C-HS1 Monitoring
Final Site Summary and Close-out Report

1.0 Background

Task C of the Florida Onsite Sewage Nitrogen Reduction Strategies Study includes monitoring at field sites in Florida to evaluate nitrogen reduction in soil and groundwater, to assess groundwater impacts from various onsite wastewater systems, and to provide data for parameter estimation, verification, and validation of models developed in Task D. The Task C.5 QAPP documents the objectives, monitoring framework, sample frequency and duration, and analytical methods to be used at the field sites. The Task C.23 Instrumentation of Wakulla County Home Site C-HS1 progress report dated June 2011 documents the test area design, number and location of monitoring points, and preliminary field parameters from monitoring points for this field site. One sample event was conducted May 19 and 20, 2011 and is documented in the Task C.24 C-HS1 Sample Event Report No. 1 dated June 2011. The results documented in the Task C.25 C-HS1 Data Summary Report No. 1 dated June 2011 led to the recommendation to abandon this site.

2.0 Purpose

This report documents the close-out of site C-HS1 including: description of the removal of monitoring points, summarization of the data collected during site instrumentation, and analysis of the first and only sample event conducted May 19 through 20, 2011. The corresponding sample event report was submitted as C-HS1 Sample Event Report No. 1 dated June 2011, as a deliverable under Task C.24. The monitoring event consisted of measurement of household water meters, groundwater elevation measured within the standpipe piezometers, measurement of field parameters, and collection of effluent and groundwater samples and their analyses in a NELAC certified laboratory. The results of this sampling event were reported in the Task C.25 C-HS1 Data Summary report No. 1 dated June 2011.

3.0 Site and Monitoring Network Description

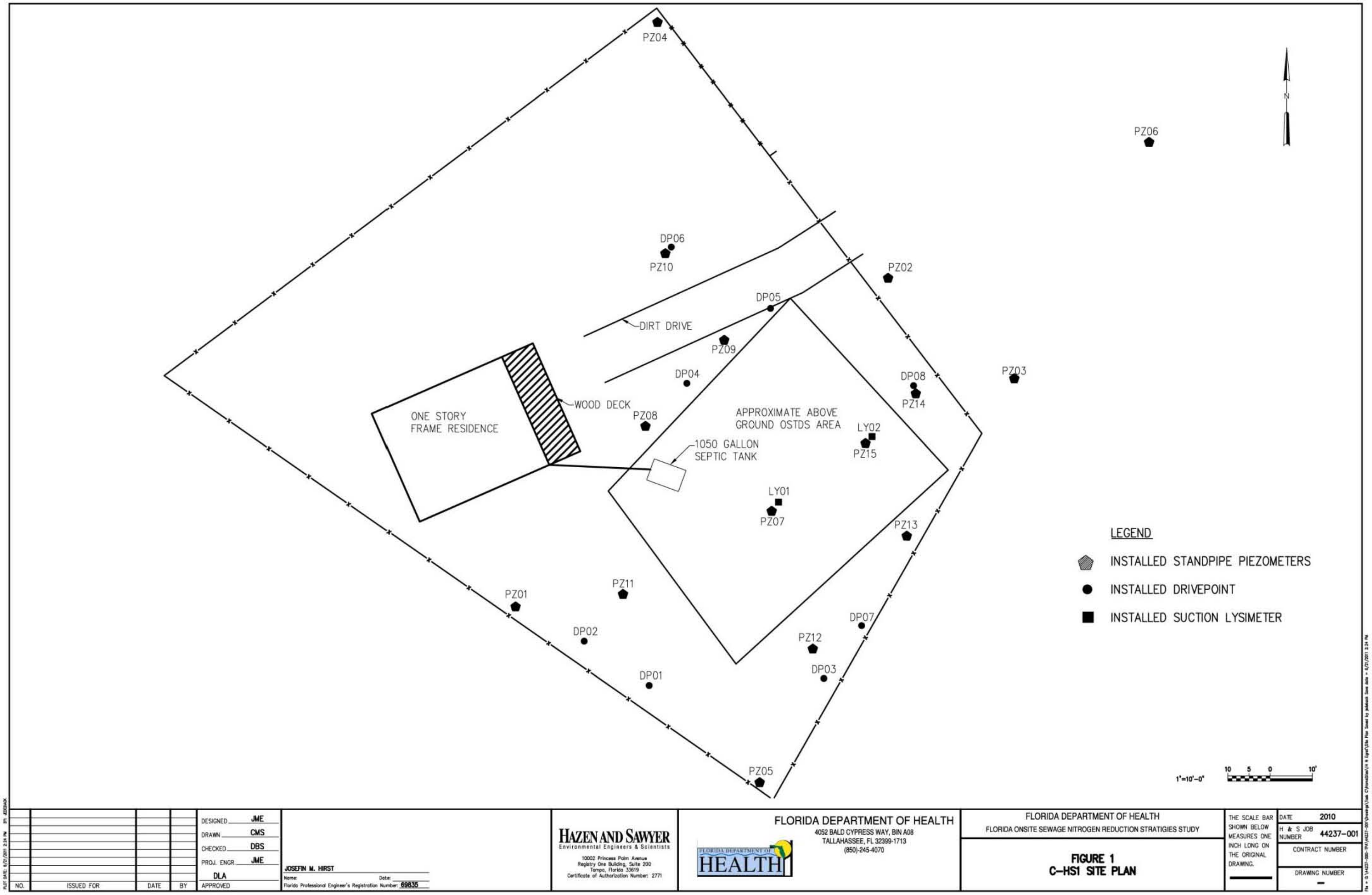
3.1 Project Site

The C-HS1 field site is located in Wakulla County, FL in a neighborhood near the Wakulla River. The drainfield mound at the site contains two drainfields. One drainfield serves the residence onsite and the second drainfield is part of the septic system for the house across the street which is located adjacent to the Wakulla River. The septic system for the residence onsite consists of a standard baffled septic tank located in the mound and has a gravity fed plastic tubing industries (PTI) multi-pipe bed drainfield. The septic system for the house across the dirt road has a standard baffled tank and a pump tank used to pump the effluent under the road to a separate PTI bed drainfield. Except for the drainfield mound, the house, and a small garden, the site is wooded and heavily vegetated.

3.2 Monitoring and Sampling Locations and Identification

A schematic of the site monitoring network is shown in Figure 1. Three types of monitoring points were installed: drive point samplers, standpipe piezometers, and soil lysimeters (refer to the Task C QAPP and Task C.23 C-HS1 Instrumentation Report for additional detail). Each groundwater monitoring location has been assigned a unique identification indicating the type of monitoring point (DP = drive point, PZ = standpipe piezometer, LY = soil lysimeter). Drive point samplers consist of a stainless steel drive tip and attached 1-inch long screen connected to flexible tubing that extends to the ground surface. Standpipe piezometers consist of a 5 foot in length, ¾ inch diameter PVC screen with a PVC riser extending to the ground surface. The two soil lysimeters have a 9 inch ceramic cup attached to 2 inch PVC pipe with a cap fitted with two valves.

Figure 1
CHS-1 Monitoring Network



4.0 Site Close-out

Since no modifications were made to the shared drainfield mound or septic systems of either residence, the site close-out consisted of the removal of all the monitoring points and restoring the site to its original configuration. A total of 25 specific monitoring points were removed during the site close-out conducted January 29, 2013 and January 31, 2013. Table 1 lists the monitoring points that were removed. Appendix A contains an acceptance of site restoration signed by the homeowner.

Table 1
Site C-HS1 Monitoring Points Removed

	ID	Type of Monitoring Point	Surface Elev (ft)	Bottom Elev (ft)	Depth Below Ground (ft)
1	DP-01	1” SST Drive Point	96.30	87.05	9.25
2	DP-02	1” SST Drive Point	95.61	86.71	8.90
3	DP-03	1” SST Drive Point	96.33	86.49	9.84
4	DP-04	1” SST Drive Point	96.32	85.71	10.61
5	DP-05	1” SST Drive Point	96.25	86.70	9.55
6	DP-06	1” SST Drive Point	96.05	87.35	8.70
7	DP-07	1” SST Drive Point	96.24	90.14	6.10
8	DP-08	1” SST Drive Point	97.41	89.89	7.52
9	PZ-01	3/4" Standpipe Piezometer, 5’ screen	95.73	85.11	10.62
10	PZ-02	3/4" Standpipe Piezometer, 5’ screen	96.17	86.99	9.18
11	PZ-03	3/4" Standpipe Piezometer, 5’ screen	96.54	88.66	7.88
12	PZ-04	3/4" Standpipe Piezometer, 5’ screen	95.77	85.76	10.01
13	PZ-05	3/4" Standpipe Piezometer, 5’ screen	96.06	87.99	8.07
14	PZ-06	3/4" Standpipe Piezometer, 5’ screen	95.57	90.26	5.31
15	PZ-07	3/4" Standpipe Piezometer, 5’ screen	99.84	87.22	12.62
16	PZ-08	3/4" Standpipe Piezometer, 5’ screen	95.91	89.69	6.22
17	PZ-09	3/4" Standpipe Piezometer, 5’ screen	96.33	86.73	9.6
18	PZ-10	3/4" Standpipe Piezometer, 5’ screen	95.97	88.80	7.17
19	PZ-11	3/4" Standpipe Piezometer, 5’ screen	97.17	85.27	11.9
20	PZ-12	3/4" Standpipe Piezometer, 5’ screen	96.36	87.93	8.43
21	PZ-13	3/4" Standpipe Piezometer, 5’ screen	97.15	89.44	7.71
22	PZ-14	3/4" Standpipe Piezometer, 5’ screen	97.31	89.84	7.47
23	PZ-15	3/4" Standpipe Piezometer, 5’ screen	99.79	86.73	13.06
24	LY-01	Soil Lysimeter	99.84	≈93.84	~6
25	LY-02	Soil Lysimeter	99.79	≈93.79	~6

Piezometers and drive points were protected by 6 inch irrigation covers, which were dug up and removed. Many of the piezometers were shallow enough to be simply pulled out of the ground by hand. The deeper piezometers were removed by using a hand auger to dig a hole next to the piezometer to a depth that allowed for manual removal. The two lysimeters were removed in a similar manner.

The drive points were more difficult to retrieve, and therefore abandoned in place. At first, pulling the drive point out of the ground by the tubing was attempted. However, this caused the tubing to stretch and eventually break off at a location below the ground surface. To remove as much of the tubing as possible, a hand auger was used when feasible to dig adjacent to the drive point tubing before pulling the tubing out of the ground. None of the drive points were recovered, because the tubing either came off at the connection end of the drive point or the tubing broke below the ground surface. All holes were filled using native soil.

5.0 Data Summary

Sample collection materials and methods are described in both the Task C.24 C-HS1 Sample Event Report No. 1 dated June 2011 and the Task C.25 C-HS1 Data Summary Report No. 1 dated June 2011.

5.1 Household Water Usage

Table 2 summarizes the water meter readings and average daily water use for the residence at site C-HS1 and the second residence which has a drainfield in the same drainfield mound at site C-HS1.

Table 2
Water Meter Readings and Water Usage for C-HS1

Residence	Date and Time Read	Meter Reading	Gallons/day
C-HS1 Residence	4/27/2011 16:30	692,569.7	
	5/20/2011 16:15	695,923.1	145.9
Neighboring Residence	4/27/2011 15:55	663,669.6	
	5/20/2011 16:15	666,348.5	116.4

5.2 Groundwater Levels

Table 3 summarizes the groundwater levels as measured in the standpipe piezometers during the November 2010, April 2011, and May 2011 site visits. Groundwater levels were measured using a flat tape water level meter graduated in feet (measurement accuracy is 0.01 ft). Elevations are relative to a benchmark onsite and not mean sea level.

Table 3

Installed Piezometer and Groundwater Elevations

ID	Bottom Elevation (ft)	GW Elevation Nov 4, 2010 (ft)	GW Elevation April 27, 2011 (ft)	GW Elevation April 29, 2011 (ft)	GW Elevation May 19, 2011 (ft)
PZ-01	85.11	90.77	91.92	92.59	91.26
PZ-02	86.99	91.10	91.97	92.41	91.46
PZ-03	88.66	91.00	92.01	92.46	91.39
PZ-04	85.76	91.23	92.14	92.75	91.64
PZ-05	87.99	90.46	91.82	92.31	91.09
PZ-06	90.26	90.86	91.69	92.26	91.08
PZ-07	87.22	Not installed	91.97	92.34	91.42
PZ-08	89.69	Not installed	Not installed	Not installed	91.43
PZ-09	86.73	Not installed	Not installed	Not installed	91.47
PZ-10	88.80	Not installed	Not installed	Not installed	91.41
PZ-11	85.27	Not installed	Not installed	Not installed	91.33
PZ-12	87.93	Not installed	Not installed	Not installed	91.18
PZ-13	89.44	Not installed	Not installed	Not installed	91.30
PZ-14	89.84	Not installed	Not installed	Not installed	91.76
PZ-15	86.73	Not installed	Not installed	Not installed	91.43

The groundwater elevations were found to fluctuate due to periods of dry weather and/or heavy precipitation; however, the general flow direction trend to the southeast appears to not change. The data indicates that the direction of the groundwater is somewhat influenced by a change in height of the water table or the Wakulla River. In November 2010, PZ-01 was 0.33 ft lower in elevation than PZ-02, indicating that the groundwater was flowing towards PZ-01. On April 27, 2011, the groundwater was higher and the gradient between PZ-01 and PZ-02 was flat, with the difference in groundwater elevation of the two piezometers being 0.05 ft. On April 28th, a heavy rain fell, significantly raising the groundwater when measured April 29th. On April 29th, the elevation in PZ-01 was 0.18 feet higher than PZ-02 indicating that the groundwater was flowing east towards the river. In May 2011, a relatively dry period, the elevation in PZ-01 was again 0.2 ft lower in elevation than PZ-02. The groundwater contours on these different dates are illustrated in Figures 2 through 5.

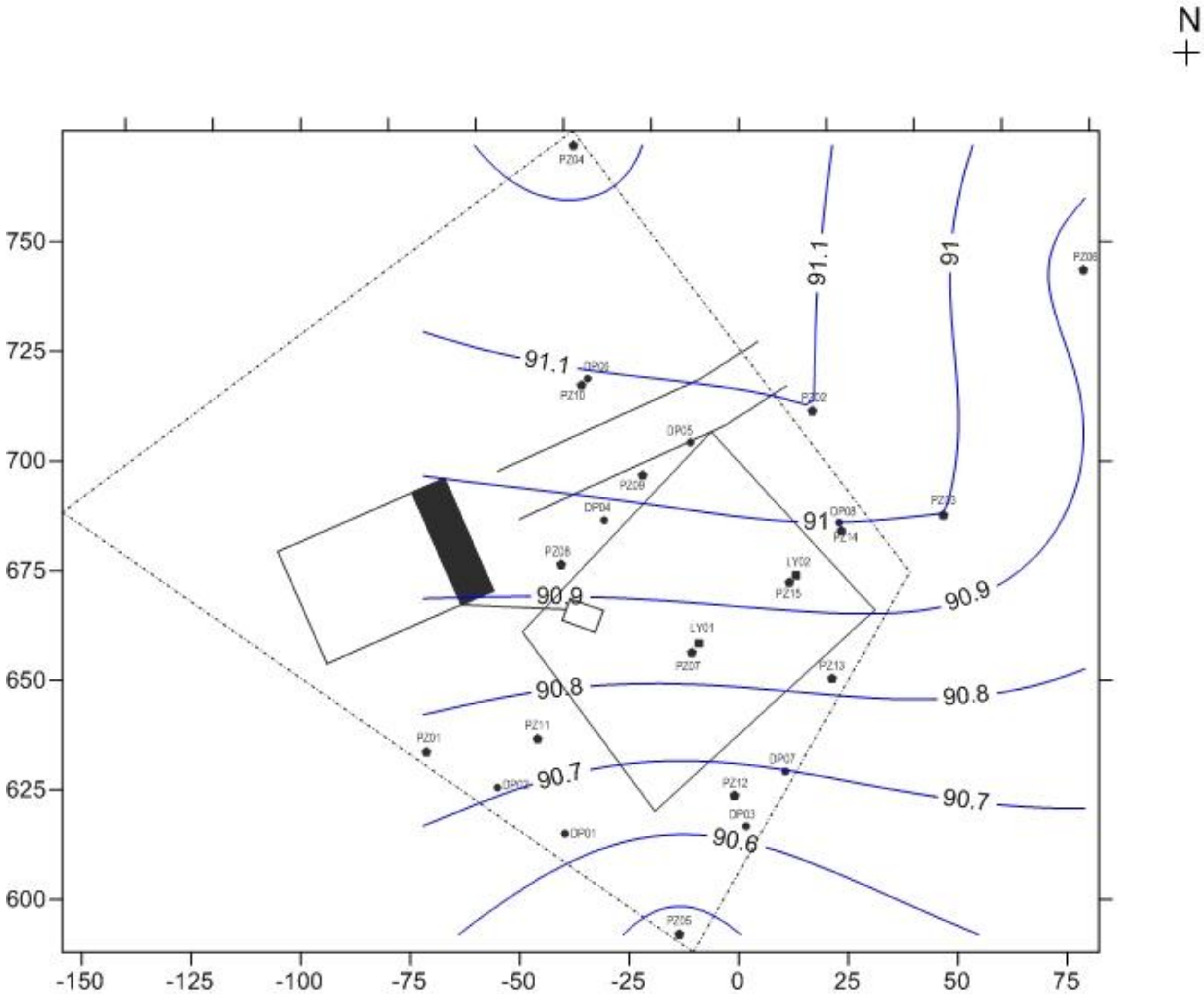


Figure 2
Surficial Groundwater Contours November 4, 2010

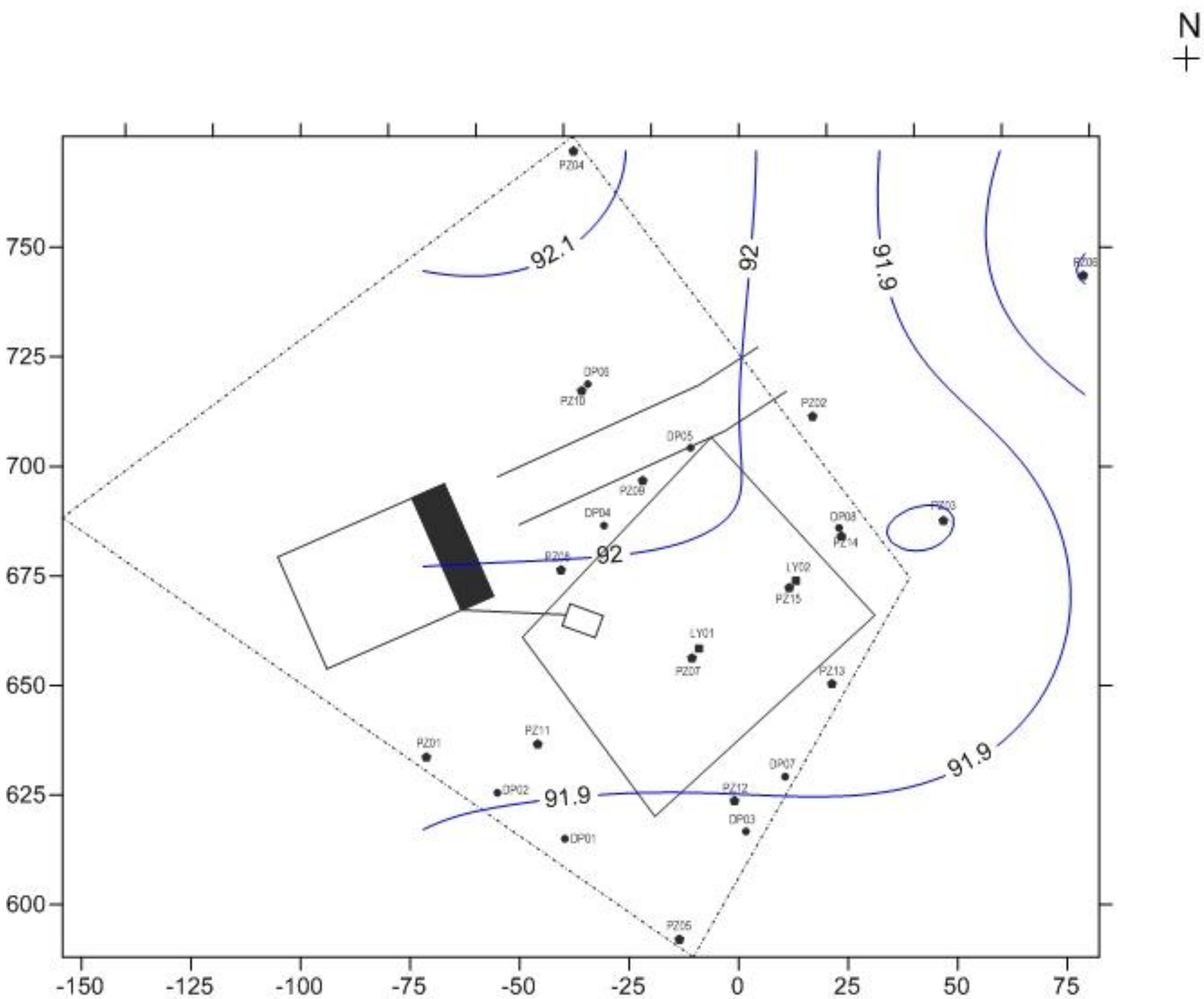


Figure 3
Surficial Groundwater Contours April 27, 2011

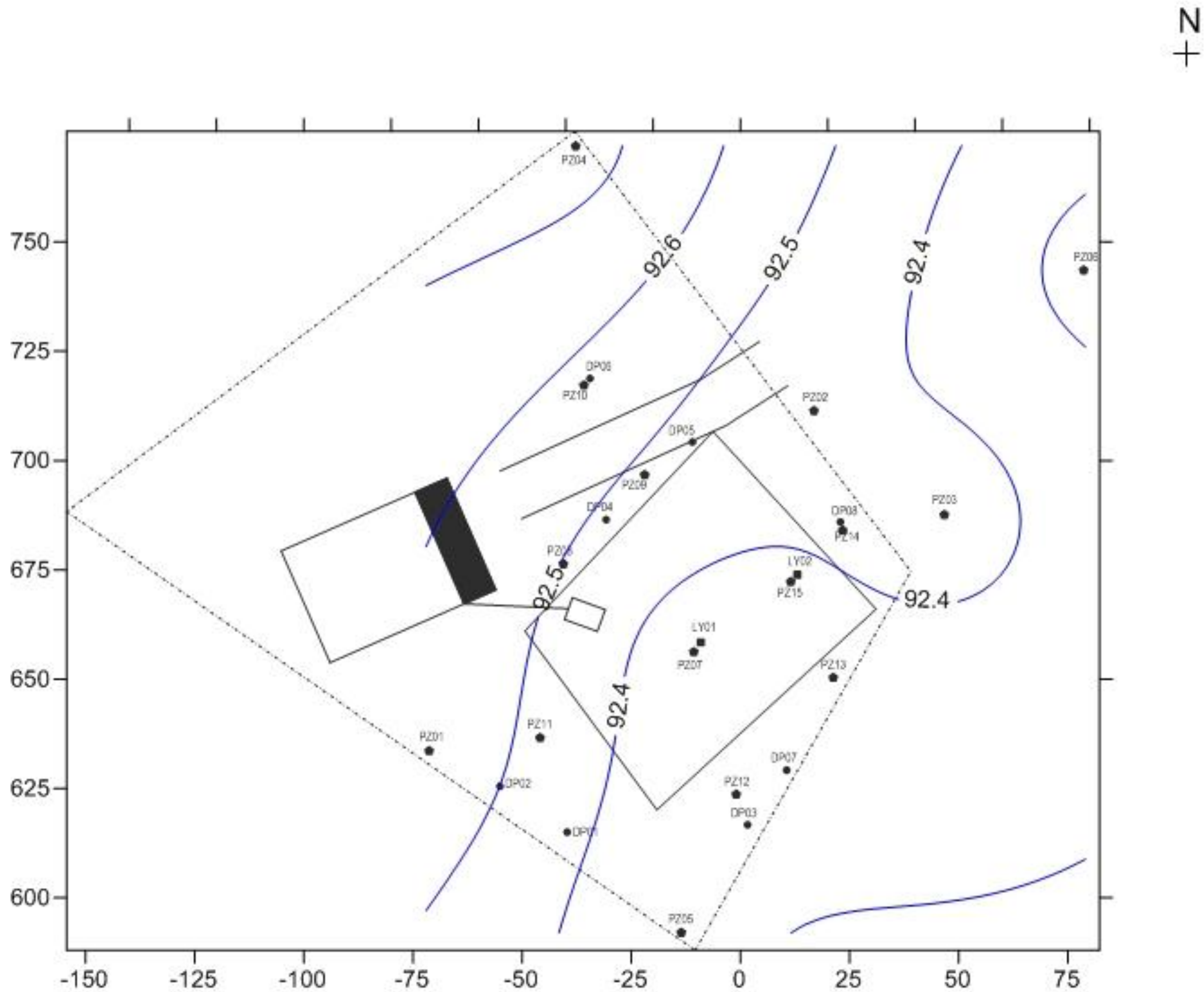


Figure 4
Surficial Groundwater Contours April 29, 2011

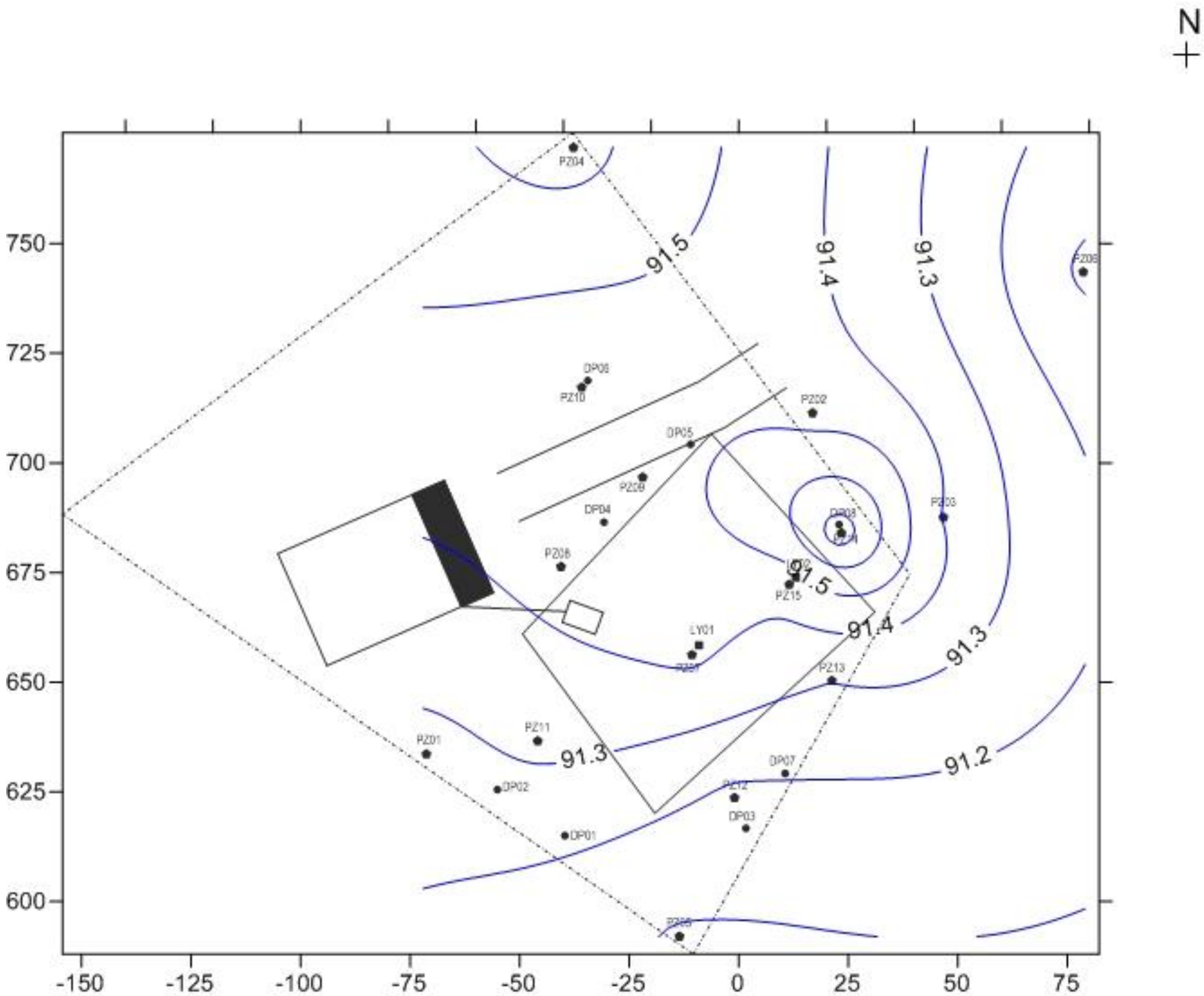


Figure 5
Surficial Groundwater Contours May 19, 2011

5.3 Water Quality Analyses

5.3.1 Field Parameters

The specific conductance, pH, and temperature of the groundwater at the standpipe piezometer and drive point locations were measured and recorded on April 29, 2011 and May 19 through 20, 2011. In April 2011, nitrogen measurements were taken using nitrate and nitrite HACH test strips and recorded. In May 2011, dissolved oxygen (DO) was also measured in addition to specific conductance, pH and temperature. Tables 4 and 5 outline the STE and groundwater field parameter measurements recorded for the STE, standpipe piezometer, drive point and lysimeters locations in April 2011 and May 2011, respectively.

Table 4
Field Parameter Measurements April 29, 2011

Sample ID	Temp (°C)	pH	Conductivity (µS)	Est. NO_2 test strip mg/L	Est. NO_3 test strip mg/L
STE	21.6	7.03	1,542	NR	NR
DP-01	20.0	6.54	946	0	0
DP-02	19.8	6.41	876	0	0
DP-03	19.9	6.62	1,040	0	0
DP-04	19.2	6.83	678	0	0
DP-05	19.3	6.59	907	0	0
DP-06	19.2	6.62	1,061	0	0
DP-07	18.8	6.52	911	0	0
DP-08	20.1	7.01	794	0	0
PZ-01	20.2	5.87	118	0	0
PZ-02	19.4	6.68	595	0	0
PZ-03	19.4	6.6	457	0	0
PZ-04	24.3	6.67	558	0	0
PZ-05	19.6	6.57	673	0	0
PZ-06	20.1	6.79	757	0	0
PZ-07	19.3	6.64	1,173	0.3	40

NR=no reading

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Table 5
Field Parameter Measurements
May 19-20, 2011

	Sample	Temp (°C)	pH	Dissolved Oxygen (mg/L)	Conductivity (µS)
1	STE	22.3	7.20	1.36	1,367
2	DP-01	18.6	6.60	0.84	845
3	DP-02	18.7	6.60	0.56	770
4	DP-03	18.6	6.60	0.44	868
5	DP-04	18.8	7.10	0.38	570
6	DP-05	20.6	7.10	1.50	830
7	DP-06	19.2	7.00	0.49	926
8	DP-07	18.9	6.60	0.46	813
9	DP-08	Dry			
10	PZ-01	18.9	5.83	0.71	75
11	PZ-02	19.2	7.10	3.02	516
12	PZ-03	19.0	7.10	1.95	500
13	PZ-04	19.2	7.20	1.45	484
14	PZ-05	18.8	6.60	2.58	752
15	PZ-06	21.3	7.29	6.86*	580
16	PZ-07	19.6	6.50	1.04	999
17	PZ-08	Not fast enough recharge for sample			
18	PZ-09	19.1	7.10	0.56	665
19	PZ-10	19.5	7.10	0.58	674
20	PZ-11	18.8	6.69	0.43	913
21	PZ-12	19.0	6.60	0.78	933
22	PZ-13	18.9	6.12	1.49	692
23	PZ-14	Not fast enough recharge for sample			
24	PZ-15	22.6	6.51	1.48	842
25	LY-01	21.6	6.42	4.57	788
26	LY-02	24.2	6.34	1.95	1,433

*Note: Bubbles were present in the sampling tube in PZ-06 due to low volume in the well, most likely elevating the dissolved oxygen reading.

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During the April sampling, PZ-07, which is installed in the mound near the downgradient end of the C-HS1 residence drainfield, was the only monitoring point that indicated NOx presence using the test strips. In both April and May, PZ-01 measured significantly lower conductivity (118 and 75 µS, respectively) than all the other drive points and piezometers. Figures 6 and 7 show the specific conductance contours of the concentrations as estimated using the Kriging method in Surfer™. The specific conductance concentrations show some movement similar to the groundwater contours. Based on the groundwater specific conductivity and pH measurements recorded, the general plume appears to extend to the southeast with the highest conductivity and pH measurements in the mound.

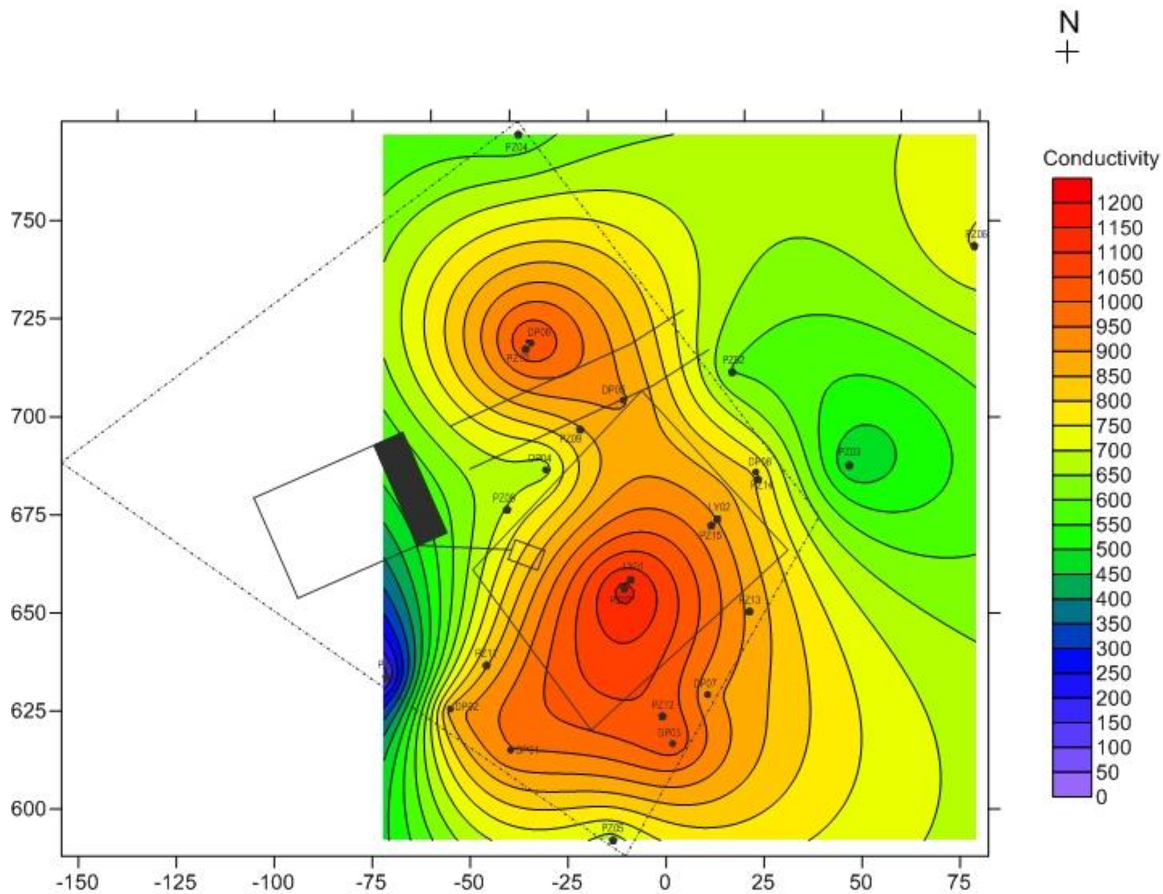

Figure 6
Specific Conductance Contours April 29, 2011

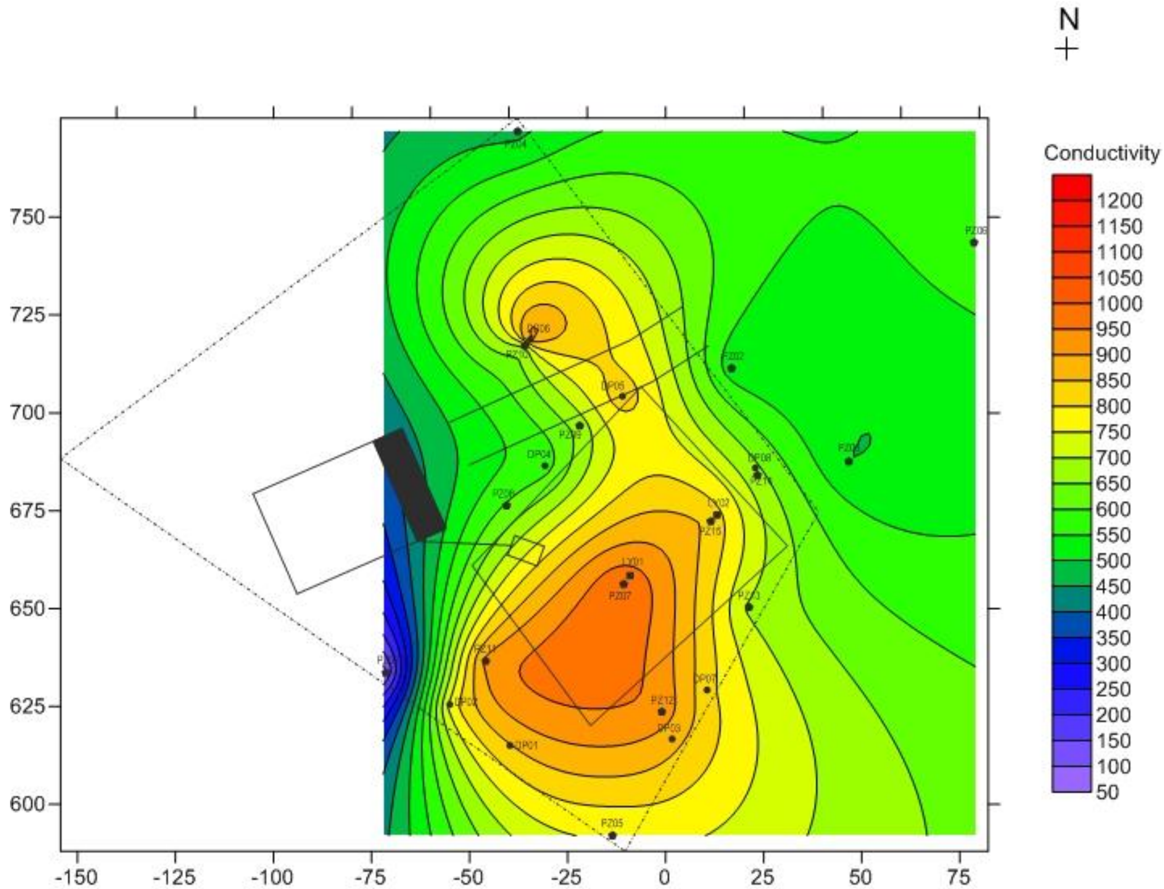

Figure 7
Specific Conductance Contours May 19 - 20, 2011

5.3.2 Analytical Parameters

In addition to measuring field parameters, all groundwater samples were analyzed for total alkalinity (as $CaCO_3$), chemical oxygen demand (COD), total Kjeldahl nitrogen (TKN-N), ammonia nitrogen (NH3-N), nitrate/nitrite nitrogen (NOX-N), and total phosphorus (TP). The STE sample was analyzed for all the above parameters, however carbonaceous biochemical oxygen demand ($CBOD_5$) was analyzed instead of COD, and total suspended solids (TSS) analysis was included. The water quality analytical results for Sample Event No. 1 conducted May 19-20, 2011 are listed in Table 6.

Table 6
Water Quality Analytical Results (May 19 and 20, 2011

Sample ID	Sample Date	Sample Time	Temp (°C)	pH	Specific Conductance (µS)	DO (mg/L)	Total Alkalinity (mg/L)	TSS (mg/L)	$CBOD_5$ (mg/L)	COD (mg/L)	TN (mg/L N)[1]	TKN (mg/L N)	Organic N (mg/L N)[2]	NH_3-N (mg/L N)	NOx (mg/L N)	TIN (mg/L N)[3]	TP (mg-P/L)	TS % by Wt.
STE Sample																		
C-HS1-STE	05/19/11	12:45	22.3	7.20	1367	1.36	610	89	92		110.16	110	17.00	93	0.16	93.16	30	0.07
Drive Points																		
C-HS1-DP01	05/20/11	10:36	18.6	6.60	845	0.84	390			55	0.82	0.81	0.58	0.23	0.01	0.24	0.055	
C-HS1-DP02	05/20/11	10:22	18.7	6.60	770	0.56	370			26	0.87	0.86	0.68	0.18	0.01	0.19	0.042	
C-HS1-DP03	05/20/11	12:38	18.6	6.60	868	0.44	420			22	0.58	0.57	0.43	0.14	0.01	0.15	0.15	
C-HS1-DP03-D	05/20/11	12:40	18.6	6.60	868	0.44	430			18	0.60	0.59	0.47	0.12	0.01	0.13	0.17	
C-HS1-DP04	05/19/11	17:30	18.8	7.10	570	0.38	280			65	0.82	0.77	0.66	0.11	0.05	0.16	0.16	
C-HS1-DP05	05/19/11	18:26	20.6	7.10	830	1.50	360			22	0.84	0.81	0.75	0.06	0.03	0.09	0.022	
C-HS1-DP06	05/19/11	16:54	19.2	7.00	926	0.49	370			69	2.21	2.2	2.07	0.13	0.01	0.14	0.22	
C-HS1-DP07	05/20/11	12:55	18.9	6.60	813	0.46	360			18	0.63	0.62	0.53	0.094	0.01	0.10	0.058	
Piezometers																		
C-HS1-PZ01	05/20/11	10:11	18.9	5.83	75	0.71	33			32	1.64	1.5	1.38	0.12	0.14	0.26	0.17	
C-HS1-PZ01-D	05/20/11	10:09	18.9	5.83	75	0.71	33			51	1.54	1.4	1.28	0.12	0.14	0.26	0.15	
C-HS1-PZ02	05/19/11	15:39	19.2	7.10	516	3.02	240			10	0.45	0.44	0.36	0.076	0.01	0.09	0.15	
C-HS1-PZ03	05/19/11	15:06	19.0	7.10	500	1.95	270			10	0.81	0.8	0.59	0.21	0.01	0.22	0.081	
C-HS1-PZ04	05/19/11	16:11	19.2	7.20	484	1.45	290			10	0.86	0.85	0.74	0.11	0.01	0.12	0.084	
C-HS1-PZ05	05/20/11	11:00	18.8	6.60	752	2.58	380			24	1.01	1	1.00	0.005	0.01	0.02	0.071	
C-HS1-PZ06	05/19/11	14:37	21.3	7.29	580	6.86	300			10	10.13	0.43	0.42	0.01	9.7	9.71	0.026	
C-HS1-PZ07	05/20/11	15:26	19.6	6.50	999	1.04	320			10	36.60	2.6	2.60	0.005	34	34.01	0.2	
C-HS1-PZ07-D	05/20/11	15:30	19.6	6.50	999	1.04	320			10	36.60	2.6	2.60	0.005	34	34.01	0.21	
C-HS1-PZ09	05/19/11	17:58	19.1	7.10	665	0.56	300			10	1.41	1.4	1.15	0.25	0.01	0.26	0.031	
C-HS1-PZ10	05/19/11	16:39	19.5	7.10	674	0.58	320			10	1.87	1	0.98	0.02	0.87	0.89	0.010	
C-HS1-PZ11	05/20/11	11:38	18.8	6.69	913	0.43	380			10	3.90	2.8	2.21	0.59	1.1	1.69	0.042	
C-HS1-PZ12	05/20/11	12:18	19.0	6.60	933	0.78	380			10	6.90	2.4	2.28	0.12	4.5	4.62	0.15	
C-HS1-PZ13	05/20/11	13:29	18.9	6.12	692	1.49	130			63	3.30	3.2	2.99	0.21	0.1	0.31	0.6	
C-HS1-PZ15	05/20/11	15:40	22.6	6.51	842	1.48	390			24	1.28	0.78	0.65	0.13	0.5	0.63	0.56	
Lysimeters																		
C-HS1-LY01	05/20/11	14:40	21.6	6.42	788	4.57	140			26	7.67	0.47	0.40	0.067	7.2	7.27	1.6	
C-HS1-LY02	05/20/11	14:18	24.2	6.34	1433	1.95	270			22	4.31	0.71	0.71	0.005	3.6	3.61	31	

Notes:

[1]Total Nitrogen (TN) is a calculated value equal to the sum of TKN and NO_X.

[2]Organic Nitrogen (ON) is a calculated value equal to the difference of TKN and NH_3.

[3]Total Inorganic Nitrogen (TIN) is a calculated value equal to the sum of NH_3 and NO_X.

Gray - Shaded data points indicate values below method detection level (mdl), mdl value used for statistical analyses.

Yellow shaded data points indicate the reported value is between the laboratory method detection limit and the laboratory practical quantitation limit.

Held beyond hold time

Sample had bubbles while pumping

5.3.3 Nitrate/Nitrite Concentrations

Based on the one sampling event, the general trend of the nitrogen plume at the site can be somewhat determined. The concentrations of NOX at all locations that groundwater sample was obtained are illustrated in Figure 8. The map shows contours of the NOX concentrations as estimated using the Kriging method in Surfer™. As is evident, an overall trend is visible. The highest concentration of NOX (Figure 8) and specific conductance (Figure 7) is close to the center of the mound with a maximum concentration in PZ-07. Surrounding the mound on all sides, the NOX concentration is very low. The slightly elevated NOX concentration seen at the eastern edge of the map (at PZ-06) appears to be unrelated to the mound. One suggestion is the presence of a pet dog at the residence which is fenced in the general area that the piezometer is located. The specific conductance concentrations show some movement similar to the groundwater contours (Figure 5).

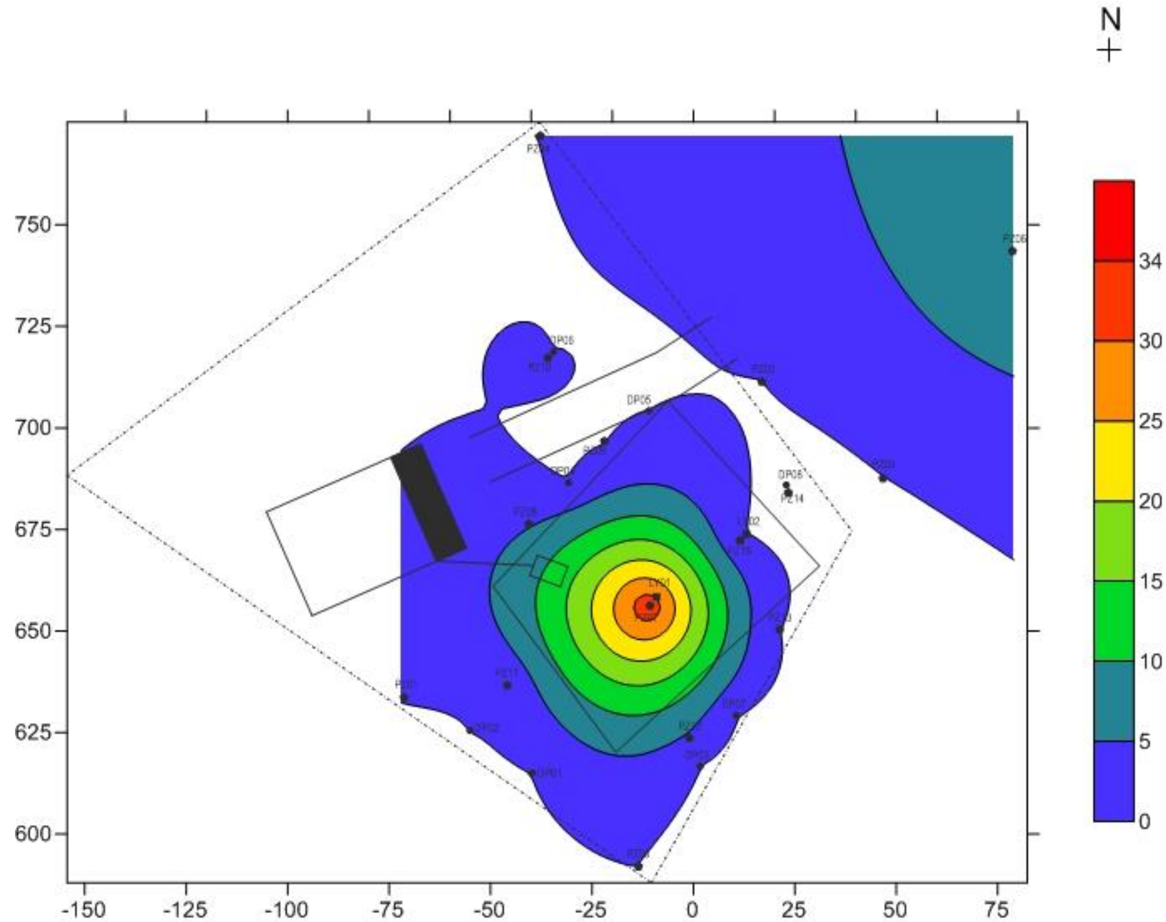

Figure 8
NOX Concentrations (mg-N/L) May 19-20, 2011

Karst is a term applied to areas where extensive dissolution of rock (in this area limestone) which has led to the development of subterranean channels through which groundwater flows in conduits (enclosed or semi-enclosed channels). These conduits can vary in size from slightly enlarged cracks to tunnels many feet in diameter and many feet in length. Two notable features due to fracture controlled flow of karst hydrology are: the often unknown flow paths and the wide variability of flow rates. The NOX map (Figure 8) indicates that the nitrogen plume flow path may be dropping vertically in a downward direction at this site. Although the May 2011 sampling event did provide some insight into the nitrogen plume at that time, the fracture/karst flow made the plume identification very difficult.

5.3.4 Correlations

Correlations between various field parameters and nitrogen concentration were conducted for the May 2011 sampling event. Such correlations can provide insight into expected nitrogen removal or can be used to approximate difficult to obtain parameter values. However, no significant correlations were observed including the relationship between specific conductance and the concentration of NOX (Figure 9).

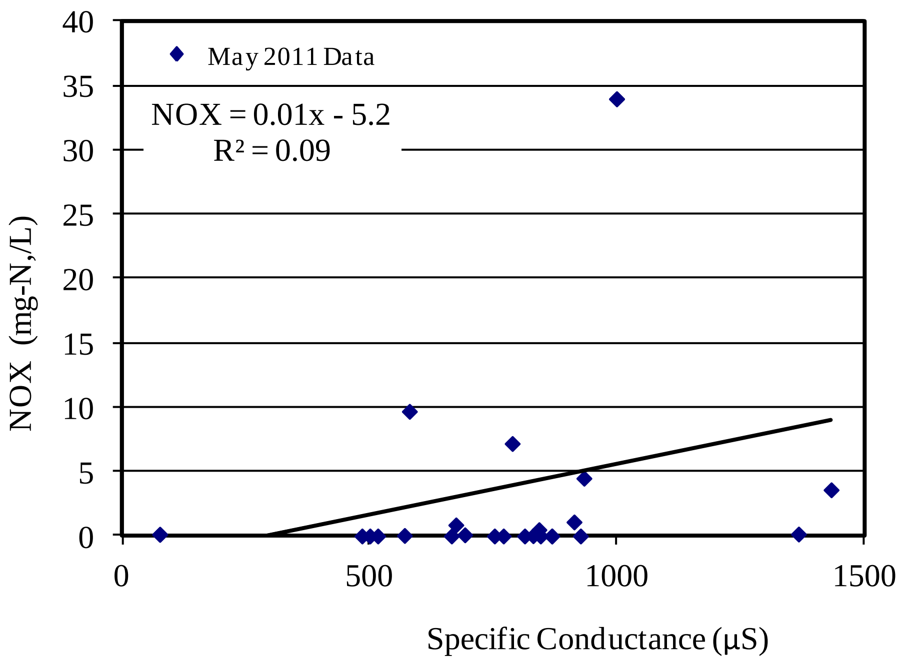

Figure 9
Correlation between Specific Conductance (uS) and Concentrations of Nitrate/Nitrite (mg-N/L)

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6.0 Summary

The decision to abandon the CHS-1 site was made as further sampling would not assist with the overriding goal to develop a simple groundwater model (Task D). The results of the May 2011 sampling event served to identify the general trend of the NOX plume and indicated that:

- Although the groundwater fluctuates, the direction of flow does not appear to change.
- There are small variations in field parameters over the site with no clear correlations between field parameters and NOX concentrations identified.
- The nitrogen plume appears to be flowing in a vertically downward direction and possibly extend towards the southeast similar to the groundwater contours with elevated concentrations in the mound.

These results indicated that further monitoring at this site would not assist in developing the simple groundwater model as the plume flow path appears to be in a vertical downward direction. Installation of additional monitoring points was impractical as the variability of the underlying limestone rock and clay layers made installation of monitoring points very difficult as discussed in the Task C.23 Instrumentation Report.

A total of 25 specific monitoring locations were removed during the site close-out conducted January 29, 2013 and January 31, 2013. Many of the piezometers were shallow enough to be simply pulled out of the ground by hand. The deeper piezometers were removed by digging a hole using a hand auger next to the piezometer to a depth that allowed for manual removal. The two lysimeters were removed in a similar manner. The drive points were more difficult to retrieve, and therefore abandoned in place with the tubing to ground surface removed. All the holes were filled using native soil, and the site was restored to its original configuration. The homeowner is satisfied with the site restoration.