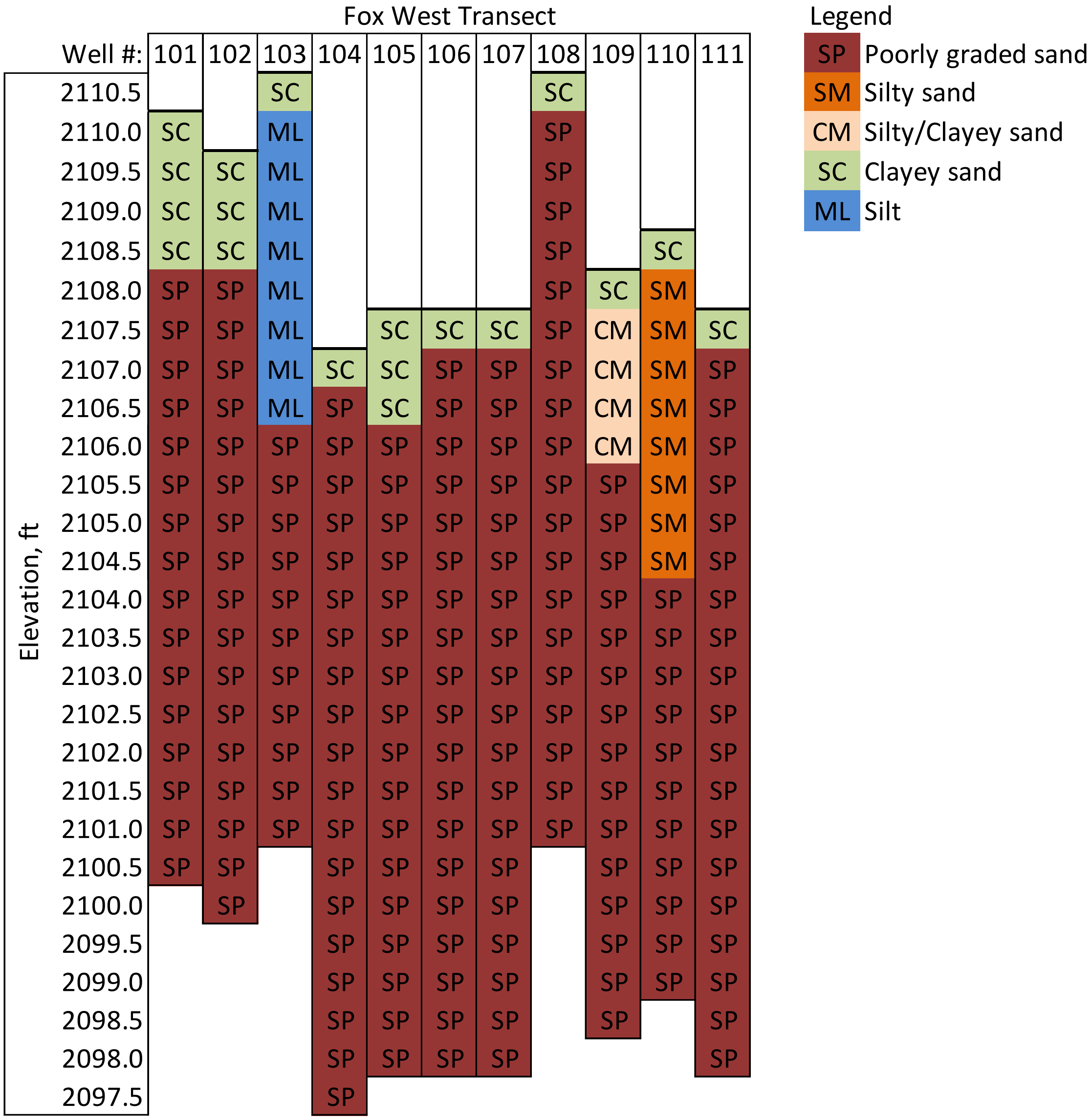
TO: WET MEADOW HYDROLOGIC MONITORING WORKING GROUP
FROM: ED OFFICE
SUBJECT: ALLUVIAL AQUIFER PROPERTIES
DATE: FEBRUARY 01, 2014

I. INTRODUCTION

The Platte River Recovery Implementation Program (PRRIP or the Program) has investigated several properties of the shallow alluvial aquifers at the Fox and Binfield wet meadow sites to aid in the development of groundwater models. This investigation is part of a larger hydrologic monitoring effort at the wet meadow sites. In March of 2013, the Program contracted Mid-State Engineering and Testing, Inc. to install 11 monitoring wells on the Fox site and 16 monitoring wells on the Binfield site, shown in **Figures A1** and **A2** of **Appendix A**. Five wells had previously been installed on the Fox site by the Program in 2011. All of the wells installed in 2013 were 2 inches in diameter and 10 feet deep. They were drilled with a hollow stem auger and unconsolidated well cuttings were examined for each well and entered into well logs. In addition to well logs, penetration tests were performed on two wells at each site and the core samples taken from these tests with a split spoon sampler underwent a sieve analysis. Unconsolidated samples from 4 wells on the Fox site and 2 wells on the Binfield site also underwent a sieve analysis. Several calculations were performed on the results of the sieve analysis to identify aquifer properties. Finally, pumping tests were performed on 2 wells at each site. The results from the well logs, penetration tests, sieve analysis, sieve analysis calculations, and pump tests are presented below.

II. WELL LOGS

Mid-State Engineering and Testing, Inc. drilled 11 wells on the Fox site and 16 wells on the Binfield site using a hollow stem auger. Unconsolidated well cuttings were examined and entered into well logs. The logs recorded color, moisture, consolidation, soil type, geologic description and other remarks. **Figures 1** and **2** show soil type logs arranged by elevation for the wells on the Fox and Binfield sites, respectively. As seen in **Figures 1** and **2**, The majority of the alluvial aquifer at both sites is comprised poorly graded sand. The sieve analysis discussed in **Section V** further investigates particle sorting. The Binfield site has small amounts of silty sand near the surface and the Fox site has a mixture of silty sand, silt, and clayey sand near the surface. Overall, both sites show homogeneous aquifer material exists five feet or less below the surface.



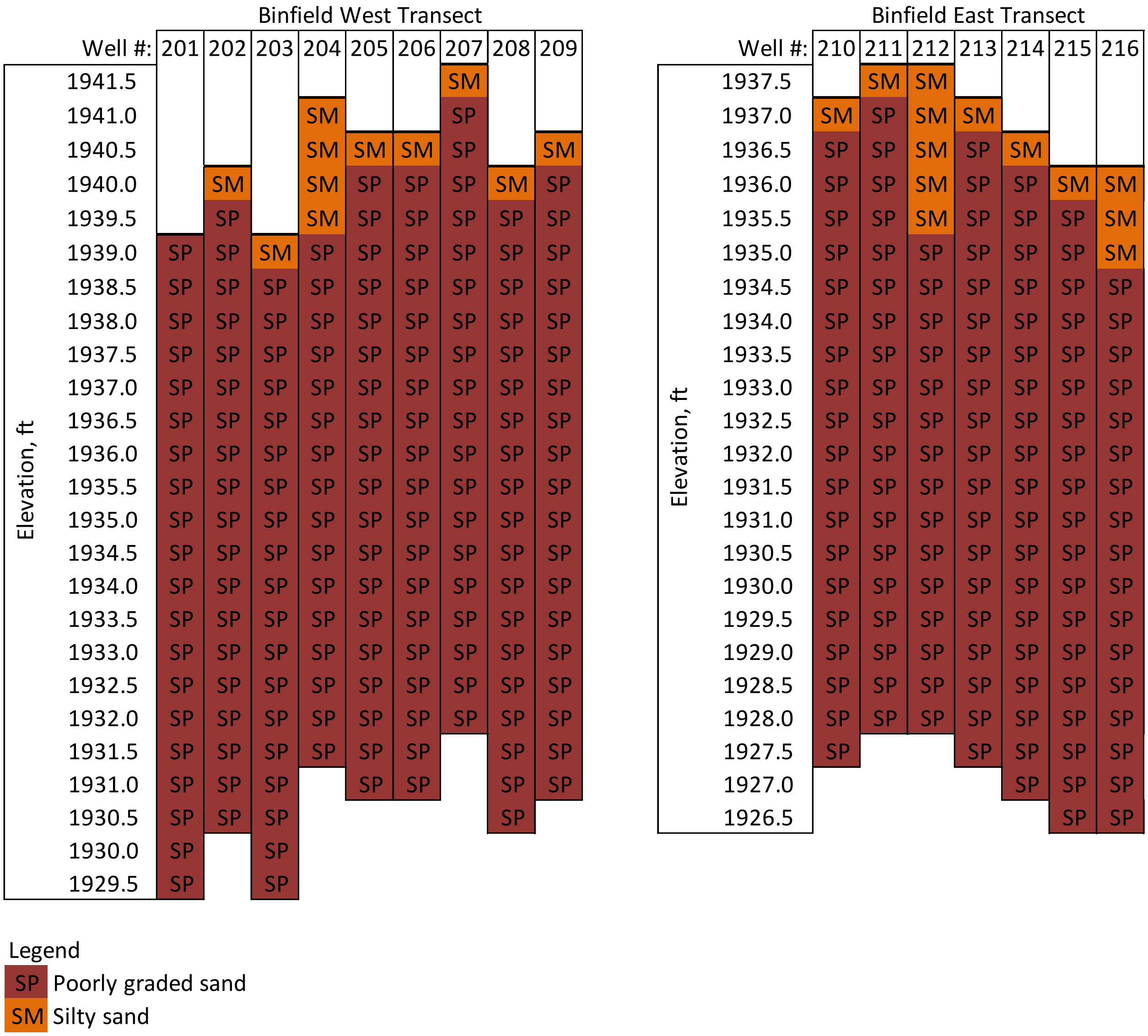
Fox West Transect

Elevation, ft / Well #:	101	102	103	104	105	106	107	108	109	110	111
2110.5			SC					SC			
2110.0	SC		ML					SP			
2109.5	SC	SC	ML					SP			
2109.0	SC	SC	ML					SP			
2108.5	SC	SC	ML					SP		SC	
2108.0	SP	SP	ML					SP	SC	SM	
2107.5	SP	SP	ML		SC	SC	SC	SP	CM	SM	SC
2107.0	SP	SP	ML	SC	SC	SP	SP	SP	CM	SM	SP
2106.5	SP	SP	ML	SP	SC	SP	SP	SP	CM	SM	SP
2106.0	SP	SP	SP	SP	SP	SP	SP	SP	CM	SM	SP
2105.5	SP	SP	SP	SP	SP	SP	SP	SP	SP	SM	SP
2105.0	SP	SP	SP	SP	SP	SP	SP	SP	SP	SM	SP
2104.5	SP	SP	SP	SP	SP	SP	SP	SP	SP	SM	SP
2104.0	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP
2103.5	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP
2103.0	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP
2102.5	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP
2102.0	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP
2101.5	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP
2101.0	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP
2100.5	SP	SP		SP	SP	SP	SP		SP	SP	SP
2100.0		SP		SP	SP	SP	SP		SP	SP	SP
2099.5				SP	SP	SP	SP		SP	SP	SP
2099.0				SP	SP	SP	SP		SP	SP	SP
2098.5				SP	SP	SP	SP		SP		SP
2098.0				SP	SP	SP	SP				SP
2097.5				SP							

Legend

SP	Poorly graded sand
SM	Silty sand
CM	Silty/Clayey sand
SC	Clayey sand
ML	Silt

Figure 1. Fox well logs



Binfield West Transect

Elevation, ft

Well #:	201	202	203	204	205	206	207	208	209
1941.5							SM		
1941.0				SM			SP		
1940.5				SM	SM	SM	SP		SM
1940.0		SM		SM	SP	SP	SP	SM	SP
1939.5		SP		SM	SP	SP	SP	SP	SP
1939.0	SP	SP	SM	SP	SP	SP	SP	SP	SP
1938.5	SP	SP	SP	SP	SP	SP	SP	SP	SP
1938.0	SP	SP	SP	SP	SP	SP	SP	SP	SP
1937.5	SP	SP	SP	SP	SP	SP	SP	SP	SP
1937.0	SP	SP	SP	SP	SP	SP	SP	SP	SP
1936.5	SP	SP	SP	SP	SP	SP	SP	SP	SP
1936.0	SP	SP	SP	SP	SP	SP	SP	SP	SP
1935.5	SP	SP	SP	SP	SP	SP	SP	SP	SP
1935.0	SP	SP	SP	SP	SP	SP	SP	SP	SP
1934.5	SP	SP	SP	SP	SP	SP	SP	SP	SP
1934.0	SP	SP	SP	SP	SP	SP	SP	SP	SP
1933.5	SP	SP	SP	SP	SP	SP	SP	SP	SP
1933.0	SP	SP	SP	SP	SP	SP	SP	SP	SP
1932.5	SP	SP	SP	SP	SP	SP	SP	SP	SP
1932.0	SP	SP	SP	SP	SP	SP	SP	SP	SP
1931.5	SP	SP	SP	SP	SP	SP		SP	SP
1931.0	SP	SP	SP		SP	SP		SP	SP
1930.5	SP	SP	SP					SP	
1930.0	SP		SP						
1929.5	SP		SP						

Binfield East Transect

Elevation, ft

Well #:	210	211	212	213	214	215	216
1937.5		SM	SM				
1937.0	SM	SP	SM	SM			
1936.5	SP	SP	SM	SP	SM		
1936.0	SP	SP	SM	SP	SP	SM	SM
1935.5	SP	SP	SM	SP	SP	SP	SM
1935.0	SP	SP	SP	SP	SP	SP	SM
1934.5	SP	SP	SP	SP	SP	SP	SP
1934.0	SP	SP	SP	SP	SP	SP	SP
1933.5	SP	SP	SP	SP	SP	SP	SP
1933.0	SP	SP	SP	SP	SP	SP	SP
1932.5	SP	SP	SP	SP	SP	SP	SP
1932.0	SP	SP	SP	SP	SP	SP	SP
1931.5	SP	SP	SP	SP	SP	SP	SP
1931.0	SP	SP	SP	SP	SP	SP	SP
1930.5	SP	SP	SP	SP	SP	SP	SP
1930.0	SP	SP	SP	SP	SP	SP	SP
1929.5	SP	SP	SP	SP	SP	SP	SP
1929.0	SP	SP	SP	SP	SP	SP	SP
1928.5	SP	SP	SP	SP	SP	SP	SP
1928.0	SP	SP	SP	SP	SP	SP	SP
1927.5	SP			SP	SP	SP	SP
1927.0					SP	SP	SP
1926.5						SP	SP

Legend
SP Poorly graded sand
SM Silty sand

Figure 2. Binfield well logs

III. STANDARD PENETRATION TEST

Standard penetration tests were conducted on wells 101, 106, 201, and 206 at depths of 3.5 to 5 feet and 7.5 to 10 feet below the surface by Mid-State Engineering and Testing, Inc. according to the standards described by the American Society for Testing and Materials (ASTM)[1]. Results from the tests are shown in **Table 1**, with the blows per foot from all four wells falling in the tight range of 5 to 12 blows. The Fox wells showed higher blows per foot, averaging just below 10, while the Binfield wells averaged 7 blows per foot. Blow counts in the range of 4 to 10 blows per food indicate loose soil packing, while blow counts from 10 to 30 blows per foot

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[1] American Society for Testing and Material (ASTM) D1586 - 11

indicate compact soils. Soils at both sites fall into the loose category with well 106 showing slightly more compact soil. Overall, soil blow counts suggest uniform material present across both sites.

Table 1. Standard penetration test results

Well	*Depth (ft)*	*Blows*	*N (Blows/ft)*	*Average N*
101	3.5-5	3/4/5	9	8
	7.5-10	2/4/3	7	
106	3.5-5	5/6/6	12	11.5
	7.5-10	4/6/5	11	
Fox average				9.8
201	3.5-5	3/3/3	6	6.5
	7.5-10	3/3/4	7	
206	3.5-5	5/5/5	10	7.5
	7.5-10	2/3/2	5	
Binfield average				7.0

IV. SIEVE ANALYSIS

Samples collected from the split spoon sampler used for the penetration tests on wells 101, 106, 201, and 206 as well as unconsolidated samples from wells 102, 103, 109, 111, 202, and 203 were used in a sieve analysis. Samples were collected at depths of 3.5 to 5 feet and 7.5 to 10 feet at each well. The sieve analysis was performed according to ASTM standards[2] using U.S. standard sieves. **Figures 3** and **4** show the results of the sieve analysis for the Fox and Binfield sites, respectively. Results from both sites show similar particle distributions across the sites and indicate homogeneous aquifer material. The upper portion of well 103 has the most notably different particle distribution due to the layer of silt shown in the well log in **Figure 1**. The upper portions of wells 101, 102, and 111 also show finer particle distributions than the bulk of the other samples. These wells have silty sand in near the surface as seen in the Fox well log (**Figure 1**).

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[2] ASTM C136 – 06.

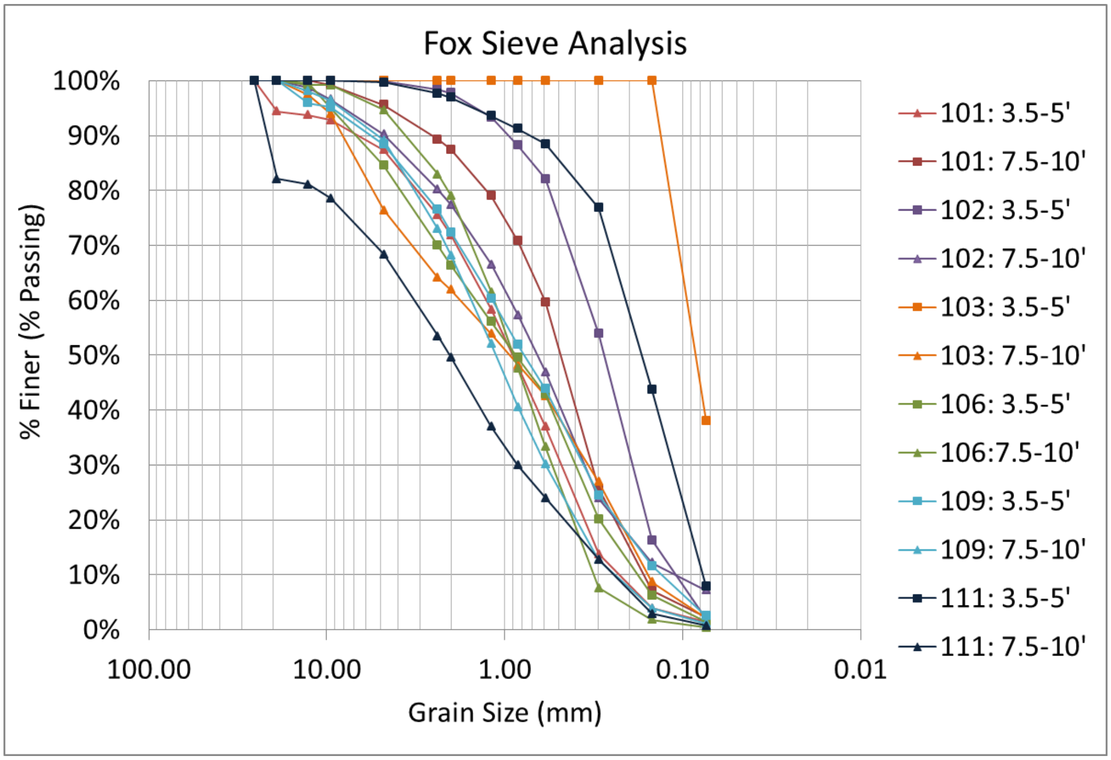

Figure 3. Fox sieve analysis results

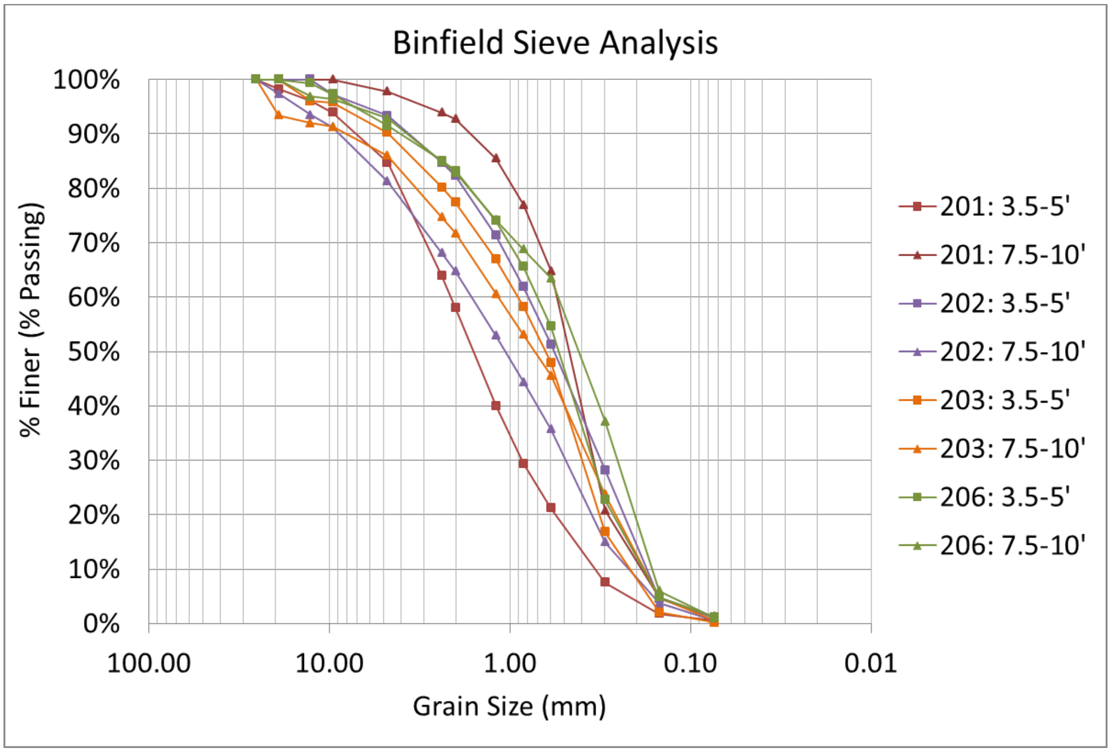

Figure 4. Binfield sieve analysis results

V. SIEVE ANALYSIS CALCULATIONS

Several soil characteristics were determined using the information from the sieve analysis. The D85, D60, D50, D30, and D10 values were identified, where 85 percent of grain diameters are less than the D85 diameter, 60 percent of grain diameters are less than the D60 value, etc. Each sample was characterized using the D50 value, with fine sands falling in the range 0.125 millimeters to 0.25 millimeters, medium sands falling in the range of 0.25 millimeters to 0.5 millimeters, and coarse sands falling in the range of 0.5 millimeters to 1 millimeter. The coefficient of uniformity was calculated as $C_u = D60/D10$ and was used to determine the degree of sorting for each sample, with C_u values below 4 indicating well sorted material, C_u values between 4 and 6 indicating moderately sorted material, and C_u values above 6 indicating poorly sorted material. **Table 2** shows the results from these calculations. About half of the samples were poorly sorted and half were well sorted with only two samples showing moderate sorting.

Table 2. Particle sorting and grain size

Well #	Depth 3.5-5'	Depth 7.5-10'
Fox Site		
101	Well sorted coarse sand	Moderately sorted coarse sand
102	Well sorted medium sand	Poorly sorted coarse sand
103	Silt	Poorly sorted coarse sand
106	Poorly sorted coarse sand	Well sorted coarse sand
109	Poorly sorted coarse sand	Poorly sorted coarse sand
111	Well sorted fine sand	Poorly sorted coarse sand
Binfield Site		
201	Poorly sorted coarse sand	Well sorted medium sand
202	Moderately sorted coarse sand	Poorly sorted coarse sand
203	Well sorted coarse sand	Poorly sorted coarse sand
206	Well sorted coarse sand	Well sorted medium sand

Hydraulic conductivity was calculated using both the Hazen equation[3] and the Shepard equation[4]. All samples had effective grains sizes (D10) between 0.1 millimeters and 0.3 millimeters with the exception of the 3.5 to 5 foot sample at well 201 which a D10 of 0.35 millimeters. This was considered to be close enough to the range required by the Hazen equation (0.1 to 0.3 millimeters) and the sample was included in the Hazen analysis. Coefficients for the Hazen equation were based on the particle size and sorting shown in **Table 2**. The values for the C_F coefficient in the Shepard equation were based on D50 values and the assumption that all sediments were channel deposits. **Table 3** shows the hydraulic conductivity values calculated for each sample with both methods as well as average values. **Figures 5** and **6** show the average hydraulic conductivity values graphically across the site. Values in **Figures 5** and **6** represent averages over the well depth as well as averages of the Hazen and Shepard methods.

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[3] Hazen, A. 1911. ‘‘Discussion: Dams on sand foundations.’’ Trans. Am. Soc. Civ. Eng., 73, 199–203

[4] Shepherd, R.G. 1989. Correlations of Permeability and Grain Size. Ground Water, 27, 5, 633-638.

Table 3. Hydraulic conductivities for the Fox and Binfield sites

	K_{HAZEN}(ft/day)			*$K_{SHEPARD}$(ft/day)*			*K_{AVG}(ft/day)*		
Well #	*Depth 3.5-5′*	*Depth 7.5-10′*	***Avg***	*Depth 3.5-5′*	*Depth 7.5-10′*	***Avg***	*Depth 3.5-5′*	*Depth 7.5-10′*	***Avg***
101	63	98	**81**	67	348	**207**	65	223	**144**
102	23	15	**19**	12	145	**78**	17	80	**49**
103	1	29	**29**	1	384	**193**	1	206	**104**
106	41	224	**132**	301	337	**319**	171	281	**226**
109	21	72	**46**	228	869	**549**	124	471	**297**
111	7	74	**40**	3	1458	**730**	5	766	**385**
								Fox Site Average	**225**
201	139	66	**103**	4129	62	**2096**	2134	64	**1099**
202	57	61	**59**	96	675	**385**	76	368	**222**
203	111	41	**76**	132	192	**162**	122	116	**119**
206	78	48	**63**	83	46	**64**	81	47	**64**
								Binfield Site Average	**376**

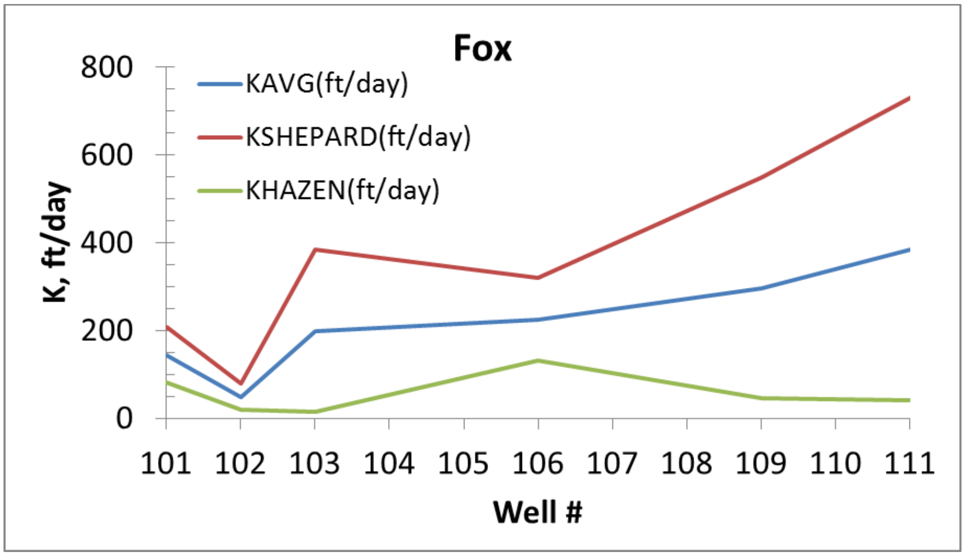

Figure 5. Fox hydraulic conductivity values

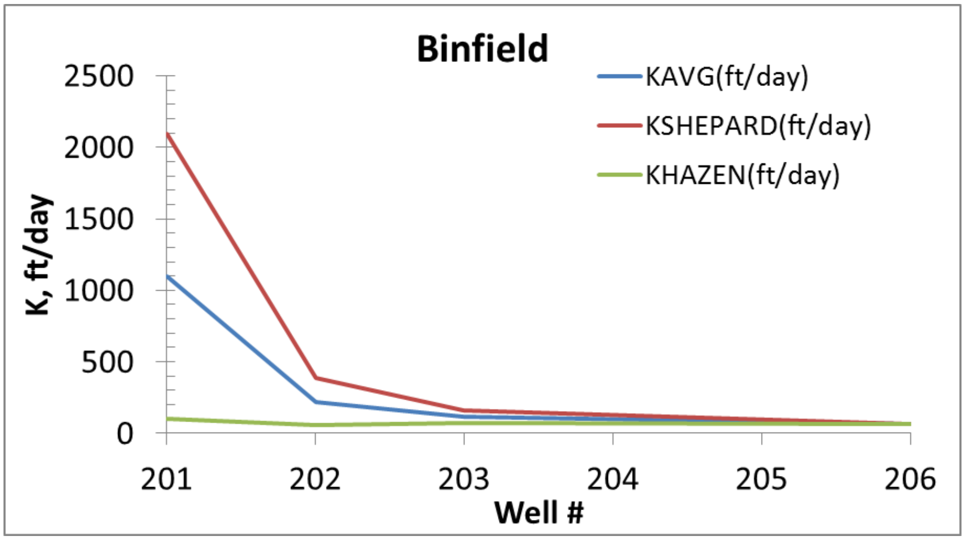

Figure 6. Binfield hydraulic conductivity values

VI. PUMPING TESTS

Pumping tests were conducted on wells 106, 111, 201, and 206 to determine aquifer transmissivity at both sites. The methods, calculations, and results are discussed in the following sections.

A. Methods

Pump tests were conducted at one well near the river and one well near the center of the site at both wet meadow locations. The monitoring wells are two inches in diameter and ten feet deep with water levels ranging from 4 to 9 feet below the surface. The pump test methodology described below was adapted from Chapter 9 of the Manual of Applied Field Hydrogeology[5].

a. Equipment

The shallow wells allowed for a surface mounted suction pump rather than a submersible pump to be used in the pump tests. A Pacific Hydrostar[6] one-inch diameter clear water pump with a max lift head of 105 feet was used in the test. The inlet piping was made from rigid PVC as one-inch suction tubing was not readily available. The inlet PVC pipe was cut and glued to accommodate the 90° bends necessary to connect it to the pump. A ball valve was installed between the inlet to the PVC piping and the pump. This valve was used to maintain suction after the pump was turned off and disconnected from the pipe. A standard 50 foot garden hose was used as an outlet hose. A gate valve was attached to the pump outlet to control the pump's flow rate. **Figure 7** shows the pump, inlet, and outlet set up.

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[5] Weight, W.D., and Sonderegger, J.L. 2001. *Manual of Applied Field Hydrogeology*. McGraw-Hill, New York.

[6] http://www.harborfreight.com/1-in-clear-water-pump-with-79cc-ohv-gas-engine-69747.html

Figure 7. PVC inlet pipe, one-inch clear water pump, and outlet hose

b. Procedure

The first step in the pump test procedure was to take initial water level readings with an electric sounding tape (e-tape). Once the initial water level was established, sediment from the well was cleared out using PVC disposable bailers to ensure the pump would not be damaged by sucking up sediment. The volume of water removed with the bailers was measured using a graduated 5-gallon bucket. Water levels were measured with e-tape the after the bailing to ensure it did not affect groundwater elevations. The PVC inlet pipe was lowered into the well and connected to the pump and the outlet hose was attached to the pump. The outlet hose was routed away from the well and set to discharge into a graduated 5 gallon bucket. A 30 PSIG In-Situ Level Troll 500 pressure transducer was lowered into the well and set to record water depth above the transducer. The transducer was connected to a laptop computer which displayed water depth in real time. The transducer also recorded water depths every 60 seconds and saved the readings in a *.csv file that was downloaded after the test had been completed.

After the pump test equipment was in place, the pump was primed and started. The flow was adjusted to the desired flow rate using the pump’s throttle and the gate valve attached to the pump outlet. The pump was then turned off and groundwater depth was monitored to determine when the water table had recovered to its initial level. When the groundwater elevation had returned to its initial level the pump test was started. The pump was turned on and groundwater depth was recorded every 15 seconds during the first 2 minutes of the test. Depths were recorded every 30 seconds from 2 to 10 minutes after the start of pumping, every 60 seconds from 10 to 20 minutes after the start of pumping, and every 5 minutes from 20 to 30 minutes after the start of pumping. The pumping rate was monitored several times during pumping by measuring the discharge using a graduated 5 gallon bucket and a stop watch.

After 30 minutes of pumping, the pump was turned off and aquifer recovery was measured. Groundwater depths were recorded every 15 seconds during the first 2 minutes of recovery, every 30 seconds from 2 to 10 minutes after turning off the pump, and every 60 seconds from 10 minutes to 20 minutes after turning the pump off. Recover readings were no longer taken after the groundwater recovered to its pre-pumping levels and remained at that level for several minutes. During the recovery phase of the pumping test, the ball valve between the pump and the PVC inlet was closed to maintain suction while the pump was disconnected from the PVC inlet piping. This prevented water in the piping from flowing back into the well and affecting recovery data. The pump was disconnected by cutting the PVC between the ball valve and the pump. The PVC was then glued back together using a coupling for the next pumping test.

B. Calculations and Results

Data from pumping tests is typically gathered by pumping at one well location and observing drawdown at another well located nearby. Sufficiently high pumping rates are required to ensure the cone of depression reaches the observation wells during the test. Due to the shallow depth of the monitoring wells and spacing of monitoring wells across the sites, pumping rates required to produce observable drawdown in nearby wells would cause the groundwater elevation to drop below the well bottom of the pumped well. While drawdown data can be collected from the pumping well itself, the practice decreases the accuracy of the assumptions that go into some of the pumping test calculations. Despite this fact, the pumping tests provided valuable insight into aquifer behavior and properties.

Data recorded from the pumping tests at all four wells was analyzed using various methods to determine aquifer transmissivity and storage coefficient values. Pumping rates, maximum drawdown, and total pumping time are shown in **Table 3** for each test. The pumping rate for the first well tested, well 111, was 4 gallons per minute. When drawdown stabilized at less than a foot during the first test, the pumping rate was increased to between 12 and 13 gallons per minute for the remaining wells 106, 201, and 206.

Table 3. Pumping rates and drawdown during the pumping tests

Well #	Pumping Rate, Q (gal/min)	Max. Drawdown, s (ft)	Pumping Time, t (min)
106	12.5	1.69	30
111	4	0.71	30
201	13	1.49	30
206	13	1.93	30

During the pumping test at well 106, a kink was discovered in the discharge hose that limited the pumping rate to 6 gallons per minute during the first two minutes of the test. The kink was removed and the pumping rate increased to 12.5 gallons per minute for the remainder of the test. As a result, the pumping test at well 106 did not produce high quality data.

Drawdown occurred rapidly in all wells, with the drawdown in the first 15 seconds of pumping accounting for over 90% of total drawdown for all wells except well 106 as the pumping rate changed after two minutes. **Figure 8** shows drawdown plotted over time for well 201. Time is plotted in logarithmic scale to allow for the small drawdown changes to be seen clearly. The first data point shows that 1.362 feet of drawdown occurred in the first 15 seconds of pumping. **Figure 9** shows the groundwater levels during the pumping and recovery phase at well 201. The sharp drop in groundwater level and sharp rise reflect rapid drawdown and recovery. A similar response was observed at all four wells during the pumping tests.

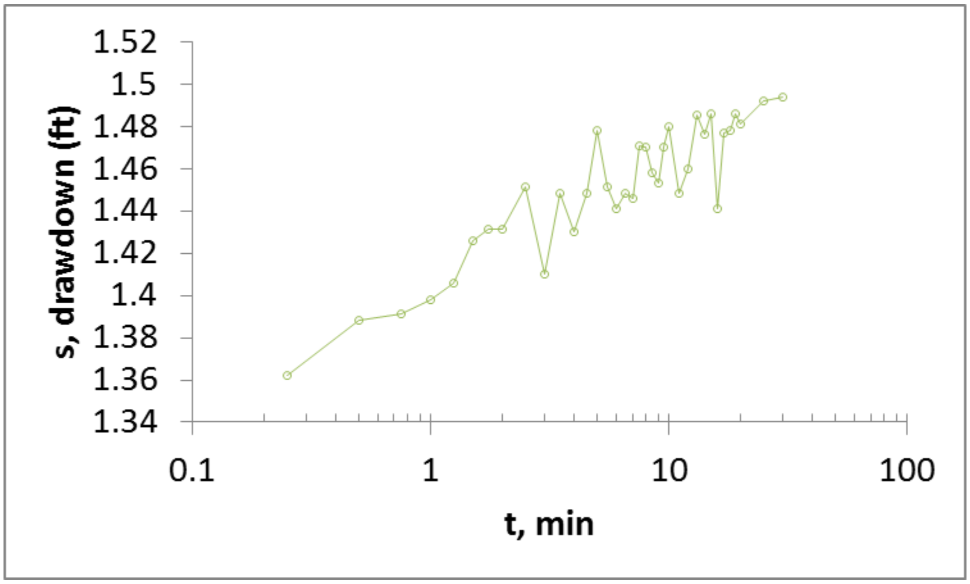

Figure 8. Drawdown over time for well 201 (time in logarithmic scale)

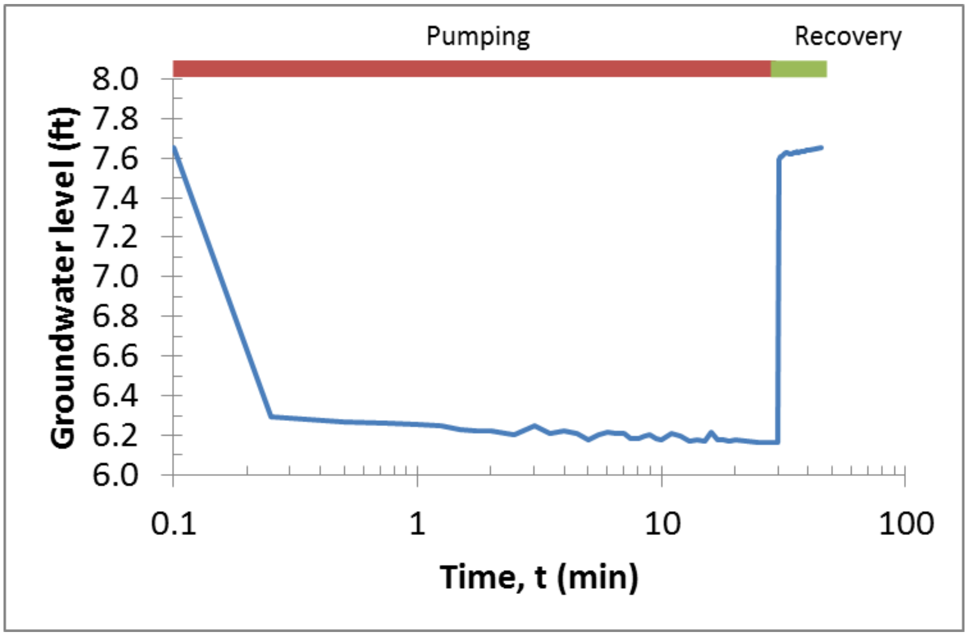

Figure 9. Groundwater level over time for well 201 during pumping and recovery (time in logarithmic scale)

a. Calculations

Data collected from the pumping tests was analyzed using the Theis method of superposition[7] to determine transmissivity and the storage coefficient values. The drawdown was plotted against the square of the radius over time (r^2/t), the *W(u)* versus *u* plot was superimposed over the data, and a match point was identified as shown in **Figure B1** in **Appendix B**. Values of T and S were calculated using *Equations 1* and *2*:

$$T = \frac{Q}{4\pi s} W(u) \qquad Equation\ 1$$

$$S = \frac{4Tu}{\frac{r^2}{t}} \qquad Equation\ 2$$

Where:
T = transmissivity in gallons/(ft*min),
Q = pumping rate in gallons/min,
s = drawdown in feet,
W(u) = the well function (dimensionless),
S = storage coefficient (dimensionless),
r = distance from pumping well (well radius used) in feet,
u = variable of the well function (dimensionless), and
t = time since pumping began in minutes.

Transmissivity values are shown in **Table 4** and storage coefficient values are shown in **Table 5**. The Theis method is typically used with data from observation wells rather than pumping wells. The transmissivity values calculated with the method provide good information on the order of magnitude of the aquifer's transmissivity and relative homogeneity. The values of the storage coefficient calculated using the Theis method are not reasonable as the rapid drawdown seen in the pumping wells resulted in a much lower storage coefficient than known to exist in typical alluvial unconfined aquifers.

The Theis method is based on several assumptions: the aquifer is assumed to have an infinite areal extent, the well is assumed to be fully penetrating and have an efficiency of 100 percent, the pumping rate is assumed to be constant, the aquifer is assumed to be homogeneous and isotropic, and no sources or sinks of water are present. While several of these assumptions are reasonable, such as a homogeneous aquifer and a constant pumping rate, many of them are not entirely valid in this instance. The aquifer is certainly not infinite in areal extent but it does extend well beyond the area of influence of the pumping test. The ten-feet-deep monitoring wells are not fully penetrating and likely have some degree of loss. Finally, the nearby Platte River likely acts as a source of water to wells 111 and 201 which are located within 100 feet of the river.

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[7] Theis, C.V., 1935. The Lowering of the Piezometer Surface and the Rate and Discharge of a Well Using Ground-Water Storage. *Transaction of the American Geophyscial Union*, Vol. 16, pp. 519-524

Transmissivity was not calculated using other methods such as the Cooper-Jacob method or the Chow method as the short pumping time and rapid drawdown did not produce data that allowed for reliable analysis with these methods.

Data collected after pumping ceased was evaluated using recovery test methods described by Theis[8]. Residual drawdown values observed during the recovery phase of the pumping test were plotted against the ratio of time from the start of pumping (t) to time from the end of pumping (t'), t/t'. A trend line was fit to the results and the slope of residual drawdown obtained and used in *Equation 3* to determine transmissivity:

$$T = \frac{2.30Q}{4\pi\Delta s'} \qquad \qquad Equation\ 3$$

Where:
T = transmissivity in gallons/(ft*min),
Q = pumping rate in gallons/min, and
$\Delta s'$ = residual drawdown in feet.

Transmissivity values from the recovery test are shown in **Table 4**.

As a final check on the values calculated with the Theis method and the recovery test, transmissivity was calculated using the specific capacity estimation method. Specific capacity is the ratio of the pumping rate, Q, to drawdown after 24 hours of pumping, s. While pumping did not occur for 24 hours, the specific capacity method may still yield insight into the relative magnitude of transmissivity values. Transmissivity was calculated for the unconfined aquifer using *Equation 4*:

$$T = 1{,}500\frac{Q}{s} \qquad \qquad Equation\ 3$$

Where:
T = transmissivity in gallons/(ft*day),
Q = pumping rate in gallons/min, and
s = drawdown in feet.

Transmissivity values from the specific capacity estimation are shown in **Table 4**.

b. Results

Transmissivity values calculated using the Theis method, the recovery test method, and the specific capacity estimation are shown in **Table 4**. All of the values are on the same order of magnitude with the exception of the recover test transmissivity calculated for well 201. The higher value may reflect the influence of the nearby Platte River. In general, transmissivities calculated using the recovery test are two to four times higher than those calculated using the Theis Method. The specific capacity transmissivities are lower than the Theis transmissivities. Overall, the transmissivity values calculated from the pumping test indicate the aquifers at the

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[8] Theis, C.V., 1935. The Lowering of the Piezometer Surface and the Rate and Discharge of a Well Using Ground-Water Storage. *Transaction of the American Geophyscial Union*, Vol. 16, pp. 519-524

Fox and Binfield sites can be considered relatively homogeneous. The application of the Theis method to the pumping well data and the use of the specific capacity estimation for pumping of less than 24 hours should cause the data to be seen as general estimates of transmissivity values rather than exact values. The assumptions discussed in the previous subsection also reduce the accuracy of the values presented below.

Table 4. Transmissivity values calculated using the Theis method of superposition and pumping test data, Recovery test data, and specific capacity approximations

Well #	Theis Method, T (ft^2/day)	Recovery Test, T (ft^2/day)	Specific Capacity, T (ft^2/day)
106	2,500	4,100	1,500
111	1,800	4,600	1,100
201	3,400	13,500	1,700
206	2,400	7,800	1,400

Storage coefficient values calculated using the Theis method are shown in **Table 5**. As mentioned in the previous subsection, they do not reflect actual values and were distorted due to the rapid draw down caused by the presence of pump in the wells used for observation.

Table 5. Storage coefficient values calculated using the Theis method of superposition and pumping test data

Well #	Storativity, S
106	1.7×10^{-9}
111	5.1×10^{-10}
201	4.7×10^{-10}
206	6.6×10^{-7}

APPENDIX A: SITE MAPS

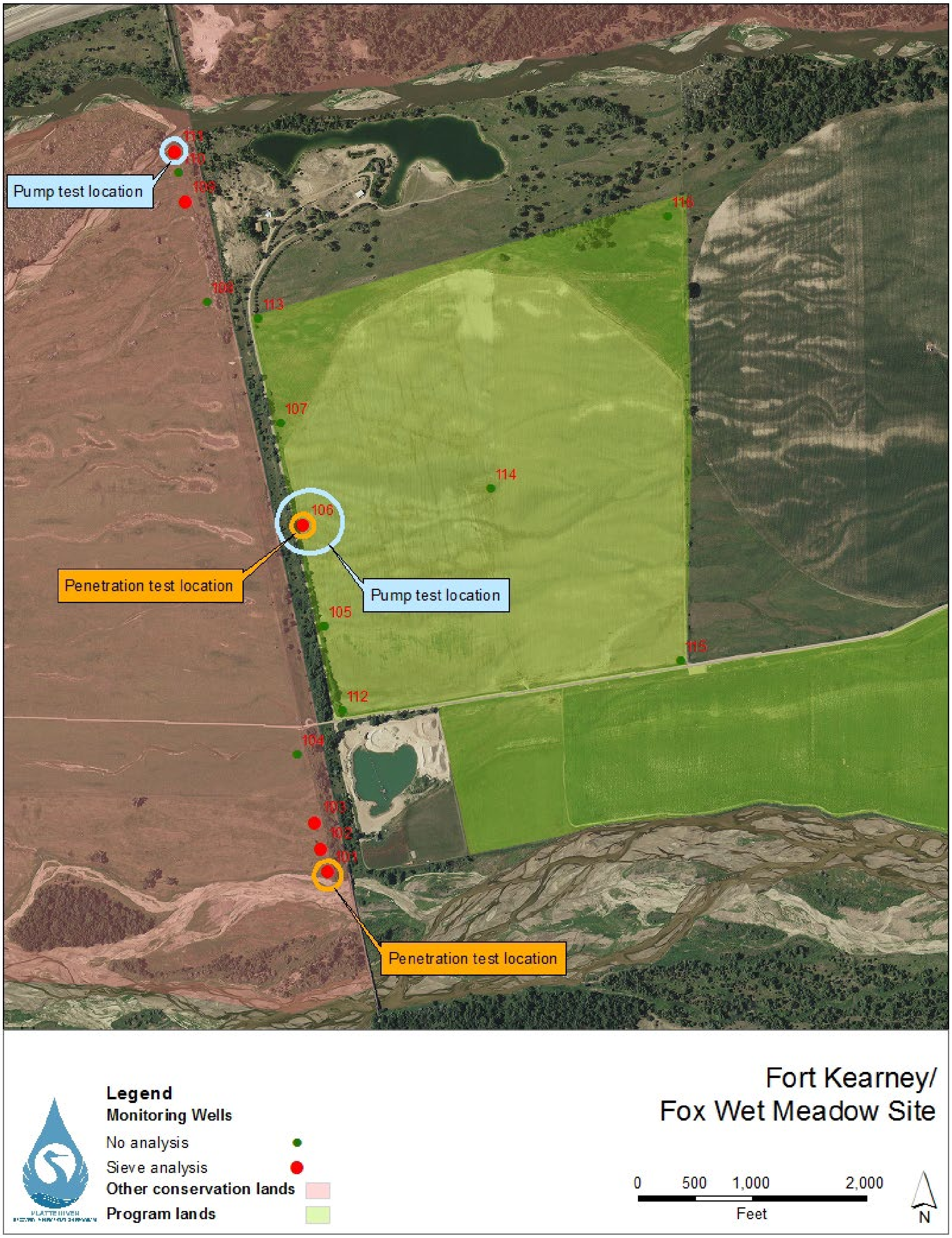


Figure A1. Fox site overview

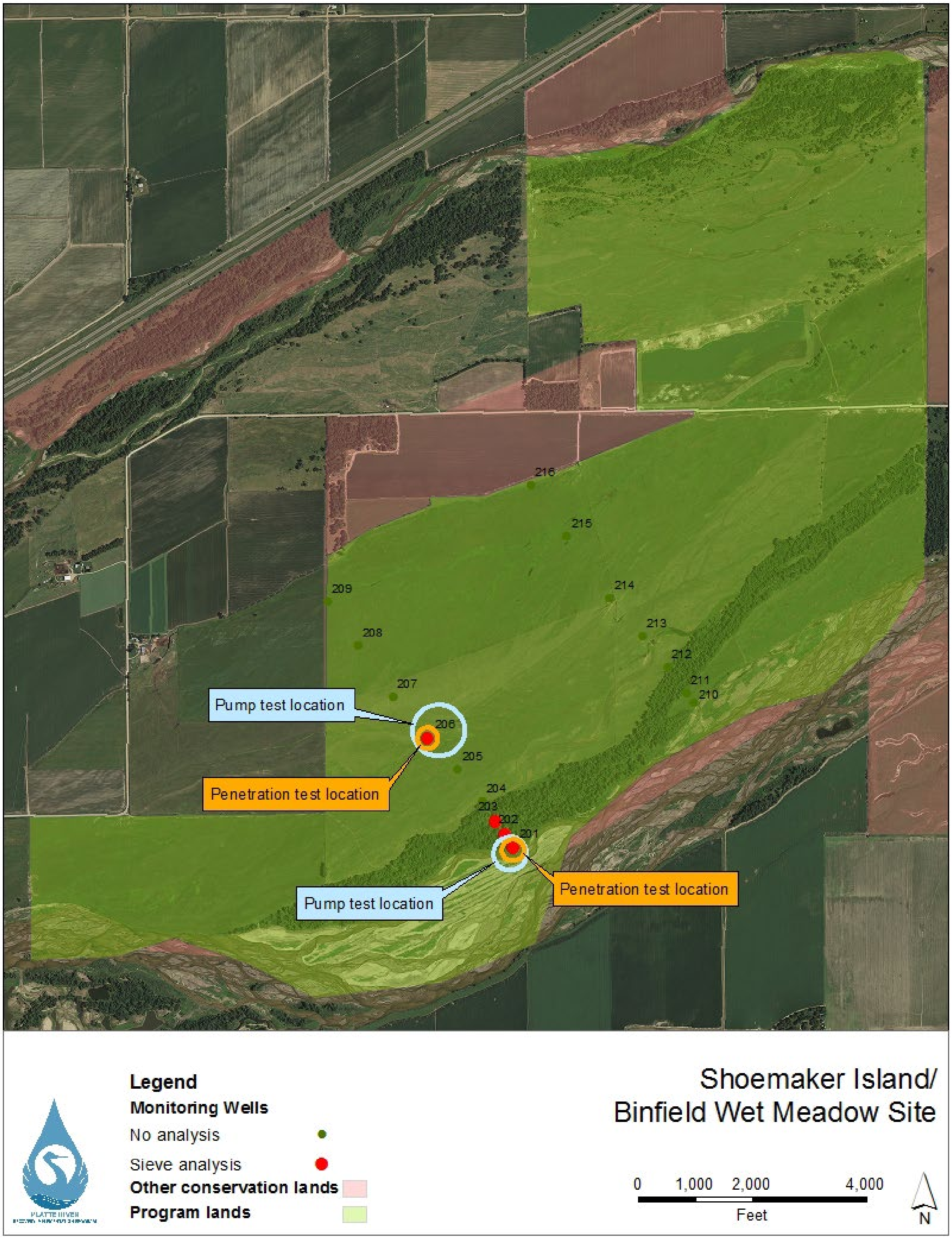
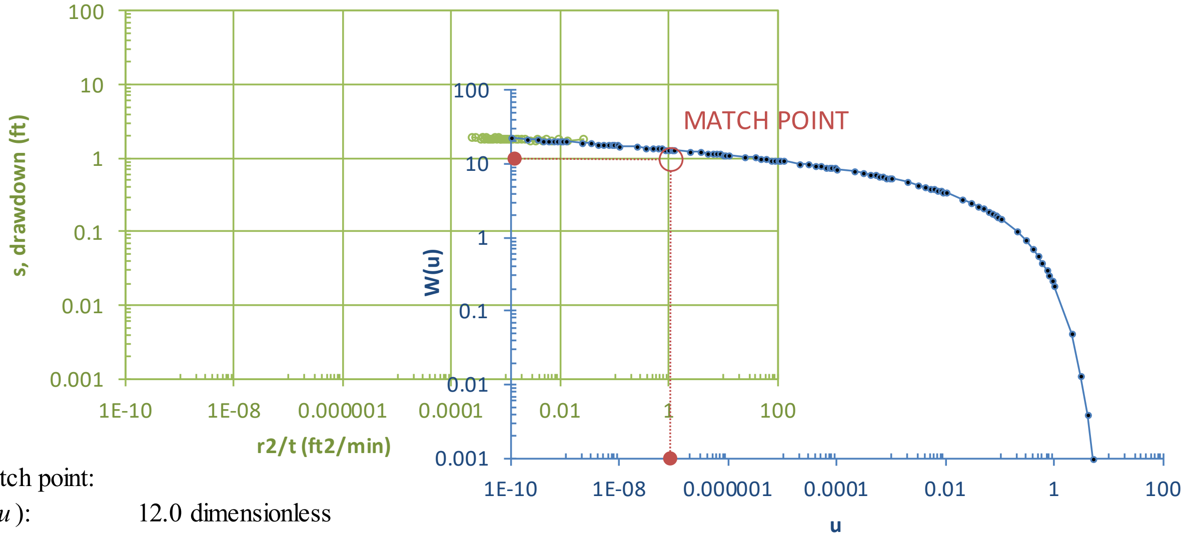


Figure A2. Fox site overview

APPENDIX B: PUMPING TEST CALCULATIONS

THEIS METHOD OF SUPERPOSITION



Match point:

W(u): 12.0 dimensionless

u: 1.0E-07 dimensionless

s: 1.0 ft

r^2/t: 1.0 ft^2/min:

$T=(Q/(4\pi s))*W(u)$

T= 12.4 Gallon/ft/min

T= 17,876 GPD/ft

T= 1.7 ft^2/min

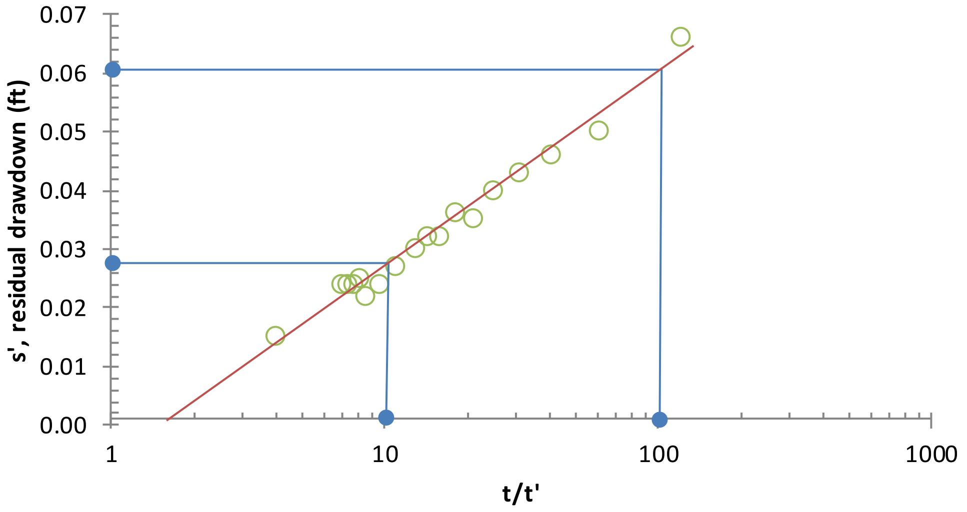
T= 2,390 ft^2/day

$S=4Tu/(r^2/t)$

S= 6.6E-07 dimensionless

Figure B1. Theis method of superposition plots and calculations for well 206.

RECOVERY TEST



Δs=	0.034	ft
T=2.30Q/(4πΔs')		
T=	21.5	Gallon/ft/min
T=	31,007	GPD/ft
T=	2.9	ft^2/min
T=	4,145	ft^2/day

Figure B2. Recovery test plot and calculations for well 106.