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Challenges of Executing a Plug and Abandonment Operation of a Geothermal Well in a Forest Reserve

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ABSTRACT

This paper discusses one representative well in particular, Puting Lupa-01, that was abandoned in December 2012. The well was a 30 year old non-commercial well located in a government forest reserve in Laguna, Philippines. The location of the well brought about several challenges that included the type of P&A equipment to be used, the handling and disposal of waste and return fluids, and local community exposure. Rigless P&A equipment was selected due to its limited footprint. The rigless P&A equipment included the use of CS Hydril pipe, adjustable work basket, BOP and pumping unit. A site specific waste management, security, and emergency response plans were tailored for the specific needs of the well abandonment.

The forest reserve rules and regulations limited the use of traditional P&A methods by not allowing any return fluids to come in contact with the ground and for all wastes generated to be hauled away. In addition, a small equipment footprint was necessary to minimize the removal of vegetation and environmental impact to the forest reserve, and to lessen the cost of rehabilitating the roads leading to the site. Rigless equipment was selected and mobilized from the United States to meet the requirements. The type of equipment selected included the ability to run a thru-tubing bridge plug, mix and pump cement, and accommodate auxiliary equipment for perforation and surveys.

Utilizing an in-house risk management process, several opportunities were identified in order to make the P&A work safely and successfully. All stakeholders were invited to identify risks related from pre-mobilization of equipment to the suspension operations. The information was captured and risk management tools were used to track safeguards and eventual lessons learned from each activity related to the P&A work.

Using the rigless P&A equipment to abandon the well in the forest reserve represented substantial savings in rig time and operational costs which resulted in recognition from the forest reserve and local community for ensuring success of the project while also addressing its “environmental implications.” The project was a success in isolating the reservoir and with achieving zero environmental incidents and injuries – demonstrating that incident free operations can be achieved in remote locations with proper planning and operational discipline.

1. INTRODUCTION

Puting Lupa-01 was drilled in June 1976 as an exploratory well in the Los Banos area. Richter Rig 2 was used to drill the well from the surface to a total depth of 4,805 feet. The well was completed with an external pack-off wellhead completion design. The well did not produce any steam after it was completed in August 1976 and because of zero steam production, the well was never used. In 2011, the well was recommended for abandonment to ensure it did not cause safety or environmental hazards. The abandonment activity included sealing the well with a bridge plug and cement plugs (Diagram 1).

2. LOCATION

The well is located in Mount Makiling (Image 1), which is a state-owned forest reserve under the jurisdiction of the University of the Philippines, Los Banos as mandated under Presidential Decree 692. The university has complete control of the forest reserve which served as a training laboratory for the advancement of scientific and technical knowledge on natural resources conversation and watershed protection (Image 2). In order to maintain control of the forest reserve the university implemented guidelines that included the prohibition of taking, cutting, destroying, or injuring, or otherwise damaging trees and other plants, fungi or other natural products or objects, except as authorized by law or regulations of the university.

One of the challenges due to the location of the well was repairing the roads leading to the well site (Image 3). The road repairs involved rehabilitating 3 kilometers of rough and narrow road terrain. In the design of the road, the company considered making repairs that would allow a minimum load capacity in order to minimize the rehabilitation cost. By understanding the type and weight of equipment for the P&A operation, the company was able to successfully rehabilitate the road fit for the equipment to travel on. Also, the road repairs were scheduled at a time when the weather was fair to prevent additional costs of repairing the road due to damages brought about by typhoons and heavy rains.

3. COMMUNITY

The well was located on university land and that meant that the P&A equipment and personnel would have to move about when there were classes ongoing and students walking around the campus. The company made use of an in-house risk management process to identify the hazards of moving equipment and personnel through a university. In the process, safeguards and safety mitigations were identified and implemented in order to minimize the risk of harming the students or causing an accident. One mitigation considered was to mobilize the equipment when students were inside their classrooms. A journey management plan was also used by the contractors involved in the mobilization in order to follow the safest route going to the well site.

The forest reserve is popular to tourists and the well site is a camping ground for campers. The company had to identify the safest way to position the equipment to minimize the footprint it would leave behind after the P&A operation. The company wanted the site to be the same for the tourists and campers to visit after the operation. In one instance, a tree located near the wellhead was not removed. The crane had to position itself in such a way that it could perform its work and at the same time minimize its environmental footprint (Image 4).

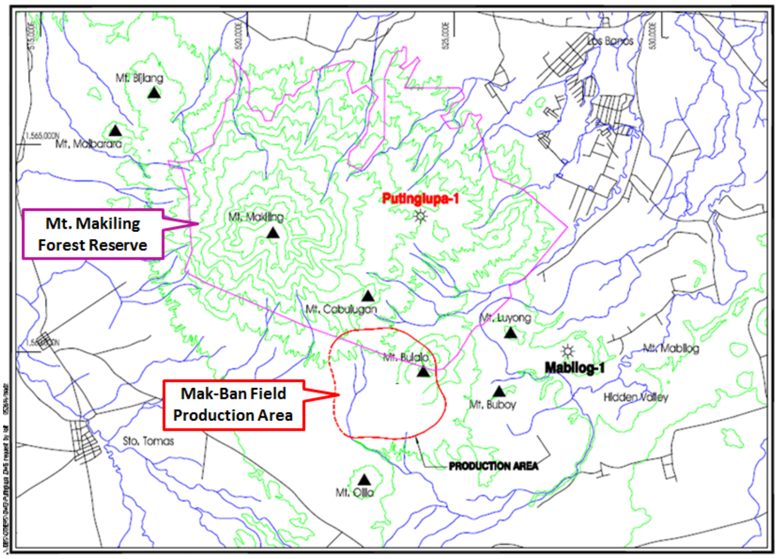


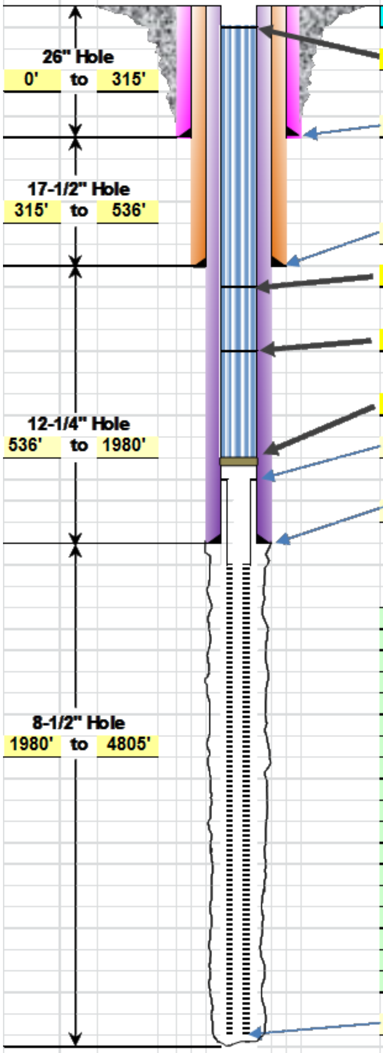
Image 1: Location of the Mount Makiling Forest Reserve, Mak-Ban Production Area and Well Puting Lupa-01

Image 2: The entrance to the well site.

Image 3: Road terrain leading to the well site.

Schematic Diagram Regular Hole Completion

Original Well Information		Work-Over Well Information		Work Over #	1
Completion Date	13-Aug-1976	Completion Date	6-Jan-13		Plug and Abandon
Rig Name	RDI Rig 2	Rig Name	Superior Rig		
KB Height	17'	KB Height	15'		



Depth	Legend	No. of jts / Csg. Access	Size	Weight	Type	Thrd	X/O
			Other comments				
49'	TOC # 6						
308'	SC	7 jts & 1 c/o	20"	94 #/ft	H-40	BTC, Smls	
519'	IC	13 jts & 1 c/o	13-3/8"	54.5 #/ft	K-55	BTC, Smls	
			13-3/8"	Float Collar @		461'	
554'	TOC# 2,3 & 4						
1271'	TOC # 1						
1749'	TOBP						
1783'	TOL	7"		Liner Adapter			
1975'	CL	50 jts 1 c/o	9-5/8"	47/40 #/ft	K-55	BTC, Smls	
			9-5/8"	Float Collar @		1911'	
4798'	PL	77 jts & 1 c/o	7"	23/29 #/ft	N80/K55	8RD LT&C	

Remarks: Plug and Abandonment

12/26/2012 to 01/01/2013 - Mobilized equipment from Mabilog site to Puting Lupa site.
01/02/2013 - RIH and set 9-5/8" Core bridge plug at 1749 ft. ; Ports on setting tool did not open after 3 attempts of shearing the pins at 500 psi., DSM decided to POOH tubing to surface and continue cement plug #1 the next day.
01/03/2013 - RIH and set tubing above bridge plug and conducted cement plug # 1 using 35 bbls of 16.0 ppg batch-mixed slurry. Attempted to conduct cement plug # 2 above the expected TOC of cement plug # 1 but tubing pressured up, DSM decided to POOH tubing to surface. Last 10 joints of cement contained gelled cement slurry.
01/04/2013 - RIH and set tubing above cement plug # 1 and conducted cement plugs 2, 3 & 4.
01/05/2013 - RIH tubing and tagged cement plug # 4 at 554 ft., POOH one joint and conducted cement plugs 5 & 6.
01/06/2013 - RIH tubing and tagged cement plug # 6 at 49 ft. POOH tubing and rigged down equipment.

Cement plug volumes:
Cement plug # 1 - 35 bbls of 16.0 ppg batch mixed slurry
Cement plugs # 2,3,4 - 15 bbls of 15.5 ppg batch mixed slurry
Cement plugs # 5, 6 - 18 bbls of 15.5 ppg batch mixed slurry

Legend:

SL	*Scab Liner*	*FS*	*Float Shoe*
TBC	*Tie-Back Casing*	*FC*	*Float Collar*
SC	*Surface Casing*	*LC*	*Landing Collar*
IC	*Intermediate Casing*	*PLC*	*Partial Lost Circ.*
CL	*Cemented Liner Casing*	*TLC*	*Total Lost Circ*
PL	*Perforated Liner Casing*	*PAS*	*Parasite Aerating String*
TOL	*Top of Liner*	*HD*	*Hangdown String*
LH	*Liner Hanger*	*TBC2*	*Secondary Tie-Back*
CC	*Conductor Casing*	*c/o*	*Cut off*

Prepared by: I.C. Santiago / S.R. Arrieta

Approved by:

Diagram 1: Final wellbore diagram of Puting Lupa-01 after the P&A operation.

4. SECURITY AND EMERGENCY RESPONSE PLAN

The remote location of the well site from the company's base camp also required special considerations to be taken into account for the site specific emergency response plan. An ambulance, with an accompanying nurse, was mobilized to the site and remained on location throughout the operation. The university also had a clinic and the head of the clinic was informed about the operation in order to seek assistance from them if an incident occurred which required medical attention. Further, there was a hospital located outside of the university which was identified as the second alternative for injuries that required medical attention.

Local watchmen and security guards were assigned to the well site throughout the operation to prevent tourists and campers entering the site. The local watchmen also served as traffic guides for the equipment travelling to the site. The watchmen would signal to the drivers of oncoming vehicles to prevent accidents. The local watchmen and security guards would also stay overnight at the site to prevent equipment being vandalized or stolen.

Image 4: Work basket and pumping setup at the site in preparation for the abandonment operation.

5. P&A OPERATION

The procedure involved using a cementing unit to quench the well prior to rigging up the adjustable work basket above the wellhead. Once the well was killed (wellbore pressure in vacuum state) the blow out preventers were installed and function tested and the work basket was installed. Two alternatives were identified for the initial isolation plug. The first alternative was a bridge plug (BP) that would be set below the identified clay cap zone. The second alternative was a customized rubber plug that would be landed on top of the production liner. After, a sand/gravel base would be placed on top of the rubber plug. All the work made use of a 70T crane to run in hole the tubing to set the bridge plug and spot the cement plugs inside the wellbore.

One of the main challenges of performing the first alternative was encountering an obstruction in the wellbore that would not allow the BP to pass through. Given that geothermal wells have a high probability of buckling or collapse, it was critical that survey work, including scale probe runs and casing inspection caliper surveys were performed prior to any well work to identify any wellbore obstructions. With current wellbore integrity data, the right tools and procedures could be selected to set the initial isolation plug. The first method was considered after scale probe data showed no obstructions from the surface to the top of the liner. The bridge plug was successfully run to 1,749 feet and no problems were encountered setting the tool. However, when an attempt was made to open the circulating ports (by dropping a steel ball and pressuring up the tool to 3,300 psi), it did not open. A decision was then made to pull the setting tool out and perform the cement plugging job with open ended tubing using the 70T crane.

Following the initial isolation job, the tubing work string was run in hole to tag the top of the isolation plug and then a Class G Cement recipe was mixed and pumped to a pre-determined depth. The weight of the cement slurry pumped was 16.0 ppg, with 0% free water and low fluid loss properties to prevent trapped water which could boil or flash due to the geothermal heat and cause the casing to burst.

Since geothermal wells are drilled in a lost circulation environment, it is difficult to see cement returns on primary cement jobs. An in-house risk management process identified four critical sections that required the 16.0 ppg cement slurry as follows: (1) an initial cement plug on top of the reservoir, (2) all perforation zones, (3) the liner lap, and (4) the surface plug. To ensure that that the reservoir fluids could not travel up the annulus, perforations are placed just below the surface casing shoe to allow a cement squeeze job to plug any potential voids behind casing. In most cases, a liner tie-back lap also existed close to the surface shoe which was covered with good quality cement to prevent a future leak path. Cementing was then continued to the surface. The well did not undergo any cycling loading as a result of steam production and the drilling history data showed good primary cement jobs. With this information, it was determined that there was no need to perforate the casing below the shoe to squeeze cement. The well was cemented with a full column of cement from the top of the isolation plug to surface using a total of five batch-mixed plugs pumped through the CS Hydril tubing.

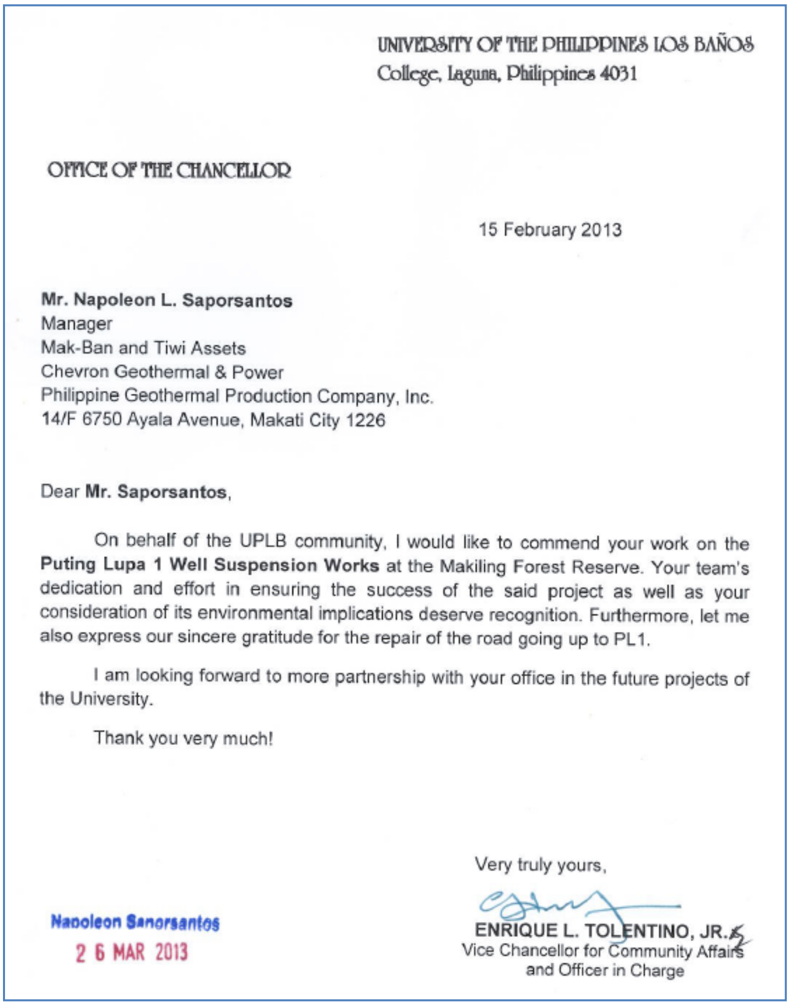
6. LESSONS LEARNED

There were several lessons learned. The pre-work (road rehabilitation, community engagement, site preparation) was very effective as were the cement plugging jobs. The entire operation was completed in 12 days, including rig and equipment mob/demob and cement plugging operations. Six days of the 12 day operation were spent mobilizing the equipment to the site. Additionally, the well activity took place during the holiday season, and one day was used to temporarily suspend work to prevent accidents from happening along the streets leading to the site because of community holiday celebrations.

Aside from the accomplishments, several areas of improvement were identified. The mobilization of equipment to the site could have been timelier and the making up and breaking of tubing tripped in and out of the hole had many areas of efficiency improvements. Yet another lesson was learned when the trucking coordinator did not communicate well enough to the rig site drilling manager about the turnaround of the trucks which cost lost time spent determining which truck should be sent to transfer the equipment to and from the site. If the truck coordinator was involved more in the mobilization discussions, less time would have been spent unloading and returning the trucks to haul the remaining equipment. Finally, although the rig contractor had 16 years of P&A work experience in the Gulf of Mexico, the crew had only managed to run an average of 15 joints of pipe per hour running in and out of the hole. The slow tripping speed was attributed to the crews' learning curves moving from offshore P&A work - to land-based P&A work.

7. CONCLUSIONS

There were some notable accomplishments. The P&A operation, including all related pre-work activities, achieved incident-free operations. There were no work stoppages or complaints from the community or any other concerned stakeholders. The project team successfully used in-house risk management processes in identifying the risks involved and installing safeguards to mitigate those risks. The many challenges to the operation were overcome resulting in safer and more efficient operations. Increased environmental protection efforts were also successfully undertaken while working in the forest reserve. Following the successful completion of the P&A operation, the university sent a commendation letter to the company stating the following: "Your team's dedication and effort in ensuring the success of the said project as well as your consideration of its environmental implications deserve recognition" (Image 5).



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OFFICE OF THE CHANCELLOR

15 February 2013

Mr. Napoleon L. Saporsantos
Manager
Mak-Ban and Tiwi Assets
Chevron Geothermal & Power
Philippine Geothermal Production Company, Inc.
14/F 6750 Ayala Avenue, Makati City 1226

Dear **Mr. Saporsantos**,

On behalf of the UPLB community, I would like to commend your work on the **Puting Lupa 1 Well Suspension Works** at the Makiling Forest Reserve. Your team's dedication and effort in ensuring the success of the said project as well as your consideration of its environmental implications deserve recognition. Furthermore, let me also express our sincere gratitude for the repair of the road going up to PL1.

I am looking forward to more partnership with your office in the future projects of the University.

Thank you very much!

Very truly yours,

ENRIQUE L. TOLENTINO, JR.
Vice Chancellor for Community Affairs
and Officer in Charge

Napoleon Saporsantos
2 6 MAR 2013

Image 5: Commendation letter from the university for the work performed at Puting Lupa-01.

8. ACKNOWLEDGEMENT

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