Bayou Corne

Evaluation of Chloride Migration from Bayou Corne Sinkhole in Mississippi River Alluvial Aquifer (MRAA)

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The migration of chloride from the Bayou Corne sinkhole into Mississippi River Alluvial Aquifer (MRAA) water supply wells in the Napoleonville Salt Dome area has been evaluated. This report presents the evaluation of these data.

1.0 Background and Model Code

In addition to surface stability and methane gas migration issues, the Bayou Corne sinkhole has resulted in the development of dissolved chloride and petroleum hydrocarbon surface and ground water impact in the immediate vicinity of the sinkhole. The chloride is believed to be derived from the brine and petroleum reservoir water that was released during the collapse event and is potentially currently migrating into the aquifer through the collapse zone.

The dissolved petroleum hydrocarbons are the result of the release of crude oil during and after the collapse event. The one sinkhole sampling event that obtained data on total petroleum hydrocarbon (TPH) dissolved concentrations in the MRAA was the sinkhole profile sampling. This sampling showed that dissolved TPH concentrations were increasing with depth in the sinkhole. However, data are not currently available to evaluate TPH migration in the MRAA. Therefore, this modeling only addresses migration of chloride in the MRAA into water supply wells. Recommendations for data collection to support modeling of dissolved TPH in the MRAA are presented in Section 4.0.

The model code used for this evaluation is WINFLOW/WINTRAN developed by Environmental Simulations, Inc. (Rumbaugh and Rumbaugh, 2012). WINFLOW is an analytical element model used for flow and particle tracking simulations. WINTRAN is the finite difference solute transport module used for simulation of contaminant migration. Both codes are part of the Aquifer32 set of hydrogeologic simulation tools (Rumbaugh and Rumbaugh, 2012).

2.0 Input Parameters and Model Scenarios

The input parameters used in these simulations are:

- Hydraulic Gradient = 0.00002 feet/feet (ft/ft) in a flow direction of South 15° East, based on regional groundwater flow directions down the Mississippi River valley
- Hydraulic Conductivity = 300 feet/day, assumed from regional aquifer characteristics
- Aquifer Thickness = 300 feet, estimate from isopach map
- Aquifer Top = -100 feet mean sea level (msl), estimate from structure contour map
- Aquifer Bottom = -400 feet msl, estimate from structure contour map
- Aquifer Porosity = 0.3, assumed based on sand and gravel aquifer characteristics
- Longitudinal Dispersivity = 50 feet, assumed value
- Transverse Dispersivity = 5 feet, assumed value

Well pumping rates for all water supply wells in the simulation area were the average values for the past 3 months derived from daily pumping data provided by the operators to Louisiana Department of Natural Resources (LDNR). While the model code can simulate transient (time-varying) pumping rates, it was concluded from the pumping data that including transient pumping in the simulations would not substantially affect the results. Therefore steady-state pumping rates were used for the simulations.

Three scenarios were simulated in this evaluation:

- Simulation 1—assumed all water supply wells in the Napoleonville Salt Dome area were pumping including Texas Brine Company (TBC) Oxy WW#3 (state registration number 007-95), the well closest to the sinkhole.

- Simulation 2—assumed that all water supply wells in the Napoleonville Salt Dome area were pumping except Oxy WW#3.

- Simulation 3—assumed that all water supply wells in the Napoleonville Salt Dome area were pumping except Oxy WW#1 (state registration number 007-72), WW#2 (state registration number 007-73), and WW#3.

3.0 Results

The results of the three chloride transport model scenarios are presented on **Figures 1 through 6**. For each simulation, the regional groundwater levels during pumping are presented on the first figure and the particle tracks and chloride plume transport results are presented on a second figure.

- Simulation 1—As shown on **Figures 1 and 2**, when pumping, Oxy WW#3, in combination with Oxy WW#1 and Oxy WW#2 will contain chloride contaminant migration from the sinkhole area.

- Simulation 2—As shown on **Figures 3 and 4**, when Oxy WW#3 is not pumping, chloride migration from the immediate area of the sinkhole can be contained by operation of Oxy WW#1 and Oxy WW#2 but any chloride contamination north or south of the sinkhole may not be contained.

- Simulation 3—As shown on **Figures 5 and 6**, in absence of pumping in Oxy WW#1 through WW#3, the chloride will migrate to the water supply wells further to the east with Oxy WW#2B (state registration number 007-131) providing the majority of the hydraulic control.

4.0 Recommendations

It is uncertain how the TPH contamination is distributed in the MRAA in the vicinity of WW#3. Furthermore, the aquifer characteristics of the MRAAfor modeling TPH transport in the vicinity of WW#3 are not available. Therefore the following data are recommended to support TPH modeling to thereby allow for a final determination that operation of WW#3 can be done in a manner that will not further exacerbate the contamination associated with the sinkhole.

- Specific capacity tests should be conducted on WW#1, WW#2, and WW#3 to estimate MRAA transmissivity and hydraulic conductivity. A specific capacity test is conducted by measuring water levels before the well is turned on, water levels and flow rates (or totalizer flow meter readings) are recorded a maximum of 2 hour intervals for 12 hours. A recording pressure transducer is recommended so the entire drawdown curve can be defined but this is not mandatory. The data are then analyzed for transmissivity and hydraulic conductivity.

- During installation of the new monitor wells in the vicinity of WW#3, soil samples should be collected at the top, middle and bottom of the screened intervals in these monitor wells. These samples should be analyzed for fraction of organic carbon (foc) concentrations by the Walkey-Black method and for grain-size including hydrometer. PTS Laboratories in Santa Fe Springs, California is one lab that can run the required foc tests (http://www.ptslabs.com/). Any geotechnical lab can perform the grain-size tests. All data should be reported in Excel format.

- The pressure/water level monitoring wells should be slug tested using the pneumatic slug test methods to measure hydraulic conductivity. To perform these tests on the wells under gas pressure will require a small pressure control head with a control valve. Such a wellhead will also be required to collect water samples from the wells. The wellhead control configuration must be set up to protect the safety of the workers at all times.

Once these data are available, the chloride model can readily be updated with the new information, TPH modeling performed, and an operational configuration/monitoring program designed to allow WW#3 to be operated while protecting the environment.

References

Rumbaugh, J., and D. Rumbaugh, 2012, Aquifer32 including WINFLOW AND WINTRAN modules, Environmental Simulations, Inc.

Legend

Water Supply Well

Model Calculated Water Level Contour (ft msl)

Simulation Runs:

Simulation 1. All dome wells operational including Oxy WW#3.

Simulation 2. All dome wells operational except Oxy WW#3.

Simulation 3. All dome wells operational except Oxy WW#1, #2, and #3.

Note: Water level was calculated using WINFLOW/WINTRAN v. 4.06.

Hydraulic Gradient = 0.00002
Hydraulic Conductivity = 300 feet/day
Aquifer Thickness = 300 feet
Aquifer Top = -100 feet msl
Aquifer Bottom = -400 feet msl
Aquifer Porosity = 0.3
Longitudinal Dispersivity = 50 feet
Transverse Dispersivity = 5 feet

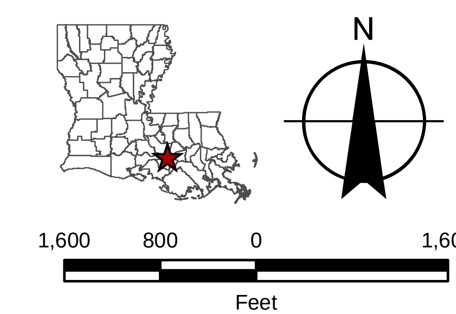

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FIGURE NUMBER 1	SIMULATION 1 WATER LEVELS

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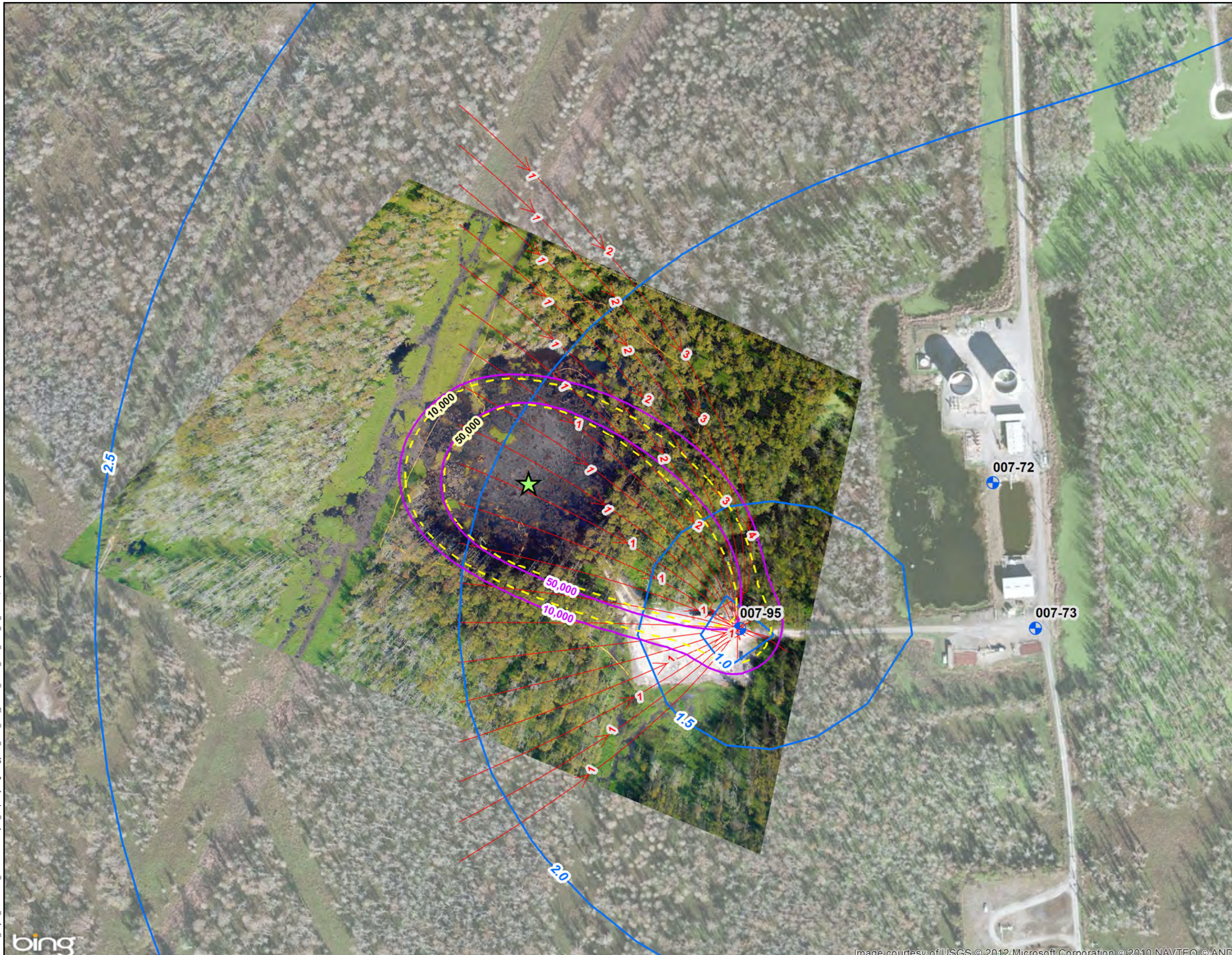
G:\LDNR_Bayou_Corne\GIS_Documents\Project_Maps\Hydrogeology\BC_HYD_004_water_level_run1_2012_11_07.mxd; Analyst: ben.holt; Date: 11/9/2012 9:06:46 AM



Legend

- Water Supply Well
- Chloride Concentration Year 1
- Chloride Concentration Year 5
- Particle Track with Time in Years
- Model Calculated Water Level Contour (ft msl)

Simulation Runs:

Simulation 1. All dome wells operational including Oxy WW#3.

Simulation 2. All dome wells operational except Oxy WW#3.

Simulation 3. All dome wells operational except Oxy WW#1, #2, and #3.

Note: Water level was calculated using WINFLOW/WINTRAN v. 4.06.

Hydraulic Gradient = 0.00002
Hydraulic Conductivity = 300 feet/day
Aquifer Thickness = 300 feet
Aquifer Top = -100 feet msl
Aquifer Bottom = -400 feet msl
Aquifer Porosity = 0.3
Longitudinal Dispersivity = 50 feet
Transverse Dispersivity = 5 feet

N

200 100 0 200

Feet

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FIGURE NUMBER 2

SIMULATION 1 CONCENTRATIONS AND PARTICLE TRACKS

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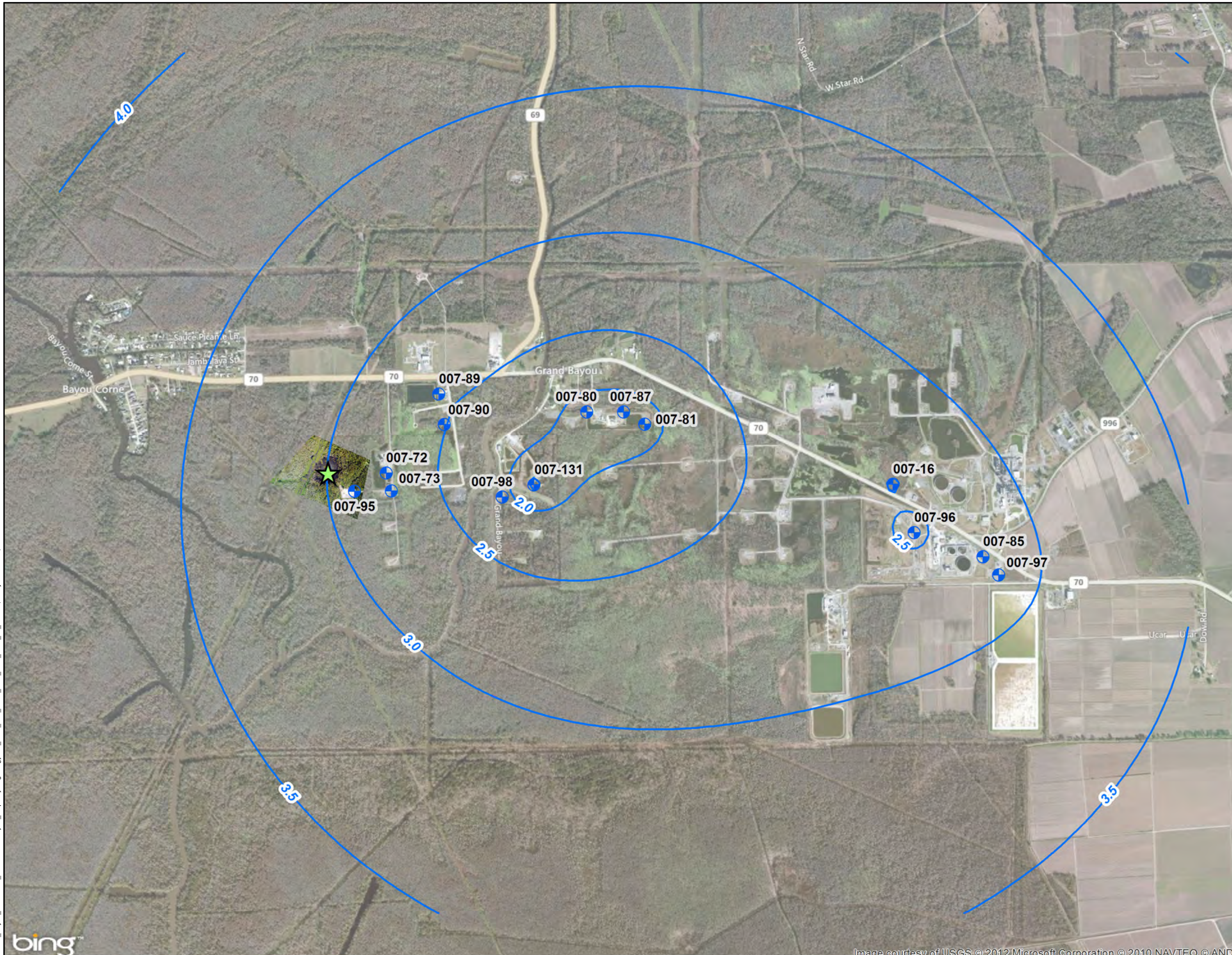
G:\LDNR_Bayou_Corne\GIS_Documents\Project_Maps\Hydrogeology\BC_HYD_001_particle_tracks_run1_2012_11_07.mxd; Analyst: ben.holt; Date: 11/9/2012 9:10:18 AM



Legend

Water Supply Well

Model Calculated Water Level Contour (ft msl)

Simulation Runs:

Simulation 1. All dome wells operational including Oxy WW#3.

Simulation 2. All dome wells operational except Oxy WW#3.

Simulation 3. All dome wells operational except Oxy WW#1, #2, and #3.

Note: Water level was calculated using WINFLOW/WINTRAN v. 4.06.

Hydraulic Gradient = 0.00002
Hydraulic Conductivity = 300 feet/day
Aquifer Thickness = 300 feet
Aquifer Top = -100 feet msl
Aquifer Bottom = -400 feet msl
Aquifer Porosity = 0.3
Longitudinal Dispersivity = 50 feet
Transverse Dispersivity = 5 feet

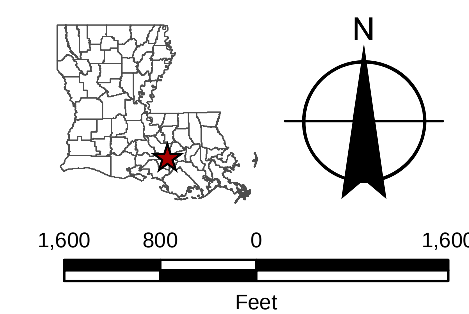


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FIGURE NUMBER 3

SIMULATION 2 WATER LEVELS

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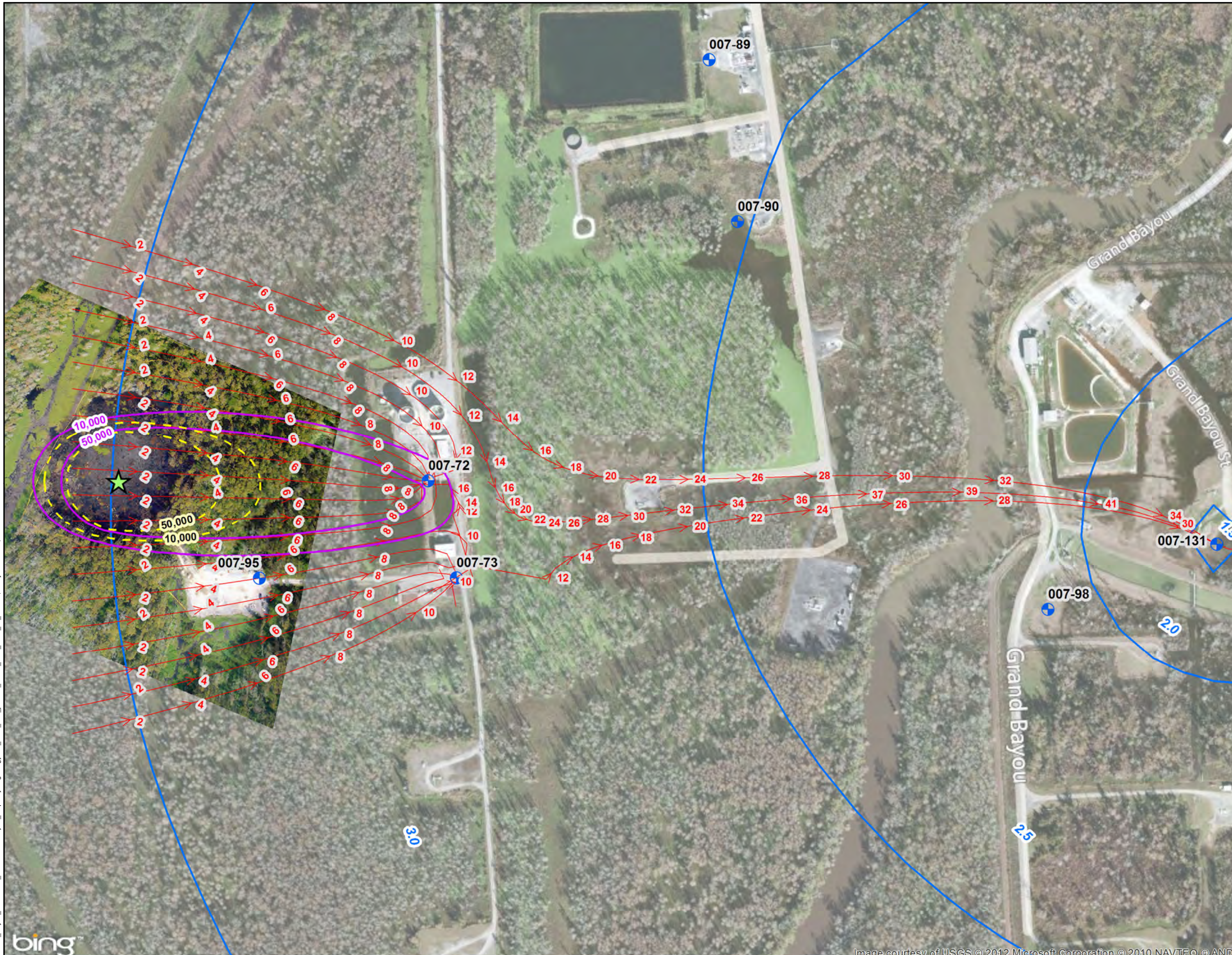
G:\LDNR_Bayou_Corne\GIS_Documents\Project_Maps\Hydrogeology\BC_HYD_005_water_level_run2_2012_11_07.mxd; Analyst: ben.holt; Date: 11/9/2012 9:27:16 AM



Legend

- Water Supply Well
- Chloride Concentration Year 1
- Chloride Concentration Year 5
- Particle Track with Time in Years
- Model Calculated Water Level Contour (ft msl)

Simulation Runs:

Simulation 1. All dome wells operational including Oxy WW#3.

Simulation 2. All dome wells operational except Oxy WW#3.

Simulation 3. All dome wells operational except Oxy WW#1, #2, and #3.

Note: Water level was calculated using WINFLOW/WINTRAN v. 4.06.

Hydraulic Gradient = 0.00002
Hydraulic Conductivity = 300 feet/day
Aquifer Thickness = 300 feet
Aquifer Top = -100 feet msl
Aquifer Bottom = -400 feet msl
Aquifer Porosity = 0.3
Longitudinal Dispersivity = 50 feet
Transverse Dispersivity = 5 feet

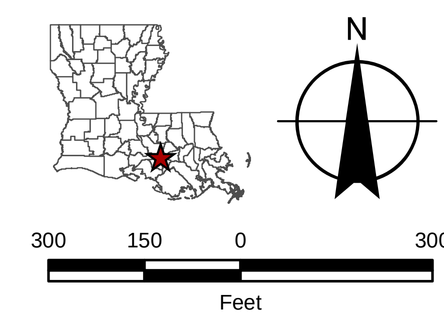


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FIGURE NUMBER 4

SIMULATION 2 CONCENTRATIONS AND PARTICLE TRACKS

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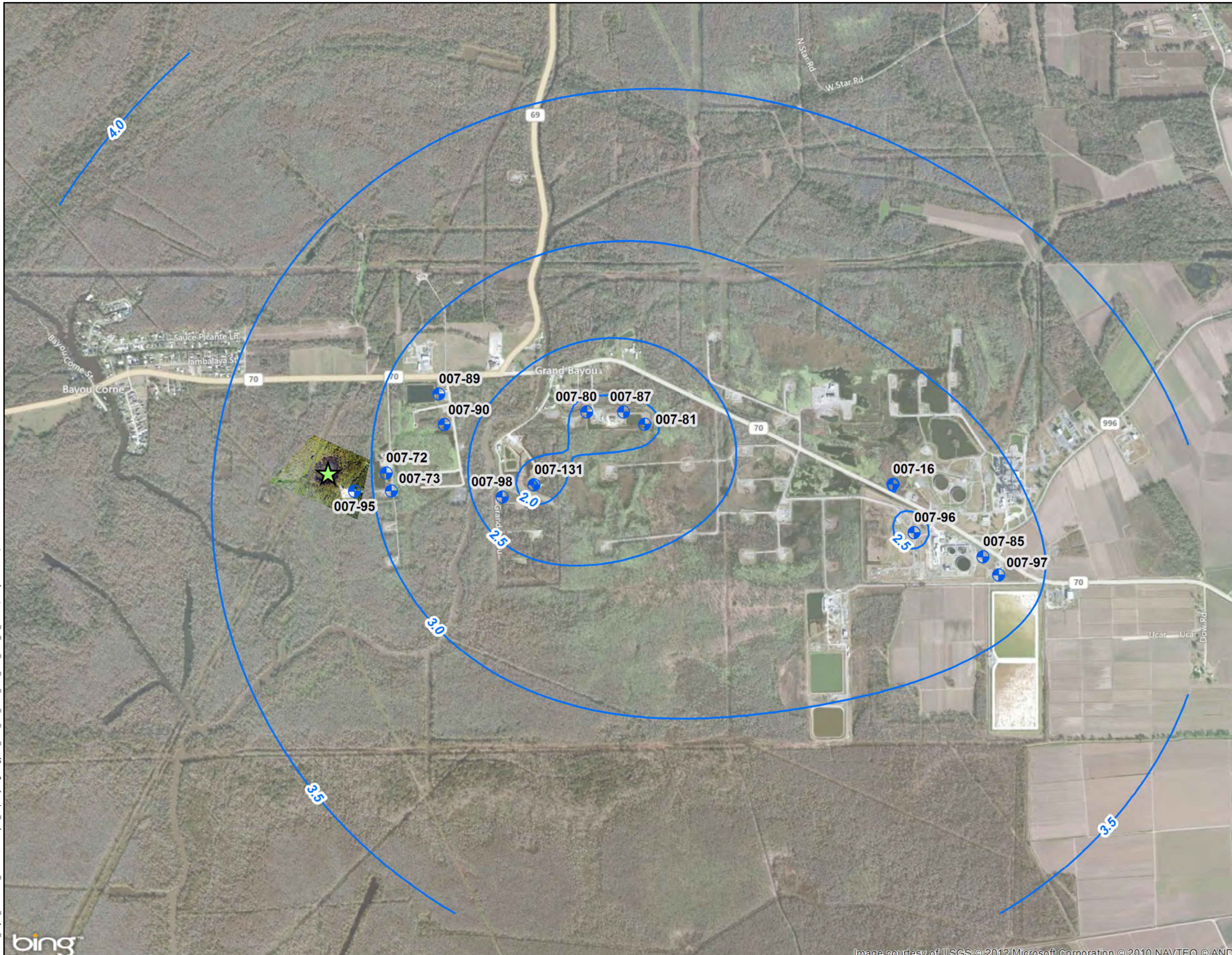

Legend

Water Supply Well

Model Calculated Water Level Contour (ft msl)

Simulation Runs:

Simulation 1. All dome wells operational including Oxy WW#3.

Simulation 2. All dome wells operational except Oxy WW#3.

Simulation 3. All dome wells operational except Oxy WW#1, #2, and #3.

Note: Water level was calculated using WINFLOW/WINTRAN v. 4.06.

Hydraulic Gradient = 0.00002
Hydraulic Conductivity = 300 feet/day
Aquifer Thickness = 300 feet
Aquifer Top = -100 feet msl
Aquifer Bottom = -400 feet msl
Aquifer Porosity = 0.3
Longitudinal Dispersivity = 50 feet
Transverse Dispersivity = 5 feet

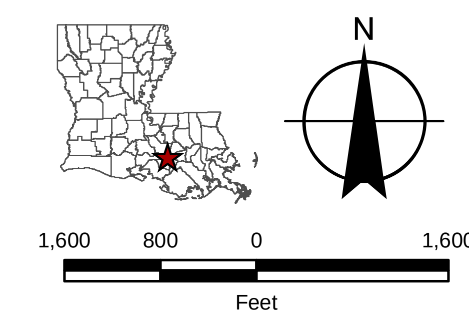

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FIGURE NUMBER 5

SIMULATION 3 WATER LEVELS

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G:\LDNR_Bayou_Corne\GIS_Documents\Project_Maps\Hydrogeology\BC_HYD_006_water_level_run3_2012_11_07.mxd; Analyst: ben.holt; Date: 11/9/2012 9:29:20 AM

Legend

- Water Supply Well
- Chloride Concentration Year 1
- Chloride Concentration Year 5
- Particle Track with Time in Years
- Model Calculated Water Level Contour (ft msl)

Simulation Runs:

Simulation 1. All dome wells operational including Oxy WW#3.

Simulation 2. All dome wells operational except Oxy WW#3.

Simulation 3. All dome wells operational except Oxy WW#1, #2, and #3.

Note: Water level was calculated using WINFLOW/WINTRAN v. 4.06.

Hydraulic Gradient = 0.00002
Hydraulic Conductivity = 300 feet/day
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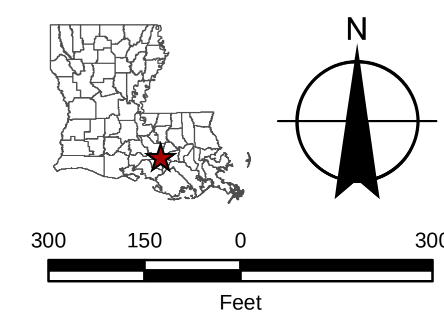

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FIGURE NUMBER	
6	**SIMULATION 3 CONCENTRATIONS AND PARTICLE TRACKS**

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