# CASE HISTORY TEMPLATE

## Baroid Industrial Drilling Products

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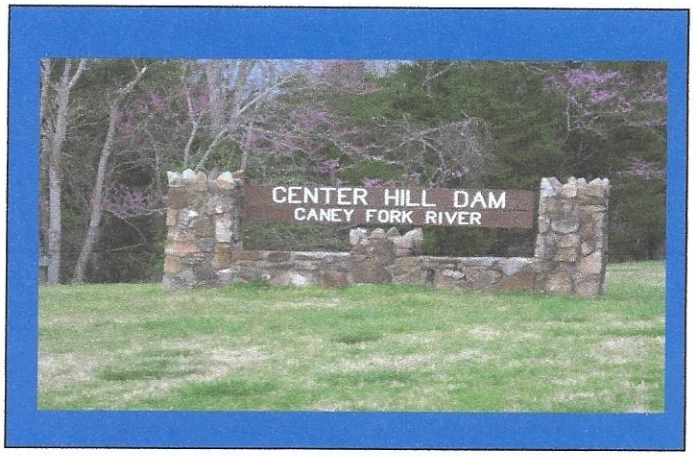
|---|---|
| Code | |
| Field Sales Rep | David Roberts |
| Date | 7-25-14 |

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| Project Title | **Center Hill Dam Remediation Project<br>U.S. Army Corps of Engineers<br>Bauer Foundation Corp.** |
| Location | Center Hill Dam, Caney Fork Reservoir |
| Owner | U.S. Army Corps of Engineers, Nashville District |
| General Contractor | Bauer Foundation Corp. |
| Geology / Enviro. | Encasement Wall Construction, CHD Soil Embankment |
| Product (SSO)<br>Menu | AQUAGEL / QUIK TROL LV / AQUACLEAR PFD |

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| Project Scope (BI Concept)<br>Menu | In 2012, the ACOE awarded contract to Bauer Foundation Corp. for the planned remediation of the soil embankment portion of the Center Hill Dam, Caney Fork Reservoir, Dekalb County, TN. The remediation project was required due to worsening solution channel developement in the base foundation rock supporting the man-made soil embankment. The initial activity will involve the construction of a segmented concrete encasement wall reaching from the existing dam spillway / generating structure shoreward to the terminus of the soil embankment, and from the embankment surface elevation vertically to the solid foundation rock. The encasement wall will be constructed in primary and secondary panel elements each measuring 88" x 128", using hydrocutter, clam excavator, and auger drill equipment. In the excavation process, a suitable drilling fluid is required to provide stability to the excavated trench panel, assist in transport of soil solids from the trench panel, maintain hydrostatic pressure inside the trench panel as soil is removed, and create a durable |

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| | filter cake to reduce the possibility of wholesale fluid loss into the soil embankment structure. |

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| Baroid IDP Solution<br>Menu | Baroid IDP contacted Bauer Foundation Corp., and early in 2012, visited the Center Hill Dam site and met with ACOE and Bauer Foundation Corp. engineers to gain a full understanding of the project scope. Bauer Foundation requested Baroid IDP recommendations on product applications, fluid formulation, and fluids maintenance. As part of a recommended Baroid IDP Solution, extensive lab work was done on site, and in the Houston Technical Services lab located at the Halliburton Services headquarters facility in Houston. In conjunction with Bauer's technical staff, and in compliance with required ACOE fluid specifications, a fluids formulation was recommended and approved, and initial fresh fluid mixing began in early May, 2013. As of early 2014, 37 primary panels and 38 secondary encasement panels have been successfully excavated and concrete poured in each panel from the top of foundation rock back to the surface. The fluid formulation has performed as expected. Basic maintenance required building new volume of fresh fluid as needed, treatment of the concrete contamination from the secondary panel excavations, and solids removal processing to control density increase from excavation solids. |

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| Fluid Properties | Table 1: Required Slurry Properties |

| | Units | Fresh | Pre- Concrete Placement | In Trench |
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| Viscosity | sec/qt | 32-40 | 32-45 | 36-50 |
| Density | g/cm3 | 1.02-1.04 | 1.02-1.10 | 1.02-1.37 |
| Bentonite | % by wt. | 3.1 | 3.1 | 3.1 |
| pH | N/A | 6.5-10.0 | 6.5-11.0 | 6.5-12.0 |
| Filtrate | ml/30 min. | 15-20 | 15-20 | 15-25 |

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| Cake | mm | 1 | 1-3 | 1-5 |
| Sand | % by vol. | <3 | <4 | no limit |

**Table 2: Fresh Slurry Recipe**

**Make-up water from Center Hill Reservoir**

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| BICARBONATE OF SODA | 0.15 lb/100 gallons |
| AQUAGEL | 3.1% by weight 26 lb/100 gallons |
| QUIK TROL GOLD LV | 0.26-0.32 lb/100 gallons |

**Table 3: Average Fresh Slurry Properties**

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| Density | 1.025 8.55 ppg. |
| Funnel Viscosity | 37 sec. |
| 600 RPM | 25 |
| 300 RPM | 15 |
| Plastic Viscosity | 10 |
| Yield Point | 5 |
| Gel Strengths | 2/5 |
| Filtrate | 18.0 ml |
| Cake | 2/32 |
| pH | 9.6 |
| Hardness | 80 ppm |
| Sand | <1/4% |

**Table 4: Solids Control Equipment**

Derrick linear motion scalper shakers with polypropylene screens (4)
Derrick linear motion flowline shakers with 35 mesh screens (4)
Bauer 15" desander hydroclones over 140 mesh screens (3 units, 2 cones each)
Derrick 6" desilter hydroclones over 140, 170, 200 mesh screens (4 units, 8 cones each)
Bauer BD-90 High Capacity Centrifuge, 396 GPM (1)

**Table 5: Fluid processing / mixing / storage system**

Solids separation tanks (7, with total capacity 63,276 gallons)
Buffer tanks (2, total capacity 18,492 gallons)
Auger storage tanks (6, total capacity 100,800 gallons)
Fresh slurry mixing tanks (2, total capacity 19,548 gallons)
Storage / holding tanks (4, total capacity 702,000 gallons)
Fresh water storage tanks (3, total capacity 63,000 gallons)
Total capacity all tanks (24) 967,116 gallons

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| | Average rate of circulation while excavating primary and secondary panels 800 CY per hour / 2,693 GPM<br><br>Table 6: Summary Comments on Treating Cement Contamination from Secondary Panel ES 1999 |

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| Menu | A. Pretreated an estimated 70K gallons of fluid volume using 2,600 lbs. of BICARBONATE OF SODA or 0.4% by weight treatment rate. There were no fluid problems noted as related to the fluid pretreatment.<br>B. After pretreatment, we continued adding bicarbonate while cutting the secondary panel. Rate of bicarbonate addition varied from 10 minutes per bag to 4 minutes per bag. Our goal was to match the bicarbonate rate of addition to the hydrocutter progress, and to maintain pH <12.0. Maximum pH was measured at 11.8. We stopped bicarbonate addition when the hydrocutter reached foundation rock, and pH decreased to 10.7. Final pH was 9.7 at 116.9' panel depth.<br>Total bicarbonate added:<br>Pretreatment 2,600 lbs.<br>Added while cutting panel 9,520 lbs.<br>Total added 12,120 lbs.<br>C. AQUACLEAR PFD was added 6-7 gallons at beginning of cutter operation.<br>D. Filtrate was maintained in 19.2-25.0 ml range with no additional QUIK TROL GOLD LV needed.<br>E. Maximum calcium from the cement milled during cutting was 250 mg, measured by strips in whole mud. Versenate hardness titration on filtrate ranged 100-140 ppm.<br>F. Density and rheology properties as follows:<br>Density 1.16-1.17 9.67-9.76 ppg<br>Funnel Viscosity 32 sec.<br>600 RPM 15 17 16<br>300 RPM 9 10 10<br>Plastic Viscosity 6 7 6<br>Yield Point 3 3 4<br>Gel Strengths 1 1 1 10 sec.<br>13 12 13 10 min.<br>20 19 20 30 min.<br>10 minute and 30 minute gel strengths very progressive due to Residual effects of the cement contamination and heavy bicarbonate additions. |

G. Utilized centrifuge to help in fine solids removal:
1.16-1.17 9.67-9.76 ppg. density input
1.09 9.09 ppg. density discharge effluent
H. On ES 1999 secondary panel, we mixed 105-115 lbs. of bicarbonate Per 1' of panel depth.

Table 7: Recommendations for treating cement contaminated fluid from remaining secondary panels

A. Pretreat fluid system with 0.4% by weight BICARBONATE OF SODA before starting. Estimate fluid volume in the circulating tanks, plus 25% of the fluid volume in the respective secondary panel to arrive at the pretreatment needed.
B. After pretreatment, be prepared to add AQUACLEAR PFD slowly if needed to maintain funnel viscosity <36 seconds per quart.
C. Calibrate pH meter and maintain pH <11.8 in intermediate buffer tanks. Mix bicarbonate at 4-10 minutes per bag as needed. Stop bicarbonate additions when hydrocutter reaches foundation rock. Fluid pH should decrease after cutting is done, and there's been time for the bicarbonate/concrete reaction to reach completion.
D. Test whole slurry and filtrate using Total Hardness test strips. Total Hardness on whole slurry should range 150-250 ppm, and on filtrate 40-120 ppm.
E. Centrifuging is important in treating the fluid to reduce density, and remove fine concrete particles and fine solids created by the bicarbonate/cement reaction. Without effective fine solids control, density and viscosity control is not achievable.
F. After concrete cutting is done, QUIK TROL GOLD LV may be added at 0.1-0.2 lb/100 gallons if needed to maintain desired filtration control.
G. Based on usage for the initial two secondary panels, plan to mix about 105-115 lb. of bicarbonate per foot of panel depth, including pretreatment. That could vary depending on the fluid pH at the start of cutting, the age of the primary concrete, and the actual rate of progress of the cutter.

In the initial planning of the Center Hill Dam remediation project, much emphasis was placed on maintaining the integrity of the dam embankment structure, as well as maintenance of fluid properties within minimum – maximum ranges as specified by the ACOE. Some important criteria included:

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| | **A. Slurry level within the primary and secondary trench panels should not fall below 2' from top of guide wall, or experience a slurry loss rate greater than 1.5 FPM.**<br>**B. Fluid formulation was required to provide acceptable properties even after heavy contamination with reactive clay solids and cement from the secondary panels.**<br>**C. All fluid additives required approval by the ACOE to insure environmental safety for disposal, and in case of a spill in to the reservoir, or Caney Fork River.**<br><br>**We were able to meet the above criteria, and avoid additional project cost due to delays. We also avoided any substantial loss of whole slurry, which would have the potential for compromising the stability and safety of the Center Hill Dam embankment structure.** |