QUIK-BORE™ Base in 1800 ft Horizontal Borehole Under the Brazos River

Introduction

QUIK-BORE™ bentonite base, high-yield boring fluid system, was specially formulated for use in horizontal directional drilling (HDD). However, this product has not been previously tested for its viability for use in long distance bores or use with solids control equipment. A field trial was conducted to test QUIK-BORE base in these conditions, along with enhancement polymers that will be used with the bentonite in normal drilling scenarios.

Project Scope:

Haros Brothers Drilling was contracted to drill an 1800 ft long bore for the installation of cables for Baylor Research Innovation Collaborative. This borehole was to be piloted to 5 inches and reamed to 14 inches using a Ditch Witch JT8020 Mach 1 and a Roller Tri-Cone bit. Once the bore was piloted and reamed, an 8 inch steel casing was to be pulled into place. Of the 1800 ft total length, 1100 ft were to be drilled beneath the Brazos River. The bore was drilled up to 45 feet beneath the earth's surface. With the river reaching a depth of 25-30 ft there was only 10-15 ft of ground above the portion of the bore that was drilled under the river. The rate of penetration was kept at a minimal speed to avoid an inadvertent release.

Solution:

QUIK-BORE base was used for the duration of the drilling project along with Baroid Industrial Drilling Products' specialized polymers. Two formulations were used while drilling this bore, in order to specifically engineer for different formation types encountered while drilling. Along with the QUIK-BORE base; QUIK-TROL® GOLD LV polymer, NO-SAG® suspension enhancer, and EZ-MUD® GOLD polymer were used for borehole stability and suspension capabilities. PENETROL® surfactant and AQUA-CLEAR® PFD thinner were also used, as needed.

QUIK-TROL® GOLD LV polymer was used for the duration of the drilling to control filtration and further enhance the filter cake developed by the QUIK-BORE base, as sand was present in all sections of the bore path.

NO-SAG® suspension enhancer was used to build viscosity and increase suspension characteristics. This additive was used in all formulations not containing EZ-MUD GOLD polymer.

EZ-MUD® GOLD polymer was used in the sections of the bore containing clay and hard gray shale in order to encapsulate these particles and delay hydration time of the non-beneficial solids.

Formulation 1 (sand and gravel portion)		**Formulation 2** (clay and shale portion)	
QUIK-BORE	20 LB/100 GAL	QUIK-BORE	20 LB/100 GAL
QUIK-TROL GOLD LV	.5-.6 LB/100 GAL	QUIK-TROL GOLD LV	.5 LB/100 GAL
NO SAG	.2 LB/100 GAL	EZ-MUD GOLD	.5 LB/100 GAL

*PENETROL surfactant and AQUA-CLEAR PFD thinner were used on an as needed basis.

***PENETROL®** surfactant was added in order to help maintain a clean bit while in the rock portion of the formation. Due to the wearing down of the original bit, it was not able to continually pilot the borehole with out balling with clay. It should be noted that the foaming action of the PENETROL surfactant being used in conjunction with a reclaimer causes cavitation of the rig pump and increases overall rotational pressures.

***AQUA-CLEAR® PFD** thinner was used to thin the fluid when funnel viscosity reached rates over 60 sec/qt. This helped reduce the funnel viscosity below 50 sec/qt. This product also helped reduce the foaming effect formed from reclaiming the drilling fluid containing the PENETROL surfactant.

Observations:

QUIK-BORE base and various polymeric additives were mixed with ease using the mixing hopper on a Tri-Flo solids control unit. This unit had a tank capacity of 3825 gallons but was only filled to 2500 at any given time due to a portion of the tank being used for waste. All products were added slowly to achieve proper hydration and avoid any un-yielded product incorporation into the system. Fluid was circulated through the hole to another mixing tank prior to solids control introduction. Therefore, fluid was contained in the entrance pit, a Ditch Witch 13V mixing tank and the tank on the solids control unit.

Figure 1: Mixing of QUIK-BORE base prior to addition of NO-SAG suspension enhancer

Average Fluid Properties of Mix Containing EZ-MUD GOLD POLYMER

Funnel Viscosity	49.75 sec/qt
600	39.5
300	25.
PV	14.24cp
YP	11.04
10S	6.16
10M	19.52
FILTRATE	12 mL/30min
MW	**8.6 lbs/gal**
SAND	0.6 %

Average Fluid Properties of Mix Containing NO-SAG Suspension Enhancer

Funnel Viscosity	39.67 sec/qt
600	35
300	24
PV	10.4cp
YP	13.3
10S	8.75
10M	17.1
FILTRATE	14.3 mL/30min
MW	8.56 lbs/gal
SAND	**3.2 %**

Figure 2: After addition of QUIK-TROL GOLD polymer and NO-SAG suspension enhancer the viscosity of the fluid visibly increases.

- The properties displayed above were measured after solids control treatment.
- Once sand content reached 5%, it was vacuumed out and replaced.
- Higher sand content of the NO-SAG suspension enhancer containing fluid was due to residual dirty fluid in the tank prior to mixing.
- 8.6 lbs/gal indicated colloidal fines were entrained into the fluid system and not removed by the solids control equipment.

Observations Continued:

The solids control unit used during this drilling operation had two banks with six de-sander cones on either side. Under the de-sanders were two shakers capable of removing solids.

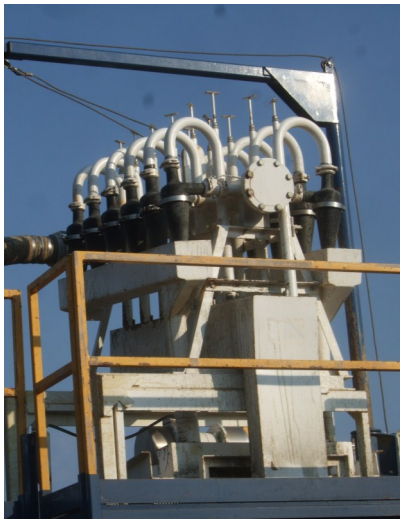

Figure 3: Tri-Flo solids control De-sander Cones

Figure 4: Shakers removing sand from returning fluid. The first 300 ft. were sand and gravel.

Figure 5: Sands removed from fluid by shaker screens.

The fluid weight of the entrance pit was measured to be 11.4 lbs/gal, at it's heaviest, by the end of the pilot shot. This density indicates the amount of solids or cuttings being cleaned from the hole. When calculated, the percent of solids being removed from the hole was 23.6%. This percentage showed that the suspension created by the fluid was competent enough remove the cuttings from the hole even when penetration was at a minimal speed (figure 7.)

Solids Calculations:

- 11.4 lb/gal = Fluid Weight of returns in pit
- 8.45 lb/gal = Fluid Weight of new drilling fluid
- 8.60 lb/gal = Fluid Weight of Re-circulated fluid
- 8.00 = standard constant for % solids calculation

- (11.4-8.45) x 8 = 23.6 % of Fluid Cleared from the bore hole
- (11.4-8.6) x 8 = 22.4% of Solids Removed by Solids Control Equipment
- (22.4/ 23.6) x 100 = 94.9

95% of solids cleared from the hole were cleaned from the fluid by the solids control unit.

Observations Continued:

The first 300-400 ft, prior to reaching the river's edge was mostly sand but a small bed of lime stone was encountered. Once at the rivers edge, consolidated rock was faced. In this section of the drive the bit was unable to cut into the formation due to worn down cones (Figure 6.) The driller was forced to trip out and wait on a new bit to arrive. When drilling reconvened the following day, the drillers were able to re-install the rods with no delays from hole collapse. The filter cake developed by QUIK-BORE base and the enhancing polymers were able to stabilize the bore hole until drilling could reconvene.

Figure 6– worn teeth on bit, balled with clay.

Figure 7a- Suspension demonstration. 1 cup of drilling fluid with NO-SAG enhancer with a handful of sand on top. Sand remained on top of the fluid until stirred in.

Figure 7b- Stirred in sand remained suspended for several hours without agitation.

Figure 8a- Washed Cuttings, small gravel and beach sand.

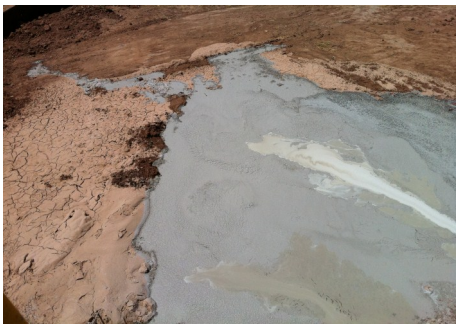

Figure 9: Spoils of the hard gray shale and sand portions of the bore, first 1000 ft.

Figure 8b- Sands removed from circulated fluid with shaker screens on solids control equipment.

With a new tri-cone bit in place the rock was penetrated with ease. Upon exiting the rock portion of the formation underneath the river, clay and hard gray shale dominated the ground structure for approximately 1000 ft. The fluid mix for this portion of the formation was changed to include EZ-MUD GOLD polymer and exclude NO-SAG suspension enhancer. Following was sand and small gravel (Figure 8) while exiting the river, at which time NO-SAG suspension enhancer was re-incorporated into the new fluid being mixed.

Observations Continued:

Approaching the last 200 ft of the drive, 3 cement barrier walls were encountered. Each wall was 1-2 ft thick and were unnoticed during the pilot shot. These walls made reaming and maintaining fluid returns in that area difficult. Without consulting Baroid IDP, the fluid mixer decided to add 100 additional pounds of QUIK-BORE base to the fluid system in order to help control fluid loss when reaming through the cement. This caused a large viscosity spike and ultimately fractured the formation, due to the added pressure. This fracture caused a total loss of returns. Due to the total loss of returns, new fluid was added, thereby lowering the concentration of the QUIK-BORE base to the appropriate and recommended concentrations. Once the adequate fluid formulation was restored, fluid returned to the pit as before, indicating no further action was needed to seal the loss zone. No further fractures were experienced during the project.

The initial reaming process started with a wing cutter reamer. This was changed to a hole opener reamer (figure 10) at the point of the inadvertent release (200 ft back through the pilot hole) in order to promote further hole cleaning. The entire 1800 ft of the bore were reamed twice for total cleaning before pulling in the 8 inch steel casing.

The density of the fluid returning from the hole ranged from 9-11.4 lbs/gal with a sand content of 5-7%. After circulating through the solids control equipment, the density was reduced to 8.5-8.6 lbs/gal and a sand content of less than 1%. This is a property indicative of fluid that is capable of dropping solids at the surface, after removing them from the bore hole. However, once the solids are cut to a colloidal size they can not be removed from the fluid system and add density to the over all fluid. By observing the plastic viscosity, it can be noted that the higher value of 14.24cp for fluids that encountered shale, clay and sand, became entrained with a higher concentration of colloidal particles, than the original fluid which was used to pass through gravel and rock. Once the density reaches a weight of 8.6 lbs/gal or higher after solids control, it must be expelled from circulation and replaced with new drilling fluid to avoid degradation of fluid properties. For this reason the fluid system was replaced 6 times (twice a week) during the project.

Figure 10- 14 inch hole opener reamer

Application Summary:

The stability provided by the high yielding QUIK-BORE base specialty bentonite and enhancing polymers, allowed for the final product—8 inch steel casing— to be pulled into place with no resistance. The project was completed in 3 weeks. This was considerably less time than what was spent on a similar bore, in a nearby location, which totaled 8 weeks for completion. By completing the borehole in under the allotted time frame, the operational cost decreased substantially. This product was proven to be suitable for long distance bore holes in combination with suspension enhancing polymers and clay and shale stabilizing polymers. Based on this trial, QUIK-BORE base also demonstrated the ability to be effectively cleaned with solids control equipment, with the ability of re-using suitable fluid at least 3 times and maintaining adequate properties.

Economic Value:

This bore was completed using 10 pallets of QUIK-BORE base, or 480 bags. Similar bores were completed on this project using BORE-GEL additive. The bores drilled with BORE-GEL® additive took the full 8 weeks to complete. By using QUIK-BORE base, and additional polymers as needed, operational costs were decreased to less than half of what was spent on previous bores. With the bore being completed in less than half the allotted time, material costs for the operation were also substantially decreased, as less drilling time demanded less product.