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A REVIEW OF HYDRAULIC WORK OVER UNIT (HWU) APPLICATION FOR WELL REPAIRS IN NIGERIA

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Abstract.
As part of efforts to encourage indigenous/local content in the area of work-over, re-completion and abandonment in Nigeria, Work over campaigns using a self elevating work-over platform (SEWOP) and a hydraulic work-over (HWU) unit was introduced in the year 2001. These projects provided an opportunity for Nigerian indigenous contractors to work closely with multinational companies with a view to develop expertise. Upon this platform was the services of the HWU introduced to the Nigerian oil & gas industry (for work-over, re-completion, well testing and abandonment) introduced to the Nigerian oil & gas industry.
The initial objective of these campaigns was to equip older wells in the land and swamp locations with Surface Control Sub-surface Safety Valves (SCSSV) and top packers, in accordance with company's well integrity management policy. This policy also required that some of these wells be abandoned to ensure the safety of the environment. It also presented an opportunity to carry out other well repairs and to install gas lift mandrels as the case may be.
The projects' priority factor (if compared with other income generating projects within the system) was low, especially for the abandonments. Hence, recognizing that funds are limited, the services of the HWU provided versatility and cost effectiveness.
Between August 2001 and March 2006, a total of about fifty three wells were successfully worked on across the Niger Delta region in land, swamp and offshore locations. These series of operations were not without challenges considering the peculiar nature of the Niger Delta terrain in terms of operation and service delivery. Within the period mentioned above, a "learning curve" was developed for hydraulic workover that can be useful to operators in the oil and gas industry. In this paper, efforts have been made to describe this "curve" for the purposes of improving business results. This paper will also review significant cost saving achievements and challenges that were encountered during the entire period under review.

Key words: Workover; abandonments; well integrity; HWU; marginal fields; completion; well repairs.

1. Introduction

A hydraulic workover unit (HWU) is basically a well servicing system that is capable of running and retrieving jointed pipes and performing light well repairs or workovers that will otherwise be performed with a rig at a much higher cost.

After four years of continuous operation in Nigeria oil and gas industry, the HWU has made an impact in well workover, re-completion and abandonment in terms of cost reduction and the quality of jobs delivered. With competent crew members and an onshore-offshore operations management team, the venture into the oil and gas industry in Nigeria with the unit and the objective of quality job deliverability can be said to have paid off. Local companies were faced with the challenge of carrying out well work over, re-completion and abandonment projects in alignment with industry standards and requirements. This was not easy at first, especially in the areas of safety and environmental protection. With aid of the multinationals and subsequent manpower training, most of the issues at stake were successfully closed out, even to the point of winning awards in safety, environmental protection and team service efficiency. Thus it has been proven that the HWU has the

capability for a wide range of application with greater efficiency leading to overall cost reduction compared to conventional workover rigs both in swamp and land operations.

2. Materials and Methods

The 225k was the first model of HWU to arrive Nigeria early 2001. By September 2001 another unit – the 460k was acquired to meet the growing demand for HWU services. Approximately one year later, a third unit was added to the fleet, thus signifying the growing awareness of the capabilities of the unit. Within a decade, six to seven units were actively working in the region. This undoubtedly added to the worldwide reputation that the HWU has gained in terms of high performance, versatility and cost reduction in general. It has also added to the inventory of independent equipments owned by local contractors.

The units in most cases arrived Nigeria as "snubbing" units. Extensive reconstruction work had to be done to put them in work-over modes. Such re-construction work included (among other things) fabricating a work-basket at the "access window", below the stationary slip (in the stack-up of the HWO equipment). Another work-basket is placed at the stationary slip window in addition to the topmost basket that comes with every "snubbing" unit. In all, a typical HWU after re-construction has three work-baskets; one at the access window, one at the stationary slip window and the topmost situated above the jack (four hydraulic cylinders). These baskets/platforms provide a work area large enough to allow personnel to safely carry out activities associated with work-over operations.

After re-construction, the units are inspected by a certified third party inspectors, commissioned function tested and then mobilized to location.

2.1 Equipment Specification and Description

The three units were designed to be mounted on the wellhead like in most snubbing operations thereby eliminating the need for a substructure as a load bearing member. The entire weight of the unit rests on the wellhead, except in special cases where the wellhead cannot accommodate undue stress. The basic specifications of these units are shown in table 1 in the appendix.

2.2 Operational Experiences

Hydraulic workover units have been used to work on several wells in land, swamp and offshore locations within the country and other African countries. Operations carried out include running and pulling of dual and single production strings; squeeze cementing; setting of cement plugs; TCP perforating; ESS installation; milling of permanent packers, cement plugs and retainers; re-completion with safety valves, vent valves and gas-lift mandrels, fishing parted tubing or lost wireline tools, well abandonment and casing retrieval, ESP installation, well clean-out services, acid stimulation, unloading with nitrogen; gravel pack installation etc. A summary of these operations and the period they were executed is in table 2 in the appendix.

These units recorded significant achievements on most of the wells worked on. Many of the operational challenges faced over and over again were gradually turned into success stories on various platforms. The highlights of experience gained and resulting benefits are briefly described below as:

- **Cost saving milestones:** HW units saved oil companies from 25% to 50% when compared to the cost of using conventional workover rigs especially in swamp and offshore locations. In the year 2004 when self elevating work-over platforms became increasing scarce and generally unavailable as a result of growing offshore activities in the region, HWU operations in the swamp locations were executed with flat barges. This innovation further reduced the cost for swamp operations. Figure-1 in the appendix shows the site layout for swamp operation with flat barges.

In most wells, actual time spent on location was about 50% of time planned due to the fact that competence and expertise had significantly increased. The figure below represents the value of work done against the planned budget for two units (225k and 460k) in 2003.

From the figure 1, costs saving achievements were possible due to the following;

I. Reduced mobilization and demobilization time compared to workover rigs
II. Reduced crew size and logistics problem

III. Reduced rig-up and rig-down time.
IV. Reduced community attention when compared to conventional rigs.
V. Production loss associated with delays involved with mobilizing conventional rigs is eliminated.

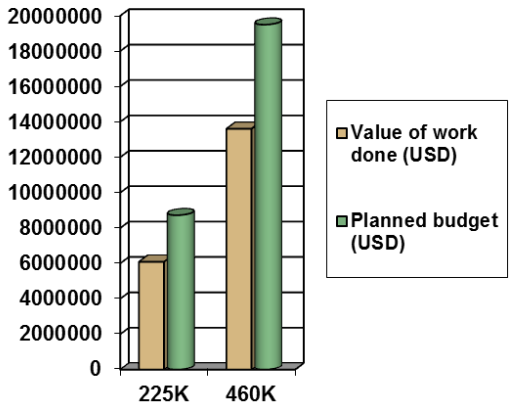

Figure 1 Value of work done versus planned budget for 225k and 460k in 2003.

- **HSE achievements:** In September 2003, during one of the land campaigns in the region, the 460k crew won a safety and environment award. This was made possible because of the following advantages associated with the HWU:
  I. Reduced exposure to hazards due to reduced personnel on location
  II. Reduced impact on environment due to compact nature of unit
- **Improved team performance:** The team developed experience and competence by going through the route of increased difficulty in operational demands. From 2003 to 2013, the performance of the units (and their personnel) had improved to the extent that most wells worked within this period were below budget and planned time. This attracted huge team performance bonuses as a compensation for significant time and cost savings.
- **Reduced community index:** The community index is an important factor in project planning in Nigeria. The hydraulic work-over projects suffered several delays in operations initially due to Niger Delta community issues. However the interest of host communities can be said to be minimal when compared to conventional workover rigs. This is due to the unconventionality of the unit, such host communities tend to categorize the HWU with coiled tubing units, wireline units and other well intervention units available in Nigeria, thus reducing the financial obligations on the operations compared to financial obligations required for conventional rig mobilization.

3. Results

As previously mentioned; an area of improvement that has been clearly identified in the entire period under review, is cost effectiveness and further cost reduction. Improved operational competence led to faster methods of accomplishing specific tasks. Implementation of standardized strategies like equipment layout; logistics scheduling; modified operational procedures; equipment and tools preferences; personnel consistency; etc produced significant accomplishments within the period under review. (See appendix C for equipment specifications etc.)

Another lesson learnt was the need to confirm casing, wellhead, cement bond integrity before rig up. The HWU experienced a few cases in swamp locations where the wellhead either collapsed or became skewed under the weight of the unit.

Hydraulic systems like every other engineering system can be optimized to reduce operational costs and improve efficiency. Over the period under review, one of the lessons learnt was how best to optimize the hydraulic system components of the HWU for better results and reduce operational costs, by using the appropriate hydraulic parts and accessories for the specific functions required.

Finally, as was earlier stated, the HWU now attracts less community attention in comparison with a conventional rig, a situation that is peculiar to the Niger Delta region. Over the years, operators have learnt on how best to package and present the unit to community liaison officers in order to attract certain concessions from host communities.

4. Recommendation.

So far in Nigeria, the HWU has been in use in land and swamp locations. Recently the unit has found application offshore west Africa. This is a further proof that the knowledge of the HWU technology is improving bearing in mind the peculiarities of offshore operations.

Hydraulic work-over services are indeed improving continuously with the passage of time. The importance of this technology can never be over-emphasized, especially in today's high rig rates. With the immergence of marginal field operators in the Nigerian oil & gas industry, the HWU has become one of the most viable options for operators. Governmental bodies and agencies must make efforts to improve business results for the marginal field operators by providing a level-playing ground for hydraulic workover services providers. This initiative will encourage the development of the services and shall attract experiences from different parts of the world.

Placing hydraulic work-over units on drilling modes are relevant areas to be looked into in the development of this technology in Nigeria. This development will encourage sidetrack drilling using the HWU in land, swamp and offshore locations, providing a less expensive means for operators especially in the development of marginal fields.

The ability of the HWU to work-over live wells in "snubbing mode" is yet to be fully explored in Nigeria. The advantages of servicing wells through in-situ completions include eliminating potential formation damage due to fluid losses, saving the cost for work-over fluid and subsequently, rig time. Certain remedial operations such as removing wax build-up, sand washing, squeeze cement jobs and small volume acid jobs can be carried out by through tubing techniques. The need to pay more attention to developing this technique in the region will further reduce operational cost.

5. Conclusion

The importance and versatility of the HWU has been demonstrated over the years with several ups and downs. This has revealed the need to accelerate this technological service (since it's championed by indigenous initiative) through implementing governmental policies that will encourage growth and improvement in service delivery.

The use of the HWU has been proven to be an innovative cost saving decision for operators when compared to other conventional alternatives.

The hydraulic workover services can be developed over time through consistent improvement on lessons learned, thus birthing quicker, efficient and more advanced ways of carrying out specific tasks, thereby saving planned budget/time for operations.

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APPENDIX :

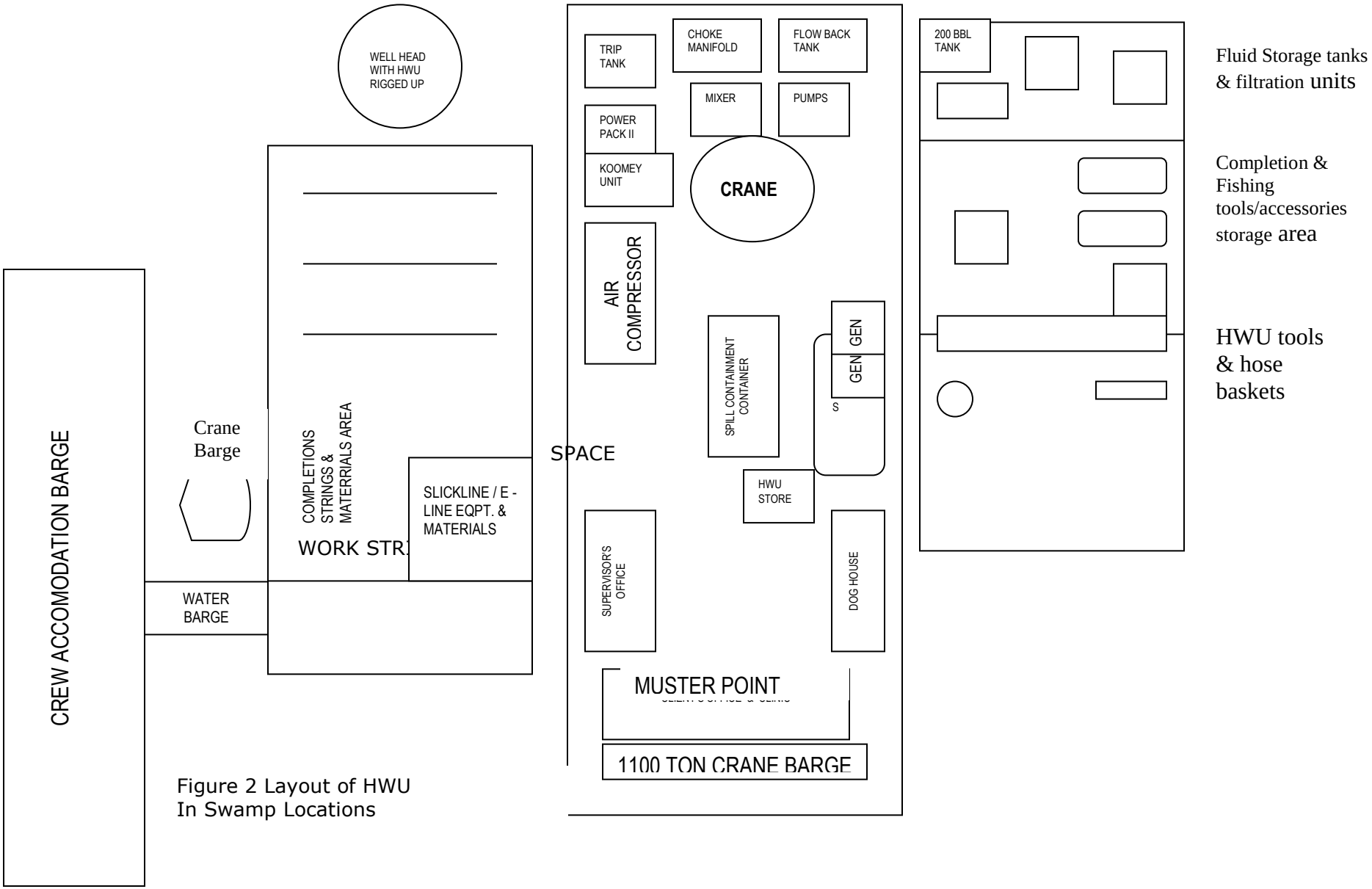
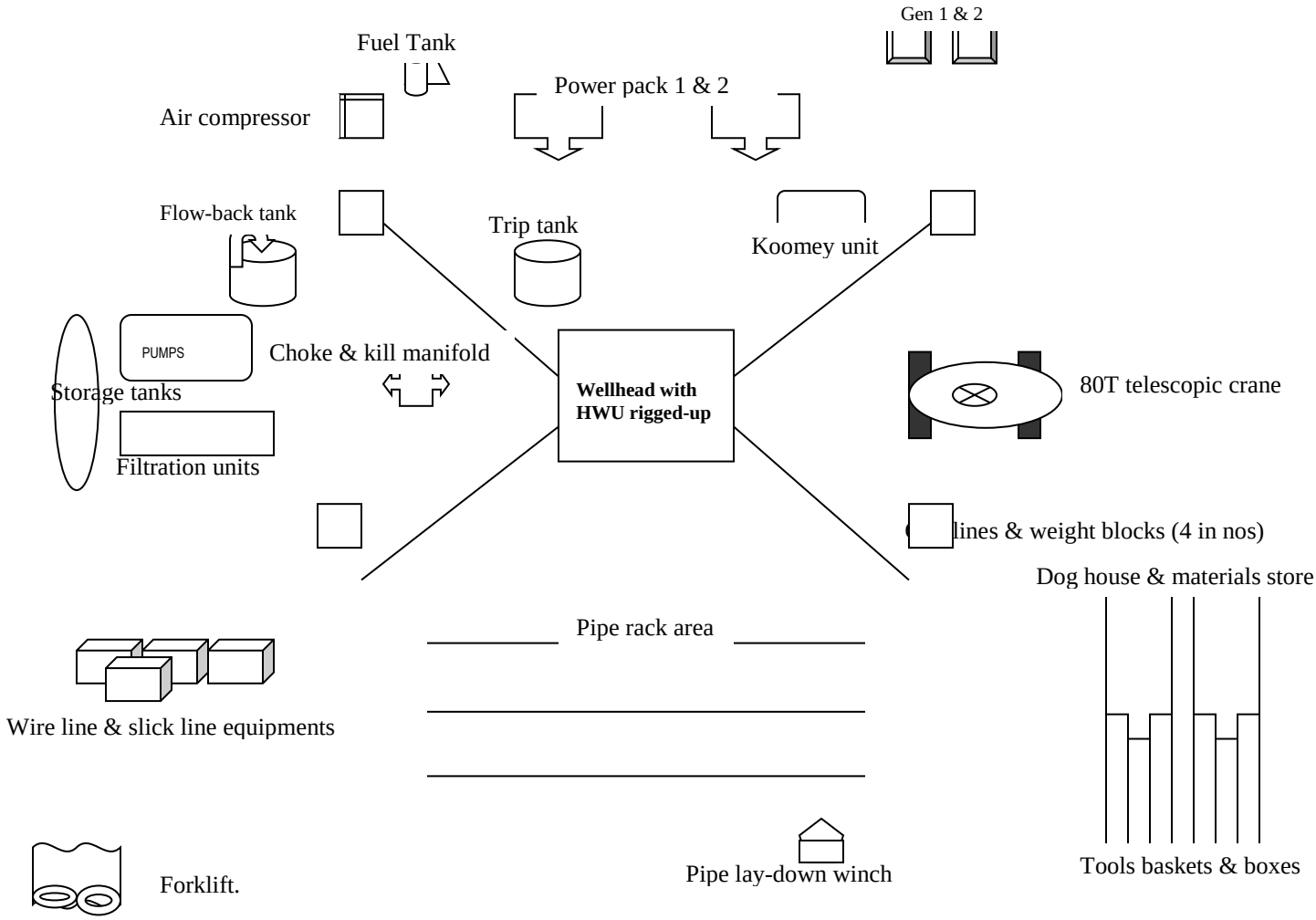


Figure 2 Layout of HWU
In Swamp Locations



Site Canteen	Company man's Office	Supervisor's Office	Sick bay	Toilet

Figure 3 Layout of HWO In Land Locations

Table 1 Equipment Specifications

Spec. description	Model 225K	Model 340K	Model 460K
Maximum pulling capacity (lbs)	225 000	344 000	460 000
Maximum snubbing capacity. (lbs)	120 000	188 000	220 000
Horsepower (HP)	To 305	To 305	To 380
Tubing size range (inches)	1´´to7 5/8	1´´to7 5/8	1´´to8 5/8
Rotary torque (ft-lbs)	5000	6600	6600
Strokes (inches)	12´	10´	10´
Maximum bore unit (inches)	11	11	11

Table 2 460k Operational Schedule

LOCATION	PERIOD	HIGHLIGHTS	TYPE OF OPERATIONS
Land (two wells)	October 2002 to February 2003	Successfully pulled 13000ft of 5-1/2" tubings	Fishing parted tubing, unloading with nitrogen, down hole cleaning services, washing perforations and acidizing.
Land	April to May 2003	Well completed under budget	Squeeze cement job on lower interval, inflow test of squeezed off interval, CRI well completion, Xmas tree installation, etc.
Land	May to June 2003	-do-	Permanent abandonment, 7-inch casing retrieval, etc.
Land	June to July 2003	The 460K team was awarded a performance bonus of 1.9million naira	Abandoning a lower interval to complete two intervals above as 2 3/8" single string selective producer with TRSCSSV installed.
Land	July to August 2003	Very good logistic/waste management	Recovery of existing tubings (long & short). GLM and SCSSSV installed on new completion strings, sand washing with fluid, chemical cutting, etc.
Land	August to Septembe r 2003	Well completed under budget	Recovery of existing tubings (long & short). Curing of circulation losses with appropriate LCM pill. GLM and SCSSSV installed on new completion string.
Land (four wells)	Sept. 2003 to Feb. 2004	460k Team was awarded the rig QHSE team of the month.	Equipped wells with SCSSV and top packer in accordance with shell's well integrity management policy.
Land (two wells)	March 2004 to date	Successfully milled two permanent packers.	Installed 'SB' plug in model 'D' packer, squeeze cement job on D1.0 interval, bit & scrapper run, drilling pass cement plug/retainer, inflow test of squeezed off interval/'SB' plug retrieval, re-perforation of D1.0 interval, Setting of FBGP-1 sump packer, 4 ½" ESS installation, 9-5/8 casing clad job, well completion, etc.
Swamp	25 February to 11 March 2005	Unit successfully pulled A-5 packer free with about 410,000ibs	Pulled existing tubing, set cement plug and bridge plug in readiness for a sidetrack operations by a conventional rig.
Swamp	14th to 28th July 2005	Well completed under budget	Cuttings re-injection well completion.
Land	1st to 31st Oct. 2005	6000psi gas reservoir. Well depth is 10000ft	Reserves evaluation/gas well testing.

Table 3 225k/340k Operational Schedule

LOCATION	UNIT	PERIOD	HIGHLIGHTS	TYPE OF OPERATIONS
Land	225k	July 2001 to September 20 2001	Successful first operation of the rig.	Recovered Long String and Short String and recompleted the well as Poor-boy Dual Selective Producer.
Land	225k	October 10, 2001 to November 23, 2001		Pulled out Single String tubing and recompleted the well as Single String Gas Producer.
Swamp (12 Wells)	225k	January 2002 to September 2002 (9 months)	Well completed under budget	Pulling & running tubings with packers, safety valves, flow controls, gas lift valves, etc.
Swamp	225k	2nd February to 4th March 2003	Well completed under budget despite 19hrs down Time.	Permanent abandonment, setting of cement plug, injectivity test multi-string cutting, old tubings and 24",18-3/8",13-3/8", 5-1/2" casing retrieval.
Swamp	225k	4th Sept. to 22nd Sept. 2003	Operations completed below budget	Permanent abandonment, setting of bridge plug,multi-string cutting, old tubings and 24", 18 3/8",13-3/8", 5-1/2" casing retrieval.
Swamp	225k	12th Aug. to 4th Sept. 2003	Operations completed in 24.29 days against 27.5 days planned	Permanent abandonment, squeeze cement job, 9 5/8", 7" 5-1/2" casing retrieval, etc.
Swamp	225k	27th Sept. to 24th Oct. 2003	Operations completed below budget	Permanent abandonment, setting of cement plug, injectivity test multi-string cutting, old tubings and 24",18-3/8",13-3/8" casing retrieval.
Swamp	225k	1st Nov. to 11th Dec. 2003	Very good logistics management	F1 perforation abandonment and E3.0 & E5.0 sands re-completion (operations suspended due to corrosion on the 13-3/8 casing).
Swamp	225k	13th Jan. to 1st Feb. 2004	Well completed without lost time Incident.	To permanently abandon well and restore site to natural state, setting of cement plug, injectivity test multi-string cutting, old tubings and 24",18-5/8",13-3/8", 9-5/8" casing retrieval.
Swamp (Three wells)	225k	July 2004 to March 2005.	Operations completed below budget	Pulling & running tubings with packers, safety valves, flow controls, gas lift valves, etc.
Swamp	225k	May 2005 (31 days)	First marginal field development operation	Running & pulling of tubings, dst/well testing e.tc.
Swamp	225k	8th August to 24th Oct. 2005	First ESP replacement Ops	Pulling of existing 3-1/2" HYD 533 tubings with ESP and replacing them with new ones.
Offshore (three wells)	340k (new)	24th Oct. 2005 to 20th March 2006	First Offshore operations in West Africa.	Pulling of existing 3-1/2" & 2-7/8" EUE tubing and replacing them with new ones. Cement milling, perforation, RST logging etc.