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MAIN CONSIDERATIONS IN THE DESIGN OF A GEOTHERMAL DRILLING PLATFORM FOR EL SALVADOR, C.A.

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ABSTRACT

Significant increases have been in the construction of new drilling platforms and the restoration of existing platforms in recent years in El Salvador, with the development of new projects and optimization of existing fields (Ahuachapán and Berlin). The demand for new practices in design and the implementation of new considerations for the selection of the best sites have become necessary. However, the activity of civil works on this issue involves other aspects key to successful projects, namely: road access, the environment, neighbouring communities, the purchase of land and the topography.

The Civil Work area of LaGeo S.A. de C.V., together with project managers and other disciplines, have been building and restoring some platforms in the following projects: Ahuachapán optimization (4 new drilling platforms and 6 restorations), Second development of Berlin (3 new drilling platforms), San Vicente field (3 new drilling platforms), total reinjection in Berlín (restoration of 1 drilling platform), binary cycle plant in Berlin (restoration of 1 drilling platform), and Chinameca field (1 new drilling platform). The development of the Chinameca field represents a big future potential and building of new drilling platforms. In addition, three other new areas: Conchagua, Obrajuelo and Chilanguera, provide good opportunities for civil works. On the other hand, the majority of geothermal projects in El Salvador are located between mountains; slopes and abundant vegetation are present. In addition, poor communities, schools, churches and houses, represent the immediate environment of the projects.

The Icelandic construction of drilling platforms is different from the Salvadorian ones. In fact, the Icelandic drilling practice has different requirements and regulations in environmental issues, as well as in the size of the drilling platform and type of rig. The present document examines and describes the main aspects to consider in the design of a drilling platform, starting with drilling activities, continuing with a description of the environment, topography, real estate, access and social considerations in order to select the best site. In addition, and as an example of design, the CHI-3 platform in Chinameca field is described. An Icelandic example is also studied. This paper concludes with a comparison of the two systems and the cost benefits of implementing the Icelandic system in El Salvador.

1. INTRODUCTION

El Salvador is located in the heart of Central America, bordered by Guatemala and Honduras. The climate is tropical, with a rainy season (May to October) and a dry season (November to April). The terrain consists mostly of mountains, with a central plateau and a narrow coastal belt. The country extends over an area of 21,040 km^2, with a population of about 6.3 million (Rodriguez and Herrera, 2003).

El Salvador has two main geothermal fields: Ahuachapan-Chipilapa and Berlin, with 32 and 16 years of exploitation, respectively. At present, 50 wells have been drilled in Ahuachapan-Chipilapa on forty three platforms and twenty four wells have been drilled in Berlin on fifteen platforms. The total area of the fields is: Ahuachapan-Chipilapa - 30 km^2 and Berlin - 20 km^2. Berlin and Ahuachapán provide the national electrical supply with 165 MW which represents 26% of the total electrical system in the country. One more field is now under exploration, Chinameca field. The main objective is the generation of 50 MW of electrical power. However, there are new areas for future development such as Obrajuelo, Conchagua and Chilanguera, with a potential of 10 MW each. The main geothermal fields are shown in Figure 1.

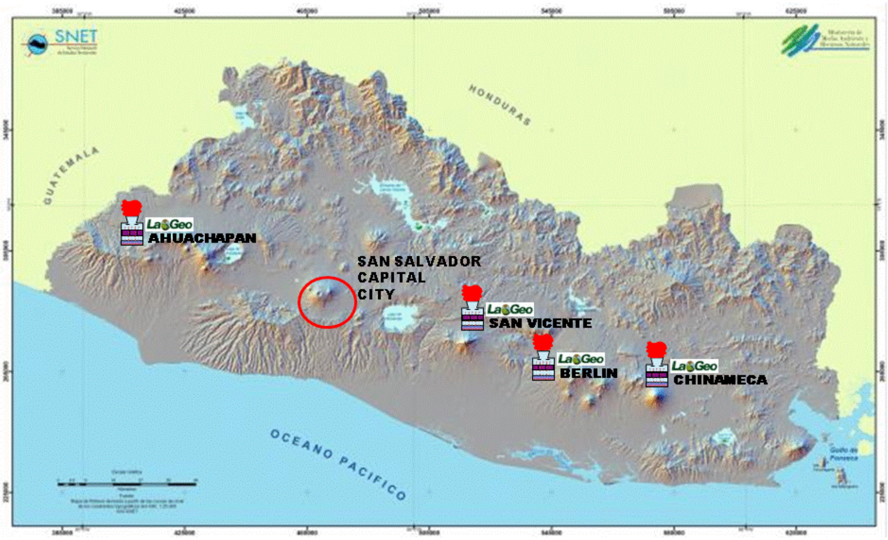


FIGURE 1: Map of El Salvador (courtesy of SNET - National Service of Territorial Studies) showing the main geothermal fields

In El Salvador, building a drilling platform upon a mountain is a common practice. For example, the TR-19 platform in Berlin geothermal field reaches as high a slope as 25%. The different elevations and the topographical coordinates of some platforms in Ahuachapán, Berlin and Chinameca fields are given in Table 1.

TABLE 1: Topographic coordinates of the main geothermal fields

Description	Ahuachapán	Berlin	Chinameca
Site	CH-11	TR-19	CHI-3
Elevation (m a.s.l.)	769	775	925
North	311314.369	311314.369	262810.932
East	413682.145	5544568.2	570284.919

Chinameca geothermal project is located in the municipality of Chinameca, State of San Miguel, approximately 140 km east of San Salvador, the capital of El Salvador. Actually the first project phase is over, with the second phase now extending until 2013. The estimated installed capacity will be 50 MWe. CHI-3, located in the Chinameca area, will be the study example in this report.

Hellisheidi geothermal field in Iceland, which is one of seven potential production fields within the region of the Hengill central volcano, is located between the mountains Stóra Skardsmýrarfjall and Stóra Reykjafell, 30 km southeast of Reykjavík city. The area is divided into the upper geothermal area above Hellisskard pass and the lower area below the pass (Chow, 2007). The scheduled production for the Hellisheiði plant is 300 MW of electricity and 400 MW of thermal energy. The plant´s purpose is to meet the increasing demand for electricity and hot water for space heating in the industrial and domestic sectors. Two steam turbines (45 MW each; 90 MW total) came online as of December 2006, an additional 33 MWe turbine in late 2007 and in the autumn 2008, two additional steam turbines (45 megawatts each; 90 MW total) are scheduled to come online (Reykjavik Energy, 2008).

2. DRILLING

2.1 Drilling activity

The drilling process requires considerable planning and infrastructure. A well site must first be selected, then all the legal documents obtained. Drilling operations can begin only after the site has been prepared, ground has been levelled, roads have been built, a derrick has been raised, and other drilling rig equipment and accessories have been installed in the pad**.** Water is a vital component in the geothermal drilling process for mixing drilling mud (water based). Water can be pumped through a pipeline from a nearby lake, pond, or water well. When the site is prepared, the drilling rig can be moved into position. A rotary rig is normally used. It is capable of drilling 50-200 m per day through use of a rotating bit driven by huge engines. Fluid or air is forced under pressure down the centre of the drill stem to continuously clean out the hole during drilling.

2.2 Equipment

Building a conventional drilling platform includes many preparatory steps as well as setting up diverse equipment, all of which must necessarily be completed before drilling starts. Figures 2, 3 and 4 describe the main components in a conventional drilling platform (J. Perez Graphics & Design, 2007) for a conventional drill rig as used in El Salvador; they show the necessary groups of components, described and identified by a number.

View 1 - Figure 2:

1) Crown block: A device comprised of sheaves or pulleys at the top of the mast over which the drilling line is run down to the hoisting drum.
2) Derrick board: A platform near the top of the mast on which the derrick man works. Also called a "monkey board".
3) Mast: A portable metal tower that is raised into a working position as a unit rather than assembled (like a derrick). A mast is used as a component of the hoisting system of a drilling rig.
4) Travelling block: An arrangement of pulleys or sheaves suspended in a derrick with wire rope and used to raise and lower equipment in the well.
5) Top drive: A power swivel which rotates the drill string without the use of a rotary table or Kelly. This is efficient due to its ability to drill three joints deep before another connection must be added.
6) Mouse hole: A hole in the drilling floor, 7-10 inches wide, located near the rotary table. It is used to store a piece of drill pipe until it is pulled up and attached to the drill string.
7) Hydraulic Hoists: Also known as an "air hoist". A small cable crane that lifts pipe and equipment up the v door. Also used to hoist personnel for maintenance on the top drive.
8) Mud return line: A pipe which carries the circulated drilling mud from the mud pumps to the wellbore.
9) Mud-gas separator: A vessel that is attached to the mud flow line to remove gas from the circulated mud when drilling through a high-pressure gas zone.

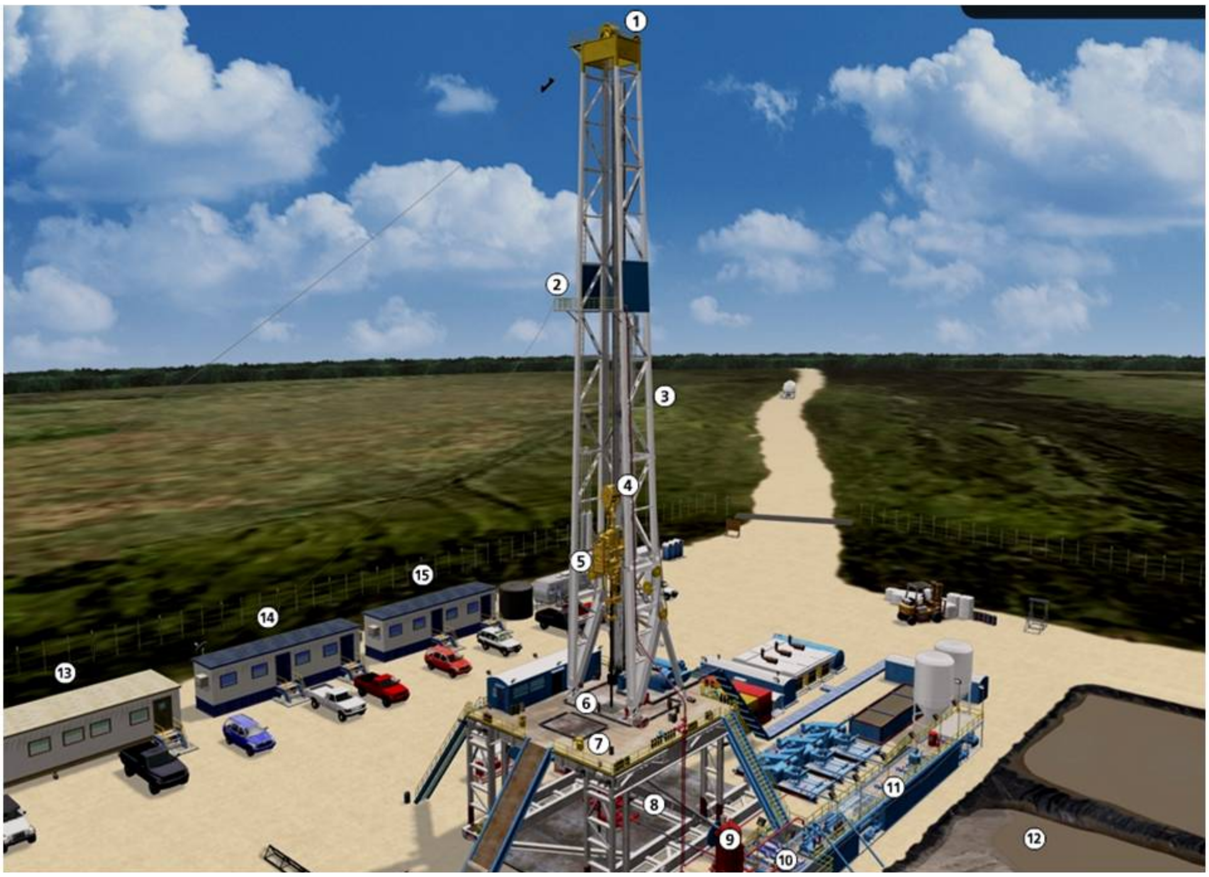


FIGURE 2: View 1 of a drilling platform and the main components (J. Perez Graphics & Design, 2007); 1. Crown block; 2. Derrick board; 3. Mast; 4. Travelling block; 5. Top drive; 6. Mouse hole; 7. Hydraulic hoists; 8. Mud return line; 9. Mud-gas separator; 10. Shale shakers; 11. Mud system; 12. Mud pit; 13. Company man's quarters; 14. Tool pusher's quarters; 15. Rig hands quarters

10) Shale shakers: A series of vibrating screens used to remove the earth cuttings from the circulating fluids from the wellbore.
11) Mud system: The equipment that separates the earth cuttings coming out of the circulating fluid back to the wellbore.
12) Mud pit: Also known as a "reserve pit". An open excavation near the drilling rig that holds used or waste mud and cutting.
13) Company man's quarters: Trailer in which the representative of the operator of the well has his office and resides while on location.
14) Tool pusher's quarters: trailer in which the rig manager (also called rig superintendent, rig foreman) has his office and resides while on location.
15) Rig hands quarters: Trailer in which the drilling crew resides when off-duty.

View 2 – Figure 3:
1) SCR house / top drive: An electrical housing unit which balances and controls the energy used to power the top drive.
2) SCR house / generator: An electrical housing unit in close proximity to the generator which balances and controls the energy used to power the other drilling equipment at the site. Also a breaker house.
3) Engine / generator set: Fuelled most commonly by diesel, the engine converts fuel combustion into motion. The motion is then converted to electricity by the generator and is used as a power source for various electrical power drill site equipment.
4) Fuel tank: Storage tanks that hold the fuel used (diesel) for the engines and generator of the system.

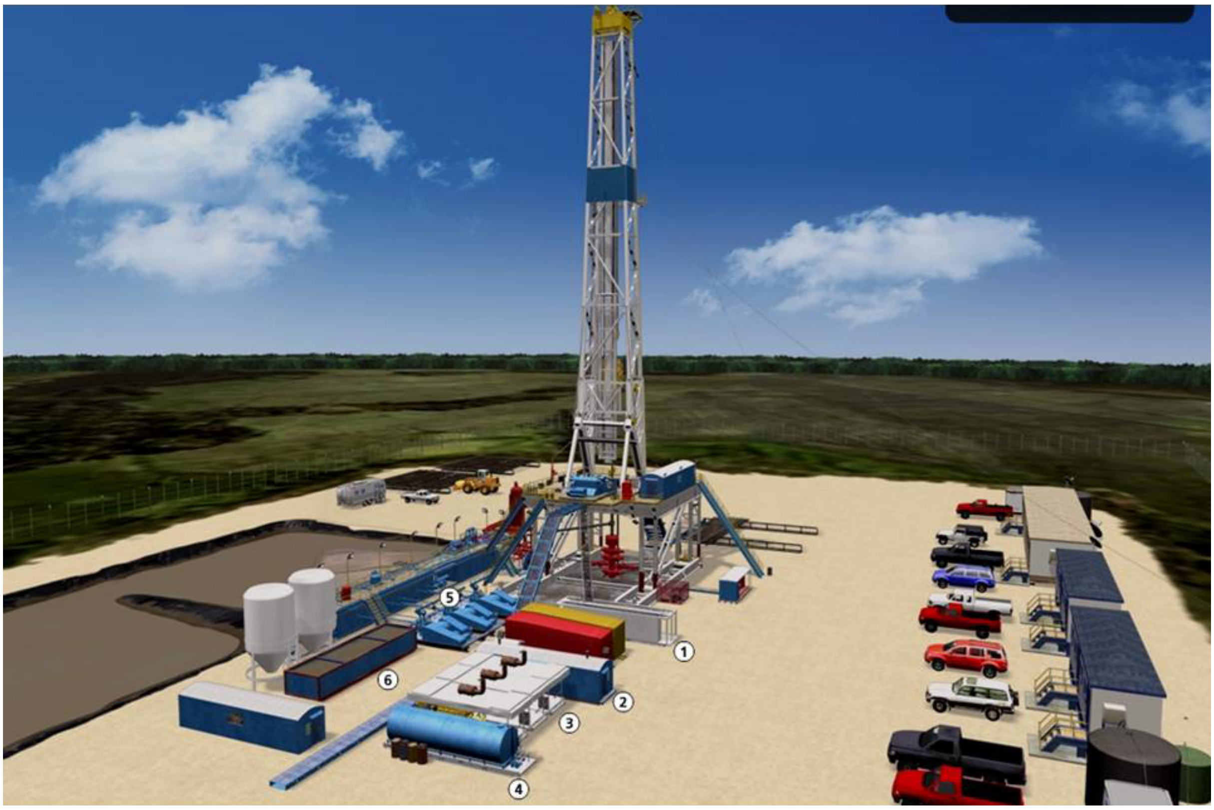


FIGURE 3: View 2 of a drilling platform and main components (J. Perez Graphics & Design, 2007): 1. SCR house/ top drive; 2. SCR house/ generator; 3. Engine / generator set; 4. Fuel tank; 5. Mud pumps; 6. Water tank

5) Mud pumps: A set of two or three piston driven pumps that are used to move circulating fluids on the rig.
6) Water tank: Stores water that is needed in the drilling operations at the drill site: drilling fluids, cementing, cooling and cleaning.

View 3 – Figure 4:

1) Stand pipe: a seamless, vertical steel pipe attached to one leg of the mast which carries drilling mud up to the rotary hose and swivel.
2) Iron roughneck: A hydraulic powered wrench which can make up or break out pipe joints by applying the correct torque. Most of the manual pipe-handling operations previously performed by the drilling crew on the rig floor have been replaced by this piece of equipment.
3) Rotary table: A motorized circular platform in the floor of the rig which rotates the Kelly bushing and the Kelly when the top drive is not in use. Turning the Kelly turns all the pipes, therefore, drilling the hole.
4) Draw works: Large equipment located on the drilling floor which uses steel wire rope to raise and lower the drilling equipment in the well.
5) Driller's console: A console with controls and indicator of main drilling parameters, located in front of the driller.
6) BOP controller: A control panel on the drilling floor which can remotely and independently operate each preventer on the BOP stack.
7) Dog house: A small building on the rig floor which is used as the driller's office, also serves as shelter for the drilling crew and storage for tools and small equipment.
8) BOP stack: Stands for blowout preventer stack. This piece of equipment is attached to the wellhead under the rig floor and utilizes vertically arranged closing elements to either close off the well or control the release of fluids to and from the wellbore.

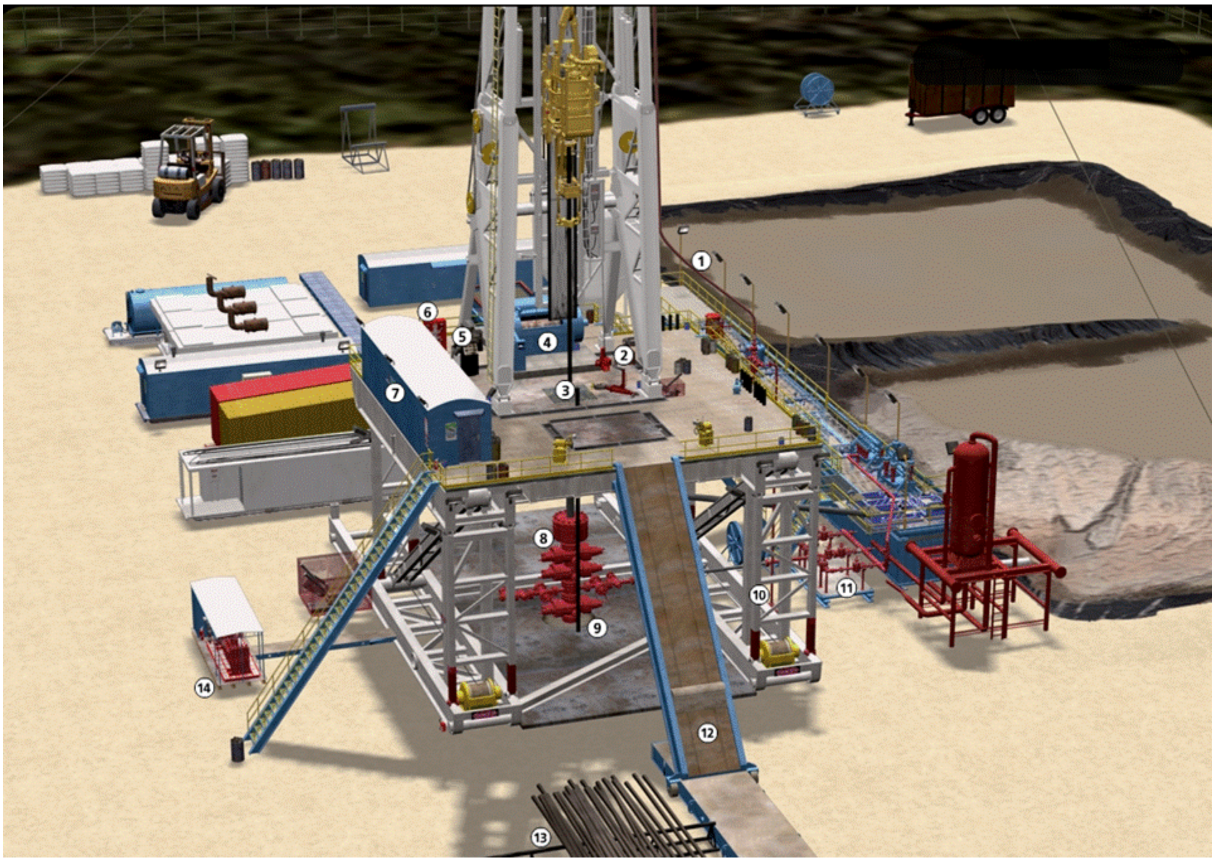


FIGURE 4: View 3 of a drilling platform and main components (J. Perez Graphics & Design, 2007): 1. Stand pipe, 2. Iron roughneck, 3. Rotary Table, 4. Draw works, 5. Driller's console, 6. BOP controller, 7. Dog house, 8. BOP stack, 9. Cellar, 10. Substructure, 11. Choke manifold, 12. Cat walk, 13. Pipe rack, 14. Accumulator.

9) Cellar: A pit around the wellhead which provides space for the installation of equipment at the top of the wellbore such as the BOP stack. Water and waste fluids also accumulate in the cellar for disposal.
10) Substructure: The steel platform and supports on which the mast and all drilling floor equipment sit. Also provides space for well control equipment and storage by elevating drilling floor components.
11) Choke manifold: A series of pipes and valves that functions to control pressures experienced during a kick once the blowout preventers are closed.
12) Cat walk: A long, flat, steel platform where pipe is laid before it is pulled up through the v door and placed into the mouse hole.
13) Pipe rack (with pipe): A steel platform located in the pad to locate the drilling pipes, prior to connecting them to the drilling assembly.
14) Accumulator: A tank which holds hydraulic fluid stored under pressure by compressed nitrogen. An accumulator is used to actuate the blowout preventer (BOP).

2.3 Rig types in El Salvador

The most common drill rig is the rotary rig type. Today's rotary drill rig consists of multiple engines that supply power, hoisting equipment that raises and lowers the drill string (drill pipe), and rotating equipment that turns the drill string and the drill bit. LaGeo S.A. de C.V. who is the main company in charge of geothermal development in El Salvador, has three different types of Rigs; the difference between them is the size, height and the capacity of perforation (depth). These Rigs belonged formerly Forasal which was responsible for the drilling activity before the Santa Barbara Company, a subsidiary of LaGeo, took over. The rigs are: Massarenti 6000, Mass 4000 and H525. Following an explanation and description of the Mass 4000, the tallest rig, the space required on a platform will be covered.

2.3.1 Massarenti MR 4000

The "MR" series rigs, fully mechanically driven, are designed to ensure ease of operation in a wide variety of extreme terrain and climatic conditions and to enable the operator to work in areas requiring all-terrain vehicles. The draw works, carrier and mast capacities are matched to provide good performances. The rig is manufactured from high strength material and equipped with heavy duty hydraulic systems capable of providing power for all the hydraulic services. The rig is trailer mounted, designed to satisfy the needs of a quick rig-up and is an easily transportable unit. In order to guarantee operations on a multi-well cluster, the rig is equipped with a skidding system so as to reduce idle time between wells. The drilling control panel is placed in such a way to provide the driller with a complete view of the drill floor area (Hydro Drilling International S.p.A., 2008).

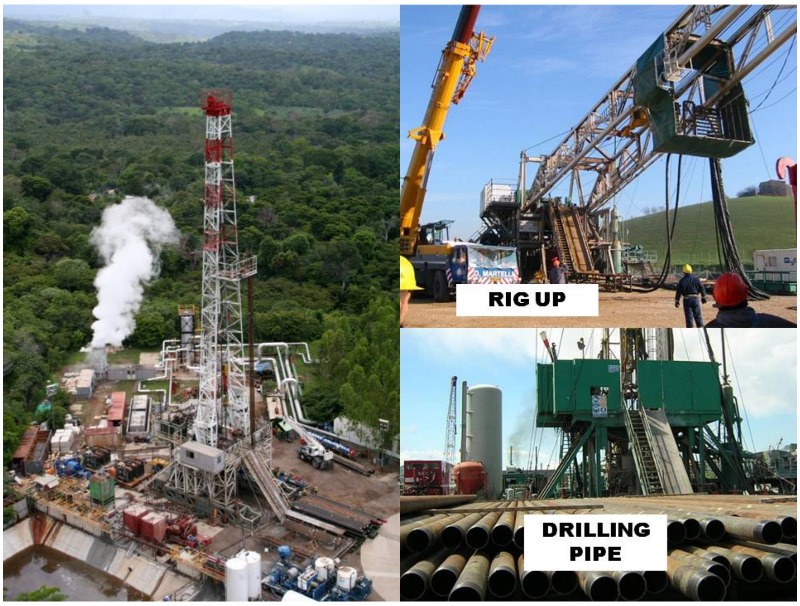


FIGURE 5: View of the Massarenti MR 4000 rig and components in Ahuachapán geothermal field

Figure 5 shows the drilling platform of AH33 (Ahuachapan Field) and when the rig is raised. It also shows the drilling pipes and the cat walk. The typical layout of the Massarenti 4000 is shown in Figure 6. The mast is 63.97 m.

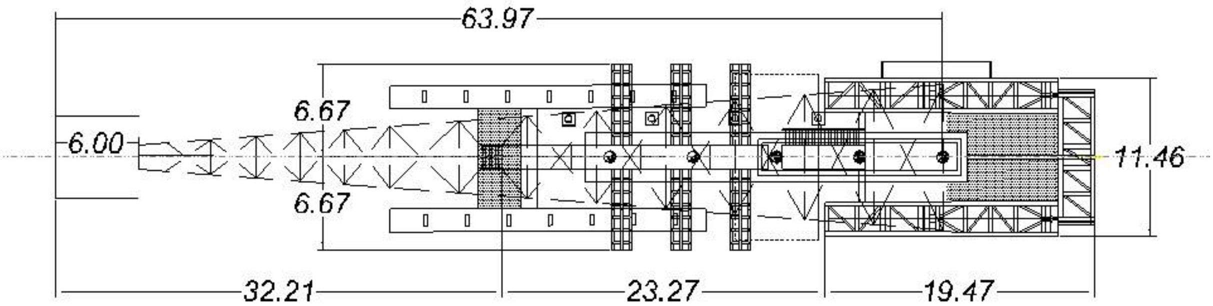


FIGURE 6: Layout of the Massarenti MR 4000 rig (unit: metres)

In Table 2, the different characteristics of a Massarenti 4000 system are listed, such as nominal depth rating, height of substructure, mud pumps, mud system, well control equipment and auxiliary equipment.

TABLE 2: Descriptions of the main characteristics of the Massarenti MR4000 rig (Hydro Drilling International S.p.A, 2008)

Main rig characteristics	**Mud system**	**Well control equipment**	**Other equipment**
Nominal depth rating 6000 ft w/ 4 ½" dps 9000 ft w/ 3 ½" dps Mast specs: 113 ft Telescopic type hydraulic raising w/guy lines tied to substr. Base beams static hook load 200,000 lbs = 90 T Racking capacity 5" dps 2,200 m 3½" dps 2,920 m 2⅞" dps 4,200 m. Substructure Height 18 ft = 5.50 m Rotary cap. 200,000 lbs = 90 T Setback cap. 150.000 lbs = 70 T	Mud Pumps 2 x Soilmec triplex 7T-350; 5" liner: 6 LPS & 2500 psi Drive D. Engine 400 hp c/w air remote control Mud system 3 tanks total cap 700 bls c/w 4 mud agitators + 1 water tank 275 bbl S/shaker 2 x Brandt Atlas 1000 linear motion Degasser Vertical separator adaptable for operation w/ rotating control head Centre pumps: No. 3 "5x6R" Drive eng. same 75 hp for mud treatment and mixing	Choke manifold 3⅛" - 5000 c/w 1 manual choke + 1 adjustable choke Blow out preventer Hydril 13⅝" - 3000 CIW double SS 13⅝ - 5000 U complete w/c 3½" - 5" rams CIW single 13⅝" - 5000 U complete w/c shear / blind rams BOP control Koomey unit	AC rig gens 1 x 350 KVA + 1 x 250 KVA – 3ph + N 50 Hz Fuel tanks 10 m^3 + 3 m^3 cap. Rig site Housing and auxiliary equipment to run operations Firefighting equipment and safety aids Drill pipes 5" - 19.5 Grade G 3½" -15.5 Grade G dcs 8" - 6½" - 4¾"

2.4 General description of drilling a well

Drilling a well is a procedure involving many people where nearly everything must go right, and there is no room for error. Dangerous and powerful machinery, bad weather, and mechanical failures must be faced daily. The work goes on for weeks or months at a time, 24 hours a day, nonstop. The average time needed for drilling a typical well (2500 m of depth) in El Salvador is three months. There are several stages during drilling that are based on known procedures for drilling geothermal wells in the drilling area of LaGeo S.A. de C.V. (PRA-431-01). The following description is based on a 2500 m deep well with an 8½" liner.

Stage 1:
When the civil works are finished (access road to the site, clearing the area, infrastructure for water and electricity), the drilling equipment is moved and installed at the pad to raise the rig. Figure 7 shows how to raise the drilling rig requiring an area approximately 60 m long and 10 m wide.

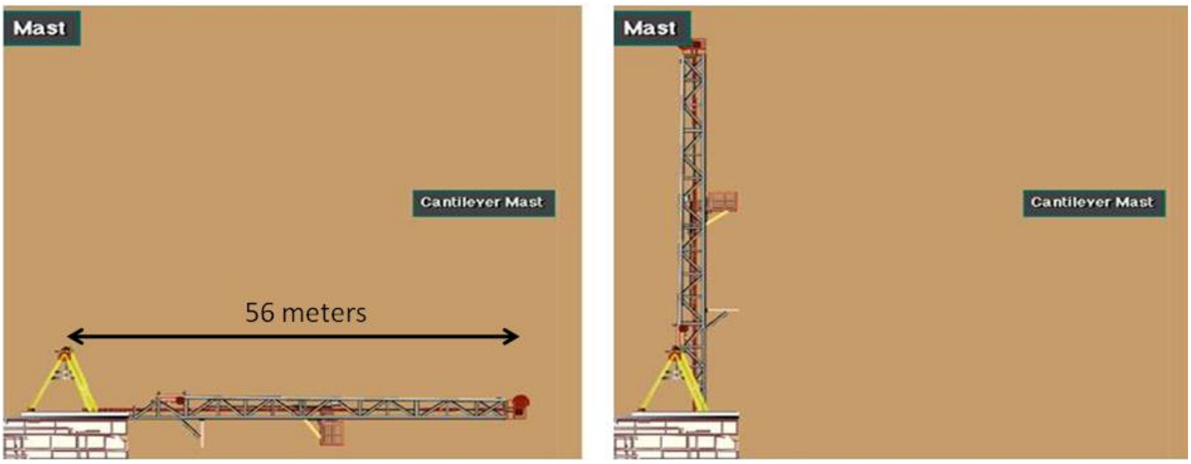


FIGURE 7: Schematic procedure of raising mast

Stage 2:
Drilling operations start (spudding in) to the first target depth, by drilling a hole 26" in diameter, monitoring and controlling the drilling fluid circulation and losses, maintaining geological control of the formation crossed. The crew then pulls out the drill string and inserts a steel pipe (20"), called "surface casing", which is cemented in place to keep the wall from caving in. It controls the borehole's stability and also prevents contamination by groundwater. After the surface casing is installed, the blowout preventerstack (BOP) is attached to it.

Stage 3:
Drilling to the second target depth is done with a 17½" drillbit, monitoring and controlling the circulation loss, and maintaining geological control. Install the pipe called "anchor casing" (13⅜" diameter) and repeat the steps in Stage 2.

Stage 4:
Drill to third target depth, hole of 12¼", monitoring and controlling the circulation loss, maintaining geological control. Insert the "production casing" (9⅝" diameter) and repeat the steps in Stage 2.

Stage 5:
Drill to the fourth target depth, an 8½" hole, with a 7⅝" drillbit, through the reservoir, monitoring and evaluating the presence of permeable zones related to the reservoir, maintaining geological control. Investigations are also carried out that include drilling cores, measuring temperature, pressures and conducting an injectivity test to evaluate the potential of the well. Install the slotted liner and finally install the well head assembly (spool, master and wings valves). When drilling is completed, the drilling rig is removed and the area is ready for connections.

2.4.1 Circulation system

The drilling operation uses fluids to reduce friction and remove rock fragments or cuttings. The circulating system pumps these fluids down the drill pipes, out of the nozzles in the drill bit, and returns them through the annulus to the surface where the debris is separated from the fluid.

The cuttings are separated from the mud in a vibrating screen called a shale shaker. They are trapped on the screen and the mud passes through the screen into the mud pits. Additional mud cleaning is done in desanders/desilters. The circulating pumps pick up this clean mud and send it back down the hole, after the mud has been cooled. The cuttings are collected in a plastic-lined pit for disposal.

Drilling mud is a mixture of water, clay (bentonite), and special minerals and chemicals. Drilling mud removes cuttings from the hole and cools and lubricates the drilling bit. Mud also maintains pressure in the hole to keep fluids in the formation from entering the hole and producing a gusher at the surface. Different mud designs are used during the drilling process to adjust to rock formations, temperature, and pressure.

2.4.2 Rock cuttings

The debris produced by the action of the bit is conveyed to the surface by the bentonite mud, used during drilling, when return of circulation is present. The debris is subsequently separated from the mud by the shale shakers and stored in a dedicated space of the pad area, equipped with drainage water collection (Lazzarotto and Sabatelli, 2005).

The debris is separated first in a sludge tank, which separates the liquid material and solid material, then liquid is deposited in the water pit and mud is removed to a mixing tank. As soon as the sludge is deposited in the tank, it is mixed proportionally with cement. After that the sludge is transferred to a site or drying platform where it is deposited and allowed to dry properly for final disposition. The procedure is described in Figure 8.

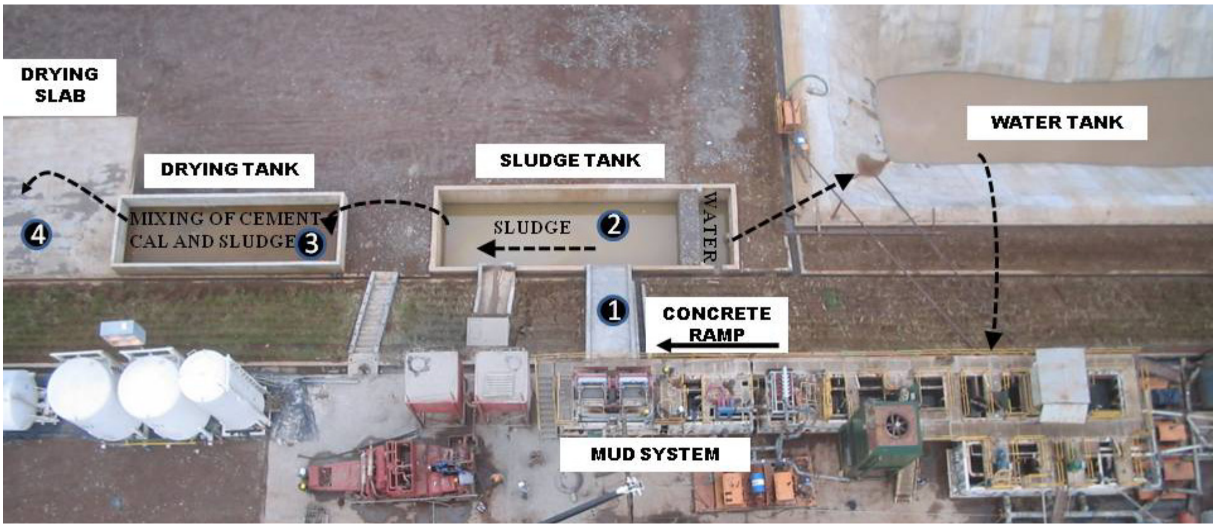


FIGURE 8: Treatment of rock debris in the CH-9 drilling platform, Ahuachapán geothermal field

2.4.3 Cementing

Cementing is the application of a cement slurry at various points inside or outside of a pipe. Cementation is a laborious task carried out in several phases using the most suitable technical equipment to completely filling the annulus (Cigni et al., 1981). The employed slurry consists of an unretarded cement obtained by intergrading a basic clinker and active silica. As water sometimes has to be used as a drilling fluid, a filtrate reducer is added to prevent dehydration of the slurry due to the lack of an adequate mud cake. The slurry is prepared in a tank at the site to ensure the mixture is homogeneous. From there it is pumped to the well with a cement pump.

2.5 Diagram of functions and relationships in the drilling area

Having described and identified the different equipment and the structure of a geothermal drilling platform, it is necessary to know the weight, reach, capacity and dimensions, and to describe in general terms the drilling activity. These are summarized in a chart, along with the roles and relationships between all the components above, in Figure 9.

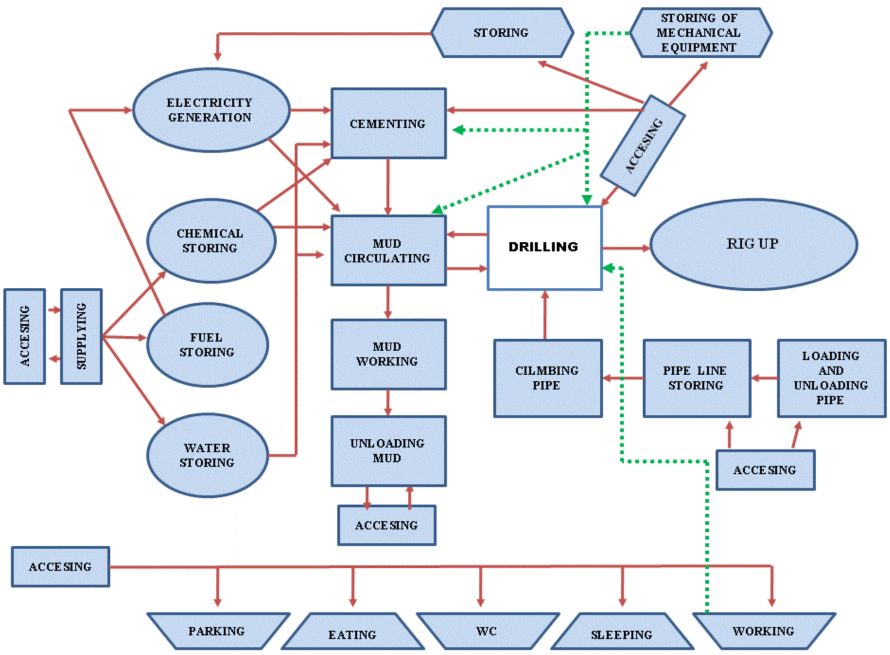


FIGURE 9: Schematic diagram of functions and relationships between different activities

Relationships exist between the different activities within and around a drilling platform. For example, drilling activities have a direct relationship with mud circulation, electrical generation, and climbing pipe and cementing; these activities must be on site during the drilling activities. On the other hand, eating and working in the office do not have any direct bearing on drilling activities; the relationships are indirect and can be sited at some distance from the rig area. Once one knows the diagram of functions and relationships, different areas for different needs can be generated, as shown in Table 3.

TABLE 3: Descriptions of the different activities translated into spaces required; identification of main areas in the platform

No.	Activity	Space required	General area
1	Drilling	Well Base of substructure	Rig zone
2	Rig up Lifting pipe Pipe line store Loading and unloading pipe	Rig up (space) Cat walk Pipe Rack Space for trucks	Rig up/pipe zone
3	Mud circulation	Mud system Shale shakers Mud-Gas separator Pumps	Mud area Pumps
	Mud work Unloading mud	Mud Pit (1500 m^3) Mud separation (150 m^3) Mud treatment (78 m^3) Mud drying Space for trucks	Mud treatment
4	Cementing	Storage tanks for dry cement mix Cement mixing and pump.system Water tank	Cement area
5	Storing chemical Storing fuel Storing water	Chemical container (2) Fuel tank Water tank	Tanks
6	Generating electricity	Power plant, air system Accumulator	Power station
7	Storing equipment	Mechanic workshop Electrical workshop Storage warehouse	Store equipment
8	Parking Eating WC Sleeping	Parking Area Restaurant WC / sewage Dormitory	Restaurant/ Dormitories/Offices/ Parking
	Office Work	Office (geologist, superintendant, manager, contractor)	
9	Access	Road	Access
10	Monitoring	Security house	Security

2.6 Distribution in areas within the platform

According to the information in Table 3, determining group activities and building a distribution area is the next step. Figure 10 shows the distribution of main areas and their locations; size is not described.

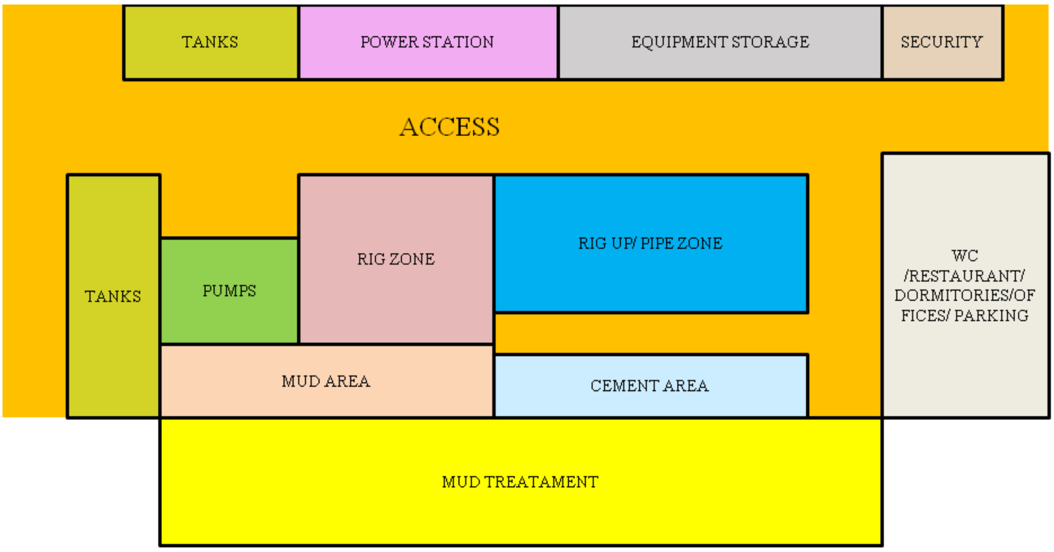


FIGURE 10: Schematic distribution in areas of a drilling platform

3. DEFINING THE TARGET

Before drilling starts, there are a series of issues that need to be solved. For example, where will the drill rig be placed? On whose land will it be? Do you have permission? Have you obtained the proper permits from governmental agencies? Are there towns near the drill site? There are many considerations to think about before the drill rig begins operations.

In order to select appropriate drill sites on which to build the platform, important considerations must be studied: in view of high project costs, optimisation of a well location is a particularly crucial factor. Geological, geophysical and geochemical studies are important for defining the main drill area; these studies are carried out beforehand. However, choosing the best site for a drilling platform involves other considerations such as environmental aspects, land rights, topography, feasibility of access and others.

3.1 Topographical considerations

In order to minimize cost and to determine the appropriate site on which to build the platform, the conditions of the land must be considered, plans made and profiled to avoid carrying out excessive cuts or the need for infilling with earth. The different stages for to determining the best site are summarized as follows:

Map scale:
Recommended scale is 1:25000; map should contain contours, planimetry, altimetry, geology, hydrology, access and villages/towns.

Aerial photos:
Aerial photography is important because it shows the three-dimensional topography of the site, and can make a first approximation of the location of the site. Figure 11 shows an aerial photograph of the area where a drilling platform could be located; through this photograph the relief of the terrain is observed, areas with fewer trees, and the location of nearby villages. Also shown is a big land space without trees or built terraces, which had been used for drying coffee; this is a good option for the

construction of the platform. The aerial photo allows a more accurate final decision on the location of the platform.

Field inspection:
People in charge of the project should preliminarily visit the site, take photographs, collect information, travel within the area and inspect different components seen on the maps.

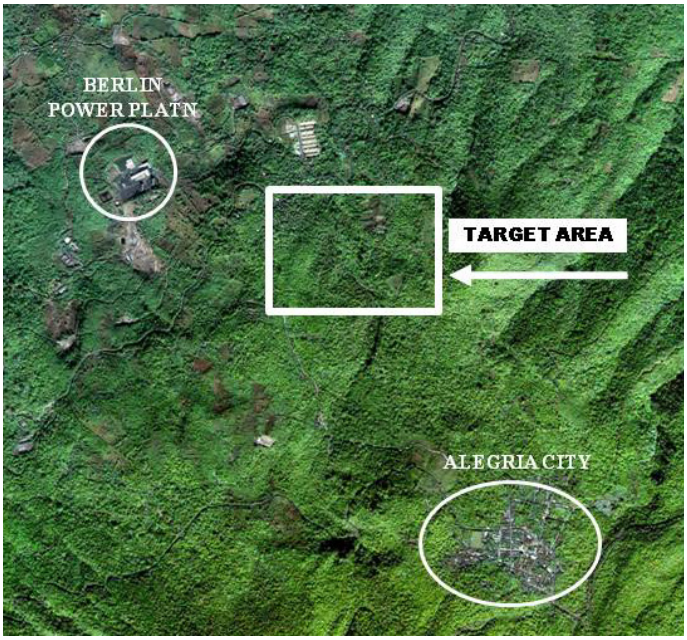


FIGURE 11: Aerial photo of the TR-19 site – the target area

Preliminary location of the site:
After all parameters have been considered in choosing the best location, one must also determine the scale of the earthwork, if the cuts are proportional to the fillings. The different levels are shown in Figure 12. This figure indicates that there are 11 contours cutting the area, each curve represents 5 m elevation. Thus, three layers (identified by colours) are approximately 15 m thick, a good choice for the location of the cellar and drilling machine.

Survey of the specific area:
The survey can be done by the owner of the project or by a contractor. The information is specific about the site, contours, altimetry, planimetry, buildings, vegetation, accesses, and land limits. Figure 13 gives a detailed survey of the site chosen, existing terraces, houses, drainage systems, internal access, schools and nearby villages, the elevations of each terrace, the electrical system, limits of the site, land boundaries, neighbours, rivers and trees. Every layer or elevation can range from 1 to 5 m. In order to know more about the area, sections and profiles can be obtained from the survey; it is recommended to develop a grid for every 5 m in preparing the topographical profiles and to create specific sections of access, rivers and buildings.

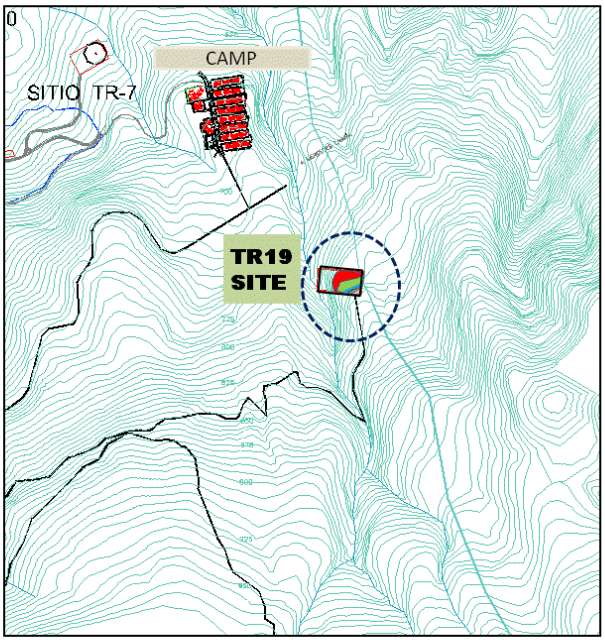


FIGURE 12: General map of the TR19 site, layers and contours

3.2 Property considerations

The right to enter and drill on a property owner's land is accomplished by obtaining a purchase. The purchase is subject to title search and proper recording in much the same way as real estate. In order to minimize costs, new platforms should be on land owned by LaGeo S.A. de C.V., but in some cases when the target is out of central area, it may become necessary to purchase the property or land. Thus begins a process of negotiation. Once the specific area to buy is known, one must follow the procedures for Land Acquisition given by the Civil Area of LaGeo S.A. de C.V. (PRA-434-07).

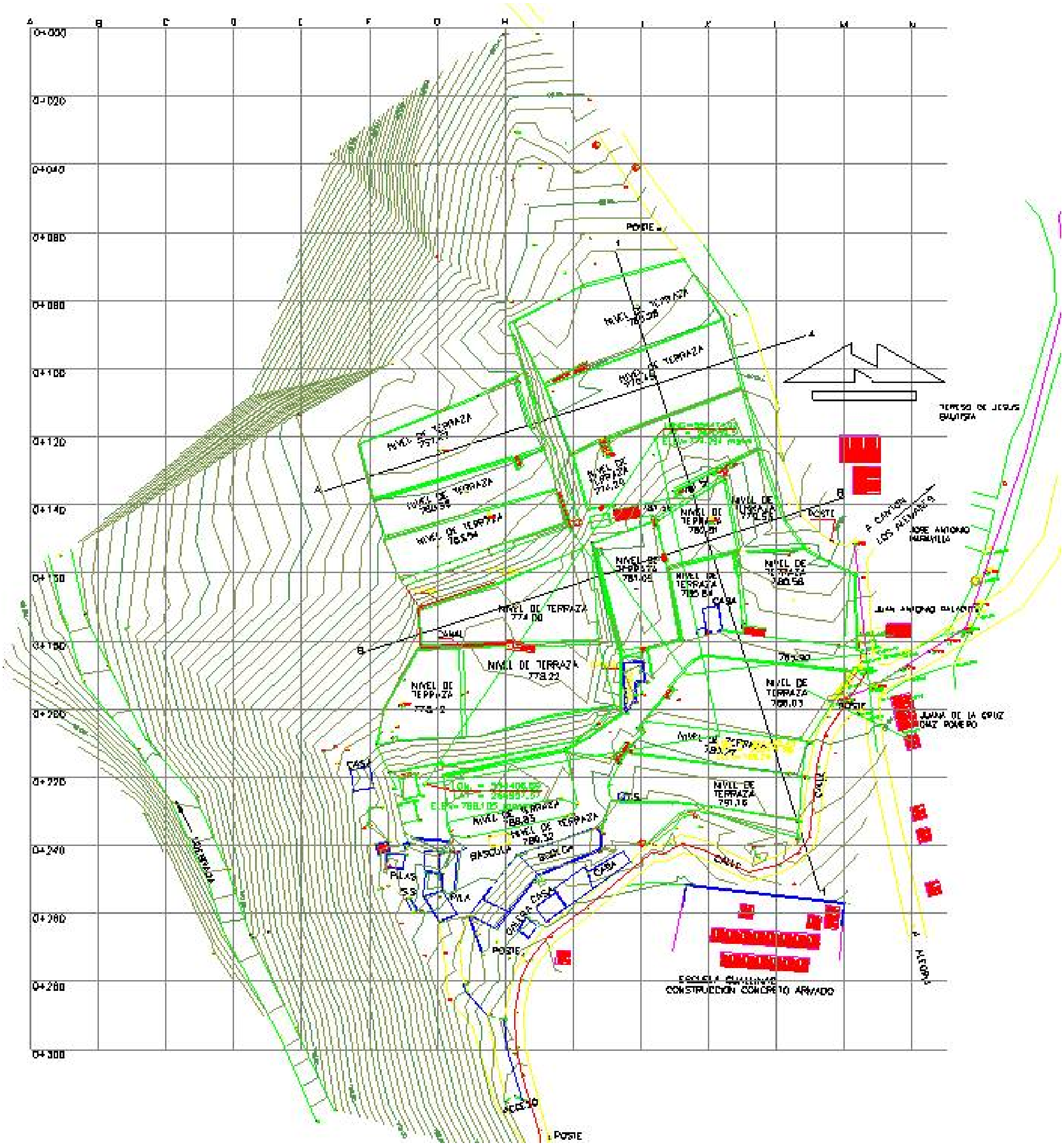


FIGURE 13: A specific survey of the TR19 site in Berlin field

Site inspection:
It is necessary to review the information available, then gather more information (photography, interviews), and finally obtain preliminary technical assessments and develop a technical report. This includes data on owners, state-owned land registers, and interviews with neighbours or people found on the site.

Topography:
To obtain work permits for a survey, one must designate the scope of the technical report, identify or locate geodesic reference marks, provide geodesic references, follow up field studies, and process the information.

Process of negotiation:
After identifying the owners, the area to be purchased and specific details provided by aerial reconnaissance, the value of the property is determined as to how much LaGeo could pay for the land,

according to the standards of payment in that area. The next step is to continue with the preparation of the purchase offer.

In accordance with the policies and procedures of the company, it is necessary to have the authorization of the board of directors of the company. The next step is to legalize the purchase and register the documents in the registry of property.

3.3 Environmental considerations

Whether building an access road, altering or changing the topography of the land, digging into the soil, altering the natural route of rainwater or entering for the first time an untouched area, all require special consideration from an environmental perspective.

Along with the appropriate selection, exploration and site preparation for drilling and processes involved in its construction, it is crucial to avoid or minimise potentially adverse effects on ecosystems and natural resources. Identifying environmental factors that may be affected by the construction of a geothermal drilling platform is necessary before selecting the drill site.

In El Salvador, the geothermal areas are located in rugged terrains, near or within coffee or cane plantations, near rural communities and in unstable areas with erosion, landslides or seismic activities, all of which are taken into consideration to avoid negative effects on the environment, neighbouring communities and facilities.

The environmental law in El Salvador was passed in 1998, while the national environment policy and benefits of natural resources (water, air, biodiversity, etc.) were passed in 2000. All of these became instruments for the public sector that defined a legal framework for environmental matters. Within LaGeo's policy, fulfilling legal requirements for any activity, work or project is always considered. According to environmental law, the permit for geothermal power generation projects requires at least five steps, starting with filling out the initial form, technical and environmental aspects of the project (as part of the screening), followed by the field inspection by MARN (Ministry of Environment and Natural Resources) technical personnel on the location of the project. The authorities then decide if EIA (Environmental Impact Assessment) is necessary and, if so, the assessment will be published in a local newspaper three times as a call for stakeholders' comments over a 10-day period.

After the MARN technical analysis, LaGeo is notified of the next requirement for fulfilling an environmental guarantee of mitigating measures in an Environmental Management Plan (EMP). MARN then grants the Environmental Permit for project execution, including programmed audits. The permit expires at the end of the activities (Arevalo, 2006).

The most important parameters of a study before, during and after drilling are shown in Table 4, describing the major impacts that require physical mitigation, for example the construction of channels, a site for garbage disposal, and water bars.

TABLE 4: Environmental impact and mitigating measures in drilling activities

Significant impact	Mitigating measures
Land surface disturbance (erosion caused by rain or wind after civil works)	Rehabilitation through slope stability, terraces, roadsides.
Landscape alteration	Reforestation and architectonic designs of facilities
Alteration in natural drainages	Dam structures, peripheral drainages, roadsides, canals
Domestic and industrial solid wastes	Debris's final deposition on legal sites, landfill, or reuse / recycling of woods, ferric materials, empty packings, etc.

3.4 Access

One of the most important considerations is access to the site; in many cases, access determines the final location of the drilling platform. Possible access entails the same activities that were described earlier in the site selection (Figure 14 shows the access survey). In most cases in El Salvador, the streets are narrow and in poor condition, without any protection or drainage work.

Figure 15 shows an aerial photo of the main street and drill access in Guallinac village. However, the length of the access road varies. Generally the shortest feasible route is selected to reduce the hauling distance and construction cost.

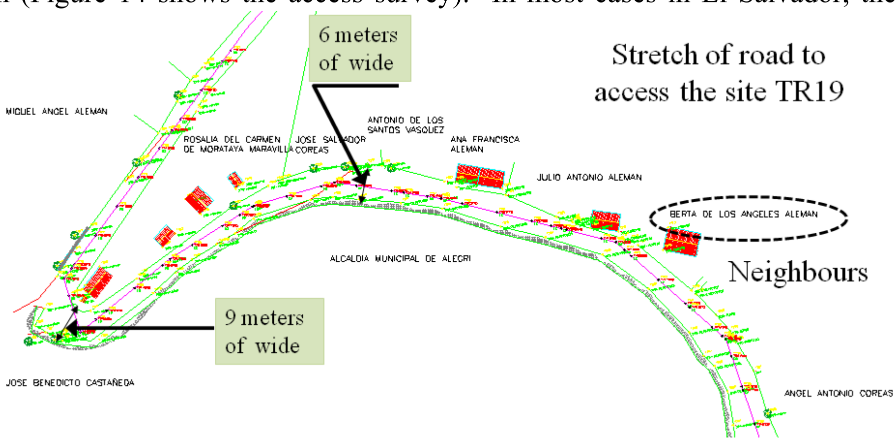


FIGURE 14: Topographical survey of access to the TR19 site

Generally, the types of equipment include track-mounted or rubber-tired dozers, scrapers and motor grades. Moving equipment to the construction site requires moving several loads (some overweight and over width) over public and private roads. For adequate access design, the slopes must be suitable for heavy transport traffic, ensuring a wide curve and a good drainage system for rainwater. When heavy equipment is moved around varies, it can be before, during and after drilling. Therefore, the appropriate materials must be used to ensure the access road is in good condition at all times. And it is important that after the completion of drilling, the access route receives maintenance.

FIGURE 15: Aerial view of the TR-19 drill site, main street and access

3.5 Social considerations

El Salvador remains largely a rural country despite the growth of San Salvador and its environs. For the vast majority of rural residents, land shortages, unemployment, underemployment, and extremely low wages combine to keep the standard of living low and the quality of life barely tolerable. Most of the drilling sites are in poor and rural areas that contain a large number of people, especially children. Geothermal projects can be sited near rural schools, villages, health clinics, churches, homes or communal spaces for meetings. Figure 16 shows the prospective drill site and the different rural houses and villages near the site and access road.

FIGURE 16: Aerial view of the TR-19 drill site, rural houses near to the site and access

Public involvement in the decision process for any ongoing project is an inherent condition according to environmental law. LaGeo, conscious of its role of being a "responsible neighbour", has created a social projection area to promote and contribute to the local development along with the local government and other institutions (GOs, NGOs, civil society) within the area of influence (Arevalo, 2006).

Before drilling a well, a company must publicize the project for the neighbouring community. Social sectors located in the area that might be affected by the project must be identified and categorized. Usually there are three classifications of social sectors: land owners, public institutions or NGOs, and communities. Information on the engineering, environmental, and social impacts, as well as the social benefits of the project must be shared with the social sector. Lastly, a final report documenting the activity must be prepared. Table 5 shows some social aspects that were evaluated before granting an environmental permit for drilling wells at the TR-19 site at Guallinac village in the Berlin geothermal field.

TABLE 5: Social aspects evaluated before granting an environmental permit (Environmental permit approval-337/2002)

Assessment	Description
Homes	80 houses
Population	80 families, 560 inhabitants, an average of 7 per family unit
Economic activity	Rampant poverty and unemployment; most of the people are labourers and do not receive aid
Culture	Local residents are religious and attend a church located in a neighbouring village
Basic service	*Health:* There is no health clinic. *Water* is collected from a source close to the town.
Education	The school is located 500 m south of the proposed site for drilling; 700 m to the north is a nursery school that caters to 38 children.
Organization	Guallinac has a community development association; LaGeo's board of directors has constructed a childcare centre. The community promotes sports and has a team of soccer

4. CIVIL COMPONENTS OF A DRILLING PLATFORM

4.1 The drilling platform

The drilling platform can be defined as a series of spaces or areas built for the drilling of one or more geothermal wells, involving perforating activities (machinery and equipment), drilling sludge management, areas of environmental protection, internal access, offices, and areas for loading and unloading. Designing different spaces requires insight into the activities to be developed, the size and weight of equipment and machinery, and the general activities during and after drilling.

In El Salvador, most of the drilling sites are in areas with fairly high slopes in the terrain. In such conditions, it is necessary to be very precise when designing platform dimensions in order to reduce construction costs. Different materials for the construction of floors, tanks, channels, access, depend on the ability of the land to withstand the weight of the equipment and platform; the type of system used, the composition of materials (sludge perforation), and the construction techniques used will depend on the requirements of the contract.

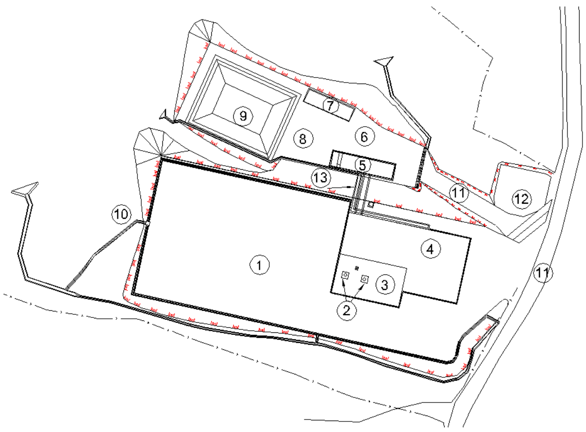
4.2 Example of a design process for a drilling platform in Chinameca, El Salvador

As an example of process design for a drilling platform, a new platform designed in the year 2007 and built in the first half of year 2008 will be described. The site is within the Chinameca geothermal field. The objective of the project was to build a 50 MWe geothermal plant. Figure 17 gives the layout of the platform, which is designed for drilling with the Massarenti 4000 drilling rig. The number of different terraces and levels built are described; there is a 5 m height difference between the two main terraces. The different levels and slope spaces have gradients of 45 degrees in some cases. In addition, rainwater routes can be observed and the location of their open channels. The limits of the property acquired and street access are also visible. Number 1 represents the main terrace, 925 m above sea level (m a.s.l.); no. 2 is a parking zone at 923 m a.s.l.; no. 3 is earmarked for sludge, drying and water tank spaces as well as for the unloading and loading of rock debris. From this level at 919 m a.s.l., the pit of the water tank was excavated.

FIGURE 17: View of levels and survey of the Chinameca drill site; 1. Main terrace; 2. Parking; 3. Sludge tank and drying area; and 4. Water tank terrace

The distribution of equipment and the different elements according to Figure 10 in Section 2.6 are shown in Figure 18. On level one, the picture shows the rig zone, rig up, pipe zone, pumps, tanks, mud area, cement area, toilets, restaurants, offices, power station, store equipment, security. After organizing and locating the different equipment on the platform and verifying that there was enough space for drilling, different areas were constructed and materials, sizes, thicknesses, shapes, according to the size of the equipment, weight, access and activities were designed and developed. Figure 19 describes the different areas and shapes, explaining the materials briefly and the giving the names of the areas (to be described in detail later).

FIGURE 18: View of the Chinameca drill site, distribution of equipment and machinery



LEGEND	
ID	**Descrption**
1	Shuting yard
2	Underground floor and guide shafts
3	Level floor slab in reinforced concrete
4	Floor slab in reinforced concrete with a gradient of 1%
5	sludge tank
6	Loading and unloading zone
7	Drying platform
8	Mixing tank
9	Water tank
10	Hidraulic system
11	Acceses
12	Space for offices, wc, dormitory
13	Sewage

FIGURE 19: View of the Chinameca drill site, different areas and description of these

The different components of the drilling platform at Chinameca (CHI-3) are shown in Figure 20. The layout is composed for all components necessary for drilling activities. The total area of the drilling platform is approximately 9000 m^2, divided into two main terraces or slabs, with 5 m elevation difference between them.

4.2.1 Description of the main terrace of the platform

The main terrace contains the rig zone, rig up / pipe zone, mud area, pumps, cement area, tanks, power station, store equipment and offices. It has an area of 4284 m^2 and is at 925 m a.s.l. Unlike the main slab and second slab, built with reinforced concrete, the rest of the terrace is built with a compressed gravel and soil compound. El Salvador is a country where most of the soil is composed of shale in the first stratus and has a different load capacity. Therefore, it is necessary to know its resistance prior to design because, in some cases, it is necessary to change this layer down to more than 2 m depth. In

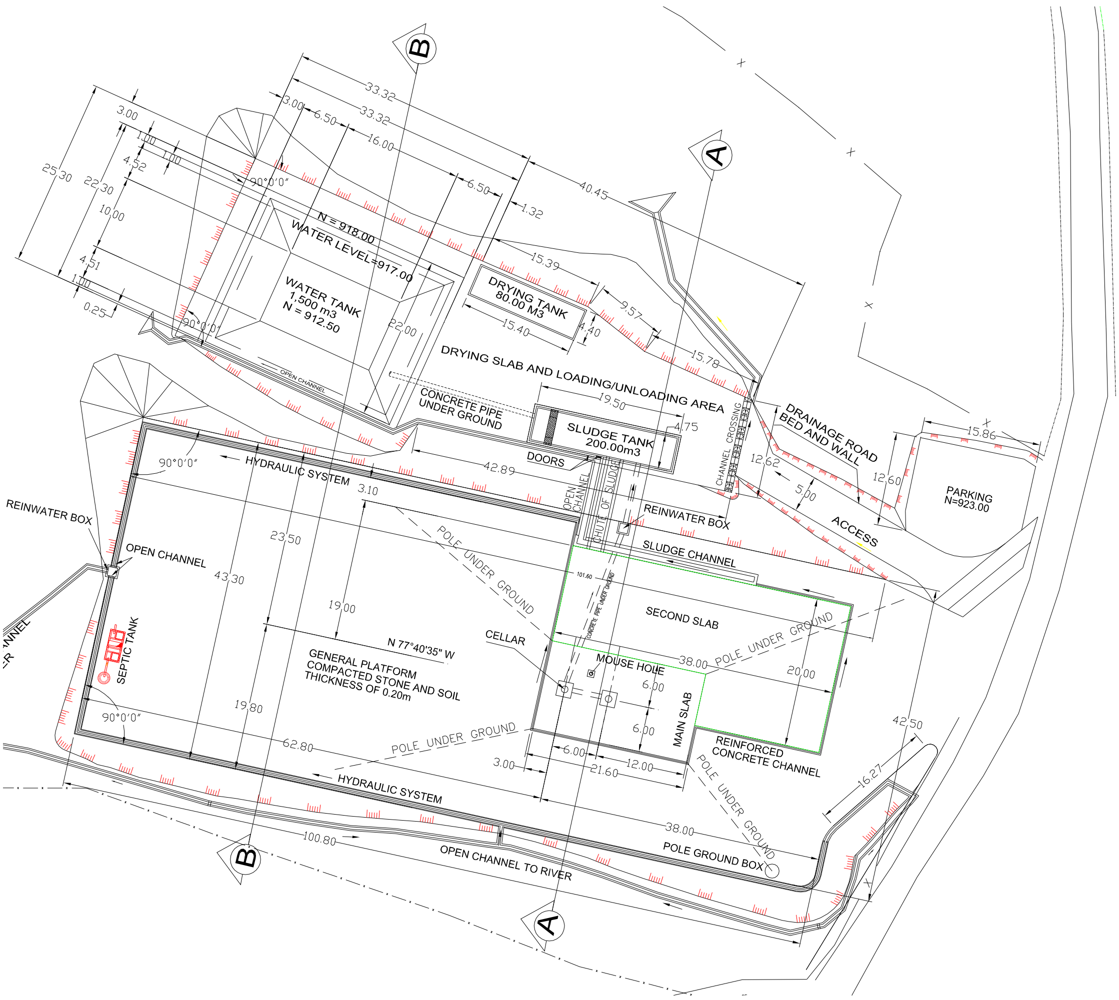


FIGURE 20: View of the Chinameca drill site, the layout of the drilling platform (units in m)

this case the thickness of the layer composed of compressed gravel and soil is 25-30 cm. The main terrace should have a minimal slope to an open channel. The drill equipment and machinery must be electrically grounded, which requires building a pole under the ground near the rig zone.

The most common way to build a main slab is with reinforced concrete with a thickness that varies between 25 and 30 cm. This slab contains one or more cellars built of reinforced concrete and not more than 1 m deep. The rainwater drains from the cellars to the sludge tank via a concrete pipe. The second slab is built with metal mesh and concrete; the average thickness is 12 cm. Both the main and second slabs have an open channel for draining rainwater and some drilling liquids. These open channels are connected with the sludge tank.

The main terrace is composed of an open channel which carries the rainwater to rivers. This open channel is built with stone and cement; it can vary in area, depending on the volume of water to be drained. Due to mud circulation, rock debris accumulates which is then deposited in the sludge tank via the concrete ramp. The terrace, which contains the sludge tank, water tank, drying tank and drying slab, is 1990 m^2 in area and at an elevation of 919 m a.s.l.

4.2.2 Description of the second terrace of the platform

The sludge tank is built with reinforced concrete, with an area of 98.75 m^2 and has a volume of 247 m^3. It is located next to the second slab and at an inferior level, as it is meant for storing debris. In addition, it has a stone wall, called a gabion, which separates the water from the sludge. Gabion structures are built by confining natural stone within individual gabion units which have been mechanically connected together to create a monolithic structure; the stones are confined inside metallic boxes with 5 cm sieves.

The drying tank is built with reinforced concrete, 68 m^2 in area and 96 m^3 in volume. After separating the sludge from the water, the sludge is mixed with cement in the drying tank; the height of the wall should be adapted to accommodate the mechanical shovel. As soon as the sludge is mixed, it is carried to the drying slab to dry off and is then transported to its final deposition. The waste sludge, after mixing, can be used in streets or spaces that need fillers; in some cases they are used to manufacture bricks. The water tank is built with galvanized mesh and concrete, the volume is variable and depends on the depth of the well.

4.2.3 Water and pumping

In drilling, it is common to use cooling water from the cooling tower of a geothermal power plant, if available. It is pumped and transported by steel pipe, 4" in diameter. The cooling water is stored at the drilling platform in the water tank described above.

4.2.4 Complementary spaces

Sewage:
A septic tank, the key component of a septic system, is a small scale sewage treatment system common in areas with no connection to main sewage pipes, provided by private corporations or local governments. It is usual to build a septic tank which is composed of one tank for separation and one for absorption. Sometimes portable toilets are used.

Stabilized highway slopes:
Many landscape techniques are used to stabilize highway slopes. In civil work for a drilling platform, it is usual to create contour wattling, also called "wattling and staking". One method is to plant brush vegetation on steep slopes, applied where a grass cover would not be strong enough to stabilize the soil of the slope. The idea is to sub-divide the slope with dense brush rows and, if necessary, seed grass between the rows for additional soil fixation. Frequently used in El Salvador is the "Vetiver". It is a clumping grass, producing new young plants around the perimeter of the clump (with mainly sterile seeds).

Often a single application may achieve the desired results but sometimes it may be necessary to combine measures to restore the stability of the slopes. For instance, on a seepage slope, it may only be necessary to drain off the water with open ditches or stone filled drains, while on other occasions it may also be necessary to re-vegetate the slope in order to fix the surface of the slope; and where vegetation does not grow back soon enough, a retaining wall may be required.

Access road
The material used in the access road is comprised of a compressed gravel and soil. First, a 30 cm layer of the top soil is dug out and filled with gravel and earth (brought to the site). This is compacted properly and a slope created toward a rainwater channel.

4.3 Design of drilling platform components

The design of the main components of a civil drilling platform is shown in Figures 21-25, with descriptions of the constructive plants, elevations and dimensions of the components. All units are in metres.

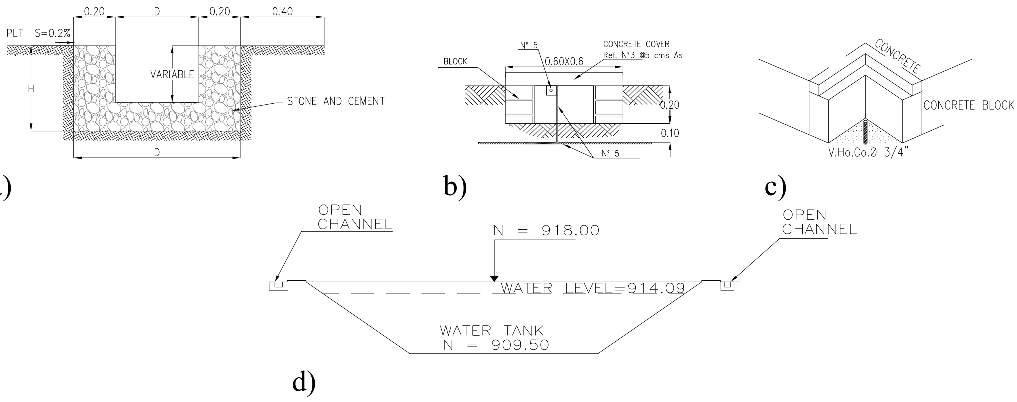


FIGURE 21: a) Rainwater channel, b) Cross-section of pole under ground, c) Pole under ground, and d) Water tank

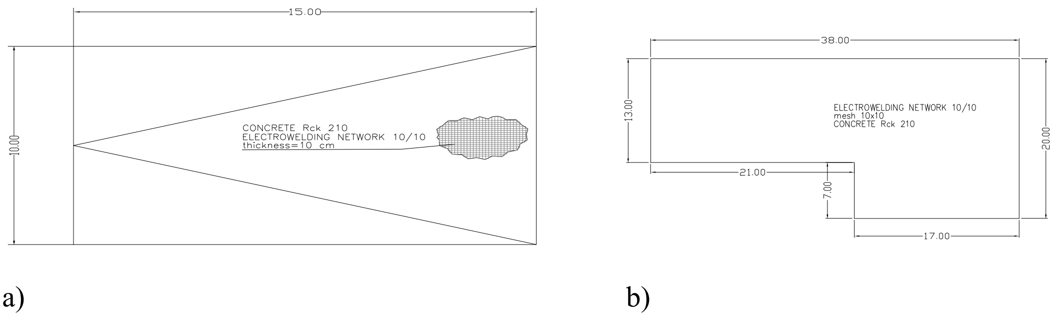


FIGURE 22: Design of the drying slab, a) Planimetry of drying slab, and b) Planimetry of second slab

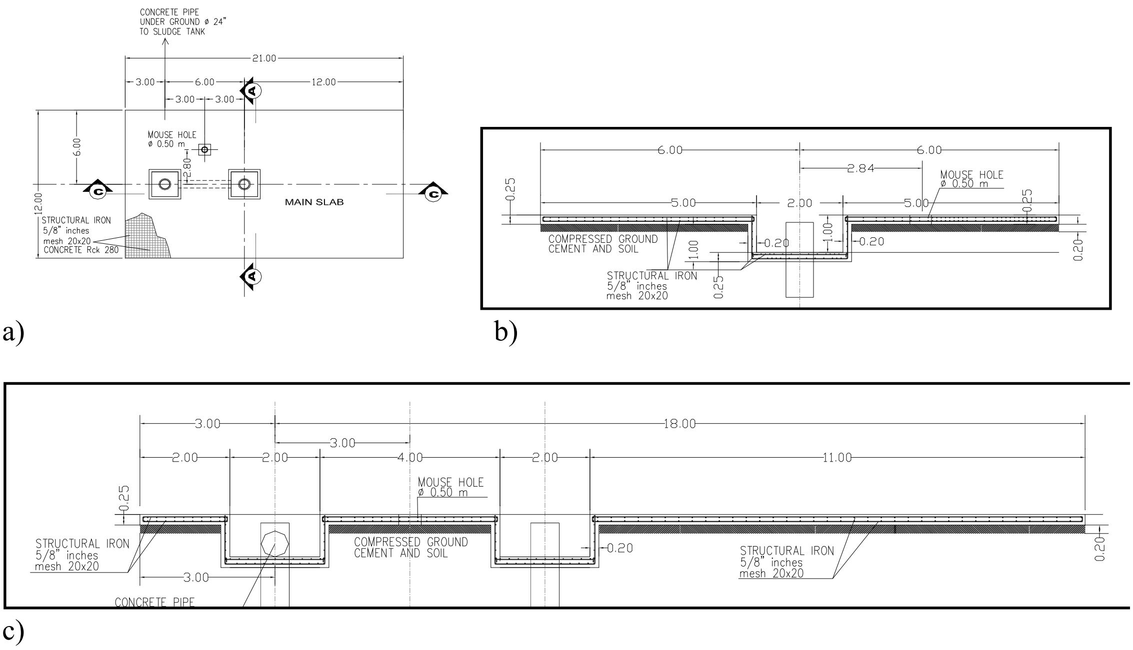
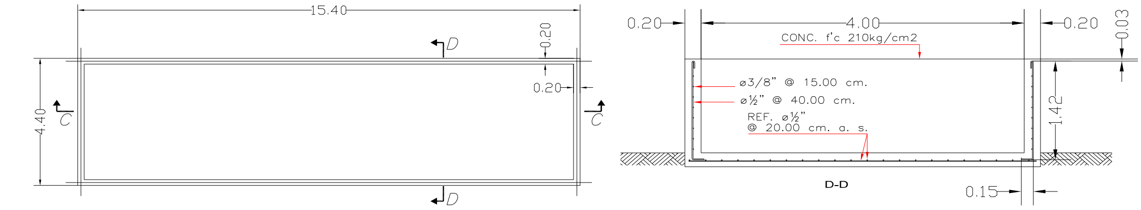
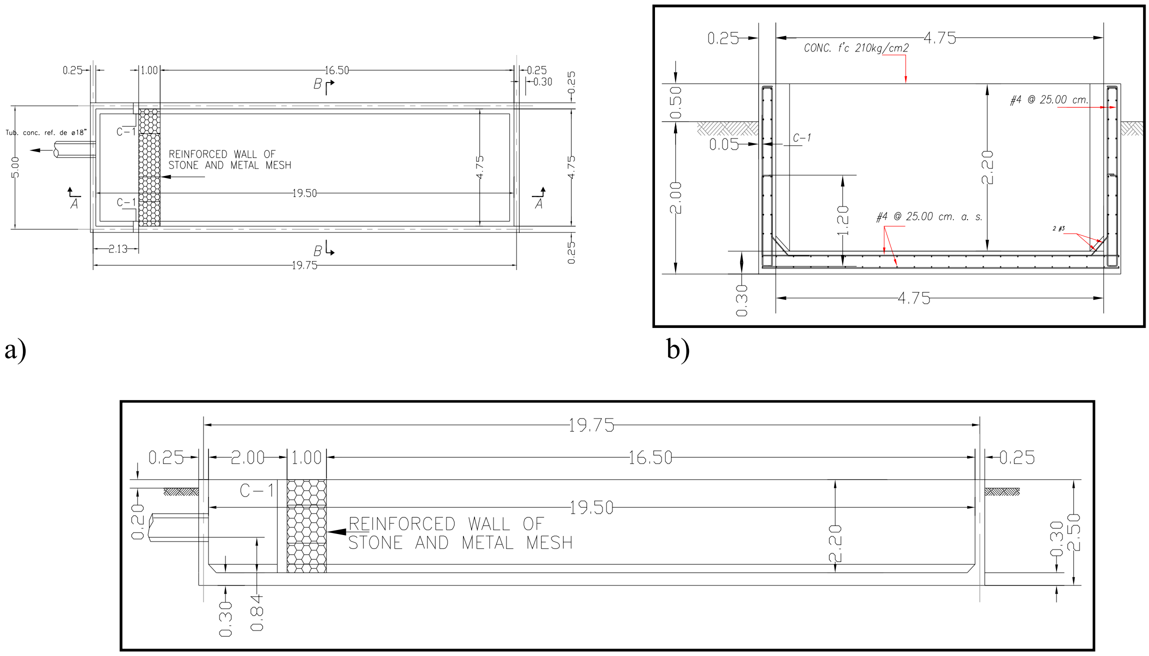


FIGURE 23: Design and dimensions of the main slab; a) Planimetry, b) Section A-A in Figure 20, and c) Section B-B in Figure 20



a) b)

FIGURE 24: Design of the drying tank, a) Planimetry of drying tank,
and b) Section D-D in Figure 24a



a) b)

c)

FIGURE 25: Design of the sludge tank, a) Planimetry of sludge tank,
b) Section B-B in Figure 25a, and c) Section C-C in Figure 25a

4.4 Conditions of the platform after drilling

After finishing drilling one or more wells, the equipment, machinery, offices etc. are removed from the drilling platform. The main and second slabs, the cellar and the master valve remain on the platform. Commonly (if successful), the well is connected to the power plant system, using pipes and supports to carry the vapour/water or both to the separator or the power plant. The drilling platform should look clean and without any drilling material. The water tank, sludge tank and mixing tank should have a protective fence on the perimeter. Sometimes the rock debris is not removed. Over time, the water dries and the debris can then be deposited at a suitable place. Monitoring of the area is important, because the tanks will contain sludge for some time.

Rehabilitation of the landscape and the areas which have been changed is paramount; the area should look similar to how it looked before intervention. Reforestation with the same species of trees in the region, or creating new areas for planting fruits or vegetables can be a good utilization of the drilling area. A good access road and security are necessary while the well or wells are generating steam.

5. EXAMPLE OF AN ICELANDIC DRILLING PLATFORM

5.1 General description

Most geothermal fields in Iceland have flat areas between mountains. The drilling platforms are built on flat sites without any group of people or cities nearby. A good study example is the Hengill geothermal area, which has geothermal manifestations covering an area of 40 km^2, 30 km southeast of Reykjavík city. The Hellisheidi field is the lava area to the south of Mt. Hengill. The eastern slopes of the area are called Kambar. Most of the lava area is covered with moss, crow and blueberries and willow. There are no trees or dense forests so the environmental impact on the landscape is minimal. But due to the construction of access roads, which are made of compacted gravel or asphalt, there is an impact on the natural landscape.

The resistance of the soil there is suitable for building drilling platforms because it is composed of extrusive igneous rocks. Thus it is not necessary to remove soil or change the properties of the base for the rig and drilling equipment. Strong rains are not present; hence a rainwater system and open channels are not required. Working on sloping terrain and the stabilization of elevated slopes is not common. Noise levels, both during construction and operation, may exceed recommended levels for an industrial site, especially during drilling and testing of production wells. The new drilling rigs, however, have extensive noise suppression and meet the EU and Icelandic noise regulations. Silencers are installed at production wells to reduce noise impact (Reykjavik Energy, 2008**).**

Figure 26 shows a typical layout of an Icelandic drilling platform (HE-44). There is only one main terrace, 3600 m^2; on the drilling platform are all the components except the water tank, sludge tank, drying tank and drying slab. Mo concrete is used except for the cellar, 9.7 m^2, but the main slab, 330 m^2, is made by replacing soil with suitable material. The rest of the area is composed of compacted gravel, 50-60 cm in thickness with a plastic liner under the rig and equipment. Levelling of the ground is necessary in some cases, but this work is minimal because most of the surface is already flat.

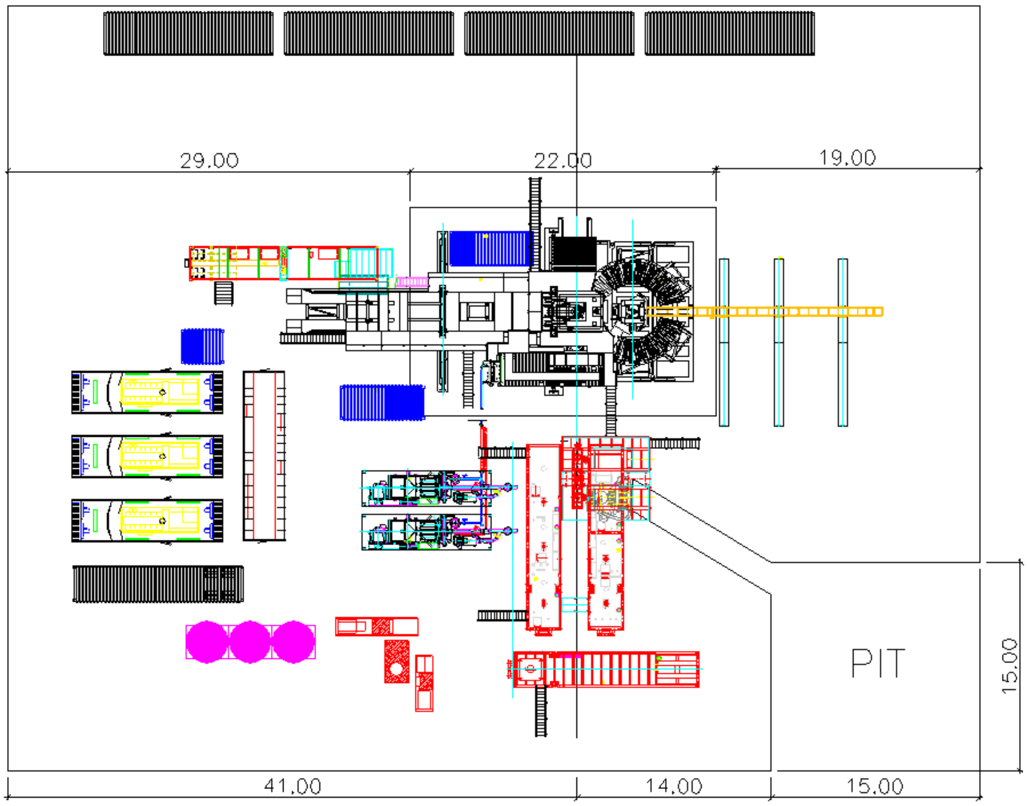
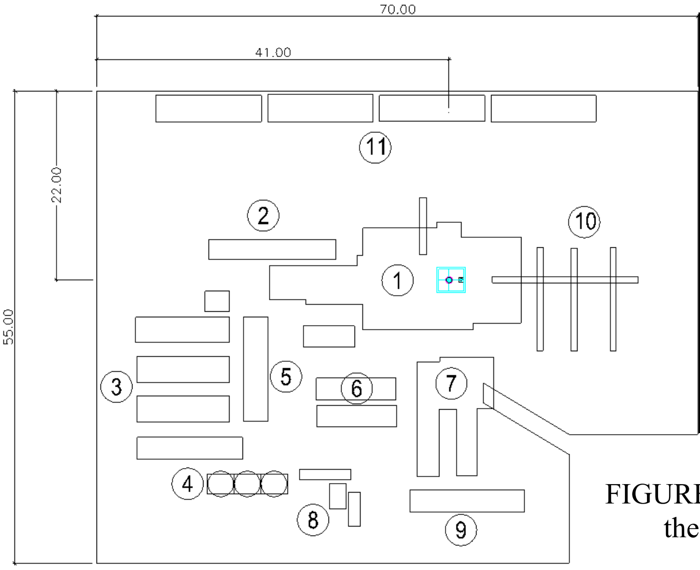


FIGURE 26: Typical layout of an Icelandic drilling platform at Hellisheidi

The rock debris is generally kept in a sludge pit, built with a protective liner. The sludge waste is deposited in the pit and the overflow water discharged to the natural terrain. The area of the sludge pit is 225 m^2 with a variable height. The solid drilling waste, cuttings cement and mud, is transported regularly by truck from the sludge pit to a dedicated dump. The sewage system is composed of portable toilets, cleaned regularly. Liquid waste from drilling activities collected by the plastic liner under the equipment goes to a collection tank buried in the platform. Figures 26-29 show the Icelandic drilling platform, equipment, areas, section and cellar. Units are in metres.



No.	DESCRIPTION
1	RIG ZONE
2	ACCUMULATER
3	GENERATER
4	COMPRESSOR AND BOOSTER
5	POWER CONTROL ROOM
6	MUD PUMPS
7	MUD TANKS
8	AIR DRILLING CAMP
9	DESANDER
10	PIPE ZONE
11	OFFICE, RESTAURANTE, WC

FIGURE 27: Layout and description of the main areas of an Icelandic drilling platform

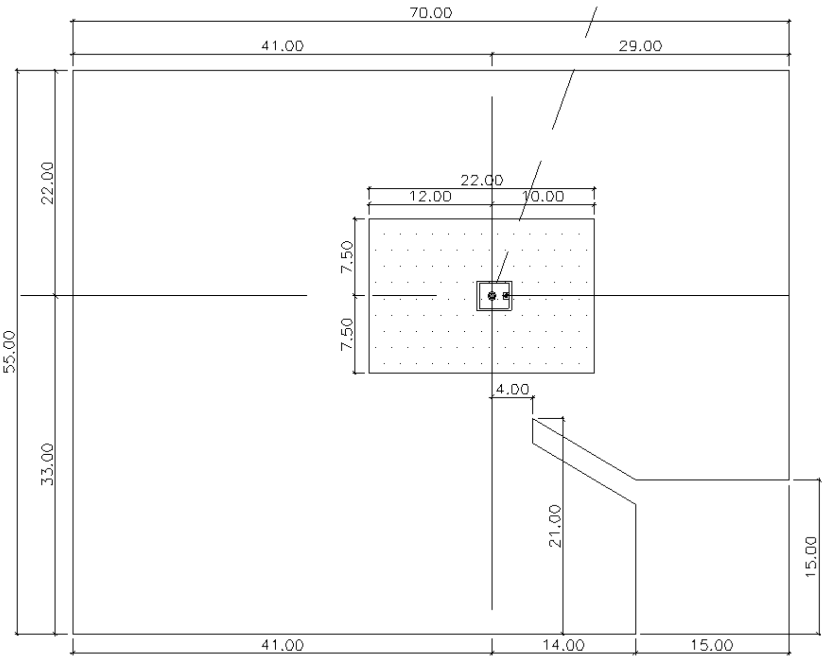


FIGURE 28: Layout of the Hellisheidi drilling platform, main slab and cellar

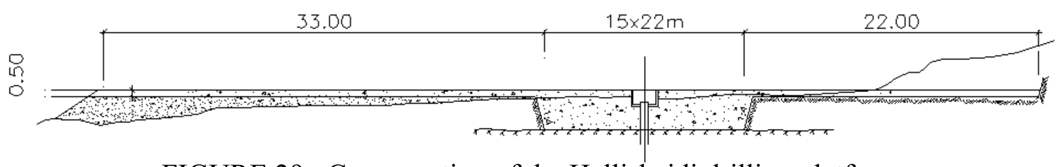


FIGURE 29: Cross-section of the Hellisheidi drilling platform

5.2 The rig type

The rigs most commonly used in the Hellisheidi field are the Drillmec HH-300 or HH-200 (made in Italy). It took time to become accustomed with this type of a rig, and to reduce the working space and number of crew.

The rigs are designed to work in a reduced footprint location to lower construction costs and reduce environmental impact; the entire pipe inventory is placed in a vertical position for more efficient pipe handling. The drilling rig is trailer mounted and reaches the proper height by means of hydraulic pistons (Figures 30 and 31), step by step up to the final elevation. The mast is erected by another couple of pistons. The top drive and its cables are already in working position. The fast up/down rig operations means time saved in moving between two different locations with a significant increase in efficiency and a substantial reduction in moving costs, especially when drilling operations are short compared to the moving time.

FIGURE 30: View of the trailer mounted Drillmec HH-300 rig

The driller has full control of all operations from the cabin (climate controlled). Automatic pipe handling system, automatic power tong, automatic slips, and mud systems and drilling parameters can be easily controlled by a single operator from the dog house. In Table 6, the specifications for the Drillmec HH-300 hydraulic drilling rig are shown.

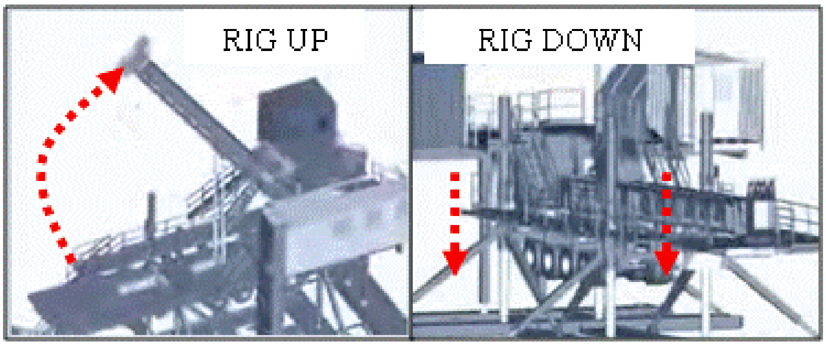


FIGURE 31: View of the Drillmec HH-300 rig being raised up and taken down

In order to reduce construction costs and reduce environmental impact, the HH-300 works in a reduced footprint location. The mud system has integrated mud control features so as to prevent mud leaks and spills. Mud collecting ditches under the drill floor, mud pumps, substructure, tanks, and pipe vertical bins guarantee a dry location. Leaks are also prevented through pneumatic sealed couplings between the bell nipple and the connector pipe (Rogers, 2006). Closed circuit for cooling of mud pumps minimizes water loss. A power management system minimizes fuel and lubricant consumption. The rigs are designed to work with a maximum 60 dB noise. A self-elevating and self-standing mast eliminates the need for manual work.

TABLE 6: DrillMec hydraulic drilling rig specifications (Rogers, 2006)

Model	Static hook load	Max pull down	Rated input	Top drive torque	Top drive stroke	Approx. mass
	lb (kg)	lb (kg)	HP (kW)	ft-lb (dan-m)	ft (m)	lb (kg)
HH-300	600,000 (272,000)	66,000 (30,000)	1542 (1150)	36,141 (4900)	52 (16)	198,420 (90,000)

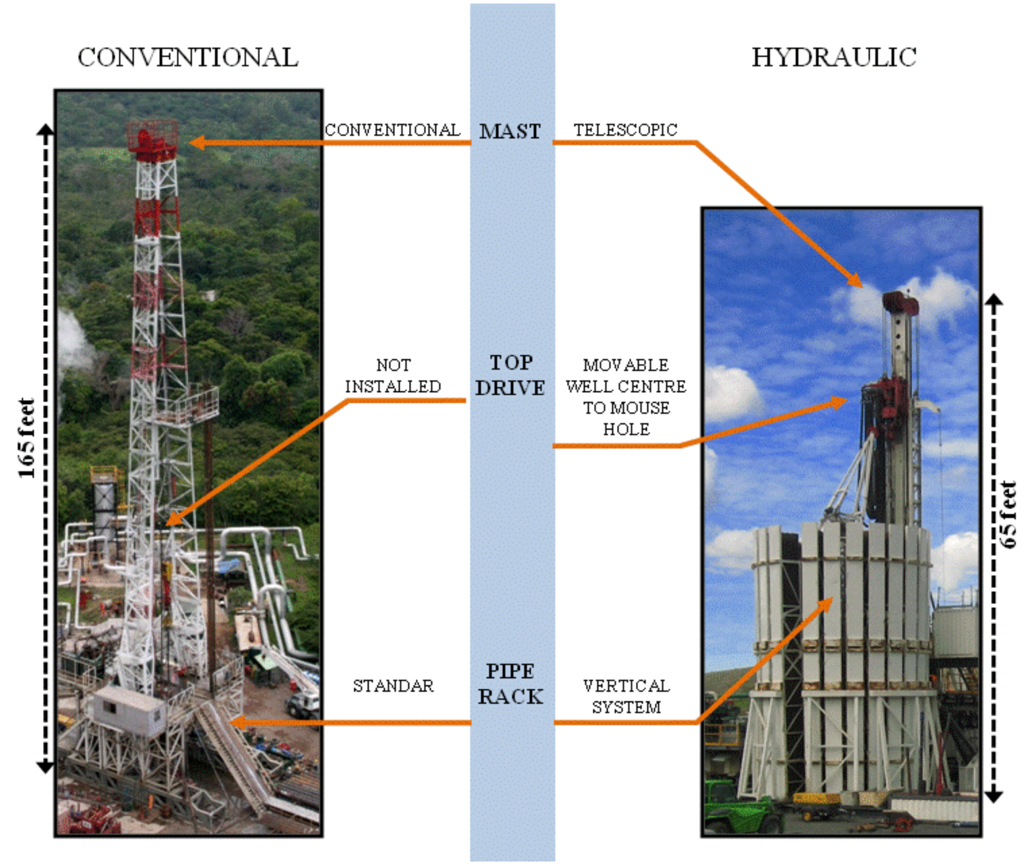


FIGURE 32: Comparison between a conventional rig and a hydraulic rig

6. COST BENEFITS

6.1 Conventional vs. hydraulic

The hydraulic hoist rig incorporates many new concepts and innovative features, along with a high level of automation and safety, allowing consistent reduction of the total drilling cost and environmental impact associated with drill field development. In Figure 32, the main characteristics are shown.

Figure 33 shows a map of the Hellisheidi field, and the two drill sites, HE-43 and HE-44. The distance between them, is 5 kilometres and the time that passed from the stopping of drilling at HE-43 until drilling was started of HE-44 was 5 days. In Table 7, some characteristics of the conventional and hydraulic rig systems are shown.

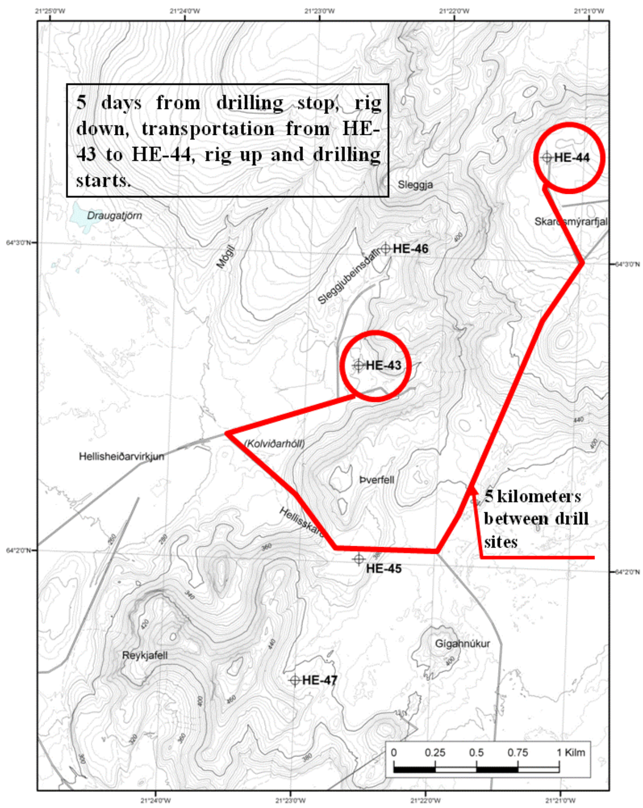


FIGURE 33: Hellisheidi field, the HE-43 and HE-44 drill sites

TABLE 7: Comparison of the main characteristics of
a rotary rig and a hydraulic rig

Conventional	Hydraulic
Manual tong	Iron roughneck
25-30 people	7-10 people
Rotary table, also top drive	Top drive
Manual pipe handling	Automatic pipe handling
4000 m^2 of drill platform	3600 m^2 of drill platform
60 loads	50 loads
5-6 days of rig up or down	1 day of rig up or down

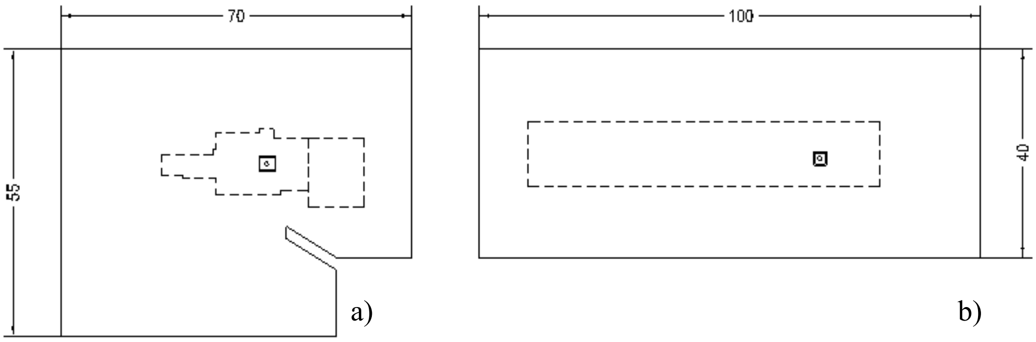


FIGURE 34: a) Icelandic drilling platform, and
b) Salvadorian drilling platform

6.2 Comparison of the platforms

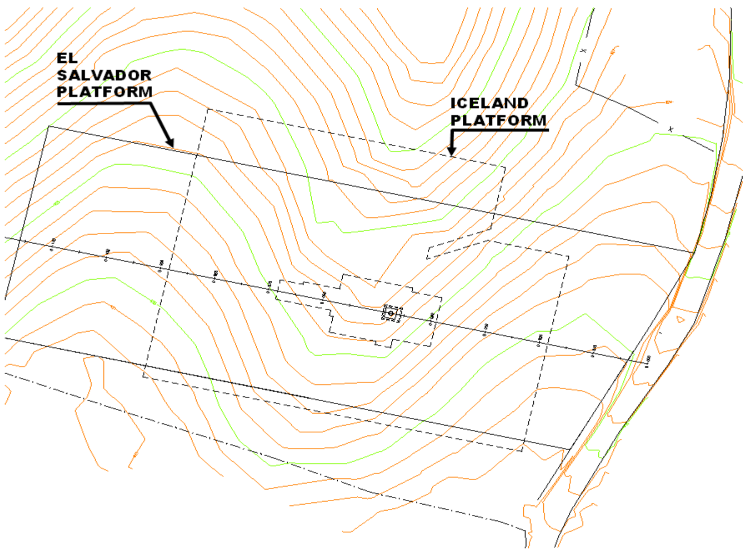


FIGURE 35: Icelandic platform inserted onto
the Chinameca platform in El Salvador

The main differences between the two systems is the work area; while one requires 4000 m^2 (El Salvador System), the Icelandic platform requires 3600 m^2, as shown in Figure 34. The thickness of the platforms was not studied in this comparison as it depends on the soil conditions, but levelling of the platforms was studied. To compute the cost and quantity of work (earthwork), the Icelandic platform system was inserted into the Chinameca area as shown in Figure 35. The methodology used was: For every 10 m, the cubic metres of the cut and fill for each system was calculated (Appendix I), detailing the sections of the platform with the two systems, natural ground and slopes. Table 8 shows the calculated results for both systems.

The results can be seen in Figure 36 (bar graph) and Table 9, which show that the quantities in cubic metres of earth and rock cut were 50% lower in the Icelandic system. On the other hand, the quantities in cubic metres of filling with earth resulted in 27% more material needed to build the Icelandic system.

TABLE 8: Calculation of earth work in the Chinameca drill site comparison between Icelandic and El Salvadorian platforms

Data		El Salvador		Iceland		El Salvador		Iceland	
Section	Distance	Cut	Fill	Cut	Fill	Cut	Fill	Cut	Fill
		Result from sections (m^2)				Calculation (m^3)			
10	10	185.4	0.	0.0	0.0	1854	0.0	0.0	0.0
30	30 20	206	0.	206	0.0	6180	0.0	4120	0.0
40	10	72.5	29.58	72.5	52.5	725	295.8	725	525
50	10	11	157	11	209.5	110	1570	110	2095
60	10	8	242	8	335.3	80	2420	80	3353
70	10	27	158.6	27	292	270	1586	270	2920
80	10 8.5	74	106	74	178	740	1060	629	1513
90	10	106.25	58.5	0.0	0.0	1063	585	0.0	0.0
100	16	105.26	44.73	0.0	0.0	1684	715.7	0.0	0.0
						12706	8232	5934	10406

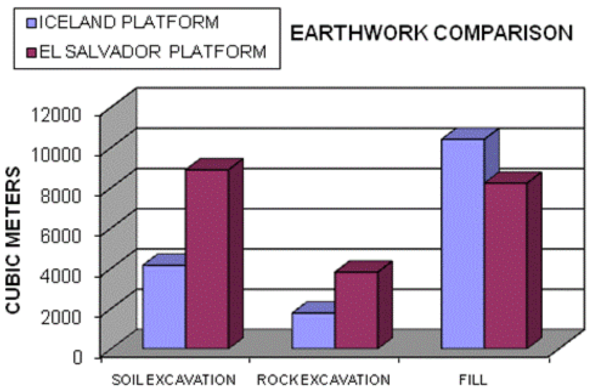


FIGURE 36: Bar chart show the comparison between the two drill site systems

TABLE 9: Comparison of the summary of total cuts and filling of earth in the Chinameca drill site (m^3)

Description	Iceland	El Salvador
Soil excavation	4154	8894
Rock excavation	1780	3812
Fill	10406	8232

7. CONCLUSIONS

Drilling a well involves a series of actions, a specified number of machinery, equipment and personnel; knowledge and descriptions of these are extremely important for designers and civil workers, in order to precisely define the work areas.

When defining the best site for constructing a drilling platform, knowledge of several factors is required:

1. The topography of the site, how steep are the slopes;
2. The access roads - the majority in El Salvador are in poor condition or else there are none at all;
3. Acquiring land;
4. Environmental permits; and
5. Social aspects - in El Salvador and Central America most of the drill sites are in or near towns or villages. Taking into consideration one's neighbours during the design process and construction is the key to successful projects.

The design and components of a drilling platform have to be described precisely, in order to fill all the requirements described previously in drilling activities.

An ideal drilling programme, upon completion of drilling, involves clean-up activities, mostly removal, cleaning and recovery of damaged areas.

Although the practice of reforestation and integration into the existing natural environment are important, it is also necessary to think about what will happen with the drilling platform after 50 years or whenever the producing lifetime of the field is over.

The Icelandic drilling platform requires a smaller area of construction than the Salvadorian drilling platform, due to the type of drilling rigs used, the treatment of sludge waste, weather, soil conditions, and other factors.

Investing in a hydraulic drilling rig will reduce the space needed for a drilling platform design as well as reduce mobilization time and offers the following benefits: reduction in noise level, reduction in staff involved in risky activities, and time reduction in rig raising. However, reduction in the platform area will not have a significant economic benefit.

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APPENDIX I: Cross-sections from 0 +20 to 0 +100
for the Icelandic system and the Salvadorian system