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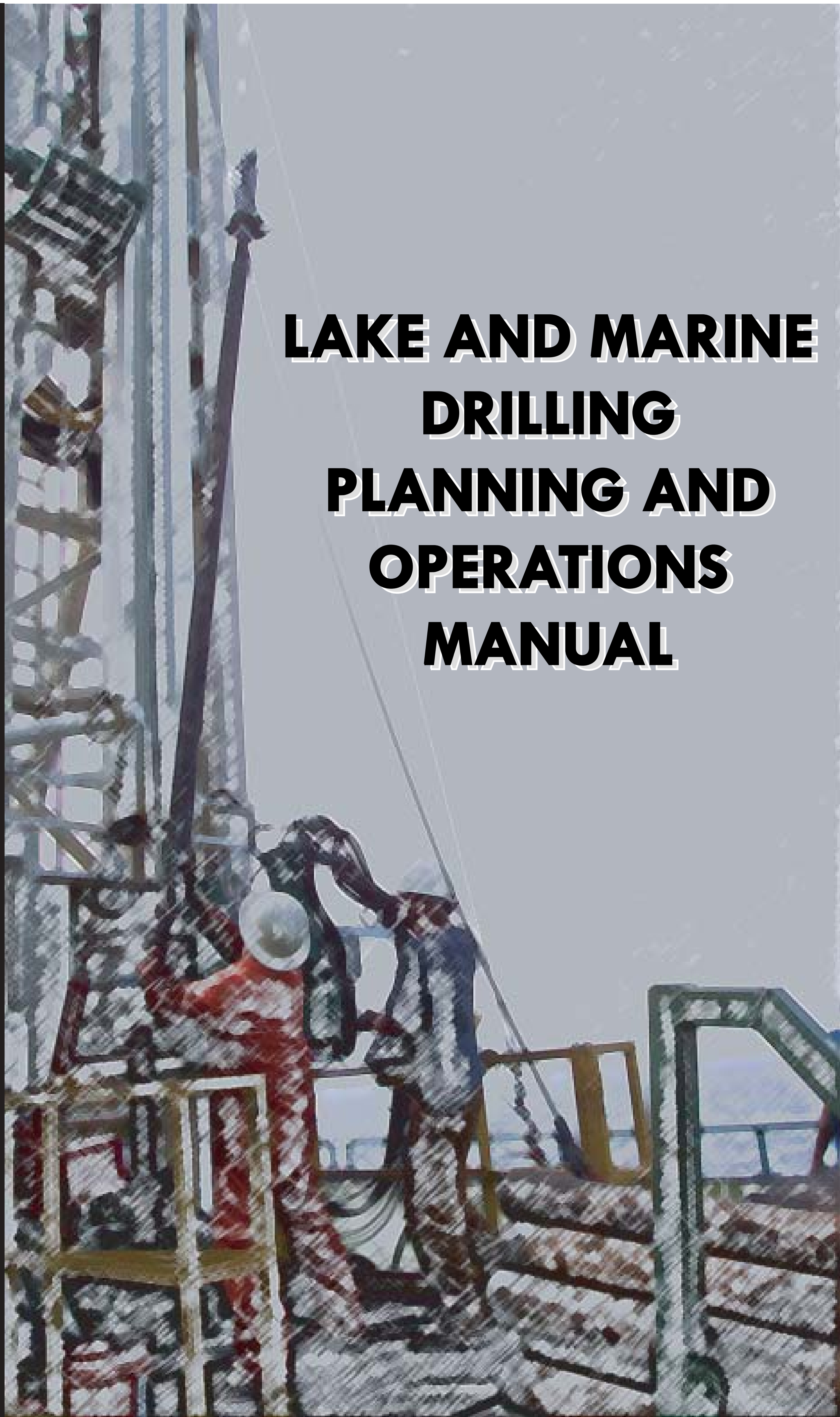
LAKE AND MARINE DRILLING PLANNING AND OPERATIONS MANUAL



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Lake and Marine Drilling Planning and Operations Manual

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Table of Contents

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DOSECC

INTRODUCTION

This manual will aid scientific investigators and operations managers in planning and budgeting off shore operations using DOSECC's drilling systems. Each drilling project has unique scientific objectives and logistical issues, and it is difficult to consider all variables in a general presentation. However, this manual provides information that we hope will be useful in the planning and budgeting process. A successful drilling project will require close coordination between the scientific and drilling teams, and that cooperation should start during the initial planning process.

The planning process focuses on the preparation of drilling proposals. DOSECC will be responsible for preparation of the drilling budget that includes supply purchases, mobilization of equipment, drilling operations and demobilization. The scientific team is responsible for budgeting for the science crew (salaries, transportation and living expenses), handling the core on site (including any on-site science investigations) and shipment of the core back to laboratory or curation facilities. Due to their knowledge of the local environment and government, the Principal Investigators are generally responsible for the acquisition of all required permits and permissions.

DOSECC is committed to the protection of all personnel and the environment in which the drilling operations are taking place. DOSECC has a written Health, Safety and Environment (HSE) policy (*http://www.dosecc.org/html/health_and_safety.html*) and will conduct drilling operations in accordance with its provisions. As participants in drilling projects, science team members will be expected to follow the DOSECC HSE policy.

EQUIPMENT DESCRIPTIONS

The drilling systems that DOSECC has developed can be supported by a variety of drilling platforms. Two of these systems, the GLAD800 and the GLAD200 include their own drilling barges, but they can also be operated from vessels of opportunity. Our active heave compensated rig (AHC800) is designed to operate from vessels of opportunity. These different drilling rigs utilize the same suite of drilling and sampling tools, the DOSECC Lake Coring (DLS) System.

GLAD800

The GLAD800 (Global Lake Drilling to 800 m) system was developed in response to the requirements of the paleo-climate community to collect long continuous core in lake sediments. The GLAD800 was built under a joint venture between DOSECC and the International Continental Scientific Drilling Program (ICDP), and it is operated by DOSECC.

There were explicit limitations on the GLAD800 system design. The depth capability is a total depth of 800 m (water + sediment) in up to 200 m of water. The sampling tools collect continuous core that has a diameter of 62 mm in plastic liners. This size is the same as that collected by the Ocean Drilling Program and was selected for compatibility with analytical and archiving facilities. The use of a smaller diameter drill string will result in a total depth capability of about 1200 m. The GLAD800 was not designed to drill in rough weather since it was not outfitted with heave compensation equipment, and there is limited shelter for the crew. The GLAD800 barge has no propulsion and must be towed by a service boat.

GLAD800 System on the Great Salt Lake, Utah

MODERN LAKE DRILLING CHALLENGES

The collection of core from modern lakes presents technical challenges:

- Tools that can continuously sample sediments of different composition and stiffness.
- A barge that can anchor in water depths up to 200 meters and safely support the drilling rig and drilling and scientific crews.
- A drilling rig that can be used on vessels of opportunity as well as its own barge.
- A modular design that can be easily shipped worldwide and deployed at remote locations.
- A cost structure that takes into consideration long period of mobilization with relatively short drilling campaigns.

The GLAD800 is a complete drilling system that includes a drill rig, drill rods and riser pipe, down-hole tools, inventory/machine shop, and facilities for preliminary core description and storage. The system can be transported in ten 20-foot containers, although additional containers may be needed to transport supplies. The rig crew normally includes three drillers and four scientists per shift with an additional person serving as drilling supervisor and barge captain. There are facilities on the barge for the initial description of core, but space is limited and the core is routinely transferred to shore at the end of each shift. On deck, there are two enclosures that are used for record keeping and shelter from the weather.

One of the key requirements for the successful operation of the GLAD800 is a service boat that is used to transport crews, fuel and supplies to and from the barge. In addition, the service boat is used to tow the GLAD800 barge between drilling locations and assist in setting anchors. Service boats can often be acquired locally; however, a viable service boat is critical to project success.

Although the GLAD800 barge has been shown to very stable under adverse weather conditions, it was not designed to operate under all weather conditions. It is important, both from the standpoint of safety and core collection efficiency, that weather conditions be considered when scheduling drilling campaigns.

- ***CS-1500 Drilling Rig*** The drilling rig for the GLAD800 system is a Christensen CS-1500 coring rig that has been modified to accommodate the engineering and environmental requirements for drilling on modern lakes. The rig modifications include solid steel plating beneath all fuel and lubricant reservoirs to prevent accidental spills from entering the water. In addition, the hoisting capacity of the rig has been significantly upgraded. The drill rig has multiple platform capacity and can also be used as a land-based coring rig. Specifications for the rig are presented in accompanying table.

Coring rates vary with depth, the coring tools employed and the types of sediment encountered. For shallow holes, a coring rate of about 25 m per 12-hour shift can be used for planning purposes. If drilling is

SPECIFICATIONS FOR DOSECC'S CS-1500 CORING RIG

Drilling Rig Weight
8,617 kg (19,000 lb)

Depth Capacity Coring
HMQ Wireline: 1,200 m
DLS Wireline: 800 m

Chuck Assembly
Type: Hydraulic Open, Spring Closed
Maximum Inside Diameter: 117 mm (4-5/8 in)
Holding Capacity: 18,181 kg (40,000 lb)

Hoisting Capacity
Main
Single Line Bare Drum 7,955 kg (17,500 lb)
Double Line-Bare Drum 15,900 kg (35,000 lb)
Cable Size: 33.6 m (110 ft) X 19.0 mm (3/4 in)
Wireline
Single Line-Bare Drum 1,136 kg (2,500 lb)
Single Line-Full Drum 382 kg (840 lb)
Line Speed: Full Drum 984 m/min (1,260 ft/min)
Cable Size: 975 m (4,000 ft) x 1/4 in

Standard Equipment
Dump Mast
Derrick in Two Sections
Foot Clamp 139.7 mm (5 1/2 in)

Feed System
Stroke: 3.5 m (11.5 ft)
Thrust: 6,800 kg (15,000 lb)
Pull: 13,600 kg (30,000 lb)

Mud Pump
* Type: FMC L11 22D (Hydraulic)
* Max Flow: 272 lpm (72 gpm)
* Max. Pressure: 7 Mpa (1,000 psi)

Power Unit
* Mfg: Cummins 175 hp
* Engine Type: 6 Cylinder Turbocharged Diesel

only taking place for one shift per day, the drill string must be withdrawn at the end of the shift. This is done to prevent the hole from collapsing around the drill string and the resultant loss of tools and pipe. Therefore, there is a depth limitation for drilling with one shift (12 hours) versus two (24 hours). Drilling objectives of greater than 50 m per hole should plan on 24-hour per day operations.

➢ ***GLAD800 Barge*** The barge developed to support the GLAD800 (R/V Kerry Kelts) can be easily transported while providing a very stable platform for the drilling operations. The barge is modular and made of eight 20-foot shipping containers arranged in a 3 x 3 array. These form a platform that is 7.3 m (24 feet) wide by 18.3 m (60 feet) long. The center container is missing and forms the moon pool through which the drilling takes place.

GLAD800 Barge Construction

Assembling the barge and placing the various drilling components on the barge requires a crane of at least 15-ton capacity. Generally, the preparation of the barge, from arrival at the lake until it is outfitted and ready to sail, requires about 3 days although this is dependent upon local facilities. The containers that form the barge are partially filled with polyurethane foam to provide flotation. The bottom portions of the containers are allowed to flood with water, helping to stabilize the barge. Each container also includes an air bladder that is used to control trim.

Barge position at the drill site is maintained by a 4-point anchoring system. The anchor lines are steel cable and their tension is controlled by four hydraulic winches. The service boat is used to assist in setting and recovering the anchors.

GLAD200

The GLAD200 is similar to the GLAD800 but is intended for use on shallow lakes with drill string requirements (water + sediment) of up to 200 m. Generally, the depth capability is considered to be 100 m of sediment in up to 100 m of water. Operational

CS500 on local barge, Hvitarvatn, Iceland (*Photo: Gifford Miller*)

SPECIFICATIONS FOR DOSECC'S CS-500 CORING RIG

Drilling Rig Weight

2267 kg (5000 lb.)

Depth Capacity

DLS Wireline: 200 m

HMQ Wireline: 300 m

Chuck Assembly

Type: Hydraulic Open, Spring Closed

Maximum Inside Diameter: 117 mm (4-5/8 in)

Holding Capacity: 18,181 kg (40,000 lb)

Hoisting Capacity

Main

Single Line Bare Drum 2727 kg (6000 lb)

Maximum Line Speed 38 m/min (126 ft/sec)

Cable Size: 13 mm (1/2 in) diameter

Wireline

Single Line-Bare Drum 1550 kg (3400 lb)

Single Line-Full Drum 540 kg (1200 lb)

Max Line Speed Bare Drum 80 m/min (260 ft/min)

Max Line Speed Full Drum 244 m/min (800 ft/min)

Cable Size: 5 mm (3/16 in) diameter

Standard Equipment

Dump Mast with 2 aluminum Derrick Sections

1.22 m (4 ft) Leveling Hydraulic supports

Foot Clamp 139.7 mm (5.5 in)

Feed System

Stroke: 1.8 m (6 ft)

Thrust: 3200 kg (7000 lb)

Retraction Pull: 4500 kg (10,000lb)

Mud Pump

FMC Triplex Bean Pump Driven by 1-Isuzu LB1 Diesel Engine

20.6 kW(27.6 Hp) @ 3450 RPM

Max Flow: 200 lpm (53 gpm)

Max Pressure: 7 Mpa (1000 psi)

Power Unit

2 Lombardini Turbocharged Diesel 1204/T Turbo Engines

Engine Type: 4 Cylinder Turbo-Charged diesels

31.2 KW (42 hp) @ 3,600 rpm each

considerations are similar to those just described for the GLAD800 system.

➢ ***CS-500 Drilling Rig*** The drill rig used on the GLAD200 system is a Christensen CS-500 coring rig. This rig can be broken down into small components (maximum weight of about 140 kg. or 300 lbs) making it ideal for remote locations. On land, the drill rig can be easily transported by pickup truck or helicopter allowing it to be deployed in remote drilling locations.

GLAD200 on Englebright Reservoir, California

➢ ***GLAD200 Barge*** The GLAD200 system includes a modular barge that is 12 m (40 feet) long by 6 m (20 feet) wide. The barge is not powered and must be towed into position. Position is maintained by a 4-point anchoring system. A service boat assists in setting these anchors. Because of its smaller size, the GLAD200 has less space for the science team than the GLAD800 system. Since it is used on smaller lakes, it is often most convenient to remove the core samples to shore or another boat for characterization.

AHC800

DOSECC's AHC800 (Active Heave Compensated to 800 meter) is an active heave compensated coring rig that is designed to sample the continental shelves and large lakes. The rig is intended for use on vessels of opportunity that hold station by either dynamic positioning or anchoring. The AHC800 is made up of 10 major components that are listed in the accompanying table.

WEIGHT AND DIMENSIONS OF MAJOR COMPONENTS OF THE AHC800

Equipment	Length (ft)	Width (ft)	Height (ft)	Weight (lbs)	Length (m)	Width (m)	Height (m)	Weight (kg)
Derrick	42	5.17	5.67	28000	12.80	1.58	1.73	12698.4
Derrick Base	19	7.33	5.67	3000	5.79	2.23	1.73	1360.5
Heave Power Pack	20	8	8.5	17000	6.10	2.44	2.59	7709.8
Drill Power Pack	20	8	8.5	5000	6.10	2.44	2.59	2267.6
Valve Stand	6.5	2.5	4	2000	1.98	0.76	1.22	907.0
Control Consol	7.08	6.08	7.5	2000	2.16	1.85	2.29	907.0
Rod Skid	22	7	3.5	4000	6.71	2.13	1.07	1814.1
Mud System	19	7	6.5	7500	5.79	2.13	1.98	3401.4
Shop - Parts Container	20	8	8.5	18000	6.10	2.44	2.59	8163.3
Storage Container	20	8	8.5	15000	6.10	2.44	2.59	6802.7

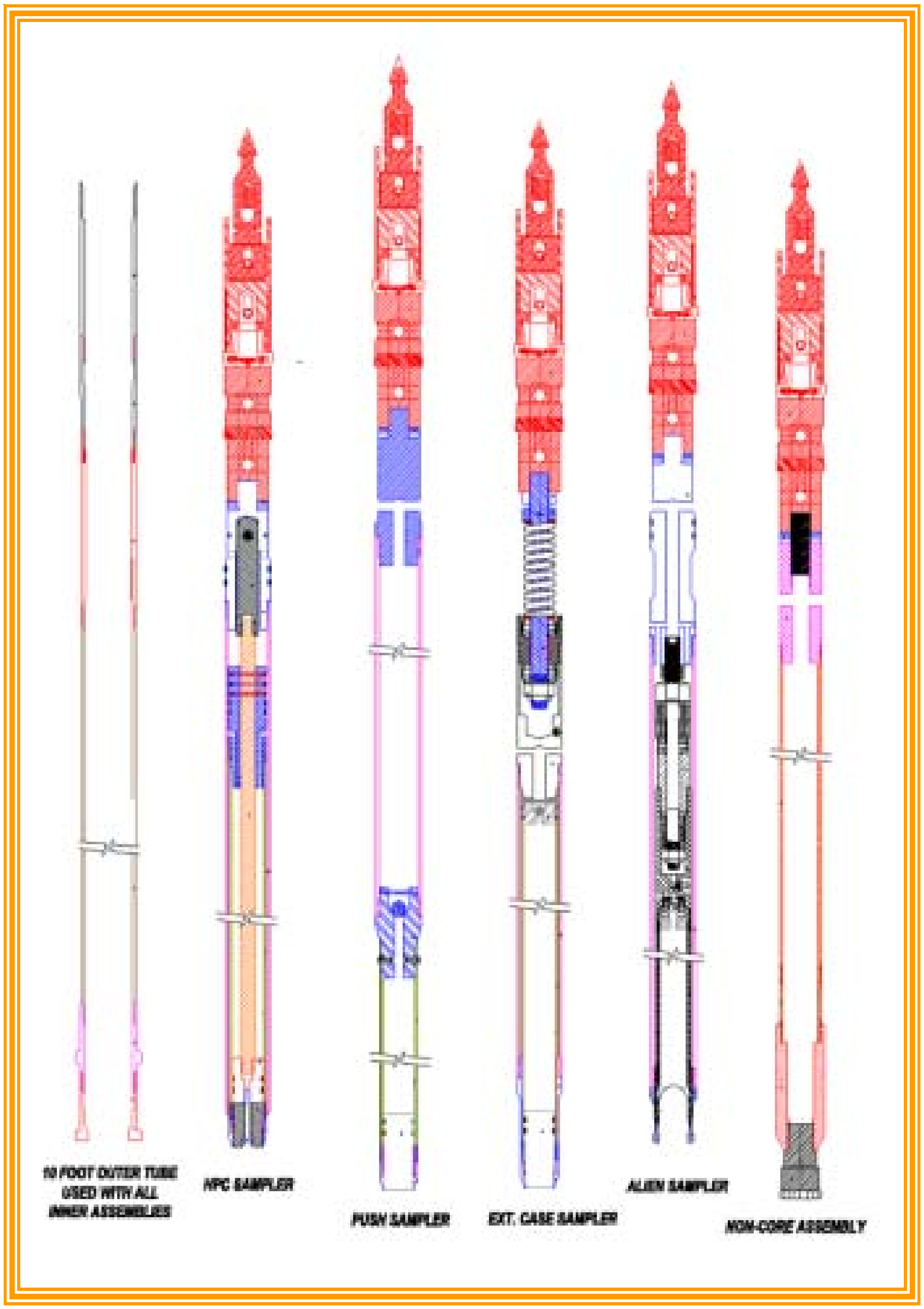
The AHC800 collects continuous core while compensating for vertical vessel motion. The vessel heave is determined by a taut line connected to a weight on the sea floor. Vertical movement is sensed through a position transducer attached to the taut line. A computer hydraulically controls two heave cylinders that keep the drilling system at the same relative position with respect to the hole bottom. The computer uses LabView Real Time ™ software and hardware with custom programming to control the hydraulic valves.

The drilling system is comprised of the riser clamp, rotation and feed system, wireline winch and helper's platform all suspended below the heave cylinders. The heave system controls not only the vertical position of the drill rods, but the riser as well. The system has a maximum holdback of 18,182 kg (40,000 lbs.). The main hoist has a capacity of up to 35,000 lbs. (15,900 kg). The heave compensator is powered by Detroit Diesel 60 series turbocharged, six cylinder engine, governed for 500 HP at 1900 RPM.

DOSECC Lake Coring System (DLS)

A variety of drilling tools are required to collect the different types of sediment encountered in modern lake and marine environments. The sampling suite includes six standard tools that are similar to those used the Ocean Drilling Program and commercial geotechnical work. The tools are listed below listed are in order of increasing stiffness of sediment. These tools fit within an outer assembly that drills a hole 139.7 mm (5.5 in) in diameter.

- Shelby “push” tube
- Hydraulic Piston Core (HPC)
- Diamond Core Bit (mining)
- Non-sampling Assembly
- Extended Nose, non-rotating (EXN)
- Extended Core Bit, rotating (The Alien)



Most of the tools are designed to collect core within a polybutyrate liner that has an inner diameter of 66 mm (2.612 in). The exception to this is the Extended Core Bit that collects core of 61 mm (2.40 in) a Lexan liner. The tools are available in 3-meter lengths.

The rods and casing (riser) come in 10- or 18.5-foot lengths, and other specifications of these tubulars are described in the accompanying table. HWT rods are used for drilling to a total string length (water + sediment) of 800 m. For longer string lengths, the smaller HMCQ size is used.

Six and 5/8-inch buttress casing is used as the riser through the water column. SWT flush joint casing is used where it is anticipated that casing will be inserted into the sediment. Straps are spot welded at the connections to eliminate the possibility that the joints will become unthreaded and lost during coring operations.

SPECIFICATION OF TUBULARS

Type	OD, inches (cm)	ID, inches (cm)	Weight/length lbs/ft (kg/m)	Length, ft (m)
HWT	4.5 (11.4)	4.0 (10.2)	11.4 (82.1)	10 (3.0)
HMCQ	3.5 (8.9)	3.1 (7.8)	5.7 (41.0)	10 (3.0)
6-5/8” Buttress Joint	6.6 (16.8)	6.0 (15.2)	20.0 (144.0)	18.5 (5.6)
6-5/8” Flush Joint (SWT)	6.6 (16.8)	6.0 (15.2)	24 (172.8)	10 (3.0)

Support Equipment

➢ Shop and Spare Parts Inventory

Offshore operations require access to spare parts and a workshop to make repairs. A workshop and inventory storage area has been built into a 20-foot container. The shop contains lighting, power tools and workbench to service equipment.

➢ Mud System

DOSECC has completed a number of core holes to greater than 100 m without the use of drilling mud but using lake water as the only circulation medium. However, successful coring through sand and coarser unconsolidated sediment requires a bentonite mud system to stabilize the hole and to prevent sloughing behind the bit. In fact, the use of heavy mud is often the key element in the successful collection of coarser materials.

PROJECT MANAGEMENT

Scientific drilling projects can be complex undertakings that require scientists and drilling personnel to function as a team. Projects will have shore-based as well as off shore activities.

APPROACH AND PROCEDURES

➢ Logistics and Project Preparation

A lake-drilling project starts long before the drill rig is mobilized. Particularly with large, overseas projects, there is a great deal of preliminary work that needs to be completed. This often requires one or two visits by the PI(s) and DOSECC representative. Appendix 1 is a checklist of items that need to be considered prior mobilization of equipment and crews.

➢ Drilling Operations

Lake drilling operations will normally be conducted 24-hours per day, seven days per week using a 3-man crew per 12 hour shift that consists of a driller and two helpers. A supervisor may also be on board to handle paperwork and any needed repairs to the equipment. The Supervisor, or the Driller in his absence, is responsible for the safety of the operation and is deemed the Person-In-Charge (PIC) as outlined in DOSECC's HSE Manual.

➢ On-Board Science Operations

The on-board science crew will nominally be comprised of a Chief Scientist and three helpers per shift. It is their responsibility to receive, document and store the core. The Chief Scientist is responsible for directing drillsite specifications and depths and therefore must either be a PI or understand the objectives of the PI(s). These people include a curator, a science assistant who concentrates on the core catcher sample and a scientist/driller assistant who assists the driller's helper in extraction of core, splitting the core into sections and reassembling the core barrel. It is advisable that the science team enter into discussions with personnel from a curatorial facility prior to drilling operations.

➢ On-site Management

It is important to establish and maintain a formal on-site management structure during the drilling operation phase. Decisions that impact drilling and scientific aspects of the project will be made on a daily basis. It is important that communications concerning drilling take place between the chief scientist and the drilling supervisor. This single point of communication will avoid confusion concerning the conduct of the drilling operations.

➢ Budgets and Financial Management

Most scientific drilling budgets are fixed, and therefore, it is important to carefully track expenses to avoid financial difficulties. Many of the costs will be known before the drilling starts however, local vendor services are generally not known until they are incurred. It is generally going to be the responsibility of drilling supervisor to document these expenses and communicate them to the DOSECC office. The DOSECC office in turn updates the PI about expenditures.

Drilling expenses are principally based on time. For instance, one of the largest costs will be crew wages and living expenses. Other costs will be related to the amount of drilling done and sample collected (fuel, consumables, wireline tools, liners, etc.)

It is important to keep in mind that should tools be lost or damaged down hole, the cost of replacement, repair and shipping to the site will be billed to the project.

➢ Roles and Responsibilities

The roles and responsibilities for key persons involved in the operational phase of a scientific drilling project are presented below. This list is provided as a guide, and it is more important that all of the responsibilities be assigned than who actually performs the tasks. As with any team approach, communication is the key to success.

Principal Investigator(s)

Individuals who are the scientific and management leaders of the project. Normally, there are 1 to 4 PIs who decide among themselves their relative roles. Responsibilities include the following.

- Raise the funds
- Interface with funding agencies
- Spokesman to the scientific community and public relations
- Facilitate logistics
- Permitting
- Establish on-site scientific staffing
- Establish subcontracts
- Maintain communications with Co-PIs

Co-Principal Investigators

Individuals responsible for specific scientific components of the project. Their responsibilities include the following.

- Aid PIs in writing proposals
- Acquire funding for their scientific studies
- Supervise the collection of samples required for their studies

Chief Scientist

Responsible for on-site management of the drilling project and making daily decisions. Ideally, this role should be served by one of the PIs. The responsibilities include:

- Interface between the science team and the drilling team
- Daily decisions relating to the conduct of the drilling activities
- Manage the on-site science activities including sample handling and data collection
- Provide any needed logistical assistance to the drilling personnel
- Spokesman to the public including local officials and press

Drilling Supervisor

The drilling supervisor serves as DOSECC's on-site operation manager. He is responsible for the drilling crews and is the principal contact for the Chief Scientist. Responsibilities include:

- Health and Safety
- Discussion of drilling technologies
- Budget monitoring

Logistics Manger

Person who coordinates the logistical aspects of a drilling project. This role may be shared among several individuals. Examples of responsibilities include the following.

- Coordinate housing and meal arrangements.
- Pay local vendors.
- Expedite delivery of fuel, supplies and equipment.
- Facilitate communications.

DRILLING PROCEDURE

The following discussion presents the standard operating procedure for a lake drilling project utilizing the GLAD800 or GLAD200 system.

The barge and coring system will be mobilized by truck to the candidate lake and launched from a boat ramp or other dock facilities. It will be necessary to have a 15-ton crane lift containers from trucks and position these containers in the water so they can be joined to form the barge. Once the barge has been constructed, the drill rig, auxiliary equipment, riser pipe, drill rod, and shop can be positioned on deck.

The completed drilling system is towed by a service boat to the drill site. The barge is positioned and secured using four anchors. Riser pipe, or casing, is lowered to near the water-sediment interface. The purpose of this casing is to stabilize the drilling assembly. The hydraulic piston corer (HPC) is lowered on drill rod within the riser to extend past the bottom of the riser. The HPC is then fired to collect a sample of water and the upper part of the sediment. The core barrel is retrieved and the plastic liner containing the core is extruded. The lower 6 cm of sediment is located below a core catcher and is preserved as a separate core catcher sample. The science team places caps on the plastic liner and cuts the core into 1.5 m lengths for ease of handling. Science team members mark and label the core and note various drilling parameters and general lithology before stowing the core.

The mud below the core catcher is either lost or is collected separately as a core-catcher sample. Continuous sampling requires two holes that are drilled next to one another, but where the sample depths are staggered to ensure that sample lost, if any, in the first hole is recovered in the second. Using this approach, a continuous sample is recovered. Unless other arrangements are considered to be beneficial, drilling will take place in two 12-hour shifts per day.

When the character of the sediment changes, different sampling tools may be required. The tools are deployed by wireline while the outer barrel remains at the bottom of the hole. In this manner, sampling tools can be changed without pulling the drill rods out of the hole. With increasing stiffness, the tools that can be employed following the HPC are extended nose (EXN), extended bit (The Alien) and diamond coring (mining) assembly. The diamond coring assembly will be used to collect samples of crystalline rock. In addition, a non-sampling rotary assembly is often used to advance the hole when sample is not required.

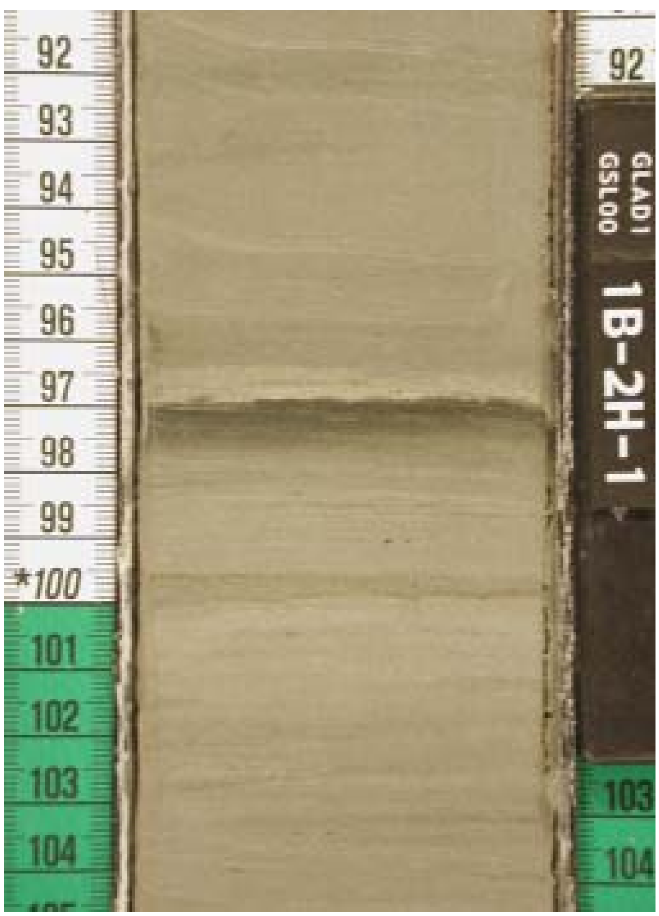
Normally, lake water is used as a circulation fluid. Fluid is pumped down the hole across the bit face and then it exits through the hole annulus. When unconsolidated sands and gravels are present, it is necessary to circulate drilling mud (bentonite). Mud is mixed in a tank on the barge using lake water and is then circulated down the core rods and returned to the sediment surface through the hole annulus.

Custody of the core is transferred to the science team at the point that the plastic liner is removed from the sampling tool. It is the responsibility of the science team to maintain proper samples records, label the core, temporarily store the core on the barge and transport it to the shore. The science team is responsible for capping the core tubes. DOSECC will provide the caps, but the science team needs to provide the material (tape or acetone) to secure the caps.

Following completion of the sampling, the drill string and riser pipe will be withdrawn from the sediment. Unconsolidated sediment will flow into the hole plugging it.

Core Barrel and Liner Handling

Once the core sample is retrieved, the core barrel is placed on the core-handling table, and the science and drilling teams work together to remove the core and prepare the tools to collect the next sample. The scientists remove the shoe (containing the core catcher) and the plastic liner from the inner core barrel. The liner is placed onto the core cradle. During this step, it is important to maintain the liner in the same orientation as it was initially laid down. The core is then cut into sections with a maximum length of 1.5 m. These sections are labeled (see below) and capped. Two caps are employed: a blue cap for the top of the section and a clear cap for the bottom. Caps may be affixed to the liner with acetone and electrical tape or electrical tape by itself. A typical core will consist of a 1.5 m section (section 1), a 1.42 m section (section 2) and a core catcher of approximate 0.08 m. With gas expansion more than a total of 3.0 m may be recovered. In difficult sediments, less than 3.0 m may be recovered.



➢ Curatorial Notes

A designated member of the science team should act as curator and will be in charge of keeping records regarding cored intervals, type of tool employed, length of recovery and determining the best estimate of the depth of the core top below mudline (mblf – meters below lake floor). There will be some overlap in this activity with the driller who will maintain records. The primary responsibility of record keeping rests with the science team. As core barrel and liner handling is a messy activity, the curator should primarily be involved with note taking rather than core handling.

For each core the following information should be recorded:

1. Time the core barrel was lowered
2. Driller's depth of the HPC shot or starting point for the EXN or Alien tools.
3. Calculation of the distance below the mud line (top and bottom) for the core –mblf (meters below lake floor).
4) Time of the shot for the HPC – note pressure at which shot took place and pressure drop and whether there was a good second

seat to determine a complete stroke.

5) Time the core came on board

6) Position of the piston within the liner

7) Length of all sections

8) Disposition of the core catcher (bagged or in liner, whether orientation is good) and the length of the core catcher.

9) Notes concerning the presence or absence of mud in the shoe.

10) Notes concerning possible gas expansion.

These notes will become critical for later determination of the depth below lake floor (mblf) of each section.

➢ *Core Labeling*

Once cut into sections, the core liner is labeled with waterproof black, markers, using the following scheme:

Expedition-Lake/Year-Site/Hole-Core/Device-Section

e.g. GLAD2-LT01-2A-17H-1

Global Lake Drilling Expedition 2, Lake Titicaca, 2001, Site 2, Hole A, Core 17, HPC, Section 1

The label should be written on opposite sides of the liner and "up arrows" written on to the pre-marked lines on the liner.

➢ *Core Catcher Handling (Shipboard)*

Often the core catcher can be removed from the shoe and extruded into a clean, short piece of plastic liner. The liner is then cut to the length of contained materials, labeled (with proper ID and up arrows) and capped. At other times, it is impossible to remove the material intact and it must be dug out. In this case there should be no up arrows and a note on the liner that there is no orientation. At times, material will forcefully extrude from the shoe due to excess gas pressure. This material should be allowed to extrude into a clean, spare piece of liner and should be included with the core catcher sample. Employ all efforts to maintain the proper orientation.

SPLICER - this program is very useful/essential for comparing MSCL and other data between cores from companion holes at a site. The software is available free from the ODP website and requires a SUN workstation running Solaris. Also available from this site is the Logging Integration program SAGAN.

➢ *Shore-based Science Activities*

It is very useful to obtain immediate observation and data from certain aspects of the core rather than waiting to ship it back to a lab. For this reason, some projects should consider preparation of a shore-based lab with equipment for core logging and sediment characterization. Core logging can be either a simple, hand-operated system for acquiring magnetic susceptibility data or a complete, whole core logging using a transportable MSCL system. Sediment characterization is usually carried out on the core catcher sample. With a simple dremel tool it is possible to split core catcher liners in the lab and prepare smear slides for sediment description and characterization of sediment components.

➢ *Core Handling – Shore-based*

Once the cores and core catcher samples have been cut into sections, the cores should be placed into a suitable container for shipping (responsibility of the science party). Previous GLAD projects have utilized waxed cardboard containers capable of storing four 1.5 m long core sections. Since the second section in each core is typically less than 1.5 m, the excess space can be utilized for storing core catcher liners. Depending upon ambient temperatures in the region, cores can then be stored in a cool, room or the science party may utilize a refrigerated container for temporary storage. In all cases it is important to keep the cores cool and to prevent them from freezing.

At the conclusion of the project, the PI's should arrange for transportation of the boxed cores to a lab for core splitting, description and sampling. Cores may be transported in a shipping container or by air freight.

PLANNING AND BUDGETING

The proponents of drilling projects have superior knowledge of the local logistics associated with the drilling campaign. It is common that additional information and site surveys may be required to complete the required planning process (see Appendix 3). Since operations impact personnel and environmental safety as well as budgets, DOSECC reserves the option of requiring an operational and safety review prior to finalizing budgets and mobilizing equipment. The following must be addressed for the planning and budgeting process to go forward.

WEATHER

Weather is a major factor in assuring that operation can be conducted in a safe manner. High winds may cause the drilling platform to shift resulting in loss of tools. Vessel heave may also make it impossible to continue drilling operations. Rain is not only uncomfortable for personnel, it can result in slippery decks and tools. It is the responsibility of the drilling supervisor to suspend operation if the safety of personnel or equipment is impacted by the weather. Therefore, it is anticipated that operations will be scheduled within weather windows when winds and precipitation are at a minimum. The National Oceanic and Atmospheric Administration maintains an informative website for weather research (www.noaa.gov).

Anchored drilling barges can be blown off site during periods of heavy winds. Under these circumstances, drilling equipment must be pulled from the sediment or there is a risk of them breaking off. A watch circle with a of radius 3% of water depth must be maintained to prevent the drilling assembly from breaking.

SITE SURVEYS

Site surveys will normally include seismic reflection lines. These should be interpreted in the context of anticipated lithologic sequence and the presence of potential hazards such as gas accumulations.

ANTICIPATED LITHOLOGIES

An important part of the planning process to predict the lithologic section that will be encountered during the drilling. The expected lithology is used to determine the type and amount of supplies that are mobilized for operations. Different rock types will require different types of bits and drilling tools. The

amount of sand and other unconsolidated clastic sediments will determine the amount of mud that is required.

➢ DRILLING HAZARDS

Drilling hazards include natural materials such as gas accumulations and man-made hazards such as buried cables or pipelines.

➢ PERMITTING

Permitting is normally the responsibility of the project proponents. DOSECC can provide assistance in this important aspect of the planning process if requested. This generally includes drill permits, personnel work permits and visas, if in foreign countries.

➢ DOCK AND SHORE SUPPORT FACILITIES

Dock facilities will be of importance for both the launching of the drilling system and the day-to-day operation of the drilling project. If suitable facilities are not available, they will need to be prepared through project funding.

➢ SERVICE/SUPPLY BOAT

At least one service/supply boat and one emergency/ escape boat is necessary for the efficient and safe operation of the drilling project. The duties of the Service/Supply Boat are as follows:

- Towing the drilling barge
- Assisting with deploying the anchors
- Transporting crews, fuel and supplies to the barge and return of core to the shore
- Standby as a safety precaution in case of injury on the drilling platform
- Evacuation in case of fire or other compromising situation

The service boat must be committed 24 hours per day, 7 days per week to the drilling operation. The responsibility of the emergency boat is to stay with the barge when it is occupied by the crew.

➢ DRILLING PLAN

The drilling plan outlines how the operation will proceed. The plan should consider the fact that the science and drilling crews will be working together for the first time. In addition, particularly for overseas operations, there is a settling period where participants are recovering from travel and a change of diet. Therefore the initial drilling location should be the least complicated. However, it is not advisable to leave the most complex location until the end of the project. The drilling plan should address the following:

- Location for each site
- Water depth
- Sampling objective
- Number of holes and sampling depth
- Anticipated lithologies
- Logging program
- Required personnel

Appendix 3 is a site-description form that can be used to established the drilling plan.

➢ LIABILITIES

Loss of drilling tools is not uncommon in lake and marine drilling. When equipment is lost the project will be billed for their replacement.

➢ OPERATIONAL REVIEW

For larger projects and particularly those that are conducted overseas, DOSECC will institute a formal review 6 months prior to project start. The purpose of this review is to make certain that sufficient progress has been made that equipment and personnel can be committed to the effort.

DOSECC'S COMMITMENT TO SAFETY

DOSECC is committed to the safety of all personnel on our drilling projects. Lake drilling will incorporate both our standard drilling safety procedures as well as safety procedures associated with off shore operations. Many of these standards are addressed in DOSECC's Health, Safety and Environmental Response Plan that is available on our web site (*http://www.dosecc.org/html/health_and_safety.html*). The following sections complement the HSE plan and discuss operations over water.

In lake drilling operations, the drilling crew and science crew are functioning in a confined space. It is very important that each understand what the other is doing. The Drilling Supervisor, or the Driller in his absence, is responsible for safety on the barge. Any potentially dangerous situations must be brought to his attention immediately. Many drill sites are remote areas where medical help is not readily available. On all projects, personal safety and group safety is paramount.

Many participants in scientific drilling projects having never been around heavy equipment, and are not familiar with ways of conducting themselves safely. Every person on a drilling operation is responsible for their own safety as well as the safety of the people they work with. When working with tubulars devices such as drill rod, casing and wireline tools there are dangers that can occur while stacking, tripping and installing. Other dangers include falling items and injury associated with moving or spinning machinery.

➢ SAFETY MEETINGS

Safety meetings will be held at the beginning of every shift. These meetings should serve as a learning experience to discuss specific aspects of the drilling safety or seamanship. These also provide a clear delineation between the pre-work mind-set, and the need to focus on the drilling operation.

➢ HOUSEKEEPING

Housekeeping is probably the utmost essential part in maintaining a safe workplace. Most accidents are due to slip/trip related incidences. Each worksite shall maintain the highest standards of housekeeping at all times.

- Floors, steps and stairs shall be kept clean and free from oil, grease, mud and other slippery substances.
- Steps, walkways, passages and doorways shall be kept clear of obstructions.
- Soiled cleaning materials, scrap and waste oil shall be placed in the appropriate containers for disposal.
- Escape routes and access to safety equipment shall not be restricted in any way.

➢ PERSONAL PROTECTION EQUIPMENT

Basic personal protection equipment (PPE) includes the following items, which are required for all personnel (Drilling or Scientific) when aboard a DOSECC drilling operation.

<u>Hard hat</u>. Hard hats are lifesavers when falling objects strike the head, or if when standing, or walking the head comes in contact with another object. It is the individual's responsibility to possess and to use a hard hat during a DOSECC drilling operation. Hard hats are time stamped commodities that are generally certified for a 3-year time frame. It is the general recommendation of DOSECC that all hardhats be within their certified time frame during operations.

<u>Hearing Protection</u>. Room on the GLAD800 or GLAD200 barge is at a premium. The proximity to loud drilling equipment can be a hazard to hearing. Disposable ear plugs are provided on DOSECC off-shore operations.

<u>Foot Protection</u>. Steel-toed boots are a mandatory item while on a DOSECC drilling operation. The accidental shift of tubular items could result in injury to the foot. It is also common to kick or stub a toe on barge components or fittings. It is the individual's responsibility to provide suitable footwear. Please note that the deck will be wet during operations and non-skid soles are recommended.

<u>Eye Protection</u>. Eye protection is necessary when working with hand tools, spinning equipment, chemicals, and contents under pressure. Individuals are responsible for their own safety glasses.

<u>Hand Protection</u>. Gloves are an important part of drilling operations. Cotton gloves will be provided by DOSECC.

<u>Personal Flotation Devices (PFD)</u>. There will be a PFD for each member of the team working off shore.

The PFD will be worn when commuting to and from the drilling barge and during any activities where personnel are working over water. For normal activities on the barge, a PFD is not required. DOSECC has and maintains PFDs for project participants and drill crew. A PFD will be supplied.

Other protective equipment that is associated with DOSECC drilling operations include:

<u>Life Rings</u>. Life rings are positioned at regular intervals on the drilling barges. In the event of a person falling overboard, the life ring is to be thrown in their direction (do not throw at them).

<u>Life Boats.</u> There will be a life boat available at all times in case it becomes necessary to evacuate the drilling barge.

<u>Immersion Suits</u>. For operations over cold water, an immersion suit for each person will be available on the drilling barge.

Fire Extinguishers Fire extinguishers are positioned throughout the barge. A safety briefing will discuss procedures to be followed in case of a fire on board. Smoking is not allowed on DOSECC barges.

➢ First Aid

In the event that an accident should occur, general first aid supplies have been stowed in the driller's doghouse on the barge. All injuries should be reported immediately to the driller. DOSECC personnel are certified in CPR and emergency first aid.

➢ Accident Reports

Accident report forms are available in the driller's house on board the barge.

➢ Material Safety Data Sheet (MSDS)

There are many chemicals used in a drilling operation. Material safety data sheets for materials used for the drilling operations are filed in the driller's house. Scientists bringing supplies on board are reminded to bring MSDS covering these supplies.

➢ ENVIRONMENTAL PROTECTION EQUIPMENT

Protection of the enviroment is required for all DOSECC drilling projects. Each operation shall make plans to minimize waste and efficiently use natural resources.

Spill-containment Boom. DOSECC's drilling barges are equipped with spill containment booms. In the unlikely event of a petroleum spill, the containment boom will be deployed and cleanup procedures will be initiated.

Spill-containment Pans. DOSECC's rigs have spill containment pans located beneath all fuel and oil tanks. These are in place to prevent fuels and lubricants from entering the environment during fueling and maintenance procedures or as a result of a leak.

➢ Pollution Prevention and Safety Review

A pollution prevention and safety review will consider environmental and personnel safety and will normally be conducted at least six months prior to the start of operations.

Appendix 1. Scientific Drilling Project Checklist

		Responsibility	Cost
Communications	Cell Phones		
	Satellite Phone		
	Email		
	Web Access		
Housing	Hotel		
	Apartments		
	Travel Trailer		
	Ship-based Accommodations		
Meals	Cook		
	Food Supplies		
	Water		
Transportation	Vehicles		
	Crews from Airport		
	Daily Commute to Rig		
	Site-to-site moves		
	Mobilization/Demobilization		
	Supplies		
	Crane		
	Forklift		
	Courier Services		
	Customs		
	Freight Expediters		
Money	Bank		
	ATM		
	Credit Cards		
Drilling Supplies/Services	Fuel		
	Water		
	Mud		
	Cement		
	Oil and Lubricants		
	Machine Shop		
	Welding		
	Excavation/Site Preparation		
Sanitation	Latrines		
	Trash Removal		
	Hazardous Material Disposal		
	Hazardous material containment		

Appendix 1 Continued

Support Facilities	Offices		
	Laboratories		
	Container Storage		
	Security		
	Water		
	Electricity		
Local Employees	Payment		
	Work Rules		
Health and Safety	Hospital		
	Ambulance		
	Fire Department		
	Safety Training (CPR/First Aid)		
	Site Emergency Plan		
	Evacuation Plan		
	Health Briefing/Inoculations		
Site Preparation	Grading		
	Fencing		
	Mud Pits		
	Cellar		
Permits and Licenses	Work Permits		
	Drilling Permits		
	Air Quality Permits		
	Land/Water Use		

APPENDIX 2
EQUIPMENT AND SUPPLIES

Personal Safety Equipment

The following personal safety equipment is required for each member of the science team.

Steel-Toe Boots
Hard Hat
Hearing Protection
Safety Glasses
Personal Floatation Device (Type 1 or 3)

Other Personal Equipment

The following additional personal equipment is recommended depending upon anticipated weather conditions during drilling operations.

Rain Gear
Sun Block
Gloves
Coveralls
Warm Clothes

Science List (some of these items may already be available on the rig - particularly the nonconsumable items)

1. Markers (for labeling core liner)
2. Electrical tape (for caps and for covering gas release holes)
3. Acetone (for affixing caps if desired)
4. Squeeze bottles (for dispensing acetone)
5. Tape measures (for measuring sections and cores) - bring several - they break
6. Measuring stick (1x2 with sewing taped affixed - giving 1.5m)
7. Rags (good absorbent ones) for cleaning sections prior to labeling
8. Pipe cutter with several sharp wheels - for cutting sections
9. Hack saws - for cutting sections (several spare blades)
10. Battery operated drill - for drilling sections to permit gas release
11. Bucket - for cleaning the deck
12. Screw driver - for assisting in core catcher removal
13. Hammer - for assisting in core catcher removal
14. Several 1"x2" firring strips and sewing tape - for making section markers

APPENDIX 3

DOSECC Site Description Forms: Page 1 of 4- General Site Information

Please fill out information in all gray boxes **New** ☐ **Revised** ☐

Section A: Proposal Information

Title of Proposal:			
Proposal Number		Date Form Submitted:	
Site Specific Objectives (Must include general objective in proposal)			
List Previous Drilling in Area			

Section B: General Site Information

Site Name:				Area of Location:	
Latitude:	Deg:	Min:		Jurisdiction:	
Longitude:	Deg:	Min:		Distance to Land:	
Priority of Site:	Primary:	Alt:		Water Depth:	

Section C: Operational Information

SEDIMENTS -- Total Thickness:		**BASEMENT**	
Proposed Penetration (m):			
General Lithologies:			
Coring Plan (Circle): PUSH HPC EXN EXB			
LOGGING PLAN **STANDARD TOOLS**		**SPECIAL TOOLS**	**LWD**
Neutron-Porosity Litho-Density Natural Gamma Ray Resistivity-Induction	FMS-Sonic Acoustic FMS	Borehole Televiewer Geochemical Resistivity-Laterolog High Temperature Magnetic/Susceptibility	Density - Neutron Resistivity - Gamma Ray
Drilling/Coring:	Logging:		Total On-Site:
Hazards/Weather: *List possible hazards due to ice, hydrocarbons, dumpsides, cables, etc.*			*What is your weather window?*

Proposal #:	**Site #:**	**Date Form Submitted:**

Form Revised: 8/1/2003

DOSECC Site Description Forms: Page 2 of 4- General Site Information

Please fill out information in all gray boxes **New** ☐ **Revised** ☐

Data Type	SSP Requirements	Exists in DB	Details of available data and data that are still to be collected
Hi Resolution Seismic reflection			Primary Line(s): Location of Site on Line (SP or Time only) Crossing Line(s)
Deep Penetration seismic reflection			Primary Line(s) Location of Site on line (SP or Time only) Crossing Line(s)
Seismic Velocity†			
Seismic Grid			
Refraction (Surface)			
Refraction (Near bottom)			
3.5 kHz			Location of Site on line (Time)
Swath Bathymetry			
Side-looking sonar (surface)			
Side-looking sonar (bottom)			
Photography or Video			
Heat Flow			
Magnetics			
Gravity			
Sediment cores			
Rock Sampling			
Water current Data			
Ice conditions			
OBS microseismicity			
Navigation			
Other			

SSP Classification:	SSP Watchdog:	Date of Late Review:

X = Required; X* = May be required for specific sites; Y= Recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T= Required for high temperature environments; † = Accurate velocity information is required for holes deeper than 400m.

APPENDIX 3

DOSECC Site Description Forms: Page 3 of 4- General Site Information

Please fill out information in all gray boxes **New** ☐ **Revised** ☐

Proposal #:	**Site #:**	**Date Form Submitted:**
Water Depth (m):	**Sed. Penetration (m):**	**Basement Penetration (m):**

Are high temperatures expected at this site? Yes ☐ **No** ☐

Are there any other special requirements for logging at this site? Yes ☐ **No** ☐

If "Yes", please describe requirements: ____________________

What do you estimate the total logging time for this site to be: ____________________

Measurement Type	Scientific Objective	Relevance (1=high, 3=low)
Neutron-Porosity		
Litho-Density		
Natural Gamma Ray		
Resistivity-Induction		
Acoustic		
FMS		
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resistivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP)		

APPENDIX 3

DOSECC Site Description Forms: Page 4 of 4- General Site Information

Please fill out information in all gray boxes **New** ☐ **Revised** ☐

Proposal #:	**Site #:**	**Date Form Submitted:**

Summary of Operation at Site: (Example: Triple APC to refusal, XCB 10 m into basement, log as shown on page 3)	
Based on Previous drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	
From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	
Are there any indications of gas hydrates at this location?	
Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	
What “special precautions will be taken during drilling?	
What abandonment procedures do you plan to follow?	
Please list other natural or man-made hazards which may effect ship’s operations: (i.e., ice, currents, cables)	
Summary: What do you consider the major risk in drilling at this site?	

Form Revised: 8/1/2003

APPENDIX 4

Useful Website Links

DOSECC http://www.dosecc.org

ICDP http://www.icdp-online.de/

NOAA http://www.noaa.gov/

Core Repositories

LACCORE National Lacustrine Core Respository, University fo Minnesota
http://lrc.geo.umn.edu/LacCore/laccore.html

MGSL Marine Geological Samples Laboratory, University of Rhode Island
http://www.gso.uri.edu/MGSLsite/mgsl_homepage.htm

NORCOR Marine Geology Repository at Oregon State University
http://corelab-www.oce.orst.edu/intro.html

WHOI Seafloor Samples Laboratory
http://www.whoi.edu/science/GG/corelab/index.html

ODP Ocean Drilling Program
http://www-odp.tamu.edu/curation/

LDEO Deep-Sea Sample Repository at Lamont Doherty
http://www.ldeo.columbia.edu/CORE_REPOSITORY/RHP1.html

Scripps Scripps Institution of Oceanography Geological Collection
http://gs.ucsd.edu/gc/

BOSCOR British Ocean Sediment Core Repository
http://europa.soc.soton.ac.uk:8080/BOSCOR/boscor.htm

NGDC National Geophysical Data Center
http://www.ngdc.noaa.gov/mgg/curator/curator.html