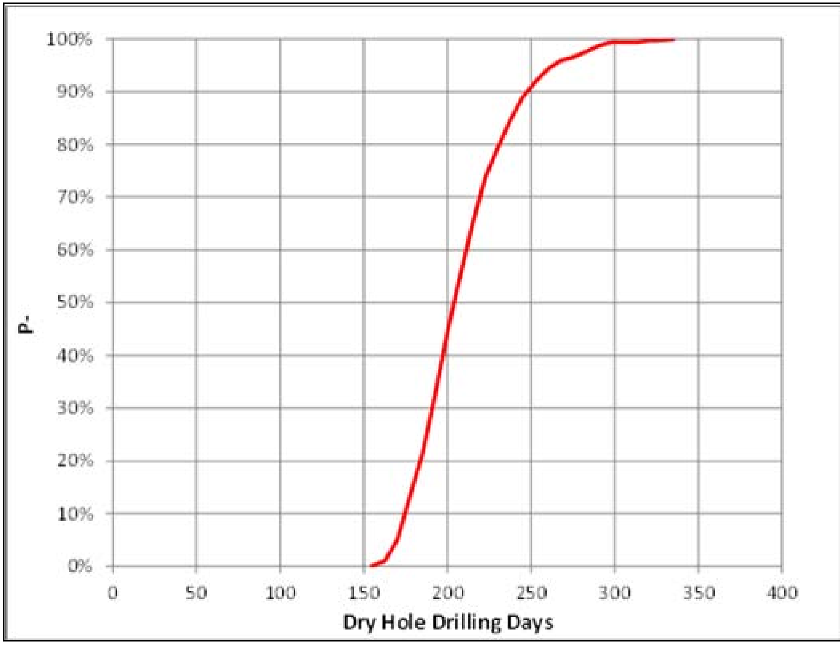
	Interval	%	Days
Coring =	500	8.0%	17
Drilling =	5,750	92.0%	60
	6,250	100%	77

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	3650	3711	61	Jetting	---	0.5	0.0	0.0	0.0	0.5	0.5
1	Sediments	3711	3885	174	Drill	21.3	0.3	1.0	0.0	6.0	7.4	7.9
2	Sediments	3885	3900	15	Drill	21.3	0.0	1.1	0.0	0.0	1.1	9.0
3	Lava	3900	4550	650	Drill	9.1	3.0	1.2	0.0	0.0	4.1	13.1
4	Dikes	4550	5350	800	Drill	9.1	3.6	1.4	0.0	7.0	12.0	25.1
5	Textured Gabbros	5350	5700	350	Drill	9.1	1.6	1.5	0.0	0.0	3.1	28.2
6	Foliated Gabbros	5700	6355	655	Drill	3.0	9.0	3.3	0.0	8.0	20.3	48.4
7	Foliated Gabbros	6355	6400	45	Drill	3.0	0.6	1.7	0.0	0.0	2.4	50.8
8	Layered Gabbros	6400	7376	976	Drill	3.0	13.3	9.4	0.0	9.0	31.8	82.6
9	Layered Gabbros	7376	8382	1006	Drill	3.0	13.8	10.8	0.0	6.0	30.5	113.1
10	Layered Gabbros	8382	9400	1018	Drill	3.0	13.9	12.2	0.0	6.0	32.1	145.2
11	Mantle	9400	9900	500	RCB Core	1.2	17.1	15.8	25.8	3.0	61.7	206.9
						Sub-Total Days =	**77**	**59**	**26**	**45**	**207**	
						Sub-Total % =	**37%**	**29%**	**12%**	**22%**	**100%**	

Figure 96. Cocos Location - Case 4a: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	161
P-10	**185**
P-50	**217**
P-90	**268**
Observed Maximum	396

Figure 97. Cocos Location - Case 4b: Probabilistic Time

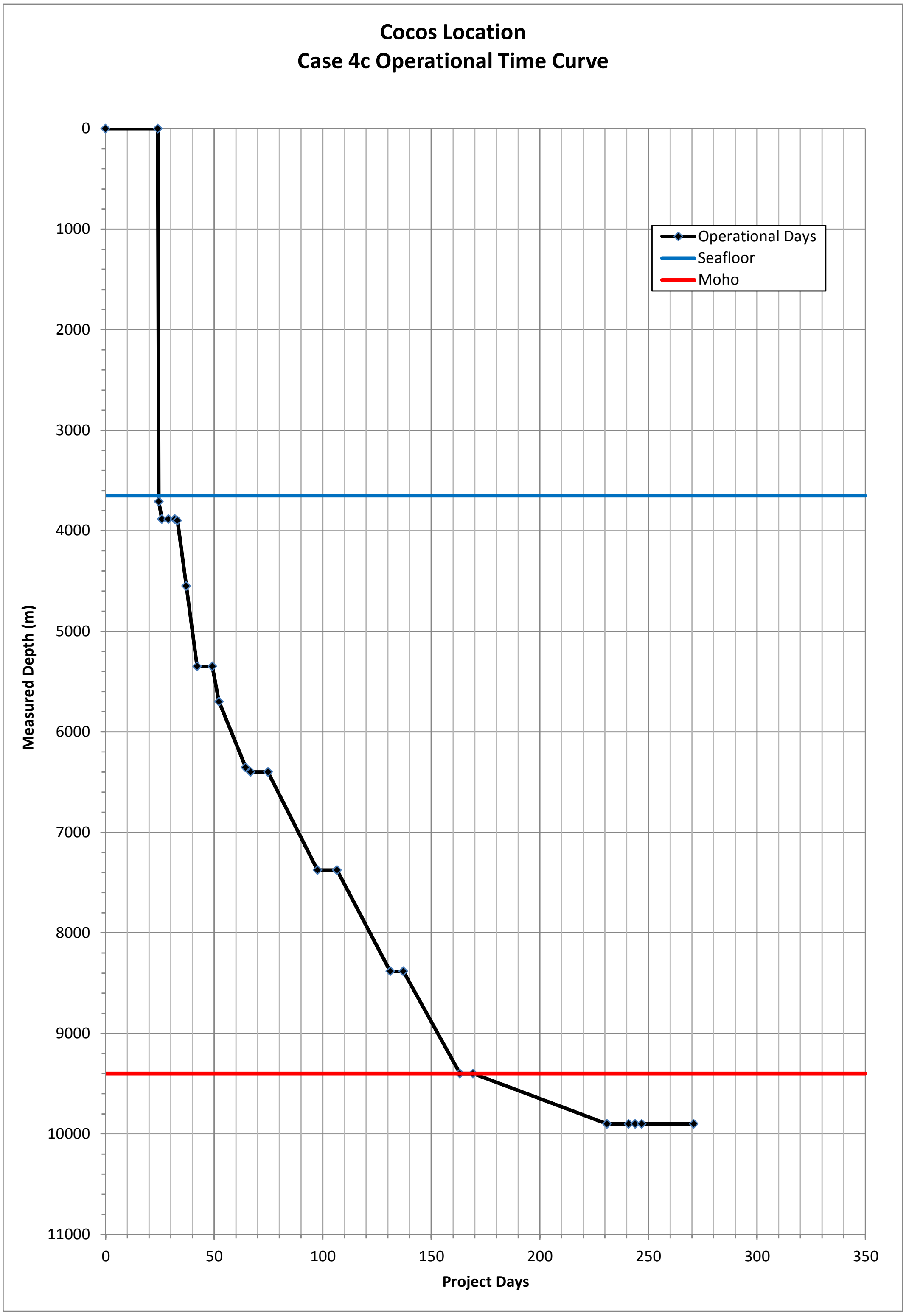


Figure 98. Cocos Location: Case 4c Drilling Curve

5.3 Hawaii Location Operational Time Estimates

5.3.1 Case 2a Operations Time:

This case assumes the original Base Case wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Move in rig	13.4					
Jet 30"	0.5	0.5	4,050	4,111	61	122
Core/UR Sediments	3.1	3.6	4,111	4,235	124	40
Set 20" casing	3.0	6.6				
Run BOP & Riser	3.0	9.6				
Core/UR Sediments	2.5	12.1	4,235	4,250	15	6
Core/UR Lava	5.5	17.6	4,250	4,467	217	39
Drill Lava	2.2	19.8	4,467	4,683		
Core/UR Lava	5.8	25.6	4,683	4,900	217	37
Core/UR Dikes	6.6	32.2	4,900	5,167	267	40
Drill Dikes	2.7	34.9	5,167	5,433	267	99
Core/UR Dikes	6.7	41.6	5,433	5,685	251	38
Set 13-3/8" Casing	6.0	47.6				
Core Dikes	1.7	49.3	5,685	5,700	15	9
Core Textured Gabbros	2.7	52.0	5,700	5,817	116	43
Drill Textured Gabbros	2.1	54.1	5,817	5,933	116	55
Core Textured Gabbros	2.7	56.8	5,933	6,050	117	43
Core Foliated Gabbros	5.7	62.5	6,050	6,284	233	41
Drill Foliated Gabbros	4.9	67.4	6,284	6,517	233	48
Core Foliated Gabbros	7.6	75.0	6,517	6,750	233	31
Core Layered Gabbros	13.6	88.6	6,750	7,207	457	34
Drill Layered Gabbros	17.7	106.3	7,207	7,894	687	39
Core Layered Gabbros	10.4	116.7	7,894	8,250	355	34
Run 11-3/4" Liner	9.0	125.7				
Drill Layered Gabbros	14.9	140.6	8,250	8,829	579	39
Core Layered Gabbros	15.2	155.8	8,829	9,286	457	30
Drill Layered Gabbros	15.8	171.6	9,286	9,865	579	37
Core Layered Gabbros	14.8	186.4	9,865	10,250	385	26
Core Mantle	65.4	251.8	10,250	10,750	500	8
5% Operational NPT	13.0	264.8				
TA hole	3.0	267.8				
Pull BOP/Riser	3.0	270.8				
De-Mobilize Rig	13.4	284.2				

Total Operational Days =	**271**
Total Project Days =	**298**

Figure 99. Hawaii Location - Case 2a: Operational Phase Summary

59% of the hole is cored, and 41% is drilled as shown below.

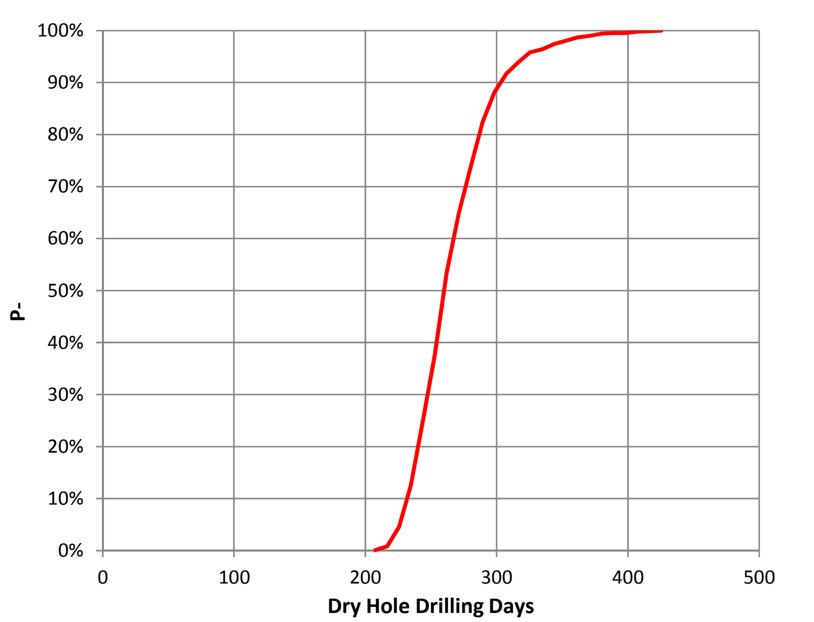
	Interval	%	Days
Coring =	3,960	59.1%	70
Drilling =	2,740	40.9%	32
	6,700	100%	102

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	4050	4111	61	Jetting	---	0.5	0	0	0	0.5	0.5
1	Sediments	4111	4235	124	Conv Core	12.2	0.4	1.1	0.0	0.0	1.6	2.1
2	Sediments	4111	4235	124	UR	12.2	0.4	1.1	0.0	6.0	7.6	9.6
3	Sediments	4235	4250	15	Conv Core	12.2	0.1	1.2	0.0	0.0	1.2	10.8
4	Sediments	4235	4250	15	UR	12.2	0.1	1.2	0.0	0.0	1.2	12.1
5	Lava	4250	4467	217	Conv Core	4.6	2.0	1.2	0.0	0.0	3.2	15.2
6	Lava	4250	4467	217	UR	7.6	1.2	1.2	0.0	0.0	2.4	17.6
7	Lava	4467	4683	217	Drill	9.1	1.0	1.3	0.0	0.0	2.2	19.8
8	Lava	4683	4900	217	Conv Core	4.6	2.0	1.3	0.0	0.0	3.3	23.1
9	Lava	4683	4900	217	UR	7.6	1.2	1.3	0.0	0.0	2.5	25.6
10	Dikes	4900	5167	267	Conv Core	4.6	2.4	1.4	0.0	0.0	3.8	29.4
11	Dikes	4900	5167	267	UR	7.6	1.5	1.4	0.0	0.0	2.8	32.3
12	Dikes	5167	5433	267	Drill	9.1	1.2	1.4	0.0	0.0	2.7	34.9
13	Dikes	5433	5685	251	Conv Core	4.6	2.3	1.5	0.0	0.0	3.8	38.7
14	Dikes	5433	5685	251	UR	7.6	1.4	1.5	0.0	6.0	8.9	47.6
15	Dikes	5685	5700	15	Conv Core	4.6	0.1	1.6	0.0	0.0	1.7	49.3
16	Textured Gabbros	5700	5817	116	Conv Core	4.6	1.1	1.6	0.0	0.0	2.6	52.0
17	Textured Gabbros	5817	5933	116	Drill	9.1	0.5	1.6	0.0	0.0	2.1	54.1
18	Textured Gabbros	5933	6050	117	Conv Core	4.6	1.1	1.6	0.0	0.0	2.7	56.8
19	Foliated Gabbros	6050	6284	233	Conv Core	2.4	4.0	1.7	0.0	0.0	5.7	62.5
20	Foliated Gabbros	6284	6517	233	Drill	3.0	3.2	1.7	0.0	0.0	4.9	67.4
21	Foliated Gabbros	6517	6750	233	Conv Core	2.4	4.0	3.6	0.0	0.0	7.6	75.0
22	Layered Gabbros	6750	7207	457	Conv Core	2.4	7.8	5.7	0.0	0.0	13.5	88.6
23	Layered Gabbros	7207	7894	687	Drill	3.0	9.4	8.3	0.0	0.0	17.7	106.2
24	Layered Gabbros	7894	8250	355	Conv Core	2.4	6.1	4.4	0.0	9.0	19.5	125.7
25	Layered Gabbros	8250	8829	579	Drill	3.0	7.9	7.0	0.0	0.0	14.9	140.6
26	Layered Gabbros	8829	9286	457	Conv Core	2.4	7.8	7.4	0.0	0.0	15.2	155.9
27	Layered Gabbros	9286	9865	579	Drill	3.0	7.9	7.9	0.0	0.0	15.8	171.6
28	Layered Gabbros	9865	10250	385	Conv Core	2.4	6.6	8.2	0.0	0.0	14.8	186.5
29	Mantle	10250	10750	500	RCB Core	1.2	17.1	17.2	28.1	3.0	65.4	251.8
						Sub-Total days =	**102**	**98**	**28**	**24**	**252**	
						Sub-Total % =	**41%**	**39%**	**11%**	**10%**	**100%**	

Figure 100. Hawaii Location - Case 2a: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	208
P-10	**232**
P-50	**260**
P-90	**303**
Observed Maximum	425

Figure 101. Hawaii Location - Case 2a: Probabilistic Time

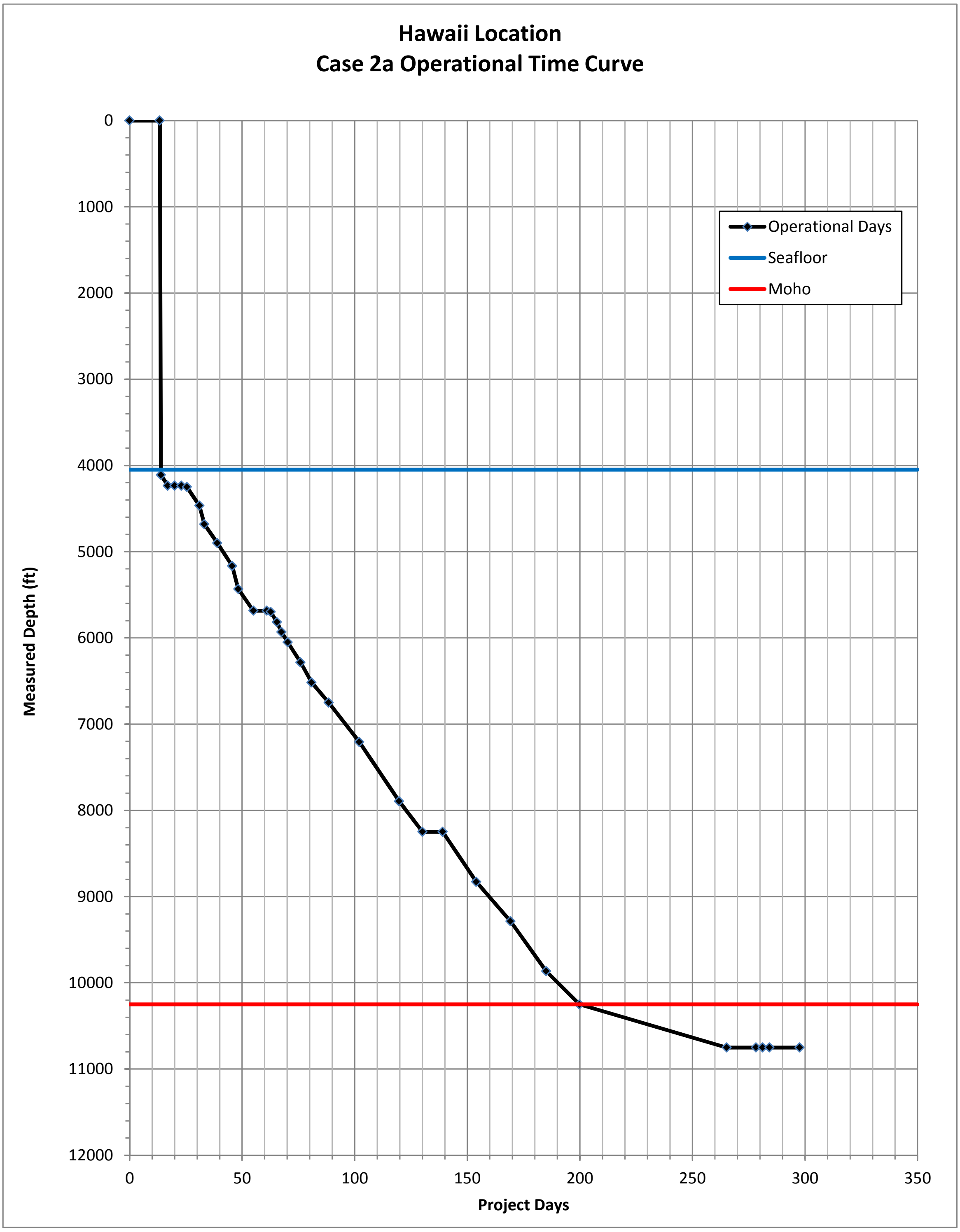


Figure 102. Hawaii Location: Case 2a Drilling Curve

5.3.2 Case 2b Operations Time:

This case assumes the Deepwater case wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Move in rig	13.4					
Jet 36"	0.5	0.5	4,050	4,111	61	122
Core/UR Sediments	3.2	3.7	4,111	4,250	139	43
Set 20" casing	3.0	6.7				
Run BOP & Riser	3.0	9.7				
Core/UR Lava	5.5	15.2	4,250	4,467	217	39
Drill Lava	2.3	17.5	4,467	4,683	217	94
Core/UR Lava	5.8	23.3	4,683	4,900	217	37
Core/UR Dikes	6.6	29.9	4,900	5,167	267	40.4
Drill Dikes	2.7	32.6	5,167	5,433	267	98.8
Core/UR Dikes	6.9	39.5	5,433	5,700	267	38.7
Set 18" Casing	6.0	45.5				
Core/UR Textured Gabbros	4.9	50.4	5,700	5,817	116	24
Drill Textured Gabbros	2.1	52.5	5,817	5,933	116	55
Core/UR Textured Gabbros	5.0	57.5	5,933	6,050	117	23
Core/UR Foliated Gabbros	11.4	68.9	6,050	6,284	233	20
Drill Foliated Gabbros	4.9	73.8	6,284	6,517	233	48
Core/UR Foliated Gabbros	15.2	89.0	6,517	6,750	233	15
Core/UR Layered Gabbros	6.9	95.9	6,750	6,843	93	13.5
Set 16" Casing	7.0	102.9				
Core/UR Layered Gabbros	20.1	123.0	6,843	7,207	364	18
Drill Layered Gabbros	18.8	141.8	7,207	7,971	764	41
Run 13-3/8" Casing	9.0	150.8				
Core Layered Gabbros	18.7	169.5	7,971	8,535	564	30
Drill Layered Gabbros	14.9	184.4	8,535	9,098	564	38
Run 11-3/4" Liner	6.0	190.4				
Core Layered Gabbros	19.9	210.3	9,098	9,662	564	28
Drill Layered Gabbros	11.2	221.5	9,662	10,089	427	38
Core Layered Gabbros	5.5	227.0	10,089	10,250	161	29
Run 9-5/8" Liner	6.0	233.0				
Core Mantle	65.4	298.4	10,250	10,750	500	8
5% Operational NPT	15.0	313.4				
TA hole	3.0	316.4				
Pull BOP/Riser	3.0	319.4				
De-Mobilize Rig	13.4					
Total Core/Drill Days =	**319**					
Total Project Days =	**346**					

Figure 103. Hawaii Location - Case 2b: Operational Phase Summary

61% of the hole is cored, and 39% is drilled as shown below.

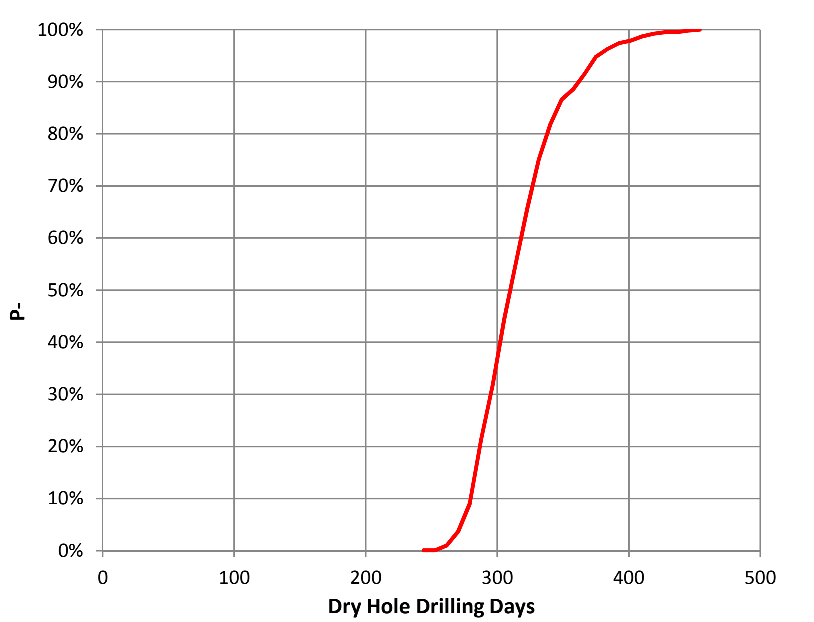
	Interval	%	Days
Coring =	4,052	60.5%	89
Drilling =	2,648	39.5%	30
	6,700	100%	120

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	4050	4111	61	Jetting	---	0.5	0	0	0	0.5	0.5
1	Sediments	4111	4250	139	Conv Core	12.2	0.5	1.1	0.0	0.0	1.6	2.1
2	Sediments	4111	4250	139	UR	12.2	0.5	1.1	0.0	6.0	7.6	9.7
3	Lava	4250	4467	217	Conv Core	4.6	2.0	1.2	0.0	0.0	3.2	12.9
4	Lava	4250	4467	217	UR	7.6	1.2	1.2	0.0	0.0	2.4	15.3
5	Lava	4467	4683	217	Drill	9.1	1.0	1.3	0.0	0.0	2.2	17.5
6	Lava	4683	4900	217	Conv Core	4.6	2.0	1.3	0.0	0.0	3.3	20.8
7	Lava	4683	4900	217	UR	7.6	1.2	1.3	0.0	0.0	2.5	23.3
8	Dikes	4900	5167	267	Conv Core	4.6	2.4	1.4	0.0	0.0	3.8	27.1
9	Dikes	4900	5167	267	UR	7.6	1.5	1.4	0.0	0.0	2.8	29.9
10	Dikes	5167	5433	267	Drill	9.1	1.2	1.4	0.0	0.0	2.7	32.6
11	Dikes	5433	5700	267	Conv Core	4.6	2.4	1.5	0.0	0.0	4.0	36.6
12	Dikes	5433	5700	267	UR	7.6	1.5	1.5	0.0	6.0	9.0	45.5
13	Textured Gabbros	5700	5817	116	Conv Core	4.6	1.1	1.6	0.0	0.0	2.6	48.2
14	Textured Gabbros	5700	5817	116	UR	7.6	0.6	1.6	0.0	0.0	2.2	50.4
15	Textured Gabbros	5817	5933	116	Drill	9.1	0.5	1.6	0.0	0.0	2.1	52.5
16	Textured Gabbros	5933	6050	117	Conv Core	4.6	1.1	1.6	0.0	0.0	2.7	55.2
17	Textured Gabbros	5933	6050	117	UR	7.6	0.6	1.6	0.0	0.0	2.3	57.5
18	Foliated Gabbros	6050	6284	233	Conv Core	2.4	4.0	1.7	0.0	0.0	5.7	63.2
19	Foliated Gabbros	6050	6284	233	UR	2.4	4.0	1.7	0.0	0.0	5.7	68.9
20	Foliated Gabbros	6284	6517	233	Drill	3.0	3.2	1.7	0.0	0.0	4.9	73.8
21	Foliated Gabbros	6517	6750	233	Conv Core	2.4	4.0	3.6	0.0	0.0	7.6	81.4
22	Foliated Gabbros	6517	6750	233	UR	2.4	4.0	3.6	0.0	0.0	7.6	89.0
23	Layered Gabbros	6750	6843	93	Conv Core	2.4	1.6	1.9	0.0	0.0	3.4	92.5
24	Layered Gabbros	6750	6843	93	UR	2.4	1.6	1.9	0.0	7.0	10.4	102.9
25	Layered Gabbros	6843	7207	364	Conv Core	2.4	6.2	3.8	0.0	0.0	10.1	113.0
26	Layered Gabbros	6843	7207	364	UR	2.4	6.2	3.8	0.0	0.0	10.1	123.0
27	Layered Gabbros	7207	7971	764	Drill	3.0	10.4	8.3	0.0	9.0	27.7	150.8
28	Layered Gabbros	7971	8535	564	Conv Core	2.4	9.6	9.0	0.0	0.0	18.7	169.4
29	Layered Gabbros	8535	9098	564	Drill	3.0	7.7	7.2	0.0	6.0	20.9	190.4
30	Layered Gabbros	9098	9662	564	Conv Core	2.4	9.6	10.3	0.0	0.0	19.9	210.3
31	Foliated Gabbros	9662	10089	427	Drill	3.0	5.8	5.4	0.0	0.0	11.2	221.5
32	Foliated Gabbros	10089	10250	161	Conv Core	2.4	2.8	2.8	0.0	6.0	11.5	233.0
33	Mantle	10250	10750	500	RCB Core	1.2	17.1	17.2	28.1	3.0	65.4	298.4
						Sub-Total days =	**120**	**108**	**28**	**43**	**298**	
						Sub-Total % =	**40%**	**36%**	**9%**	**14%**	**100%**	

Figure 104. Hawaii Location - Case 2a: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	244
P-10	**280**
P-50	**310**
P-90	**362**
Observed Maximum	454

Figure 105. Hawaii Location - Case 2b: Probabilistic Time

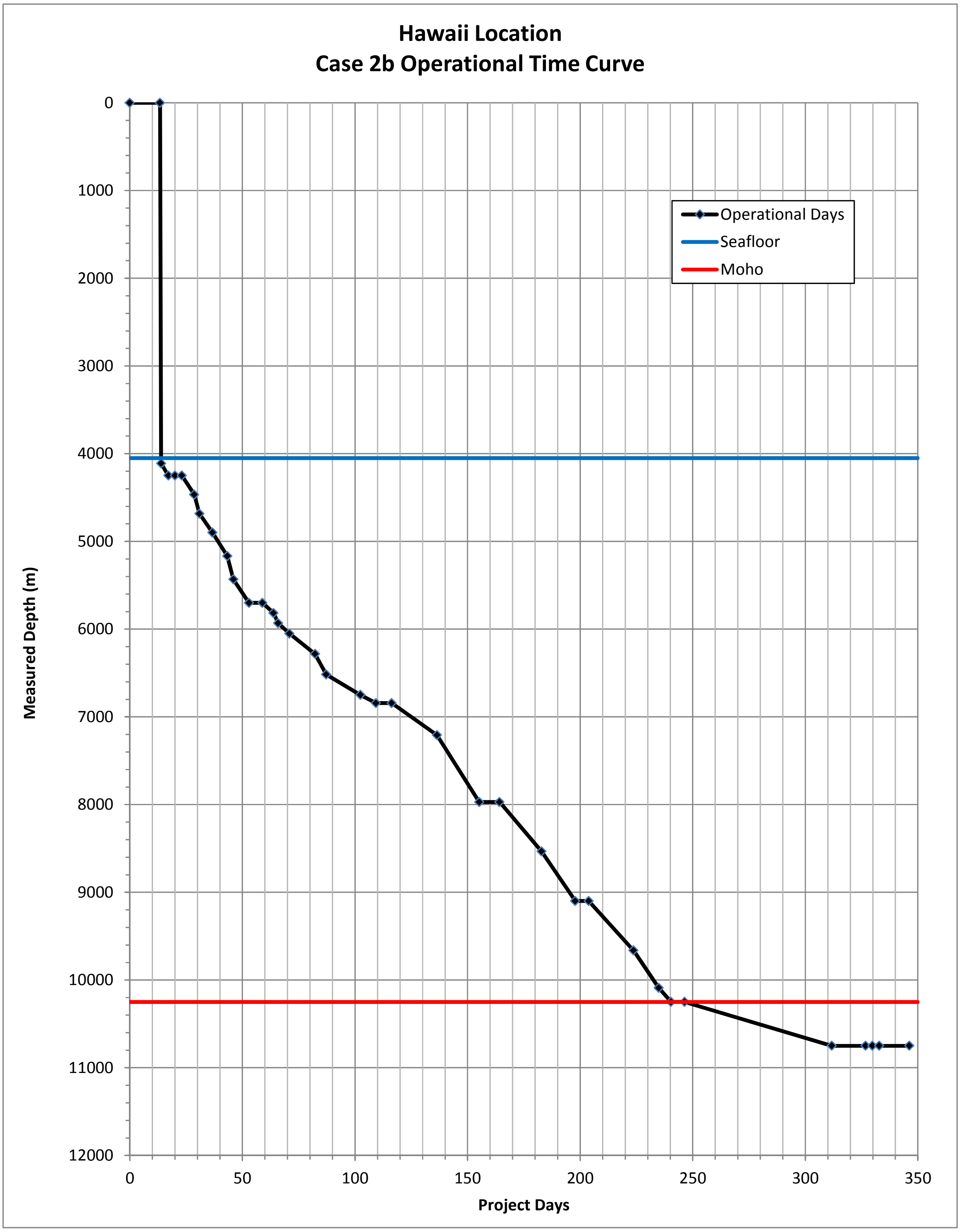


Figure 106. Hawaii Location: Case 2b Drilling Curve

5.3.3 Case 2c Operations Time:

This case assumes the Expandable Case wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Move in rig	13.4					
Jet 36"	0.5	0.5	4,050	4,111	61	122
Core/UR Sediments	3.2	3.7	4,111	4,250	139	43
Set 22" casing	3.0	6.7	0	0	0	0
Run BOP & Riser	3.0	9.7	0	0	0	0
Core/UR Lava	5.6	15.3	4,250	4,467	217	39
Drill Lava	2.2	17.5	4,467	4,683	217	99
Core/UR Lava	5.8	23.3	4,683	4,900	217	37
Core/UR Dikes	6.6	29.9	4,900	5,167	267	40
Drill Dikes	2.7	32.6	5,167	5,433	267	99
Core/UR Dikes	6.9	39.5	5,433	5,700	267	39
Run 16.5" SET Casing	7.0	46.5	0	0	0	0.0
Core/UR Textured Gabbros	4.9	51.4	5,700	5,817	116	24
Drill Textured Gabbros	2.1	53.5	5,817	5,933	116	55
Core/UR Textured Gabbros	5.0	58.5	5,933	6,050	117	23
Core/UR Foliated Gabbros	11.4	69.9	6,050	6,284	233	20
Drill Foliated Gabbros	4.9	74.8	6,284	6,517	233	48
Core/UR Foliated Gabbros	15.2	90.0	6,517	6,750	233	15
Core/UR Layered Gabbros	6.9	96.9	6,750	6,843	93	13
Run 16.5" SET Casing	8.0	104.9	0	0	0	0.0
Core/UR Layered Gabbros	20.1	125.0	6,843	7,207	364	18
Drill Layered Gabbros	18.8	143.8	7,207	7,971	764	41
Run 16" Casing	9.0	152.8	0	0	0	0
Core Layered Gabbros	37.3	190.1	7,971	8,535	564	15
Drill Layered Gabbros	14.9	205.0	8,535	9,098	564	38
Run 13-3/8" Liner	6.0	211.0	0	0	0	0
Core Layered Gabbros	19.9	230.9	9,098	9,662	564	28
Drill Layered Gabbros	11.2	242.1	9,662	10,089	427	38
Core Layered Gabbros	5.6	247.7	10,089	10,250	161	29
Run 11-3/4" Liner	6.0	253.7	0	0	0	0
Core Mantle	65.4	319.1	10,250	10,750	500	8
5% Operational NPT	16.0	335.1				
TA hole	3.0	338.1				
Pull BOP/Riser	3.0	**341.1**				
De-Mobilize Rig	13.4					
Total Core/Drill Days =	**341**					
Total Project Days =	**368**					

Figure 107. Hawaii Location - Case 2c: Operational Phase Summary

61% of the hole is cored, and 39% is drilled as shown below.

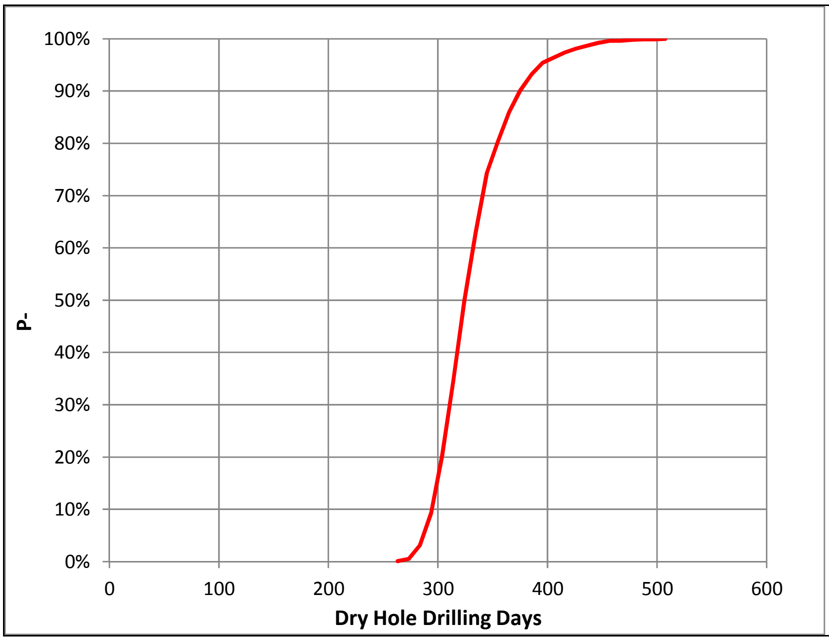
	Interval	%	Days
Coring =	4,052	60.5%	99
Drilling =	2,648	39.5%	30
	6,700	100%	129

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	4050	4111	61	Jetting	---	0.5	0	0	0	0.5	0.5
1	Sediments	4111	4250	139	Conv Core	12.2	0.5	1.1	0.0	0.0	1.6	2.1
2	Sediments	4111	4250	139	UR	12.2	0.5	1.1	0.0	6.0	7.6	9.7
3	Lava	4250	4467	217	Conv Core	4.6	2.0	1.2	0.0	0.0	3.2	12.9
4	Lava	4250	4467	217	UR	7.6	1.2	1.2	0.0	0.0	2.4	15.3
5	Lava	4467	4683	217	Drill	9.1	1.0	1.3	0.0	0.0	2.2	17.5
6	Lava	4683	4900	217	Conv Core	4.6	2.0	1.3	0.0	0.0	3.3	20.8
7	Lava	4683	4900	217	UR	7.6	1.2	1.3	0.0	0.0	2.5	23.3
8	Dikes	4900	5167	267	Conv Core	4.6	2.4	1.4	0.0	0.0	3.8	27.1
9	Dikes	4900	5167	267	UR	7.6	1.5	1.4	0.0	0.0	2.8	29.9
10	Dikes	5167	5433	267	Drill	9.1	1.2	1.4	0.0	0.0	2.7	32.6
11	Dikes	5433	5700	267	Conv Core	4.6	2.4	1.5	0.0	0.0	4.0	36.6
12	Dikes	5433	5700	267	UR	7.6	1.5	1.5	0.0	7.0	10.0	46.5
13	Textured Gabbros	5700	5817	116	Conv Core	4.6	1.1	1.6	0.0	0.0	2.6	49.2
14	Textured Gabbros	5700	5817	116	UR	7.6	0.6	1.6	0.0	0.0	2.2	51.4
15	Textured Gabbros	5817	5933	116	Drill	9.1	0.5	1.6	0.0	0.0	2.1	53.5
16	Textured Gabbros	5933	6050	117	Conv Core	4.6	1.1	1.6	0.0	0.0	2.7	56.2
17	Textured Gabbros	5933	6050	117	UR	7.6	0.6	1.6	0.0	0.0	2.3	58.5
18	Foliated Gabbros	6050	6284	233	Conv Core	2.4	4.0	1.7	0.0	0.0	5.7	64.2
19	Foliated Gabbros	6050	6284	233	UR	2.4	4.0	1.7	0.0	0.0	5.7	69.9
20	Foliated Gabbros	6284	6517	233	Drill	3.0	3.2	1.7	0.0	0.0	4.9	74.8
21	Foliated Gabbros	6517	6750	233	Conv Core	2.4	4.0	3.6	0.0	0.0	7.6	82.4
22	Foliated Gabbros	6517	6750	233	UR	2.4	4.0	3.6	0.0	0.0	7.6	90.0
23	Layered Gabbros	6750	6843	93	Conv Core	2.4	1.6	1.9	0.0	0.0	3.4	93.5
24	Layered Gabbros	6750	6843	93	UR	2.4	1.6	1.9	0.0	8.0	11.4	104.9
25	Layered Gabbros	6843	7207	364	Conv Core	2.4	6.2	3.8	0.0	0.0	10.1	115.0
26	Layered Gabbros	6843	7207	364	UR	2.4	6.2	3.8	0.0	0.0	10.1	125.0
27	Layered Gabbros	7207	7971	764	Drill	3.0	10.4	8.3	0.0	9.0	27.7	152.8
28	Layered Gabbros	7971	8535	564	Conv Core	2.4	9.6	9.0	0.0	0.0	18.7	171.4
29	Layered Gabbros	7971	8535	564	UR	2.4	9.6	9.0	0.0	0.0	18.7	190.1
30	Layered Gabbros	8535	9098	564	Drill	3.0	7.7	7.2	0.0	6.0	20.9	211.0
31	Layered Gabbros	9098	9662	564	Conv Core	2.4	9.6	10.3	0.0	0.0	19.9	230.9
32	Foliated Gabbros	9662	10089	427	Drill	3.0	5.8	5.4	0.0	0.0	11.2	242.2
33	Foliated Gabbros	10089	10250	161	Conv Core	2.4	2.8	2.8	0.0	6.0	11.5	253.7
34	Mantle	10250	10750	500	RCB Core	1.2	17.1	17.2	28.1	3.0	65.4	319.1
						Sub-Total days =	**129**	**117**	**28**	**45**	**319**	
						Sub-Total % =	**40%**	**37%**	**9%**	**14%**	**100%**	

Figure 108. Hawaii Location - Case 2c: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	263
P-10	**294**
P-50	**324**
P-90	**375**
Observed Maximum	507

Figure 109. Hawaii Location - Case 2c: Probabilistic Time

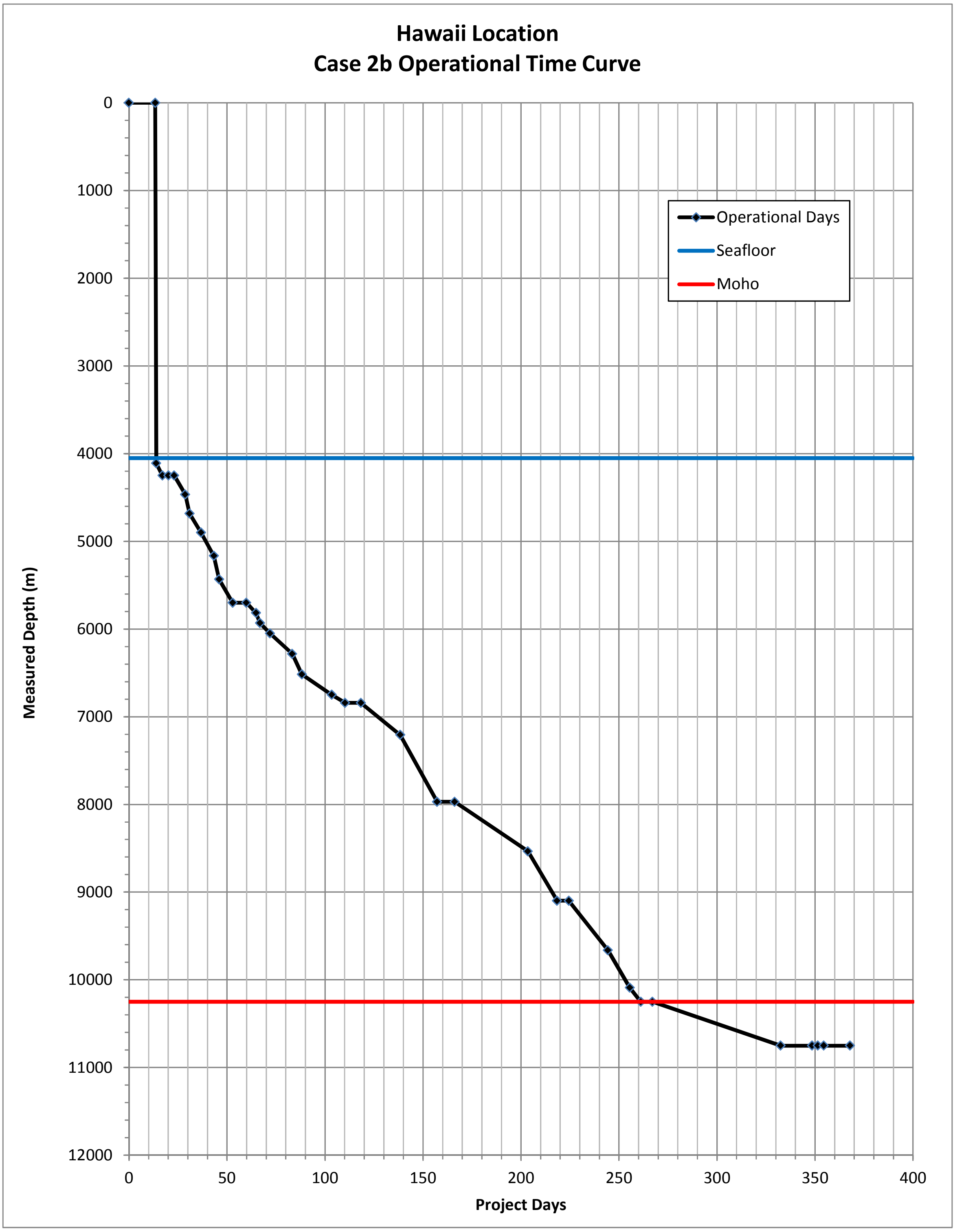


Figure 110. Hawaii Location: Case 2c Drilling Curve

5.3.4 Case 4a Operations Time:

This case assumes the original Base Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (ft)	To (ft)	Interval (ft)	Avg ft/day
Move in rig	13.4					
Jet 36"	0.5	0.5	4,050	4,111	61	0
Drill Sediments	1.4	1.9	4,111	4,235	124	90
Set 20" casing	3.0	4.9	0	0	0	0
Run BOP & Riser	3.0	7.9	0	0	0	0
Drill Sediments	1.2	9.1	4,235	4,250	15	13
Drill Lava	4.2	13.3	4,250	4,900	650	154
Drill Dikes	5.0	18.3	4,900	5,685	785	156
Set 13-3/8" Casing	6.0	24.3	0	0	0	0
Drill Dikes	1.6	25.9	5,685	5,700	15	9
Drill Textured Gabbr	3.2	29.1	5,700	6,050	350	109
Drill Foliated Gabbro	16.6	45.7	6,050	6,750	700	42
Drill Layered Gabbro	10.1	55.8	6,750	7,207	457	45
Drill Layered Gabbro	24.8	80.6	7,207	8,250	1,043	42
Run 11-3/4" Liner	9.0	89.6	0	0	0	0
Drill Layered Gabbro	50.1	139.7	8,250	10,250	2,000	40
Core Mantle	65.4	205.1	10,250	10,750	500	8
5% Operational NPT	10.0	215.1				
TA hole	3.0	218.1				
Pull BOP/Riser	3.0	221.1				
De-Mobilize Rig	13.4					

l Operational Days =	**221**
Total Project Days =	**248**

Figure 111. Hawaii Location - Case 4a: Operational Phase Summary

8% of the hole is cored, and 92% is drilled as shown below.

	Interval	%	Days
Coring =	500	7.5%	17
Drilling =	6,200	92.5%	66
	6,700	100%	83

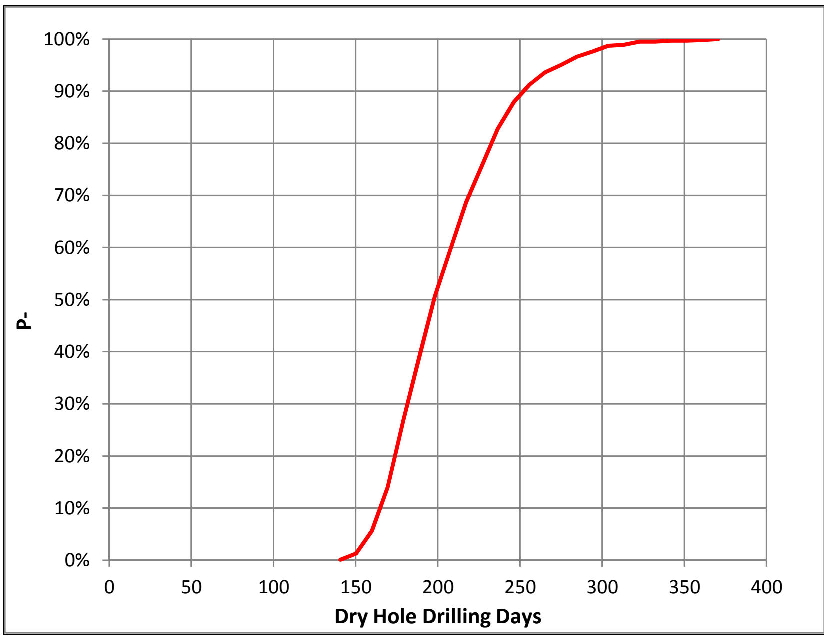
The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L"

time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	4050	4111	61	Jetting	---	0.5	0	0	0	0.5	0.5
1	Sediments	4111	4235	124	Drill	21.3	0.2	1.1	0.0	6.0	7.4	7.9
2	Sediments	4235	4250	15	Drill	21.3	0.0	1.2	0.0	0.0	1.2	9.1
3	Lava	4250	4900	650	Drill	9.1	3.0	1.3	0.0	0.0	4.2	13.3
4	Dikes	4900	5685	785	Drill	9.1	3.6	1.4	0.0	6.0	11.0	24.3
5	Dikes	5685	5700	15	Drill	9.1	0.1	1.6	0.0	0.0	1.6	25.9
6	Textured Gabbros	5700	6050	350	Drill	9.1	1.6	1.6	0.0	0.0	3.2	29.1
7	Foliated Gabbros	6050	6750	700	Drill	3.0	9.6	7.0	0.0	0.0	16.6	45.7
8	Layered Gabbros	6750	7207	457	Drill	3.0	6.3	3.8	0.0	0.0	10.1	55.8
9	Layered Gabbros	7207	8250	1043	Drill	3.0	14.3	10.6	0.0	9.0	33.8	89.6
10	Layered Gabbros	8250	10250	2000	Drill	3.0	27.3	22.8	0.0	0.0	50.1	139.7
11	Mantle	10250	10750	500	RCB Core	1.2	17.1	17.2	28.1	3.0	65.4	205.1
						Sub-Total days =	**83**	**70**	**28**	**24**	**205**	
						Sub-Total % =	**41%**	**34%**	**14%**	**12%**	**100%**	

Figure 112. Hawaii Location - Case 4a: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	141
P-10	**165**
P-50	**198**
P-90	**252**
Observed Maximum	371

Figure 113. Hawaii Location - Case 4a: Probabilistic Time

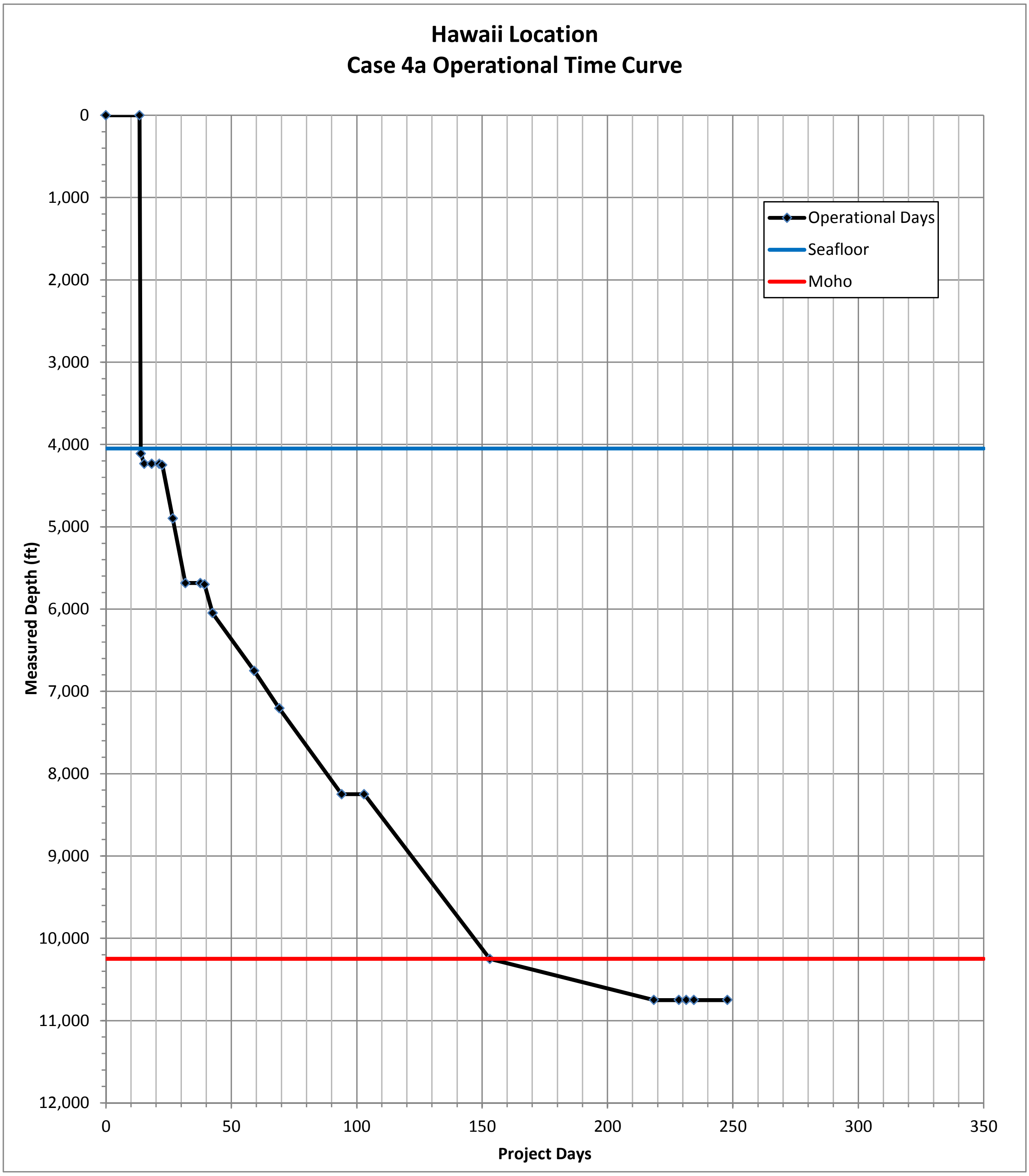


Figure 114. Hawaii Location: Case 4a Drilling Curve

5.3.5 Case 4b Operations Time:

This case assumes the Deepwater Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Mobilize Rig	13.4					
Jet 36"	0.5	0.5	4,050	4,111	61	122
Drill Sediments	1.4	1.9	4,111	4,235	124	90
Set 22" casing	3.0	4.9				
Run BOP & Riser	3.0	7.9				
Drill Sediments	1.2	9.1	4,235	4,250	15	13
Drill Lava	4.2	13.3	4,250	4,900	650	154
Drill Dikes	5.1	18.4	4,900	5,700	800	0
Set 18" Casing	6.0	24.4				
Drill Textured Gabbros	3.2	27.6	5,700	6,050	350	109
Drill Foliated Gabbros	16.6	44.2	6,050	6,750	700	42
Drill Layered Gabbros	3.1	47.3	6,750	6,843	93	30
Set 16" Casing	7.0	54.3				
Drill Layered Gabbros	25.5	79.9	6,843	7,971	1,128	44
Run 13-3/8" Liner	9.0	88.9				
Drill Layered Gabbros	27.1	115.9	7,971	9,098	1,128	44
Run 11-3/4" Liner	6.0	121.9				
Drill Layered Gabbros	31.6	153.6	9,098	10,250	1,128	44
Run 9-5/8" Liner	6.0	159.6				
Core Mantle	65.4	224.9	10,250	10,750	500	8
5% Operational NPT	11.0	235.9				
TA hole	3.0	238.9				
Pull BOP/Riser	3.0	241.9				
De-Mobilize Rig	13.4					

Total Core/Drill Days =	**242**
Total Project Days =	**269**

Figure 115. Hawaii Location - Case 4b: Operational Phase Summary

8% of the hole is cored, and 92% is drilled as shown below.

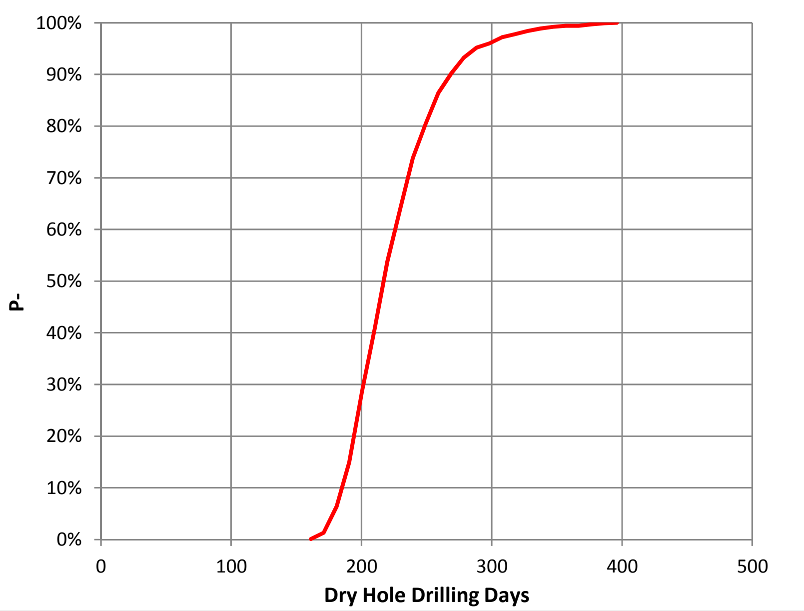
	Interval	%	Days
Coring =	500	7.5%	17
Drilling =	6,200	92.5%	66
	6,700	100%	83

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	4050	4111	61	Jetting	---	0.5	0	0	0	0.5	0.5
1	Sediments	4111	4235	124	Drill	21.3	0.2	1.1	0.0	6.0	7.4	7.9
2	Sediments	4235	4250	15	Drill	21.3	0.0	1.2	0.0	0.0	1.2	9.1
3	Lava	4250	4900	650	Drill	9.1	3.0	1.3	0.0	0.0	4.2	13.3
4	Dikes	4900	5700	800	Drill	9.1	3.6	1.4	0.0	6.0	11.1	24.4
5	Textured Gabbros	5700	6050	350	Drill	9.1	1.6	1.6	0.0	0.0	3.2	27.6
6	Foliated Gabbros	6050	6750	700	Drill	3.0	9.6	7.0	0.0	0.0	16.6	44.1
7	Layered Gabbros	6750	6843	93	Drill	3.0	1.3	1.9	0.0	7.0	10.1	54.3
8	Layered Gabbros	6843	7971	1128	Drill	3.0	15.4	10.1	0.0	9.0	34.5	88.8
9	Layered Gabbros	7971	9098	1128	Drill	3.0	15.4	11.7	0.0	6.0	33.1	121.9
10	Layered Gabbros	9098	10250	1152	Drill	3.0	15.7	15.9	0.0	6.0	37.6	159.5
11	Mantle	10250	10750	500	RCB Core	1.2	17.1	17.2	28.1	3.0	65.4	224.9
						Sub-Total days =	**83**	**70**	**28**	**43**	**225**	
						Sub-Total % =	**37%**	**31%**	**12%**	**19%**	**100%**	

Figure 116. Hawaii Location - Case 4b: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	161
P-10	**185**
P-50	**217**
P-90	**268**
Observed Maximum	396

Figure 117. Hawaii Location - Case 4b: Probabilistic Time

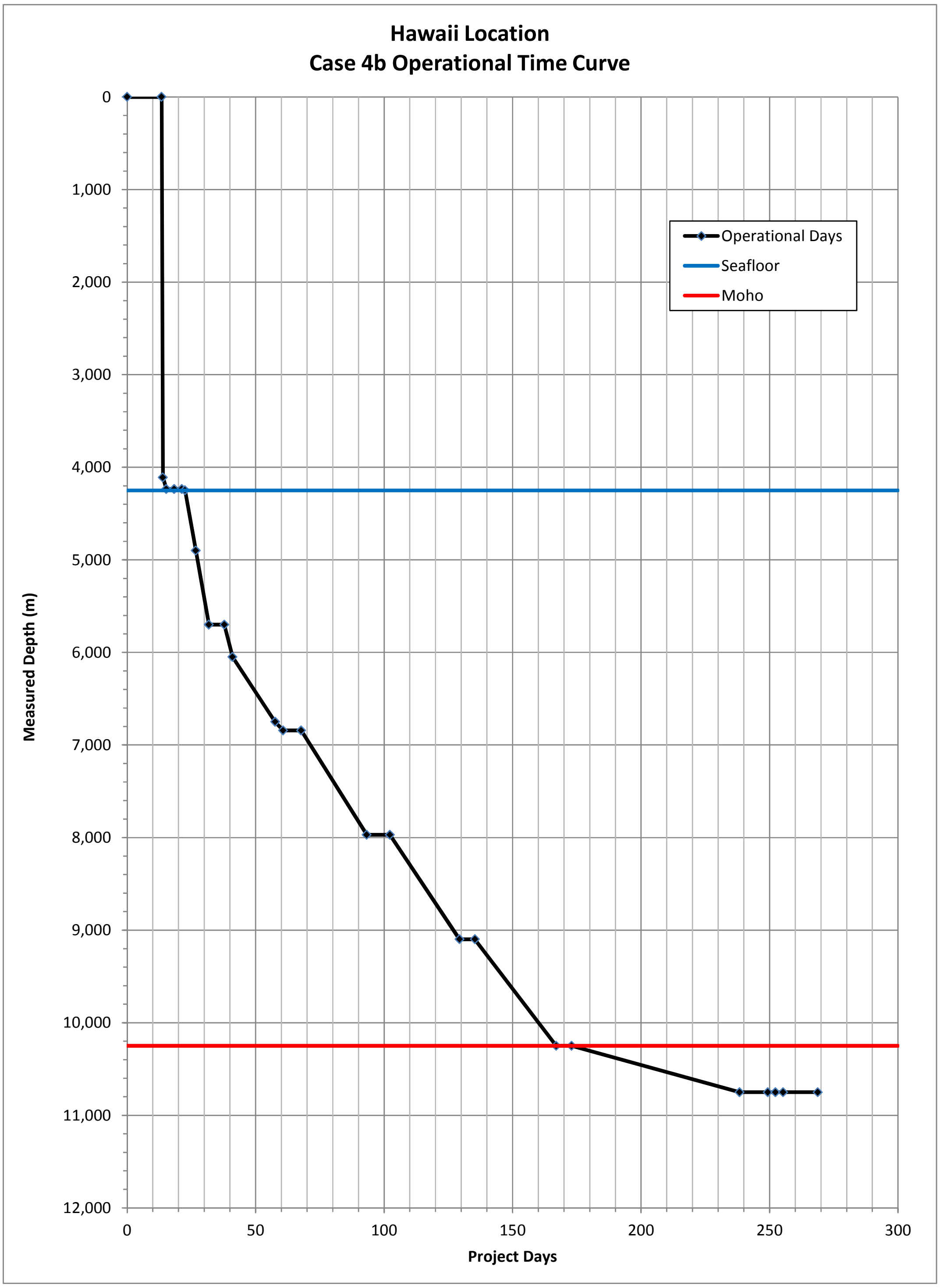


Figure 118. Hawaii Location: Case 4b Drilling Curve

5.3.6 Case 4c Operations Time:

This case assumes the Expandable Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Mobilize Rig	13.4					
Jet 36"	0.5	0.5	4,050	4,111	61	122
Drill Sediments	1.4	1.9	4,111	4,235	124	90
Set 22" casing	3.0	4.9				
Run BOP & Riser	3.0	7.9				
Drill Sediments	1.2	9.1	4,235	4,250	15	13
Drill Lava	4.2	13.3	4,250	4,900	650	154
Drill Dikes	5.1	18.4	4,900	5,700	800	0
Set 16.5" SET Casing	7.0	25.4				
Drill Textured Gabbros	3.2	28.6	5,700	6,050	350	109
Drill Foliated Gabbros	16.6	45.2	6,050	6,750	700	42
Drill Layered Gabbros	3.1	48.3	6,750	6,843	93	30
Set 16.5" SET Casing	8.0	56.3				
Drill Layered Gabbros	25.5	81.9	6,843	7,971	1,128	44
Run 16" Liner	9.0	90.9				
Drill Layered Gabbros	27.1	117.9	7,971	9,098		
Run 13-3/8" Liner	6.0	123.9				
Drill Layered Gabbros	31.6	155.6	9,098	10,250		
Run 11-3/4" Liner	6.0	161.6				
Core Mantle	65.4	226.9	10,250	10,750	500	8
5% Operational NPT	11.0	237.9				
TA hole	3.0	240.9				
Pull BOP/Riser	3.0	243.9				
De-Mobilize Rig	13.4					
Total Core/Drill Days =	**244**					
Total Project Days =	**271**					

Figure 119. Hawaii Location - Case 4c: Operational Phase Summary

8% of the hole is cored, and 92% is drilled as shown below.

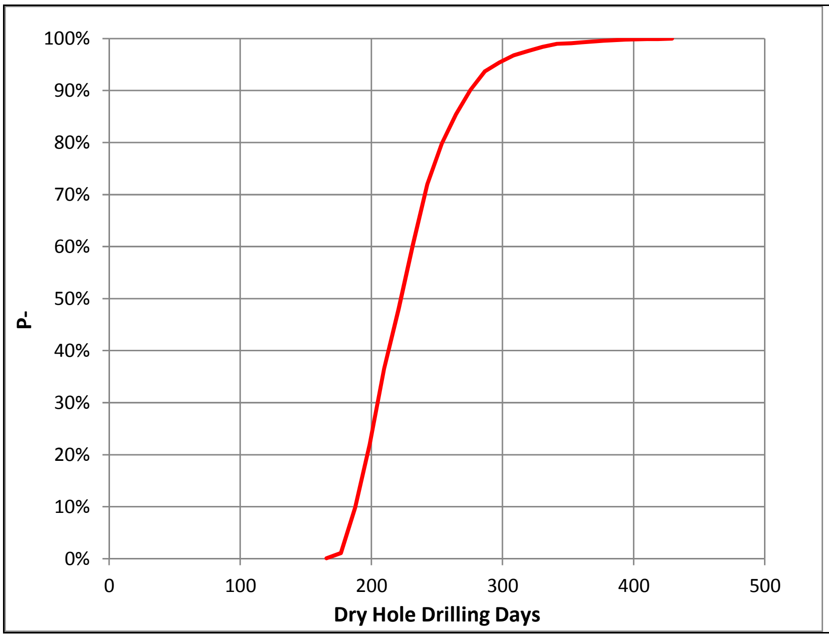
	Interval	%	Days
Coring =	500	7.5%	17
Drilling =	6200	92.5%	66
	6700	100%	83

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	4,050	4,111	61	Jetting	---	0.5	0.0	0.0	0.0	0.5	0.5
1	Sediments	4,111	4,235	124	Drill	70	0.2	1.1	0.0	6.0	7.4	7.9
2	Sediments	4,235	4,250	15	Drill	70	0.0	1.2	0.0	0.0	1.2	9.1
3	Lava	4,250	4,900	650	Drill	30	3.0	1.3	0.0	0.0	4.2	13.3
4	Dikes	4,900	5,700	800	Drill	30	3.6	1.4	0.0	7.0	12.1	25.4
5	Textured Gabbros	5,700	6,050	350	Drill	30	1.6	1.6	0.0	0.0	3.2	28.6
6	Foliated Gabbros	6,050	6,750	700	Drill	10	9.6	7.0	0.0	0.0	16.6	45.1
7	Layered Gabbros	6,750	6,843	93	Drill	10	1.3	1.9	0.0	8.0	11.1	56.3
8	Layered Gabbros	6,843	7,971	1128	Drill	10	15.4	10.1	0.0	9.0	34.5	90.8
9	Layered Gabbros	7,971	9,098	1128	Drill	10	15.4	11.7	0.0	6.0	33.1	123.9
10	Layered Gabbros	9,098	10,250	1152	Drill	10	15.7	15.9	0.0	6.0	37.6	161.5
11	Mantle	10,250	10,750	500	RCB Core	4	17.1	17.2	28.1	3.0	65.4	226.9
						Sub-Total days =	**83**	**70**	**28**	**45**	**227**	
						Sub-Total % =	**37%**	**31%**	**12%**	**20%**	**100%**	

Figure 120. Hawaii Location - Case 4c: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	166
P-10	**188**
P-50	**223**
P-90	**275**
Observed Maximum	429

Figure 121. Hawaii Location - Case 4c: Probabilistic Time

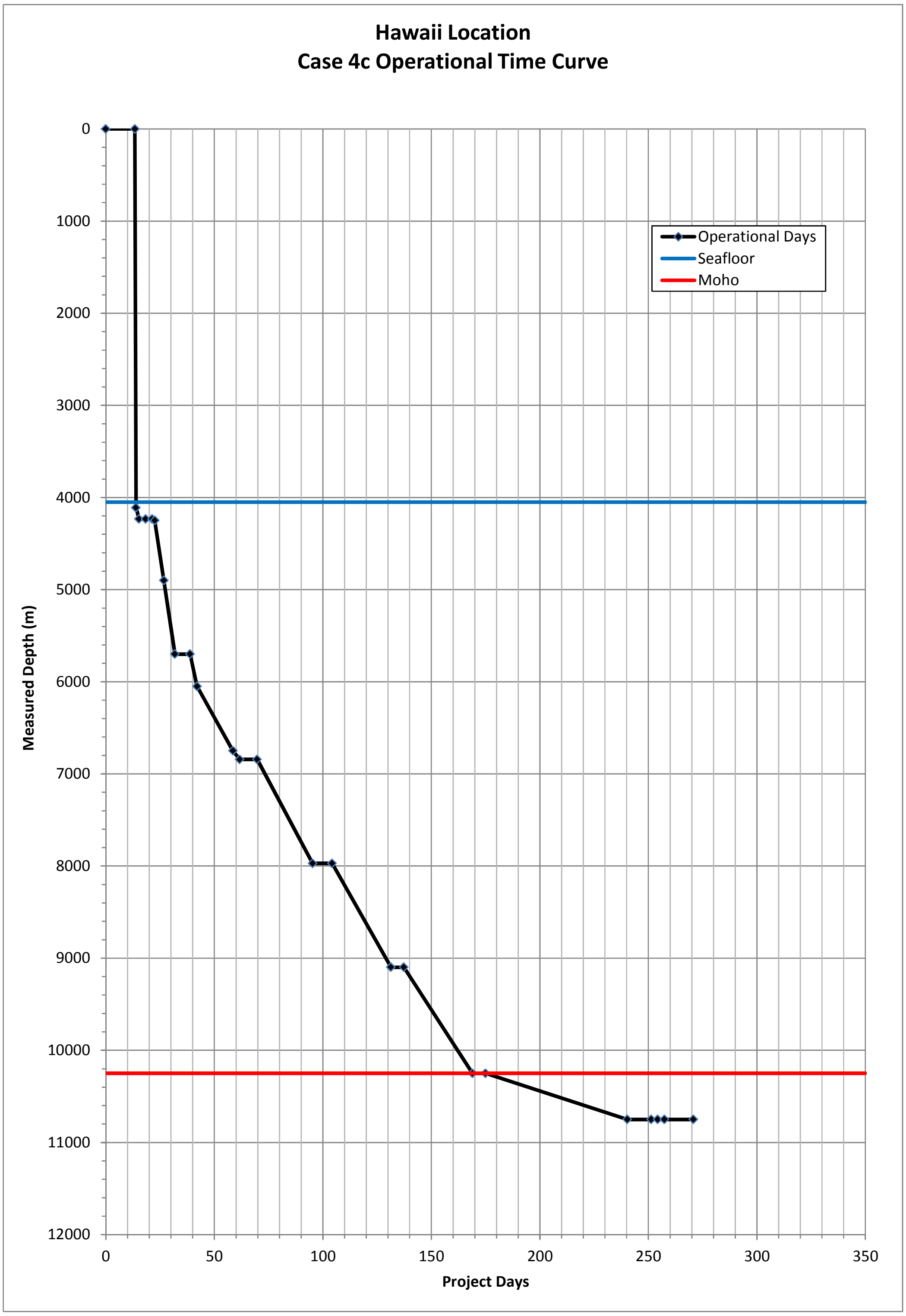


Figure 122. Hawaii Location: Case 4c Drilling Curve

5.4 Baja Location Operational Time Estimates

5.4.1 Case 2a Operations Time:

This case assumes the original Base Case wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (ft)	To (ft)	Interval (ft)	Avg ft/day
Move in rig	18.1					
Jet 36"	0.5	0.5	4,300	4,361	61	122
Core/UR Sediments	2.6	3.1	4,361	4,385	24	9
Set 20" casing	3.0	6.1				
Run BOP & Riser	3.0	9.1				
Core/UR Sediments	2.6	11.7	4,385	4,400	15	6
Core/UR Lava	5.5	17.2	4,400	4,617	217	39
Drill Lava	2.3	19.5	4,617	4,834	217	94
Core/UR Lava	5.8	25.3	4,834	5,050	216	37
Core/UR Dikes	6.7	32.0	5,050	5,317	267	40
Drill Dikes	2.7	34.7	5,317	5,580	264	98
Core/UR Dikes	6.9	41.6	5,580	5,835	255	37
Set 13-3/8" Casing	6.0	47.6				
Core/UR Dikes	1.7	49.3	5,835	5,850	15	9
Core Textured Gabbros	2.7	52.0	5,850	5,967	116	43
Drill Textured Gabbros	2.2	54.2	5,967	6,083	116	53
Core Textured Gabbros	2.7	56.9	6,083	6,200	117	43
Core Foliated Gabbros	5.7	62.6	6,200	6,433	233	41
Drill Foliated Gabbros	5.0	67.6	6,433	6,667	233	47
Core Foliated Gabbros	7.7	75.3	6,667	6,900	233	30
Core Layered Gabbros	13.7	89.0	6,900	7,357	457	33
Drill Layered Gabbros	13.6	102.6	7,357	7,900	543	40
Run 11-3/4" Liner	9.0	111.6				
Core Layered Gabbros	14.5	126.1	7,900	8,357	457	32
Drill Layered Gabbros	10.9	137.0	8,357	8,815	457	42
Core Layered Gabbros	15.2	152.2	8,815	9,272	457	30
Drill Layered Gabbros	11.5	163.7	9,272	9,729	457	40
Core Layered Gabbros	5.6	169.3	9,729	9,900	171	31
Core Mantle	63.9	233.2	9,900	10,400	500	8
5% Operational NPT	12.0	245.2				
TA hole	3.0	248.2				
Pull BOP/Riser	3.0	**251.2**				
De-Mobilize Rig	18.1					
Total Operational Days =	**251**					
Total Project Days =	**287**					

Figure 123. Baja Location - Case 2a: Operational Phase Summary

61% of the hole is cored, and 39% is drilled as shown below.

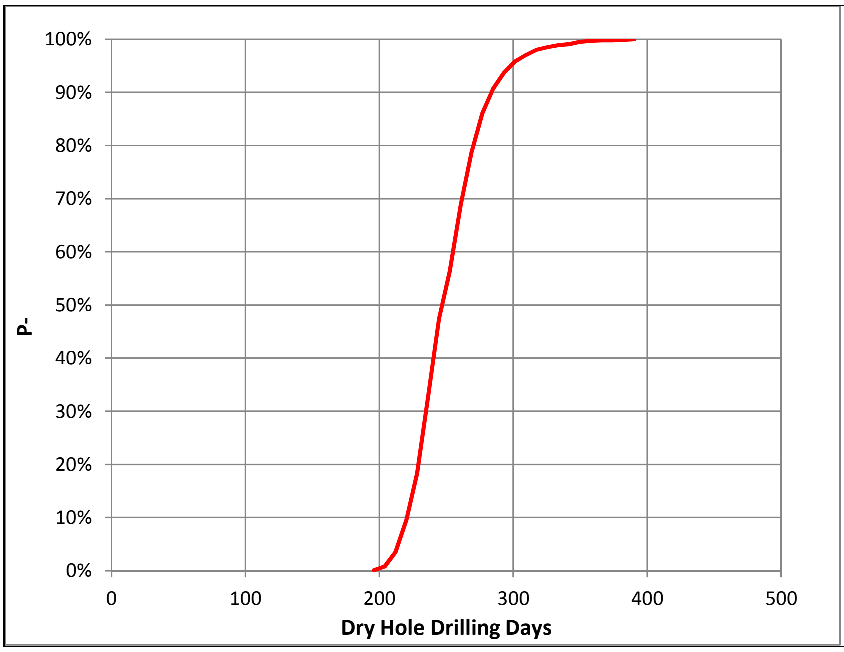
	Interval	%	Days
Coring =	3,752	61.5%	68
Drilling =	2,349	38.5%	26
	6,100	100%	94

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							**Section Time (days)**				**Section**	**Cum**
Section	**Stratigraphy**	**From**	**To**	**Interval**	**Operation**	**ROP**	**Ops Time**	**Bit Trip**	**W/L**	**Flat**	**Days**	**Days**
0.1	Sediments	4300	4361	61	Jetting	---	0.5	0	0	0	0.5	0.5
1	Sediments	4361	4385	24	Conv Core	12.2	0.1	1.2	0.0	0.0	1.3	1.8
2	Sediments	4361	4385	24	UR	12.2	0.1	1.2	0.0	6.0	7.3	9.1
3	Sediments	4385	4400	15	Conv Core	12.2	0.1	1.2	0.0	0.0	1.3	10.3
4	Sediments	4385	4400	15	UR	12.2	0.1	1.2	0.0	0.0	1.3	11.6
5	Lava	4400	4617	217	Conv Core	4.6	2.0	1.2	0.0	0.0	3.2	14.8
6	Lava	4400	4617	217	UR	7.6	1.2	1.2	0.0	0.0	2.4	17.2
7	Lava	4617	4834	217	Drill	9.1	1.0	1.3	0.0	0.0	2.3	19.5
8	Lava	4834	5050	216	Conv Core	4.6	2.0	1.4	0.0	0.0	3.3	22.8
9	Lava	4834	5050	216	UR	7.6	1.2	1.4	0.0	0.0	2.5	25.3
10	Dikes	5050	5317	267	Conv Core	4.6	2.4	1.4	0.0	0.0	3.8	29.2
11	Dikes	5050	5317	267	UR	7.6	1.5	1.4	0.0	0.0	2.9	32.0
12	Dikes	5317	5580	264	Drill	9.1	1.2	1.5	0.0	0.0	2.7	34.7
13	Dikes	5580	5835	255	Conv Core	4.6	2.3	1.6	0.0	0.0	3.9	38.6
14	Dikes	5580	5835	255	UR	7.6	1.4	1.6	0.0	6.0	9.0	47.6
15	Dikes	5835	5850	15	Conv Core	4.6	0.1	1.6	0.0	0.0	1.7	49.3
16	Textured Gabbros	5850	5967	116	Conv Core	4.6	1.1	1.6	0.0	0.0	2.7	52.0
17	Textured Gabbros	5967	6083	116	Drill	9.1	0.5	1.6	0.0	0.0	2.2	54.2
18	Textured Gabbros	6083	6200	117	Conv Core	4.6	1.1	1.7	0.0	0.0	2.7	56.9
19	Foliated Gabbros	6200	6433	233	Conv Core	2.4	4.0	1.7	0.0	0.0	5.7	62.6
20	Foliated Gabbros	6433	6667	233	Drill	3.0	3.2	1.8	0.0	0.0	5.0	67.6
21	Foliated Gabbros	6667	6900	233	Conv Core	2.4	4.0	3.7	0.0	0.0	7.7	75.3
22	Layered Gabbros	6900	7357	457	Conv Core	2.4	7.8	5.8	0.0	0.0	13.7	89.0
23	Layered Gabbros	7357	7900	543	Drill	3.0	7.4	6.3	0.0	9.0	22.7	111.6
24	Layered Gabbros	7900	8357	457	Conv Core	2.4	7.8	6.7	0.0	0.0	14.5	126.1
25	Layered Gabbros	8357	8815	457	Drill	3.0	6.3	4.7	0.0	0.0	10.9	137.1
26	Layered Gabbros	8815	9272	457	Conv Core	2.4	7.8	7.4	0.0	0.0	15.2	152.3
27	Layered Gabbros	9272	9729	457	Drill	3.0	6.3	5.2	0.0	0.0	11.4	163.7
28	Layered Gabbros	9729	9900	171	Conv Core	2.4	2.9	2.7	0.0	0.0	5.6	169.3
29	Mantle	9900	10400	500	RCB Core	1.2	17.1	16.7	27.1	3.0	63.9	233.2
						Sub-Total days =	**94**	**88**	**27**	**24**	**233**	
						Sub-Total % =	**40%**	**38%**	**12%**	**10%**	**100%**	

Figure 124. Baja Location - Case 2a: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	196
P-10	**221**
P-50	**247**
P-90	**284**
Observed Maximum	390

Figure 125. Baja Location - Case 2a: Probabilistic Time

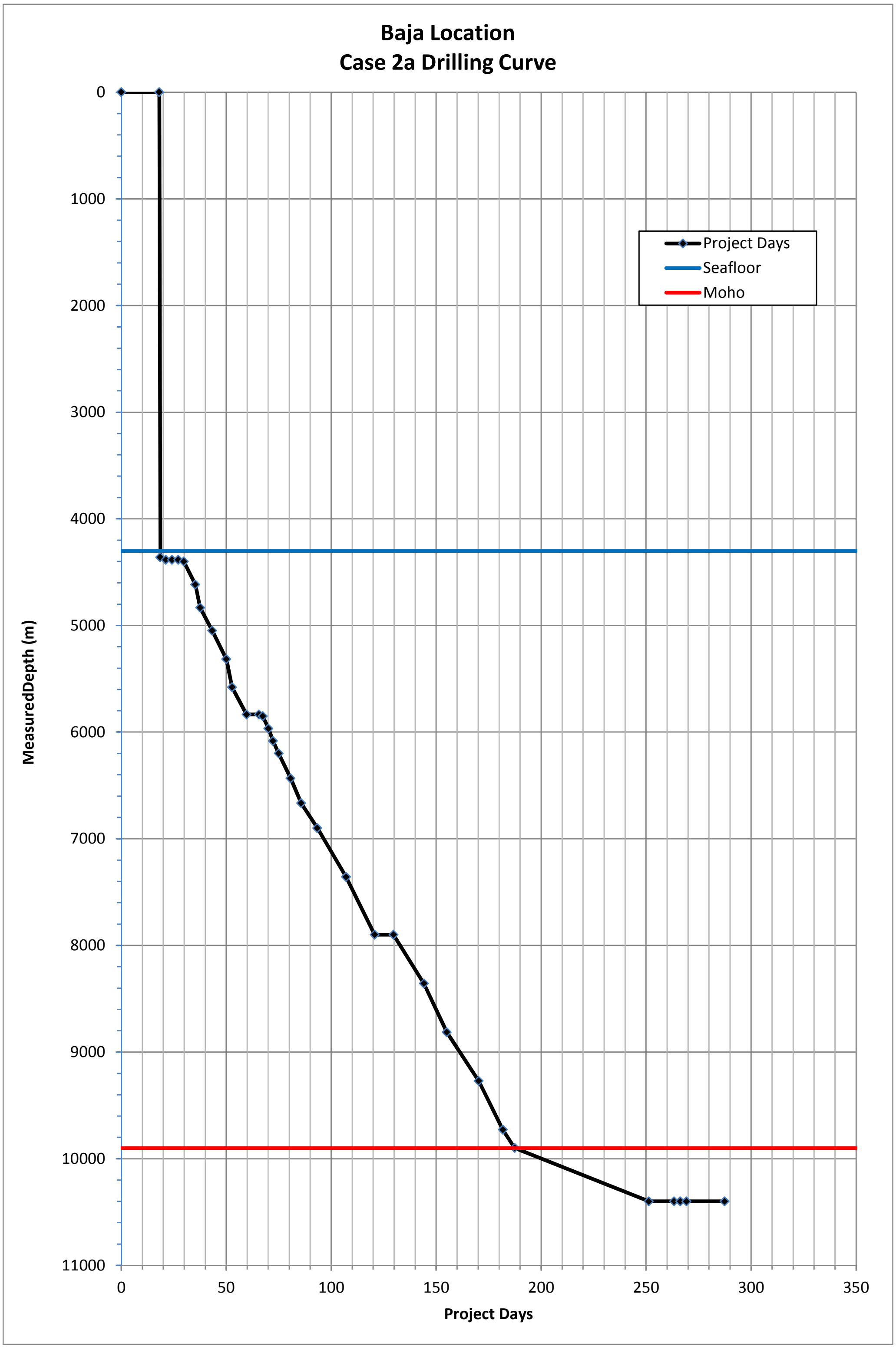


Figure 126. Baja Location: Case 2a Drilling Curve

5.4.2 Case 2b Operations Time:

This case assumes the Deepwater case wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Move in rig	18.1					
Jet 36"	0.5	0.5	4,300	4,361	61	122
Core/UR Sediments	2.6	3.1	4,361	4,385	24	9
Set 20" casing	3.0	6.1				
Run BOP & Riser	3.0	9.1				
Core/UR Sediments	2.5	11.6	4,385	4,400	15	6
Core/UR Lava	5.6	17.2	4,400	4,617	217	39
Drill Lava	2.3	19.5	4,617	4,834	217	94
Core/UR Lava	5.8	25.3	4,834	5,050	216	37
Core/UR Dikes	6.7	32.0	5,050	5,317	267	40
Drill Dikes	2.7	34.7	5,317	5,580	264	98
Core/UR Dikes	7.1	41.8	5,580	5,850	270	38
Set 18" Casing	6.0	47.8				
Core/UR Textured Gabbros	4.9	52.7	5,850	5,967	116	24
Drill Textured Gabbros	2.2	54.9	5,967	6,083	116	53
Core/UR Textured Gabbros	5.1	60.0	6,083	6,200	117	23
Core/UR Foliated Gabbros	11.4	71.4	6,200	6,433	233	20
Drill Foliated Gabbros	5.0	76.4	6,433	6,667	233	47
Core/UR Foliated Gabbros	13.9	90.3	6,667	6,858	191	14
Set 16" Casing	7.0	97.3				
Core/UR Foliated Gabbros	5.2	102.5	6,858	6,900	42	8
Core/UR Layered Gabbros	27.3	129.8	6,900	7,357	457	17
Drill Layered Gabbros	13.2	143.0	7,357	7,864	507	38
Run 13-3/8" Casing	9.0	152.0				
Core Layered Gabbros	15.1	167.1	7,864	8,357	493	33
Drill Layered Gabbros	13.6	180.7	8,357	8,839	482	35
Run 11-3/4" Liner	6.0	186.7				
Core Layered Gabbros	14.8	201.5	8,839	9,272	433	29
Drill Layered Gabbros	11.4	212.9	9,272	9,726	454	40
Core Layered Gabbros	5.7	218.6	9,726	9,900	174	31
Run 9-5/8" Liner	6.0	224.6	0	0	0	0
Core Mantle	63.9	288.5	9,900	10,400	500	8
5% Operational NPT	14.0	302.5				
TA hole	3.0	305.5				
Pull BOP/Riser	3.0	**308.5**				
De-Mobilize Rig	18.1					

Total Core/Drill Days =	**309**
Total Project Days =	**345**

Figure 127. Baja Location - Case 2b: Operational Phase Summary

62% of the hole is cored, and 38% is drilled as shown below.

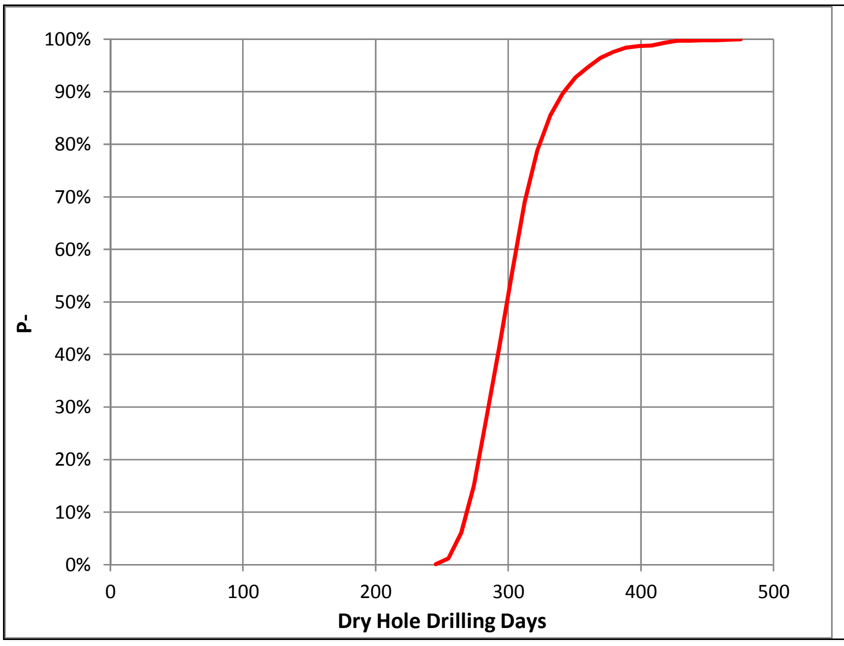
	Interval	%	Days
Coring =	3,766	61.7%	85
Drilling =	2,334	38.3%	26
	6,100	100%	111

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	4300	4361	61	Jetting	---	0.5	0	0	0	0.5	0.5
1	Sediments	4361	4385	24	Conv Core	12.2	0.1	1.2	0.0	0.0	1.3	1.8
2	Sediments	4361	4385	24	UR	12.2	0.1	1.2	0.0	6.0	7.3	9.1
3	Sediments	4385	4400	15	Conv Core	12.2	0.1	1.2	0.0	0.0	1.3	10.3
4	Sediments	4385	4400	15	UR	12.2	0.1	1.2	0.0	0.0	1.3	11.6
5	Lava	4400	4617	217	Conv Core	4.6	2.0	1.2	0.0	0.0	3.2	14.8
6	Lava	4400	4617	217	UR	7.6	1.2	1.2	0.0	0.0	2.4	17.2
7	Lava	4617	4834	217	Drill	9.1	1.0	1.3	0.0	0.0	2.3	19.5
8	Lava	4834	5050	216	Conv Core	4.6	2.0	1.4	0.0	0.0	3.3	22.8
9	Lava	4834	5050	216	UR	7.6	1.2	1.4	0.0	0.0	2.5	25.3
10	Dikes	5050	5317	267	Conv Core	4.6	2.4	1.4	0.0	0.0	3.8	29.2
11	Dikes	5050	5317	267	UR	7.6	1.5	1.4	0.0	0.0	2.9	32.0
12	Dikes	5317	5580	264	Drill	9.1	1.2	1.5	0.0	0.0	2.7	34.7
13	Dikes	5580	5850	270	Conv Core	4.6	2.5	1.6	0.0	0.0	4.0	38.8
14	Dikes	5580	5850	270	UR	7.6	1.5	1.6	0.0	6.0	9.0	47.8
15	Textured Gabbros	5850	5967	116	Conv Core	4.6	1.1	1.6	0.0	0.0	2.7	50.5
16	Textured Gabbros	5850	5967	116	UR	7.6	0.6	1.6	0.0	0.0	2.3	52.7
17	Textured Gabbros	5967	6083	116	Drill	9.1	0.5	1.6	0.0	0.0	2.2	54.9
18	Textured Gabbros	6083	6200	117	Conv Core	4.6	1.1	1.7	0.0	0.0	2.7	57.6
19	Textured Gabbros	6083	6200	117	UR	7.6	0.6	1.7	0.0	0.0	2.3	60.0
20	Foliated Gabbros	6200	6433	233	Conv Core	2.4	4.0	1.7	0.0	0.0	5.7	65.7
21	Foliated Gabbros	6200	6433	233	UR	2.4	4.0	1.7	0.0	0.0	5.7	71.4
22	Foliated Gabbros	6433	6667	233	Drill	3.0	3.2	1.8	0.0	0.0	5.0	76.4
23	Foliated Gabbros	6667	6858	191	Conv Core	2.4	3.3	3.7	0.0	0.0	7.0	83.3
24	Foliated Gabbros	6667	6858	191	UR	2.4	3.3	3.7	0.0	7.0	14.0	97.3
25	Foliated Gabbros	6858	6900	42	Conv Core	2.4	0.7	1.9	0.0	0.0	2.6	99.9
26	Foliated Gabbros	6858	6900	42	UR	2.4	0.7	1.9	0.0	0.0	2.6	102.5
27	Layered Gabbros	6900	7357	457	Conv Core	2.4	7.8	5.8	0.0	0.0	13.7	116.2
28	Layered Gabbros	6900	7357	457	UR	2.4	7.8	5.8	0.0	0.0	13.7	129.8
29	Layered Gabbros	7357	7864	507	Drill	3.0	6.9	6.2	0.0	9.0	22.2	152.0
30	Layered Gabbros	7864	8357	493	Conv Core	2.4	8.4	6.7	0.0	0.0	15.1	167.1
31	Layered Gabbros	8357	8839	482	Drill	3.0	6.6	7.1	0.0	6.0	19.6	186.7
32	Layered Gabbros	8839	9272	433	Conv Core	2.4	7.4	7.4	0.0	0.0	14.8	201.5
33	Layered Gabbros	9272	9726	454	Drill	3.0	6.2	5.2	0.0	0.0	11.4	212.9
34	Layered Gabbros	9726	9900	174	Conv Core	2.4	3.0	2.7	0.0	6.0	11.7	224.6
35	Mantle	9900	10400	500	RCB Core	1.2	17.1	16.7	27.1	3.0	63.9	288.5
						Sub-Total days =	**111**	**107**	**27**	**43**	**288**	
						Sub-Total % =	**39%**	**37%**	**9%**	**15%**	**100%**	

Figure 128. Baja Location - Case 2b: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	245
P-10	**269**
P-50	**299**
P-90	**342**
Observed Maximum	475

Figure 129. Baja Location - Case 2b: Probabilistic Time

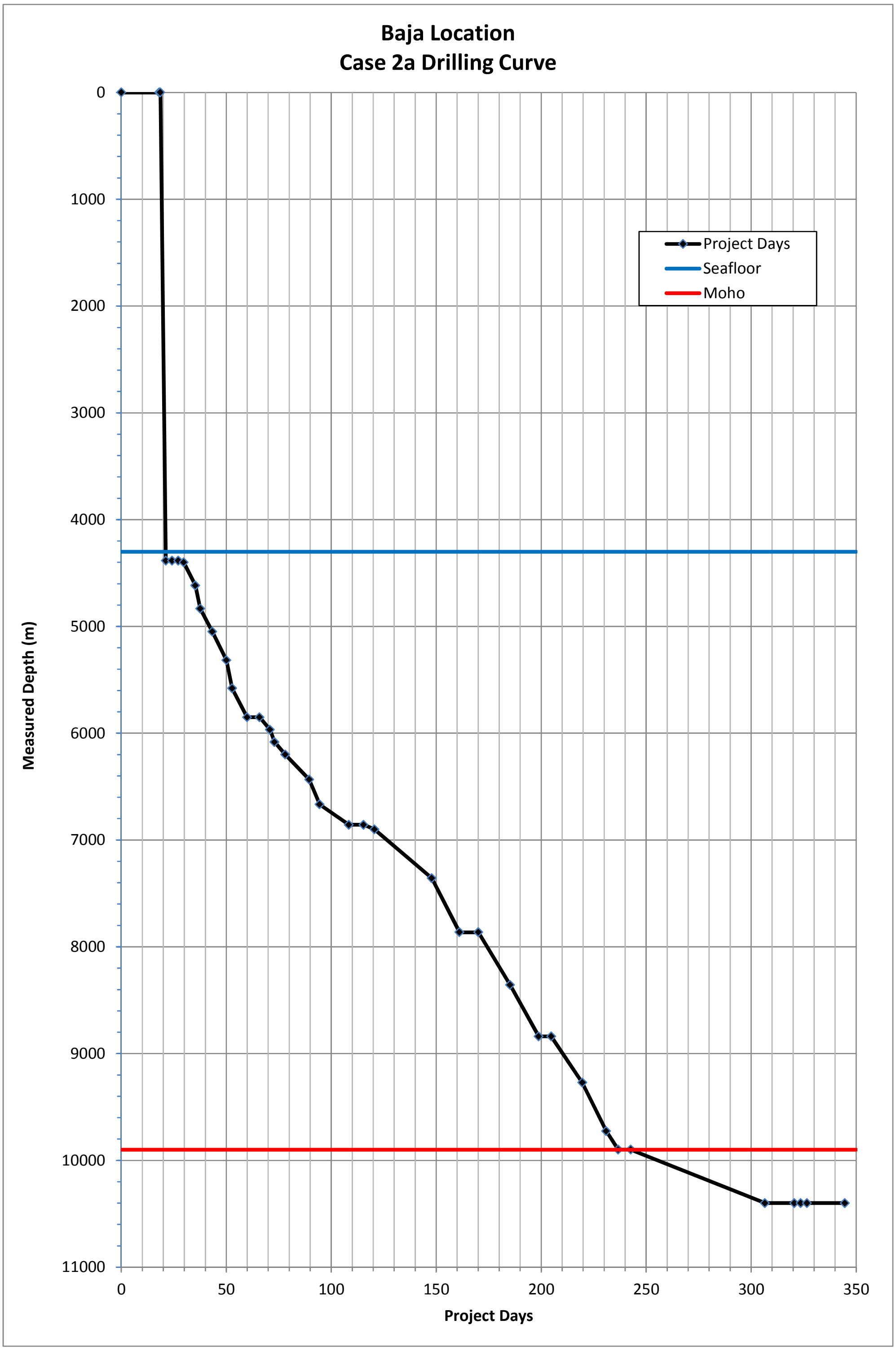


Figure 130. Baja Location: Case 2b Drilling Curve

5.4.3 Case 2c Operations Time:

This case assumes the Expandable Case wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Move in rig	18.1					
Jet 36"	0.5	0.5	4,300	4,361	61	122
Core/UR Sediments	2.6	3.1	4,361	4,385	24	9
Set 20" casing	3.0	6.1				
Run BOP & Riser	3.0	9.1				
Core/UR Sediments	2.5	11.6	4,385	4,400	15	6
Core/UR Lava	5.6	17.2	4,400	4,617	217	39
Drill Lava	2.3	19.5	4,617	4,834	217	94
Core/UR Lava	5.8	25.3	4,834	5,050	216	37
Core/UR Dikes	6.7	32.0	5,050	5,317	267	40
Drill Dikes	2.7	34.7	5,317	5,580	264	98
Core/UR Dikes	7.1	41.8	5,580	5,850	270	38
Run 16.5" SET Casing	7.0	48.8				
Core/UR Textured Gabbros	4.9	53.7	5,850	5,967	116	24
Drill Textured Gabbros	2.2	55.9	5,967	6,083	116	53
Core/UR Textured Gabbros	5.1	61.0	6,083	6,200	117	23
Core/UR Foliated Gabbros	11.4	72.4	6,200	6,433	233	20
Drill Foliated Gabbros	5.0	77.4	6,433	6,667	233	47
Core/UR Foliated Gabbros	13.9	91.3	6,667	6,858	191	14
Run 16.5" SET Casing	8.0	99.3				
Core/UR Foliated Gabbros	5.2	104.5	6,858	6,900	42	8
Core/UR Layered Gabbros	27.3	131.8	6,900	7,357	457	17
Drill Layered Gabbros	13.2	145.0	7,357	7,864	507	38
Run 16" Casing	9.0	154.0				
Core Layered Gabbros	30.2	184.2	7,864	8,357	493	16
Drill Layered Gabbros	13.6	197.8	8,357	8,839	482	35
Run 13-3/8" Liner	6.0	203.8				
Core Layered Gabbros	14.8	218.6	8,839	9,272	433	29
Drill Layered Gabbros	11.4	230.0	9,272	9,726	454	40
Core Layered Gabbros	5.7	235.7	9,726	9,900	174	31
Run 9-5/8" Liner	6.0	241.7				
Core Mantle	63.9	305.6	9,900	10,400	500	8
5% Operational NPT	15.0	320.6				
TA hole	3.0	323.6				
Pull BOP/Riser	3.0	**326.6**				
De-Mobilize Rig	18.1					

Total Core/Drill Days =	**327**
Total Project Days =	**363**

Figure 131. Baja Location - Case 2c Operational Phase Summary

62% of the hole is cored, and 38% is drilled as shown below.

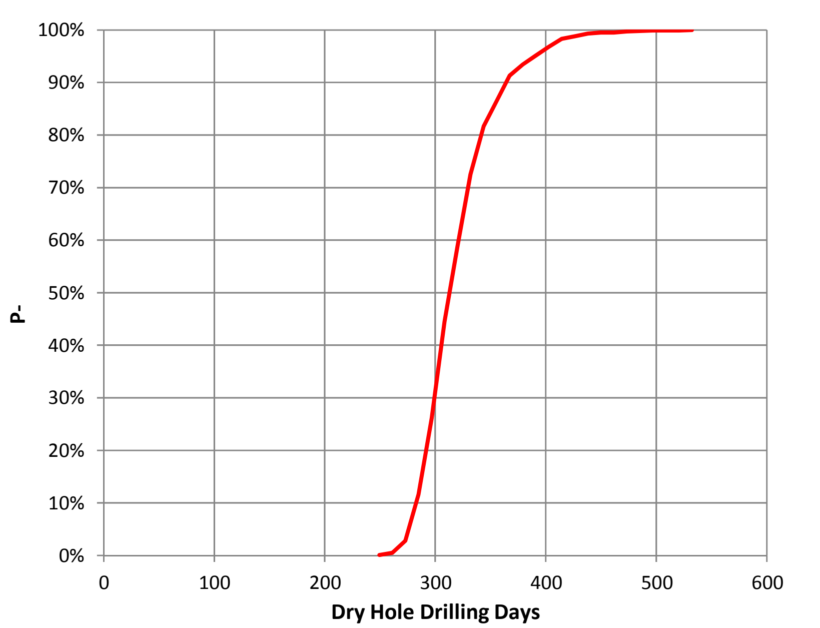
	Interval	%	Days
Coring =	3,766	61.7%	94
Drilling =	2,334	38.3%	26
	6,100	100%	120

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	4300	4361	61	Jetting	---	0.5	0	0	0	0.5	0.5
1	Sediments	4361	4385	24	Conv Core	12.2	0.1	1.2	0.0	0.0	1.3	1.8
2	Sediments	4361	4385	24	UR	12.2	0.1	1.2	0.0	6.0	7.3	9.1
3	Sediments	4385	4400	15	Conv Core	12.2	0.1	1.2	0.0	0.0	1.3	10.3
4	Sediments	4385	4400	15	UR	12.2	0.1	1.2	0.0	0.0	1.3	11.6
5	Lava	4400	4617	217	Conv Core	4.6	2.0	1.2	0.0	0.0	3.2	14.8
6	Lava	4400	4617	217	UR	7.6	1.2	1.2	0.0	0.0	2.4	17.2
7	Lava	4617	4834	217	Drill	9.1	1.0	1.3	0.0	0.0	2.3	19.5
8	Lava	4834	5050	216	Conv Core	4.6	2.0	1.4	0.0	0.0	3.3	22.8
9	Lava	4834	5050	216	UR	7.6	1.2	1.4	0.0	0.0	2.5	25.3
10	Dikes	5050	5317	267	Conv Core	4.6	2.4	1.4	0.0	0.0	3.8	29.2
11	Dikes	5050	5317	267	UR	7.6	1.5	1.4	0.0	0.0	2.9	32.0
12	Dikes	5317	5580	264	Drill	9.1	1.2	1.5	0.0	0.0	2.7	34.7
13	Dikes	5580	5850	270	Conv Core	4.6	2.5	1.6	0.0	0.0	4.0	38.8
14	Dikes	5580	5850	270	UR	7.6	1.5	1.6	0.0	7.0	10.0	48.8
15	Textured Gabbros	5850	5967	116	Conv Core	4.6	1.1	1.6	0.0	0.0	2.7	51.5
16	Textured Gabbros	5850	5967	116	UR	7.6	0.6	1.6	0.0	0.0	2.3	53.7
17	Textured Gabbros	5967	6083	116	Drill	9.1	0.5	1.6	0.0	0.0	2.2	55.9
18	Textured Gabbros	6083	6200	117	Conv Core	4.6	1.1	1.7	0.0	0.0	2.7	58.6
19	Textured Gabbros	6083	6200	117	UR	7.6	0.6	1.7	0.0	0.0	2.3	61.0
20	Foliated Gabbros	6200	6433	233	Conv Core	2.4	4.0	1.7	0.0	0.0	5.7	66.7
21	Foliated Gabbros	6200	6433	233	UR	2.4	4.0	1.7	0.0	0.0	5.7	72.4
22	Foliated Gabbros	6433	6667	233	Drill	3.0	3.2	1.8	0.0	0.0	5.0	77.4
23	Foliated Gabbros	6667	6858	191	Conv Core	2.4	3.3	3.7	0.0	0.0	7.0	84.3
24	Foliated Gabbros	6667	6858	191	UR	2.4	3.3	3.7	0.0	8.0	15.0	99.3
25	Foliated Gabbros	6858	6900	42	Conv Core	2.4	0.7	1.9	0.0	0.0	2.6	101.9
26	Foliated Gabbros	6858	6900	42	UR	2.4	0.7	1.9	0.0	0.0	2.6	104.5
27	Layered Gabbros	6900	7357	457	Conv Core	2.4	7.8	5.8	0.0	0.0	13.7	118.2
28	Layered Gabbros	6900	7357	457	UR	2.4	7.8	5.8	0.0	0.0	13.7	131.8
29	Layered Gabbros	7357	7864	507	Drill	3.0	6.9	6.2	0.0	9.0	22.2	154.0
30	Layered Gabbros	7864	8357	493	Conv Core	2.4	8.4	6.7	0.0	0.0	15.1	169.1
31	Layered Gabbros	7864	8357	493	UR	2.4	8.4	6.7	0.0	0.0	15.1	184.2
32	Layered Gabbros	8357	8839	482	Drill	3.0	6.6	7.1	0.0	6.0	19.6	203.8
33	Layered Gabbros	8839	9272	433	Conv Core	2.4	7.4	7.4	0.0	0.0	14.8	218.6
34	Layered Gabbros	9272	9726	454	Drill	3.0	6.2	5.2	0.0	0.0	11.4	230.0
35	Layered Gabbros	9726	9900	174	Conv Core	2.4	3.0	2.7	0.0	6.0	11.7	241.7
36	Mantle	9900	10400	500	RCB Core	1.2	17.1	16.7	27.1	3.0	63.9	305.6
						Sub-Total days =	120	114	27	45	306	
						Sub-Total % =	39%	37%	9%	15%	100%	

Figure 132. Baja Location - Case 2b: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	245
P-10	**269**
P-50	**299**
P-90	**342**
Observed Maximum	475

Figure 133. Baja Location - Case 2c: Probabilistic Time

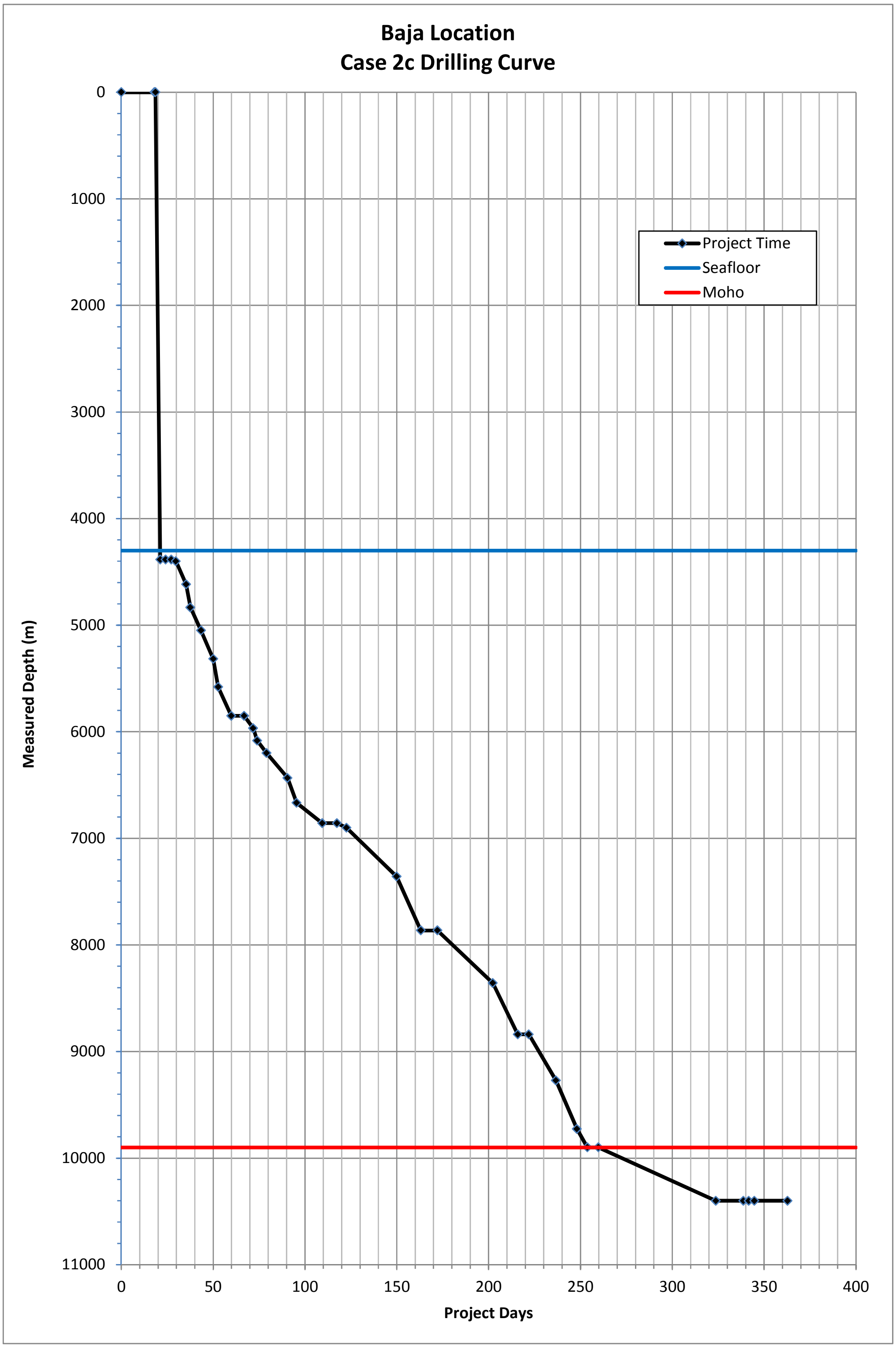


Figure 134. Baja Location: Case 2c Drilling Curve

5.4.4 Case 4a Operations Time:

This case assumes the original Base Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Move in rig	18.1					
Jet 36"	0.5	0.5	4,300	4,361	61	
Drill Sediments	1.2	1.7	4,361	4,385	24	19
Set 20" casing	3.0	4.7				
Run BOP & Riser	3.0	7.7				
Drill Sediments	1.2	9.0	4,385	4,400	15	12
Drill Lava	4.3	13.2	4,400	5,050	650	153
Drill Dikes	5.1	18.3	5,050	5,835	785	155
Set 13-3/8" Casing	6.0	24.3				
Drill Dikes	1.7	26.0	5,835	5,850	15	9
Drill Textured Gabbros	3.2	29.2	5,850	6,200	350	108
Drill Foliated Gabbros	16.7	45.9	6,200	6,900	700	42
Drill Layered Gabbros	23.8	69.7	6,900	7,900	1,000	42
Run 11-3/4" Liner	9.0	78.7				
Drill Layered Gabbros	49.2	128.0	7,900	9,900	2,000	41
Core Mantle	63.9	191.8	9,900	10,400	500	8
5% Operational NPT	10.0	201.8				
TA hole	3.0	204.8				
Pull BOP/Riser	3.0	207.8				
De-Mobilize Rig	18.1					
Total Operational Days =	**208**					
Total Project Days =	**244**					

Figure 135. Baja Location - Case 4a Operational Phase Summary

8% of the hole is cored, and 92% is drilled as shown below.

	Interval	%	Days
Coring =	500	8.2%	17
Drilling =	5600	91.8%	59
	6100	100%	76

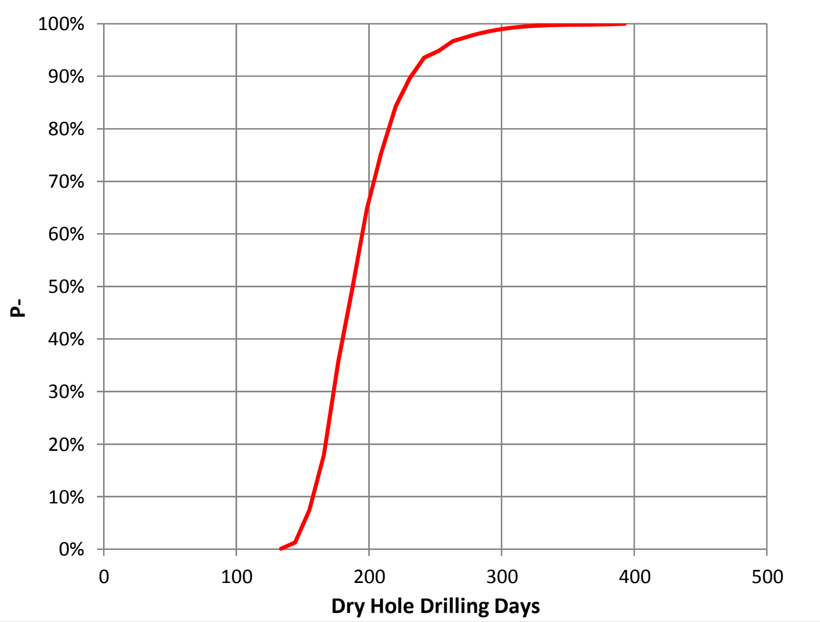
The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L"

time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	**Stratigraphy**	**From**	**To**	**Interval**	**Operation**	**ROP**	**Ops Time**	**Bit Trip**	**W/L**	**Flat**	**Days**	**Days**
0.1	Sediments	4300	4361	61	Jetting	---	0.5	0.0	0.0	0.0	0.5	0.5
1	Sediments	4361	4385	24	Drill	21.3	0.0	1.2	0.0	6.0	7.2	7.7
2	Sediments	4385	4400	15	Drill	21.3	0.0	1.2	0.0	0.0	1.2	9.0
3	Lava	4400	5050	650	Drill	9.1	3.0	1.3	0.0	0.0	4.3	13.2
4	Dikes	5050	5835	785	Drill	9.1	3.6	1.5	0.0	6.0	11.1	24.3
5	Dikes	5835	5850	15	Drill	9.1	0.1	1.6	0.0	0.0	1.7	26.0
6	Textured Gabbros	5850	6200	350	Drill	9.1	1.6	1.6	0.0	0.0	3.2	29.2
7	Foliated Gabbros	6200	6900	700	Drill	3.0	9.6	7.2	0.0	0.0	16.7	45.9
8	Layered Gabbros	6900	7900	1000	Drill	3.0	13.7	10.1	0.0	9.0	32.8	78.7
9	Layered Gabbros	7900	9900	2000	Drill	3.0	27.3	21.9	0.0	0.0	49.2	128.0
10	Mantle	9900	10400	500	RCB Core	1.2	17.1	16.7	27.1	3.0	63.9	191.8
						Sub-Total days =	**76**	**64**	**27**	**24**	**192**	
						Sub-Total % =	**40%**	**33%**	**14%**	**13%**	**100%**	

Figure 136. Baja Location - Case 4a: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	134
P-10	**158**
P-50	**188**
P-90	**232**
Observed Maximum	393

Figure 137. Baja Location - Case 4a: Probabilistic Time

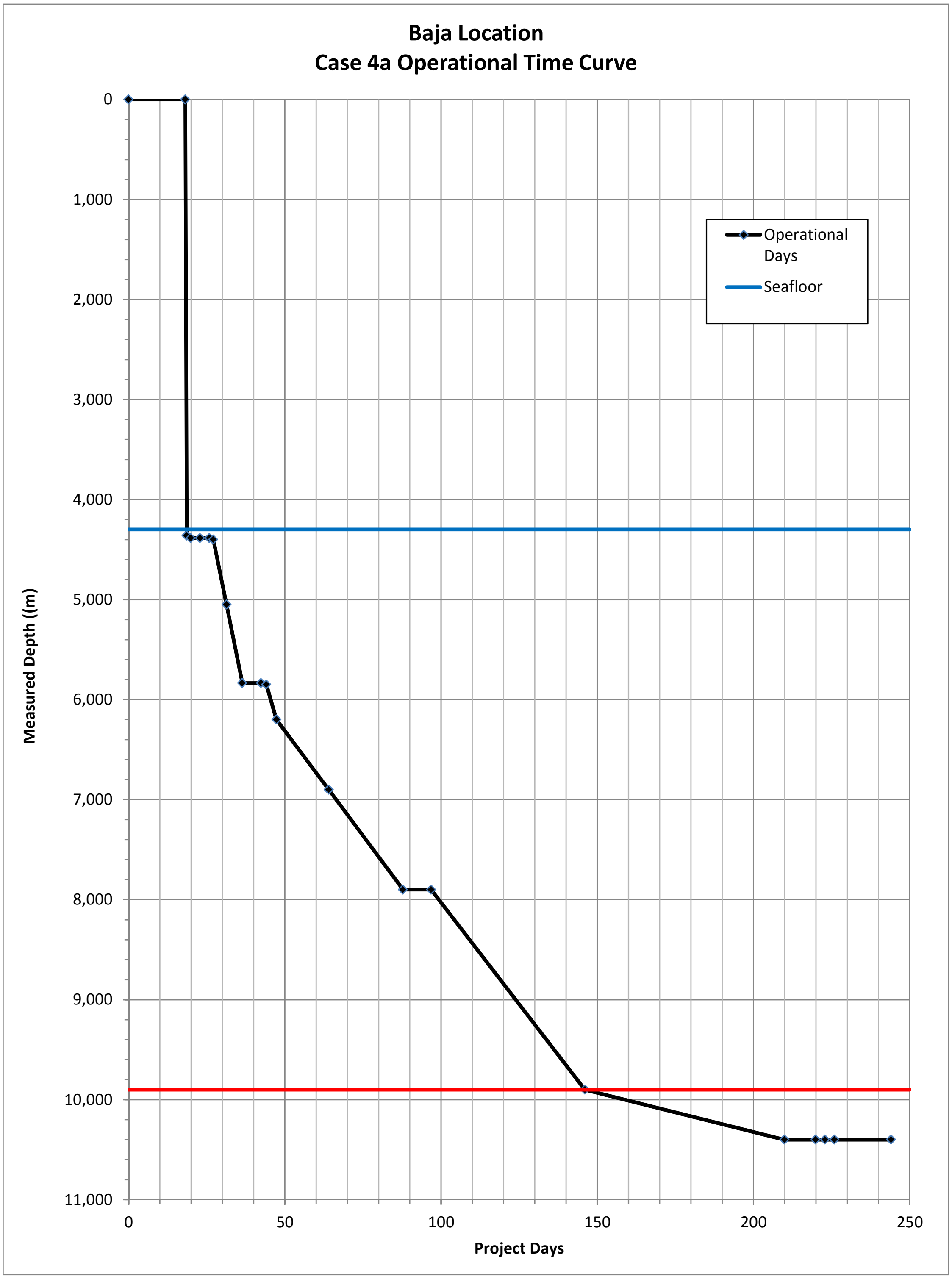


Figure 138. Baja Location: Case 4a Drilling Curve

5.4.5 Case 4b Operations Time:

This case assumes the Deepwater Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Mobilize Rig	18.1					
Jet 36"	0.5	0.5	4,300	4,361	61	121.92
Drill Sediments	1.2	1.7	4,361	4,385	24	19
Set 22" casing	3.0	4.8				
Run BOP & Riser	3.0	7.8				
Drill Sediments	1.2	9.0	4,385	4,400	15	12.4
Drill Lava	4.3	13.3	4,400	5,050	650	152.8
Drill Dikes	5.1	18.4	5,050	5,850	800	
Set 18" Casing	6.0	24.4				
Drill Textured Gabbros	3.2	27.6	5,850	6,200	350	107.9
Drill Foliated Gabbros	14.4	42.0	6,200	6,858	658	45.9
Set 16" Casing	7.0	49.0				
Drill Foliated Gabbros	2.5	51.5	6,858	6,900	42	17.1
Drill Layered Gabbros	23.3	74.7	6,900	7,864	964	41.4
Run 13-3/8" Liner	9.0	83.7				
Drill Layered Gabbros	24.8	108.5	7,864	8,839		
Run 11-3/4" Liner	6.0	114.5				
Drill Layered Gabbros	27.3	141.8	8,839	9,900		
Run 9-5/8" Liner	6.0	147.8				
Core Mantle	63.9	211.6	9,900	10,400	500	7.8
5% Operational NPT	11.0	222.6				
TA hole	3.0	225.6				
Pull BOP/Riser	3.0	228.6				
De-Mobilize Rig	18.1	0.0				

Total Operational Days =	**229**
Total Project Days =	**265**

Figure 139. Baja Location - Case 4b Operational Phase Summary

8% of the hole is cored, and 92% is drilled as shown below.

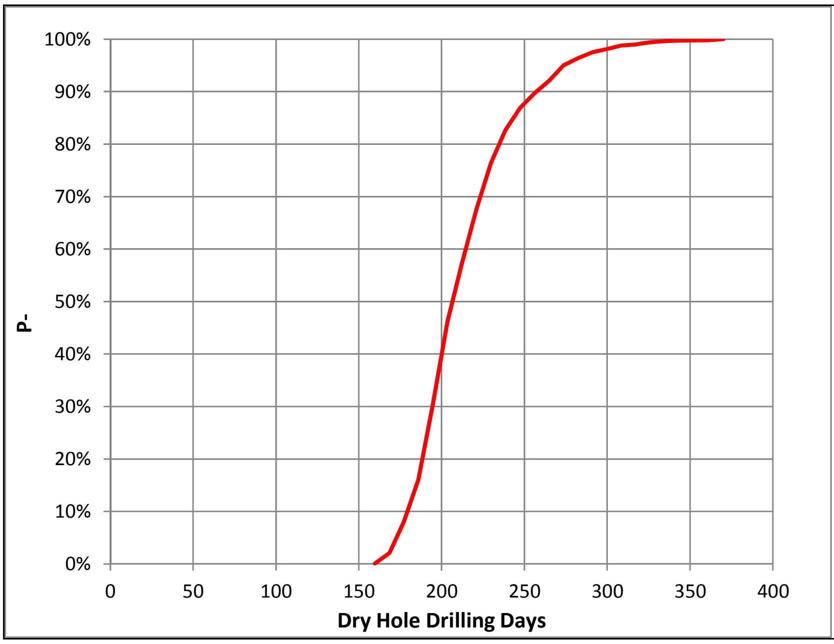
	Interval	%	Days
Coring =	500	8.2%	17
Drilling =	5600	91.8%	59
	6100	100%	76

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	4300	4361	61	Jetting	---	0.5	0.0	0.0	0.0	0.5	0.5
1	Sediments	4361	4385	24	Drill	21.3	0.0	1.2	0.0	6.0	7.2	7.7
2	Sediments	4385	4400	15	Drill	21.3	0.0	1.2	0.0	0.0	1.2	9.0
3	Lava	4400	5050	650	Drill	9.1	3.0	1.3	0.0	0.0	4.3	13.2
4	Dikes	5050	5850	800	Drill	9.1	3.6	1.5	0.0	6.0	11.1	24.4
5	Textured Gabbros	5850	6200	350	Drill	9.1	1.6	1.6	0.0	0.0	3.2	27.6
6	Foliated Gabbros	6200	6858	658	Drill	3.0	9.0	5.4	0.0	7.0	21.4	49.0
7	Foliated Gabbros	6858	6900	42	Drill	3.0	0.6	1.9	0.0	0.0	2.5	51.4
8	Layered Gabbros	6900	7864	964	Drill	3.0	13.2	10.1	0.0	9.0	32.3	83.7
9	Layered Gabbros	7864	8839	975	Drill	3.0	13.3	11.4	0.0	6.0	30.8	114.4
10	Layered Gabbros	8839	9900	1061	Drill	3.0	14.5	12.8	0.0	6.0	33.3	147.7
11	Mantle	9900	10400	500	RCB Core	1.2	17.1	16.7	27.1	3.0	63.9	211.6
						Sub-Total days =	**76**	**65**	**27**	**43**	**212**	
						Sub-Total % =	**36%**	**31%**	**13%**	**20%**	**100%**	

Figure 140. Baja Location - Case 4b: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	160
P-10	**179**
P-50	**207**
P-90	**257**
Observed Maximum	370

Figure 141. Baja Location - Case 4b: Probabilistic Time

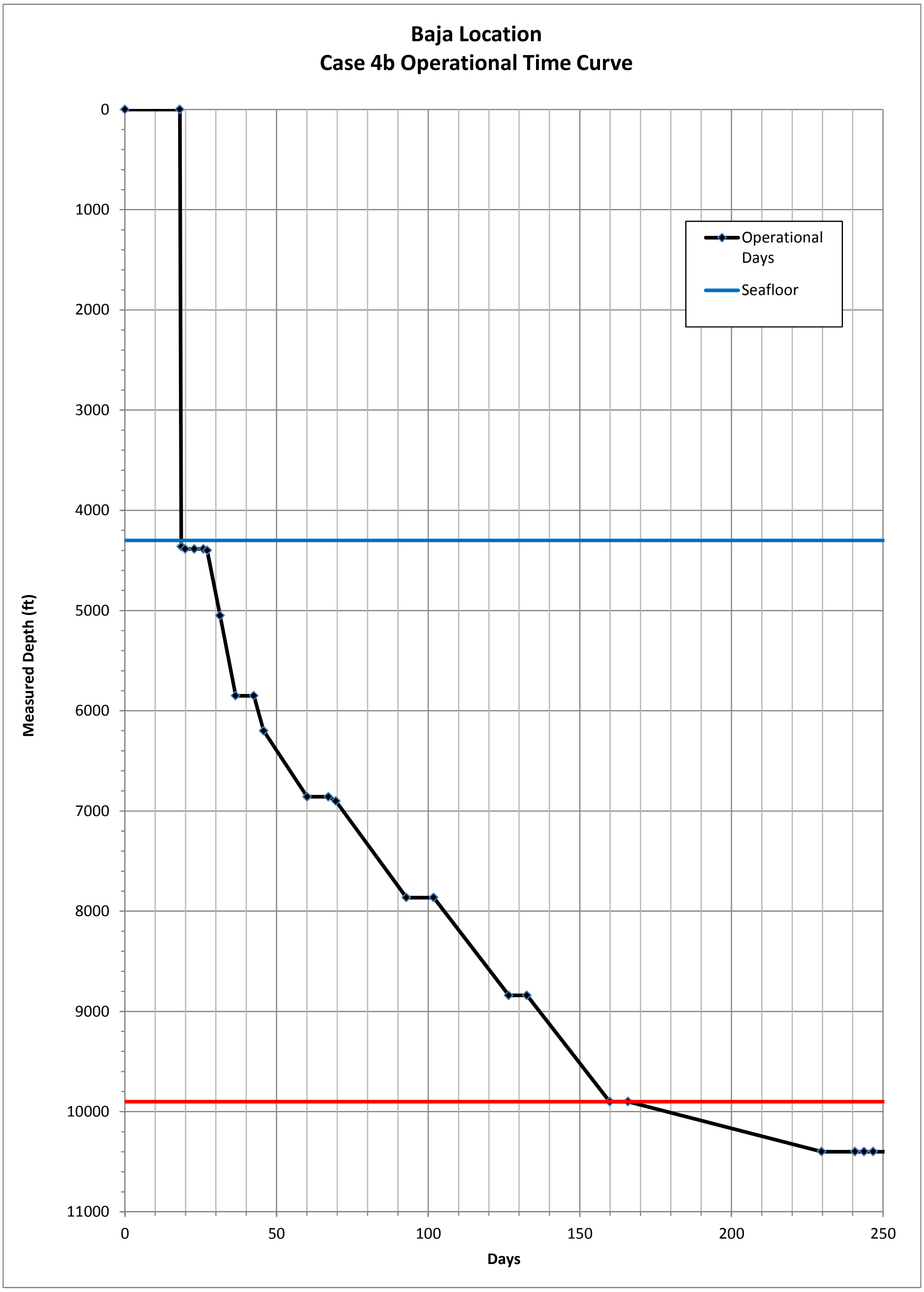


Figure 142. Baja Location: Case 4b Drilling Curve

5.4.6 Case 4c Operations Time:

This case assumes the Expandable Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the time estimate for this case is shown below.

Phase	Interval Days	Cum Days	From (m)	To (m)	Interval (m)	Avg m/day
Mobilize Rig	18.1					
Jet 36"	0.5	0.5	4,300	4,361	61	121.92
Drill Sediments	1.2	1.7	4,361	4,385	24	19
Set 22" casing	3.0	4.8				
Run BOP & Riser	3.0	7.8				
Drill Sediments	1.2	9.0	4,385	4,400	15	12.4
Drill Lava	4.3	13.3	4,400	5,050	650	152.8
Drill Dikes	5.1	18.4	5,050	5,850	800	0.0
Set 16.5" SET Casing	7.0	25.4				
Drill Textured Gabbros	3.2	28.6	5,850	6,200	350	107.9
Drill Foliated Gabbros	14.4	43.0	6,200	6,858	658	45.9
Drill Foliated Gabbros	2.5	45.5	6,858	6,900	42	17.1
Set 16.5 SET" Casing	8.0	53.5				
Drill Layered Gabbros	23.3	76.7	6,900	7,864	964	41.4
Run 16" Liner	9.0	85.7				
Drill Layered Gabbros	24.8	110.5	7,864	8,839		
Run 13-3/8" Liner	6.0	116.5				
Drill Layered Gabbros	27.3	143.8	8,839	9,900		
Run 11-3/4" Liner	6.0	149.8				
Core Mantle	63.9	213.6	9,900	10,400	500	7.8
5% Operational NPT	11.0	224.6				
TA hole	3.0	227.6				
Pull BOP/Riser	3.0	230.6				
De-Mobilize Rig	18.1	0.0				

Total Operational Days =	**231**
Total Project Days =	**267**

Figure 143. Baja Location - Case 4c Operational Phase Summary

8% of the hole is cored, and 92% is drilled as shown below.

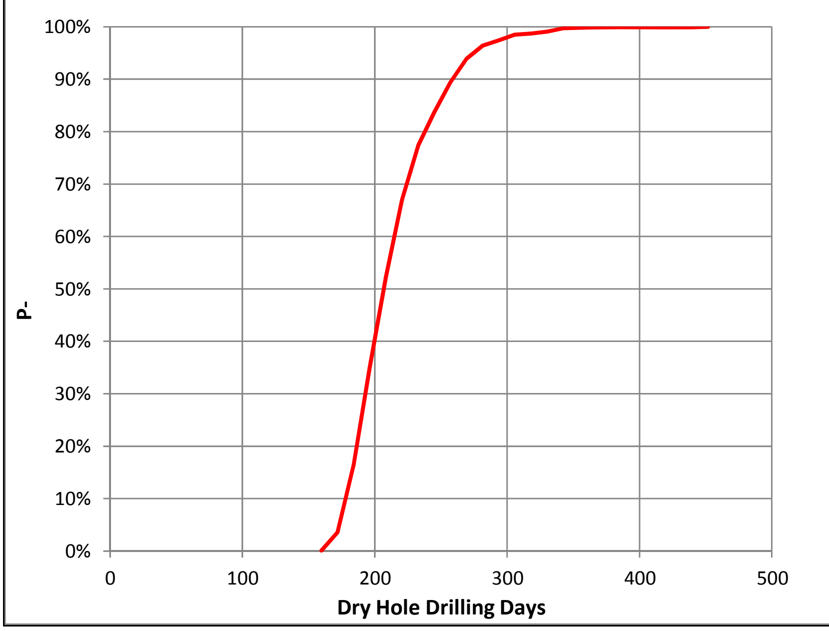
	Interval	%	Days
Coring =	500	8.2%	17
Drilling =	5600	91.8%	59
	6100	100%	76

The following table shows a detailed breakdown for the key operations in terms of total days and percentage of the total time for the operations time estimate. "Ops Time" includes the time spent, drilling, coring and underreaming the hole. "Bit Trip" is the time spent on bit trips. "W/L" time is the time spent making RCB wireline trips. "Flat" time is the time running BOP's, running wire-line logs and casing.

Section Summary							Section Time (days)				Section	Cum
Section	Stratigraphy	From	To	Interval	Operation	ROP	Ops Time	Bit Trip	W/L	Flat	Days	Days
0.1	Sediments	4300	4361	61	Jetting	---	0.5	0.0	0.0	0.0	0.5	0.5
1	Sediments	4361	4385	24	Drill	21.3	0.0	1.2	0.0	6.0	7.2	7.7
2	Sediments	4385	4400	15	Drill	21.3	0.0	1.2	0.0	0.0	1.2	9.0
3	Lava	4400	5050	650	Drill	9.1	3.0	1.3	0.0	0.0	4.3	13.2
4	Dikes	5050	5850	800	Drill	9.1	3.6	1.5	0.0	7.0	12.1	25.4
5	Textured Gabbros	5850	6200	350	Drill	9.1	1.6	1.6	0.0	0.0	3.2	28.6
6	Foliated Gabbros	6200	6858	658	Drill	3.0	9.0	5.4	0.0	8.0	22.4	51.0
7	Foliated Gabbros	6858	6900	42	Drill	3.0	0.6	1.9	0.0	0.0	2.5	53.4
8	Layered Gabbros	6900	7864	964	Drill	3.0	13.2	10.1	0.0	9.0	32.3	85.7
9	Layered Gabbros	7864	8839	975	Drill	3.0	13.3	11.4	0.0	6.0	30.8	116.4
10	Layered Gabbros	8839	9900	1061	Drill	3.0	14.5	12.8	0.0	6.0	33.3	149.7
11	Mantle	9900	10400	500	RCB Core	1.2	17.1	16.7	27.1	3.0	63.9	213.6
						Sub-Total days =	**76**	**65**	**27**	**45**	**214**	
						Sub-Total % =	**36%**	**30%**	**13%**	**21%**	**100%**	

Figure 144. Baja Location - Case 4c: Operations Time Breakdown

Below are the results of the probabilistic estimate of operational time including the P10, P50 and P90 values and a chart showing the cumulative probability of time.



Observed Minimum	160
P-10	**178**
P-50	**207**
P-90	**259**
Observed Maximum	452

Figure 145. Baja Location - Case 4c: Probabilistic Time

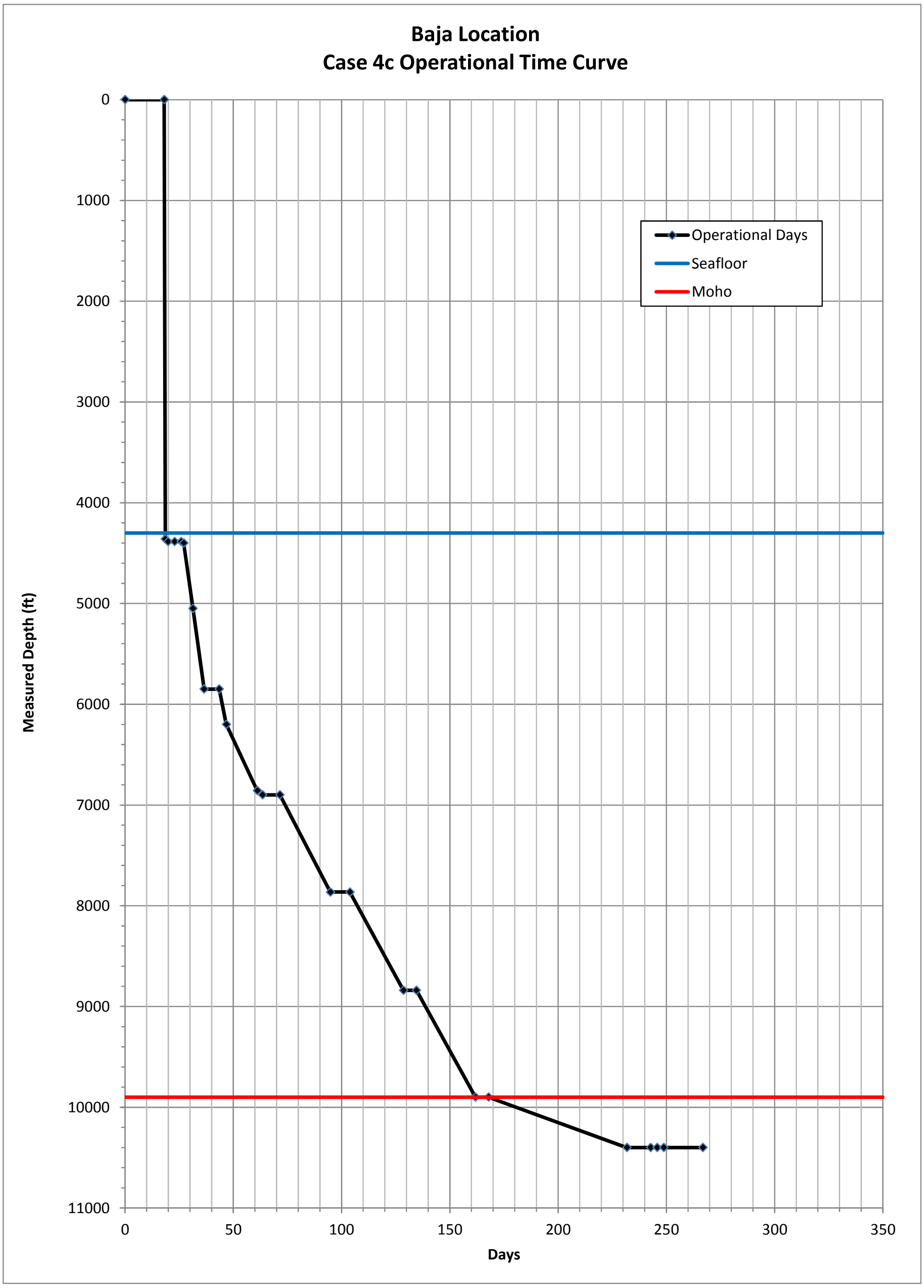


Figure 146. Baja Location: Case 4c Drilling Curve

6 Revised Operational Cost Estimates

The Feasibility System study included a rough cost estimate for each case that assumed a daily operating cost of $1,000,000 per day, which is typical for complex oil and gas deepwater wells. For this report, a more detailed cost estimate was prepared for the three wellbore configuration options discussed in Section 3.1 at all three candidate locations. In addition, a probabilistic methodology for estimating costs was also used to gain a better understanding of the effect of the uncertainty around the time required to drill the hole to TD. A Monte Carlo simulator was used to determine the P10, P50, and P90 costs in addition using the ROP distribution discussed in Section 4 in addition to the nominal cost estimate

The cost estimate considered the following major cost categories. Recall that for accounting purposes the costs for oil and gas wells are classified as being either intangible or tangible. Intangible costs are basically for non-salvageable items such as labor, drilling rig time, drilling fluids, services and so on. Intangible costs are typically charged on a daily basis. Tangible costs are technically salvageable items such as the wellhead and tubulars, but are typically permanently installed in the well.

Intangible Cost Categories	Tangible Cost Categories
Location/ Regulatory Costs	Drive Pipe
Rig Mobilization, Demobilization	Conductor Casing
Drilling Rig - Day Rate	Surface Casing
Bits, Drill Collars & Stabilizers	Intermediate Casing
Directional & Downhole Services	Intermediate Casing
Fuel, Water & Lube	Intermediate Casing
Drilling Fluids Services	Intermediate Casing
Electric Logging & Cased Hole Logs	Production Liner
Cementing	Production Tie-back
Mud Logging and Geological Services	Tubing
Land Transportation	Liner Equipment
Boat Transportation	Whipstock Equipment
Helicopter Transportation	Subsurface Completion Equipment
Tubular Services	Wellheads
Shorebase / Dock Services	Miscellaneous/Other
Communications	Tangible Contingency
Miscellaneous Rental Equipment	
Miscellaneous Special Services	
Other Services / Costs	
Intangible Contingency	

Figure 147. List of Cost Estimate Categories

Some of the individual cost element assumptions with each category like fuel usage were based on known Chikyu data. Estimates for such things as MWD and LWD tools, cement, and tubulars were based on representative oilfield analogs. The cost estimates therefore represent scoping, or order of magnitude costs. An example of the detailed cost estimating assumptions is provided in Appendix 2.

Key Assumptions:

- The location cost category includes a lump sum estimate for a conventional metocean study and a site survey assuming a third party contractor does the work. It is recognized that, for example, IODP typically conducts its own site surveys, but an estimate of the location related costs has been included in the cost estimate because arguably the money would only be spent if a mantle hole is drilled. The cost estimate of $3,000,000 is based on previous discussions with two companies that do this kind of work for the oil and gas industry, RPS Evans-Hamilton and Fugro Geos, during the High Impact Systems project in 2012.

- The costs of mobilizing the Chikyu from Japan to the location, and then demobilizing the rig back to Japan is included as a lump sum. The cost is based on the distance travelled, fuel consumption during transit, and the Chikyu's day rate.

- Chikyu Day Rate is estimated to be $300,000 per day. The assumption was based on taking the published average day rate for oil and gas drill ships during 2012 ($438,000/day) and then reducing the cost to account for the fact that this is a non-commercial project and things like market conditions, profit and depreciation do not apply.

- At present, the Chikyu does not have enough marine drilling riser to drill in the water depths found at any of the three candidate locations. The cost of purchasing an additional ±1524m (5,000 ft) of conventional steel riser (similar to what is being used now) and additional buoyancy modules needed is included in the cost estimate as a lump sum. The cost estimate of $61,000,000 is based on a quote provided by NOV during the High Impact Systems project in 2012.

- A 15% contingency was assumed for the intangible costs, and a 10% contingency was assumed for the tangible costs to account for uncertainty in the estimates for the various individual cost elements. The intangible contingency percentage used for deep water oil and gas wells ranges between 10-35% and 0-15% for tangibles items depending on the complexity of the well and its location.

- The nominal project cost estimate is determined based on the nominal days required to drill the hole which in turn was determined using the most likely ROP values as discussed in Section 4. The probabilistic costs were determined by re-calculating the cost each time a new value for days was generated by the Monte Carlo simulator. In other words, the probabilistic costs are based on the distribution of time required to drill/core the hole and not on distributions of the individual cost elements.

6.1 Results Summary

A summary of the revised cost estimates for all three locations is provided below. Figure 148 is a tabular listing of results for all 18 cases. Figures 149 through 151 graphically compare the results of each case by location. The detailed results for each case are provided in the subsequent sections.

Recall that:

- Case 2: Assumes that long sections of continuous core are taken across the major lithologic and geophysical transition intervals of key sections. For the time estimate it was assumed that the upper third of each main stratigraphic interval was cored, the middle third was drilled, and the lower third was cored.
- Case 4: Assumes that the hole is drilled to the Moho and that just the mantle is cored.
- Subcategory "a" is the Base Case wellbore configuration.
- Subcategory "b' is the Deepwater wellbore configuration
- Subcategory "c' is the Expandable wellbore configuration.

Location	Water Depth (m)	Total Depth (m)	Project Days	Case	Estimated Total Cost (MM$)				Feasibility Study
					Project	P10	P50	P90	
Cocos	3,650	9,900	276	2a	$226	$206	$218	$237	$617
			320	2b	$253	$232	$245	$311	
			337	2c	$264	$243	$256	$276	
			250	4a	$212	$187	$201	$221	$418
			268	4b	$226	$199	$215	$240	
			271	4c	$230	$205	$220	$242	
Hawaii	4,050	10,750	298	2a	$238	$219	$233	$254	$737
			346	2b	$267	$248	$263	$289	
			368	2c	$282	$258	$273	$299	
			248	4a	$212	$184	$200	$228	$443
			239	4b	$227	$199	$215	$240	
			271	4c	$231	$203	$220	$247	
Baja	4,300	10,400	287	2a	$232	$217	$230	$248	$693
			345	2b	$266	$246	$261	$283	
			363	2c	$278	$256	$271	$297	
			244	4a	$209	$184	$199	$221	$425
			265	4b	$224	$199	$213	$238	
			267	4c	$230	$204	$218	$244	

Figure 148. Cost Estimate Results for all Cases

Note again that there has been a significant decrease in the latest cost estimates compared to those of the original feasibility study. The average cost of all the cases is $236 million. The lowest estimate is $184 million and the highest is $315 million.

- **Case comparison by location**

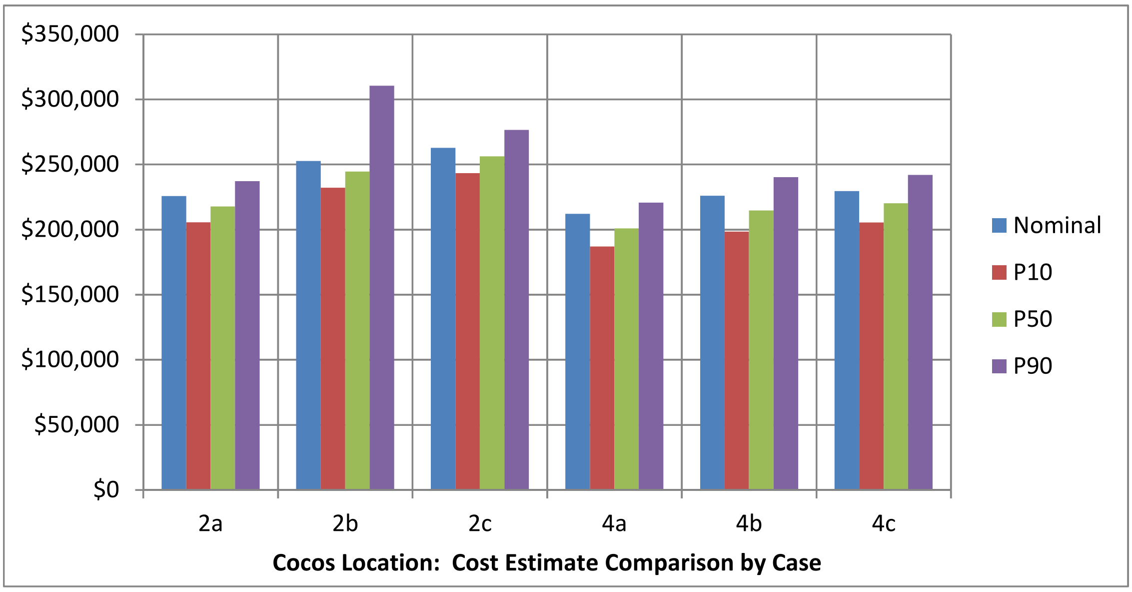


Figure 149. Cocos Location – Cost Estimate Comparison

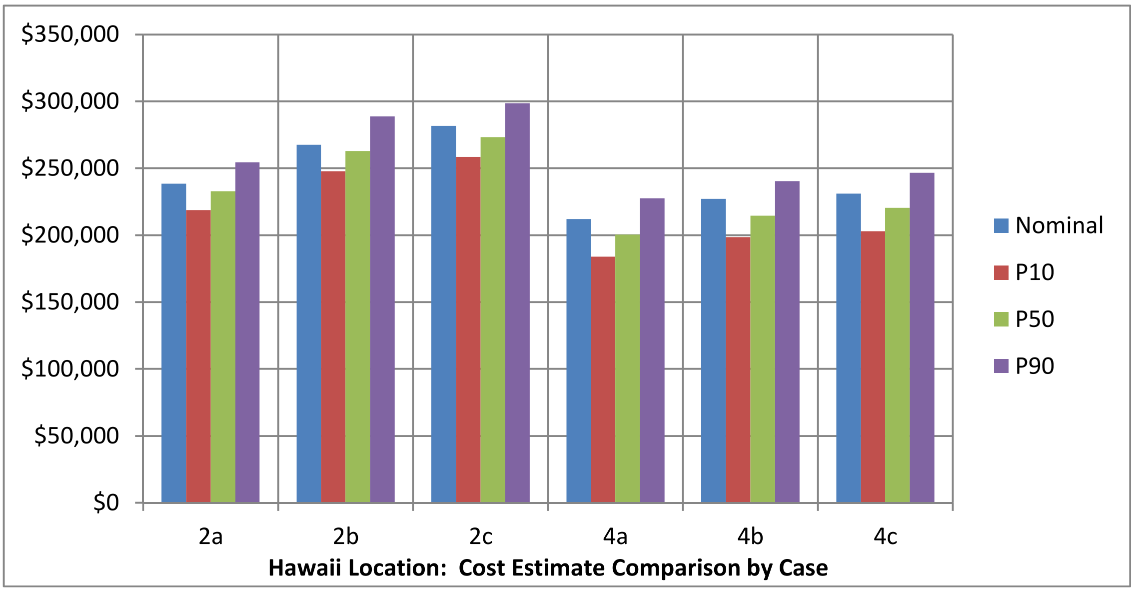


Figure 150. Hawaii Location – Cost Estimate Comparison

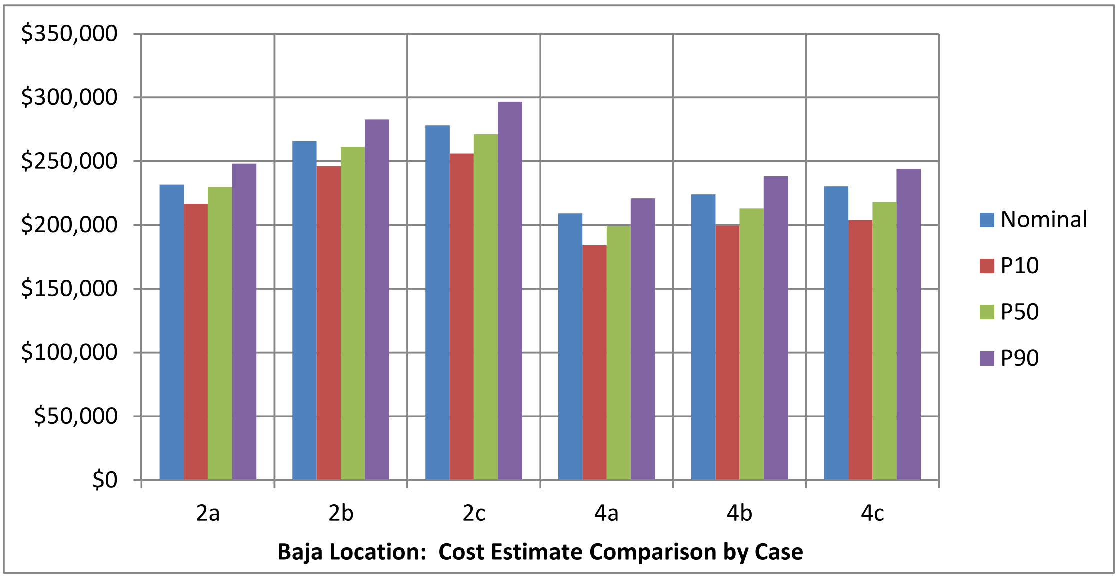


Figure 151. Baja Location – Cost Estimate Comparison

The following table compares the average project costs and the average P-50 costs between the candidate locations in order to provide a simplified look at the differences between the locations. The P-50 value is shown because it is typically used in oil and gas project economics calculations.

Location	Water Depth (m)	Total Depth (m)	Avg Project Days	Case	Avg Est Total Cost (MM$)	
					Project	P50
Cocos	3,650	9,900	311	2a-2b	$247	$240
			263	4a-4b	$223	$212
Hawaii	4,050	10,750	337	2a-2b	$262	$256
			253	4a-4b	$212	$212
Baja	4,300	10,400	332	2a-2b	$259	$254
			259	4a-4b	$221	$210

Figure 152. Average Cost Comparisons – Three Locations

6.1.1 Cost Sensitivity

As illustrated below using Cocos Case 4c as an example, the single biggest cost driver accounting for over 50% of the total cost is the Chikyu's day rate costs, which are purely a function of the amount of time it takes to drill the hole. This is followed by the intangible contingency cost (13%), the mobilization and demobilization cost (8%), and the fuel cost (6%). This means that the drilling and coring days required have the largest influence on the overall project cost, and that the costs of the individual cost elements are almost irrelevant.

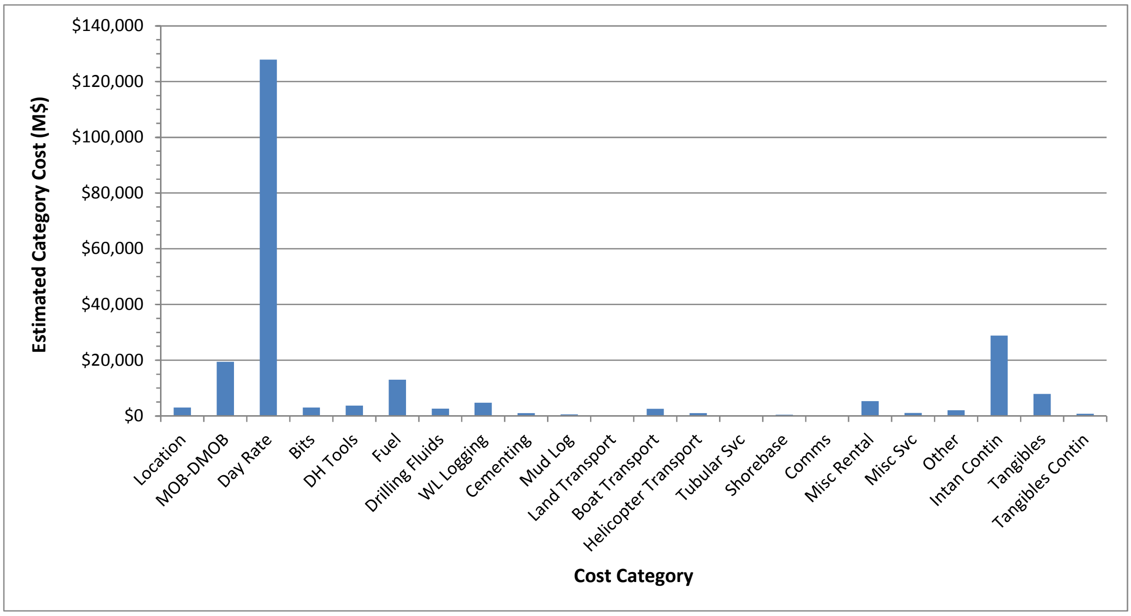


Figure 153. Cost Element Comparison

6.1.2 Cost of Drilling vs. Coring

As previously noted, the operational estimates were done only for two drill/core cases since these adequately illustrate the philosophical differences between the amount of time spent coring versus time spent drilling. Case 2 for the Hawaii and Baja locations assume that approximately 61% of the hole is cored compared to around 8% for Case 4. The Cocos location is slightly different since it is assumed that the interval from sediments through the base of the dikes does not need to be cored since this has already been done during the various expeditions at the 1256D site. Therefore the Case 2 at the Cocos location assumes that around 44% of the hole is cored. The wellbore configurations are the same for the "a", "b" and 'c' sub-cases, so the main difference is the amount of time spent coring or drilling. Therefore, as shown below, the "cost" of coring can be estimated by comparing the difference in total cost between the two like cases.

Location	Total Depth (m)		High Core	Nominal		Low Core	Nominal		Cost
	mbrf	mbsf	Case	Ops Days	Cost	Case	Ops Days	Cost	Difference
Cocos	9,900	6,250	2a	228	$225,672	4a	202	$211,997	$13,675
			2b	272	$252,600	4b	220	$225,985	$26,615
			2c	289	$264,129	4c	223	$229,649	$34,480

Figure 154. Cocos Location - Coring vs. Drilling Cost Comparison

Location	Total Depth (m)		High Core	Nominal		Low Core	Nominal		Cost
	mbrf	mbsf	Case	Ops Days	Cost	Case	Ops Days	Cost	Difference
Hawaii	10,750	6,700	2a	271	$238,340	4a	221	$211,970	$26,370
			2b	319	$267,445	4b	242	$227,067	$40,378
			2c	341	$281,703	4c	244	$230,963	$50,740

Figure 155. Hawaii Location - Coring vs. Drilling Cost Comparison

Location	Total Depth (m)		High Core	Nominal		Low Core	Nominal		Cost
	mbrf	mbsf	Case	Ops Days	Cost	Case	Ops Days	Cost	Difference
Baja	10,400	6,100	2a	251	$231,907	4a	208	$209,195	**$22,712**
			2b	308	$265,799	4b	229	$224,193	**$41,606**
			2c	327	$278,213	4c	231	$230,274	**$47,939**

Figure 156. Baja Location - Coring vs. Drilling Cost Comparison

The additional coring costs comparing Case 4 to Case 2 averages $25,000M at the Cocos location, $39,000M at the Hawaii location and $37,000 at the Baja location.

6.2 Cocos Location Cost Estimates

6.2.1 Case 2a Cost Estimate:

This case assumes the original Base Case wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. However for the Cocos location it is assumed that the sediments, lava and dike intervals do not need to be cored because of previous IODP experience on the 1256D hole. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
276	$223,109	$2,563	$225,672	$205,546	$217,945	$237,169

Figure 157. Cocos Location: Case 2a – Cost Estimate

The following chart shows the cumulative probability of cost.

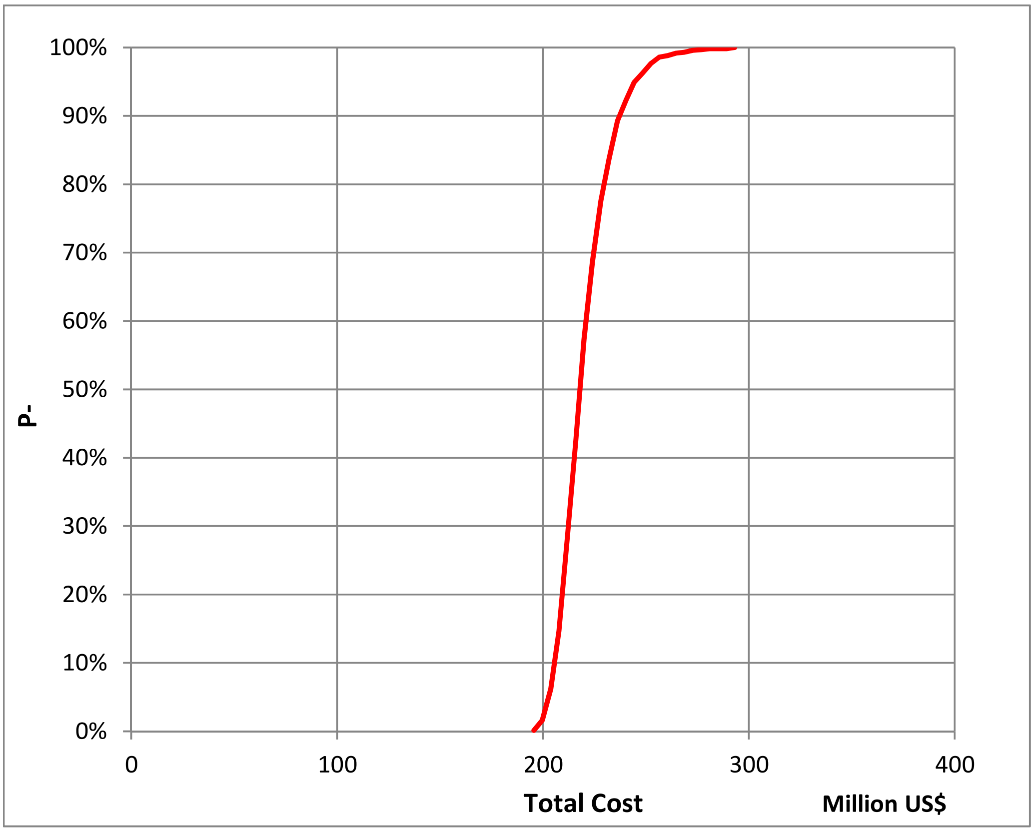


Figure 158. Cocos Location – Case 2a Probabilistic Cost

SCOPING COST ESTIMATE SUMMARY Rev 4

BEAM - Cocos Case 2a

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**	Revision No.	**1**	Date:	**30-Jun-13**	
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#2a**	Water Depth **3650m** **11,975 ft**	Proposed TD **9900m** **32,480 ft**	Formation **Moho / Mantle**	
Location	Surface Location:	**Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W**				
Cocos	Btm. Hole Location:	**Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W**				

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume
Case 4a: Orig Base Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	**Dry Hole Drlg**	**Complete**	**TOTAL**
	228 Days		**228 Days**
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$19,400,000	$0	$19,400,000
Drilling Rig - Day Work at $300,000 / Day	$129,400,000	$0	$129,400,000
Bits, Drill Collars & Stabilizers	$3,707,000	$0	$3,707,000
Directional & Downhole Services	$3,790,000	$0	$3,790,000
Fuel, Water & Lube	$13,338,000	$0	$13,338,000
Drilling Fluids Services	$2,653,000	$0	$2,653,000
Electric Logging & Cased Hole Logs	$4,784,000	$0	$4,784,000
Cementing	$685,000	$0	$685,000
Mud Logging and Geological Services	$559,000	$0	$559,000
Land Transportation	$103,000	$0	$103,000
Boat Transportation	$2,622,000	$0	$2,622,000
Helicopter Transportation	$1,026,000	$0	$1,026,000
Tubular Services	$100,000	$0	$100,000
Shorebase / Dock Services	$456,000	$0	$456,000
Communications	$228,000	$0	$228,000
Miscellaneous Rental Equipment	$5,234,000	$0	$5,234,000
Miscellaneous Special Services	$1,135,000	$0	$1,135,000
Other Services / Costs	$1,767,000	$0	$1,767,000
Intan Contingency at 15%	$29,102,000	$0	$29,102,000
TOTAL INTANGIBLE	**$223,109,228**	**$0**	**$223,109,228**

TANGIBLE ITEMS	**OD**	**Footage**	**$/ft**			
Drive Pipe	30"	200	$500.00	$100,000	$0	$100,000
Conductor	20"	770	$180.00	$139,000	$0	$139,000
Surface	13-3/8"	5,527	$140.00	$774,000	$0	$774,000
Intermediate	11-3/4"	7,076	$80.00	$567,000	$0	$567,000
Intermediate	0	0	$0.00	$0	$0	$0
Intermediate	0	0	$0.00	$0	$0	$0
Intermediate	0	0	$0.00	$0	$0	$0
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$150,000	$0	$150,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$233,000	$0	$233,000
TOTAL TANGIBLE				**$2,563,000**	**$0**	**$2,563,000**
Total Dry Hole Cost				**$225,672,228**	**$0**	**$225,672,228**
Total Completion Cost				**$0**	**$0**	**$0**
Total Drill and Complete				**$225,672,228**	**$0**	**$225,672,228**

Prepared by: **WSWhitney / NPilisi**

SCOPING COST ESTIMATE DETAILS

Rev 4

BEAM - Cocos Case 2a

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: CDEX / JAMSTEC			Revision No. 1		Date: 30-Jun-13
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#2a**		Water Depth **3650m** **11,975 ft**	Proposed TD **9900m** **32,480 ft**	Objective **Moho / Mantle**
Location **Cocos**	Surface Location: **Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W** Btm. Hole Location: **Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume
Case 4a: Orig Base Case Well Configuration

Avg Intan $/day: **$978,548**

Drilling Rig : Chikyu Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	Qty	Rate	Basis	Amount	Dry Hole Drlg	Complete	TOTAL
			Operational Time =		**228 Days**		**228 Days**
Location/ Regulatory Costs					$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)			Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)			Lump Sum	$2,000,000			
Regulatory			Lump Sum	$20,000			
Rig Mobilization, Demobilization					$19,400,000		$19,400,000
Mobilization (from Japan)			Lump Sum	$9,700,000			
Demobilization (to Japan)			Lump Sum	$9,700,000			
Drilling Rig - Day Work					$129,400,000	$0	$129,400,000
Drilling Day Rate	228 Days	$300,000 /day		$68,400,000			
Existing Riser System Modifications			Lump Sum	$14,000,000			
Additional Riser			Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers					$3,707,000	$0	$3,707,000
Drill Bits	16 No.	$70,000 /bit		$1,120,000			
Drill String Rentals: DC's, Jars, Stab, HWT	228 Days	$4,000 /day		$912,000			
Core Bits	22 No.	$60,000 /bit		$1,320,000			
Coring Services	142 Days	$2,500 /day		$355,000			
Directional & Downhole Services					$3,790,000	$0	$3,790,000
Surveys/Gyros/Single & Multi-Shots			Lump Sum	$20,000			
MWD / LWD Mob / De-mob			Lump Sum	$30,000			
Standard MWD Rental	114 Days	$3,000 /day		$342,000			
Standard LWD Rental	114 Days	$7,000 /day		$798,000			
MWD / LWD Engineers (2)	228 Days	$2,000 /day		$456,000			
Mud Motors & Associated Tools	182 Days	$3,000 /day		$547,200			
High Temp MWD Rental	114 Days	$4,000 /day		$456,000			
High temp LWD Rental	114 Days	$10,000 /day		$1,140,000			
Fuel, Water & Lube					$13,338,000	$0	$13,338,000
Rig Fuel	228 Days	$53,000 /day		$12,084,000			
Boat Fuel	114 Days	$4,000 /day		$456,000			
Helicopter Fuel	114 Days	$3,000 /day		$342,000			
Lubricants	228 Days	$1,300 /day		$296,400			
Fresh Water	228 Days	$700 /day		$159,600			
Drilling Fluids Services					$2,653,000	$0	$2,653,000
Drilling Fluids - WBM			Lump Sum	$1,900,000			
Mud Engineer	228 Days	$800 /day		$182,400			
Cuttings Disposal	228 Days	$2,500 /day		$570,000			
Electric Logging & Cased Hole Logs					$4,784,000		$4,784,000
Wireline Unit and Personnel	228 Days	$3,000 /day		$684,000			
Standard Open Hole Logging			Lump Sum	$1,500,000			
High Temp Open Hole Logging			Lump Sum	$2,500,000			
Cased Hole Logging			Lump Sum	$100,000			
Cementing					$685,000	$0	$685,000
20"			Lump Sum	$100,000			
13-3/8"			Lump Sum	$150,000			
11-3/4"			Lump Sum	$100,000			
Retainers, Service Man, Manifold, Etc.			Lump Sum	$50,000			
Unit Charge	228 Days	$1,250 /day		$285,000			

Mud Logging and Geological Services						$559,000	$0	$559,000
	Logging Unit Operating rate	228 Days	$1,250 /day		$285,000			
	Personnel Charges	228 Days	$1,200 /day		$273,600			
Land Transportation						$103,000	$0	$103,000
	Trucking	114 Days	$900 /day		$102,600			
Boat Transportation						$2,622,000	$0	$2,622,000
	Work Boat - Spot Hire	114 Days	$14,000 /day		$1,596,000			
	Crew Boat - Spot Hire	114 Days	$9,000 /day		$1,026,000			
Helicopter Transportation						$1,026,000	$0	$1,026,000
	Helicopter - spot hire	114 Days	$9,000 /day		$1,026,000			
Tubular Services						$100,000	$0	$100,000
	QAQC			Lump Sum	$100,000			
Shorebase / Dock Services						$456,000	$0	$456,000
	Shorebase /Dispatcher	228 Days	$2,000 /day		$456,000			$0
Communications						$228,000	$0	$228,000
	VSAT	228 Days	$1,000 /day		$228,000			
Miscellaneous Rental Equipment						$5,234,000	$0	$5,234,000
	Solids Control	228 Days	$400 /day		$91,200			
	Fishing Tools	228 Days	$1,500 /day		$342,000			
	Casing Running Equipment	40 Days	$6,000 Day		$240,000			
	Other Rentals	228 Days	$20,000 Day		$4,560,000			
		Days						
		Days						
Miscellaneous Special Services						$1,135,000	$0	$1,135,000
	Weather Forecasting	228 Days	$150 /day		$34,200			
	Engineering Services - Riser Analysis			Lump Sum	$300,000			
	Engineering Services - Drill String Design			Lump Sum	$200,000			
	Engineering Services - Casing Design			Lump Sum	$50,000			
	Engineering Services - Wellbore Stability			Lump Sum	$100,000			
	Engineering Services - Operational Support			Lump Sum	$200,000			
	Engineering Services - Risk Assessments			Lump Sum	$200,000			
	Engineering Services - Other			Lump Sum	$50,000			
Other Services / Costs						$1,767,000	$0	$1,767,000
	Misc Contract Labor	228 Days	$1,500 /day		$342,000			
	Casing Running Service	40 Days	$10,000 /day		$400,000			
	Well Insurance			Lump Sum	$500,000			
	Overhead	228 Days	$1,100 /day		$250,800			
	Catering	228 Days	$1,200 /day		$273,600			
Intangible Contingency			15% = Amount	*ST Drlg =*	*$194,007,000*	$29,102,000	$0	$29,102,000
				ST Comp =	*$0*			
					TOTAL INTANGIBLE	**$223,109,000**	**$0**	**$223,109,000**

TANGIBLE ITEMS

	OD	4 =#Strings	Length	$/ft			
Drive Pipe	30"		200	$500.00	$100,000	$0	$100,000
Conductor	20"		770	$180.00	$139,000	$0	$139,000
Surface	13-3/8"		5,527	$140.00	$774,000	$0	$774,000
Intermediate	11-3/4"		7,076	$80.00	$567,000	$0	$567,000
Intermediate							
Intermediate							
Intermediate							
Production Liner							
Production Tie-back							
Tubing							
Liner Equipment					$150,000	$0	$150,000
Whipstock Equipment & BP							
Subsurface Completion							
Wellheads					$500,000	$0	$500,000
Miscellaneous / Other					$100,000	$0	$100,000
Tangible Contingency		10% Amount	*ST Drlg =*	*$2,330,000*	$233,000	$0	$233,000
			ST Comp =	*$0*			
				TOTAL TANGIBLE	**$2,563,000**	**$0**	**$2,563,000**
				Total Dry Hole Cost	**$225,672,000**	**$0**	**$225,672,000**
				Total Completion Cost	**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**			TOTAL WELL COST	**$225,672,000**	**$0**	**$225,672,000**

6.2.2 *Case 2b Cost Estimate:*

This case assumes the Deepwater wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. However for the Cocos location it is assumed that the sediments, lava and dike intervals do not need to be cored because of previous IODP experience on the 1256D hole. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
320	$246,552	$6,048	$252,600	$232,208	$244,685	$263,013

Figure 159. Cocos Location: Case 2c – Cost Estimate

The following chart shows the cumulative probability of cost.

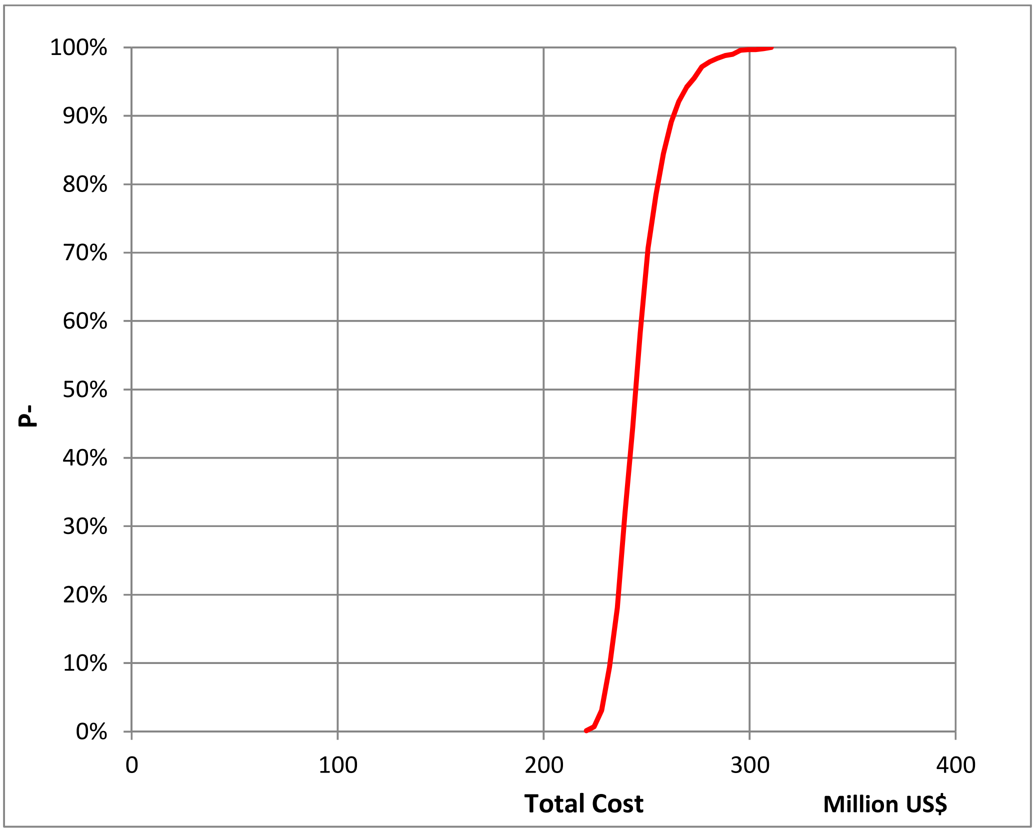


Figure 160. Cocos Location – Case 2b Probabilistic Cost

SCOPING COST ESTIMATE SUMMARY Rev 4

BEAM - Cocos Case 2b

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**		Revision No.	**1**	Date:	**20-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#2b**	Water Depth **3650m** **11,975 ft**	Proposed TD **9900m** **32,480 ft**	Formation **Moho / Mantle**	
Location	Surface Location:	**Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W**				
Cocos	Btm. Hole Location:	**Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W**				

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume
Case 4b: Conventional Deepwater Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	Dry Hole Drlg 272 Days	Complete	TOTAL 272 Days
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$19,400,000	$0	$19,400,000
Drilling Rig - Day Work at $300,000 / Day	$142,600,000	$0	$142,600,000
Bits, Drill Collars & Stabilizers	$4,286,000	$0	$4,286,000
Directional & Downhole Services	$4,511,000	$0	$4,511,000
Fuel, Water & Lube	$15,912,000	$0	$15,912,000
Drilling Fluids Services	$2,798,000	$0	$2,798,000
Electric Logging & Cased Hole Logs	$4,916,000	$0	$4,916,000
Cementing	$1,090,000	$0	$1,090,000
Mud Logging and Geological Services	$667,000	$0	$667,000
Land Transportation	$123,000	$0	$123,000
Boat Transportation	$3,128,000	$0	$3,128,000
Helicopter Transportation	$1,224,000	$0	$1,224,000
Tubular Services	$150,000	$0	$150,000
Shorebase / Dock Services	$544,000	$0	$544,000
Communications	$272,000	$0	$272,000
Miscellaneous Rental Equipment	$6,377,000	$0	$6,377,000
Miscellaneous Special Services	$1,141,000	$0	$1,141,000
Other Services / Costs	$2,234,000	$0	$2,234,000
Intan Contingency at 15%	$32,159,000	$0	$32,159,000
TOTAL INTANGIBLE	**$246,552,272**	**$0**	**$246,552,272**

TANGIBLE ITEMS	OD	Footage	$/ft	Dry Hole Drlg	Complete	TOTAL
Drive Pipe	36"	200	$650.00	$130,000	$0	$130,000
Conductor	22"	770	$180.00	$139,000	$0	$139,000
Surface	18"	4,907	$160.00	$786,000	$0	$786,000
Intermediate	16"	8,305	$155.00	$1,288,000	$0	$1,288,000
Intermediate	13-3/8"	12,225	$140.00	$1,712,000	$0	$1,712,000
Intermediate	11-3/4"	3,600	$80.00	$288,000	$0	$288,000
Intermediate	9-5/8"	3,640	$70.00	$255,000	$0	$255,000
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$300,000	$0	$300,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$550,000	$0	$550,000
TOTAL TANGIBLE				**$6,048,000**	**$0**	**$6,048,000**
Total Dry Hole Cost				**$252,600,272**	**$0**	**$252,600,272**
Total Completion Cost				**$0**	**$0**	**$0**
Prepared by: **WSWhitney / NPilisi** — **Total Drill and Complete**				**$252,600,272**	**$0**	**$252,600,272**

SCOPING COST ESTIMATE DETAILS Rev 4

BEAM - Cocos Case 2b

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: CDEX / JAMSTEC		**Revision No.**	1	**Date:**	20-Jun-13
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#2b**	Water Depth **3650m** **11,975 ft**	Proposed TD **9900m** **32,480 ft**	Objective **Moho / Mantle**	
Location **Cocos**	Surface Location: **Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W** Btm. Hole Location: **Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume
Case 4b: Conventional Deepwater Case Well Configuration

Avg Intan $/day: **$906,441**

Drilling Rig : Chikyu — Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	Qty	Unit	Rate	Basis	Amount	Dry Hole Drlg	Complete	TOTAL
				Operational Time =		272 Days		272 Days
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$19,400,000		$19,400,000
Mobilization (from Japan)				Lump Sum	$9,700,000			
Demobilization (to Japan)				Lump Sum	$9,700,000			
Drilling Rig - Day Work						$142,600,000	$0	$142,600,000
Drilling Day Rate	272	Days	$300,000 /day		$81,600,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$4,286,000	$0	$4,286,000
Drill Bits	22	No.	$70,000 /bit		$1,540,000			
Drill String Rentals: DC's, Jars, Stab, HWT	272	Days	$4,000 /day		$1,088,000			
Core Bits	21	No.	$60,000 /bit		$1,260,000			
Coring Services	159	Days	$2,500 /day		$397,500			
Directional & Downhole Services						$4,511,000	$0	$4,511,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	136	Days	$3,000 /day		$408,000			
Standard LWD Rental	136	Days	$7,000 /day		$952,000			
MWD / LWD Engineers (2)	272	Days	$2,000 /day		$544,000			
Mud Motors & Associated Tools	218	Days	$3,000 /day		$652,800			
High Temp MWD Rental	136	Days	$4,000 /day		$544,000			
High temp LWD Rental	136	Days	$10,000 /day		$1,360,000			
Fuel, Water & Lube						$15,912,000	$0	$15,912,000
Rig Fuel	272	Days	$53,000 /day		$14,416,000			
Boat Fuel	136	Days	$4,000 /day		$544,000			
Helicopter Fuel	136	Days	$3,000 /day		$408,000			
Lubricants	272	Days	$1,300 /day		$353,600			
Fresh Water	272	Days	$700 /day		$190,400			
Drilling Fluids Services						$2,798,000	$0	$2,798,000
Drilling Fluids - WBM				Lump Sum	$1,900,000			
Mud Engineer	272	Days	$800 /day		$217,600			
Cuttings Disposal	272	Days	$2,500 /day		$680,000			
Electric Logging & Cased Hole Logs						$4,916,000		$4,916,000
Wireline Unit and Personnel	272	Days	$3,000 /day		$816,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$1,090,000	$0	$1,090,000
22"				Lump Sum	$100,000			
18"				Lump Sum	$100,000			
16"				Lump Sum	$150,000			
13.375"				Lump Sum	$150,000			
11.75"				Lump Sum	$100,000			
9.625"				Lump Sum	$100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	272	Days	$1,250 /day		$340,000			

Item	Description	Qty	Unit	Rate	Basis	Cost	Dry Hole	Completion	Total
Mud Logging and Geological Services							$667,000	$0	$667,000
	Logging Unit Operating rate	272	Days	$1,250 /day		$340,000			
	Personnel Charges	272	Days	$1,200 /day		$326,400			
Land Transportation							$123,000	$0	$123,000
	Trucking	136	Days	$900 /day		$122,400			
Boat Transportation							$3,128,000	$0	$3,128,000
	Work Boat - Spot Hire	136	Days	$14,000 /day		$1,904,000			
	Crew Boat - Spot Hire	136	Days	$9,000 /day		$1,224,000			
Helicopter Transportation							$1,224,000	$0	$1,224,000
	Helicopter - spot hire	136	Days	$9,000 /day		$1,224,000			
Tubular Services							$150,000	$0	$150,000
	QAQC				Lump Sum	$150,000			
Shorebase / Dock Services							$544,000	$0	$544,000
	Shorebase /Dispatcher	272	Days	$2,000 /day		$544,000			$0
Communications							$272,000	$0	$272,000
	VSAT	272	Days	$1,000 /day		$272,000			
Miscellaneous Rental Equipment							$6,377,000	$0	$6,377,000
	Solids Control	272	Days	$400 /day		$108,800			
	Fishing Tools	272	Days	$1,500 /day		$408,000			
	Casing Running Equipment	70	Days	$6,000 Day		$420,000			
	Other Rentals	272	Days	$20,000 Day		$5,440,000			
			Days						
			Days						
Miscellaneous Special Services							$1,141,000	$0	$1,141,000
	Weather Forecasting	272	Days	$150 /day		$40,800			
	Engineering Services - Riser Analysis				Lump Sum	$300,000			
	Engineering Services - Drill String Design				Lump Sum	$200,000			
	Engineering Services - Casing Design				Lump Sum	$50,000			
	Engineering Services - Wellbore Stability				Lump Sum	$100,000			
	Engineering Services - Operational Support				Lump Sum	$200,000			
	Engineering Services - Risk Assessments				Lump Sum	$200,000			
	Engineering Services - Other				Lump Sum	$50,000			
Other Services / Costs							$2,234,000	$0	$2,234,000
	Misc Contract Labor	272	Days	$1,500 /day		$408,000			
	Casing Running	70	Days	$10,000 /day		$700,000			
	Well Insurance				Lump Sum	$500,000			
	Overhead	272	Days	$1,100 /day		$299,200			
	Catering	272	Days	$1,200 /day		$326,400			
Intangible Contingency				15% Amount	*ST Drlg =*	*$214,393,000*	$32,159,000	$0	$32,159,000
					ST Comp =	*$0*			
					TOTAL INTANGIBLE		**$246,552,000**	**$0**	**$246,552,000**

TANGIBLE ITEMS

Item	OD	7 =#Strings	Length		$/ft	Dry Hole	Completion	Total
Drive Pipe	36"		200		$650.00	$130,000	$0	$130,000
Conductor	22"		770		$180.00	$139,000	$0	$139,000
Surface	18"		4,907		$160.00	$786,000	$0	$786,000
Intermediate	16"		8,305		$155.00	$1,288,000	$0	$1,288,000
Intermediate	13-3/8"		12,225		$140.00	$1,712,000	$0	$1,712,000
Intermediate	11-3/4"		3,600		$80.00	$288,000	$0	$288,000
Intermediate	9-5/8"		3,640		$70.00	$255,000	$0	$255,000
Production Liner								
Production Tie-back								
Tubing								
Liner Equipment						$300,000	$0	$300,000
Whipstock Equipment & BP								
Subsurface Completion								
Wellheads						$500,000	$0	$500,000
Miscellaneous / Other						$100,000	$0	$100,000
Tangible Contingency		10% = Amount		*ST Drlg =*	*$5,498,000*	$550,000	$0	$550,000
				ST Comp =	*$0*			
					TOTAL TANGIBLE	**$6,048,000**	**$0**	**$6,048,000**
					Total Dry Hole Cost	**$252,600,000**	**$0**	**$252,600,000**
					Total Completion Cost	**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**				TOTAL WELL COST	**$252,600,000**	**$0**	**$252,600,000**

6.2.3 Case 2c Cost Estimate:

This case assumes the Deepwater wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. However for the Cocos location it is assumed that the sediments, lava and dike intervals do not need to be cored because of previous IODP experience on the 1256D hole. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
337	$255,250	$8,879	$264,129	$243,306	$256,370	$276,480

Figure 161. Cocos Location: Case 2c – Cost Estimate

The following charts shows the cumulative probability of cost.

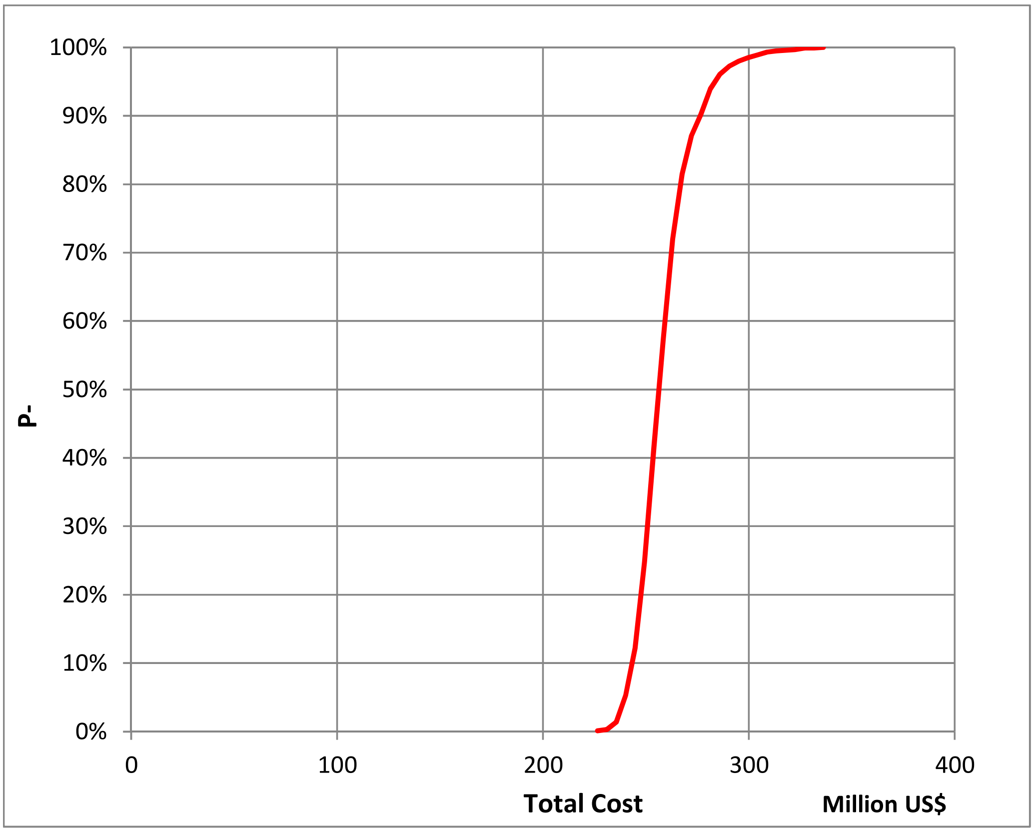


Figure 162. Cocos Location – Case 2c Probabilistic Cost

SCOPING COST ESTIMATE SUMMARY

Rev 4

BEAM - Cocos Case 2c

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: CDEX / JAMSTEC		Revision No.	1	Date:	20-Jun-13
Prospect or Field Mantle Hole	Lease Name N/A	Case No. #2b	Water Depth 3650m 11,975 ft	Proposed TD 9900m 32,480 ft	Formation Moho / Mantle	
Location Cocos	Surface Location: Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W Btm. Hole Location: Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume
Case 4b: Conventional Deepwater Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	Dry Hole Drlg	Complete	TOTAL
	289 Days		289 Days
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$19,400,000	$0	$19,400,000
Drilling Rig - Day Work at $300,000 / Day	$147,700,000	$0	$147,700,000
Bits, Drill Collars & Stabilizers	$4,531,000	$0	$4,531,000
Directional & Downhole Services	$4,790,000	$0	$4,790,000
Fuel, Water & Lube	$16,907,000	$0	$16,907,000
Drilling Fluids Services	$2,854,000	$0	$2,854,000
Electric Logging & Cased Hole Logs	$4,967,000	$0	$4,967,000
Cementing	$1,112,000	$0	$1,112,000
Mud Logging and Geological Services	$709,000	$0	$709,000
Land Transportation	$131,000	$0	$131,000
Boat Transportation	$3,324,000	$0	$3,324,000
Helicopter Transportation	$1,301,000	$0	$1,301,000
Tubular Services	$150,000	$0	$150,000
Shorebase / Dock Services	$578,000	$0	$578,000
Communications	$289,000	$0	$289,000
Miscellaneous Rental Equipment	$6,750,000	$0	$6,750,000
Miscellaneous Special Services	$1,144,000	$0	$1,144,000
Other Services / Costs	$2,299,000	$0	$2,299,000
Intan Contingency at 15%	$33,294,000	$0	$33,294,000
TOTAL INTANGIBLE	**$255,250,289**	**$0**	**$255,250,289**

TANGIBLE ITEMS	OD	Footage	$/ft	Dry Hole Drlg	Complete	TOTAL
Drive Pipe	36"	200	$650.00	$130,000	$0	$130,000
Conductor	22"	770	$180.00	$139,000	$0	$139,000
Surface	16.5" SET	5,107	$300.00	$1,533,000	$0	$1,533,000
Intermediate	16.5" SET	3,598	$300.00	$1,080,000	$0	$1,080,000
Intermediate	16"	11,755	$155.00	$1,823,000	$0	$1,823,000
Intermediate	13-3/8"	15,525	$140.00	$2,174,000	$0	$2,174,000
Intermediate	11-3/4"	3,640	$80.00	$292,000	$0	$292,000
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$300,000	$0	$300,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$808,000	$0	$808,000
TOTAL TANGIBLE				**$8,879,000**	**$0**	**$8,879,000**
Total Dry Hole Cost				**$264,129,289**	**$0**	**$264,129,289**
Total Completion Cost				**$0**	**$0**	**$0**
Total Drill and Complete				**$264,129,289**	**$0**	**$264,129,289**

Prepared by: **WSWhitney / NPilisi**

SCOPING COST ESTIMATE

Rev 4

BEAM - Cocos Case 2c

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# **xxx**	Operator: **CDEX / JAMSTEC**		Revision No. **1**		Date: **20-Jun-13**	
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#2b**	Water Depth **3650m 11,975 ft**	Proposed TD **9900m 32,480 ft**	Objective **Moho / Mantle**	
Location **Cocos**	Surface Location: **Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W**					
	Btm. Hole Location: **Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume
Case 4b: Conventional Deepwater Case Well Configuration

Avg Intan $/day: **$883,218**

Drilling Rig : Chikyu — Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	Qty	Unit	Rate	Basis	Cost	Dry Hole Drlg	Complete	TOTAL
					Operational Time =	**289 Days**		**289 Days**
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$19,400,000		$19,400,000
Mobilization (from Japan)				Lump Sum	$9,700,000			
Demobilization (to Japan)				Lump Sum	$9,700,000			
Drilling Rig - Day Work						$147,700,000	$0	$147,700,000
Drilling Day Rate	289	Days	$300,000 /day		$86,700,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$4,531,000	$0	$4,531,000
Drill Bits	24	No.	$70,000 /bit		$1,680,000			
Drill String Rentals: DC's, Jars, Stab, HWT	289	Days	$4,000 /day		$1,156,000			
Core Bits	21	No.	$60,000 /bit		$1,260,000			
Coring Services	174	Days	$2,500 /day		$435,000			
Directional & Downhole Services						$4,790,000	$0	$4,790,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	145	Days	$3,000 /day		$433,500			
Standard LWD Rental	145	Days	$7,000 /day		$1,011,500			
MWD / LWD Engineers (2)	289	Days	$2,000 /day		$578,000			
Mud Motors & Associated Tools	231	Days	$3,000 /day		$693,600			
High Temp MWD Rental	145	Days	$4,000 /day		$578,000			
High temp LWD Rental	145	Days	$10,000 /day		$1,445,000			
Fuel, Water & Lube						$16,907,000	$0	$16,907,000
Rig Fuel	289	Days	$53,000 /day		$15,317,000			
Boat Fuel	145	Days	$4,000 /day		$578,000			
Helicopter Fuel	145	Days	$3,000 /day		$433,500			
Lubricants	289	Days	$1,300 /day		$375,700			
Fresh Water	289	Days	$700 /day		$202,300			
Drilling Fluids Services						$2,854,000	$0	$2,854,000
Drilling Fluids - WBM				Lump Sum	$1,900,000			
Mud Engineer	289	Days	$800 /day		$231,200			
Cuttings Disposal	289	Days	$2,500 /day		$722,500			
Electric Logging & Cased Hole Logs						$4,967,000		$4,967,000
Wireline Unit and Personnel	289	Days	$3,000 /day		$867,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$1,112,000	$0	$1,112,000
22"				Lump Sum	$100,000			
16.5" SET				Lump Sum	$100,000			
16.5" SET				Lump Sum	$150,000			
16"				Lump Sum	$150,000			
13.375"				Lump Sum	$100,000			
11.75"				Lump Sum	$100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	289	Days	$1,250 /day		$361,250			

Mud Logging and Geological Services					$709,000	$0	$709,000
Logging Unit Operating rate	289 Days	$1,250 /day		$361,250			
Personnel Charges	289 Days	$1,200 /day		$346,800			
Land Transportation					$131,000	$0	$131,000
Trucking	145 Days	$900 /day		$130,050			
Boat Transportation					$3,324,000	$0	$3,324,000
Work Boat - Spot Hire	145 Days	$14,000 /day		$2,023,000			
Crew Boat - Spot Hire	145 Days	$9,000 /day		$1,300,500			
Helicopter Transportation					$1,301,000	$0	$1,301,000
Helicopter - spot hire	145 Days	$9,000 /day		$1,300,500			
Tubular Services					$150,000	$0	$150,000
QAQC			Lump Sum	$150,000			
Shorebase / Dock Services					$578,000	$0	$578,000
Shorebase /Dispatcher	289 Days	$2,000 /day		$578,000			$0
Communications					$289,000	$0	$289,000
VSAT	289 Days	$1,000 /day		$289,000			
Miscellaneous Rental Equipment					$6,750,000	$0	$6,750,000
Solids Control	289 Days	$400 /day		$115,600			
Fishing Tools	289 Days	$1,500 /day		$433,500			
Casing Running Equipment	70 Days	$6,000 Day		$420,000			
Other Rentals	289 Days	$20,000 Day		$5,780,000			
	Days						
	Days						
Miscellaneous Special Services					$1,144,000	$0	$1,144,000
Weather Forecasting	289 Days	$150 /day		$43,350			
Engineering Services - Riser Analysis			Lump Sum	$300,000			
Engineering Services - Drill String Design			Lump Sum	$200,000			
Engineering Services - Casing Design			Lump Sum	$50,000			
Engineering Services - Wellbore Stability			Lump Sum	$100,000			
Engineering Services - Operational Support			Lump Sum	$200,000			
Engineering Services - Risk Assessments			Lump Sum	$200,000			
Engineering Services - Other			Lump Sum	$50,000			
Other Services / Costs					$2,299,000	$0	$2,299,000
Misc Contract Labor	289 Days	$1,500 /day		$433,500			
Casing Running	70 Days	$10,000 /day		$700,000			
Well Insurance			Lump Sum	$500,000			
Overhead	289 Days	$1,100 /day		$317,900			
Catering	289 Days	$1,200 /day		$346,800			
Intangible Contingency		**15%** Amount	*ST Drlg =*	*$221,956,000*	$33,294,000	$0	$33,294,000
			ST Comp =	*$0*			
				TOTAL INTANGIBLE	**$255,250,000**	**$0**	**$255,250,000**

TANGIBLE ITEMS

	OD	7 =#Strings	Length	$/ft			
Drive Pipe	36"		200	650	$130,000	$0	$130,000
Conductor	22"		770	180	$139,000	$0	$139,000
Surface	16.5" SET		5,107	300	$1,533,000	$0	$1,533,000
Intermediate	16.5" SET		3,598	300	$1,080,000	$0	$1,080,000
Intermediate	16"		11,755	155	$1,823,000	$0	$1,823,000
Intermediate	13-3/8"		15,525	140	$2,174,000	$0	$2,174,000
Intermediate	11-3/4"		3,640	80	$292,000	$0	$292,000
Production Liner							
Production Tie-back							
Tubing							
Liner Equipment					$300,000	$0	$300,000
Whipstock Equipment & BP							
Subsurface Completion							
Wellheads					$500,000	$0	$500,000
Miscellaneous / Other					$100,000	$0	$100,000
Tangible Contingency		**10%** = Amount	*ST Drlg =*	*$8,071,000*	$808,000	$0	$808,000
			ST Comp =	*$0*			
				TOTAL TANGIBLE	**$8,879,000**	**$0**	**$8,879,000**
				Total Dry Hole Cost	**$264,129,000**	**$0**	**$264,129,000**
				Total Completion Cost	**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**			TOTAL WELL COST	**$264,129,000**	**$0**	**$264,129,000**

6.2.4 Case 4a Cost Estimate:

This case assumes the original Base Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the cost estimate for this case is shown below.
.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
250	$209,434	$2,563	$211,997	$186,990	$200,870	$220,780

Figure 163. Cocos Location: Case 4a – Cost Estimate

The following chart shows the cumulative probability of cost.

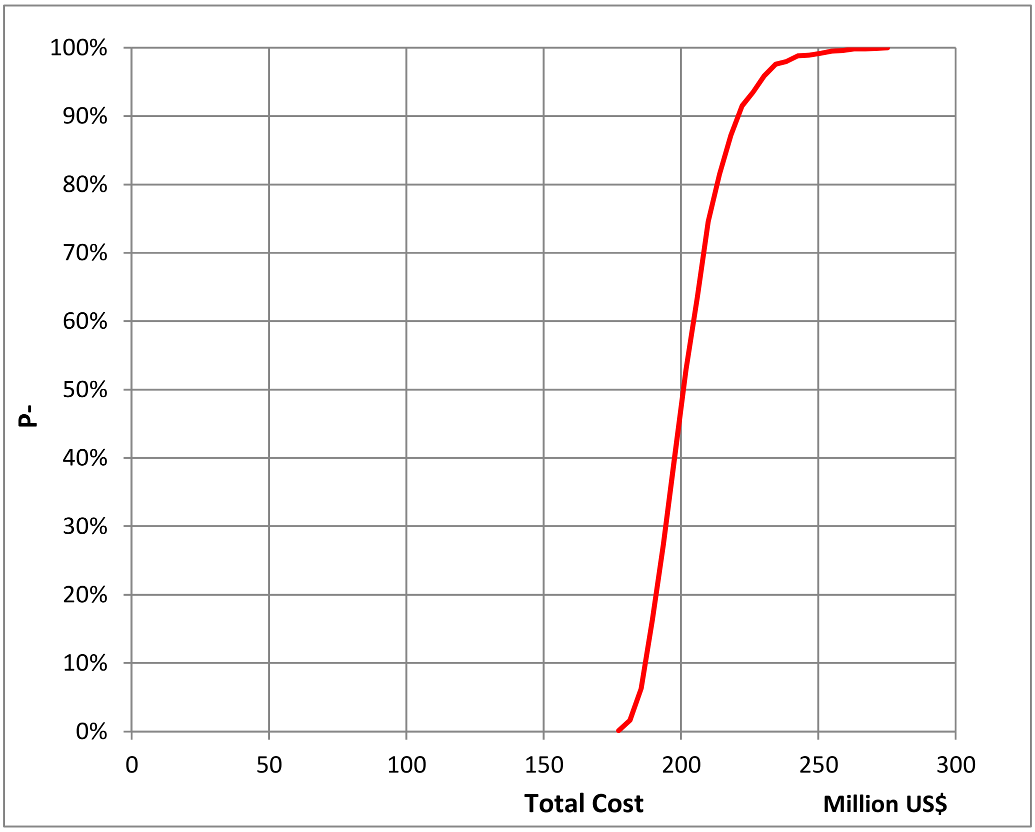


Figure 164. Cocos Location – Case 4a Probabilistic Cost

SCOPING COST ESTIMATE SUMMARY Rev 4

BEAM - Cocos Case 4a ** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**			Revision No.	**1**	Date:	**20-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4a**		Water Depth **3650m** **11,975 ft**	Proposed TD **9900m** **32,480 ft**	Formation **Moho / Mantle**	
Location **Cocos**	Surface Location: **Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W** Btm. Hole Location: **Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W**						

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 1640 ft / 500m of the Mantle
Case 4a: Orig Base Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	**Dry Hole Drlg**	**Complete**	**TOTAL**
	202 Days		**202 Days**
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$19,400,000	$0	$19,400,000
Drilling Rig - Day Work at $300,000 / Day	$121,600,000	$0	$121,600,000
Bits, Drill Collars & Stabilizers	$3,003,000	$0	$3,003,000
Directional & Downhole Services	$3,363,000	$0	$3,363,000
Fuel, Water & Lube	$11,817,000	$0	$11,817,000
Drilling Fluids Services	$2,567,000	$0	$2,567,000
Electric Logging & Cased Hole Logs	$4,706,000	$0	$4,706,000
Cementing	$653,000	$0	$653,000
Mud Logging and Geological Services	$495,000	$0	$495,000
Land Transportation	$91,000	$0	$91,000
Boat Transportation	$2,323,000	$0	$2,323,000
Helicopter Transportation	$909,000	$0	$909,000
Tubular Services	$100,000	$0	$100,000
Shorebase / Dock Services	$404,000	$0	$404,000
Communications	$202,000	$0	$202,000
Miscellaneous Rental Equipment	$4,664,000	$0	$4,664,000
Miscellaneous Special Services	$1,131,000	$0	$1,131,000
Other Services / Costs	$1,668,000	$0	$1,668,000
Intan Contingency at 15%	$27,318,000	$0	$27,318,000
TOTAL INTANGIBLE	**$209,434,202**	**$0**	**$209,434,202**

TANGIBLE ITEMS	**OD**	**Footage**	**$/ft**			
Drive Pipe	30"	200	$500.00	$100,000	$0	$100,000
Conductor	20"	770	$180.00	$139,000	$0	$139,000
Surface	13-3/8"	5,527	$140.00	$774,000	$0	$774,000
Intermediate	11-3/4"	7,076	$80.00	$567,000	$0	$567,000
Intermediate	0	0	$0.00	$0	$0	$0
Intermediate	0	0	$0.00	$0	$0	$0
Intermediate	0	0	$0.00	$0	$0	$0
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$150,000	$0	$150,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$233,000	$0	$233,000
TOTAL TANGIBLE				**$2,563,000**	**$0**	**$2,563,000**
Total Dry Hole Cost				**$211,997,202**	**$0**	**$211,997,202**
Total Completion Cost				**$0**	**$0**	**$0**
Prepared by: **WSWhitney / NPilisi** — **Total Drill and Complete**				**$211,997,202**	**$0**	**$211,997,202**

SCOPING COST ESTIMATE DETAILS Rev 4

BEAM - Cocos Case 4a

*** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: CDEX / JAMSTEC			Revision No.	1	Date:	20-Jun-13	
Prospect or Field: Mantle Hole	Lease Name: N/A	Case No.: #4a		Water Depth: 3650m 11,975 ft	Proposed TD: 9900m 32,480 ft	Objective: Moho / Mantle		
Location: Cocos	Surface Location: Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W							
	Btm. Hole Location: Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W							

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 1640 ft / 500m of the Mantle
Case 4a: Orig Base Case Well Configuration

Avg Intan $/day: $1,036,802

Drilling Rig : Chikyu — Directional Plan: Vertical Hole

INTANGIBLE ITEMS	Qty	Unit	Rate	Basis	Amount	Dry Hole Drlg	Complete	TOTAL
				Operational Time =		202 Days		202 Days
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$19,400,000		$19,400,000
Mobilization (from Japan)				Lump Sum	$9,700,000			
Demobilization (to Japan)				Lump Sum	$9,700,000			
Drilling Rig - Day Work						$121,600,000	$0	$121,600,000
Drilling Day Rate	202	Days	$300,000 /day		$60,600,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$3,003,000	$0	$3,003,000
Drill Bits	24	No.	$70,000 /bit		$1,680,000			
Drill String Rentals: DC's, Jars, Stab, HWT	202	Days	$4,000 /day		$808,000			
Core Bits	6	No.	$60,000 /bit		$360,000			
Coring Services	62	Days	$2,500 /day		$155,000			
Directional & Downhole Services						$3,363,000	$0	$3,363,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	101	Days	$3,000 /day		$303,000			
Standard LWD Rental	101	Days	$7,000 /day		$707,000			
MWD / LWD Engineers (2)	202	Days	$2,000 /day		$404,000			
Mud Motors & Associated Tools	162	Days	$3,000 /day		$484,800			
High Temp MWD Rental	101	Days	$4,000 /day		$404,000			
High temp LWD Rental	101	Days	$10,000 /day		$1,010,000			
Fuel, Water & Lube						$11,817,000	$0	$11,817,000
Rig Fuel	202	Days	$53,000 /day		$10,706,000			
Boat Fuel	101	Days	$4,000 /day		$404,000			
Helicopter Fuel	101	Days	$3,000 /day		$303,000			
Lubricants	202	Days	$1,300 /day		$262,600			
Fresh Water	202	Days	$700 /day		$141,400			
Drilling Fluids Services						$2,567,000	$0	$2,567,000
Drilling Fluids - WBM				Lump Sum	$1,900,000			
Mud Engineer	202	Days	$800 /day		$161,600			
Cuttings Disposal	202	Days	$2,500 /day		$505,000			
Electric Logging & Cased Hole Logs						$4,706,000		$4,706,000
Wireline Unit and Personnel	202	Days	$3,000 /day		$606,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$653,000	$0	$653,000
20"				Lump Sum	$100,000			
13-3/8"				Lump Sum	$150,000			
11-3/4"				Lump Sum	$100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	202	Days	$1,250 /day		$252,500			

Mud Logging and Geological Services							$495,000	$0	$495,000
	Logging Unit Operating rate	202	Days	$1,250 /day		$252,500			
	Personnel Charges	202	Days	$1,200 /day		$242,400			
Land Transportation							$91,000	$0	$91,000
	Trucking	101	Days	$900 /day		$90,900			
Boat Transportation							$2,323,000	$0	$2,323,000
	Work Boat - Spot Hire	101	Days	$14,000 /day		$1,414,000			
	Crew Boat - Spot Hire	101	Days	$9,000 /day		$909,000			
Helicopter Transportation							$909,000	$0	$909,000
	Helicopter - spot hire	101	Days	$9,000 /day		$909,000			
Tubular Services							$100,000	$0	$100,000
	QAQC				Lump Sum	$100,000			
Shorebase / Dock Services							$404,000	$0	$404,000
	Shorebase /Dispatcher	202	Days	$2,000 /day		$404,000			$0
Communications							$202,000	$0	$202,000
	VSAT	202	Days	$1,000 /day		$202,000			
Miscellaneous Rental Equipment							$4,664,000	$0	$4,664,000
	Solids Control	202	Days	$400 /day		$80,800			
	Fishing Tools	202	Days	$1,500 /day		$303,000			
	Casing Running Equipment	40	Days	$6,000 Day		$240,000			
	Other Rentals	202	Days	$20,000 Day		$4,040,000			
			Days						
			Days						
Miscellaneous Special Services							$1,131,000	$0	$1,131,000
	Weather Forecasting	202	Days	$150 /day		$30,300			
	Engineering Services - Riser Analysis				Lump Sum	$300,000			
	Engineering Services - Drill String Design				Lump Sum	$200,000			
	Engineering Services - Casing Design				Lump Sum	$50,000			
	Engineering Services - Wellbore Stability				Lump Sum	$100,000			
	Engineering Services - Operational Support				Lump Sum	$200,000			
	Engineering Services - Risk Assessments				Lump Sum	$200,000			
	Engineering Services - Other				Lump Sum	$50,000			
Other Services / Costs							$1,668,000	$0	$1,668,000
	Misc Contract Labor	202	Days	$1,500 /day		$303,000			
	Casing Running Service	40	Days	$10,000 /day		$400,000			
	Well Insurance				Lump Sum	$500,000			
	Overhead	202	Days	$1,100 /day		$222,200			
	Catering	202	Days	$1,200 /day		$242,400			
Intangible Contingency				15% = Amount	*ST Drlg =*	*$182,116,000*	$27,318,000	$0	$27,318,000
					ST Comp =	*$0*			
					TOTAL INTANGIBLE		**$209,434,000**	**$0**	**$209,434,000**

TANGIBLE ITEMS

	OD	4 = # Strings	Length		$/ft			
Drive Pipe	30"		200		$500.00	$100,000	$0	$100,000
Conductor	20"		770		$180.00	$139,000	$0	$139,000
Surface	13-3/8"		5,527		$140.00	$774,000	$0	$774,000
Intermediate	11-3/4"		7,076		$80.00	$567,000	$0	$567,000
Intermediate								
Intermediate								
Intermediate								
Production Liner								
Production Tie-back								
Tubing								
Liner Equipment						$150,000	$0	$150,000
Whipstock Equipment & BP								
Subsurface Completion								
Wellheads						$500,000	$0	$500,000
Miscellaneous / Other						$100,000	$0	$100,000
Tangible Contingency		10% Amount		*ST Drlg =*	*$2,330,000*	$233,000	$0	$233,000
				ST Comp =	*$0*			
				TOTAL TANGIBLE		**$2,563,000**	**$0**	**$2,563,000**
				Total Dry Hole Cost		**$211,997,000**	**$0**	**$211,997,000**
				Total Completion Cost		**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**			TOTAL WELL COST		**$211,997,000**	**$0**	**$211,997,000**

6.2.5 Case 4b Cost Estimate:

This case assumes the original Base Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
269	$219,937	$6,048	$225,985	$198,614	$214,640	$240,231

Figure 165. Cocos Location: Case 4b – Cost Estimate

The following chart shows the cumulative probability of cost.

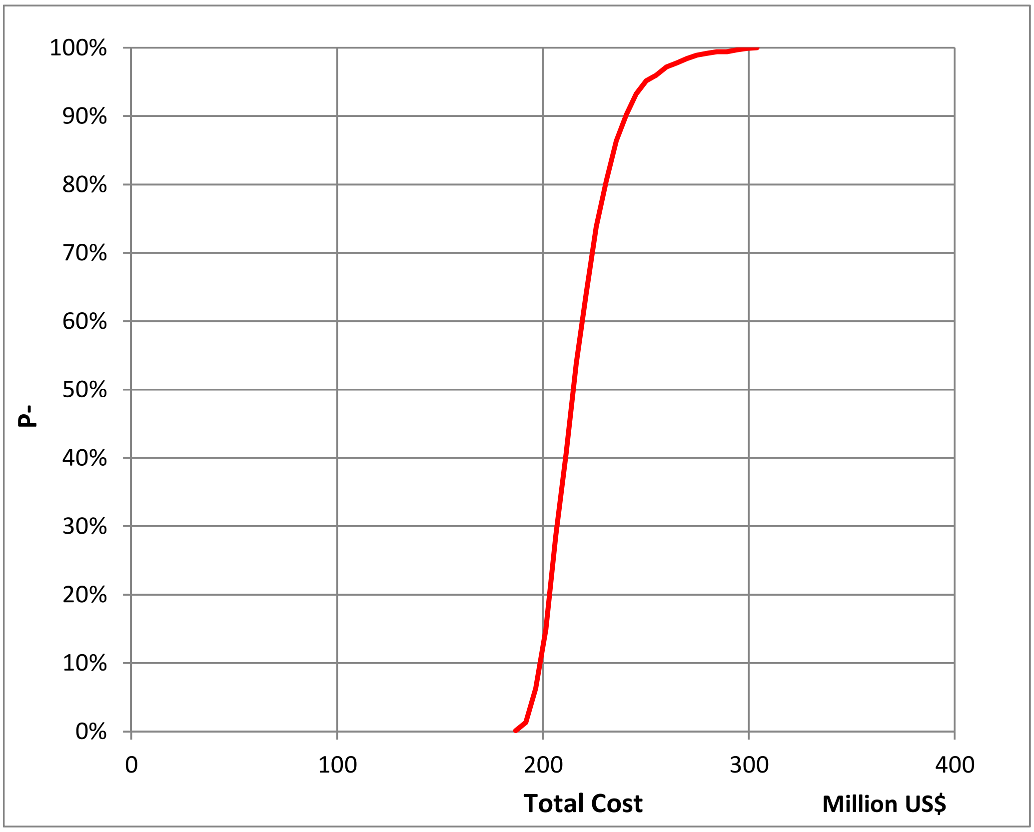


Figure 166. Cocos Location – Case 4b Probabilistic Cost

SCOPING COST ESTIMATE Rev 4

BEAM - Cocos Case 4b ** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**		Revision No.	**1**	Date:	**20-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4b**	Water Depth **3650m** **11,975 ft**	Proposed TD **9900m** **32,480 ft**	Formation **Moho / Mantle**	
Location **Cocos**	Surface Location: **Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W** Btm. Hole Location: **Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 1640 ft / 500m of the Mantle
Case 4b: Conventional Deepwater Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	**Dry Hole Drlg**	**Complete**	**TOTAL**
	221 Days		**221 Days**
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$19,400,000	$0	$19,400,000
Drilling Rig - Day Work at $300,000 / Day	$127,300,000	$0	$127,300,000
Bits, Drill Collars & Stabilizers	$3,079,000	$0	$3,079,000
Directional & Downhole Services	$3,675,000	$0	$3,675,000
Fuel, Water & Lube	$12,929,000	$0	$12,929,000
Drilling Fluids Services	$2,630,000	$0	$2,630,000
Electric Logging & Cased Hole Logs	$4,763,000	$0	$4,763,000
Cementing	$1,027,000	$0	$1,027,000
Mud Logging and Geological Services	$542,000	$0	$542,000
Land Transportation	$100,000	$0	$100,000
Boat Transportation	$2,542,000	$0	$2,542,000
Helicopter Transportation	$995,000	$0	$995,000
Tubular Services	$150,000	$0	$150,000
Shorebase / Dock Services	$442,000	$0	$442,000
Communications	$221,000	$0	$221,000
Miscellaneous Rental Equipment	$5,260,000	$0	$5,260,000
Miscellaneous Special Services	$1,134,000	$0	$1,134,000
Other Services / Costs	$2,040,000	$0	$2,040,000
Intan Contingency at 15%	$28,688,000	$0	$28,688,000
TOTAL INTANGIBLE	**$219,937,221**	**$0**	**$219,937,221**

TANGIBLE ITEMS	**OD**	**Footage**	**$/ft**			
Drive Pipe	36"	200	$650.00	$130,000	$0	$130,000
Conductor	22"	770	$180.00	$139,000	$0	$139,000
Surface	18"	4,907	$160.00	$786,000	$0	$786,000
Intermediate	16"	8,305	$155.00	$1,288,000	$0	$1,288,000
Intermediate	13-3/8"	12,225	$140.00	$1,712,000	$0	$1,712,000
Intermediate	11-3/4"	3,600	$80.00	$288,000	$0	$288,000
Intermediate	9-5/8"	3,640	$70.00	$255,000	$0	$255,000
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$300,000	$0	$300,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$550,000	$0	$550,000
TOTAL TANGIBLE				**$6,048,000**	**$0**	**$6,048,000**
Total Dry Hole Cost				**$225,985,221**	**$0**	**$225,985,221**
Total Completion Cost				**$0**	**$0**	**$0**
Prepared by: **WSWhitney / NPilisi** — **Total Drill and Complete**				**$225,985,221**	**$0**	**$225,985,221**

SCOPING COST ESTIMATE

Rev 4

BEAM - Cocos Case 4b

*** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: CDEX / JAMSTEC	Revision No. 1		Date: 20-Jun-13
Prospect or Field: Mantle Hole	Lease Name: N/A	Case No.: #4b	Water Depth: 3650m / 11,975 ft	Proposed TD: 9900m / 32,480 ft; Objective: Moho / Mantle
Location: Cocos	Surface Location: Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W			
	Btm. Hole Location: Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W			

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 1640 ft / 500m of the Mantle
Case 4b: Conventional Deepwater Case Well Configuration

Avg Intan $/day: $995,190

Drilling Rig : Chikyu — Directional Plan: Vertical Hole

INTANGIBLE ITEMS	Qty	Unit	Rate	Basis	Amount	Dry Hole Drlg	Complete	TOTAL
					Operational Time =	221 Days		221 Days
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$19,400,000		$19,400,000
Mobilization (from Japan)				Lump Sum	$9,700,000			
Demobilization (to Japan)				Lump Sum	$9,700,000			
Drilling Rig - Day Work						$127,300,000	$0	$127,300,000
Drilling Day Rate	221	Days	$300,000 /day		$66,300,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$3,079,000	$0	$3,079,000
Drill Bits	24	No.	$70,000 /bit		$1,680,000			
Drill String Rentals: DC's, Jars, Stab, HWT	221	Days	$4,000 /day		$884,000			
Core Bits	6	No.	$60,000 /bit		$360,000			
Coring Services	62	Days	$2,500 /day		$155,000			
Directional & Downhole Services						$3,675,000	$0	$3,675,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	111	Days	$3,000 /day		$331,500			
Standard LWD Rental	111	Days	$7,000 /day		$773,500			
MWD / LWD Engineers (2)	221	Days	$2,000 /day		$442,000			
Mud Motors & Associated Tools	177	Days	$3,000 /day		$530,400			
High Temp MWD Rental	111	Days	$4,000 /day		$442,000			
High temp LWD Rental	111	Days	$10,000 /day		$1,105,000			
Fuel, Water & Lube						$12,929,000	$0	$12,929,000
Rig Fuel	221	Days	$53,000 /day		$11,713,000			
Boat Fuel	111	Days	$4,000 /day		$442,000			
Helicopter Fuel	111	Days	$3,000 /day		$331,500			
Lubricants	221	Days	$1,300 /day		$287,300			
Fresh Water	221	Days	$700 /day		$154,700			
Drilling Fluids Services						$2,630,000	$0	$2,630,000
Drilling Fluids - WBM				Lump Sum	$1,900,000			
Mud Engineer	221	Days	$800 /day		$176,800			
Cuttings Disposal	221	Days	$2,500 /day		$552,500			
Electric Logging & Cased Hole Logs						$4,763,000		$4,763,000
Wireline Unit and Personnel	221	Days	$3,000 /day		$663,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$1,027,000	$0	$1,027,000
22"				Lump Sum	$100,000			
18"				Lump Sum	$100,000			
16"				Lump Sum	$150,000			
13.375"				Lump Sum	$150,000			
11.75"				Lump Sum	$100,000			
9.625"				Lump Sum	$100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	221	Days	$1,250 /day		$276,250			

Category	Item	Qty	Unit	Rate	Basis	Amount	Dry Hole	Completion	Total
Mud Logging and Geological Services							$542,000	$0	$542,000
	Logging Unit Operating rate	221	Days	$1,250 /day		$276,250			
	Personnel Charges	221	Days	$1,200 /day		$265,200			
Land Transportation							$100,000	$0	$100,000
	Trucking	111	Days	$900 /day		$99,450			
Boat Transportation							$2,542,000	$0	$2,542,000
	Work Boat - Spot Hire	111	Days	$14,000 /day		$1,547,000			
	Crew Boat - Spot Hire	111	Days	$9,000 /day		$994,500			
Helicopter Transportation							$995,000	$0	$995,000
	Helicopter - spot hire	111	Days	$9,000 /day		$994,500			
Tubular Services							$150,000	$0	$150,000
	QAQC				Lump Sum	$150,000			
Shorebase / Dock Services							$442,000	$0	$442,000
	Shorebase /Dispatcher	221	Days	$2,000 /day		$442,000			$0
Communications							$221,000	$0	$221,000
	VSAT	221	Days	$1,000 /day		$221,000			
Miscellaneous Rental Equipment							$5,260,000	$0	$5,260,000
	Solids Control	221	Days	$400 /day		$88,400			
	Fishing Tools	221	Days	$1,500 /day		$331,500			
	Casing Running Equipment	70	Days	$6,000 Day		$420,000			
	Other Rentals	221	Days	$20,000 Day		$4,420,000			
			Days						
			Days						
Miscellaneous Special Services							$1,134,000	$0	$1,134,000
	Weather Forecasting	221	Days	$150 /day		$33,150			
	Engineering Services - Riser Analysis				Lump Sum	$300,000			
	Engineering Services - Drill String Design				Lump Sum	$200,000			
	Engineering Services - Casing Design				Lump Sum	$50,000			
	Engineering Services - Wellbore Stability				Lump Sum	$100,000			
	Engineering Services - Operational Support				Lump Sum	$200,000			
	Engineering Services - Risk Assessments				Lump Sum	$200,000			
	Engineering Services - Other				Lump Sum	$50,000			
Other Services / Costs							$2,040,000	$0	$2,040,000
	Misc Contract Labor	221	Days	$1,500 /day		$331,500			
	Casing Running	70	Days	$10,000 /day		$700,000			
	Well Insurance				Lump Sum	$500,000			
	Overhead	221	Days	$1,100 /day		$243,100			
	Catering	221	Days	$1,200 /day		$265,200			
Intangible Contingency				**15%** Amount	*ST Drlg =*	*$191,249,000*	$28,688,000	$0	$28,688,000
					ST Comp =	*$0*			
					TOTAL INTANGIBLE		**$219,937,000**	**$0**	**$219,937,000**

TANGIBLE ITEMS

Item	OD	7 =#Strings	Length		$/ft	Dry Hole	Completion	Total
Drive Pipe	36"		200		$650.00	$130,000	$0	$130,000
Conductor	22"		770		$180.00	$139,000	$0	$139,000
Surface	18"		4,907		$160.00	$786,000	$0	$786,000
Intermediate	16"		8,305		$155.00	$1,288,000	$0	$1,288,000
Intermediate	13-3/8"		12,225		$140.00	$1,712,000	$0	$1,712,000
Intermediate	11-3/4"		3,600		$80.00	$288,000	$0	$288,000
Intermediate	9-5/8"		3,640		$70.00	$255,000	$0	$255,000
Production Liner								
Production Tie-back								
Tubing								
Liner Equipment						$300,000	$0	$300,000
Whipstock Equipment & BP								
Subsurface Completion								
Wellheads						$500,000	$0	$500,000
Miscellaneous / Other						$100,000	$0	$100,000
Tangible Contingency			**10%** = Amount	*ST Drlg =*	*$5,498,000*	$550,000	$0	$550,000
				ST Comp =	*$0*			
					TOTAL TANGIBLE	**$6,048,000**	**$0**	**$6,048,000**
					Total Dry Hole Cost	**$225,985,000**	**$0**	**$225,985,000**
					Total Completion Cost	**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**				**TOTAL WELL COST**	**$225,985,000**	**$0**	**$225,985,000**

6.2.6 Case 4c Cost Estimate:

This case assumes the original Base Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
271	$220,935	$8,714	$229,649	$205,488	$220,162	$241,916

Figure 167. Cocos Location: Case 4c – Cost Estimate

The following chart shows the cumulative probability of cost.

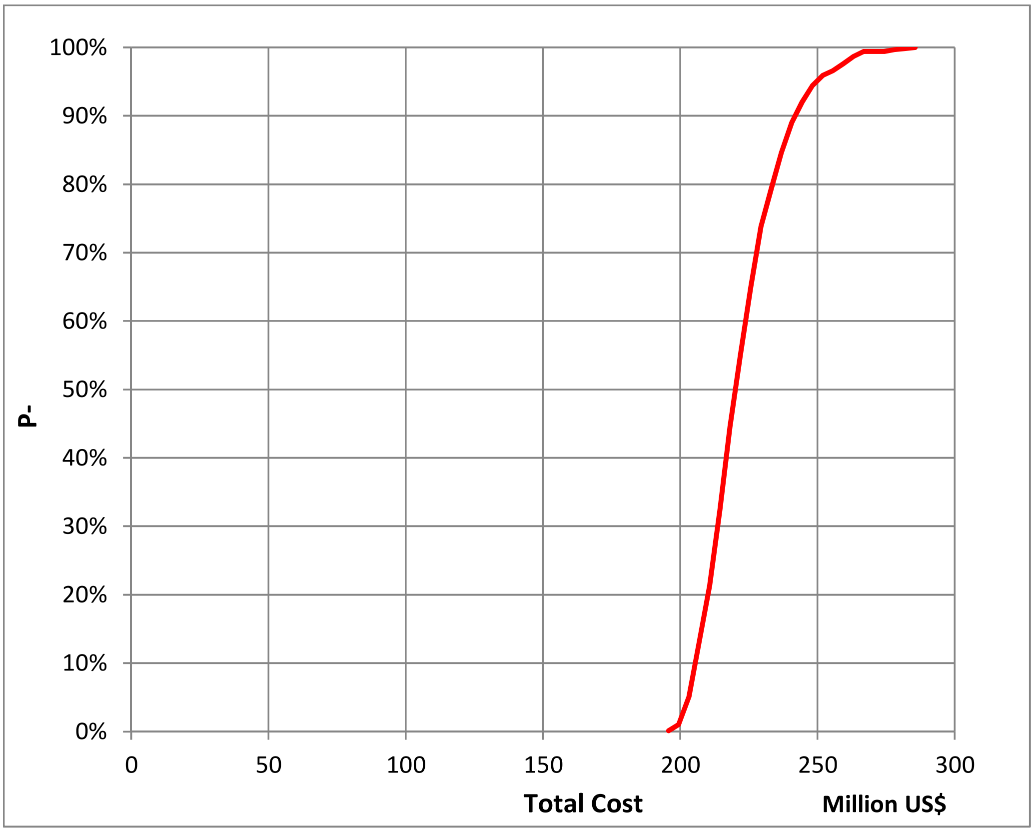


Figure 168. Cocos Location – Case 4b Probabilistic Cost

SCOPING COST ESTIMATE

Rev 4

BEAM - Cocos Case 4c

** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**		Revision No.	**1**	Date:	**20-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4c**	Water Depth **3650m** **11,972 ft**	Proposed TD **9900m** **32,480 ft**	Formation **Moho / Mantle**	
Location **Hawaii**	Surface Location: **Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W** Btm. Hole Location: **Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 1640 ft / 500m of the Mantle
Case 4c: Expandable Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	Dry Hole Drlg	Complete	TOTAL
	223 Days		**223 Days**
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$19,400,000	$0	$19,400,000
Drilling Rig - Day Work at $300,000 / Day	$127,900,000	$0	$127,900,000
Bits, Drill Collars & Stabilizers	$3,087,000	$0	$3,087,000
Directional & Downhole Services	$3,708,000	$0	$3,708,000
Fuel, Water & Lube	$13,046,000	$0	$13,046,000
Drilling Fluids Services	$2,636,000	$0	$2,636,000
Electric Logging & Cased Hole Logs	$4,769,000	$0	$4,769,000
Cementing	$1,029,000	$0	$1,029,000
Mud Logging and Geological Services	$547,000	$0	$547,000
Land Transportation	$101,000	$0	$101,000
Boat Transportation	$2,565,000	$0	$2,565,000
Helicopter Transportation	$1,004,000	$0	$1,004,000
Tubular Services	$150,000	$0	$150,000
Shorebase / Dock Services	$446,000	$0	$446,000
Communications	$223,000	$0	$223,000
Miscellaneous Rental Equipment	$5,304,000	$0	$5,304,000
Miscellaneous Special Services	$1,134,000	$0	$1,134,000
Other Services / Costs	$2,048,000	$0	$2,048,000
Intan Contingency at 15%	$28,818,000	$0	$28,818,000
TOTAL INTANGIBLE	**$220,935,223**	**$0**	**$220,935,223**

TANGIBLE ITEMS	OD	Footage	$/ft	Dry Hole Drlg	Complete	TOTAL
Drive Pipe	36"	200	$650.00	$130,000	$0	$130,000
Conductor	22"	770	$180.00	$139,000	$0	$139,000
Surface	16.5" SET	5,107	$300.00	$1,533,000	$0	$1,533,000
Intermediate	16.5" SET	3,598	$300.00	$1,080,000	$0	$1,080,000
Intermediate	16"	11,755	$155.00	$1,823,000	$0	$1,823,000
Intermediate	13-3/8"	15,525	$140.00	$2,174,000	$0	$2,174,000
Intermediate	11-3/4"	3,640	$80.00	$292,000	$0	$292,000
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$150,000	$0	$150,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$793,000	$0	$793,000
TOTAL TANGIBLE				**$8,714,000**	**$0**	**$8,714,000**
Total Dry Hole Cost				**$229,649,223**	**$0**	**$229,649,223**
Total Completion Cost				**$0**	**$0**	**$0**
Total Drill and Complete				**$229,649,223**	**$0**	**$229,649,223**

Prepared by: **WSWhitney / NPilisi**

SCOPING COST ESTIMATE Rev 4

BEAM - Cocos Case 4c

*** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: CDEX / JAMSTEC					Revision No. 1		Date: 20-Jun-13
Prospect or Field: Mantle Hole	Lease Name: N/A		Case No.: #4c		Water Depth: 3650m / 11,972 ft	Proposed TD: 9900m / 32,480 ft	Objective: Moho / Mantle	
Location: Hawaii	Surface Location: Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W							
	Btm. Hole Location: Lat: 6.7 - 8.7°N / Long: 89.5 - 91.9°W							

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 1640 ft / 500m of the Mantle
Case 4c: Expandable Case Well Configuration

Avg Intan $/day: $990,740

Drilling Rig : Chikyu — Directional Plan: Vertical Hole

INTANGIBLE ITEMS	Qty	Unit	Rate		Amount	Dry Hole Drlg	Complete	TOTAL
				Operational Time =		223 Days		223 Days
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$19,400,000		$19,400,000
Mobilization (from Japan)				Lump Sum	$9,700,000			
Demobilization (to Japan)				Lump Sum	$9,700,000			
Drilling Rig - Day Work						$127,900,000	$0	$127,900,000
Drilling Day Rate	223	Days	$300,000 /day		$66,900,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$3,087,000	$0	$3,087,000
Drill Bits	24	No.	$70,000 /bit		$1,680,000			
Drill String Rentals: DC's, Jars, Stab, HWT	223	Days	$4,000 /day		$892,000			
Core Bits	6	No.	$60,000 /bit		$360,000			
Coring Services	62	Days	$2,500 /day		$155,000			
Directional & Downhole Services						$3,708,000	$0	$3,708,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	112	Days	$3,000 /day		$334,500			
Standard LWD Rental	112	Days	$7,000 /day		$780,500			
MWD / LWD Engineers (2)	223	Days	$2,000 /day		$446,000			
Mud Motors & Associated Tools	178	Days	$3,000 /day		$535,200			
High Temp MWD Rental	112	Days	$4,000 /day		$446,000			
High temp LWD Rental	112	Days	$10,000 /day		$1,115,000			
Fuel, Water & Lube						$13,046,000	$0	$13,046,000
Rig Fuel	223	Days	$53,000 /day		$11,819,000			
Boat Fuel	112	Days	$4,000 /day		$446,000			
Helicopter Fuel	112	Days	$3,000 /day		$334,500			
Lubricants	223	Days	$1,300 /day		$289,900			
Fresh Water	223	Days	$700 /day		$156,100			
Drilling Fluids Services						$2,636,000	$0	$2,636,000
Drilling Fluids - WBM				Lump Sum	$1,900,000			
Mud Engineer	223	Days	$800 /day		$178,400			
Cuttings Disposal	223	Days	$2,500 /day		$557,500			
Electric Logging & Cased Hole Logs						$4,769,000		$4,769,000
Wireline Unit and Personnel	223	Days	$3,000 /day		$669,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$1,029,000	$0	$1,029,000
22"				Lump Sum	$100,000			
16.5" SET				Lump Sum	$100,000			
16.5" SET				Lump Sum	$100,000			
16"				Lump Sum	$150,000			
13.375"				Lump Sum	$150,000			
11.75"				Lump Sum	$100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	223	Days	$1,250 /day		$278,750			

Item	Detail	Qty	Unit	Rate	Lump Sum	Amount	Dry Hole	Completion	Total
Mud Logging and Geological Services							$547,000	$0	$547,000
	Logging Unit Operating rate	223	Days	$1,250 /day		$278,750			
	Personnel Charges	223	Days	$1,200 /day		$267,600			
Land Transportation							$101,000	$0	$101,000
	Trucking	112	Days	$900 /day		$100,350			
Boat Transportation							$2,565,000	$0	$2,565,000
	Work Boat - Spot Hire	112	Days	$14,000 /day		$1,561,000			
	Crew Boat - Spot Hire	112	Days	$9,000 /day		$1,003,500			
Helicopter Transportation							$1,004,000	$0	$1,004,000
	Helicopter - spot hire	112	Days	$9,000 /day		$1,003,500			
Tubular Services							$150,000	$0	$150,000
	QAQC				Lump Sum	$150,000			
Shorebase / Dock Services							$446,000	$0	$446,000
	Shorebase /Dispatcher	223	Days	$2,000 /day		$446,000			$0
Communications							$223,000	$0	$223,000
	VSAT	223	Days	$1,000 /day		$223,000			
Miscellaneous Rental Equipment							$5,304,000	$0	$5,304,000
	Solids Control	223	Days	$400 /day		$89,200			
	Fishing Tools	223	Days	$1,500 /day		$334,500			
	Casing Running Equipment	70	Days	$6,000 Day		$420,000			
	Other Rentals	223	Days	$20,000 Day		$4,460,000			
			Days						
			Days						
Miscellaneous Special Services							$1,134,000	$0	$1,134,000
	Weather Forecasting	223	Days	$150 /day		$33,450			
	Engineering Services - Riser Analysis				Lump Sum	$300,000			
	Engineering Services - Drill String Design				Lump Sum	$200,000			
	Engineering Services - Casing Design				Lump Sum	$50,000			
	Engineering Services - Wellbore Stability				Lump Sum	$100,000			
	Engineering Services - Operational Support				Lump Sum	$200,000			
	Engineering Services - Risk Assessments				Lump Sum	$200,000			
	Engineering Services - Other				Lump Sum	$50,000			
Other Services / Costs							$2,048,000	$0	$2,048,000
	Misc Contract Labor	223	Days	$1,500 /day		$334,500			
	Casing Running	70	Days	$10,000 /day		$700,000			
	Well Insurance				Lump Sum	$500,000			
	Overhead	223	Days	$1,100 /day		$245,300			
	Catering	223	Days	$1,200 /day		$267,600			
Intangible Contingency				15% Amount	*ST Drlg =*	*$192,117,000*	$28,818,000	$0	$28,818,000
					ST Comp =	*$0*			
						TOTAL INTANGIBLE	**$220,935,000**	**$0**	**$220,935,000**

TANGIBLE ITEMS

Item	OD	7 =#Strings	Length		$/ft	Dry Hole	Completion	Total
Drive Pipe	36"		200		$650.00	$130,000	$0	$130,000
Conductor	22"		770		$180.00	$139,000	$0	$139,000
Surface	16.5" SET		5,107		$300.00	$1,533,000	$0	$1,533,000
Intermediate	16.5" SET		3,598		$300.00	$1,080,000	$0	$1,080,000
Intermediate	16"		11,755		$155.00	$1,823,000	$0	$1,823,000
Intermediate	13-3/8"		15,525		$140.00	$2,174,000	$0	$2,174,000
Intermediate	11-3/4"		3,640		$80.00	$292,000	$0	$292,000
Production Liner								
Production Tie-back								
Tubing								
Liner Equipment						$150,000	$0	$150,000
Whipstock Equipment & BP								
Subsurface Completion								
Wellheads						$500,000	$0	$500,000
Miscellaneous / Other						$100,000	$0	$100,000
Tangible Contingency		10% Amount		*ST Drlg =*	*$7,921,000*	$793,000	$0	$793,000
				ST Comp =	*$0*			
					TOTAL TANGIBLE	**$8,714,000**	**$0**	**$8,714,000**
					Total Dry Hole Cost	**$229,649,000**	**$0**	**$229,649,000**
					Total Completion Cost	**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**				TOTAL WELL COST	**$229,649,000**	**$0**	**$229,649,000**

6.3 Hawaii Location Cost Estimates

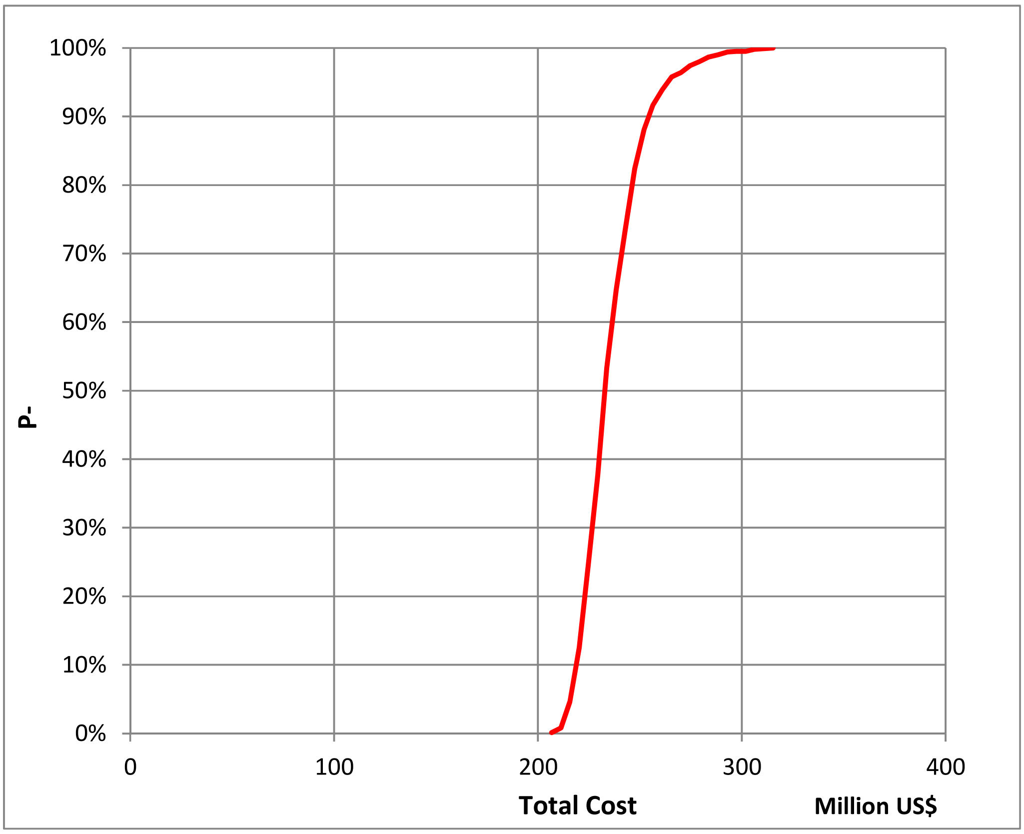
6.3.1 Case 2a Cost Estimate:

This case assumes the original Base Case wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
298	$235,590	$2,650	$238,240	$218,820	$232,893	$254,373

Figure 169. Hawaii Location: Case 2a – Cost Estimate

The following chart shows the cumulative probability of cost.



SCOPING COST ESTIMATE SUMMARY Rev 4

BEAM - Hawaii, Case 2a **** DRAFT ****

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**		Revision No.	**1**	Date:	**30-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4a**	Water Depth **4050m** **13,287 ft**	Proposed TD **10,750m** **35,269 ft**	Formation **Moho / Mantle**	
Location **Hawaii**	Surface Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W** Btm. Hole Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4a: Orig Base Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	**Dry Hole Drlg** **271 Days**	**Complete**	**TOTAL** **271 Days**
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$10,800,000	$0	$10,800,000
Drilling Rig - Day Work at $300,000 / Day	$142,300,000	$0	$142,300,000
Bits, Drill Collars & Stabilizers	$4,649,000	$0	$4,649,000
Directional & Downhole Services	$4,495,000	$0	$4,495,000
Fuel, Water & Lube	$15,854,000	$0	$15,854,000
Drilling Fluids Services	$2,895,000	$0	$2,895,000
Electric Logging & Cased Hole Logs	$4,913,000	$0	$4,913,000
Cementing	$739,000	$0	$739,000
Mud Logging and Geological Services	$664,000	$0	$664,000
Land Transportation	$122,000	$0	$122,000
Boat Transportation	$3,117,000	$0	$3,117,000
Helicopter Transportation	$1,220,000	$0	$1,220,000
Tubular Services	$100,000	$0	$100,000
Shorebase / Dock Services	$542,000	$0	$542,000
Communications	$271,000	$0	$271,000
Miscellaneous Rental Equipment	$6,175,000	$0	$6,175,000
Miscellaneous Special Services	$1,141,000	$0	$1,141,000
Other Services / Costs	$1,930,000	$0	$1,930,000
Intan Contingency at 15%	$30,743,000	$0	$30,743,000
TOTAL INTANGIBLE	**$235,690,271**	**$0**	**$235,690,271**

TANGIBLE ITEMS	**OD**	**Footage**	**$/ft**			
Drive Pipe	36"	200	$500.00	$100,000	$0	$100,000
Conductor	20"	606	$180.00	$110,000	$0	$110,000
Surface	13-3/8"	5,364	$140.00	$751,000	$0	$751,000
Intermediate	11-3/4"	8,715	$80.00	$698,000	$0	$698,000
Intermediate	0	0	$0.00	$0	$0	$0
Intermediate	0	0	$0.00	$0	$0	$0
Intermediate	0	0	$0.00	$0	$0	$0
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$150,000	$0	$150,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$241,000	$0	$241,000
TOTAL TANGIBLE				**$2,650,000**	**$0**	**$2,650,000**
Total Dry Hole Cost				**$238,340,271**	**$0**	**$238,340,271**
Total Completion Cost				**$0**	**$0**	**$0**
Prepared by: **WSWhitney / NPilisi** — **Total Drill and Complete**				**$238,340,271**	**$0**	**$238,340,271**

SCOPING COST ESTIMATE DETAILS Rev 4

BEAM - Hawaii, Case 2a *** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: **CDEX / JAMSTEC**		**Revision No.**	**1**	**Date:**	**30-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4a**	Water Depth **4050m** **13,287 ft**	Proposed TD **10,750m** **35,269 ft**	Objective **Moho / Mantle**	
Location **Hawaii**	Surface Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W** Btm. Hole Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4a: Orig Base Case Well Configuration

Avg Intan $/day **$869,705**

Drilling Rig : Chikyu Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS						**Dry Hole Drlg**	**Complete**	**TOTAL**
					Operational Time =	**271 Days**		**271 Days**
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$10,800,000		$10,800,000
Mobilization (from Japan)				Lump Sum	$5,400,000			
Demobilization (to Japan)				Lump Sum	$5,400,000			
Drilling Rig - Day Work						$142,300,000	$0	$142,300,000
Drilling Day Rate	271	Days	$300,000 /day		$81,300,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$4,649,000	$0	$4,649,000
Drill Bits	20	No.	$70,000 /bit		$1,400,000			
Drill String Rentals: DC's, Jars, Stab, HWT	271	Days	$4,000 /day		$1,084,000			
Core Bits	29	No.	$60,000 /bit		$1,740,000			
Coring Services	170	Days	$2,500 /day		$425,000			
Directional & Downhole Services						$4,495,000	$0	$4,495,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	136	Days	$3,000 /day		$406,500			
Standard LWD Rental	136	Days	$7,000 /day		$948,500			
MWD / LWD Engineers (2)	271	Days	$2,000 /day		$542,000			
Mud Motors & Associated Tools	217	Days	$3,000 /day		$650,400			
High Temp MWD Rental	136	Days	$4,000 /day		$542,000			
High temp LWD Rental	136	Days	$10,000 /day		$1,355,000			
Fuel, Water & Lube						$15,854,000	$0	$15,854,000
Rig Fuel	271	Days	$53,000 /day		$14,363,000			
Boat Fuel	136	Days	$4,000 /day		$542,000			
Helicopter Fuel	136	Days	$3,000 /day		$406,500			
Lubricants	271	Days	$1,300 /day		$352,300			
Fresh Water	271	Days	$700 /day		$189,700			
Drilling Fluids Services						$2,895,000	$0	$2,895,000
Drilling Fluids - WBM				Lump Sum	$2,000,000			
Mud Engineer	271	Days	$800 /day		$216,800			
Cuttings Disposal	271	Days	$2,500 /day		$677,500			
Electric Logging & Cased Hole Logs						$4,913,000		$4,913,000
Wireline Unit and Personnel	271	Days	$3,000 /day		$813,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$739,000	$0	$739,000
20"				Lump Sum	$100,000			
13-3/8"				Lump Sum	$150,000			
11-3/4"				Lump Sum	$100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	271	Days	$1,250 /day		$338,750			

Item	Qty	Unit	Rate	Lump Sum	Amount	Dry Hole	Completion	Total
Mud Logging and Geological Services						$664,000	$0	$664,000
Logging Unit Operating rate	271	Days	$1,250 /day		$338,750			
Personnel Charges	271	Days	$1,200 /day		$325,200			
Land Transportation						$122,000	$0	$122,000
Trucking	136	Days	$900 /day		$121,950			
Boat Transportation						$3,117,000	$0	$3,117,000
Work Boat - Spot Hire	136	Days	$14,000 /day		$1,897,000			
Crew Boat - Spot Hire	136	Days	$9,000 /day		$1,219,500			
Helicopter Transportation						$1,220,000	$0	$1,220,000
Helicopter - spot hire	136	Days	$9,000 /day		$1,219,500			
Tubular Services						$100,000	$0	$100,000
QAQC				Lump Sum	$100,000			
Shorebase / Dock Services						$542,000	$0	$542,000
Shorebase /Dispatcher	271	Days	$2,000 /day		$542,000			$0
Communications						$271,000	$0	$271,000
VSAT	271	Days	$1,000 /day		$271,000			
Miscellaneous Rental Equipment						$6,175,000	$0	$6,175,000
Solids Control	271	Days	$400 /day		$108,400			
Fishing Tools	271	Days	$1,500 /day		$406,500			
Casing Running Equipment	40	Days	$6,000 Day		$240,000			
Other Rentals	271	Days	$20,000 Day		$5,420,000			
		Days						
		Days						
Miscellaneous Special Services						$1,141,000	$0	$1,141,000
Weather Forecasting	271	Days	$150 /day		$40,650			
Engineering Services - Riser Analysis				Lump Sum	$300,000			
Engineering Services - Drill String Design				Lump Sum	$200,000			
Engineering Services - Casing Design				Lump Sum	$50,000			
Engineering Services - Wellbore Stability				Lump Sum	$100,000			
Engineering Services - Operational Support				Lump Sum	$200,000			
Engineering Services - Risk Assessments				Lump Sum	$200,000			
Engineering Services - Other				Lump Sum	$50,000			
Other Services / Costs						$1,930,000	$0	$1,930,000
Misc Contract Labor	271	Days	$1,500 /day		$406,500			
Casing Running	40	Days	$10,000 /day		$400,000			
Well Insurance				Lump Sum	$500,000			
Overhead	271	Days	$1,100 /day		$298,100			
Catering	271	Days	$1,200 /day		$325,200			
Intangible Contingency		15%	Amount	*ST Drlg =*	*$204,947,000*	$30,743,000	$0	$30,743,000
				ST Comp =	*$0*			
					TOTAL INTANGIBLE	**$235,690,000**	**$0**	**$235,690,000**

TANGIBLE ITEMS

Item	OD	4 =#Strings	Length	$/ft	Dry Hole	Completion	Total
Drive Pipe	36"		200	$500.00	$100,000	$0	$100,000
Conductor	20"		606	$180.00	$110,000	$0	$110,000
Surface	13-3/8"		5,364	$140.00	$751,000	$0	$751,000
Intermediate	11-3/4"		8,715	$80.00	$698,000	$0	$698,000
Intermediate							
Intermediate							
Intermediate							
Production Liner							
Production Tie-back							
Tubing							
Liner Equipment					$150,000	$0	$150,000
Whipstock Equipment & BP							
Subsurface Completion							
Wellheads					$500,000	$0	$500,000
Miscellaneous / Other					$100,000	$0	$100,000
Tangible Contingency	10% Amount		*ST Drlg =*	*$2,409,000*	$241,000	$0	$241,000
			ST Comp =	*$0*			
				TOTAL TANGIBLE	**$2,650,000**	**$0**	**$2,650,000**
				Total Dry Hole Cost	**$238,340,000**	**$0**	**$238,340,000**
				Total Completion Cost	**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**			TOTAL WELL COST	**$238,340,000**	**$0**	**$238,340,000**

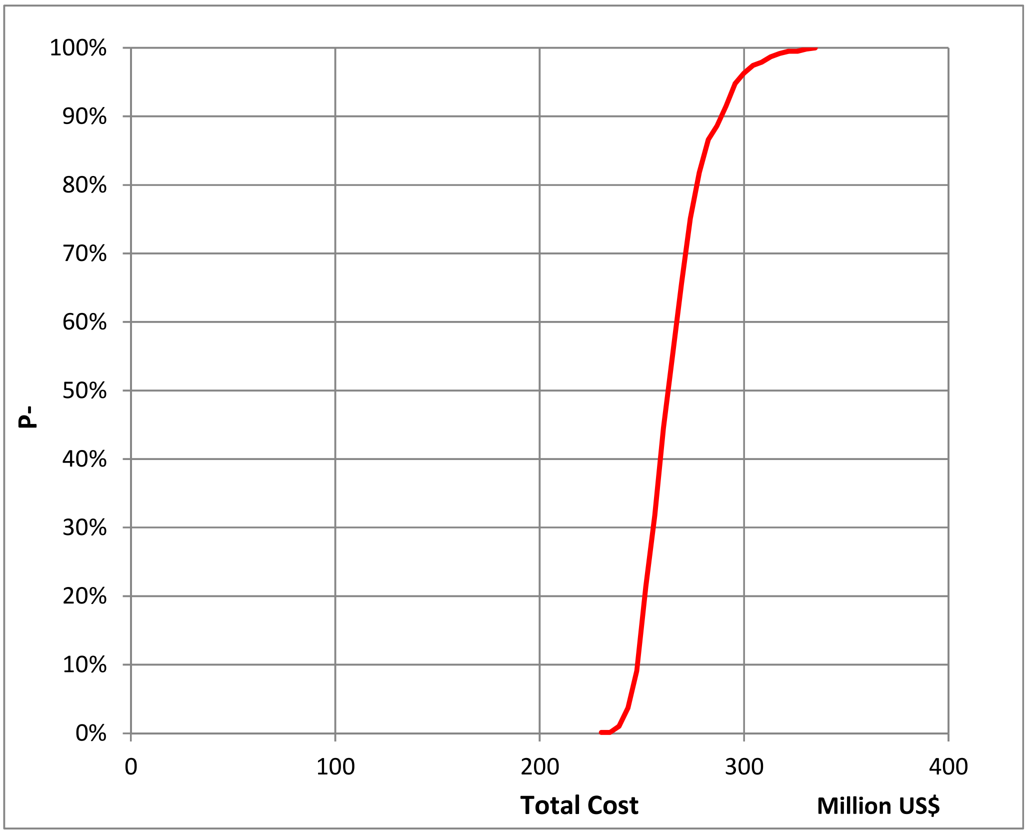
6.3.2 *Case 2b Cost Estimate:*

This case assumes the Deepwater wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
346	$261,192	$6,253	$267,445	$247,832	$262,870	$288,898

Figure 170. Hawaii Location: Case 2c – Cost Estimate

The following charts shows the cumulative probability of cost.



SCOPING COST ESTIMATE SUMMARY Rev 4

BEAM - Hawaii, Case 2b ** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**		Revision No.	**1**	Date:	**30-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4b**	Water Depth **4050m** **13,287 ft**	Proposed TD **10,750m** **35,269 ft**	Formation **Moho / Mantle**	
Location **Hawaii**	Surface Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W** Btm. Hole Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4b: Conventional Deepwater Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	**Dry Hole Drlg**	**Complete**	**TOTAL**
	319 Days		**319 Days**
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$10,800,000	$0	$10,800,000
Drilling Rig - Day Work at $300,000 / Day	$156,700,000	$0	$156,700,000
Bits, Drill Collars & Stabilizers	$5,294,000	$0	$5,294,000
Directional & Downhole Services	$5,282,000	$0	$5,282,000
Fuel, Water & Lube	$18,662,000	$0	$18,662,000
Drilling Fluids Services	$3,053,000	$0	$3,053,000
Electric Logging & Cased Hole Logs	$5,057,000	$0	$5,057,000
Cementing	$1,149,000	$0	$1,149,000
Mud Logging and Geological Services	$782,000	$0	$782,000
Land Transportation	$144,000	$0	$144,000
Boat Transportation	$3,669,000	$0	$3,669,000
Helicopter Transportation	$1,436,000	$0	$1,436,000
Tubular Services	$150,000	$0	$150,000
Shorebase / Dock Services	$638,000	$0	$638,000
Communications	$319,000	$0	$319,000
Miscellaneous Rental Equipment	$7,407,000	$0	$7,407,000
Miscellaneous Special Services	$1,148,000	$0	$1,148,000
Other Services / Costs	$2,413,000	$0	$2,413,000
Intan Contingency at 15%	$34,069,000	$0	$34,069,000
TOTAL INTANGIBLE	**$261,192,319**	**$0**	**$261,192,319**

TANGIBLE ITEMS	**OD**	**Footage**	**$/ft**			
Drive Pipe	36"	200	$650.00	$130,000	$0	$130,000
Conductor	22"	656	$180.00	$119,000	$0	$119,000
Surface	18"	4,858	$160.00	$778,000	$0	$778,000
Intermediate	16"	8,707	$155.00	$1,350,000	$0	$1,350,000
Intermediate	13-3/8"	12,863	$140.00	$1,801,000	$0	$1,801,000
Intermediate	11-3/4"	4,000	$80.00	$320,000	$0	$320,000
Intermediate	9-5/8"	4,078	$70.00	$286,000	$0	$286,000
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$300,000	$0	$300,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$569,000	$0	$569,000
TOTAL TANGIBLE				**$6,253,000**	**$0**	**$6,253,000**
Total Dry Hole Cost				**$267,445,319**	**$0**	**$267,445,319**
Total Completion Cost				**$0**	**$0**	**$0**
Total Drill and Complete				**$267,445,319**	**$0**	**$267,445,319**

Prepared by: **WSWhitney / NPilisi**

SCOPING COST ESTIMATE DETAIL

Rev 4

BEAM - Hawaii, Case 2b

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: **CDEX / JAMSTEC**		**Revision No.**	**1**	**Date:**	**30-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4b**	Water Depth **4050m** **13,287 ft**	Proposed TD **10,750m** **35,269 ft**	Objective **Moho / Mantle**	
Location **Hawaii**	Surface Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W** Btm. Hole Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4b: Conventional Deepwater Case Well Configuration

Avg Intan $/day: **$818,784**

Drilling Rig : Chikyu — Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	Qty	Unit	Rate	Basis	Amount	Dry Hole Drlg	Complete	TOTAL
					Operational Time =	**319 Days**		**319 Days**
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$10,800,000		$10,800,000
Mobilization (from Japan)				Lump Sum	$5,400,000			
Demobilization (to Japan)				Lump Sum	$5,400,000			
Drilling Rig - Day Work						$156,700,000	$0	$156,700,000
Drilling Day Rate	319	Days	$300,000 /day		$95,700,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$5,294,000	$0	$5,294,000
Drill Bits	26	No.	$70,000 /bit		$1,820,000			
Drill String Rentals: DC's, Jars, Stab, HWT	319	Days	$4,000 /day		$1,276,000			
Core Bits	28	No.	$60,000 /bit		$1,680,000			
Coring Services	207	Days	$2,500 /day		$517,500			
Directional & Downhole Services						$5,282,000	$0	$5,282,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	160	Days	$3,000 /day		$478,500			
Standard LWD Rental	160	Days	$7,000 /day		$1,116,500			
MWD / LWD Engineers (2)	319	Days	$2,000 /day		$638,000			
Mud Motors & Associated Tools	255	Days	$3,000 /day		$765,600			
High Temp MWD Rental	160	Days	$4,000 /day		$638,000			
High temp LWD Rental	160	Days	$10,000 /day		$1,595,000			
Fuel, Water & Lube						$18,662,000	$0	$18,662,000
Rig Fuel	319	Days	$53,000 /day		$16,907,000			
Boat Fuel	160	Days	$4,000 /day		$638,000			
Helicopter Fuel	160	Days	$3,000 /day		$478,500			
Lubricants	319	Days	$1,300 /day		$414,700			
Fresh Water	319	Days	$700 /day		$223,300			
Drilling Fluids Services						$3,053,000	$0	$3,053,000
Drilling Fluids - WBM				Lump Sum	$2,000,000			
Mud Engineer	319	Days	$800 /day		$255,200			
Cuttings Disposal	319	Days	$2,500 /day		$797,500			
Electric Logging & Cased Hole Logs						$5,057,000		$5,057,000
Wireline Unit and Personnel	319	Days	$3,000 /day		$957,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$1,149,000	$0	$1,149,000
22"				Lump Sum	100,000			
18"				Lump Sum	100,000			
16"				Lump Sum	150,000			
13.375"				Lump Sum	150,000			
11.75"				Lump Sum	100,000			
9.625"				Lump Sum	100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	319	Days	$1,250 /day		$398,750			

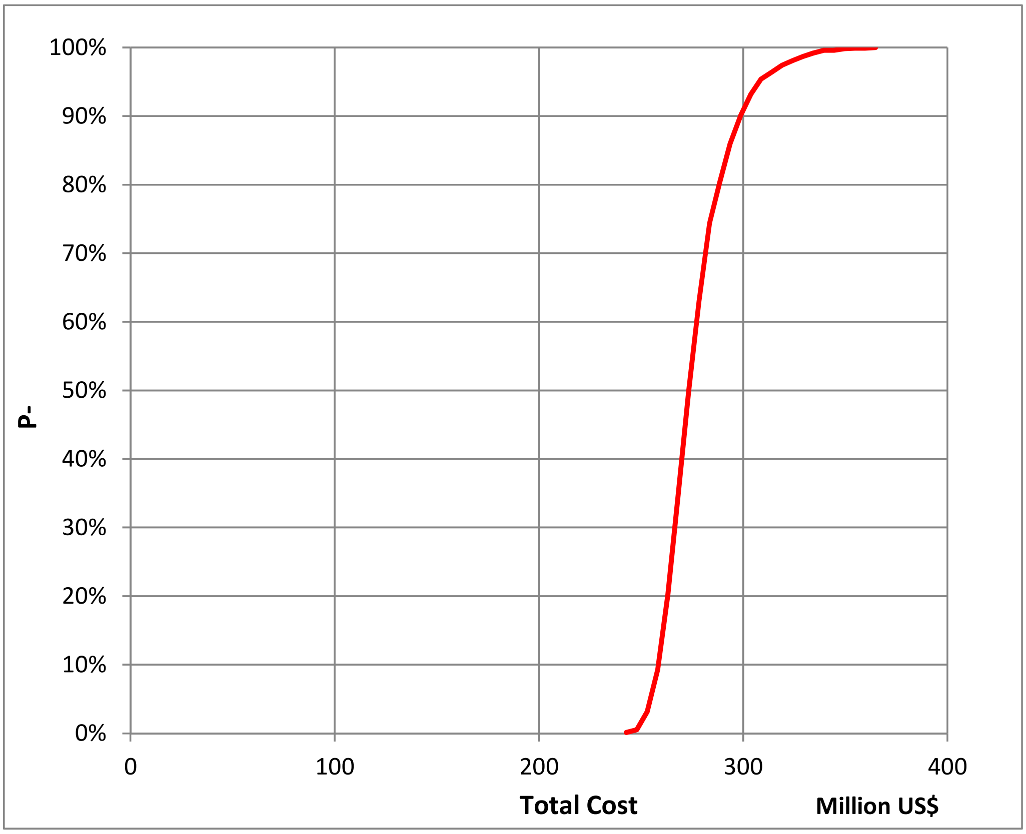
6.3.3 Case 2c Cost Estimate:

This case assumes the Deepwater wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third.. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
368	$272,554	$9,149	$281,703	$258,399	$273,358	$298,607

Figure 171. Hawaii Location: Case 2c – Cost Estimate

The following charts shows the cumulative probability of cost.



SCOPING COST ESTIMATE SUMMARY

Rev 4

BEAM - Hawaii, Case 2c

** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**		Revision No.	**1**	Date:	**30-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4b**	Water Depth **4050m** **13,287 ft**	Proposed TD **10,750m** **35,269 ft**	Formation **Moho / Mantle**	
Location **Hawaii**	Surface Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W** Btm. Hole Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4b: Conventional Deepwater Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	Dry Hole Drlg	Complete	TOTAL
	341 Days		**341 Days**
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$10,800,000	$0	$10,800,000
Drilling Rig - Day Work at $300,000 / Day	$163,300,000	$0	$163,300,000
Bits, Drill Collars & Stabilizers	$5,709,000	$0	$5,709,000
Directional & Downhole Services	$5,643,000	$0	$5,643,000
Fuel, Water & Lube	$19,949,000	$0	$19,949,000
Drilling Fluids Services	$3,126,000	$0	$3,126,000
Electric Logging & Cased Hole Logs	$5,123,000	$0	$5,123,000
Cementing	$1,177,000	$0	$1,177,000
Mud Logging and Geological Services	$836,000	$0	$836,000
Land Transportation	$154,000	$0	$154,000
Boat Transportation	$3,922,000	$0	$3,922,000
Helicopter Transportation	$1,535,000	$0	$1,535,000
Tubular Services	$150,000	$0	$150,000
Shorebase / Dock Services	$682,000	$0	$682,000
Communications	$341,000	$0	$341,000
Miscellaneous Rental Equipment	$7,888,000	$0	$7,888,000
Miscellaneous Special Services	$1,152,000	$0	$1,152,000
Other Services / Costs	$2,496,000	$0	$2,496,000
Intan Contingency at 15%	$35,551,000	$0	$35,551,000
TOTAL INTANGIBLE	**$272,554,341**	**$0**	**$272,554,341**

TANGIBLE ITEMS	OD	Footage	$/ft	Dry Hole Drlg	Complete	TOTAL
Drive Pipe	36"	200	$650.00	$130,000	$0	$130,000
Conductor	22"	656	$180.00	$119,000	$0	$119,000
Surface	16.5" SET	5,058	$300.00	$1,518,000	$0	$1,518,000
Intermediate	16.5" SET	4,049	$300.00	$1,215,000	$0	$1,215,000
Intermediate	16"	12,507	$155.00	$1,939,000	$0	$1,939,000
Intermediate	13-3/8"	16,563	$140.00	$2,319,000	$0	$2,319,000
Intermediate	11-3/4"	4,078	$80.00	$327,000	$0	$327,000
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$150,000	$0	$150,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$832,000	$0	$832,000
TOTAL TANGIBLE				**$9,149,000**	**$0**	**$9,149,000**
Total Dry Hole Cost				**$281,703,341**	**$0**	**$281,703,341**
Total Completion Cost				**$0**	**$0**	**$0**
Prepared by: **WSWhitney / NPilisi** — **Total Drill and Complete**				**$281,703,341**	**$0**	**$281,703,341**

SCOPING COST ESTIMATE DETAIL — Rev 4

BEAM - Hawaii, Case 2c

*** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: CDEX / JAMSTEC		Revision No.	1	Date:	30-Jun-13
Prospect or Field: Mantle Hole	Lease Name: N/A	Case No.: #4b	Water Depth: 4050m 13,287 ft	Proposed TD: 10,750m 35,269 ft	Objective: Moho / Mantle	
Location: Hawaii	Surface Location: Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W					
	Btm. Hole Location: Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4b: Conventional Deepwater Case Well Configuration

Avg Intan $/day: $799,279

Drilling Rig : Chikyu — Directional Plan: Vertical Hole

INTANGIBLE ITEMS						Dry Hole Drlg	Complete	TOTAL
				Operational Time =		341 Days		341 Days
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
	Metocean Study (desktop study, data collection/processing)			Lump Sum	$1,000,000			
	Site Survey (desktop study, bathymetry)			Lump Sum	$2,000,000			
	Regulatory			Lump Sum	$20,000			
Rig Mobilization, Demobilization						$10,800,000		$10,800,000
	Mobilization (from Japan)			Lump Sum	$5,400,000			
	Demobilization (to Japan)			Lump Sum	$5,400,000			
Drilling Rig - Day Work						$163,300,000	$0	$163,300,000
	Drilling Day Rate	341 Days	$300,000 /day		$102,300,000			
	Existing Riser System Modifications			Lump Sum	$14,000,000			
	Additional Riser			Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$5,709,000	$0	$5,709,000
	Drill Bits	30 No.	$70,000 /bit		$2,100,000			
	Drill String Rentals: DC's, Jars, Stab, HWT	341 Days	$4,000 /day		$1,364,000			
	Core Bits	28 No.	$60,000 /bit		$1,680,000			
	Coring Services	226 Days	$2,500 /day		$565,000			
Directional & Downhole Services						$5,643,000	$0	$5,643,000
	Surveys/Gyros/Single & Multi-Shots			Lump Sum	$20,000			
	MWD / LWD Mob / De-mob			Lump Sum	$30,000			
	Standard MWD Rental	171 Days	$3,000 /day		$511,500			
	Standard LWD Rental	171 Days	$7,000 /day		$1,193,500			
	MWD / LWD Engineers (2)	341 Days	$2,000 /day		$682,000			
	Mud Motors & Associated Tools	273 Days	$3,000 /day		$818,400			
	High Temp MWD Rental	171 Days	$4,000 /day		$682,000			
	High temp LWD Rental	171 Days	$10,000 /day		$1,705,000			
Fuel, Water & Lube						$19,949,000	$0	$19,949,000
	Rig Fuel	341 Days	$53,000 /day		$18,073,000			
	Boat Fuel	171 Days	$4,000 /day		$682,000			
	Helicopter Fuel	171 Days	$3,000 /day		$511,500			
	Lubricants	341 Days	$1,300 /day		$443,300			
	Fresh Water	341 Days	$700 /day		$238,700			
Drilling Fluids Services						$3,126,000	$0	$3,126,000
	Drilling Fluids - WBM			Lump Sum	$2,000,000			
	Mud Engineer	341 Days	$800 /day		$272,800			
	Cuttings Disposal	341 Days	$2,500 /day		$852,500			
Electric Logging & Cased Hole Logs						$5,123,000		$5,123,000
	Wireline Unit and Personnel	341 Days	$3,000 /day		$1,023,000			
	Standard Open Hole Logging			Lump Sum	$1,500,000			
	High Temp Open Hole Logging			Lump Sum	$2,500,000			
	Cased Hole Logging			Lump Sum	$100,000			
Cementing						$1,177,000	$0	$1,177,000
	22"			Lump Sum	100,000			
	16.5" SET			Lump Sum	100,000			
	16.5" SET			Lump Sum	150,000			
	16"			Lump Sum	150,000			
	13.375"			Lump Sum	100,000			
	11.750"			Lump Sum	100,000			
	Retainers, Service Man, Manifold, Etc.			Lump Sum	$50,000			
	Unit Charge	341 Days	$1,250 /day		$426,250			

Item	Description	Qty	Unit	Rate	Basis	Amount	Dry Hole	Completion	Total
Mud Logging and Geological Services							$836,000	$0	$836,000
	Logging Unit Operating rate	341	Days	$1,250 /day		$426,250			
	Personnel Charges	341	Days	$1,200 /day		$409,200			
Land Transportation							$154,000	$0	$154,000
	Trucking	171	Days	$900 /day		$153,450			
Boat Transportation							$3,922,000	$0	$3,922,000
	Work Boat - Spot Hire	171	Days	$14,000 /day		$2,387,000			
	Crew Boat - Spot Hire	171	Days	$9,000 /day		$1,534,500			
Helicopter Transportation							$1,535,000	$0	$1,535,000
	Helicopter - spot hire	171	Days	$9,000 /day		$1,534,500			
Tubular Services							$150,000	$0	$150,000
	QAQC				Lump Sum	$150,000			
Shorebase / Dock Services							$682,000	$0	$682,000
	Shorebase /Dispatcher	341	Days	$2,000 /day		$682,000			$0
Communications							$341,000	$0	$341,000
	VSAT	341	Days	$1,000 /day		$341,000			
Miscellaneous Rental Equipment							$7,888,000	$0	$7,888,000
	Solids Control	341	Days	$400 /day		$136,400			
	Fishing Tools	341	Days	$1,500 /day		$511,500			
	Casing Running Equipment	70	Days	$6,000 Day		$420,000			
	Other Rentals	341	Days	$20,000 Day		$6,820,000			
			Days						
			Days						
Miscellaneous Special Services							$1,152,000	$0	$1,152,000
	Weather Forecasting	341	Days	$150 /day		$51,150			
	Engineering Services - Riser Analysis				Lump Sum	$300,000			
	Engineering Services - Drill String Design				Lump Sum	$200,000			
	Engineering Services - Casing Design				Lump Sum	$50,000			
	Engineering Services - Wellbore Stability				Lump Sum	$100,000			
	Engineering Services - Operational Support				Lump Sum	$200,000			
	Engineering Services - Risk Assessments				Lump Sum	$200,000			
	Engineering Services - Other				Lump Sum	$50,000			
Other Services / Costs							$2,496,000	$0	$2,496,000
	Misc Contract Labor	341	Days	$1,500 /day		$511,500			
	Casing Running	70	Days	$10,000 /day		$700,000			
	Well Insurance				Lump Sum	$500,000			
	Overhead	341	Days	$1,100 /day		$375,100			
	Catering	341	Days	$1,200 /day		$409,200			
Intangible Contingency			15% Amount		*ST Drlg =*	*$237,003,000*	$35,551,000	$0	$35,551,000
					ST Comp =	*$0*			
						TOTAL INTANGIBLE	**$272,554,000**	**$0**	**$272,554,000**

TANGIBLE ITEMS

Item	OD	7 =#Strings	Length		$/ft	Dry Hole	Completion	Total
Drive Pipe	36"		200		650.0	$130,000	$0	$130,000
Conductor	22"		656		180.0	$119,000	$0	$119,000
Surface	16.5" SET		5,058		300.0	$1,518,000	$0	$1,518,000
Intermediate	16.5" SET		4,049		300.0	$1,215,000	$0	$1,215,000
Intermediate	16"		12,507		155.0	$1,939,000	$0	$1,939,000
Intermediate	13-3/8"		16,563		140.0	$2,319,000	$0	$2,319,000
Intermediate	11-3/4"		4,078		80.0	$327,000	$0	$327,000
Production Liner								
Production Tie-back								
Tubing								
Liner Equipment						$150,000	$0	$150,000
Whipstock Equipment & BP								
Subsurface Completion								
Wellheads						$500,000	$0	$500,000
Miscellaneous / Other						$100,000	$0	$100,000
Tangible Contingency		10% Amount		*ST Drlg =*	*$8,317,000*	$832,000	$0	$832,000
				ST Comp =	*$0*			
					TOTAL TANGIBLE	**$9,149,000**	**$0**	**$9,149,000**
					Total Dry Hole Cost	**$281,703,000**	**$0**	**$281,703,000**
					Total Completion Cost	**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**				**TOTAL WELL COST**	**$281,703,000**	**$0**	**$281,703,000**

6.3.4 Case 4a Cost Estimate:

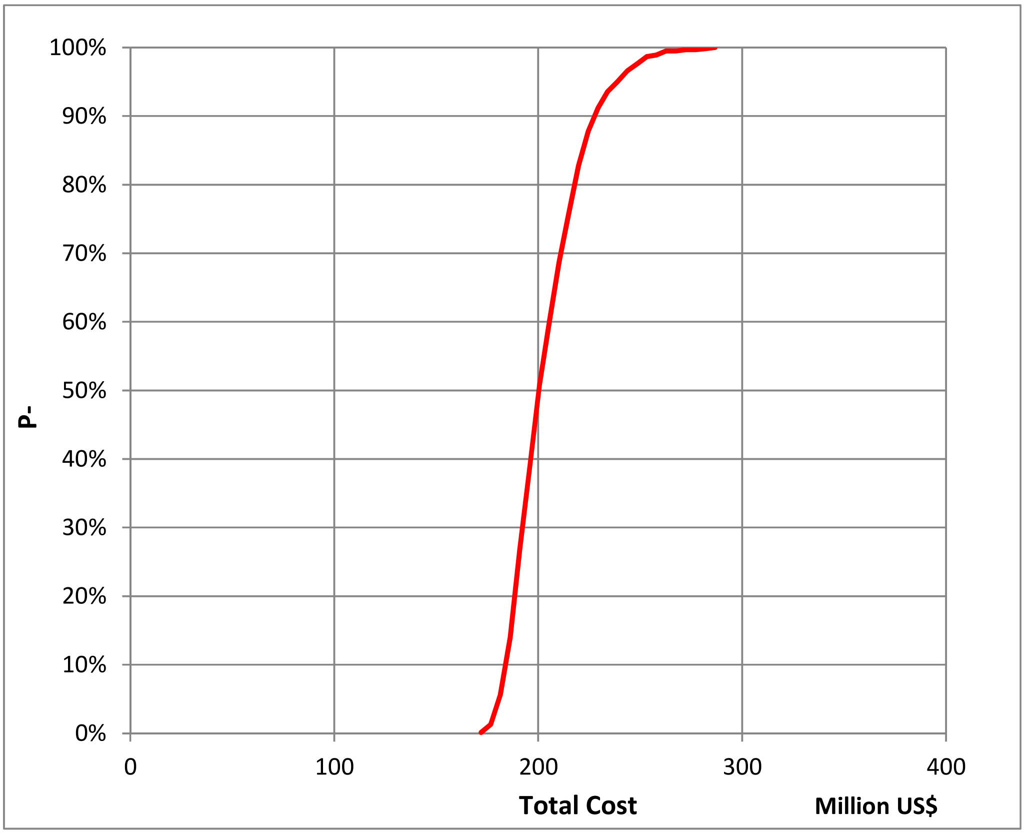
This case assumes the original Base Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the cost estimate for this case is shown below.

.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
248	$209,320	$2,650	$211,970	$183,967	$200,309	$227,601

Figure 172. Hawaii Location: Case 4a – Cost Estimate

The following chart shows the cumulative probability of cost.



SCOPING COST ESTIMATE SUMMARY Rev 4

BEAM - Hawaii, Case 4a ** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**		Revision No.	**1**	Date:	**30-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4a**	Water Depth **4050m** **13,287 ft**	Proposed TD **10,750m** **35,269 ft**	Formation **Moho / Mantle**	
Location **Hawaii**	Surface Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W** Btm. Hole Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4a: Orig Base Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	Dry Hole Drlg 221 Days	Complete	TOTAL 221 Days
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$10,800,000	$0	$10,800,000
Drilling Rig - Day Work at $300,000 / Day	$127,300,000	$0	$127,300,000
Bits, Drill Collars & Stabilizers	$3,227,000	$0	$3,227,000
Directional & Downhole Services	$3,675,000	$0	$3,675,000
Fuel, Water & Lube	$12,929,000	$0	$12,929,000
Drilling Fluids Services	$2,730,000	$0	$2,730,000
Electric Logging & Cased Hole Logs	$4,763,000	$0	$4,763,000
Cementing	$677,000	$0	$677,000
Mud Logging and Geological Services	$542,000	$0	$542,000
Land Transportation	$100,000	$0	$100,000
Boat Transportation	$2,542,000	$0	$2,542,000
Helicopter Transportation	$995,000	$0	$995,000
Tubular Services	$100,000	$0	$100,000
Shorebase / Dock Services	$442,000	$0	$442,000
Communications	$221,000	$0	$221,000
Miscellaneous Rental Equipment	$5,080,000	$0	$5,080,000
Miscellaneous Special Services	$1,134,000	$0	$1,134,000
Other Services / Costs	$1,740,000	$0	$1,740,000
Intan Contingency at 15%	$27,303,000	$0	$27,303,000
TOTAL INTANGIBLE	**$209,320,221**	**$0**	**$209,320,221**

TANGIBLE ITEMS	OD	Footage	$/ft	Dry Hole Drlg	Complete	TOTAL
Drive Pipe	36"	200	$500.00	$100,000	$0	$100,000
Conductor	20"	606	$180.00	$110,000	$0	$110,000
Surface	13-3/8"	5,364	$140.00	$751,000	$0	$751,000
Intermediate	11-3/4"	8,715	$80.00	$698,000	$0	$698,000
Intermediate	0	0	$0.00	$0	$0	$0
Intermediate	0	0	$0.00	$0	$0	$0
Intermediate	0	0	$0.00	$0	$0	$0
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$150,000	$0	$150,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$241,000	$0	$241,000
TOTAL TANGIBLE				**$2,650,000**	**$0**	**$2,650,000**
Total Dry Hole Cost				**$211,970,221**	**$0**	**$211,970,221**
Total Completion Cost				**$0**	**$0**	**$0**
Total Drill and Complete				**$211,970,221**	**$0**	**$211,970,221**

Prepared by: **WSWhitney / NPilisi**

SCOPING COST ESTIMATE DETAILS

Rev 4

BEAM - Hawaii, Case 4a

*** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: **CDEX / JAMSTEC**		**Revision No.**	**1**	**Date:**	**30-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4a**	Water Depth **4050m** **13,287 ft**	Proposed TD **10,750m** **35,269 ft**	Objective **Moho / Mantle**	
Location **Hawaii**	Surface Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W** Btm. Hole Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4a: Orig Base Case Well Configuration

Avg Intan $/day: **$947,149**

Drilling Rig : Chikyu — Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	Qty	Unit	Rate	Basis	Amount	Dry Hole Drlg	Complete	TOTAL
					Operational Time =	**221 Days**		**221 Days**
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$10,800,000		$10,800,000
Mobilization (from Japan)				Lump Sum	$5,400,000			
Demobilization (to Japan)				Lump Sum	$5,400,000			
Drilling Rig - Day Work						$127,300,000	$0	$127,300,000
Drilling Day Rate	221	Days	$300,000 /day		$66,300,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$3,227,000	$0	$3,227,000
Drill Bits	26	No.	$70,000 /bit		$1,820,000			
Drill String Rentals: DC's, Jars, Stab, HWT	221	Days	$4,000 /day		$884,000			
Core Bits	6	No.	$60,000 /bit		$360,000			
Coring Services	65	Days	$2,500 /day		$162,500			
Directional & Downhole Services						$3,675,000	$0	$3,675,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	111	Days	$3,000 /day		$331,500			
Standard LWD Rental	111	Days	$7,000 /day		$773,500			
MWD / LWD Engineers (2)	221	Days	$2,000 /day		$442,000			
Mud Motors & Associated Tools	177	Days	$3,000 /day		$530,400			
High Temp MWD Rental	111	Days	$4,000 /day		$442,000			
High temp LWD Rental	111	Days	$10,000 /day		$1,105,000			
Fuel, Water & Lube						$12,929,000	$0	$12,929,000
Rig Fuel	221	Days	$53,000 /day		$11,713,000			
Boat Fuel	111	Days	$4,000 /day		$442,000			
Helicopter Fuel	111	Days	$3,000 /day		$331,500			
Lubricants	221	Days	$1,300 /day		$287,300			
Fresh Water	221	Days	$700 /day		$154,700			
Drilling Fluids Services						$2,730,000	$0	$2,730,000
Drilling Fluids - WBM				Lump Sum	$2,000,000			
Mud Engineer	221	Days	$800 /day		$176,800			
Cuttings Disposal	221	Days	$2,500 /day		$552,500			
Electric Logging & Cased Hole Logs						$4,763,000		$4,763,000
Wireline Unit and Personnel	221	Days	$3,000 /day		$663,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$677,000	$0	$677,000
20"				Lump Sum	$100,000			
13-3/8"				Lump Sum	$150,000			
11-3/4"				Lump Sum	$100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	221	Days	$1,250 /day		$276,250			

Mud Logging and Geological Services							$542,000	$0	$542,000
	Logging Unit Operating rate	221	Days	$1,250 /day		$276,250			
	Personnel Charges	221	Days	$1,200 /day		$265,200			
Land Transportation							$100,000	$0	$100,000
	Trucking	111	Days	$900 /day		$99,450			
Boat Transportation							$2,542,000	$0	$2,542,000
	Work Boat - Spot Hire	111	Days	$14,000 /day		$1,547,000			
	Crew Boat - Spot Hire	111	Days	$9,000 /day		$994,500			
Helicopter Transportation							$995,000	$0	$995,000
	Helicopter - spot hire	111	Days	$9,000 /day		$994,500			
Tubular Services							$100,000	$0	$100,000
	QAQC				Lump Sum	$100,000			
Shorebase / Dock Services							$442,000	$0	$442,000
	Shorebase /Dispatcher	221	Days	$2,000 /day		$442,000			$0
Communications							$221,000	$0	$221,000
	VSAT	221	Days	$1,000 /day		$221,000			
Miscellaneous Rental Equipment							$5,080,000	$0	$5,080,000
	Solids Control	221	Days	$400 /day		$88,400			
	Fishing Tools	221	Days	$1,500 /day		$331,500			
	Casing Running Equipment	40	Days	$6,000 Day		$240,000			
	Other Rentals	221	Days	$20,000 Day		$4,420,000			
			Days						
			Days						
Miscellaneous Special Services							$1,134,000	$0	$1,134,000
	Weather Forecasting	221	Days	$150 /day		$33,150			
	Engineering Services - Riser Analysis				Lump Sum	$300,000			
	Engineering Services - Drill String Design				Lump Sum	$200,000			
	Engineering Services - Casing Design				Lump Sum	$50,000			
	Engineering Services - Wellbore Stability				Lump Sum	$100,000			
	Engineering Services - Operational Support				Lump Sum	$200,000			
	Engineering Services - Risk Assessments				Lump Sum	$200,000			
	Engineering Services - Other				Lump Sum	$50,000			
Other Services / Costs							$1,740,000	$0	$1,740,000
	Misc Contract Labor	221	Days	$1,500 /day		$331,500			
	Casing Running	40	Days	$10,000 /day		$400,000			
	Well Insurance				Lump Sum	$500,000			
	Overhead	221	Days	$1,100 /day		$243,100			
	Catering	221	Days	$1,200 /day		$265,200			
Intangible Contingency		15%	Amount		*ST Drlg =*	*$182,017,000*	$27,303,000	$0	$27,303,000
					ST Comp =	*$0*			
					TOTAL INTANGIBLE		**$209,320,000**	**$0**	**$209,320,000**

TANGIBLE ITEMS

	OD	4 =#Strings	Length		$/ft			
Drive Pipe	36"		200		$500.00	$100,000	$0	$100,000
Conductor	20"		606		$180.00	$110,000	$0	$110,000
Surface	13-3/8"		5,364		$140.00	$751,000	$0	$751,000
Intermediate	11-3/4"		8,715		$80.00	$698,000	$0	$698,000
Intermediate								
Intermediate								
Intermediate								
Production Liner								
Production Tie-back								
Tubing								
Liner Equipment						$150,000	$0	$150,000
Whipstock Equipment & BP								
Subsurface Completion								
Wellheads						$500,000	$0	$500,000
Miscellaneous / Other						$100,000	$0	$100,000
Tangible Contingency		10% Amount		*ST Drlg =*	*$2,409,000*	$241,000	$0	$241,000
				ST Comp =	*$0*			
					TOTAL TANGIBLE	**$2,650,000**	**$0**	**$2,650,000**
					Total Dry Hole Cost	**$211,970,000**	**$0**	**$211,970,000**
					Total Completion Cost	**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**				TOTAL WELL COST	**$211,970,000**	**$0**	**$211,970,000**

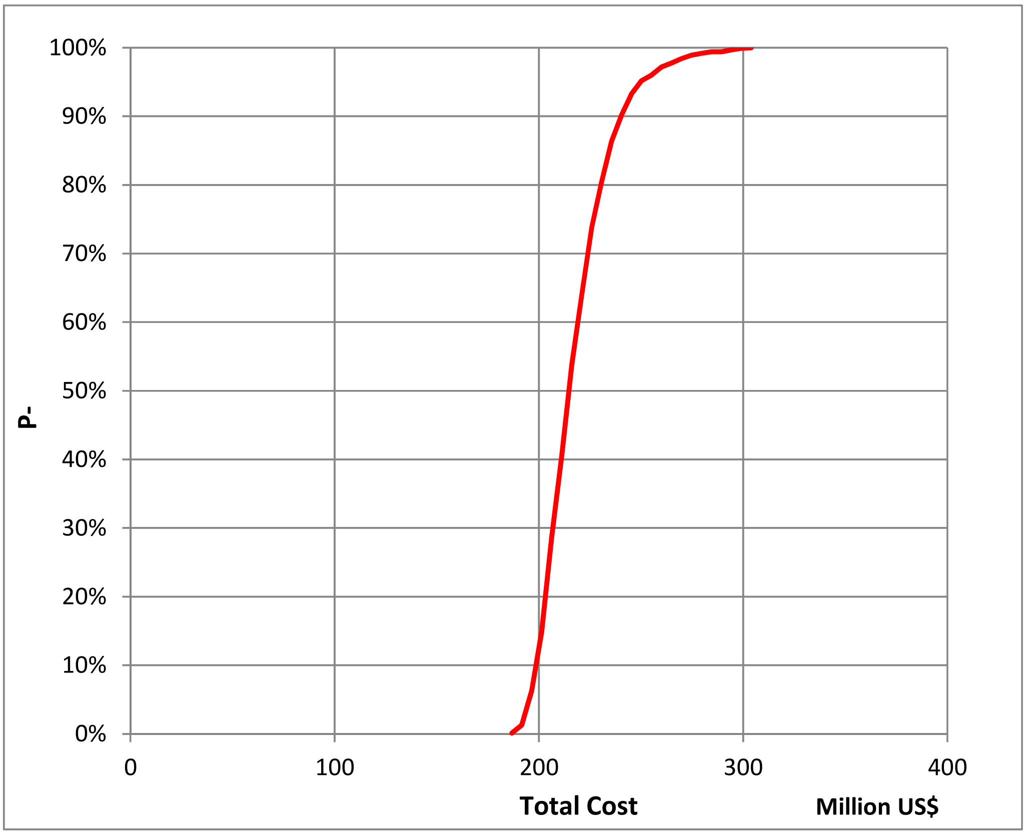
6.3.5 Case 4b Cost Estimate:

This case assumes the original Base Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
239	$220,814	$6,253	$227,067	$198,614	$214,640	$240,231

Figure 173. Hawaii Location: Case 4b – Cost Estimate

The following chart shows the cumulative probability of cost.



SCOPING COST ESTIMATE DETAIL Rev 4

BEAM - Hawaii, Case 4b ** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**		Revision No.	**1**	Date:	**30-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4b**	Water Depth **4050m** **13,287 ft**	Proposed TD **10,750m** **35,269 ft**	Formation **Moho / Mantle**	
Location **Hawaii**	Surface Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W** Btm. Hole Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4b: Conventional Deepwater Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	Dry Hole Drlg	Complete	TOTAL
	242 Days		242 Days
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$10,800,000	$0	$10,800,000
Drilling Rig - Day Work at $300,000 / Day	$133,600,000	$0	$133,600,000
Bits, Drill Collars & Stabilizers	$3,311,000	$0	$3,311,000
Directional & Downhole Services	$4,019,000	$0	$4,019,000
Fuel, Water & Lube	$14,157,000	$0	$14,157,000
Drilling Fluids Services	$2,799,000	$0	$2,799,000
Electric Logging & Cased Hole Logs	$4,826,000	$0	$4,826,000
Cementing	$1,053,000	$0	$1,053,000
Mud Logging and Geological Services	$593,000	$0	$593,000
Land Transportation	$109,000	$0	$109,000
Boat Transportation	$2,783,000	$0	$2,783,000
Helicopter Transportation	$1,089,000	$0	$1,089,000
Tubular Services	$150,000	$0	$150,000
Shorebase / Dock Services	$484,000	$0	$484,000
Communications	$242,000	$0	$242,000
Miscellaneous Rental Equipment	$5,720,000	$0	$5,720,000
Miscellaneous Special Services	$1,137,000	$0	$1,137,000
Other Services / Costs	$2,120,000	$0	$2,120,000
Intan Contingency at 15%	$28,802,000	$0	$28,802,000
TOTAL INTANGIBLE	**$220,814,242**	**$0**	**$220,814,242**

TANGIBLE ITEMS	OD	Footage	$/ft	Dry Hole Drlg	Complete	TOTAL
Drive Pipe	36"	200	$650.00	$130,000	$0	$130,000
Conductor	22"	656	$180.00	$119,000	$0	$119,000
Surface	18"	4,858	$160.00	$778,000	$0	$778,000
Intermediate	16"	8,707	$155.00	$1,350,000	$0	$1,350,000
Intermediate	13-3/8"	12,863	$140.00	$1,801,000	$0	$1,801,000
Intermediate	11-3/4"	4,000	$80.00	$320,000	$0	$320,000
Intermediate	9-5/8"	4,078	$70.00	$286,000	$0	$286,000
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$300,000	$0	$300,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$569,000	$0	$569,000
TOTAL TANGIBLE				**$6,253,000**	**$0**	**$6,253,000**
Total Dry Hole Cost				**$227,067,242**	**$0**	**$227,067,242**
Total Completion Cost				**$0**	**$0**	**$0**
Prepared by: **WSWhitney / NPilisi** — **Total Drill and Complete**				**$227,067,242**	**$0**	**$227,067,242**

SCOPING COST ESTIMATE SUMMARY Rev 4

BEAM - Hawaii, Case 4b

*** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: CDEX / JAMSTEC				Revision No.	1	Date:	30-Jun-13
Prospect or Field: Mantle Hole	Lease Name: N/A	Case No. #4b			Water Depth: 4050m, 13,287 ft	Proposed TD: 10,750m, 35,269 ft	Objective: Moho / Mantle	
Location: Hawaii	Surface Location: Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W							
	Btm. Hole Location: Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W							

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4b: Conventional Deepwater Case Well Configuration

Avg Intan $/day: $912,455

Drilling Rig : Chikyu — Directional Plan: Vertical Hole

INTANGIBLE ITEMS	Qty	Unit	Rate	Basis	Amount	Dry Hole Drlg	Complete	TOTAL
Operational Time =						242 Days		242 Days
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$10,800,000		$10,800,000
Mobilization (from Japan)				Lump Sum	$5,400,000			
Demobilization (to Japan)				Lump Sum	$5,400,000			
Drilling Rig - Day Work						$133,600,000	$0	$133,600,000
Drilling Day Rate	242	Days	$300,000 /day		$72,600,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$3,311,000	$0	$3,311,000
Drill Bits	26	No.	$70,000 /bit		$1,820,000			
Drill String Rentals: DC's, Jars, Stab, HWT	242	Days	$4,000 /day		$968,000			
Core Bits	6	No.	$60,000 /bit		$360,000			
Coring Services	65	Days	$2,500 /day		$162,500			
Directional & Downhole Services						$4,019,000	$0	$4,019,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	121	Days	$3,000 /day		$363,000			
Standard LWD Rental	121	Days	$7,000 /day		$847,000			
MWD / LWD Engineers (2)	242	Days	$2,000 /day		$484,000			
Mud Motors & Associated Tools	194	Days	$3,000 /day		$580,800			
High Temp MWD Rental	121	Days	$4,000 /day		$484,000			
High temp LWD Rental	121	Days	$10,000 /day		$1,210,000			
Fuel, Water & Lube						$14,157,000	$0	$14,157,000
Rig Fuel	242	Days	$53,000 /day		$12,826,000			
Boat Fuel	121	Days	$4,000 /day		$484,000			
Helicopter Fuel	121	Days	$3,000 /day		$363,000			
Lubricants	242	Days	$1,300 /day		$314,600			
Fresh Water	242	Days	$700 /day		$169,400			
Drilling Fluids Services						$2,799,000	$0	$2,799,000
Drilling Fluids - WBM				Lump Sum	$2,000,000			
Mud Engineer	242	Days	$800 /day		$193,600			
Cuttings Disposal	242	Days	$2,500 /day		$605,000			
Electric Logging & Cased Hole Logs						$4,826,000		$4,826,000
Wireline Unit and Personnel	242	Days	$3,000 /day		$726,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$1,053,000	$0	$1,053,000
22"				Lump Sum	100,000			
18"				Lump Sum	100,000			
16"				Lump Sum	150,000			
13.375"				Lump Sum	150,000			
11.75"				Lump Sum	100,000			
9.625"				Lump Sum	100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	242	Days	$1,250 /day		$302,500			

Mud Logging and Geological Services						$593,000	$0	$593,000
	Logging Unit Operating rate	242 Days	$1,250 /day		$302,500			
	Personnel Charges	242 Days	$1,200 /day		$290,400			
Land Transportation						$109,000	$0	$109,000
	Trucking	121 Days	$900 /day		$108,900			
Boat Transportation						$2,783,000	$0	$2,783,000
	Work Boat - Spot Hire	121 Days	$14,000 /day		$1,694,000			
	Crew Boat - Spot Hire	121 Days	$9,000 /day		$1,089,000			
Helicopter Transportation						$1,089,000	$0	$1,089,000
	Helicopter - spot hire	121 Days	$9,000 /day		$1,089,000			
Tubular Services						$150,000	$0	$150,000
	QAQC			Lump Sum	$150,000			
Shorebase / Dock Services						$484,000	$0	$484,000
	Shorebase /Dispatcher	242 Days	$2,000 /day		$484,000			$0
Communications						$242,000	$0	$242,000
	VSAT	242 Days	$1,000 /day		$242,000			
Miscellaneous Rental Equipment						$5,720,000	$0	$5,720,000
	Solids Control	242 Days	$400 /day		$96,800			
	Fishing Tools	242 Days	$1,500 /day		$363,000			
	Casing Running Equipment	70 Days	$6,000 Day		$420,000			
	Other Rentals	242 Days	$20,000 Day		$4,840,000			
		Days						
		Days						
Miscellaneous Special Services						$1,137,000	$0	$1,137,000
	Weather Forecasting	242 Days	$150 /day		$36,300			
	Engineering Services - Riser Analysis			Lump Sum	$300,000			
	Engineering Services - Drill String Design			Lump Sum	$200,000			
	Engineering Services - Casing Design			Lump Sum	$50,000			
	Engineering Services - Wellbore Stability			Lump Sum	$100,000			
	Engineering Services - Operational Support			Lump Sum	$200,000			
	Engineering Services - Risk Assessments			Lump Sum	$200,000			
	Engineering Services - Other			Lump Sum	$50,000			
Other Services / Costs						$2,120,000	$0	$2,120,000
	Misc Contract Labor	242 Days	$1,500 /day		$363,000			
	Casing Running	70 Days	$10,000 /day		$700,000			
	Well Insurance			Lump Sum	$500,000			
	Overhead	242 Days	$1,100 /day		$266,200			
	Catering	242 Days	$1,200 /day		$290,400			
Intangible Contingency			15% Amount	*ST Drlg =*	*$192,012,000*	$28,802,000	$0	$28,802,000
				ST Comp =	*$0*			
					TOTAL INTANGIBLE	**$220,814,000**	**$0**	**$220,814,000**

TANGIBLE ITEMS

	OD	7 =#Strings	Length	$/ft			
Drive Pipe	36"		200	$650.00	$130,000	$0	$130,000
Conductor	22"		656	$180.00	$119,000	$0	$119,000
Surface	18"		4,858	$160.00	$778,000	$0	$778,000
Intermediate	16"		8,707	$155.00	$1,350,000	$0	$1,350,000
Intermediate	13-3/8"		12,863	$140.00	$1,801,000	$0	$1,801,000
Intermediate	11-3/4"		4,000	$80.00	$320,000	$0	$320,000
Intermediate	9-5/8"		4,078	$70.00	$286,000	$0	$286,000
Production Liner							
Production Tie-back							
Tubing							
Liner Equipment					$300,000	$0	$300,000
Whipstock Equipment & BP							
Subsurface Completion							
Wellheads					$500,000	$0	$500,000
Miscellaneous / Other					$100,000	$0	$100,000
Tangible Contingency		10% Amount	*ST Drlg =*	*$5,684,000*	$569,000	$0	$569,000
			ST Comp =	*$0*			
				TOTAL TANGIBLE	**$6,253,000**	**$0**	**$6,253,000**
				Total Dry Hole Cost	**$227,067,000**	**$0**	**$227,067,000**
				Total Completion Cost	**$0**	**$0**	**$0**
Prepared by: WSWhitney / NPilisi				TOTAL WELL COST	**$227,067,000**	**$0**	**$227,067,000**

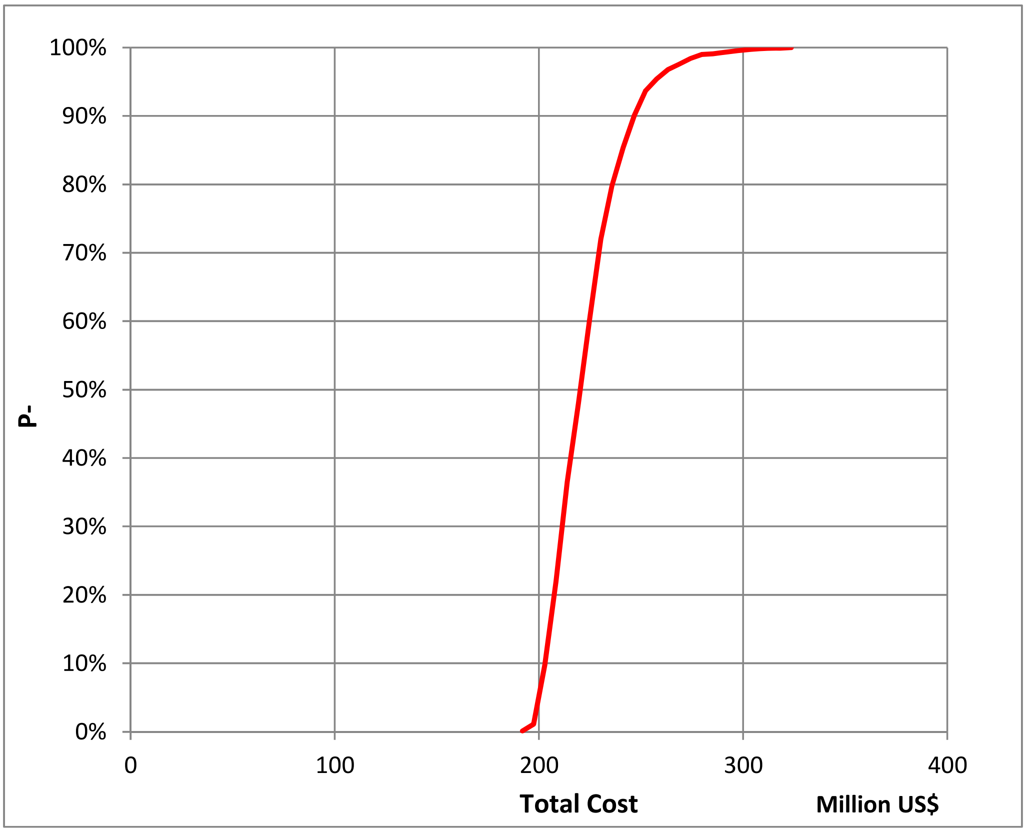
6.3.6 Case 4c Cost Estimate:

This case assumes the original Base Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
271	$221,814	$9,149	$230,963	$202,990	$220,246	$246,661

Figure 174. Hawaii Location: Case 4c – Cost Estimate

The following chart shows the cumulative probability of cost.



SCOPING COST ESTIMATE SUMMARY Rev 4

BEAM - Hawaii, Case 4c ** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**		Revision No.	**1**	Date:	**30-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4b**	Water Depth **4050m** **13,287 ft**	Proposed TD **10,750m** **35,269 ft**	Formation **Moho / Mantle**	
Location **Hawaii**	Surface Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W** Btm. Hole Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4c: Expandable Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	**Dry Hole Drlg**	**Complete**	**TOTAL**
	244 Days		**244 Days**
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$10,800,000	$0	$10,800,000
Drilling Rig - Day Work at $300,000 / Day	$134,200,000	$0	$134,200,000
Bits, Drill Collars & Stabilizers	$3,319,000	$0	$3,319,000
Directional & Downhole Services	$4,052,000	$0	$4,052,000
Fuel, Water & Lube	$14,274,000	$0	$14,274,000
Drilling Fluids Services	$2,806,000	$0	$2,806,000
Electric Logging & Cased Hole Logs	$4,832,000	$0	$4,832,000
Cementing	$1,055,000	$0	$1,055,000
Mud Logging and Geological Services	$598,000	$0	$598,000
Land Transportation	$110,000	$0	$110,000
Boat Transportation	$2,806,000	$0	$2,806,000
Helicopter Transportation	$1,098,000	$0	$1,098,000
Tubular Services	$150,000	$0	$150,000
Shorebase / Dock Services	$488,000	$0	$488,000
Communications	$244,000	$0	$244,000
Miscellaneous Rental Equipment	$5,764,000	$0	$5,764,000
Miscellaneous Special Services	$1,137,000	$0	$1,137,000
Other Services / Costs	$2,128,000	$0	$2,128,000
Intan Contingency at 15%	$28,933,000	$0	$28,933,000
TOTAL INTANGIBLE	**$221,814,244**	**$0**	**$221,814,244**

TANGIBLE ITEMS	**OD**	**Footage**	**$/ft**			
Drive Pipe	36"	200	$650.00	$130,000	$0	$130,000
Conductor	22"	656	$180.00	$119,000	$0	$119,000
Surface	16.5" SET	5,058	$300.00	$1,518,000	$0	$1,518,000
Intermediate	16.5" SET	4,049	$300.00	$1,215,000	$0	$1,215,000
Intermediate	16"	12,507	$155.00	$1,939,000	$0	$1,939,000
Intermediate	13.375"	16,563	$140.00	$2,319,000	$0	$2,319,000
Intermediate	11.75"	4,078	$80.00	$327,000	$0	$327,000
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$150,000	$0	$150,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$832,000	$0	$832,000
TOTAL TANGIBLE				**$9,149,000**	**$0**	**$9,149,000**
Total Dry Hole Cost				**$230,963,244**	**$0**	**$230,963,244**
Total Completion Cost				**$0**	**$0**	**$0**
Prepared by: **WSWhitney / NPilisi** — **Total Drill and Complete**				**$230,963,244**	**$0**	**$230,963,244**

SCOPING COST ESTIMATE DETAIL

Rev 4

BEAM - Hawaii, Case 4c

***** DRAFT ****

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx | Operator: **CDEX / JAMSTEC** | **Revision No.** 1 | **Date:** 30-Jun-13

Prospect or Field: **Mantle Hole** | Lease Name: **N/A** | Case No.: **#4b** | Water Depth: **4050m / 13,287 ft** | Proposed TD: **10,750m / 35,269 ft** | Objective: **Moho / Mantle**

Location: **Hawaii** | Surface Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W** | Btm. Hole Location: **Lat: 22.9 - 23.9°N / Long: 154.5 - 155.8°W**

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4c: Expandable Case Well Configuration

Avg Intan $/day: **$909,074**

Drilling Rig : Chikyu | Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	Qty	Unit	Rate	Basis	Amount	Dry Hole Drlg	Complete	TOTAL
					Operational Time =	**244 Days**		**244 Days**
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$10,800,000		$10,800,000
Mobilization (from Japan)				Lump Sum	$5,400,000			
Demobilization (to Japan)				Lump Sum	$5,400,000			
Drilling Rig - Day Work						$134,200,000	$0	$134,200,000
Drilling Day Rate	244	Days	$300,000 /day		$73,200,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$3,319,000	$0	$3,319,000
Drill Bits	26	No.	$70,000 /bit		$1,820,000			
Drill String Rentals: DC's, Jars, Stab, HWT	244	Days	$4,000 /day		$976,000			
Core Bits	6	No.	$60,000 /bit		$360,000			
Coring Services	65	Days	$2,500 /day		$162,500			
Directional & Downhole Services						$4,052,000	$0	$4,052,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	122	Days	$3,000 /day		$366,000			
Standard LWD Rental	122	Days	$7,000 /day		$854,000			
MWD / LWD Engineers (2)	244	Days	$2,000 /day		$488,000			
Mud Motors & Associated Tools	195	Days	$3,000 /day		$585,600			
High Temp MWD Rental	122	Days	$4,000 /day		$488,000			
High temp LWD Rental	122	Days	$10,000 /day		$1,220,000			
Fuel, Water & Lube						$14,274,000	$0	$14,274,000
Rig Fuel	244	Days	$53,000 /day		$12,932,000			
Boat Fuel	122	Days	$4,000 /day		$488,000			
Helicopter Fuel	122	Days	$3,000 /day		$366,000			
Lubricants	244	Days	$1,300 /day		$317,200			
Fresh Water	244	Days	$700 /day		$170,800			
Drilling Fluids Services						$2,806,000	$0	$2,806,000
Drilling Fluids - WBM				Lump Sum	$2,000,000			
Mud Engineer	244	Days	$800 /day		$195,200			
Cuttings Disposal	244	Days	$2,500 /day		$610,000			
Electric Logging & Cased Hole Logs						$4,832,000		$4,832,000
Wireline Unit and Personnel	244	Days	$3,000 /day		$732,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$1,055,000	$0	$1,055,000
22"				Lump Sum	100,000			
16.5" SET				Lump Sum	100,000			
16.5" SET				Lump Sum	100,000			
16"				Lump Sum	150,000			
13.375"				Lump Sum	150,000			
11.75"				Lump Sum	100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	244	Days	$1,250 /day		$305,000			

Category	Item	Qty	Unit	Rate	Lump Sum	Amount	Dry Hole	Completion	Total
Mud Logging and Geological Services							$598,000	$0	$598,000
	Logging Unit Operating rate	244	Days	$1,250 /day		$305,000			
	Personnel Charges	244	Days	$1,200 /day		$292,800			
Land Transportation							$110,000	$0	$110,000
	Trucking	122	Days	$900 /day		$109,800			
Boat Transportation							$2,806,000	$0	$2,806,000
	Work Boat - Spot Hire	122	Days	$14,000 /day		$1,708,000			
	Crew Boat - Spot Hire	122	Days	$9,000 /day		$1,098,000			
Helicopter Transportation							$1,098,000	$0	$1,098,000
	Helicopter - spot hire	122	Days	$9,000 /day		$1,098,000			
Tubular Services							$150,000	$0	$150,000
	QAQC				Lump Sum	$150,000			
Shorebase / Dock Services							$488,000	$0	$488,000
	Shorebase /Dispatcher	244	Days	$2,000 /day		$488,000			$0
Communications							$244,000	$0	$244,000
	VSAT	244	Days	$1,000 /day		$244,000			
Miscellaneous Rental Equipment							$5,764,000	$0	$5,764,000
	Solids Control	244	Days	$400 /day		$97,600			
	Fishing Tools	244	Days	$1,500 /day		$366,000			
	Casing Running Equipment	70	Days	$6,000 Day		$420,000			
	Other Rentals	244	Days	$20,000 Day		$4,880,000			
			Days						
			Days						
Miscellaneous Special Services							$1,137,000	$0	$1,137,000
	Weather Forecasting	244	Days	$150 /day		$36,600			
	Engineering Services - Riser Analysis				Lump Sum	$300,000			
	Engineering Services - Drill String Design				Lump Sum	$200,000			
	Engineering Services - Casing Design				Lump Sum	$50,000			
	Engineering Services - Wellbore Stability				Lump Sum	$100,000			
	Engineering Services - Operational Support				Lump Sum	$200,000			
	Engineering Services - Risk Assessments				Lump Sum	$200,000			
	Engineering Services - Other				Lump Sum	$50,000			
Other Services / Costs							$2,128,000	$0	$2,128,000
	Misc Contract Labor	244	Days	$1,500 /day		$366,000			
	Casing Running	70	Days	$10,000 /day		$700,000			
	Well Insurance				Lump Sum	$500,000			
	Overhead	244	Days	$1,100 /day		$268,400			
	Catering	244	Days	$1,200 /day		$292,800			
Intangible Contingency				15% Amount	*ST Drlg =*	*$192,881,000*	$28,933,000	$0	$28,933,000
					ST Comp =	*$0*			
						TOTAL INTANGIBLE	**$221,814,000**	**$0**	**$221,814,000**

TANGIBLE ITEMS

Item	OD	7 =#Strings	Length		$/ft	Dry Hole	Completion	Total
Drive Pipe	36"		200		$650.00	$130,000	$0	$130,000
Conductor	22"		656		$180.00	$119,000	$0	$119,000
Surface	16.5" SET		5,058		$300.00	$1,518,000	$0	$1,518,000
Intermediate	16.5" SET		4,049		$300.00	$1,215,000	$0	$1,215,000
Intermediate	16"		12,507		$155.00	$1,939,000	$0	$1,939,000
Intermediate	13.375"		16,563		$140.00	$2,319,000	$0	$2,319,000
Intermediate	11.75"		4,078		$80.00	$327,000	$0	$327,000
Production Liner								
Production Tie-back								
Tubing								
Liner Equipment						$150,000	$0	$150,000
Whipstock Equipment & BP								
Subsurface Completion								
Wellheads						$500,000	$0	$500,000
Miscellaneous / Other						$100,000	$0	$100,000
Tangible Contingency		10% Amount		*ST Drlg =*	*$8,317,000*	$832,000	$0	$832,000
				ST Comp =	*$0*			
					TOTAL TANGIBLE	**$9,149,000**	**$0**	**$9,149,000**
					Total Dry Hole Cost	**$230,963,000**	**$0**	**$230,963,000**
					Total Completion Cost	**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**				**TOTAL WELL COST**	**$230,963,000**	**$0**	**$230,963,000**

6.4 Baja Location Cost Estimates

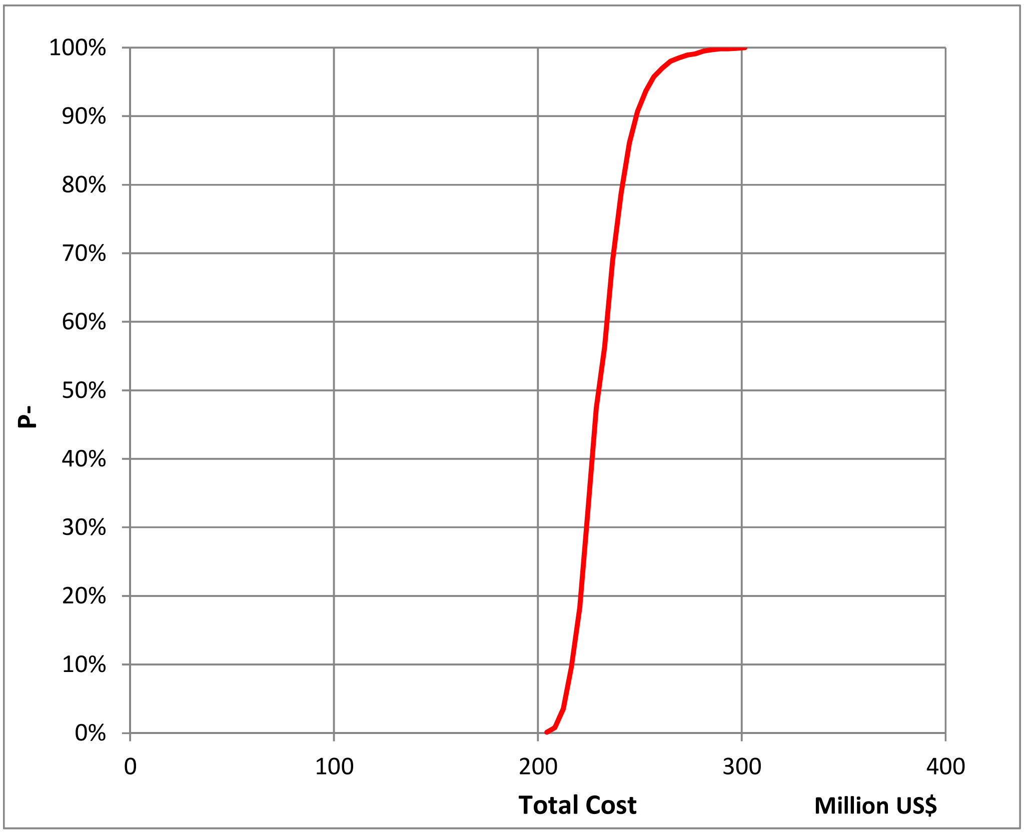
6.4.1 Case 2a Cost Estimate:

This case assumes the original Base Case wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
287	$229,515	$2,392	$231,907	$216,678	$229,814	$248,251

Figure 175. Baja Location: Case 2a – Cost Estimate

The following chart shows the cumulative probability of cost.



SCOPING COST ESTIMATE Rev 4

BEAM - Baja Case 2a

**** DRAFT ****

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**			Revision No.	**1**	Date:	**30-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4a**		Water Depth **4300m** **14,107 ft**	Proposed TD **10,400m** **34,120 ft**	Formation **Moho / Mantle**	
Location **Baja**	Surface Location: **Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W** Btm. Hole Location: **Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W**						

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4a: Orig Base Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	**Dry Hole Drlg** **251 Days**	**Complete**	**TOTAL** **251 Days**
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$14,600,000	$0	$14,600,000
Drilling Rig - Day Work at $300,000 / Day	$136,300,000	$0	$136,300,000
Bits, Drill Collars & Stabilizers	$4,284,000	$0	$4,284,000
Directional & Downhole Services	$4,167,000	$0	$4,167,000
Fuel, Water & Lube	$14,684,000	$0	$14,684,000
Drilling Fluids Services	$2,629,000	$0	$2,629,000
Electric Logging & Cased Hole Logs	$4,853,000	$0	$4,853,000
Cementing	$714,000	$0	$714,000
Mud Logging and Geological Services	$615,000	$0	$615,000
Land Transportation	$113,000	$0	$113,000
Boat Transportation	$2,887,000	$0	$2,887,000
Helicopter Transportation	$1,130,000	$0	$1,130,000
Tubular Services	$100,000	$0	$100,000
Shorebase / Dock Services	$502,000	$0	$502,000
Communications	$251,000	$0	$251,000
Miscellaneous Rental Equipment	$5,737,000	$0	$5,737,000
Miscellaneous Special Services	$1,138,000	$0	$1,138,000
Other Services / Costs	$1,854,000	$0	$1,854,000
Intan Contingency at 15%	$29,937,000	$0	$29,937,000
TOTAL INTANGIBLE	**$229,515,251**	**$0**	**$229,515,251**

TANGIBLE ITEMS	**OD**	**Footage**	**$/ft**			
Drive Pipe	30"	200	$500.00	$100,000	$0	$100,000
Conductor	20"	279	$180.00	$51,000	$0	$51,000
Surface	13-3/8"	5,036	$140.00	$706,000	$0	$706,000
Intermediate	11-3/4"	7,076	$80.00	$567,000	$0	$567,000
Intermediate	0	0	$0.00	$0	$0	$0
Intermediate	0	0	$0.00	$0	$0	$0
Intermediate	0	0	$0.00	$0	$0	$0
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$150,000	$0	$150,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$218,000	$0	$218,000
			TOTAL TANGIBLE	**$2,392,000**	**$0**	**$2,392,000**
			Total Dry Hole Cost	**$231,907,251**	**$0**	**$231,907,251**
			Total Completion Cost	**$0**	**$0**	**$0**
Prepared by: **WSWhitney / NPilisi**			**Total Drill and Complete**	**$231,907,251**	**$0**	**$231,907,251**

SCOPING COST ESTIMATE DETAIL Rev 4

BEAM - Baja Case 2a

*** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: CDEX / JAMSTEC			Revision No.	1	Date:	30-Jun-13	
Prospect or Field: Mantle Hole	Lease Name: N/A	Case No.: #4a		Water Depth: 4300m 14,107 ft	Proposed TD: 10,400m 34,120 ft	Objective: Moho / Mantle		
Location: Baja	Surface Location: Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W							
	Btm. Hole Location: Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W							

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4a: Orig Base Case Well Configuration

Avg Intan $/day: **$914,402**

Drilling Rig : Chikyu — Directional Plan: Vertical Hole

INTANGIBLE ITEMS	Qty	Unit	Rate	Basis	Amount	Dry Hole Drlg	Complete	TOTAL
				Operational Time =		251 Days		251 Days
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$14,600,000		$14,600,000
Mobilization (from Japan)				Lump Sum	$7,300,000			
Demobilization (to Japan)				Lump Sum	$7,300,000			
Drilling Rig - Day Work						$136,300,000	$0	$136,300,000
Drilling Day Rate	251	Days	$300,000 /day		$75,300,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$4,284,000	$0	$4,284,000
Drill Bits	17	No.	$70,000 /bit		$1,190,000			
Drill String Rentals: DC's, Jars, Stab, HWT	251	Days	$4,000 /day		$1,004,000			
Core Bits	28	No.	$60,000 /bit		$1,680,000			
Coring Services	164	Days	$2,500 /day		$410,000			
Directional & Downhole Services						$4,167,000	$0	$4,167,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	126	Days	$3,000 /day		$376,500			
Standard LWD Rental	126	Days	$7,000 /day		$878,500			
MWD / LWD Engineers (2)	251	Days	$2,000 /day		$502,000			
Mud Motors & Associated Tools	201	Days	$3,000 /day		$602,400			
High Temp MWD Rental	126	Days	$4,000 /day		$502,000			
High temp LWD Rental	126	Days	$10,000 /day		$1,255,000			
Fuel, Water & Lube						$14,684,000	$0	$14,684,000
Rig Fuel	251	Days	$53,000 /day		$13,303,000			
Boat Fuel	126	Days	$4,000 /day		$502,000			
Helicopter Fuel	126	Days	$3,000 /day		$376,500			
Lubricants	251	Days	$1,300 /day		$326,300			
Fresh Water	251	Days	$700 /day		$175,700			
Drilling Fluids Services						$2,629,000	$0	$2,629,000
Drilling Fluids - WBM				Lump Sum	$1,800,000			
Mud Engineer	251	Days	$800 /day		$200,800			
Cuttings Disposal	251	Days	$2,500 /day		$627,500			
Electric Logging & Cased Hole Logs						$4,853,000		$4,853,000
Wireline Unit and Personnel	251	Days	$3,000 /day		$753,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$714,000	$0	$714,000
20"				Lump Sum	$100,000			
13-3/8"				Lump Sum	$150,000			
11-3/4"				Lump Sum	$100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	251	Days	$1,250 /day		$313,750			

Mud Logging and Geological Services						$615,000	$0	$615,000
Logging Unit Operating rate	251	Days	$1,250 /day		$313,750			
Personnel Charges	251	Days	$1,200 /day		$301,200			
Land Transportation						$113,000	$0	$113,000
Trucking	126	Days	$900 /day		$112,950			
Boat Transportation						$2,887,000	$0	$2,887,000
Work Boat - Spot Hire	126	Days	$14,000 /day		$1,757,000			
Crew Boat - Spot Hire	126	Days	$9,000 /day		$1,129,500			
Helicopter Transportation						$1,130,000	$0	$1,130,000
Helicopter - spot hire	126	Days	$9,000 /day		$1,129,500			
Tubular Services						$100,000	$0	$100,000
QAQC				Lump Sum	$100,000			
Shorebase / Dock Services						$502,000	$0	$502,000
Shorebase /Dispatcher	251	Days	$2,000 /day		$502,000			$0
Communications						$251,000	$0	$251,000
VSAT	251	Days	$1,000 /day		$251,000			
Miscellaneous Rental Equipment						$5,737,000	$0	$5,737,000
Solids Control	251	Days	$400 /day		$100,400			
Fishing Tools	251	Days	$1,500 /day		$376,500			
Casing Running Equipment	40	Days	$6,000 Day		$240,000			
Other Rentals	251	Days	$20,000 Day		$5,020,000			
		Days						
		Days						
Miscellaneous Special Services						$1,138,000	$0	$1,138,000
Weather Forecasting	251	Days	$150 /day		$37,650			
Engineering Services - Riser Analysis				Lump Sum	$300,000			
Engineering Services - Drill String Design				Lump Sum	$200,000			
Engineering Services - Casing Design				Lump Sum	$50,000			
Engineering Services - Wellbore Stability				Lump Sum	$100,000			
Engineering Services - Operational Support				Lump Sum	$200,000			
Engineering Services - Risk Assessments				Lump Sum	$200,000			
Engineering Services - Other				Lump Sum	$50,000			
Other Services / Costs						$1,854,000	$0	$1,854,000
Misc Contract Labor	251	Days	$1,500 /day		$376,500			
Casing Running	40	Days	$10,000 /day		$400,000			
Well Insurance				Lump Sum	$500,000			
Overhead	251	Days	$1,100 /day		$276,100			
Catering	251	Days	$1,200 /day		$301,200			
Intangible Contingency	15%	Amount		*ST Drlg =*	*$199,578,000*	$29,937,000	$0	$29,937,000
				ST Comp =	*$0*			
				TOTAL INTANGIBLE		**$229,515,000**	**$0**	**$229,515,000**

TANGIBLE ITEMS

	OD	4 =#Strings	Length		$/ft			
Drive Pipe	30"		200		$500.00	$100,000	$0	$100,000
Conductor	20"		279		$180.00	$51,000	$0	$51,000
Surface	13-3/8"		5,036		$140.00	$706,000	$0	$706,000
Intermediate	11-3/4"		7,076		$80.00	$567,000	$0	$567,000
Intermediate								
Intermediate								
Intermediate								
Production Liner								
Production Tie-back								
Tubing								
Liner Equipment						$150,000	$0	$150,000
Whipstock Equipment & BP								
Subsurface Completion								
Wellheads						$500,000	$0	$500,000
Miscellaneous / Other						$100,000	$0	$100,000
Tangible Contingency		10% Amount		*ST Drlg =*	*$2,174,000*	$218,000	$0	$218,000
				ST Comp =	*$0*			
				TOTAL TANGIBLE		**$2,392,000**	**$0**	**$2,392,000**
				Total Dry Hole Cost		**$231,907,000**	**$0**	**$231,907,000**
				Total Completion Cost		**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**			TOTAL WELL COST		**$231,907,000**	**$0**	**$231,907,000**

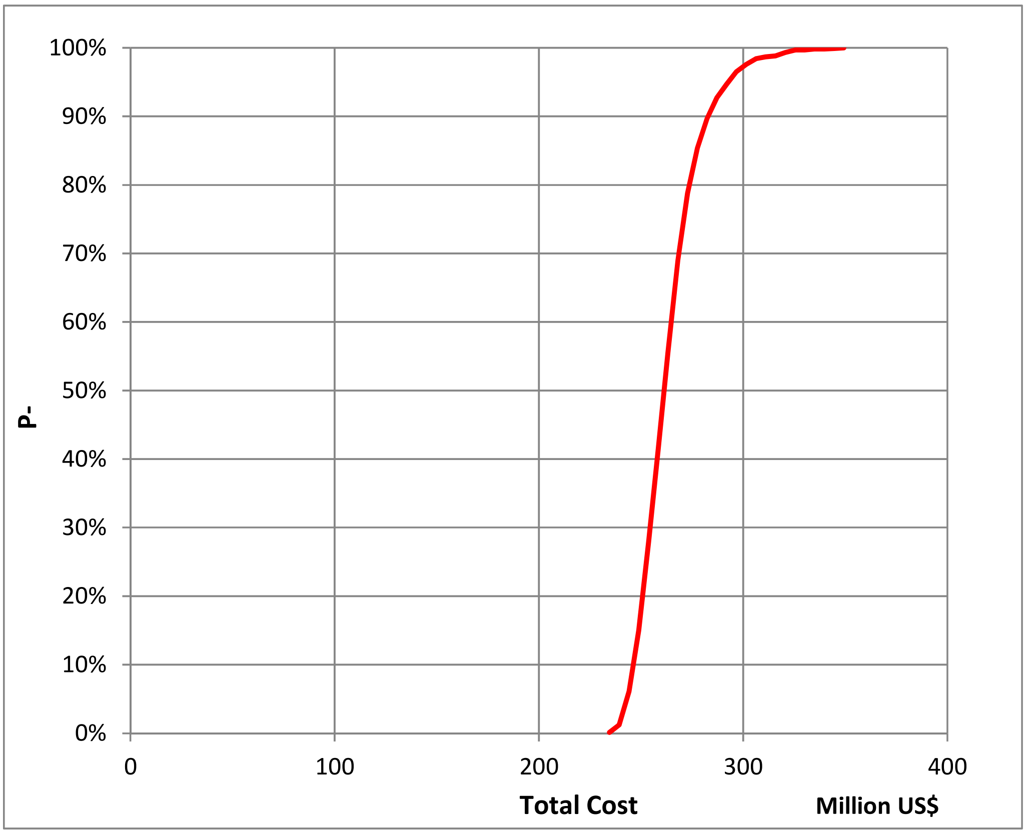
6.4.2 Case 2b Cost Estimate:

This case assumes the Deepwater wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
345	$259,910	$5,889	$265,799	$246,177	$261,328	$282,808

Figure 176. Baja Location: Case 2c – Cost Estimate

The following chart shows the cumulative probability of cost.



SCOPING COST ESTIMATE SUMMARY Rev 4

BEAM - Baja Case 2b ** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**		Revision No.	**1**		Date:	**30-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4b**	Water Depth **4300m** **14,107 ft**	Proposed TD **10,400m** **34,120 ft**	Formation **Moho / Mantle**		
Location **Baja**	Surface Location: **Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W** Btm. Hole Location: **Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W**						

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4b: Conventional Deepwater Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	**Dry Hole Drlg** **308 Days**	**Complete**	**TOTAL** **308 Days**
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$14,600,000	$0	$14,600,000
Drilling Rig - Day Work at $300,000 / Day	$153,400,000	$0	$153,400,000
Bits, Drill Collars & Stabilizers	$5,312,000	$0	$5,312,000
Directional & Downhole Services	$5,102,000	$0	$5,102,000
Fuel, Water & Lube	$18,018,000	$0	$18,018,000
Drilling Fluids Services	$2,817,000	$0	$2,817,000
Electric Logging & Cased Hole Logs	$5,024,000	$0	$5,024,000
Cementing	$1,135,000	$0	$1,135,000
Mud Logging and Geological Services	$755,000	$0	$755,000
Land Transportation	$139,000	$0	$139,000
Boat Transportation	$3,542,000	$0	$3,542,000
Helicopter Transportation	$1,386,000	$0	$1,386,000
Tubular Services	$150,000	$0	$150,000
Shorebase / Dock Services	$616,000	$0	$616,000
Communications	$308,000	$0	$308,000
Miscellaneous Rental Equipment	$7,166,000	$0	$7,166,000
Miscellaneous Special Services	$1,147,000	$0	$1,147,000
Other Services / Costs	$2,371,000	$0	$2,371,000
Intan Contingency at 15%	$33,902,000	$0	$33,902,000
TOTAL INTANGIBLE	**$259,910,308**	**$0**	**$259,910,308**

TANGIBLE ITEMS	**OD**	**Footage**	**$/ft**			
Drive Pipe	36"	200	$650.00	$130,000	$0	$130,000
Conductor	22"	279	$180.00	$51,000	$0	$51,000
Surface	18"	4,907	$160.00	$786,000	$0	$786,000
Intermediate	16"	8,314	$155.00	$1,289,000	$0	$1,289,000
Intermediate	13-3/8"	11,693	$140.00	$1,638,000	$0	$1,638,000
Intermediate	11-3/4"	3,500	$80.00	$280,000	$0	$280,000
Intermediate	9-5/8"	3,980	$70.00	$279,000	$0	$279,000
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$300,000	$0	$300,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$536,000	$0	$536,000
TOTAL TANGIBLE				**$5,889,000**	**$0**	**$5,889,000**
Total Dry Hole Cost				**$265,799,308**	**$0**	**$265,799,308**
Total Completion Cost				**$0**	**$0**	**$0**
Total Drill and Complete				**$265,799,308**	**$0**	**$265,799,308**

Prepared by: **WSWhitney / NPilisi**

SCOPING COST ESTIMATE DETAL — Rev 4

BEAM - Baja Case 2b

*** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: CDEX / JAMSTEC		Revision No. 1		Date: 30-Jun-13	
Prospect or Field: Mantle Hole	Lease Name: N/A	Case No.: #4b	Water Depth: 4300m, 14,107 ft	Proposed TD: 10,400m, 34,120 ft	Objective: Moho / Mantle	
Location: Baja	Surface Location: Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W					
	Btm. Hole Location: Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4b: Conventional Deepwater Case Well Configuration

Avg Intan $/day: **$843,864**

Drilling Rig : Chikyu — Directional Plan: Vertical Hole

INTANGIBLE ITEMS	Qty	Unit	Rate	Basis	Amount	Dry Hole Drlg	Complete	TOTAL
					Operational Time =	308 Days		308 Days
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$14,600,000		$14,600,000
Mobilization (from Japan)				Lump Sum	$7,300,000			
Demobilization (to Japan)				Lump Sum	$7,300,000			
Drilling Rig - Day Work						$153,400,000	$0	$153,400,000
Drilling Day Rate	308	Days	$300,000 /day		$92,400,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$5,312,000	$0	$5,312,000
Drill Bits	27	No.	$70,000 /bit		$1,890,000			
Drill String Rentals: DC's, Jars, Stab, HWT	308	Days	$4,000 /day		$1,232,000			
Core Bits	28	No.	$60,000 /bit		$1,680,000			
Coring Services	204	Days	$2,500 /day		$510,000			
Directional & Downhole Services						$5,102,000	$0	$5,102,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	154	Days	$3,000 /day		$462,000			
Standard LWD Rental	154	Days	$7,000 /day		$1,078,000			
MWD / LWD Engineers (2)	308	Days	$2,000 /day		$616,000			
Mud Motors & Associated Tools	246	Days	$3,000 /day		$739,200			
High Temp MWD Rental	154	Days	$4,000 /day		$616,000			
High temp LWD Rental	154	Days	$10,000 /day		$1,540,000			
Fuel, Water & Lube						$18,018,000	$0	$18,018,000
Rig Fuel	308	Days	$53,000 /day		$16,324,000			
Boat Fuel	154	Days	$4,000 /day		$616,000			
Helicopter Fuel	154	Days	$3,000 /day		$462,000			
Lubricants	308	Days	$1,300 /day		$400,400			
Fresh Water	308	Days	$700 /day		$215,600			
Drilling Fluids Services						$2,817,000	$0	$2,817,000
Drilling Fluids - WBM				Lump Sum	$1,800,000			
Mud Engineer	308	Days	$800 /day		$246,400			
Cuttings Disposal	308	Days	$2,500 /day		$770,000			
Electric Logging & Cased Hole Logs						$5,024,000		$5,024,000
Wireline Unit and Personnel	308	Days	$3,000 /day		$924,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$1,135,000	$0	$1,135,000
22"				Lump Sum	$100,000			
18"				Lump Sum	$100,000			
16"				Lump Sum	$150,000			
13.375"				Lump Sum	$150,000			
11.75"				Lump Sum	$100,000			
9.625"				Lump Sum	$100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	308	Days	$1,250 /day		$385,000			

Item	Qty	Unit	Rate	Basis	Amount	Dry Hole	Completion	Total
Mud Logging and Geological Services						$755,000	$0	$755,000
Logging Unit Operating rate	308	Days	$1,250 /day		$385,000			
Personnel Charges	308	Days	$1,200 /day		$369,600			
Land Transportation						$139,000	$0	$139,000
Trucking	154	Days	$900 /day		$138,600			
Boat Transportation						$3,542,000	$0	$3,542,000
Work Boat - Spot Hire	154	Days	$14,000 /day		$2,156,000			
Crew Boat - Spot Hire	154	Days	$9,000 /day		$1,386,000			
Helicopter Transportation						$1,386,000	$0	$1,386,000
Helicopter - spot hire	154	Days	$9,000 /day		$1,386,000			
Tubular Services						$150,000	$0	$150,000
QAQC				Lump Sum	$150,000			
Shorebase / Dock Services						$616,000	$0	$616,000
Shorebase /Dispatcher	308	Days	$2,000 /day		$616,000			$0
Communications						$308,000	$0	$308,000
VSAT	308	Days	$1,000 /day		$308,000			
Miscellaneous Rental Equipment						$7,166,000	$0	$7,166,000
Solids Control	308	Days	$400 /day		$123,200			
Fishing Tools	308	Days	$1,500 /day		$462,000			
Casing Running Equipment	70	Days	$6,000 Day		$420,000			
Other Rentals	308	Days	$20,000 Day		$6,160,000			
		Days						
		Days						
Miscellaneous Special Services						$1,147,000	$0	$1,147,000
Weather Forecasting	308	Days	$150 /day		$46,200			
Engineering Services - Riser Analysis				Lump Sum	$300,000			
Engineering Services - Drill String Design				Lump Sum	$200,000			
Engineering Services - Casing Design				Lump Sum	$50,000			
Engineering Services - Wellbore Stability				Lump Sum	$100,000			
Engineering Services - Operational Support				Lump Sum	$200,000			
Engineering Services - Risk Assessments				Lump Sum	$200,000			
Engineering Services - Other				Lump Sum	$50,000			
Other Services / Costs						$2,371,000	$0	$2,371,000
Misc Contract Labor	308	Days	$1,500 /day		$462,000			
Casing Running	70	Days	$10,000 /day		$700,000			
Well Insurance				Lump Sum	$500,000			
Overhead	308	Days	$1,100 /day		$338,800			
Catering	308	Days	$1,200 /day		$369,600			
Intangible Contingency	15%	Amount		*ST Drlg =*	*$226,008,000*	$33,902,000	$0	$33,902,000
				ST Comp =	*$0*			
					TOTAL INTANGIBLE	**$259,910,000**	**$0**	**$259,910,000**

TANGIBLE ITEMS

Item	OD	7 =#Strings	Length		$/ft	Dry Hole	Completion	Total
Drive Pipe	36"		200		$650.00	$130,000	$0	$130,000
Conductor	22"		279		$180.00	$51,000	$0	$51,000
Surface	18"		4,907		$160.00	$786,000	$0	$786,000
Intermediate	16"		8,314		$155.00	$1,289,000	$0	$1,289,000
Intermediate	13-3/8"		11,693		$140.00	$1,638,000	$0	$1,638,000
Intermediate	11-3/4"		3,500		$80.00	$280,000	$0	$280,000
Intermediate	9-5/8"		3,980		$70.00	$279,000	$0	$279,000
Production Liner								
Production Tie-back								
Tubing								
Liner Equipment						$300,000	$0	$300,000
Whipstock Equipment & BP								
Subsurface Completion								
Wellheads						$500,000	$0	$500,000
Miscellaneous / Other						$100,000	$0	$100,000
Tangible Contingency		10% Amount		*ST Drlg =*	*$5,353,000*	$536,000	$0	$536,000
				ST Comp =	*$0*			
					TOTAL TANGIBLE	**$5,889,000**	**$0**	**$5,889,000**
					Total Dry Hole Cost	**$265,799,000**	**$0**	**$265,799,000**
					Total Completion Cost	**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**				TOTAL WELL COST	**$265,799,000**	**$0**	**$265,799,000**

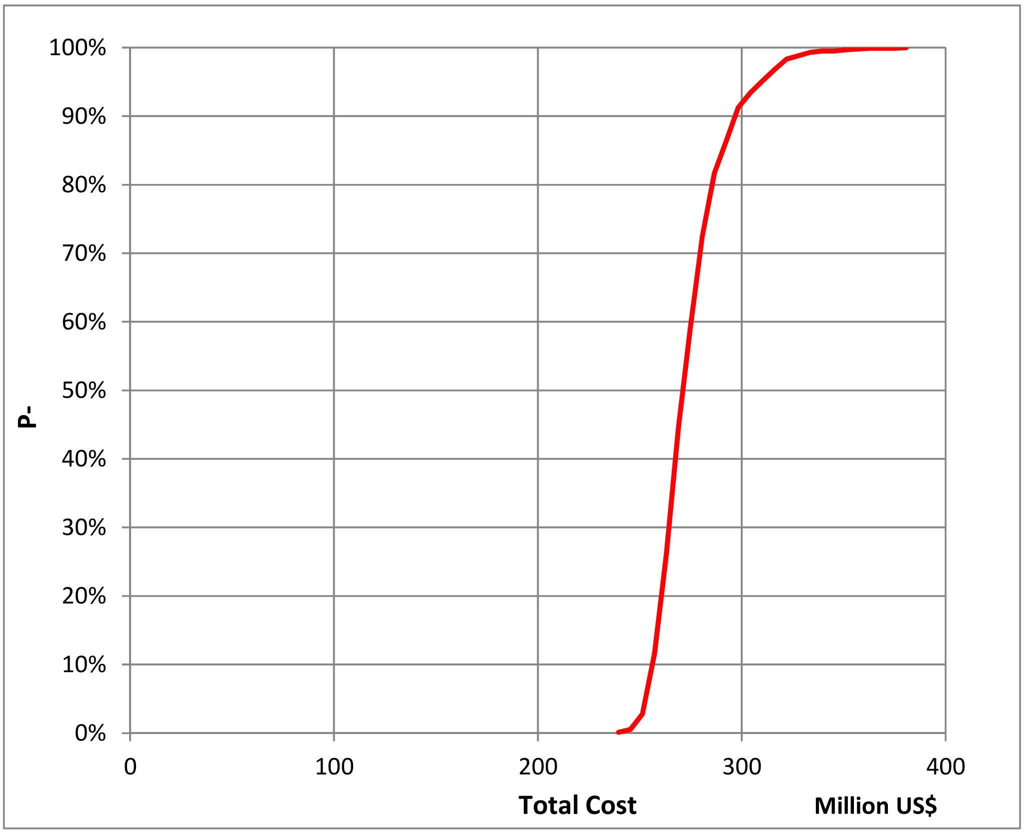
6.4.3 Case 2c Cost Estimate:

This case assumes the Deepwater wellbore configuration, coring the upper third of each stratigraphic section, drilling the middle third, and then coring the bottom third.. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
363	$269,685	$8,528	$278,213	$246,177	$261,328	$282,808

Figure 177. Baja Location: Case 2c – Cost Estimate

The following chart shows the cumulative probability of cost.



SCOPING COST ESTIMATE SUMMARY Rev 4

BEAM - Baja Case 2c **** DRAFT ****

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**		Revision No.	**1**	Date:	**30-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4b**	Water Depth **4300m** **14,107 ft**	Proposed TD **10,400m** **34,120 ft**	Formation **Moho / Mantle**	
Location **Baja**	Surface Location: **Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W** Btm. Hole Location: **Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4b: Conventional Deepwater Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	**Dry Hole Drlg**	**Complete**	**TOTAL**
	327 Days		**327 Days**
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$14,600,000	$0	$14,600,000
Drilling Rig - Day Work at $300,000 / Day	$159,100,000	$0	$159,100,000
Bits, Drill Collars & Stabilizers	$5,636,000	$0	$5,636,000
Directional & Downhole Services	$5,413,000	$0	$5,413,000
Fuel, Water & Lube	$19,130,000	$0	$19,130,000
Drilling Fluids Services	$2,880,000	$0	$2,880,000
Electric Logging & Cased Hole Logs	$5,081,000	$0	$5,081,000
Cementing	$1,159,000	$0	$1,159,000
Mud Logging and Geological Services	$802,000	$0	$802,000
Land Transportation	$148,000	$0	$148,000
Boat Transportation	$3,761,000	$0	$3,761,000
Helicopter Transportation	$1,472,000	$0	$1,472,000
Tubular Services	$150,000	$0	$150,000
Shorebase / Dock Services	$654,000	$0	$654,000
Communications	$327,000	$0	$327,000
Miscellaneous Rental Equipment	$7,582,000	$0	$7,582,000
Miscellaneous Special Services	$1,150,000	$0	$1,150,000
Other Services / Costs	$2,443,000	$0	$2,443,000
Intan Contingency at 15%	$35,177,000	$0	$35,177,000
TOTAL INTANGIBLE	**$269,685,327**	**$0**	**$269,685,327**

TANGIBLE ITEMS	**OD**	**Footage**	**$/ft**	Dry Hole Drlg	Complete	TOTAL
Drive Pipe	36"	200	$650.00	$130,000	$0	$130,000
Conductor	22"	279	$180.00	$51,000	$0	$51,000
Surface	16.5" SET	5,107	$300.00	$1,533,000	$0	$1,533,000
Intermediate	16.5" SET	3,607	$300.00	$1,083,000	$0	$1,083,000
Intermediate	16"	11,714	$155.00	$1,816,000	$0	$1,816,000
Intermediate	13-3/8"	14,893	$140.00	$2,086,000	$0	$2,086,000
Intermediate	11-3/4"	3,780	$80.00	$303,000	$0	$303,000
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$150,000	$0	$150,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$776,000	$0	$776,000
TOTAL TANGIBLE				**$8,528,000**	**$0**	**$8,528,000**
Total Dry Hole Cost				**$278,213,327**	**$0**	**$278,213,327**
Total Completion Cost				**$0**	**$0**	**$0**
Prepared by: **WSWhitney / NPilisi** — **Total Drill and Complete**				**$278,213,327**	**$0**	**$278,213,327**

SCOPING COST ESTIMATE DETAIL Rev 4

BEAM - Baja Case 2c

*** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: CDEX / JAMSTEC		Revision No.	1	Date:	30-Jun-13
Prospect or Field: Mantle Hole	Lease Name: N/A	Case No.: #4b	Water Depth: 4300m 14,107 ft	Proposed TD: 10,400m 34,120 ft	Objective: Moho / Mantle	
Location: Baja	Surface Location: Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W					
	Btm. Hole Location: Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4b: Conventional Deepwater Case Well Configuration

Avg Intan $/day: **$824,725**

Drilling Rig : Chikyu Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	Qty	Unit	Rate	Basis	Amount	Dry Hole Drlg	Complete	TOTAL
					Operational Time =	327 Days		327 Days
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$14,600,000		$14,600,000
Mobilization (from Japan)				Lump Sum	$7,300,000			
Demobilization (to Japan)				Lump Sum	$7,300,000			
Drilling Rig - Day Work						$159,100,000	$0	$159,100,000
Drilling Day Rate	327	Days	$300,000 /day		$98,100,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$5,636,000	$0	$5,636,000
Drill Bits	30	No.	$70,000 /bit		$2,100,000			
Drill String Rentals: DC's, Jars, Stab, HWT	327	Days	$4,000 /day		$1,308,000			
Core Bits	28	No.	$60,000 /bit		$1,680,000			
Coring Services	219	Days	$2,500 /day		$547,500			
Directional & Downhole Services						$5,413,000	$0	$5,413,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	164	Days	$3,000 /day		$490,500			
Standard LWD Rental	164	Days	$7,000 /day		$1,144,500			
MWD / LWD Engineers (2)	327	Days	$2,000 /day		$654,000			
Mud Motors & Associated Tools	262	Days	$3,000 /day		$784,800			
High Temp MWD Rental	164	Days	$4,000 /day		$654,000			
High temp LWD Rental	164	Days	$10,000 /day		$1,635,000			
Fuel, Water & Lube						$19,130,000	$0	$19,130,000
Rig Fuel	327	Days	$53,000 /day		$17,331,000			
Boat Fuel	164	Days	$4,000 /day		$654,000			
Helicopter Fuel	164	Days	$3,000 /day		$490,500			
Lubricants	327	Days	$1,300 /day		$425,100			
Fresh Water	327	Days	$700 /day		$228,900			
Drilling Fluids Services						$2,880,000	$0	$2,880,000
Drilling Fluids - WBM				Lump Sum	$1,800,000			
Mud Engineer	327	Days	$800 /day		$261,600			
Cuttings Disposal	327	Days	$2,500 /day		$817,500			
Electric Logging & Cased Hole Logs						$5,081,000		$5,081,000
Wireline Unit and Personnel	327	Days	$3,000 /day		$981,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$1,159,000	$0	$1,159,000
22"				Lump Sum	$100,000			
16.5 SET"				Lump Sum	$100,000			
16.5 SET"				Lump Sum	$100,000			
16"				Lump Sum	$150,000			
13.375"				Lump Sum	$150,000			
11.750"				Lump Sum	$100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	327	Days	$1,250 /day		$408,750			

Category	Item	Qty	Unit	Rate	Basis	Amount	Dry Hole	Completion	Total
Mud Logging and Geological Services							$802,000	$0	$802,000
	Logging Unit Operating rate	327	Days	$1,250 /day		$408,750			
	Personnel Charges	327	Days	$1,200 /day		$392,400			
Land Transportation							$148,000	$0	$148,000
	Trucking	164	Days	$900 /day		$147,150			
Boat Transportation							$3,761,000	$0	$3,761,000
	Work Boat - Spot Hire	164	Days	$14,000 /day		$2,289,000			
	Crew Boat - Spot Hire	164	Days	$9,000 /day		$1,471,500			
Helicopter Transportation							$1,472,000	$0	$1,472,000
	Helicopter - spot hire	164	Days	$9,000 /day		$1,471,500			
Tubular Services							$150,000	$0	$150,000
	QAQC				Lump Sum	$150,000			
Shorebase / Dock Services							$654,000	$0	$654,000
	Shorebase /Dispatcher	327	Days	$2,000 /day		$654,000			$0
Communications							$327,000	$0	$327,000
	VSAT	327	Days	$1,000 /day		$327,000			
Miscellaneous Rental Equipment							$7,582,000	$0	$7,582,000
	Solids Control	327	Days	$400 /day		$130,800			
	Fishing Tools	327	Days	$1,500 /day		$490,500			
	Casing Running Equipment	70	Days	$6,000 Day		$420,000			
	Other Rentals	327	Days	$20,000 Day		$6,540,000			
			Days						
			Days						
Miscellaneous Special Services							$1,150,000	$0	$1,150,000
	Weather Forecasting	327	Days	$150 /day		$49,050			
	Engineering Services - Riser Analysis				Lump Sum	$300,000			
	Engineering Services - Drill String Design				Lump Sum	$200,000			
	Engineering Services - Casing Design				Lump Sum	$50,000			
	Engineering Services - Wellbore Stability				Lump Sum	$100,000			
	Engineering Services - Operational Support				Lump Sum	$200,000			
	Engineering Services - Risk Assessments				Lump Sum	$200,000			
	Engineering Services - Other				Lump Sum	$50,000			
Other Services / Costs							$2,443,000	$0	$2,443,000
	Misc Contract Labor	327	Days	$1,500 /day		$490,500			
	Casing Running	70	Days	$10,000 /day		$700,000			
	Well Insurance				Lump Sum	$500,000			
	Overhead	327	Days	$1,100 /day		$359,700			
	Catering	327	Days	$1,200 /day		$392,400			
Intangible Contingency				15% Amount	*ST Drlg =*	*$234,508,000*	$35,177,000	$0	$35,177,000
					ST Comp =	*$0*			
						TOTAL INTANGIBLE	**$269,685,000**	**$0**	**$269,685,000**

TANGIBLE ITEMS

Item	OD	7 =#Strings	Length		$/ft	Dry Hole	Completion	Total
Drive Pipe	36"		200		$650.00	$130,000	$0	$130,000
Conductor	22"		279		$180.00	$51,000	$0	$51,000
Surface	16.5" SET		5,107		$300.00	$1,533,000	$0	$1,533,000
Intermediate	16.5" SET		3,607		$300.00	$1,083,000	$0	$1,083,000
Intermediate	16"		11,714		$155.00	$1,816,000	$0	$1,816,000
Intermediate	13-3/8"		14,893		$140.00	$2,086,000	$0	$2,086,000
Intermediate	11-3/4"		3,780		$80.00	$303,000	$0	$303,000
Production Liner								
Production Tie-back								
Tubing								
Liner Equipment						$150,000	$0	$150,000
Whipstock Equipment & BP								
Subsurface Completion								
Wellheads						$500,000	$0	$500,000
Miscellaneous / Other						$100,000	$0	$100,000
Tangible Contingency		10% Amount		*ST Drlg =*	*$7,752,000*	$776,000	$0	$776,000
				ST Comp =	*$0*			
					TOTAL TANGIBLE	**$8,528,000**	**$0**	**$8,528,000**
					Total Dry Hole Cost	**$278,213,000**	**$0**	**$278,213,000**
					Total Completion Cost	**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**				TOTAL WELL COST	**$278,213,000**	**$0**	**$278,213,000**

6.4.4 *Case 4a Cost Estimate:*

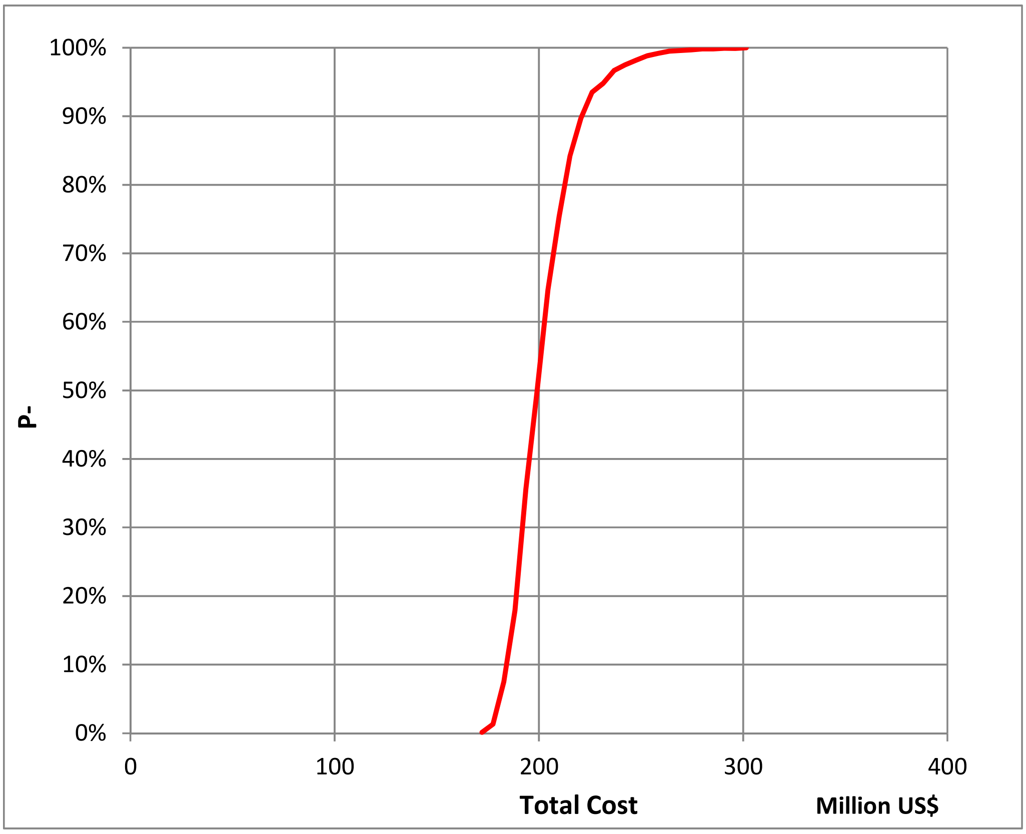
This case assumes the original Base Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the cost estimate for this case is shown below.

.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
244	$206,803	$2,392	$209,195	$184,132	$199,057	$221,027

Figure 178. Baja Location: Case 4a – Cost Estimate

The following chart shows the cumulative probability of cost.



SCOPING COST ESTIMATE SUMMARY Rev 4

BEAM - Baja Case 4a ** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: CDEX / JAMSTEC			Revision No. 1		Date: 30-Jun-13
Prospect or Field: Mantle Hole	Lease Name: N/A	Case No.: #4a	Water Depth: 4300m 14,107 ft	Proposed TD: 10,400m 34,120 ft	Formation: Moho / Mantle	
Location: Baja	Surface Location: Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W					
	Btm. Hole Location: Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4a: Orig Base Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	Dry Hole Drlg 208 Days	Complete	TOTAL 208 Days
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$14,600,000	$0	$14,600,000
Drilling Rig - Day Work at $300,000 / Day	$123,400,000	$0	$123,400,000
Bits, Drill Collars & Stabilizers	$3,032,000	$0	$3,032,000
Directional & Downhole Services	$3,462,000	$0	$3,462,000
Fuel, Water & Lube	$12,168,000	$0	$12,168,000
Drilling Fluids Services	$2,487,000	$0	$2,487,000
Electric Logging & Cased Hole Logs	$4,724,000	$0	$4,724,000
Cementing	$660,000	$0	$660,000
Mud Logging and Geological Services	$510,000	$0	$510,000
Land Transportation	$94,000	$0	$94,000
Boat Transportation	$2,392,000	$0	$2,392,000
Helicopter Transportation	$936,000	$0	$936,000
Tubular Services	$100,000	$0	$100,000
Shorebase / Dock Services	$416,000	$0	$416,000
Communications	$208,000	$0	$208,000
Miscellaneous Rental Equipment	$4,796,000	$0	$4,796,000
Miscellaneous Special Services	$1,132,000	$0	$1,132,000
Other Services / Costs	$1,691,000	$0	$1,691,000
Intan Contingency at 15%	$26,975,000	$0	$26,975,000
TOTAL INTANGIBLE	**$206,803,208**	**$0**	**$206,803,208**

TANGIBLE ITEMS	OD	Footage	$/ft	Dry Hole Drlg	Complete	TOTAL
Drive Pipe	30"	200	$500.00	$100,000	$0	$100,000
Conductor	20"	279	$180.00	$51,000	$0	$51,000
Surface	13-3/8"	5,036	$140.00	$706,000	$0	$706,000
Intermediate	11-3/4"	7,076	$80.00	$567,000	$0	$567,000
Intermediate	0	0	$0.00	$0	$0	$0
Intermediate	0	0	$0.00	$0	$0	$0
Intermediate	0	0	$0.00	$0	$0	$0
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$150,000	$0	$150,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$218,000	$0	$218,000
TOTAL TANGIBLE				**$2,392,000**	**$0**	**$2,392,000**
Total Dry Hole Cost				**$209,195,208**	**$0**	**$209,195,208**
Total Completion Cost				**$0**	**$0**	**$0**
Total Drill and Complete				**$209,195,208**	**$0**	**$209,195,208**

Prepared by: **WSWhitney / NPilisi**

SCOPING COST ESTIMATE DETAIL

Rev 4

BEAM - Baja Case 4a

*** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: CDEX / JAMSTEC	Revision No. 1	Date: 30-Jun-13	
Prospect or Field: Mantle Hole	Lease Name: N/A	Case No.: #4a	Water Depth: 4300m, 14,107 ft	Proposed TD: 10,400m, 34,120 ft
Objective: Moho / Mantle				
Location: Baja	Surface Location: Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W	Btm. Hole Location: Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W		

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4a: Orig Base Case Well Configuration

Avg Intan $/day: $994,245

Drilling Rig : Chikyu — Directional Plan: Vertical Hole

INTANGIBLE ITEMS	Qty	Unit	Rate	Basis	Amount	Dry Hole Drlg	Complete	TOTAL
				Operational Time =		208 Days		208 Days
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$14,600,000		$14,600,000
Mobilization (from Japan)				Lump Sum	$7,300,000			
Demobilization (to Japan)				Lump Sum	$7,300,000			
Drilling Rig - Day Work						$123,400,000	$0	$123,400,000
Drilling Day Rate	208	Days	$300,000 /day		$62,400,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$3,032,000	$0	$3,032,000
Drill Bits	24	No.	$70,000 /bit		$1,680,000			
Drill String Rentals: DC's, Jars, Stab, HWT	208	Days	$4,000 /day		$832,000			
Core Bits	6	No.	$60,000 /bit		$360,000			
Coring Services	64	Days	$2,500 /day		$160,000			
Directional & Downhole Services						$3,462,000	$0	$3,462,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	104	Days	$3,000 /day		$312,000			
Standard LWD Rental	104	Days	$7,000 /day		$728,000			
MWD / LWD Engineers (2)	208	Days	$2,000 /day		$416,000			
Mud Motors & Associated Tools	166	Days	$3,000 /day		$499,200			
High Temp MWD Rental	104	Days	$4,000 /day		$416,000			
High temp LWD Rental	104	Days	$10,000 /day		$1,040,000			
Fuel, Water & Lube						$12,168,000	$0	$12,168,000
Rig Fuel	208	Days	$53,000 /day		$11,024,000			
Boat Fuel	104	Days	$4,000 /day		$416,000			
Helicopter Fuel	104	Days	$3,000 /day		$312,000			
Lubricants	208	Days	$1,300 /day		$270,400			
Fresh Water	208	Days	$700 /day		$145,600			
Drilling Fluids Services						$2,487,000	$0	$2,487,000
Drilling Fluids - WBM				Lump Sum	$1,800,000			
Mud Engineer	208	Days	$800 /day		$166,400			
Cuttings Disposal	208	Days	$2,500 /day		$520,000			
Electric Logging & Cased Hole Logs						$4,724,000		$4,724,000
Wireline Unit and Personnel	208	Days	$3,000 /day		$624,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$660,000	$0	$660,000
20"				Lump Sum	$100,000			
13-3/8"				Lump Sum	$150,000			
11-3/4"				Lump Sum	$100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	208	Days	$1,250 /day		$260,000			

Item	Qty	Unit	Rate	Basis	Amount	Dry Hole	Completion	Total
Mud Logging and Geological Services						$510,000	$0	$510,000
Logging Unit Operating rate	208	Days	$1,250 /day		$260,000			
Personnel Charges	208	Days	$1,200 /day		$249,600			
Land Transportation						$94,000	$0	$94,000
Trucking	104	Days	$900 /day		$93,600			
Boat Transportation						$2,392,000	$0	$2,392,000
Work Boat - Spot Hire	104	Days	$14,000 /day		$1,456,000			
Crew Boat - Spot Hire	104	Days	$9,000 /day		$936,000			
Helicopter Transportation						$936,000	$0	$936,000
Helicopter - spot hire	104	Days	$9,000 /day		$936,000			
Tubular Services						$100,000	$0	$100,000
QAQC				Lump Sum	$100,000			
Shorebase / Dock Services						$416,000	$0	$416,000
Shorebase /Dispatcher	208	Days	$2,000 /day		$416,000			$0
Communications						$208,000	$0	$208,000
VSAT	208	Days	$1,000 /day		$208,000			
Miscellaneous Rental Equipment						$4,796,000	$0	$4,796,000
Solids Control	208	Days	$400 /day		$83,200			
Fishing Tools	208	Days	$1,500 /day		$312,000			
Casing Running Equipment	40	Days	$6,000 Day		$240,000			
Other Rentals	208	Days	$20,000 Day		$4,160,000			
		Days						
		Days						
Miscellaneous Special Services						$1,132,000	$0	$1,132,000
Weather Forecasting	208	Days	$150 /day		$31,200			
Engineering Services - Riser Analysis				Lump Sum	$300,000			
Engineering Services - Drill String Design				Lump Sum	$200,000			
Engineering Services - Casing Design				Lump Sum	$50,000			
Engineering Services - Wellbore Stability				Lump Sum	$100,000			
Engineering Services - Operational Support				Lump Sum	$200,000			
Engineering Services - Risk Assessments				Lump Sum	$200,000			
Engineering Services - Other				Lump Sum	$50,000			
Other Services / Costs						$1,691,000	$0	$1,691,000
Misc Contract Labor	208	Days	$1,500 /day		$312,000			
Casing Running	40	Days	$10,000 /day		$400,000			
Well Insurance				Lump Sum	$500,000			
Overhead	208	Days	$1,100 /day		$228,800			
Catering	208	Days	$1,200 /day		$249,600			
Intangible Contingency		15% Amount		*ST Drlg =*	*$179,828,000*	$26,975,000	$0	$26,975,000
				ST Comp =	*$0*			
					TOTAL INTANGIBLE	**$206,803,000**	**$0**	**$206,803,000**

TANGIBLE ITEMS

Item	OD	4 =#Strings	Length		$/ft	Dry Hole	Completion	Total
Drive Pipe	30"		200		$500.00	$100,000	$0	$100,000
Conductor	20"		279		$180.00	$51,000	$0	$51,000
Surface	13-3/8"		5,036		$140.00	$706,000	$0	$706,000
Intermediate	11-3/4"		7,076		$80.00	$567,000	$0	$567,000
Intermediate								
Intermediate								
Intermediate								
Production Liner								
Production Tie-back								
Tubing								
Liner Equipment						$150,000	$0	$150,000
Whipstock Equipment & BP								
Subsurface Completion								
Wellheads						$500,000	$0	$500,000
Miscellaneous / Other						$100,000	$0	$100,000
Tangible Contingency		10% Amount		*ST Drlg =*	*$2,174,000*	$218,000	$0	$218,000
				ST Comp =	*$0*			
					TOTAL TANGIBLE	**$2,392,000**	**$0**	**$2,392,000**
					Total Dry Hole Cost	**$209,195,000**	**$0**	**$209,195,000**
					Total Completion Cost	**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**				TOTAL WELL COST	**$209,195,000**	**$0**	**$209,195,000**

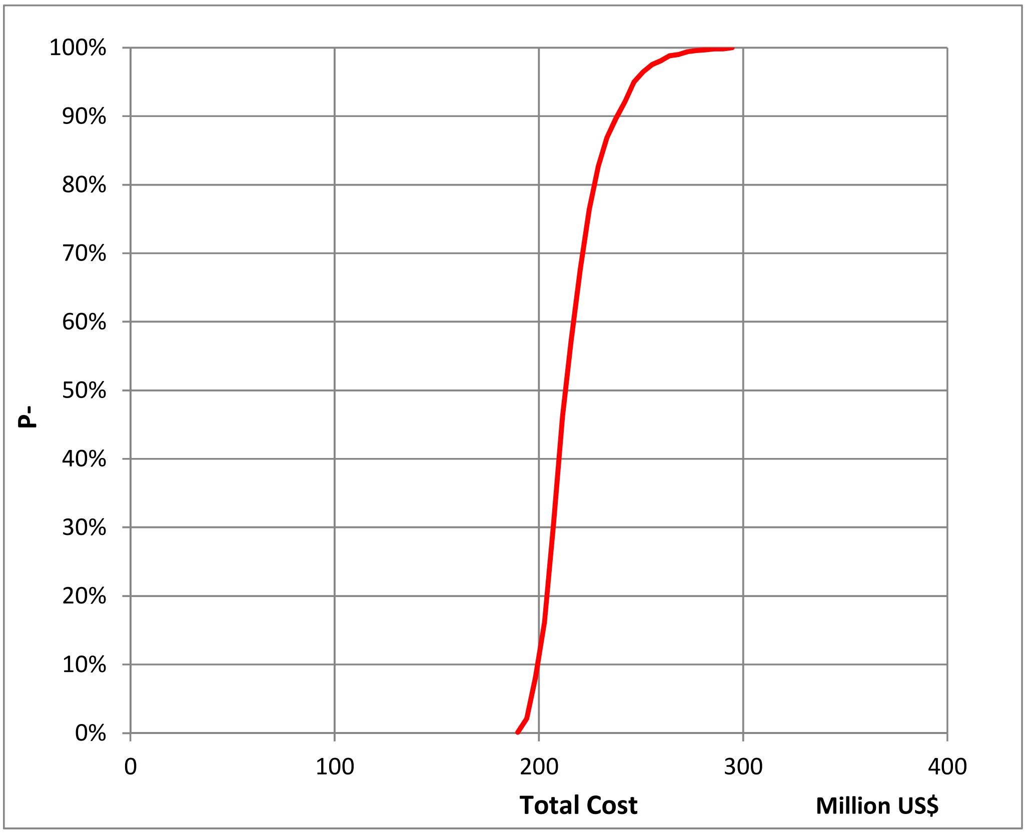
6.4.5 Case 4b Cost Estimate:

This case assumes the original Base Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
265	$218,304	$5,889	$224,193	$199,389	$212,987	$238,289

Figure 179. Baja Location: Case 4b – Cost Estimate

The following chart shows the cumulative probability of cost.



__SCOPING COST ESTIMATE SUMMARY__ Rev 4

BEAM - Baja Case 4b ** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**			Revision No.	**1**	Date:	**30-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4b**		Water Depth **4300m** **14,107 ft**	Proposed TD **10,400m** **34,120 ft**	Formation **Moho / Mantle**	
Location **Baja**	Surface Location: **Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W** Btm. Hole Location: **Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W**						

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4b: Conventional Deepwater Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	**Dry Hole Drlg** **229 Days**	**Complete**	**TOTAL** **229 Days**
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$14,600,000	$0	$14,600,000
Drilling Rig - Day Work at $300,000 / Day	$129,700,000	$0	$129,700,000
Bits, Drill Collars & Stabilizers	$3,116,000	$0	$3,116,000
Directional & Downhole Services	$3,806,000	$0	$3,806,000
Fuel, Water & Lube	$13,397,000	$0	$13,397,000
Drilling Fluids Services	$2,556,000	$0	$2,556,000
Electric Logging & Cased Hole Logs	$4,787,000	$0	$4,787,000
Cementing	$1,037,000	$0	$1,037,000
Mud Logging and Geological Services	$562,000	$0	$562,000
Land Transportation	$104,000	$0	$104,000
Boat Transportation	$2,634,000	$0	$2,634,000
Helicopter Transportation	$1,031,000	$0	$1,031,000
Tubular Services	$150,000	$0	$150,000
Shorebase / Dock Services	$458,000	$0	$458,000
Communications	$229,000	$0	$229,000
Miscellaneous Rental Equipment	$5,436,000	$0	$5,436,000
Miscellaneous Special Services	$1,135,000	$0	$1,135,000
Other Services / Costs	$2,071,000	$0	$2,071,000
Intan Contingency at 15%	$28,475,000	$0	$28,475,000
TOTAL INTANGIBLE	**$218,304,229**	**$0**	**$218,304,229**

TANGIBLE ITEMS	**OD**	**Footage**	**$/ft**			
Drive Pipe	36"	200	$650.00	$130,000	$0	$130,000
Conductor	22"	279	$180.00	$51,000	$0	$51,000
Surface	18"	4,907	$160.00	$786,000	$0	$786,000
Intermediate	16"	8,314	$155.00	$1,289,000	$0	$1,289,000
Intermediate	13-3/8"	11,693	$140.00	$1,638,000	$0	$1,638,000
Intermediate	11-3/4"	3,500	$80.00	$280,000	$0	$280,000
Intermediate	9-5/8"	3,980	$70.00	$279,000	$0	$279,000
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$300,000	$0	$300,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$536,000	$0	$536,000
TOTAL TANGIBLE				**$5,889,000**	**$0**	**$5,889,000**
Total Dry Hole Cost				**$224,193,229**	**$0**	**$224,193,229**
Total Completion Cost				**$0**	**$0**	**$0**
Prepared by: **WSWhitney / NPilisi** — **Total Drill and Complete**				**$224,193,229**	**$0**	**$224,193,229**

SCOPING COST ESTIMATE DETAIL Rev 4

BEAM - Baja Case 4b

*** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: CDEX / JAMSTEC		Revision No.	1	Date:	30-Jun-13
Prospect or Field: Mantle Hole	Lease Name: N/A	Case No.: #4b	Water Depth: 4300m 14,107 ft	Proposed TD: 10,400m 34,120 ft	Objective: Moho / Mantle	
Location: Baja	Surface Location: Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W Btm. Hole Location: Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4b: Conventional Deepwater Case Well Configuration

Avg Intan $/day: $953,293

Drilling Rig : Chikyu — Directional Plan: Vertical Hole

INTANGIBLE ITEMS						Dry Hole Drlg	Complete	TOTAL
				Operational Time =		229 Days		229 Days
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
	Metocean Study (desktop study, data collection/processing)			Lump Sum	$1,000,000			
	Site Survey (desktop study, bathymetry)			Lump Sum	$2,000,000			
	Regulatory			Lump Sum	$20,000			
Rig Mobilization, Demobilization						$14,600,000		$14,600,000
	Mobilization (from Japan)			Lump Sum	$7,300,000			
	Demobilization (to Japan)			Lump Sum	$7,300,000			
Drilling Rig - Day Work						$129,700,000	$0	$129,700,000
	Drilling Day Rate	229 Days	$300,000 /day		$68,700,000			
	Existing Riser System Modifications			Lump Sum	$14,000,000			
	Additional Riser			Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$3,116,000	$0	$3,116,000
	Drill Bits	24 No.	$70,000 /bit		$1,680,000			
	Drill String Rentals: DC's, Jars, Stab, HWT	229 Days	$4,000 /day		$916,000			
	Core Bits	6 No.	$60,000 /bit		$360,000			
	Coring Services	64 Days	$2,500 /day		$160,000			
Directional & Downhole Services						$3,806,000	$0	$3,806,000
	Surveys/Gyros/Single & Multi-Shots			Lump Sum	$20,000			
	MWD / LWD Mob / De-mob			Lump Sum	$30,000			
	Standard MWD Rental	115 Days	$3,000 /day		$343,500			
	Standard LWD Rental	115 Days	$7,000 /day		$801,500			
	MWD / LWD Engineers (2)	229 Days	$2,000 /day		$458,000			
	Mud Motors & Associated Tools	183 Days	$3,000 /day		$549,600			
	High Temp MWD Rental	115 Days	$4,000 /day		$458,000			
	High temp LWD Rental	115 Days	$10,000 /day		$1,145,000			
Fuel, Water & Lube						$13,397,000	$0	$13,397,000
	Rig Fuel	229 Days	$53,000 /day		$12,137,000			
	Boat Fuel	115 Days	$4,000 /day		$458,000			
	Helicopter Fuel	115 Days	$3,000 /day		$343,500			
	Lubricants	229 Days	$1,300 /day		$297,700			
	Fresh Water	229 Days	$700 /day		$160,300			
Drilling Fluids Services						$2,556,000	$0	$2,556,000
	Drilling Fluids - WBM			Lump Sum	$1,800,000			
	Mud Engineer	229 Days	$800 /day		$183,200			
	Cuttings Disposal	229 Days	$2,500 /day		$572,500			
Electric Logging & Cased Hole Logs						$4,787,000		$4,787,000
	Wireline Unit and Personnel	229 Days	$3,000 /day		$687,000			
	Standard Open Hole Logging			Lump Sum	$1,500,000			
	High Temp Open Hole Logging			Lump Sum	$2,500,000			
	Cased Hole Logging			Lump Sum	$100,000			
Cementing						$1,037,000	$0	$1,037,000
	22"			Lump Sum	$100,000			
	18"			Lump Sum	$100,000			
	16"			Lump Sum	$150,000			
	13.375"			Lump Sum	$150,000			
	11.75"			Lump Sum	$100,000			
	9.625"			Lump Sum	$100,000			
	Retainers, Service Man, Manifold, Etc.			Lump Sum	$50,000			
	Unit Charge	229 Days	$1,250 /day		$286,250			

Category	Item	Qty	Rate	Lump Sum	Amount	Dry Hole	Completion	Total
Mud Logging and Geological Services						$562,000	$0	$562,000
	Logging Unit Operating rate	229 Days	$1,250 /day		$286,250			
	Personnel Charges	229 Days	$1,200 /day		$274,800			
Land Transportation						$104,000	$0	$104,000
	Trucking	115 Days	$900 /day		$103,050			
Boat Transportation						$2,634,000	$0	$2,634,000
	Work Boat - Spot Hire	115 Days	$14,000 /day		$1,603,000			
	Crew Boat - Spot Hire	115 Days	$9,000 /day		$1,030,500			
Helicopter Transportation						$1,031,000	$0	$1,031,000
	Helicopter - spot hire	115 Days	$9,000 /day		$1,030,500			
Tubular Services						$150,000	$0	$150,000
	QAQC			Lump Sum	$150,000			
Shorebase / Dock Services						$458,000	$0	$458,000
	Shorebase /Dispatcher	229 Days	$2,000 /day		$458,000			$0
Communications						$229,000	$0	$229,000
	VSAT	229 Days	$1,000 /day		$229,000			
Miscellaneous Rental Equipment						$5,436,000	$0	$5,436,000
	Solids Control	229 Days	$400 /day		$91,600			
	Fishing Tools	229 Days	$1,500 /day		$343,500			
	Casing Running Equipment	70 Days	$6,000 Day		$420,000			
	Other Rentals	229 Days	$20,000 Day		$4,580,000			
		Days						
		Days						
Miscellaneous Special Services						$1,135,000	$0	$1,135,000
	Weather Forecasting	229 Days	$150 /day		$34,350			
	Engineering Services - Riser Analysis			Lump Sum	$300,000			
	Engineering Services - Drill String Design			Lump Sum	$200,000			
	Engineering Services - Casing Design			Lump Sum	$50,000			
	Engineering Services - Wellbore Stability			Lump Sum	$100,000			
	Engineering Services - Operational Support			Lump Sum	$200,000			
	Engineering Services - Risk Assessments			Lump Sum	$200,000			
	Engineering Services - Other			Lump Sum	$50,000			
Other Services / Costs						$2,071,000	$0	$2,071,000
	Misc Contract Labor	229 Days	$1,500 /day		$343,500			
	Casing Running	70 Days	$10,000 /day		$700,000			
	Well Insurance			Lump Sum	$500,000			
	Overhead	229 Days	$1,100 /day		$251,900			
	Catering	229 Days	$1,200 /day		$274,800			
Intangible Contingency		15% Amount		*ST Drlg =*	*$189,829,000*	$28,475,000	$0	$28,475,000
				ST Comp =	*$0*			
					TOTAL INTANGIBLE	**$218,304,000**	**$0**	**$218,304,000**

TANGIBLE ITEMS

Item	OD	7 =#Strings	Length	$/ft	Dry Hole	Completion	Total
Drive Pipe	36"		200	$650.00	$130,000	$0	$130,000
Conductor	22"		279	$180.00	$51,000	$0	$51,000
Surface	18"		4,907	$160.00	$786,000	$0	$786,000
Intermediate	16"		8,314	$155.00	$1,289,000	$0	$1,289,000
Intermediate	13-3/8"		11,693	$140.00	$1,638,000	$0	$1,638,000
Intermediate	11-3/4"		3,500	$80.00	$280,000	$0	$280,000
Intermediate	9-5/8"		3,980	$70.00	$279,000	$0	$279,000
Production Liner							
Production Tie-back							
Tubing							
Liner Equipment					$300,000	$0	$300,000
Whipstock Equipment & BP							
Subsurface Completion							
Wellheads					$500,000	$0	$500,000
Miscellaneous / Other					$100,000	$0	$100,000
Tangible Contingency	10% Amount		*ST Drlg =*	*$5,353,000*	$536,000	$0	$536,000
			ST Comp =	*$0*			
				TOTAL TANGIBLE	**$5,889,000**	**$0**	**$5,889,000**
				Total Dry Hole Cost	**$224,193,000**	**$0**	**$224,193,000**
				Total Completion Cost	**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**			TOTAL WELL COST	**$224,193,000**	**$0**	**$224,193,000**

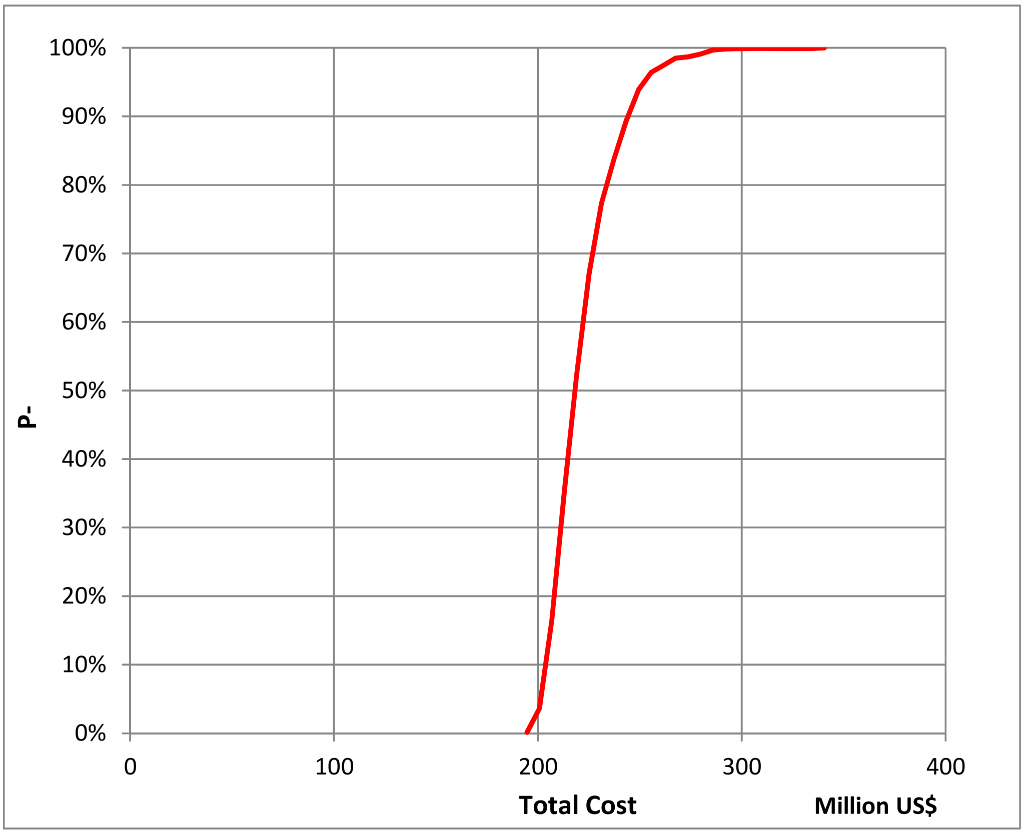
6.4.6 *Case 4c Cost Estimate:*

This case assumes the original Base Case wellbore configuration, and drilling to the Moho and then coring just the mantle. A summary of the cost estimate for this case is shown below.

Project	Nominal Costs (M$)			Stochastic Costs		
Days	Intan	Tan	Total	P10	P50	P90
267	$221,746	$8,528	$230,274	$203,813	$218,213	$244,136

Figure 180. Baja Location: Case 4c – Cost Estimate

The following chart shows the cumulative probability of cost.



SCOPING COST ESTIMATE SUMMARY Rev 4

BEAM - Baja Case 4c ** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development ___

AFE# XXX	Operator: **CDEX / JAMSTEC**		Revision No.	**1**	Date:	**30-Jun-13**
Prospect or Field **Mantle Hole**	Lease Name **N/A**	Case No. **#4c**	Water Depth **4300m** **14108**	Proposed TD **10,400m** **34,120 ft**	Formation **Moho / Mantle**	
Location **Baja**	Surface Location: **Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W** Btm. Hole Location: **Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W**					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4c: Expandable Case Well Configuration

Drilling Rig : **Chikyu** Directional Plan: **Vertical Hole**

INTANGIBLE ITEMS	**Dry Hole Drlg**	**Complete**	**TOTAL**
	231 Days		**231 Days**
Location/ Regulatory Costs	$3,020,000	$0	$3,020,000
Rig Mobilization, Demobilization	$14,600,000	$0	$14,600,000
Drilling Rig - Day Work at $300,000 / Day	$130,300,000	$0	$130,300,000
Bits, Drill Collars & Stabilizers	$5,252,000	$0	$5,252,000
Directional & Downhole Services	$3,839,000	$0	$3,839,000
Fuel, Water & Lube	$13,514,000	$0	$13,514,000
Drilling Fluids Services	$2,563,000	$0	$2,563,000
Electric Logging & Cased Hole Logs	$4,793,000	$0	$4,793,000
Cementing	$1,039,000	$0	$1,039,000
Mud Logging and Geological Services	$566,000	$0	$566,000
Land Transportation	$104,000	$0	$104,000
Boat Transportation	$2,657,000	$0	$2,657,000
Helicopter Transportation	$1,040,000	$0	$1,040,000
Tubular Services	$150,000	$0	$150,000
Shorebase / Dock Services	$462,000	$0	$462,000
Communications	$231,000	$0	$231,000
Miscellaneous Rental Equipment	$5,479,000	$0	$5,479,000
Miscellaneous Special Services	$1,135,000	$0	$1,135,000
Other Services / Costs	$2,078,000	$0	$2,078,000
Intan Contingency at 15%	$28,924,000	$0	$28,924,000
TOTAL INTANGIBLE	**$221,746,231**	**$0**	**$221,746,231**

TANGIBLE ITEMS	**OD**	**Footage**	**$/ft**			
Drive Pipe	36"	200	$650.00	$130,000	$0	$130,000
Conductor	22"	279	$180.00	$51,000	$0	$51,000
Surface	16.5" SET	5,107	$300.00	$1,533,000	$0	$1,533,000
Intermediate	16.5" SET	3,607	$300.00	$1,083,000	$0	$1,083,000
Intermediate	16"	11,714	$155.00	$1,816,000	$0	$1,816,000
Intermediate	13-3/8"	14,893	$140.00	$2,086,000	$0	$2,086,000
Intermediate	11-3/4"	3,780	$80.00	$303,000	$0	$303,000
Production Liner	0	0	$0.00	$0	$0	$0
Production Tie-back	0	0	$0.00	$0	$0	$0
Tubing	0	0	$0.00	$0	$0	$0
Liner Equipmt				$150,000	$0	$150,000
Whipstock Equipment				$0	$0	$0
Subsurface Completion				$0	$0	$0
Wellheads				$500,000	$0	$500,000
Miscellaneous/Other				$100,000	$0	$100,000
Tan Contingency at 10%				$776,000	$0	$776,000
TOTAL TANGIBLE				**$8,528,000**	**$0**	**$8,528,000**
Total Dry Hole Cost				**$230,274,231**	**$0**	**$230,274,231**
Total Completion Cost				**$0**	**$0**	**$0**
Prepared by: **WSWhitney / NPilisi** — **Total Drill and Complete**				**$230,274,231**	**$0**	**$230,274,231**

SCOPING COST ESTIMATE DETAIL Rev 4

BEAM - Baja Case 4c *** DRAFT **

Prepared For: IODP / JAMSTEC / CDEX

Exploratory _X__
Development __

AFE# xxx	Operator: CDEX / JAMSTEC		Revision No.	1	Date:	30-Jun-13
Prospect or Field: Mantle Hole	Lease Name: N/A	Case No.: #4c	Water Depth: 4300m / 14,108	Proposed TD: 10,400m / 34,120 ft	Objective: Moho / Mantle	
Location: Baja	Surface Location: Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W					
	Btm. Hole Location: Lat: 25.0 - 33.0°N / Long: 120.0 - 127.0°W					

Purpose of Expenditure:
Scientific Drilling to the Mantle. Assume drilling to the Moho, then coring 500m of the Mantle
Case 4c: Expandable Case Well Configuration

Avg Intan $/day: $959,939

Drilling Rig : Chikyu — Directional Plan: Vertical Hole

INTANGIBLE ITEMS	Qty	Unit	Rate	Basis	Amount	Dry Hole Drlg	Complete	TOTAL
					Operational Time =	231 Days		231 Days
Location/ Regulatory Costs						$3,020,000	$0	$3,020,000
Metocean Study (desktop study, data collection/processing)				Lump Sum	$1,000,000			
Site Survey (desktop study, bathymetry)				Lump Sum	$2,000,000			
Regulatory				Lump Sum	$20,000			
Rig Mobilization, Demobilization						$14,600,000		$14,600,000
Mobilization (from Japan)				Lump Sum	$7,300,000			
Demobilization (to Japan)				Lump Sum	$7,300,000			
Drilling Rig - Day Work						$130,300,000	$0	$130,300,000
Drilling Day Rate	231	Days	$300,000 /day		$69,300,000			
Existing Riser System Modifications				Lump Sum	$14,000,000			
Additional Riser				Lump Sum	$47,000,000			
Bits, Drill Collars & Stabilizers						$5,252,000	$0	$5,252,000
Drill Bits	30	No.	$70,000 /bit		$2,100,000			
Drill String Rentals: DC's, Jars, Stab, HWT	231	Days	$4,000 /day		$924,000			
Core Bits	28	No.	$60,000 /bit		$1,680,000			
Coring Services	219	Days	$2,500 /day		$547,500			
Directional & Downhole Services						$3,839,000	$0	$3,839,000
Surveys/Gyros/Single & Multi-Shots				Lump Sum	$20,000			
MWD / LWD Mob / De-mob				Lump Sum	$30,000			
Standard MWD Rental	116	Days	$3,000 /day		$346,500			
Standard LWD Rental	116	Days	$7,000 /day		$808,500			
MWD / LWD Engineers (2)	231	Days	$2,000 /day		$462,000			
Mud Motors & Associated Tools	185	Days	$3,000 /day		$554,400			
High Temp MWD Rental	116	Days	$4,000 /day		$462,000			
High temp LWD Rental	116	Days	$10,000 /day		$1,155,000			
Fuel, Water & Lube						$13,514,000	$0	$13,514,000
Rig Fuel	231	Days	$53,000 /day		$12,243,000			
Boat Fuel	116	Days	$4,000 /day		$462,000			
Helicopter Fuel	116	Days	$3,000 /day		$346,500			
Lubricants	231	Days	$1,300 /day		$300,300			
Fresh Water	231	Days	$700 /day		$161,700			
Drilling Fluids Services						$2,563,000	$0	$2,563,000
Drilling Fluids - WBM				Lump Sum	$1,800,000			
Mud Engineer	231	Days	$800 /day		$184,800			
Cuttings Disposal	231	Days	$2,500 /day		$577,500			
Electric Logging & Cased Hole Logs						$4,793,000		$4,793,000
Wireline Unit and Personnel	231	Days	$3,000 /day		$693,000			
Standard Open Hole Logging				Lump Sum	$1,500,000			
High Temp Open Hole Logging				Lump Sum	$2,500,000			
Cased Hole Logging				Lump Sum	$100,000			
Cementing						$1,039,000	$0	$1,039,000
22"				Lump Sum	$100,000			
16.5" SET				Lump Sum	$100,000			
16.5" SET				Lump Sum	$100,000			
16"				Lump Sum	$150,000			
13.375"				Lump Sum	$150,000			
11.75"				Lump Sum	$100,000			
Retainers, Service Man, Manifold, Etc.				Lump Sum	$50,000			
Unit Charge	231	Days	$1,250 /day		$288,750			

Item	Description	Qty	Unit	Rate		Amount			
Mud Logging and Geological Services							$566,000	$0	$566,000
	Logging Unit Operating rate	231	Days	$1,250 /day		$288,750			
	Personnel Charges	231	Days	$1,200 /day		$277,200			
Land Transportation							$104,000	$0	$104,000
	Trucking	116	Days	$900 /day		$103,950			
Boat Transportation							$2,657,000	$0	$2,657,000
	Work Boat - Spot Hire	116	Days	$14,000 /day		$1,617,000			
	Crew Boat - Spot Hire	116	Days	$9,000 /day		$1,039,500			
Helicopter Transportation							$1,040,000	$0	$1,040,000
	Helicopter - spot hire	116	Days	$9,000 /day		$1,039,500			
Tubular Services							$150,000	$0	$150,000
	QAQC				Lump Sum	$150,000			
Shorebase / Dock Services							$462,000	$0	$462,000
	Shorebase /Dispatcher	231	Days	$2,000 /day		$462,000			$0
Communications							$231,000	$0	$231,000
	VSAT	231	Days	$1,000 /day		$231,000			
Miscellaneous Rental Equipment							$5,479,000	$0	$5,479,000
	Solids Control	231	Days	$400 /day		$92,400			
	Fishing Tools	231	Days	$1,500 /day		$346,500			
	Casing Running Equipment	70	Days	$6,000 Day		$420,000			
	Other Rentals	231	Days	$20,000 Day		$4,620,000			
			Days						
			Days						
Miscellaneous Special Services							$1,135,000	$0	$1,135,000
	Weather Forecasting	231	Days	$150 /day		$34,650			
	Engineering Services - Riser Analysis				Lump Sum	$300,000			
	Engineering Services - Drill String Design				Lump Sum	$200,000			
	Engineering Services - Casing Design				Lump Sum	$50,000			
	Engineering Services - Wellbore Stability				Lump Sum	$100,000			
	Engineering Services - Operational Support				Lump Sum	$200,000			
	Engineering Services - Risk Assessments				Lump Sum	$200,000			
	Engineering Services - Other				Lump Sum	$50,000			
Other Services / Costs							$2,078,000	$0	$2,078,000
	Misc Contract Labor	231	Days	$1,500 /day		$346,500			
	Casing Running	70	Days	$10,000 /day		$700,000			
	Well Insurance				Lump Sum	$500,000			
	Overhead	231	Days	$1,100 /day		$254,100			
	Catering	231	Days	$1,200 /day		$277,200			
Intangible Contingency		15%	Amount		*ST Drlg =*	*$192,822,000*	$28,924,000	$0	$28,924,000
					ST Comp =	*$0*			
						TOTAL INTANGIBLE	**$221,746,000**	**$0**	**$221,746,000**

TANGIBLE ITEMS

	OD	7 =#Strings	Length	$/ft			
Drive Pipe	36"		200	$650.00	$130,000	$0	$130,000
Conductor	22"		279	$180.00	$51,000	$0	$51,000
Surface	16.5" SET		5,107	$300.00	$1,533,000	$0	$1,533,000
Intermediate	16.5" SET		3,607	$300.00	$1,083,000	$0	$1,083,000
Intermediate	16"		11,714	$155.00	$1,816,000	$0	$1,816,000
Intermediate	13-3/8"		14,893	$140.00	$2,086,000	$0	$2,086,000
Intermediate	11-3/4"		3,780	$80.00	$303,000	$0	$303,000
Production Liner							
Production Tie-back							
Tubing							
Liner Equipment					$150,000	$0	$150,000
Whipstock Equipment & BP							
Subsurface Completion							
Wellheads					$500,000	$0	$500,000
Miscellaneous / Other					$100,000	$0	$100,000
Tangible Contingency		10% Amount	*ST Drlg =*	*$7,752,000*	$776,000	$0	$776,000
			ST Comp =	*$0*			
				TOTAL TANGIBLE	**$8,528,000**	**$0**	**$8,528,000**
				Total Dry Hole Cost	**$230,274,000**	**$0**	**$230,274,000**
				Total Completion Cost	**$0**	**$0**	**$0**
Prepared by:	**WSWhitney / NPilisi**			TOTAL WELL COST	**$230,274,000**	**$0**	**$230,274,000**

7 Implementation Timeline

As described in this section, an integrated project timeline has been developed that describes what needs to be done to move this project from its current feasibility stage to an execution stage. It is an effort to provide a detailed roadmap that considers the key milestones, decision points, and the steps that need to be taken to provide the highest probability of success for the Mantle Drilling project. It has been assumed that the target date for the start of operations would be January 2018 as per the IODP project road map shown in Section 2.2.

The framework for developing the timeline is based on a well delivery process that is used in the oil and gas industry for this kind of complex deep water project. A generic description of the five phases of the well delivery process is provided below. Note that it typically takes 12-18 months to work through this process for deep water oil and gas projects. Detailed flowcharts for each of these phases and a typical deepwater project timeline are also provided for reference in Appendix 4.

Well Delivery Process Description

1. Front End Engineering – Well Objectives Definition
   This process involves meeting with the project stakeholders (geoscience, management, engineering, etc.) in order to fully understand and then define the objectives of the well which are written into a Statement of Requirements (SOR) document. This is arguably the most important process since the lack of clear objectives defined early in the planning process can lead to needless confusion, duplication of effort and unnecessary costs. This process culminates with the preparation of a Basis of Design (BOD) document or Design Premise Document (DPD) which, once approved by management, serves as the guide for all subsequent planning and design work.

2. Front End Engineering – Initial Well Planning
   This process involves the thorough review of the offset or analog well data in order to identify potential problem areas, and to understand what worked and what did not during the offset/analog well operations. These lessons learned are then accounted for during the well planning work. An initial well design is generated including a preliminary tubulars design, drilling fluids design, cement design, and so on. Ideally, this work should result in several well design options that satisfy the requirements of the well objectives. A scoping cost is then developed for each option as well as a comparison of the relative risks. These options are then presented to management and a decision is made on which option to move forward with.

3. Detailed Well Planning
   Once the selected option has been decided on and approved, the detailed well planning and design work can begin. This includes getting outside input on the various technical issues and guidance in the form of a HAZID meeting and a peer review of the well plan. An important part of this process is the development of a tender strategy, the development of the work scope for the various services that will be required, and then the tendering of the services. This process should culminate with the preparation of a draft drilling program.

4. <u>Detailed Well Planning – Finalize Well Plan</u>
   When the services contracts are awarded the well design can be finalized with input from the key service companies, and a final well cost estimate is prepared. A "drill well on paper" (DWOP) exercise is then held with the rig crew and service company representatives and then the final drilling program is prepared based on the feedback from the DWOP.

5. <u>Operations Execution and Close Out</u>
   During the operations execution, the engineering and geoscience team provides technical support for the operation, monitors and tracks the operational progress against the plan, and prepares any program revisions that might be required due to changing or unexpected conditions. At the end of the work, a reconciliation between the estimated and actual well costs is prepared as well as an analysis of the operational performance metrics. This culminates with the preparation of a detailed end of well report.

7.1 High Level Timeline Overview

The following Figure shows a high level version of the implementation timeline. The timing is based around 3 key assumptions. The first is that the operations would begin in January 2018. The second has that dedicated work on the project cannot begin before March 2014 which is the start of JAMSTEC's fiscal year. The third, is that the additional marine riser that will be required will not need to be purchased unless the mantle project is approved.

The most notable feature in the timeline is part C - Long Lead Time Items. The 3 year lead time associated with purchasing the additional riser needed to drill at any of the three candidate locations has the most impact on the implementation timeline.

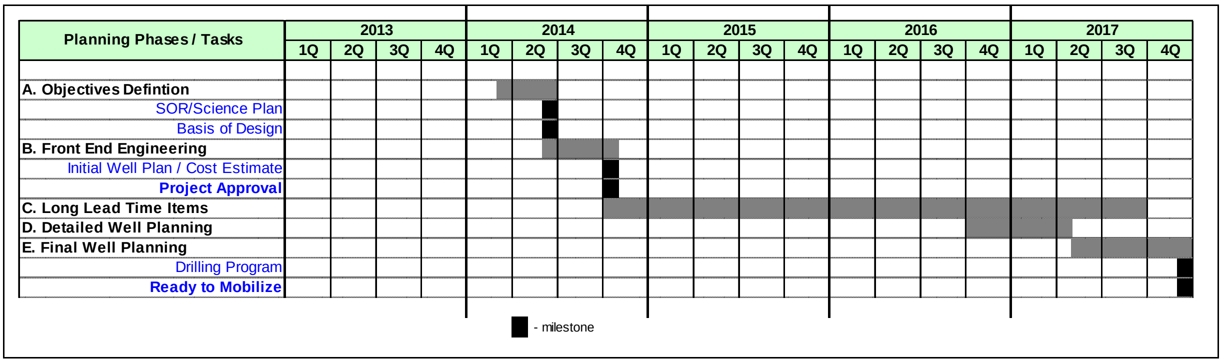


Figure 181. High-level Implementation Timeline

The riser will need to be delivered prior to the start of operations so that it can be integrated onto the Chikyu. If a September 2017 delivery is assumed, then a commitment to purchase the riser needs to be made in September 2014 because of the lead time. This means that the time available to do the upfront work needed to develop the science plan, do the initial well planning, and present the project for approval is the 8 months from March to September 2014. Because of this, there is also an unusually long gap between when this upfront work needs to be done and when the final planning work needs to done for a January 2018 project start.

7.2 Detailed Timeline Discussion

Below is a more detailed implementation timeline that lists the key tasks associated with each phase as well as the key milestones and decision points. A larger version of this timeline is provided in Appendix 3.

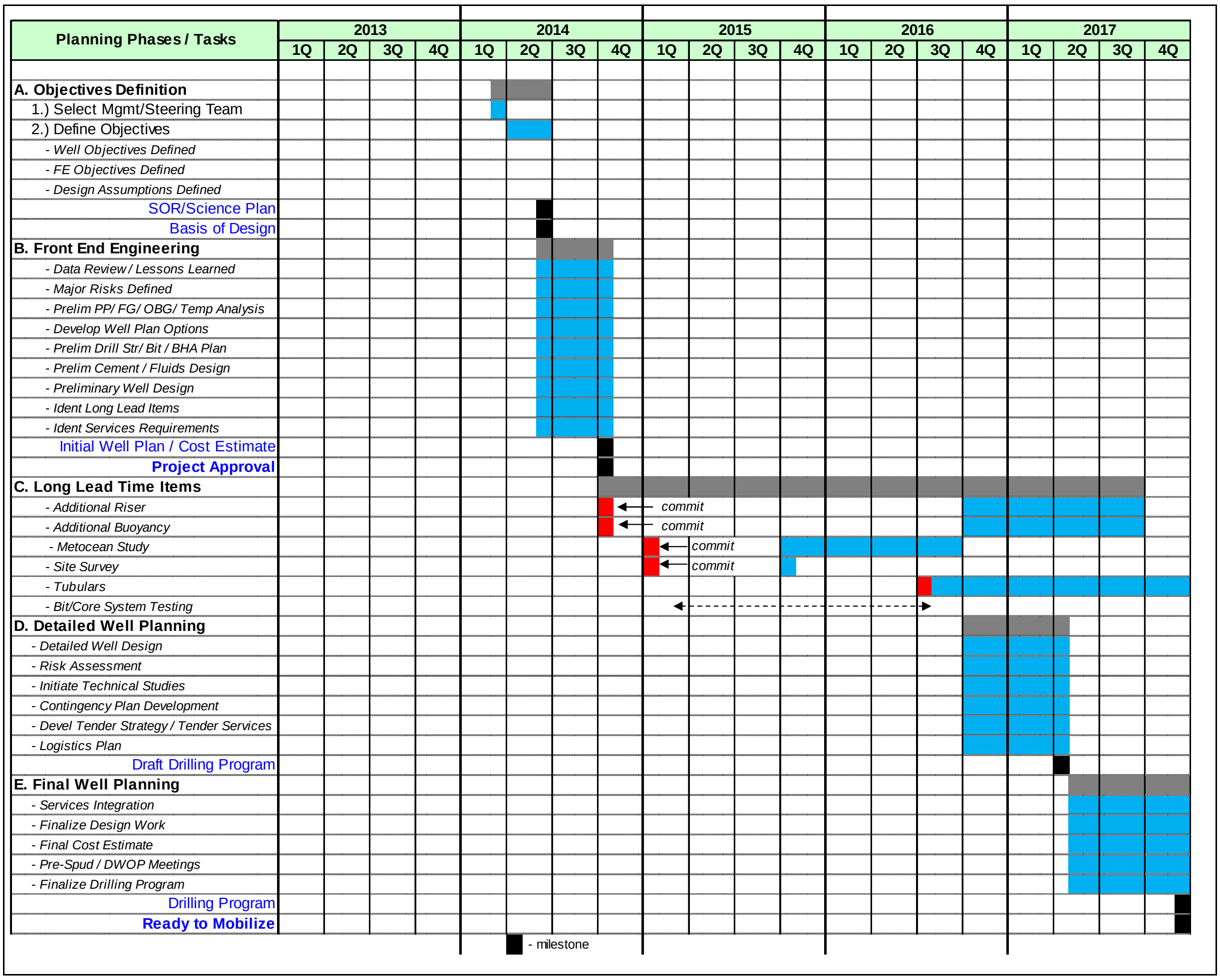


Figure 182. Detailed Implementation Timeline

A. <u>Objectives Definition</u>

The objective of this phase is to formally define the objectives of the project. The milestones would be the preparation of the Statement of Requirements (SOR) or science plan, and Basis of Design (BOD) documents.

- Logically, the first thing that would be needed is the creation of the management function to oversee the project. This could be a classic management team with one individual having overall responsibility and several direct reports, or it could be some sort of steering committee. Regardless, a dedicated team will be needed to oversee the project to provide direction, prioritization of efforts, arbitrate differences, and have final decision making authority. Part of this process would also be to develop an project organizational chart, identify the functional requirements and define roles and responsibilities

- The next step would be to bring together the project stakeholders to define the objectives. The oilfield equivalent of stakeholders would include representatives of the management, geology, geophysics, reservoir, environmental, safety, drilling and completions engineering, and the operations functions. An important goal of this effort would be to define what the minimum requirements are, in terms of types of data that need to be obtained, and the amount of data that needs to be collected along with the associated evaluation program (coring, wireline logging, LWD, cuttings) required to gather the data. Additionally, a prioritized list of data that would be "nice to have" if circumstances allow should also be developed. Ideally, this effort would also include the selection of the candidate location to allow a more focused effort during the Front End Engineering phase, but this is probably not required at this stage. The results would then be documented in an SOR or science plan.

- Finally, the key information and initial assumptions that are to be used in the design of the well would be documented in the BOD. This would include geologic information (formation tops, thicknesses, seismic sections), identification of offset or analog hole data, geothermal temperature profile, subsurface formation pressure and strength profile, considerations to be used in the tubulars selection and design, riser design, cementing and drilling fluids systems design, and environmental, health, and safety considerations.

  As discussed in section 3.2 a vital aspect of this effort will be to define and then mitigate the uncertainties around the down hole conditions in order to develop the appropriate well design. This will require a concerted joint effort between the science community, industry subject matter experts and the well design engineers to define the most likely down hole conditions that can be expected, and which aspects have the most uncertainty.

B. <u>Front End Engineering</u>

The objective of this phase would develop an initial well design (or designs) so that a more comprehensive cost estimate can be prepared which can then be presented to the management team in order to get a formal decision on whether or not to go ahead with the project before having to make any significant financial commitments. The milestones would be the development of the initial well design(s), cost estimate and project approval.

- With the project objectives and the design basis defined, the engineering team now has the information and tools needed to prepare an initial well design and develop an estimate of the project costs.

- The first step of this process typically involves a thorough review of the offset or analog hole data in order to identify the major issues and risks and to identify the previous "lessons learned" that should be incorporated into the well plan.

- There is seldom just one way to design a well so several different design options are typically developed along with initial designs for the tubulars, drill string, drilling fluids and cement systems, riser and so on. In addition, the key risks are identified as well as what additional information (i.e. additional technical studies) are needed to help mitigate the risks.

- Once the foundational design work has been done, cost estimate can be prepared for each design option. The options, cost estimates and an evaluation of the risks associated with each option would then be presented to management who now has the information needed to decide whether or not to move ahead with the project. Note that if a decision on the location was not been made during the objectives definition phase, then this work would need to be done for all three locations, and the final decision will need to made on where the hole will be drilled as part of the management review.

Given the assumptions around which this timeline is based, the time available for these two phases is the 8 months from March to September 2014. The time available was arbitrarily split between the two phases so four months are allocated to each. This is a rather tight time frame given the amount of work that needs to be done, particularly if the final location decision is not made early on in the process.

C. <u>Long Lead Time Items</u>

Long lead time items are equipment or services that need a longer than usual period of time to manufacture or source. As such, they typically require a financial commitment much earlier than what is needed (or desired) for the majority of the products or services that will be used during a project. In this case, the lead time associated with purchasing the additional riser and buoyancy needed to drill at any of the three candidate locations has the most impact on the implementation timeline

- The lead time for conventional steel riser is currently running at 3 years based on information and a quote provided by NOV. This is also consistent with information provided by the other riser manufactures. Obviously the lead time associated with aluminum, titanium, hybrid, or composite risers would be longer. As such, the commitment for purchasing the additional riser would need to be made in September 2014 in order to have it delivered in September 2017 so that there is time to incorporate it onto the Chikyu prior to the start of the project.

- Collecting the required metocean data takes about a year. Ideally the information should be available before the start of the detailed well planning phase, in which case the data collection efforts would need to begin around September 2015 and committed to in January 2015 because of the lead time required to organize the survey. The site survey does not take as much time to complete, but it is assumed that this would be done at the same time as the metocean survey to minimize mobilization costs. Recall from Section 5 that it has been assumed that this work would be done by a third party contractor.

- The typical lead time for purchasing tubulars is between 10 to 18 months and does not need to be delivered until just before the start of operations. Depending on the final wellbore configuration that is selected, the commitment for the tubulars would need to done somewhere between the 3rd quarter of 2016 and the 1st quarter of 2017.

- As was discussed in Section 2.2, conducting field tests of promising bit designs on other representative IODP projects in order to optimize the bit selection would be very beneficial considering that time has the largest influence on costs. Although this is not technically a long lead time item, it will require some time to organize and conduct the design iterations. There should be an ample amount of time available to conduct these field tests between the time the project would be approved and when the detailed design work needs to start.

- It is conceivable that high temperature down hole tools could become a long lead time if specific tools need to be developed specifically for this project because they are not yet available in the industry. This is not specifically listed in the timeline because it depends on the science plan, the location selected, and the state of industry technology 2-3 years from now.

Note that these long lead time requirements imply that a financial commitment of some $64,000,000 has to be made around 3 years before the start of the project.

D. Detailed Well Planning

This phase normally begins right after the project is approved and involves conducting the required detailed design work that builds on the initial work done during the front end engineering phase. The milestone would be a draft drilling program. The key aspects of this phase include:

- Detailed designs for the tubulars, drill string, BHA's, drilling fluids and cement systems, riser and so on.

- Development of risk mitigation strategies and contingency plans.

- Development of a logistics and operations support plan

- Initiation of the technical studies needed to resolve particular technical issues. These may be done internally or may require outside expertise. These studies could include:
  - Riser analysis
  - Drill string design
  - Wellbore stability
  - Tubulars design
  - Risk assessment / HAZID / Peer Review support
  - Drill fluids design
  - Cementing system design

- Development of a tender strategy and the development of the work scope for the various services that will be required, followed by the tendering and selection of the services companies.

E. Final Well Planning

At this point the major service companies (drilling fluids, cementing, bits, MWD/LWD, etc) will have been selected, and the design work can be completed with their input based on the actual tools, equipment, expertise, and services that will be provided for the project. A DWOP exercise is typically held towards the end of this phase. This is held with the rig crews and service company representatives in order to walk through the well plan in detail to familiarize them with the plans and to get their suggestions and feedback. The milestone is a finalized drilling program and operations are ready to commence as soon as the Chikyu arrives on location. It has been assumed that the detailed and final well planning efforts will take around 15 months which is not uncommon for complex deepwater wells. As such, this work would need to begin in the 4th quarter of 2016.

Commentary

Clearly the main driver for timing for this implementation plan is the lead time required to for the additional riser, and the assumption that the mantle project must be approved before a commitment is made to purchase the riser. If these issues are de-linked so that the decision to purchase the riser is independent of whether the mantle project will go forward, then the riser will still need to be ordered in September 2014, but the work on the mantle project will not need to begin until around late 2015 or possibly early 2016.

8 Conclusions

The key conclusions and recommendations from this study are as follows.

- The Base Case wellbore configuration developed during the Feasibility Study may be overly optimistic in terms of the number of casing strings that may be needed to get to TD. The uncertainty with respect to the down hole conditions and the hole stability problem that occurred at the 1256D site suggests that the wellbore configuration needs to be able to accommodate additional contingency casing strings to allow for unexpected wellbore stability problems. The wellbore configurations provided represent the range of options. The Base Case represents the most simple configuration and arguably most risky in terms of being able to get to TD and accomplish the goals of the project. The Expandable Cases represents the most complex/expensive but least risky option in terms of being able to get to TD.

- The uncertainty over the down hole condition poses the biggest risk with respect to being able to actually get to the mantle. Mitigating these risks will require a concerted joint effort between the science community, industry subject matter experts, and the well design engineers to define the most likely down hole conditions that can be expected, and which aspects have the most uncertainty. The results of this effort can then serve as the basis for developing an appropriate wellbore configuration.

- The uncertainty over drilling and coring performance and the resulting impact on operational time cost poses the biggest risk associated with being able to complete this project within a reasonable amount of time at a reasonable cost. This uncertainty can be reduced by working a drilling tools service companies in order to take advantage of the full range of experience and services they can provide during both the planning and operational phases of the project in order to optimize the bit selection and drilling practices.

- The main driver of project cost is the number of days it will take to drill/core the hole which accounts for over 50% of the total cost. The effect of the other cost elements is almost irrelevant.

- The cost of coring large sections of the hole vs. drilling to the Moho and just coring the mantle adds between $14 to $51 million to the project cost depending on the location,

- The 3 year lead time associated with purchasing the additional riser needed to drill at any of the locations is the main timeline driver. The riser would need to be ordered around September 2014 to be ready in time for a January 2018 project start. Assuming that the project needs to be approved before the making the financial commitment for the riser, then upfront project work including the development of the science plan will need to start around March 2014. If these issues are de-linked so that the decision to purchase the riser is independent of whether the mantle project will go forward, then the riser will still need to be ordered in September 2014, but the work on the project will not need to begin until around late 2015 or possibly early 2016

- Based on the results of the new set of drilling riser analyses and sensitivity studies, it appears that steel riser can be used without changing current industry practices to a maximum of 3657m (12,000 ft) water depth, and for certain drilling conditions (i.e. mud weight and metocean data). Beyond this water depth, some critical responses from the drilling riser (i.e. VME stress) and riser components (i.e. rotation of the upper and lower flex joints) violate the current API 16Q criteria if riser joints made of steel are used.

  In order to push the envelope using steel material, the maximum allowable VME will have to be increased from 67% of minimum yield to a higher ratio. It is important to note that API 16Q currently does not address riser response criteria for ultra-deepwater wells with water depth greater than 3048m (10,000 ft) and also that the VME criteria is limited to 67% of minimum yield to avoid accounting for and tracking riser joint fatigue during the life of the riser. To push the envelope, and to be able to use steel riser for water depth greater than 3657m, a new set of riser response criteria will have to be developed and a design/operational risk assessment will also have to be conducted. Regarding the VME maximum limit, this could very well be increased from 67% to 80% or 90% but the fatigue damage of the riser joints will also have to be monitored during the entire life of the riser. This is feasible for drilling operations conducted with the Chikyu since it currently uses a riser monitoring system which is capable of tracking stress and fatigue in the riser. Also, tests to increase the mean allowable rotation angle at the two flex joints will have be performed.

  Finally, the technical solution that would follow current API 16Q riser response criteria, and that will enable to drill in water depths up to 4267m (i.e. Hawaii and Baja) will be to use drilling hybrid riser joints or joints with advanced materials such as titanium or composite. The high minimum yield and strength to weight ratio of titanium and composite materials relative to steel would not require any adjustment to API 16Q recommended practices criteria, or a need for riser component limits, or even risk assessments. Nonetheless, the high cost associated with titanium and the lack of experience with composite materials for ultra-deepwater offshore applications can be seen as a different technical limitation for conduct drilling operations in water depths greater than 3657m. Composite materials seem very attractive, but these materials have not been tested or field deployed for deepwater drilling riser systems. Indeed, the ability to keep the same weight and strength for a given riser joint made of composite material, as well as maintaining the structural integrity of the drilling riser connectors, remain a great challenge yet to be resolved.

Appendix 1: Evolution of ROP Assumptions

The evolution of the rate ROP assumptions used in the time and cost estimates is illustrated below.

- **2011 Feasibility Study Assumptions**

Stratigraphy	Coring	Drilling	
Sediments	3.0	15.2	m/hr
Lava	1.5	3.0	m/hr
Dikes	1.5	3.0	m/hr
Textured Gabbros	1.2	2.4	m/hr
Foliated Gabbros	1.2	2.4	m/hr
Layered Gabbros	0.9	1.5	m/hr
Mantle	0.9	0.0	m/hr

- **Ideal Estimates per NOV – 2012**

Hole Section	Rate of Penetration (ft/hr)		Rate of Penetration (m/hr)		Bit Life
	Ideal Bit	Ideal Bit/Motor	Ideal Bit	Ideal Bit/Motor	(hours)
Upper part of the hole :	70.0	100.0	21.3	30.5	110
Lower part of the hole :	50.0	70.0	15.2	21.3	70

- **2012 High Impact Study Assumptions**

Stratigraphy	RCB Coring	Drilling	
Sediments	4.0	21.3	m/hr
Lava	2.1	9.1	m/hr
Dikes	2.1	9.1	m/hr
Textured Gabbros	1.5	9.1	m/hr
Foliated Gabbros	1.5	3.0	m/hr
Layered Gabbros	1.2	3.0	m/hr
Mantle	1.2	1.8	m/hr

Bit Life < 7010m = 110 hrs

Bit Life > 7010m = 70 hrs

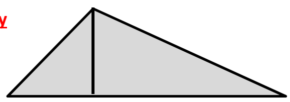
- ## 2013 Implementation Plan Study Assumptions

Stratigraphy	Coring	Drilling	Coring	UR	
Sediments	12.0	26.2	14.4	16.5	m/hr
Lava	1.7	21.1	4.3	7.6	m/hr
Dikes	4.9	10.4	3.2	8.1	m/hr
Textured Gabbros	2.8	10.2	2.6	3.6	m/hr
Foliated Gabbros	2.0	6.5	4.3	2.1	m/hr
Layered Gabbros	1.6	5.2	2.9	2.9	m/hr
Mantle	1.3	2.7	2.4	1.8	m/hr

- ## 2013 Implementation Plan Study Stochastic Assumptions

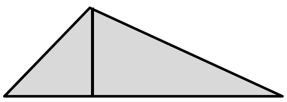
ROP by Stratigraphy

Sediments



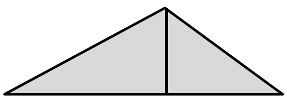
	RCB Core	Drill	Conv Core	UR	
Min =	2.4	9.1	3.0	9.1	m/hr
ML =	4.0	21.3	12.2	12.2	m/hr
Max =	15.2	30.5	15.2	24.4	m/hr

Lava, Dikes
Textured Gabbros



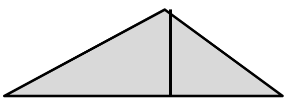
	RCB Core	Drill	Conv Core	UR	
Min =	1.2	3.0	1.5	3.0	m/hr
ML =	2.1	9.1	4.6	7.6	m/hr
Max =	6.1	21.3	6.1	9.1	m/hr

Foliated Gabbros
Layered Gabbros



	RCB Core	Drill	Conv Core	UR	
Min =	0.9	1.5	1.5	1.5	m/hr
ML =	1.5	3.0	2.4	2.4	m/hr
Max =	2.4	9.1	4.6	6.1	m/hr

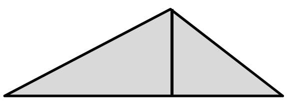
Mantle



	RCB Core	Drill	Conv Core	UR	
Min =	0.9	1.5	0.9	0.9	m/hr
ML =	1.2	1.8	1.5	1.5	m/hr
Max =	2.1	6.1	3.0	4.6	m/hr

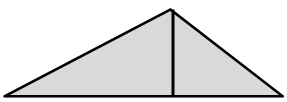
Bit Life by Depth

Bit Life <= 6706m



	Bit Life	
Min =	30	hrs
ML =	110	hrs
Max =	150	hrs

Bit Life > 6706m



	Bit Life	
Min =	20	hrs
ML =	70	hrs
Max =	110	hrs

Appendix 2: Example Cost Estimate Element Assumptions

The following is an example of the cost estimate assumptions that were used for each cost element using the Cocos Case 4b as an example. The same basic assumptions were used for all of the cost estimates.

BEAM - Budget Cost Estimate Assumptions
Cocos, Case 4b

Revised: 10 June, 2013

Location/ Regulatory Costs

Metocean Study
- Obtain data regarding weather, wind, waves and currents at the location. Needed for riser/conductor analysis, stationing keeping / weather downtime prediction. Data collection takes about a year
- Cost / work scope info per meetings with RPS and Fugro. Reference BEAM report from 2012

RPS 750,000 12 month water column study
Fugro 1,000,000 12 month water column study

Assume: **1,000,000**

Site Survey
- Obtain seafloor bathymetry data, slope stability, AUV hi-res data, soil strength assessment

Fugro Survey costs $50-60,000 /day
Ballpark cost $2 million

Assume: **2,000,000**
Which is 33.3 days

Regulatory
- Presumably there are some cost associated with telling the appropriate authorities what's going on
- Est per oil field analog

Assume: **20,000**

Rig Mobilization, Demobilization

Mobilization

From : Tokyo
Distance : 6600 miles
Avg Speed : 10 kts
Time : 23.9 days

Speed	Time (d)	Day rate	Rig Cost
10	23.9	300,000	7,170,000
5	47.8	300,000	14,340,000

Fuel Costs per IODP	kl/day	gal/d	$/gal	$/day	Tot Days	Tot $
Fuel - Transit (5 kt) kl/d	50	13,209	4.00	52,836	47.8	2,525,561
Fuel - Transit (10 kt) kl/d	100	26,417	4.00	105,668	23.9	2,525,465

Lump Sum = **16,865,561** at 5 knots
Lump Sum = **9,695,465** at 10 knots

Going fast is cheaper **Assume:** **9,700,000**

De-Mobilization
- Assume rig de-mob's back to Japan at same cost as Mob

Drilling Rig - Day Work

Day rate assumption - Start with the average oilfield drill ship day rate for 2012 per Ocean Industry Magazine, then reduce the cost to account for the fact that this is a non-profit operation

Worldwide day rates

Year/Month	Minimum	Average	Maximum
Drillship			
2012 Jan	$155,000	$432,407	$690,000
2012 Feb	$155,000	$438,974	$672,000
2012 Mar	$155,000	$438,541	$671,000

Monthly Avgs
432,407
438,974
438,541
443,204
439,230
433,976

2012 Apr	$157,000	$443,204	$671,000
2012 May	$157,000	$439,230	$671,000
2012 June	$50,000	$433,976	$671,000
2012 July	$50,000	$438,074	$671,000
2012 Aug	$50,000	$442,213	$671,000
2012 Sept	$50,000	$429,391	$671,000
2012 Oct	$50,000	$427,920	$672,000
2012 Nov	$50,000	$443,074	$672,000
2012 Dec	$50,000	$450,437	$672,000

438,074
442,213
429,391
427,920
443,074
450,437

438,120 = Average

		NP Adj*	Day Rate
Assume:	**438,000**	138,000	**300,000**

*Non-Profit Adjustment: Adjustment from normal commercial pricing that considers market conditions, profit, depreciation and other cost components that do not apply in this case.

Additional Riser
- additional 5000 ft of riser required. **Assume: 47,000,000**
- cost per NOV quote, April 2013

Existing Riser System Modifications
- costs for new buoyancy modules and associated rig mods **Assume: 14,000,000**
- cost per NOV quote, April 2013

Bits, Drill Collars & Stabilizers

Bit Costs
- Determine number of drill/core bits needed from ops time estimate spreadsheet
- Avg bit cost per oilfield analog

Drill Bits	# Needed	$/bit	Bit $
	24	70,000	**1,680,000**

Core Bits	# Needed	$/bit	Bit $
	6	60,000	**360,000**

Core Services
- per oilfield analog **Assume: 2,500** /day **Assume: 62** Days Needed

Drill String Rentals - General
- per oilfield analog **Assume: 4,000** /day includes reamers, etc

Directional & Downhole Services

Costs per oilfield analogs

Surveys/Gyros/Single & Multi-Shots	**Assume:**	**20,000**	lump sum	
MWD / LWD Mob / De-mob	**Assume:**	**30,000**	lump sum	
Standard MWD Rental	**Assume:**	**3,000**	/day	
Standard LWD Rental	**Assume:**	**7,000**	/day	
MWD / LWD Engineers (2)	**Assume:**	**2,000**	/day	battery disposal, 6-700/set
Mud Motors & Associated Tools	**Assume:**	**3,000**	/day	
High Temp MWD Rental	**Assume:**	**4,000**	/day	
High temp LWD Rental	**Assume:**	**10,000**	/day	

Fuel, Water & Lube

Rig Fuel
- Usage per IODP is 40-60 kl/day during DP operations

kl/day	gal/d	$/gal	$/day
50	13,209	4.00	52,836

Assume: **53,000** /day

Costs per oilfield analogs

Boat Fuel	**Assume:**	**4,000**	/day
Helicopter Fuel	**Assume:**	**3,000**	/day

Assume spot hire services, since likely won't need them every day.

Lubricants
- Usage per IODP is 0.6 kl/day

2012 total (yen)	2012 total (USD	$/day
45,000,000	450,000	1232.88

Assume: **1,300** /day

Fresh Water
- Usage per IODP

2012 total (yen)	2012 total (USD	$/day
5,000,000	50,000	136.99

Assume: **700** /day
per oilfield analog

Drilling Fluid Services

WBM Cost
- per Buck Dear
- *"I would assume $2 million as the riser volume is huge assuming a 20" riser and there are expensive chemicals for temperature stability and fluid loss control." = 91.00 $/ft*

Assume: **1,900,000** WBM System

Mud Cost =	1,865,955
Hole Footage =	20,505
Cost/ft =	91.0

Mud Engineer
- per oilfield analog **Assume:** **800** /day

Cuttings Disposal
- per oilfield analog **Assume:** **2,500** /day Current practice is not to discharge WBM cuttings

Electric Logging & Cased Hole Logs

Costs per oilfield analogs

Wireline Unit and Personnel	**Assume:**	**3,000**	/day
Standard Open Hole Logging	**Assume:**	**1,500,000**	lump sum
High Temp Open Hole Logging	**Assume:**	**2,500,000**	lump sum
Cased Hole Logging	**Assume:**	**100,000**	lump sum

Cementing

Costs per oilfield analogs

22"	**Assume:**	**100,000**	lump sum
18"	**Assume:**	**100,000**	lump sum
16"	**Assume:**	**150,000**	lump sum

13.375"	Assume:	150,000	lump sum
11.75"	Assume:	100,000	lump sum
9.625"	Assume:	100,000	lump sum
Unit Charge	Assume:	1,250	/day
Retainers, Misc Equip	Assume:	50,000	lump sum

Mud Logging and Geological Services

Costs per oilfield analogs

Logging Unit Operating rate	Assume:	1,250	/day
Personnel Charges	Assume:	1,200	/day

Transportation

Costs per oilfield analogs
- Presumably don't need these every day, but will be some costs due to project duration

Land	Assume:	900	/day
Work Boat	Assume:	14,000	/day
Crew Boat	Assume:	9,000	/day
Helicopter	Assume:	9,000	/day
Days Needed	Assume:	100	

Tubular Services

Costs per oilfield analogs

QAQC	Assume:	150,000	lump sum

Shorebase / Dock Services

Costs per oilfield analogs

Shorebase /Dispatcher	Assume:	2,000	/day

Communications

Costs per IODP

		Yen/mon	$/mon	$/day			
Comms	V-Sat	3,000,000	30,000	1000	Assume:	1,000	/day

Miscellaneous Rental Equipment

Costs per oilfield analogs

Solids Control	Assume:	400	/day			
Fishing Tools	Assume:	1,500	/day			
Casing Running Equipment	Assume:	6,000	/day	Assume:	70	Days Needed
Other Rentals	Assume:	20,000	/day			10d/String

Miscellaneous Special Services

Costs per oilfield analogs

Weather Forecasting	**Assume:**	**150**	/day
Engineering Services - Riser Analysis	**Assume:**	**300,000**	lump sum
Engineering Services - Drill String Design	**Assume:**	**200,000**	lump sum
Engineering Services - Casing Design	**Assume:**	**50,000**	lump sum
Engineering Services - Wellbore Stability	**Assume:**	**100,000**	lump sum
Engineering Services - Operational Support	**Assume:**	**200,000**	lump sum
Engineering Services - Risk Assessments	**Assume:**	**200,000**	lump sum
Engineering Services - Other	**Assume:**	**50,000**	lump sum

Other Services / Costs

Costs per oilfield analogs

Misc Contract Labor	**Assume:**	**1,500**	/day			
Casing Running	**Assume:**	**10,000**	/day	**Assume:**	**70**	Days Needed
Well Insurance	**Assume:**	**500,000**	lump sum			10d/String
Overhead	**Assume:**	**1,100**	/day			
Catering	**Assume:**	**1,200**	/day			

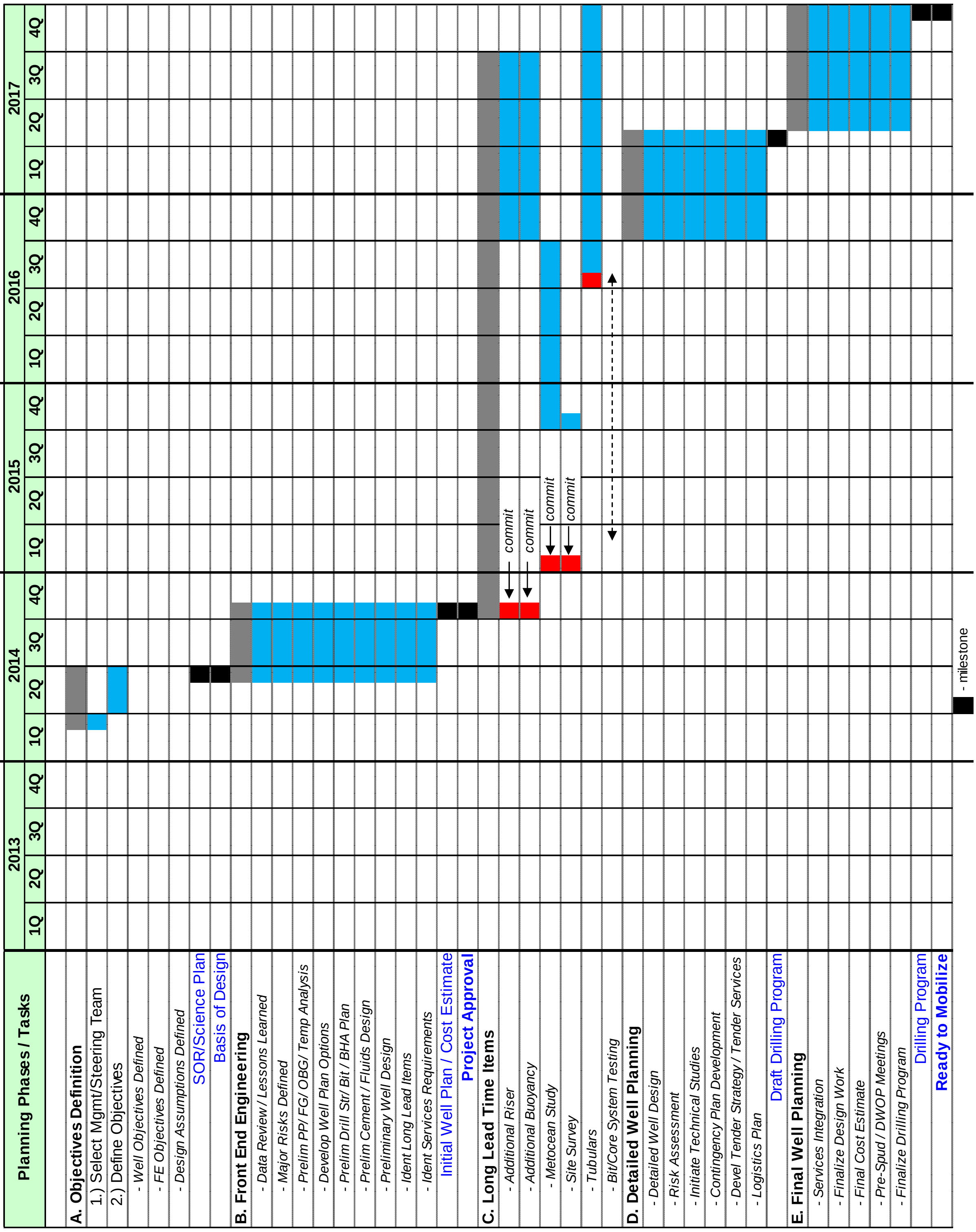
TANGIBLE ITEMS

Costs per oilfield analogs

	From	To	Length			
36"	11,975	12,175	200	**Assume:**	**650**	$/ft
22"	11,975	12,745	770	**Assume:**	**180**	$/ft
18"	12,645	17,552	4,907	**Assume:**	**160**	$/ft
16"	12,545	20,850	8,305	**Assume:**	**155**	$/ft
13-3/8"	11,975	24,200	12,225	**Assume:**	**140**	$/ft
11-3/4"	23,900	27,500	3,600	**Assume:**	**80**	$/ft
9-5/8"	27,200	30,840	3,640	**Assume:**	**70**	$/ft

Liner Equipment	**Assume:**	**300,000**	lump sum ($150,000 each)
Wellheads	**Assume:**	**500,000**	lump sum
Miscellaneous / Other	**Assume:**	**100,000**	lump sum

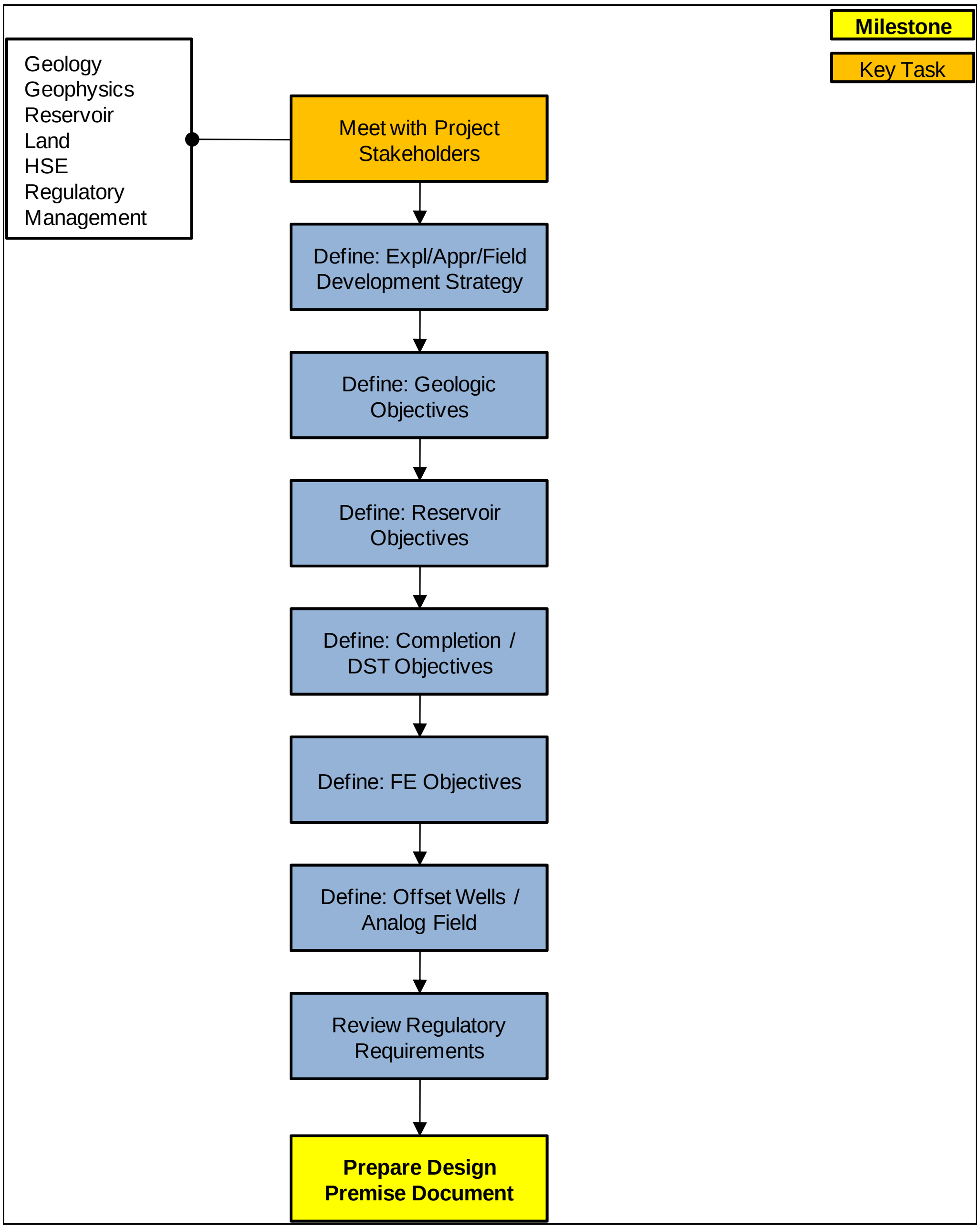
Appendix 3: Implementation Timeline



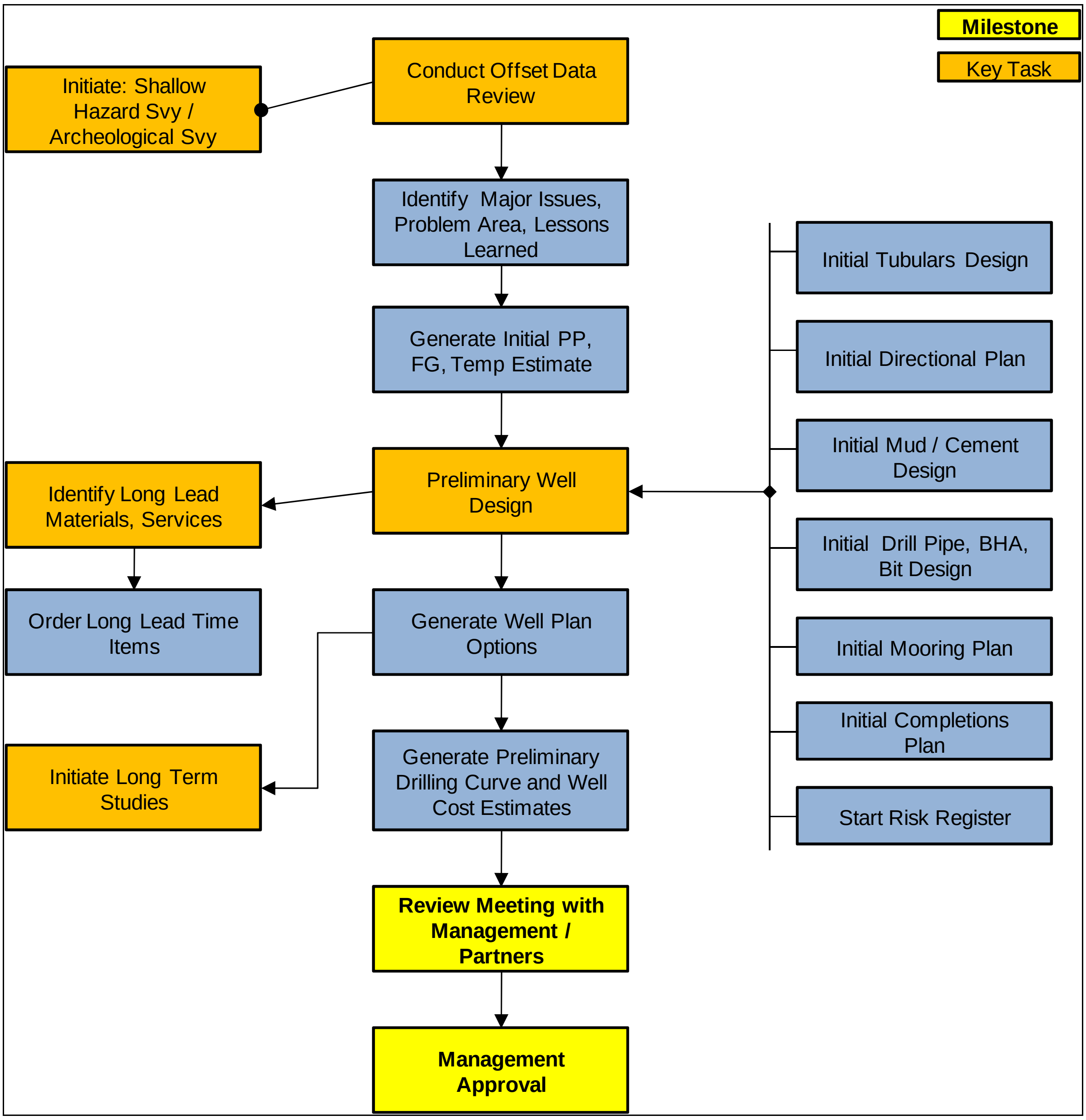
Appendix 3: Example Well Delivery Process Flowcharts

The following are generic flowcharts that describe the various phases of the well delivery process that is used for planning deepwater drilling projects in the oil and gas business. Obviously not everything will be directly applicable to the BEAM project, but they are provided for reference.

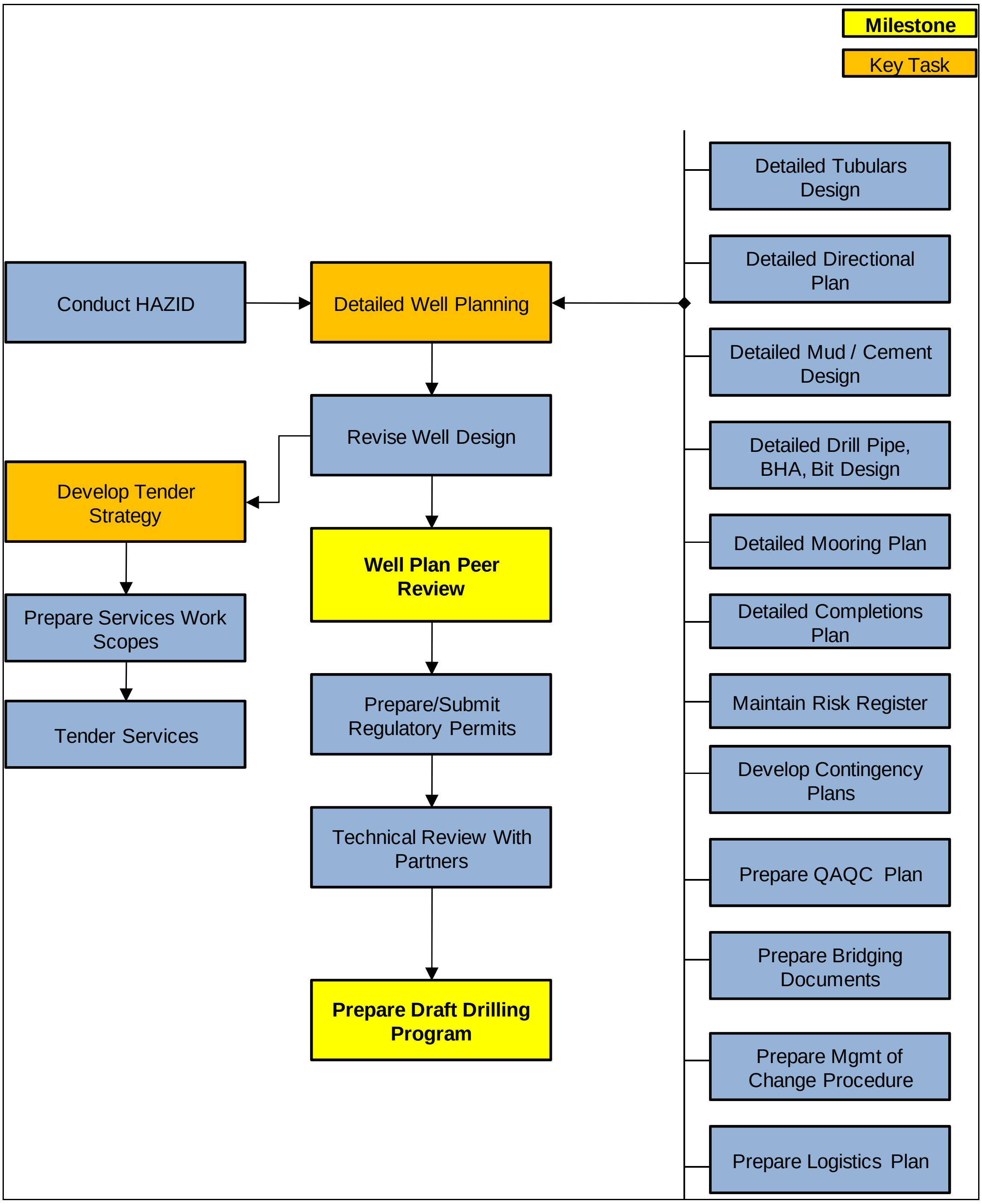
1. Front End Engineering – Well Objectives Definition



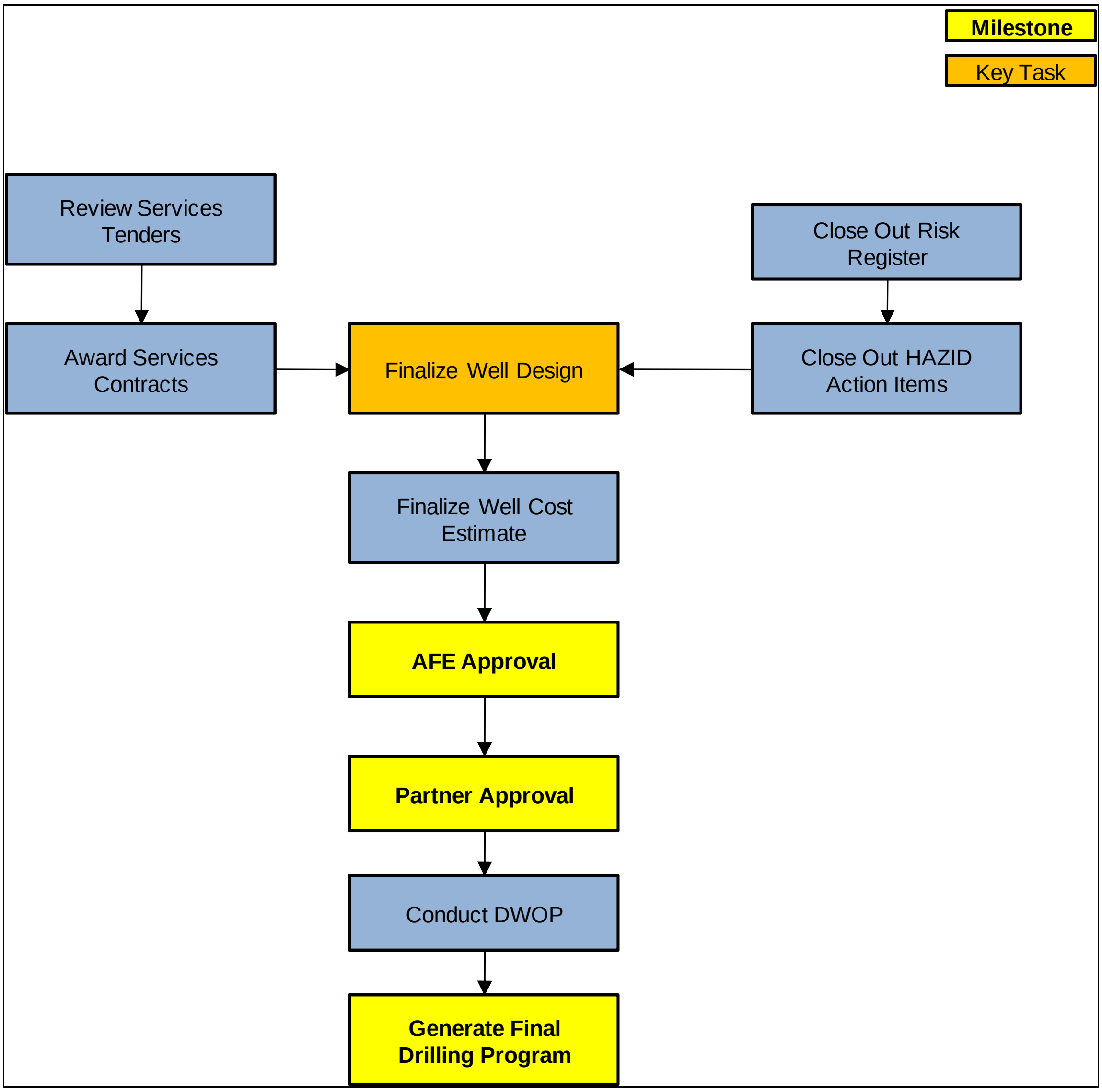
2. Front End Engineering – Initial Well Planning



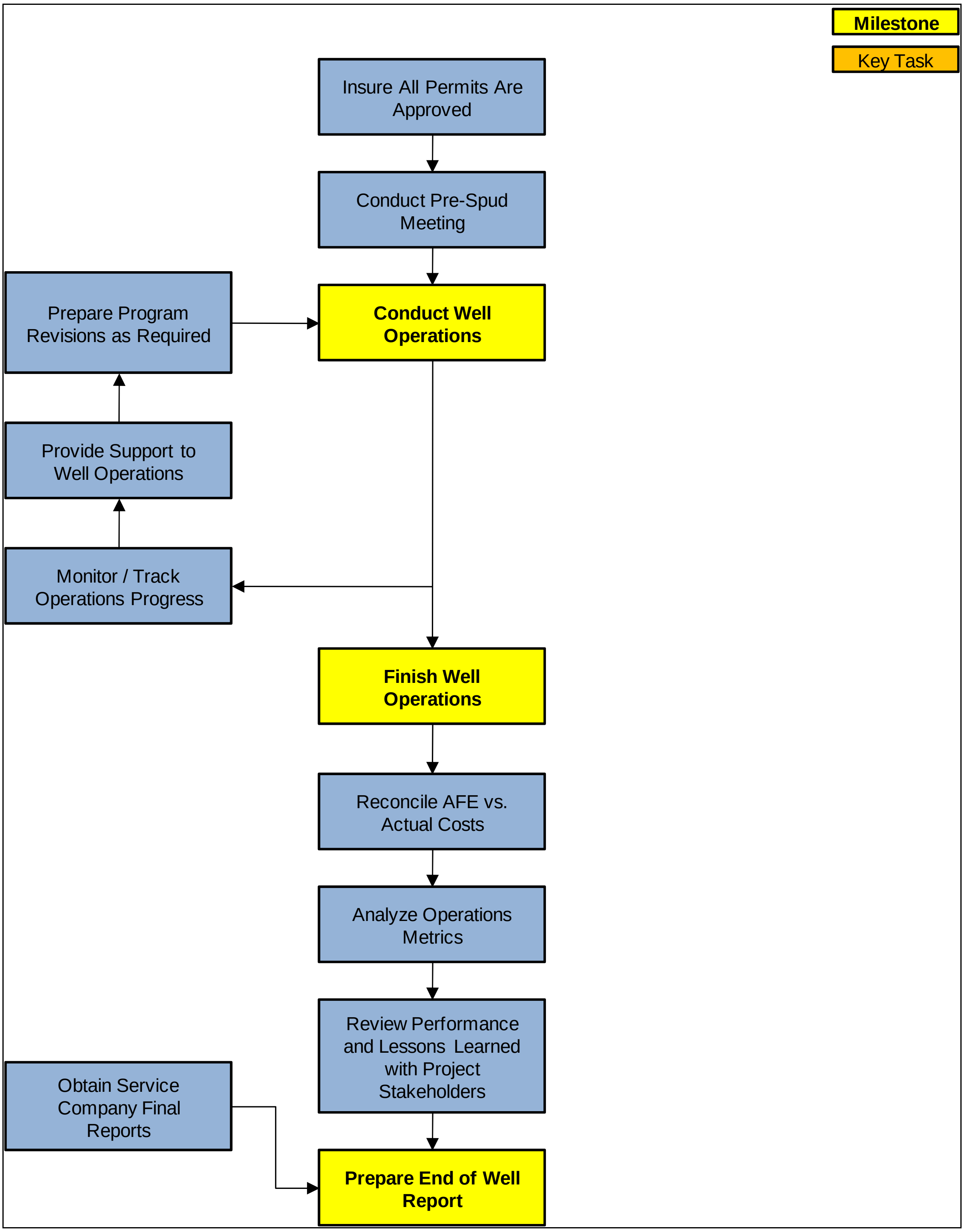
3. Detailed Well Planning



4. Detailed Well Planning – Finalize Well Plan



5. Operations Execution and Close Out



Generic Deepwater Well Planning Timeline Example

For reference, the following is a generic planning timeline for a deepwater well. The planning process typically takes 12-18 months depending on the complexity of the project and its location.

Generic Deepwater Well Planning Timeline

Well Planning Phases / Tasks	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12	Month 13
A. Front End Engineering (FEED)													
1.) Well Objectives Definition													
- Well Objectives Defined													
- FE Objectives Defined													
- Offset Wells / Analog Field Defined													
- Completion/DST Objectives Defined													
Basis of Design													
2.) Initial Well Planning													
- Offset Data Review / Lessons Learned													
- Major Risks Defined													
- Prelim PP / FG / Temp Analysis													
- Develop Well Plan Options / Scenarios													
- Preliminary Well Design / Schematic													
- Prepare Casing Design													
- Prelim Drill Str / Landing Str / BHA Plan													
- Prelim Cement / Fluids Design													
Initial Well Plan(s)													
Initial Cost Estimate(s)													
Management Approval													
B. Detailed Well Planning													
1.) Well Design													
- Detailed Well Design													
- Anchor Handling / Mooring Procedure													
- Order Long Lead Time Items													
- Rig Acceptance Strategy													
- Develop Tender Strategy / Tender Services													
- Logistics Plan													
- Contingency Plan Development													
- Permit to Drill													
2.) Services Tendering													
C. Final Well Planning													
1.) Finalize Well Design													
- Final Cost Estimate													
- Prepare Drilling Program													
- Pre-Spud / DWOP Meetings													
Drilling Program													
D. Spud													