**Formation Evaluation Log**

### Company: **Northwest Natural**
#### Well: **IW 23ach-3-65**
#### Field: **Bruer Pool Inject/WD Storage**
#### County: **Columbia, OR**

**Location:** SE 1/4 Sec. 3, T6N-R5W; WB&M Coordinates: 2346.8' N 86°26' W and 1593.8' N 3°33' E from SE corner. Y: 874129.60 X:1292387.90 FIN

**API No.:** 36-009-00366
**Spud Date:** 5/11/07
**Total Depth:** 5/18/07
**Elevation:** K.B. 1047.3'  G.L. 1033.3'

**Company Geologist:** Jack Meyer
**Company Engineer:** Clayton Roth
**Company Pusher:** Ed Vader
**Directional Engineer:** Scientific Drilling

**Mud Company:** Beaver Drilling Fluids
**Mud Engineer:** Ed Vader
**Drilling Contractor:** TD Well Service
**Rig Pusher:** Jerry Gann
**Rig No.:** 101
**Geolog Unit No.:** 19
**Logging Geologists:** Jim Ferguson Matt Brown

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**Log Interval**

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<td>50' TO 3518'</td>
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**Mud Types**

Gel Chem TO 3518'

**Mud Pumps**

**Pump #1:** EMSCO DB 550 (16'' x 5-1/2'')

**Pump #2:** OILWELL H 560 37 (8'' x 5-1/2'')

**Total Depth**

**Measured:** 3518'
**True Vertical:** 2599.08' Proj.

**Hole Size**

17-1/2'' TO 590'
12-1/4'' TO 626'
8-3/4'' TO 3518'

**Casing Data**

20'' AT 20'
13-3/8'' AT 563'

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**Legend**

- **BG** - Background Gas
- **CB** - Core Bit
- **CG** - Connection Gas
- **CK** - Filter Cake
- **CKF** - Check for Flow
- **CL** - Salinity, ppm Cl
- **CR** - Circulate Returns
- **DB** - Diamond Bit
- **DC** - Depth Correction
- **DCB** - Diamond Core Bit
- **DF** - Derrick Floor
- **DG** - Drilling Gas
- **DS** - Directional Survey
- **DST** - Drill Stem Test
- **EL** - Electric Log
- **E.M.A.** - Equivalent Methane in Air, 1% = 50 Units
- **EM** - Methane
- **F** - Filtrate, API cc's
- **F/T** - Flowline Temperature
- **GCM** - Gas Cut Mud
- **GCW** - Gas Cut Water
- **G & OCM** - Gas and Oil Cut Mud
- **GL** - Ground Level
- **GB** - Background Bit
- **GCB** - Gem Core Bit
- **GCL** - Gem Core Bit
- **GMC** - Gas Cut Mud
- **H** - Hole Size
- **HCW** - High Cut Water

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**Drill Rate**

- **ft/hr:**
- **Backup Scale - x10**

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**Logging Geologists:**
- **Jack Meyer**
- **Clayton Roth**
- **Ed Vader**
- **Scientific Drilling**
- **TD Well Service**
- **Jerry Gann**
- **Jim Ferguson**
- **Matt Brown**

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**Drill Stem Test**

**Total Gas**

**Ditch Cuttings Graph**

**Chromatograph**

**Lithology Descriptions & Remarks**

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Begin Logging at 4:30 PM on 5/11/07
Ran 20" conductor pipe; set at 20'. Drill out with 8-3/4" bit.

Mw 8.7+ Vis 34

Siltst: Medium gray moderately firm, occasionally grading to very fine grain sandst, poorly cemented mostly with clay matrix, some carbonaceous with traces fossil fragments

Sandst: light gray moderately firm friable, very fine to fine with rare medium mostly subangl clear, white qtz with predom clay matrix

Sandy siltst: medium to dark gray, friable soft, with common very fine grain sandst of clear, white and transul quartz occasionally very clayey, argillaceous

Mw 8.7 Vis 32

Siltst: Medium gray moderately firm, occasionally grading to very fine grain sandst, poorly cemented mostly with clay matrix, some carbonaceous with traces fossil fragments

Siltst: It-med gry, fn-med grain, subang-submd, firm-friable, argillaceous siltstone, lt gry, fn grain subang-submd, claystone, clear-milky, fn grain, submd, quartz sand

Mw 8.7 Vis 42

Siltst: It-med gry, fn-med grain, subang-submd, firm-friable, argillaceous siltstone, lt gry, fn grain subang-submd, claystone, clear-milky, fn grain, submd, quartz sand, occ blk, volcanic fragments
Drill 8-3/4" hole 617', open 17-1/2" to 590'. Run and cement 13-3/8" casing with shoe at 590'. Rig up BOP Drill ahead.

Mw 8.6  Vis 35

Siltst: lt-med gry, fn-med grain, subang-subrnd, firm-friable, argillaceous, sandy siltstone, lt gry, fn grain subang-subrnd, claystone, clear-milky, fn grain, subrnd, quartz sand, lt-med gry, subang-subrnd, hard calc sandstone, occ blk, volcanic fragments & shell fragments

Run and cement 13-3/8" casing with shoe at 563'  Rig BOP Drill ahead

Rig up new BHA pick up directional tools MWD and MM

Clayst: medium gray brown, moderately soft, occasionally very sandy and silty with some carbonaceous matrl and rare fossil fragments, argillaceous, soluable in part, sticky soft

Clay : medium gray brown, occasionally very silty to sandy
Siltst: medium gray with some gray brown, occ firm with some fissility, some grading to very fine grain sandstone, carbonaceous slightly calcareous

Survey at 1248' Incl 10.00°
Az 322.30° TVD 1246.67'
N 14.97' W 16.65'

MW 8.6 Vis 44

Siltst: lt-mid gry, fn grain, subang-subrnd, moderately firm-firm, siltstone, lt-mid gry-tan, slou-subsolu, occ sticky, silty clay, occ volcanic fragments

Survey at 1403' Incl 16.40°
Az 335.60° TVD 1397.54'
N 45.63' W 33.65'

Siltst: lt-mid gry, fn grain, subang-subrnd, moderately firm-firm, siltstone, lt gry, fn grain, friable clay stone, lt-mid gry-tan, slou-subsolu, occ sticky, silty clay, poss tuff, occ volcanic fragments

Survey at 1509' Incl 19.30°
Az 339.07° TVD 1498.49'
N 75.77' W 45.10'

Siltst: lt-mid gry, fn grain, subang-subrnd, moderately firm-firm, siltstone, lt-mid gry-tan, slou-subsolu, occ sticky, silty clay, occ volcanic fragments

Survey at 1668' Incl 25.06°
Az 329.02° TVD 1646.00'
N 128.34' W 17.13'

Siltst: lt-mid gry, fn grain, subang-subrnd, moderately firm-firm, siltstone, lt gry, fn grain, friable clay stone, lt-mid gry-tan, slou-subsolu, occ sticky, silty clay, occ volcanic fragments

Survey at 15/6/07
WOB 10 K
PP 1200
RPM 0-45 (w/MM)
SPM 60 / 120

Occasionally very silty to sandy, moderately soft, rare lignite and fossil fragments, soluble in part, sticky soft, amorphous
Survey at 1759'  
Incl 28.03°  
Az 331.21°  
TVD 1727.13'  
N 163.88°  
W 92.94°

Mw 8.8  
Vis 43

Silt: It-med gry, fn grain, subang-subrnd, moderately firm-firm, siltstone, lt gry, fn grain, friable clay stone, lt-med gry-brn, slou-subsolu, occ sticky, silty clay, poss lt-drk gry, hard calc sandstone w/ basaltic components

Survey at 1966'  
Incl 27.50°  
Az 332.45°  
TVD 1910.27'  
N 234.86°  
W 137.70°

Mw 8.8+  
Vis 52

Sandst: light to medium gray, firm to hard, very fine to fine with some minor medium grains, predominately subrounded clear, white and transul quartz, common mafics with some vari colored volcanics grains with well cemented calcareous matrix

Survey at 2126'  
Incl 33.30°  
Az 319.70°  
TVD 2053.16'  
N 307.07°  
W 179.03°

Mw 8.8+  
Vis 52

Clayst: medium to light gray with some mottled gray brown, occasionaly very silty to sandy, mostly sticky soft, soluable in part, with rare lignite and fossil fragments, amorphous

Survey at 2166'  
Incl 33.30°  
Az 319.70°  
TVD 2053.16'  
N 307.07°  
W 179.03°

Mw 8.8+  
Vis 52

Sandy Siltst: medium to light gray brown moderately firm slightly calcareous, occasionaly grading to very fine grain sandst, argillaceous

Survey at 2200'  
Incl 33.30°  
Az 319.70°  
TVD 2053.16'  
N 307.07°  
W 179.03°

Mw 8.8+  
Vis 52

Siltst: medium gray moderately firm slightly calcareous, occasionaly grading to very fine grain sandst, argillaceous
Survey at 2303'
Incl 39.0°
Az 304.40°
TVD 2196.72'
N 372.77' W258.41'

Calc-Limestone: medium gray to gray brown with some green olive tint, occasionally grading to very fine grain sandstone, some argillaceous with rare fossil fragments

Survey at 2462'
Incl 45.00°
Az 296.50°
TVD 2314.67'
N 428.55' W 349.01'

Siltst: medium gray to gray brown with some green olive tint, occasionally grading to very fine grain sandstone with abundant clay with some clay matrix, argillaceous, poor fissility with rare fossil fragments

Survey at 2670'
Incl 59.40°
Az 286.90°
TVD 2442.39'
N 488.74' W 500.78'

Sand: clear-milky, vfn-fn grain, subang-subrnd, quartz sand, lt gry, fn-med grain, subang-subrnd, hard calc sandstone, lt-med gray, subsolu, gummy, sticky, sandy clay, med gry, subang, argillaceous siltstone, occ fossil fragments & pyrite

Survey at 2670'
Incl 59.40°
Az 286.90°
TVD 2442.39'
N 488.74' W 500.78'

Clay: lt-med gry, subsolu, gummy, sticky, sandy clay, med gry, subang, argillaceous siltstone, clear-milky, vfn-fn grain, subang-subrnd, quartz sand, occ fossil fragments & pyrite

Survey at 2670'
Incl 59.40°
Az 286.90°
TVD 2442.39'
N 488.74' W 500.78'

Clay: lt-med gry, subsolu, gummy, sticky, sandy clay, med gry, subang, argillaceous siltstone, clear-milky, vfn-fn grain, subang-subrnd, quartz sand, occ fossil fragments & pyrite
Survey at 2826' Incl 65.78°
Az 280.56° TVD 2513.40'
N 520.98' W 653.71'

Clay: lt-med gry, subsolu, gummy, sticky, sandy clay, med gry, subang, argillaceous siltstone, clear-milky, vfn-fn grain, subang-subrnd, quartz sand, occ tuff & pyrite

Mw 9.2+ Vis 51

Survey at 3023' Incl 78.86°
Az 280.17° TVD 2577.35'
N 553.58' W 817.40'

Sand: clear-milky, vfn-fn grain, subang-subrnd, quartz sand, lt-med gry, subsolu, gummy, sticky, sandy clay, lt gry, fn-med grain, subang-subrnd, hard calc sandstone, occ muscovite & pyrite

Mw 9.3 Vis 42

Survey at 3180' Incl 85.79°
Az 282.08° TVD 2600.33'
N 582.88' W 969.84'

Sand: clear-milky, vfn-fn grain, subang-subrnd, quartz sand, lt-med gry, subsolu, gummy, sticky, sandy clay, lt gry, fn-med grain, subang-subrnd, hard calc sandstone, med brn-gry, fn grain, subang, firm siltstone, muscovite, pyrite & occ chlorite

Mw 9.15 Vis 40

Survey at 3277' Incl 89.30°
Az 283.00° TVD 2604.97'
N 603.61' W 1064.47'

Sand: clear-milky, vfn-fn grain, subang-subrnd, quartz sand, lt-med gry, subsolu, gummy, sticky, sandy clay, lt gry, fn-med grain, subang-subrnd, hard calc sandstone, med brn-gry, fn grain, subang, firm siltstone, abundant mica & pyrite, occ chlorite & tuff

Mw 9.15 Vis 40
Formation Evaluation Log

Comments:

Sand: clear-milky, fm-in grain, subang-subrnd, quartz sand, lt gry, fn-med grain, subang-subrnd, hard calc sandstone, med brn-gry, fn grain, subang, firm siltstone, abundant mica & pyrite, occ lignite

Sand: Light gray, unconsolidated very fine to fine with common medium grain predominately clear, white and transul quartz, very micaceous with muscovite, occasionaly with lignite, and welded tuff

Survey at 3469' Incl 92.00°
Az 281.70° TVD 2600.83'
Mw 9.0+ Vis 47

- Total Depth 3518': Driller
- Projected TVD 2599.08'
- TG 53u

NORTHWEST NATURAL
IW 23ach-3-65
Bruer Pool Inject/WD Storage
SE 1/4 Sec. 3, T6N-R5W; WB&M

FORMATION EVALUATION LOG

Scale: 2" = 100'