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LaGeo S.A. de C.V.

ENVIRONMENTAL CONSIDERATIONS FOR GEOTHERMAL DRILLING IN EL SALVADOR

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ABSTRACT

Each stage of cycle geothermal project in El Salvador takes in account well drilling for power generation. Pre-feasibility stage its search the presence of the resource; Feasibility, the size of reservoir and power plant design to be installed. Lastly, during construction, operation and extending stages, extra or replacement wells are requested to raise or maintain the total installed capacity of geothermal power.

Environmental assessment for geothermal well drilling indicates various significant environmental aspects due the nature of the processes and the surroundings where the project is executed. Therefore, an environmental analysis and its action must be included into design, since planning stage in order to environmental legal compliance and corporate social responsibility too, what will allow an effective environmental management plan and improve the environmental performance of the global project.

This paper shows the main environmental considerations that developer of geothermal project should take into account in order keep a balance between the project and their social environment and natural resources.

1. INTRODUCTION

Use geothermal energy includes three main processes, which are: well-drilling to extract geothermal fluid from the reservoir, fluid separation and transportation at the surface, and mechanical to electrical energy converting.

Well-drilling target is intercept geothermal reservoir at depths ranging from 600 to 2,500 m, which, generally is formed by hot permeable rock, with a large enough volume to allow the storage and circulation at high temperature and pressure of the geothermal fluid. This work is carried out using drilling equipment with the following systems: hoisting system, circulation system, rotary system, rig power system and blowout preventer control system. These systems, and other auxiliares services (well cementing, directional drilling, air drilling, workshops, cutting treatment, offices, etc.), are located and operate at the drill pad. See Figure 1.

Drill pad are identified as the unit of environmental analysis, where emissions (noise, solid, liquid, and gas waste) and consumptions (water, cement, fuel, bentonite, polymer, thinning agent, corrosion

inhibitor, pH control agent, etc.) are generated, which should be evaluated with respect to their environment to identify impacts and to prepare an effective environmental management plan.

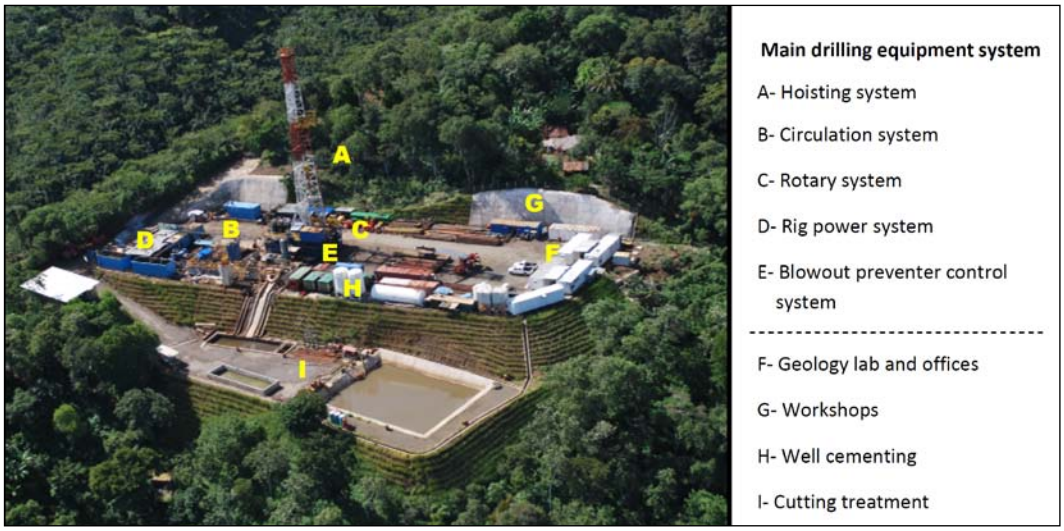

FIGURE 1: Drill pad with the main drilling equipment systems and other auxiliaries services

Well drilling is carried out in each of the geothermal development phases: pre-feasibility, feasibility, construction, operation and extension of the power plant. Pre-feasibility stage, searching the presence of the resource; Feasibility, the size of reservoir and power plant design to be installed. Lastly, during construction, operation and extending stages, extra or replacement wells are requested to raise or maintain the total installed capacity of geothermal power plants.

2. ENVIRONMENTAL EVALUATION PROCESS AND WELL DRILLING

In El Salvador, the environmental evaluation process is carried out as follows: a) submittal of the environmental form: the developer submits basic information about the project or activity to the environmental authority; b) Analysis and field inspection: the environmental authority classifies the project or activity as low impact or meaningful impact. If the impact is low, it grants a favourable resolution of non requirement of environmental impact assessment, while if there are meaningful impacts, it requests an environmental impact study based on terms of reference that it provides.

In El Salvador, the environmental evaluation process is carried out for each well or group of wells to be drilled in a drill pad, based on articles 19 and 20 of the Environmental Law. For this situation, the developer has several environmental permits in each of the phases of project. Currently, LaGeo is promoting a proposal that allows for submitting an environmental form for each phase of geothermal project: a) pre-feasibility, b) feasibility, and c) construction and operation. Therefore, the aim is that each phase of the project will have a package of documents (environmental impact assessment, environmental compliance bond, environmental permit and environmental management plan). This will facilitate the control and follow-up carried out by the environmental authority throughout the evaluation audits and will allow for reducing waiting times between the drilling of a well and another during the same phase of the project.

The well drilling can be divided into four stages: planning, construction of the drill pad, operation (well drilling) and closure. Figure 2 shows the stages and main activities during geothermal well drilling.

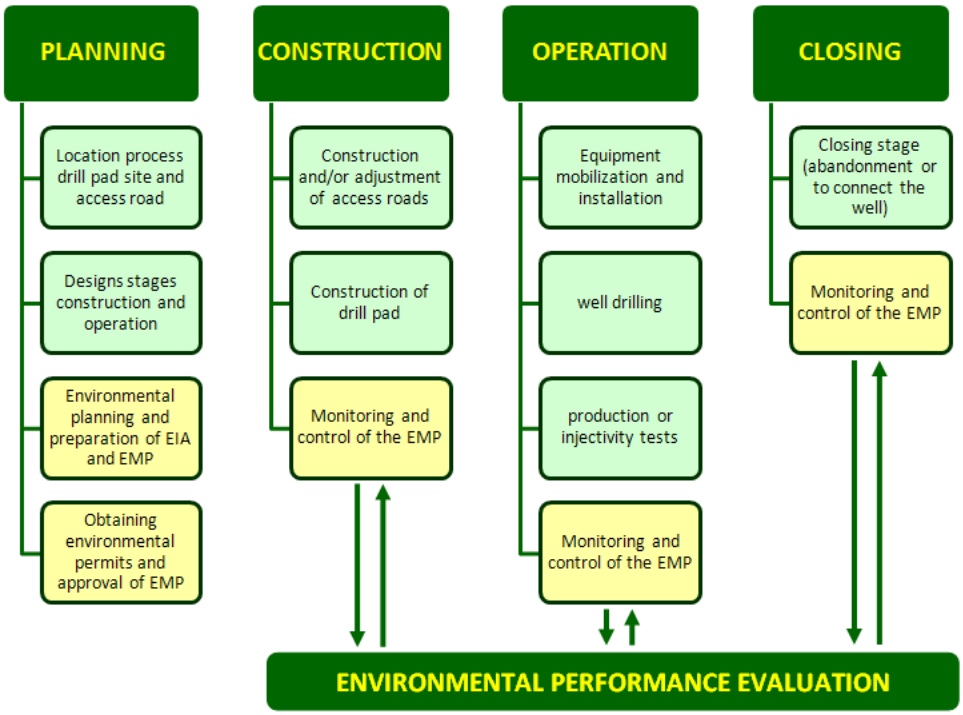

FIGURE 2: Stages and main activities during geothermal well drilling

3. CONSIDERATIONS IN THE PLANNING

The main activities to be considered are: drill pad location, definition of access routes, design of the construction and operation phases (well-drilling), preparation of environmental impact assessment, environmental management plan and environmental permits.

In this stage, it is necessary to count on environmental information about the physical, biological, socio-economic and cultural components at a regional scale. The developer must take in account the natural environment inventory that could be affected by the project. This information must be obtained through a multidisciplinary team that not only compiles it, but that identifies the receptor environment sensitivity.

3.1 Participation in the preliminary and final design

The adequate location of drill pad and their access routes can prevent and/or reduce many of the environmental impacts during well drilling. The location process of drill pad is shown in Figure 3.

Various alternatives for pad location will be carried out according to the following criteria:

a) Ecological importance and landscape: lesser effects on the natural and landscape resources present in the area.
b) Terrain suitability: enough capacity to withstand drilling equipment and lesser susceptibility of the terrain to natural risks.
c) Incidence in the socio-economic environment: the socio-economic impact evaluation comes out with more positive aspects than negative ones.

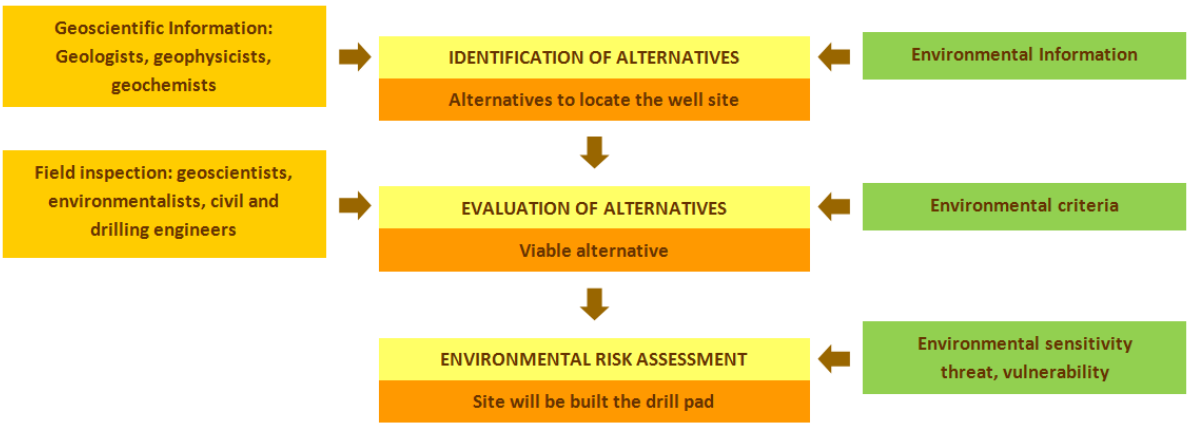

FIGURE 3: The location process of drill pad

Once the location of the well sites is known, the multidisciplinary team will carry out a collection of information of the natural environment in the area of direct and indirect influence affected. These influence areas are:

d) Area of direct influence: physical space where an environmental component is affected directly by the project's environmental aspects; and,
e) Area of indirect influence: physical space where the environmental component that is directly affected, affects other environmental component(s) not related to the project.

Evaluation of environmental aspects will be carried out to prepare the environmental management plan that will apply to all activities to be carried out during the stage under execution. The main task during the planning phase is guarantee that the final design includes the results of the environmental survey and its respective environmental management plan.

3.2 Environmental impact assessment

If the environmental impact assessment is required by the authority, then multidisciplinary team will carry out the additional studies to complete the environmental management plan in order to comply with all the requirements established in TOR´s.

Main prevention and /or control measures are contented into environmental management as result the environmental aspects assessment and must be implemented in well drilling during next stages.

4. CONSIDERATIONS DURING DRILL PAD CONSTRUCTION

The main environmental considerations for stage construction of drill pads are:

4.1 Soil and vegetation management

In order to minimize space requirements, the sizing of drill pad will depend specifically on the size of the drilling equipment to be used and the topography of site.

Before remove vegetation should be identified the boundaries of the drill pad construction area and an inventory of trees, which takes into consideration: the name of each species, diameter at chest height and identification of environmental or cultural value in order to carry out the reforestation and conservation plan according to the environmental management plan. The removal of vegetation must

be strictly limited to the outlined areas. This material must be cutting and incorporated to forest zones or must be handed out to the community that requests it.

With regard to the soil, the edaphic conditions previous to removal should be identified, and stored according to the characteristics found. During the removal and storage of the soil, should be avoided contamination with sterile soil, compaction and loss by erosion.

4.2 Management of excavation waste

The zones for the disposal of construction, demolition and excavation waste (CDEW) should be identified in EIA and selected based on the following aspects: volume of material to be disposed of, distance to the project, physical characteristics of disposal zones (topography, drainage and geological). Besides, considering zones that could harm the environmental and landscape conditions or where the population could be exposed to any type of risk must be avoided.

The thinner material must be located in the internal part to minimize water filtration; the coarser material must be located in external part in order to protect the slope. The slopes will be formed according to the characteristics of the materials. When the disposal zone is closed, it must be re-vegetated and final stabilization work must be carried out.

4.3 Run-off water management

Drill pad construction will have an impact on the local water resource due to site waterproofing; a form of reducing impact is to carry out drainage work and to reduce run-off water through a rain water infiltration system.

To reduce run-off water contamination due to mixing with other substances, work areas at risk of spills and leaks must have waterproofed floors and count on a perimeter channel connected to the oily water network.

4.4 Contingency plan

The contingency plan is a set of procedures to ensure adequate response to emergencies during the construction of drill pad, drilling operation and closure phase. The plan should be focused on those possible impacts whose occurrence can't be prevented or mitigated through the instruments provided by the environmental management plan. The main events to be considered are: natural phenomena (earthquakes, storms), fire, technological accidents (blowouts, spills of drill mud, oil or fuel). The contingency plan should have the following minimum content:

a) Objectives and scope
b) Risk analysis and identification of emergencies
c) Organization and responsibilities
d) Emergency detection system
e) Procedures for notifying and responding to emergencies, and
f) Training program

The plan must be communicated at all levels and validated in the field by the executor.

4.5 Monitoring and control

An essential consideration is the preparation and execution of an environmental monitoring and control program for the construction, operation and closure stages, in order to determine the project's environmental performance.

The environmental performance measures the compliance with the obligations legal and the efficiency of the environmental management plan to manage significant environmental aspects. The information generated by environmental monitoring is used by the developer to make decisions and to prepare the periodic reports to the environmental authority, local government and the community for their respective control.

The monitoring and control contribute to identify the environmental impacts not expected in the project's environmental planning and to incorporate continuous improvement into environmental management.

5. CONSIDERATIONS IN WELL DRILLING

Main activities in well drilling (operation phase) are: Rig location and provisional services, fluid mud preparation, drilling, cementing and production or injectivity tests. Most significant environmental aspects and their control were identified in each activity are shown as following:

Solid wastes: Most known solid wastes in wells drilling are: cuttings, sludge, scrap metal, domestic wastes and packing material. Cuttings and sludge are treated in a set pond where the liquid phase is separated from the solid particles. The liquid phase goes into the recycle water pond. The final disposal of the cuttings is in an authorized areas.

Scrap metal are sold at local smelters. Domestic and packing material are managed at local landfills and the nearby of drilling site.

Oils: Using oils during internal combustion engines maintenance, guarantee a good condition to feed all the rig power system, but the waste oils are co-processing into the furnaces at the local cement industry.

Sewage: Any drilling site for sanitary purposes will contain a septic tank and well absorption system, what avoid the soil contamination. Additionally, one portable toilet per 15 employees will be available on site pad and should be cleaned up weekly through an authorized company.

Fuel management: It shall comply with minimum safety requirements for fuel storage in drill site with operating permit issued by the competent authority.

Procedures and personnel trained in safety measures to fuel transfer, spills and fire control will be available into an action plan. Further, the accident prevention signs must be installed and also, leaks inspection program will carry out frequently.

Noise: Power system equipment, cementing and air drilling are the main sources of noise inside the rig site. Installation of noise barriers as a common mitigation measures for control noise, mainly when houses are located in the nearby of the pad. LaGeo has recorded a range between 60 - 70 decibels in dwellings located 25 m from the drill pad perimeter.

Gas Emissions: CO_2 and H_2S parameters require permanent monitoring in nearby communities and inside the rig pad. The concentrations obtained should be compared against baseline values, industrial and occupational health safety in order to identify whether the levels represent a health risks or the data are below the local regulation

Social management: In El Salvador, areas with geothermal potential are situated in the middle of very poor communities, which may resent the impact of constructing access roads and well pads. It requires some research, understanding, and negotiation, to be able to address their legitimate concerns – beyond strict legal compliance – before a project can move ahead without problems.

In the case of LaGeo, this requirement is part of the corporate social responsibility policy, which requires the company to become actively involved in the local development plans, both in elaboration and execution.

6. CONSIDERATIONS DURING ABANDONMENT

The main activities are: decommissioning, closure of sludge treatment systems and cleaning the area. It should develop a plan of abandonment and restoration that covers aspects such as decommissioning, cleaning of occupied areas, control or eliminate environmental liabilities and the component of communication with nearby communities and local government.

According the results obtained in the drilling stage assesses whether a closure is made for abandonment or for connection of the well.

7. CONCLUSIONS

- The environmental assessments for the drilling of geothermal wells identified several significant environmental aspects, due to the nature of the processes and the social and environmental context in which it is developed. If the environmental aspects from the well drilling process are managed according to the right procedures, do not represent a risk to produce negatives effects.

- Effective environmental management plan includes environmental considerations and actions based on legal compliance and corporate social responsibility, during the planning stages, not only to like a part of EIA to get environmental permit but also has to be consider during the design. This allows improves environmental performance at each stage of the project.

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