# Groundwater Availability Modeling Under Drought Conditions

## Lower Raccoon River Aquifer Dallas and Polk Counties, Iowa Drought Assessment

**Iowa Geological and Water Survey**
**Water Resources Investigation Report 7**

Iowa Department of Natural Resources
Chuck Gipp, Director

January 2013

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Prepared by

J. Michael Gannon

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# ACKNOWLEDGEMENTS

The author would like to acknowledge the contributions of the individuals who assisted in the production of this report. First, much of our understanding of the Lower Raccoon River aquifer in Iowa is built on the work of previous Iowa Geological Survey geologists. The report layout was completed by Mindy Kralicek. Editorial reviews were conducted by Keith Schilling, Ryan Clark, Jason Vogelgesang, Michael Anderson, and Lynette Seigley.

# EXECUTIVE SUMMARY

Increased demands for groundwater by agriculture, industries, and municipalities have raised concerns about the future availability of groundwater in Iowa. In 2007, the Iowa Legislature began funding a comprehensive Water Resources Management program, which was implemented by the Iowa Department of Natural Resources. A key aspect of the program is to evaluate and quantify the groundwater resources across the state using computer simulation models. These models help answer questions such as: "How much water can be pumped from an aquifer over 10, 20, or 100 years?" or "Will my well go dry?"

A groundwater study was initiated to understand the shallow groundwater resources in the Lower Raccoon River aquifer. The primary objective of this study was to evaluate the aquifer for future water supply development under drought conditions. A groundwater flow model of the Lower Raccoon River aquifer was created using Visual MODFLOW 2011.1. The model was used to generate source water capture zones, evaluate surface water and groundwater interaction, and estimate maximum sustainable pumping rates. Water level data during the summer of 2012 were used to help calibrate the model. Based on the mass balance calculations in the model, the percentage of water production supplied by the Raccoon River (from Dallas Center to West Des Moines) was 52 percent, and 29 percent was supplied by induced recharge from the numerous sand and gravel quarries. The remaining 19 percent of the water production is supplied by precipitation recharge and groundwater inflow into the model area. The percentage of induced recharge varied from 0 percent at Van Meter to 89 percent at Des Moines Water Works radial wellfield. Induced recharge from the Raccoon River (from Dallas Center to West Des Moines) allows public wells to maintain water production during prolonged dry periods. Limitations in water production exist when streamflow along the Raccoon River drops below 17.1 cubic feet per second (43.4 cfs if the Fleur Drive infiltration gallery is included).

Based on available pumping records, an average of 14.6 billion gallons of water are pumped from the Lower Raccoon River aquifer each year. Additional water production is available from the aquifer, but limitations exist during extremely dry years. Additional pumping capacity ranges from 10 percent in the West Des Moines wellfield, to over 1,000 percent at Adel. Potential well yields greater than 500 gallons per minute (gpm) are found near Adel, Van Meter, and West Des Moines. The highest potential well yields occur east of Adel, and are the result of the cobble and boulder zone found at the base of the aquifer, and the abundance of induced recharge from the nearby sand and gravel quarries and the Raccoon River.

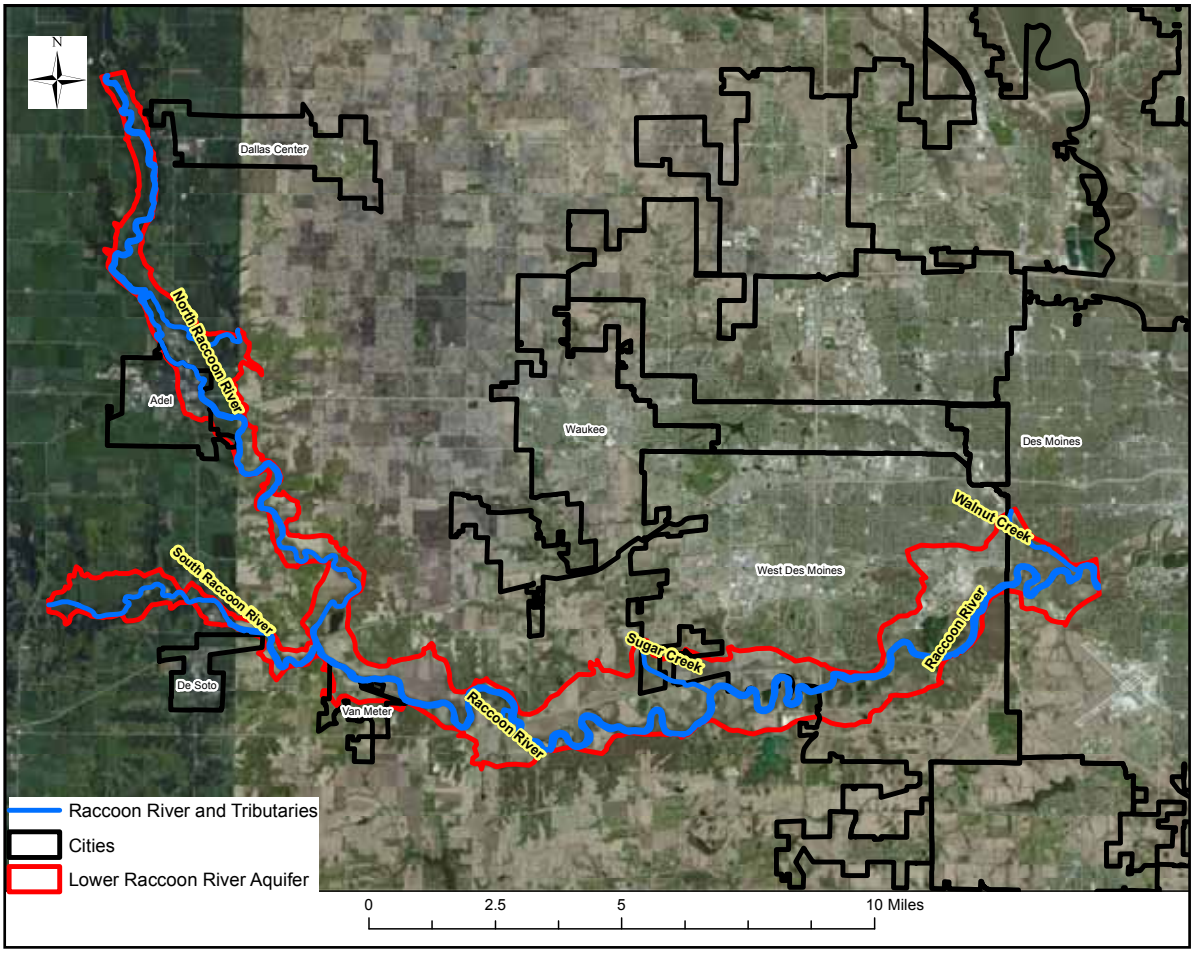



**Figure 1.** Extent of the Lower Raccoon River aquifer study area.

## INTRODUCTION

The purpose of this study was to evaluate the groundwater resources in the alluvial aquifer located along the Raccoon, North Raccoon, and South Raccoon rivers in Dallas and Polk counties, Iowa (Figure 1). For the purpose of this report, the alluvial aquifer will be referred to as the Lower Raccoon River aquifer. The primary objective of this study is to evaluate the water resources of the Lower Raccoon River aquifer under severe drought conditions. The field activities and evaluation was conducted by the Geology and Groundwater Section of the Iowa Department of Natural Resources (IDNR).

## CLIMATE

The climate of central Iowa is classified as sub-humid. Based on data compiled by Iowa State University (Iowa State University, 2012), the average annual precipitation in Dallas and Polk counties ranges from 33 to 34 inches per year. The Des Moines International Airport has averaged 33.8 inches per year from 1893 to present. Approximately 18 to 20 inches of precipitation typically occurs during the months of April through October.

Central Iowa has historically experienced moderate to severe droughts. Table 1 shows the minimum annual precipitation amounts for a select number of cities in central Iowa (Iowa

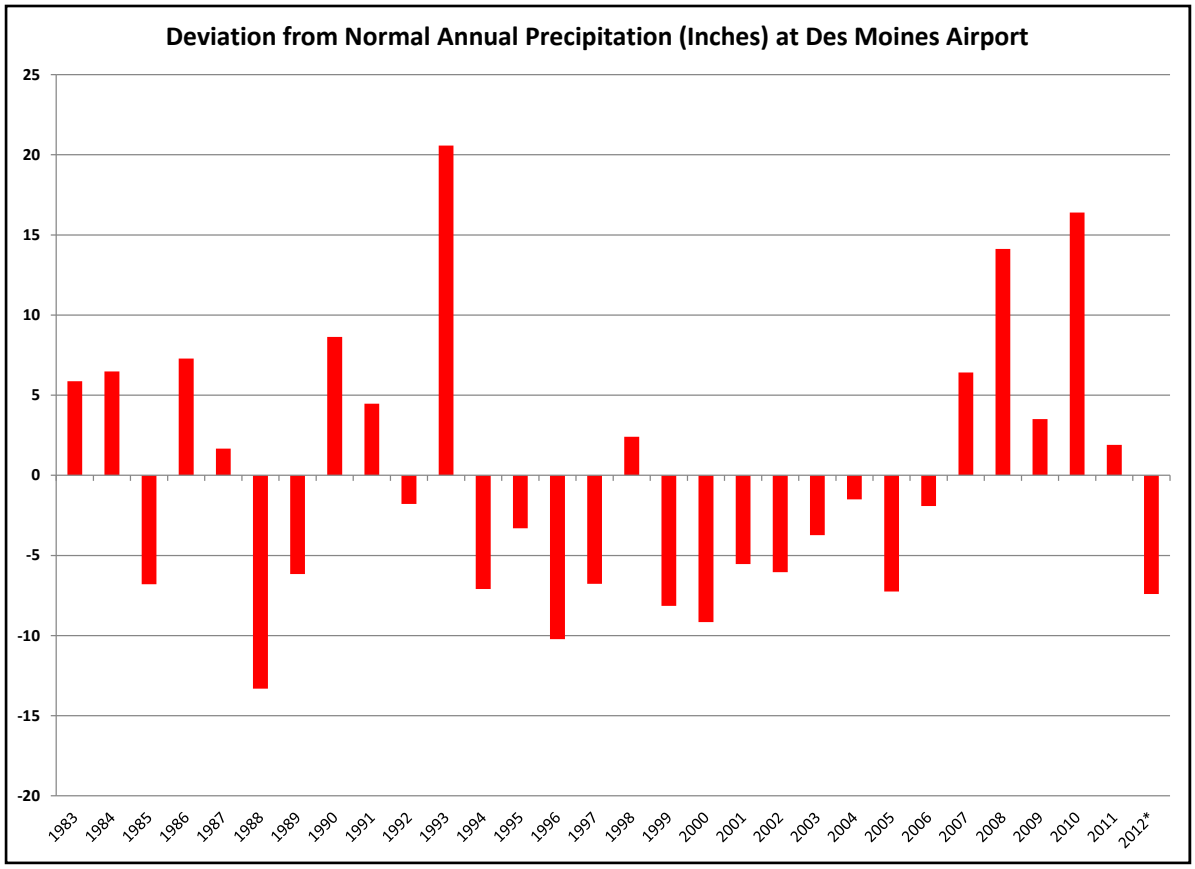



**Figure 2.** Deviations from normal annual precipitation at Des Moines Airport (1983 up to Nov. 1, 2012).

State University, 2012). The minimum annual precipitation amounts ranged from 15.31 inches in Indianola to 17.97 inches in Perry. Figure 2 shows the deviation from normal annual precipitation for the last 30 years at the Des Moines airport. Based on historical precipitation data, there has been an increasing trend in annual precipitation in Des Moines over the last 118 years ranging from 33.09 inches from 1893 to 1922, to 35.3 inches from 1983 to 2012.

## SURFACE WATER

Figure 3 shows the average daily streamflow in the Raccoon River based on the United States Geological Survey (USGS) gaging station near Van Meter, Iowa, over the last 30 years. The lowest average daily flow at Van Meter over the last 30 years was 65 cubic feet per second (cfs) on December 11, 2000, and the lowest recorded average daily flow was 10 cfs measured from January 30 through February 1, 1940.

The Iowa Administrative Code (IAC) 567 Chapter 52.4 has rules that protect consumptive water users during moderate to severe droughts for rivers with watersheds greater than or equal to 50 square miles (this includes the Raccoon River watershed). These rules involve

**Table 1**. Minimum annual precipitation for select communities along the Raccoon River.

| Location | Minimum Inches (Year) |
|---|---|
| Ankeny | 17.52 (1988) |
| Des Moines | 17.07 (1956) |
| Indianola | 15.31 (1894) |
| Perry | 17.97 (1988) |

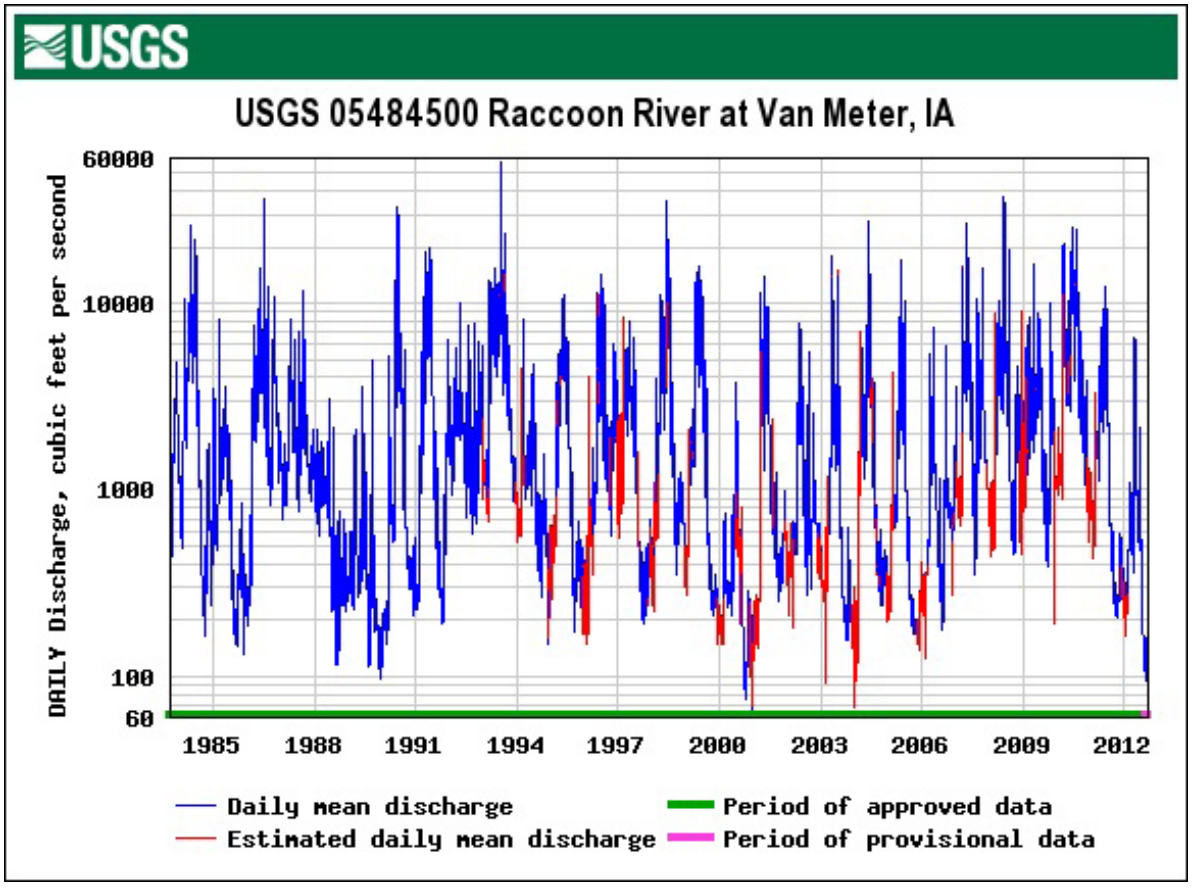



**Figure 3.** Daily average streamflow at USGS Stream gage at Van Meter (1983 to 2012).

the concept of protective low-flow in streams and rivers. The protective low-flow value is defined as the discharge in cfs that is equal to or exceeds this discharge 84 percent of the time over a certain period of time (generally 10 years or more). When streamflow measurements are below the protective low-flow value, withdrawals from irrigation wells and surface water intakes within 1/8 mile from the river must cease. The protected low-flow discharge measurements as listed in Chapter 52.4 for the Van Meter gage is 190 cfs. Table 2 lists the number of times the low-flow value has been reached in any given water year from 1983 to 2012. Note the higher frequency of low streamflow conditions from 1988 through 1989 and 2000 through 2005, and the lack of low streamflow conditions from 2007 to 2011. Low streamflow conditions can be attributed to low average annual rainfall in Des Moines during 1988, 1989, and 2000 through 2005 (Iowa State University, 2012).

In addition to the low-flow values at Van Meter, the Des Moines Water Works is required to maintain minimum streamflows in the Raccoon River at the Interstate 35 bridge, which is downstream of their radial collector wells.

The 7Q10 value is defined as the lowest average flow for seven consecutive days that is expected to occur once over a 10-year period. When streamflow drops below the 7Q10 value, withdrawals from irrigation wells within 1/4 mile from the river and irrigation intakes must cease pumping. The 7Q10

**Table 2.** The number of days streamflow discharge was below USGS low-flow measurements at the USGS Van Meter gage station.

| | # of Exceedances of Chapter 52 low flow | Average Annual Precipitation |
|---|---|---|
| Water Year | Van Meter Gage (190 cfs) | Inches |
| 1983 | 0 | 41.17 |
| 1984 | 3 | 41.78 |
| 1985 | 38 | 28.50 |
| 1986 | 6 | 42.58 |
| 1987 | 0 | 36.97 |
| 1988 | 26 | 21.99 |
| 1989 | 89 | 29.14 |
| 1990 | 31 | 43.93 |
| 1991 | 1 | 39.77 |
| 1992 | 0 | 33.51 |
| 1993 | 0 | 55.88 |
| 1994 | 2 | 28.20 |
| 1995 | 5 | 32.00 |
| 1996 | 5 | 25.08 |
| 1997 | 0 | 28.53 |
| 1998 | 0 | 37.70 |
| 1999 | 7 | 27.15 |
| 2000 | 123 | 26.14 |
| 2001 | 33 | 29.76 |
| 2002 | 1 | 29.25 |
| 2003 | 40 | 31.57 |
| 2004 | 29 | 33.80 |
| 2005 | 59 | 28.05 |
| 2006 | 5 | 33.38 |
| 2007 | 0 | 41.71 |
| 2008 | 0 | 49.43 |
| 2009 | 0 | 38.81 |
| 2010 | 0 | 51.70 |
| 2011 | 0 | 37.20 |
| 2012* | 110 | 23.01 |

*Data from January 1-November 1, 2012

discharge measurements for the Van Meter gaging station based on Chapter 52.4 is 37 cfs. Streamflow values at the Van Meter gaging station did not exceed the 7Q10 discharge throughout the period from January 1, 1983, through September 18, 2012. The last time the streamflow value at Van Meter dropped at or below 37 cfs was October 9 through 12, 1956.

The 1/8 mile low-flow zone and the 1/4 mile 7Q10 zone for the Raccoon River and its major tributaries were delineated using ESRI ArcMap software. One well was located within the protected low-flow zone and a total of four wells were located in the 7Q10 zone (includes the low-flow zone well). The wells found in each of these zones are listed in Table 3. In addition to the wells found within the low-flow zone, three surface water intakes used for irrigation are also listed in Table 3.

**Table 3.** Wells and surface water intakes found in the 1/8 mile and 1/4 mile buffers for protect low-flow and 7Q10 streamflow values.

| Water Use Permit Owner | Type | Buffer Distance from River | Flow Restriction |
|---|---|---|---|
| Glenn Oaks Country Club | 3 Irrigation wells | 1/4-mile | 7Q10 |
| West Des Moines Soccer | Irrigation well | 1/8-mile | Low Flow & 7Q10 |
| Hill Crest Country Club | Surface Intake | Not Applicable | Low Flow & 7Q10 |
| Van Meter Recreation | Surface Intake | Not Applicable | Low Flow & 7Q10 |
| Ruan Jonbar Ranch | Surface Intake | Not Applicable | Low Flow & 7Q10 |

## GEOLOGY

The thickness of alluvial deposits along the Raccoon River varies from two to 60 feet, but averages approximately 30 feet (Iowa Geological Survey, 1979). The alluvial deposits are not uniform or homogeneous but vary from silt and clay to cobbles and boulders (Thompson, 1982). The yields expected in wells screened in these sediments depend on the thickness of alluvium, the grain size or texture, and interconnectedness of the various sand and gravel units.

The Lower Raccoon River aquifer consists of sand, gravel, cobbles, and boulders deposited by the modern river system and is highly variable in both thickness and grain size. Cobble and boulder zones are found near Van Meter, Adel, and in isolated areas throughout the aquifer. Tremendous well yields are produced in these cobble zones. Based on existing data from 139 geologic logs, the sand and gravel thickness is shown on Figure 4. The sand and gravel is overlain by fine-grained sediments that consist of clay, silt, and silty-sand. These finer grained sediments range in thickness from two to 20 feet. The Lower Raccoon River aquifer is underlain by either glacial till, or Pennsylvanian shale and limestone throughout the study area.

## HYDROGEOLOGY

Regional groundwater flow is directed toward the Raccoon River. The hydraulic gradient is assumed to be similar to the land surface topography in most locations, and during most of the year the Raccoon River is a gaining stream. Exceptions to this likely occur during high river stage when temporary bank storage may cause a transient reversal in flow direction, and near high capacity wells where pumping stress may reverse the groundwater flow direction and create induced recharge from the river into the aquifer. Groundwater recharge sources are precipitation, induced recharge from surface water, and seepage from glacial drift and terraces along the valley wall.

It is difficult to measure the groundwater recharge based on annual precipitation data. In Iowa much of the groundwater recharge occurs in the early spring and fall. The actual amount of groundwater recharge depends on the intensity and distribution of the precipitation events, and when they occur seasonally.

### Groundwater Storage and Availability

Based on a surface area of approximately 32 square miles within our study area (Figure 1), an average saturated aquifer thickness of 20 feet, and an effective porosity of 25 percent, approximately 33 billion gallons of groundwater is stored in the Lower Raccoon River aquifer within our study area. Based on an average recharge of six inches per year, approximately 3.2 billion gallons per year (bgy) of water recharges the aquifer directly as precipitation (based on modeling result). Based on a severe drought recharge of three inches per year, approximately 1.6 billion gallons of water recharges the aquifer (based on modeling result). The amount of induced recharge from

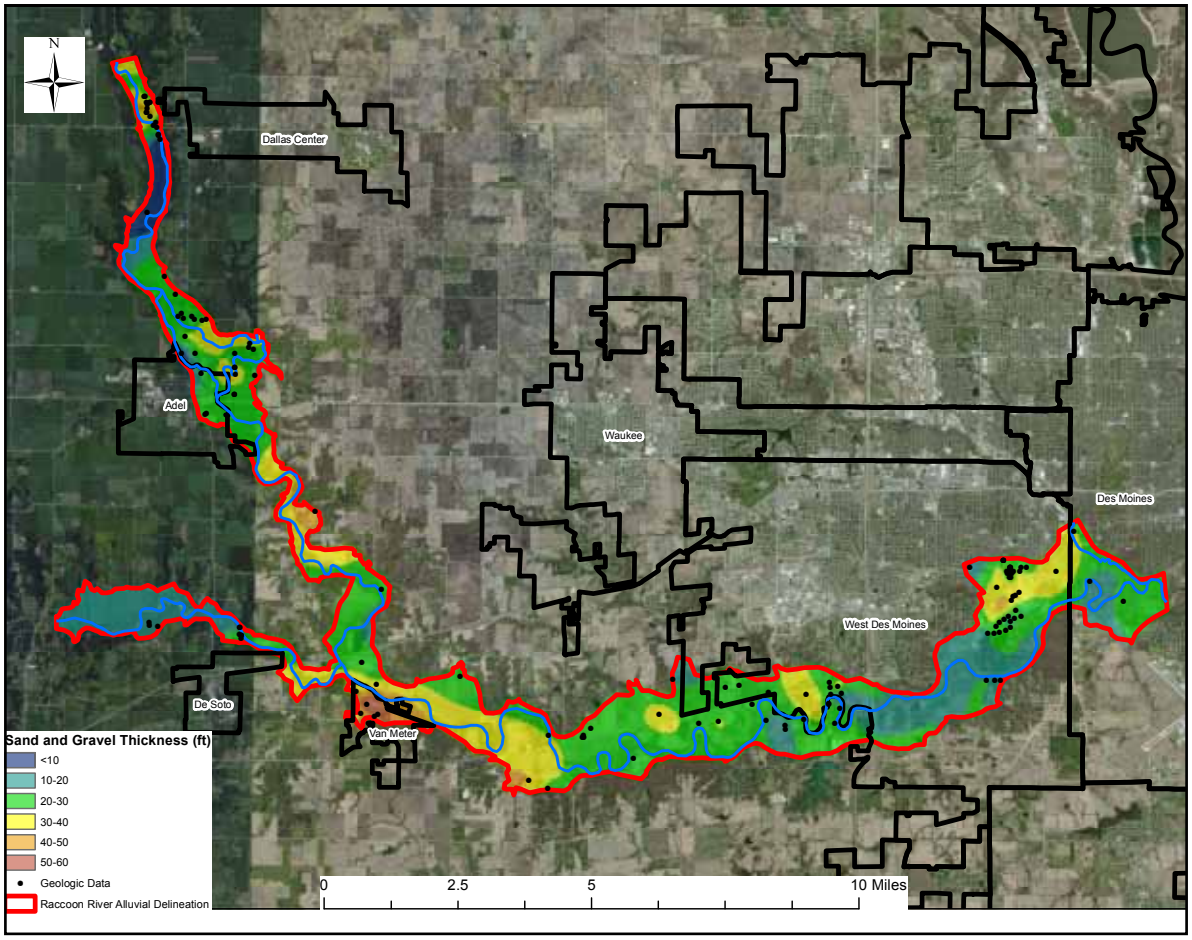



**Figure 4**. Isopach (thickness) map of the Lower Raccoon River aquifer and its tributaries.

the Raccoon River, its tributaries, and the many sand and gravel quarries was estimated using Visual MODFLOW, and will be discussed in the Groundwater Modeling section. The other important water supply consideration is the impact caused by local pumping stress, which is different than the aquifer average storage or recharge. The application of a calibrated groundwater flow model will help evaluate the local water concerns, and will be discussed in the Groundwater Modeling section of this report.

Total current groundwater use for the study area, not including private wells, is approximately 7.77 bgy. Approximately 5.1 bgy is removed by the six Des Moines Water Works radial collector wells. The Des Moines Water Works infiltration gallery located on Fleur Drive also removes 6.9 bgy, but is approximately four miles downstream of our study area. The radial collector wells and infiltration gallery receive the vast majority of their recharge from the Raccoon River, and the water pumped from these wells is considered groundwater under the direct influence of surface water.

## Public Drinking Water Wells

Thirteen public water supplies are located within the study area. They include the City of Adel (four active alluvial wells), City of Dallas Center (four active alluvial wells), Des Moines

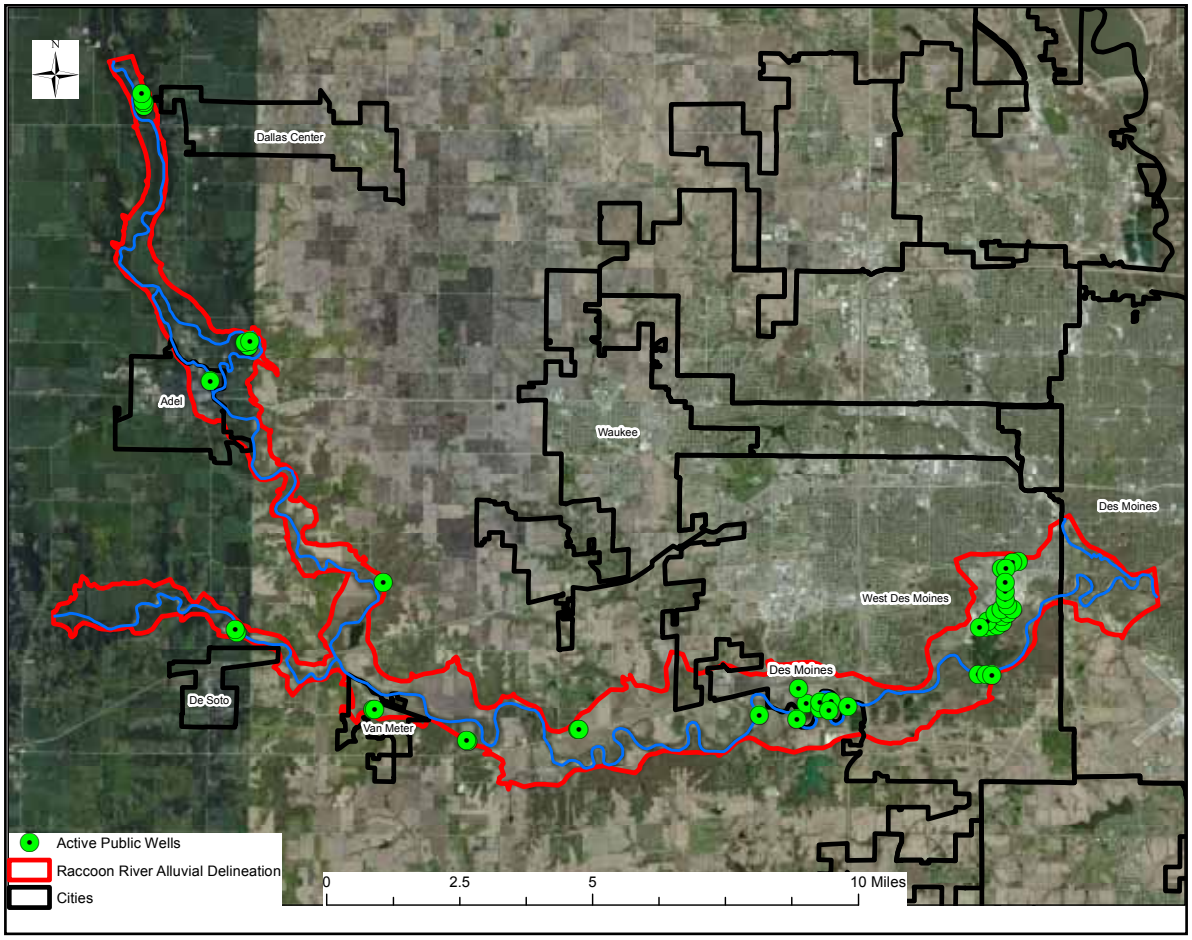



**Figure 5.** Location of active public wells in the Lower Raccoon River aquifer.

Water Works (six radial collector wells), City of De Soto (two active alluvial wells), City of Van Meter (two active alluvial wells), City of West Des Moines (19 active alluvial wells), Beach Girls (one active alluvial well), River Oaks Development (one active alluvial well), Fox Creek Water District (two active alluvial wells), Prairie Village mobile home park (2 active alluvial wells), Southwest Polk Water Supply (3 active alluvial wells), West Grand Golf Course (1 active alluvial well), and Wildwood Water Corporation (1 active alluvial well). The locations of the public wells within the aquifer are shown in Figure 5. Total permitted annual water use is shown in Table 4.

## Irrigation Wells

A large percentage of the land use in the study area is in row crop agriculture. Some of the corn acreage is irrigated due to the sandy soil in the valley. In addition to agricultural irrigation, four golf courses (three have irrigation wells and one has a surface water intake) and one soccer facility also have water use permits. There are eight known irrigation wells identified within the study area (Figure 6). Maximum annual irrigation water usages were obtained from the IDNR water-use database and are listed in Table 4. The actual pumping rate per well is unknown, and the withdrawal per well is

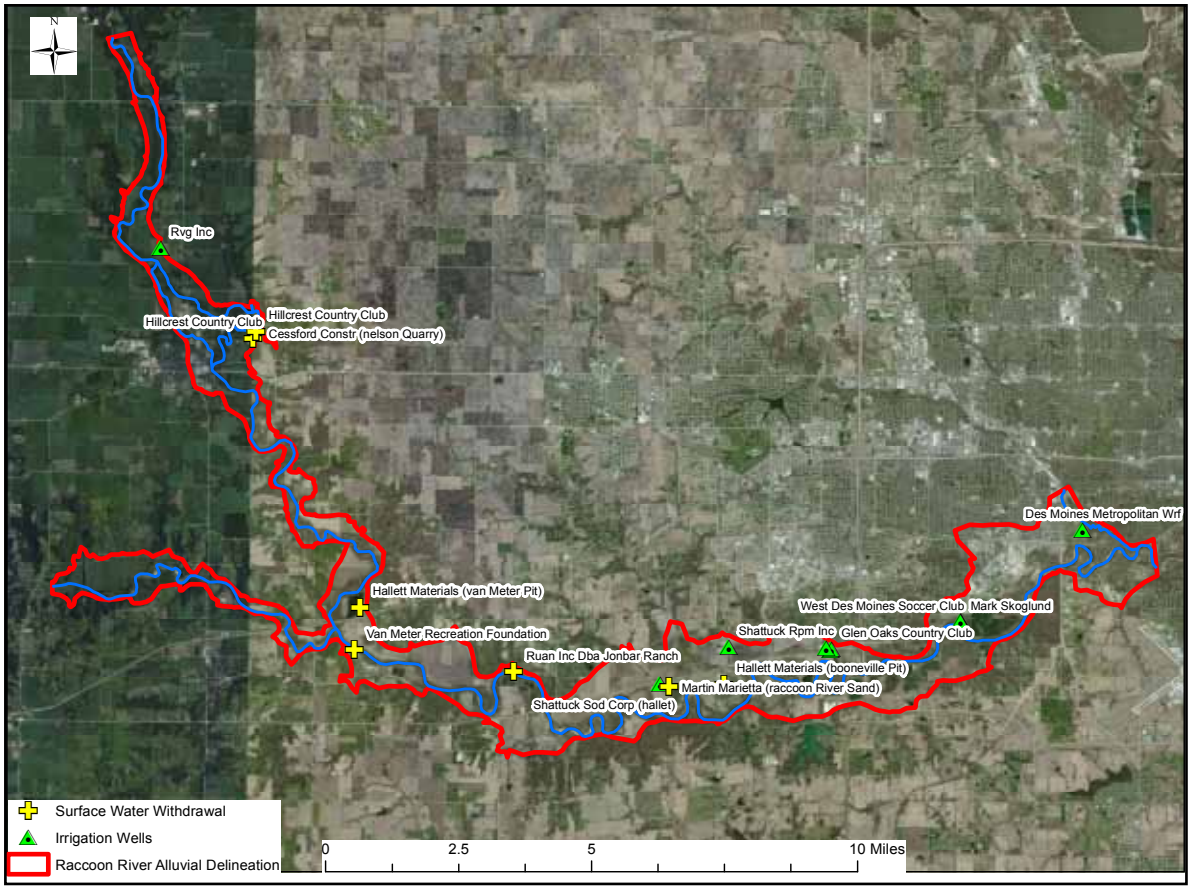



**Figure 6.** Location of irrigation wells and surface water intakes in Lower Raccoon River aquifer.

**Table 4.** Permitted water use and actual water use for public, industrial, and irrigation wells in the Lower Raccoon River aquifer.

| Water Use Permit Owner | Type | Permited Usage (mgy) | Maximum Historical Actual Usage (mgy) |
|---|---|---|---|
| Shattluck RMP (Dallas Co.) | Irrigation well | 68.4 | 16.1 |
| Shattluck RMP (Polk Co.) | Irrigation well | 65.2 | 5.4 |
| Shattluck Sod Farm | Irrigation well | 48.9 | 1.3 |
| Glenn Oaks Country Club | 3 Irrigation wells | 73.3 | 47.7 |
| West Des Moines Soccer | Irrigation well | 16.0 | 1.2 |
| Des Moines Water | Wells | 2.3 | 0.0 |
| RVG Golf Course | Irrigation well | 40.4 | 25.1 |
| Hill Crest Country Club | Surface Intake | 32.6 | 21.5 |
| West Grand Golf Course | Public Water Supply | Not Available | 0.1 |
| Van Meter Recreation | Surface Intake | 9.1 | 0.0 |
| Ruan Jonbar Ranch | Surface Intake | 137.8 | 0.0 |
| Hallett Material Van Meter | Quarry de-watering | 252.0 | 17.1 |
| Hallett Material Booneville | Quarry de-watering | 1303.0 | 0.0 |
| Martin Marietta (Raccoon River) | Quarry de-watering | 263.0 | 13.1 |
| Prairie Village MHP (2 wells) | Public Water Supply | Not Available | 2.7 |
| Fox Creek Water Dist. (2 wells) | Public Water Supply | 51 | 40.1 |
| River Oaks Development | Public Water Supply | Not Available | 2.9 |
| Van Meter (2 wells) | Public Water Supply | 32 | 34.3 |
| Beach Girls | Public Water Supply | Not Available | 0.3 |
| Southwest Polk (3 wells) | Public Water Supply | 24 | 13.4 |
| De Soto (2 Wells) | Public Water Supply | 40 | 35.2 |
| West Des Moines (19 Wells) | Public Water Supply | 2990 | 2153 |
| Wildwood Water Corporation | Public Water Supply | 18 | 5 |
| Adel (4 Wells) | Public Water Supply | 375 | 157.9 |
| Dallas Center (4 Wells) | Public Water Supply | 88 | 66.9 |
| Des Moines Water Works (6 Radial wells) | Public Water Supply | Not Available | 5110 |

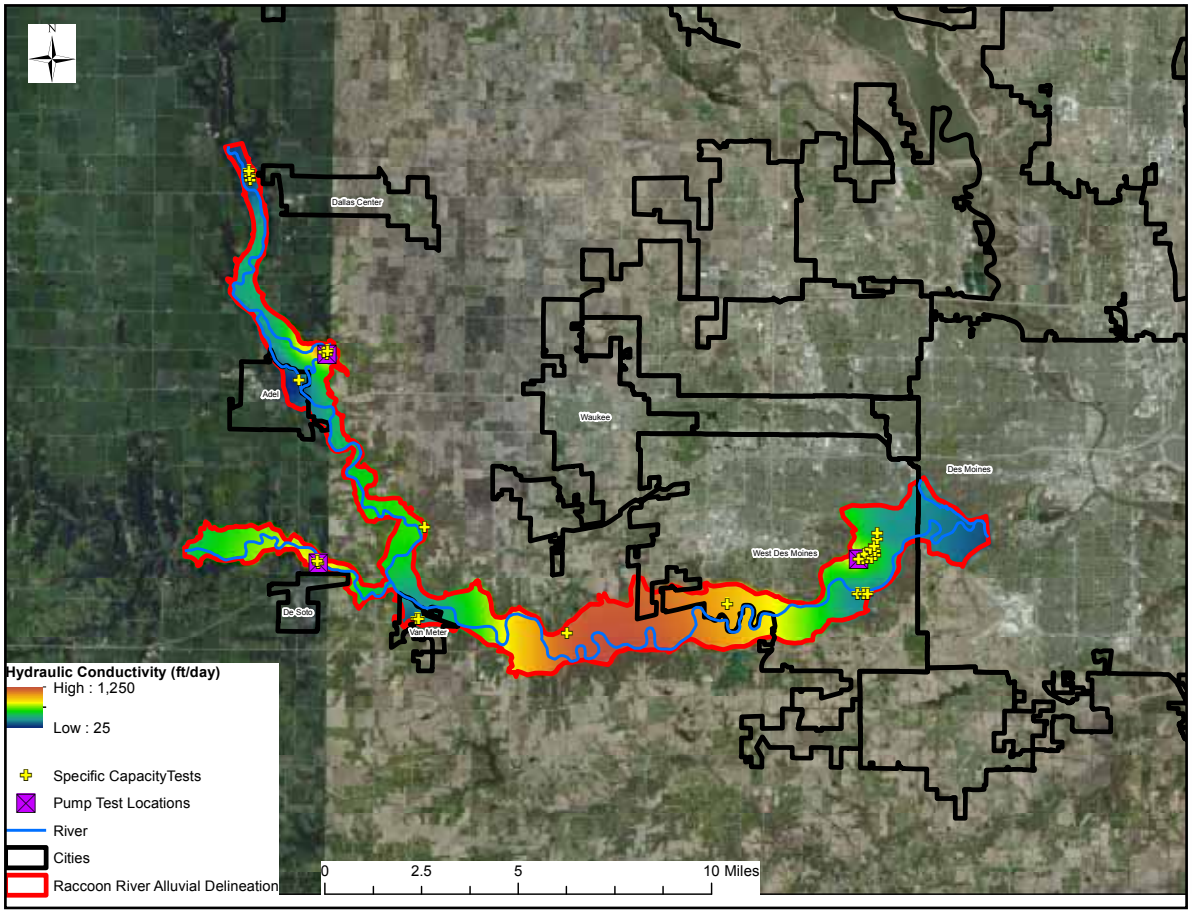



**Figure 7.** Aquifer test locations in the Lower Raccoon River aquifer and the horizontal hydraulic conductivity distribution.

the average based on the total usage divided by the number of known irrigation wells.

## Aquifer Test Results

Hydraulic properties are used to define and characterize aquifers and include specific yield or storage, transmissivity, and hydraulic conductivity. The most reliable aquifer properties are those obtained from controlled aquifer tests with known pumping rates, pumping duration, accurate well locations, and accurate water level measurements. Four new aquifer pump tests were conducted in the Lower Raccoon River aquifer and include Adel Well 1, De Soto Well 1, and two pump tests using West Des Moines Well 21.

In addition to the aquifer pump tests, a total of 31 specific capacity tests were made available by various consultants, well drillers, and communities. The distribution of these tests is shown in Figure 7. Table 5 lists the pump test results and the specific capacity results for each test, the method of analyses, transmissivity values, aquifer thickness, hydraulic conductivity values, and storativity values (aquifer pump test results only). Original data and graphs of the test results are shown in Appendix A.

Based on aquifer test results, the transmissivity of the Lower Raccoon River aquifer was found to range from 1,500 feet$^2$/day at Dallas Center Well 8 to 44,000 feet$^2$/day at Adel Well 1. The arithmetic mean transmissivity value is 8,300 feet$^2$/day. The relatively high transmis-

**Table 5.** Aquifer pump test results for wells open in the Lower Raccoon River aquifer. (Methods based on Freeze and Cherry, 1979.)

| Wnumber | Well Name | Well Depth (ft) | Thickness (ft) | Method | Transmissivity (ft2/day) | Hydraulic Conductivity (ft/day) | Storativity |
|---|---|---|---|---|---|---|---|
| 37863 | Fox Creek #3 | 48 | 25 | Specific Capacity | 16600 | 664 | Not Applicable |
| 57592 | Van Meter #3 | 66 | 32 | Specific Capacity | 2857 | 89 | Not Applicable |
| 42693 | Van Meter #2 | 61 | 50 | Specific Capacity | 7200 | 144 | Not Applicable |
| 39235 | West Grand Golf #1 | 42 | 37 | Specific Capacity | 20000 | 541 | Not Applicable |
| 42737 | Southwest Polk #4 | 38 | 24 | Specific Capacity | 3200 | 133 | Not Applicable |
| 42735 | Southwest Polk #2 | 37 | 23 | Specific Capacity | 4400 | 191 | Not Applicable |
| 42736 | Southwest Polk #3 | 38 | 24 | Specific Capacity | 3300 | 138 | Not Applicable |
| 38719 | De Soto #1 | 40 | 22 | Specific Capacity | 1960 | 89 | Not Applicable |
| 53395 | De Soto #2 | 46 | 22 | Specific Capacity | 4700 | 214 | Not Applicable |
| 40319 | West Des Moines 20 | 36 | 27 | Specific Capacity | 5600 | 207 | Not Applicable |
| 40317 | West Des Moines 18 | 41 | 26 | Specific Capacity | 9600 | 369 | Not Applicable |
| 40316 | West Des Moines 17 | 38 | 28 | Specific Capacity | 9000 | 321 | Not Applicable |
| 56849 | West Des Moines 16 | 32 | 25 | Specific Capacity | 7500 | 300 | Not Applicable |
| 40318 | West Des Moines 19 | 43 | 30 | Specific Capacity | 8100 | 270 | Not Applicable |
| 56848 | West Des Moines 15 | 34 | 23 | Specific Capacity | 8100 | 352 | Not Applicable |
| 56847 | West Des Moines 14 | 35 | 20 | Specific Capacity | 8100 | 405 | Not Applicable |
| 56850 | West Des Moines 22 | 45 | 18 | Specific Capacity | 5600 | 311 | Not Applicable |
| 43093 | West Des Moines 9 | 42 | 24 | Specific Capacity | 4000 | 167 | Not Applicable |
| 43092 | West Des Moines 8 | 42 | 34 | Specific Capacity | 6600 | 194 | Not Applicable |
| 37867 | Wildwood | 45 | 25 | Specific Capacity | 8400 | 336 | Not Applicable |
| 34350 | Adel #5 | 59 | 43 | Specific Capacity | 1740 | 40 | Not Applicable |
| 34348 | Adel #2 | 45 | 28 | Specific Capacity | 12993 | 464 | Not Applicable |
| 34351 | Adel #3 | 42 | 11 | Specific Capacity | 20130 | 1830 | Not Applicable |
| 34349 | Adel #1 | 44 | 33 | Specific Capacity | 6800 | 206 | Not Applicable |
| 38704 | Dallas Center 7 | 57 | 26 | Specific Capacity | 2000 | 77 | Not Applicable |
| 45615 | Dallas Center 9 | 49 | 34 | Specific Capacity | 5500 | 162 | Not Applicable |
| 37884 | Dallas Center 8 | 50 | 25 | Specific Capacity | 1500 | 60 | Not Applicable |
| 59770 | W. Des Moines Soccer | 28 | 18 | Specific Capacity | 2000 | 111 | Not Applicable |
| 47069 | Glenn Oaks #3 | 48 | 33 | Specific Capacity | 16700 | 506 | Not Applicable |
| 47067 | Glenn Oaks #1 | 41 | 13 | Specific Capacity | 7500 | 577 | Not Applicable |
| 37861 | East Dallas | 32 | 19 | Specific Capacity | 3300 | 174 | Not Applicable |
| 34349 | Adel #1 | 44 | 30 | Cooper-Jacobs | 44000 | 1467 | 0.5 |
| 40320 | W. Des Moines OB1 | 37 | 20 | Theis | 13700 | 685 | 0.01 |
| 40320 | W. Des Moines OB2 | 37 | 20 | Theis | 14600 | 730 | 0.2 |
| 38719 | De Soto #1 | 40 | 31 | Cooper-Jacobs | 14700 | 474 | 0.05 |

sivity values near Adel are the result of cobble and boulder zones found near the base of the alluvial aquifer.

Hydraulic conductivity can be calculated by dividing the transmissivity by the overall aquifer thickness. Hydraulic conductivity was found to range from 40 to 1,830 feet/day, with an arithmetic mean of 360 feet/day. The regional horizontal hydraulic conductivity distribution is shown on Figure 7 and is based on data found in Table 5.

## Estimated Well Yield

The potential well yield was estimated by converting the transmissivity value to specific capacity (Table 5) and multiplying by one-half of the saturated sand and gravel thickness (average value of the available head in the Lower Raccoon River aquifer). The potential well yield distribution is shown on Figure 8. Potential well yields greater than 500 gallons per minute (gpm) may be possible near Adel, Van Meter, and West Des Moines. The highest potential well yields occur east of Adel. Actual well yields may vary considerably from those shown on Figure 8 due to local conditions.

## GROUNDWATER MODELING

The model software Visual MODFLOW version 2011.1 was used to simulate the groundwater flow in the alluvial aquifer in the proposed study area under severe drought conditions. A three-layered model was used for the simulation. Borehole logs were obtained from the IDNR GEOSAM database, and elevation data were obtained from LiDAR (two-foot contour intervals). The model boundary conditions and inputs include the following:

- Layer 1 varies in thickness from 11 feet to 25 feet, and is primarily silty sand. The horizontal hydraulic conductivity was assigned a value of 25 feet/day. The verti-

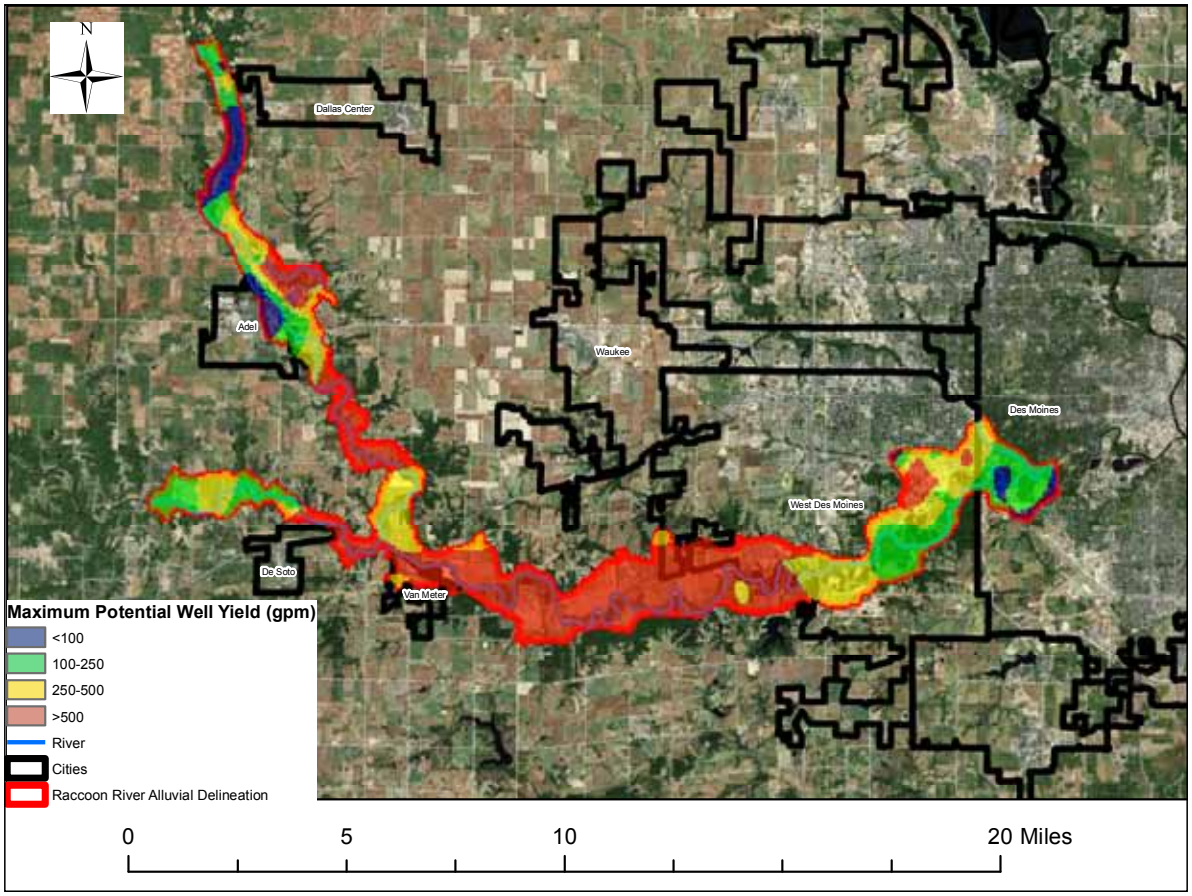



**Figure 8.** Potential maximum well yield in gallons per minute (gpm) based on specific capacity values and available drawdown.

cal hydraulic conductivity value was assigned a value 1/10 of the horizontal hydraulic conductivity.

- Layer 2 is the sand and gravel aquifer. The horizontal hydraulic conductivity was calibrated within the model and is shown in Figure 7. The vertical hydraulic conductivity value was assigned a value 1/10 of the horizontal hydraulic conductivity.
- Layer 3 is primarily silty clay (glacial till or shale). The horizontal hydraulic conductivity was assigned a value of 0.03 feet/day. The vertical hydraulic conductivity value was assigned a value 1/10 of the horizontal hydraulic conductivity.
- The uplands were considered no-flow boundaries. This was represented by de-activating the grids outside the alluvial aquifer boundary. This was estimated using Natural Resources Conservation Service (NRCS) soils data and LiDAR elevation data.
- The Raccoon River and its tributaries were represented as river boundaries. The surface water elevations were estimated using stage data from USGS gage stations near Van Meter, West Des Moines, and at 63rd Street in Des Moines. LiDAR data was used to supplement river elevations between gage stations. A water level depth of 1 foot was used. The vertical conductivity of the streambed was estimated at 1/10 the average horizontal

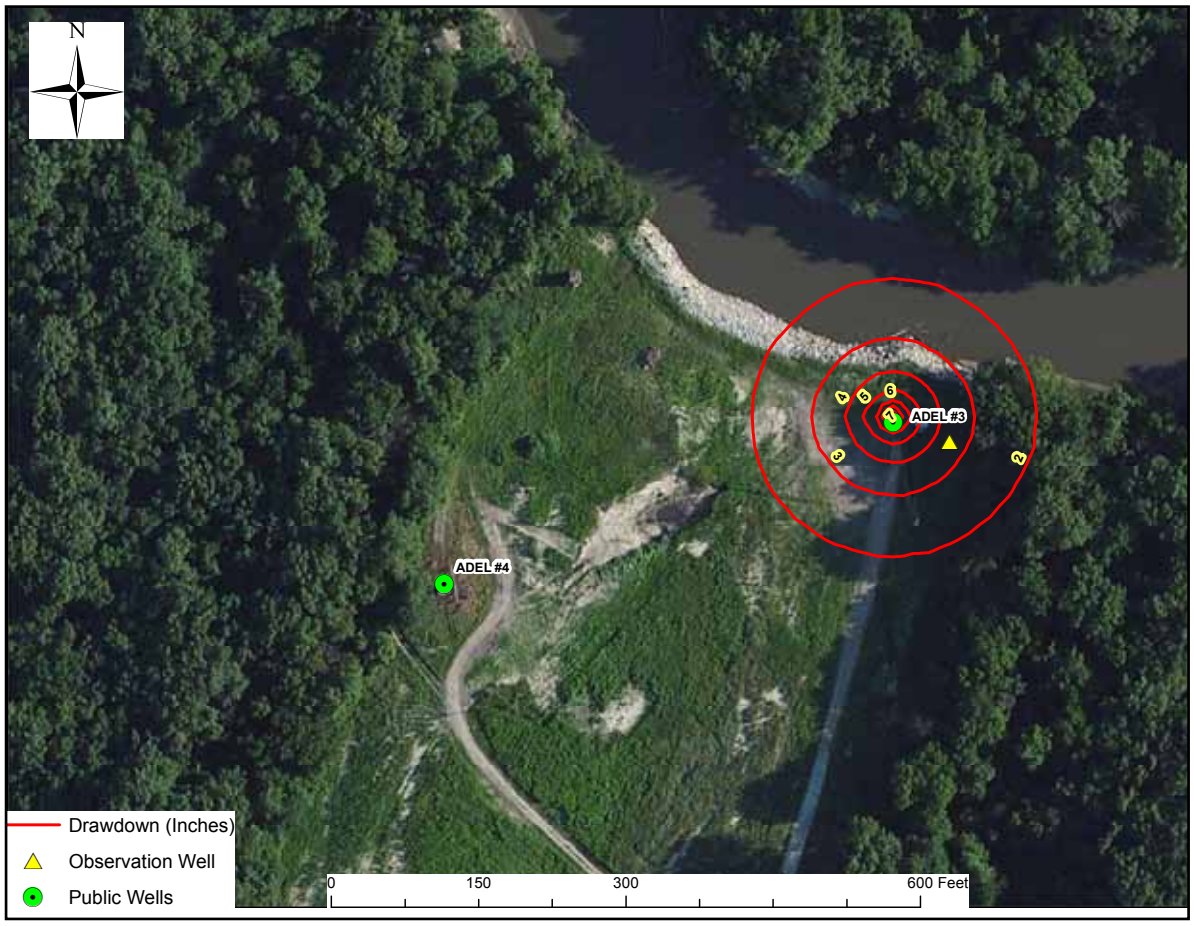



**Figure 9.** Simulated drawdown in feet for the City of Adel pump test.

conductivity of the alluvial aquifer. The model represented baseflow (summertime) conditions, and the stage was kept the same throughout the simulated time period.

- General head boundaries were used in the numerous sand and gravel pits in the area. These general head values were obtained from LiDAR elevation data.
- General head boundaries were used to represent smaller tributaries and benches. Groundwater elevations were estimated from the closest well or observation point.
- Public wells and additional water use wells were included in the model simulation. Annual usage was obtained from the IDNR water-use database for year 2011. Additional information was obtained from the water operators in De Soto, Adel, West Des Moines, and Des Moines Water Works.
- Specific yield values ranged from 0.1 to 0.2, and were based on the pump test results. Specific storage values ranged from 0.0002 and 0.003.
- Average annual recharge was calibrated to be six inches per year. Drought conditions were calibrated to be three inches per year.
- The total number of rows and columns were 463 by 474. The grid size varied from 7.5 feet to 290 feet.

## Calibration Results

The model was initially run to simulate non-pumping conditions. The model was calibrated using static water levels measured in IDNR

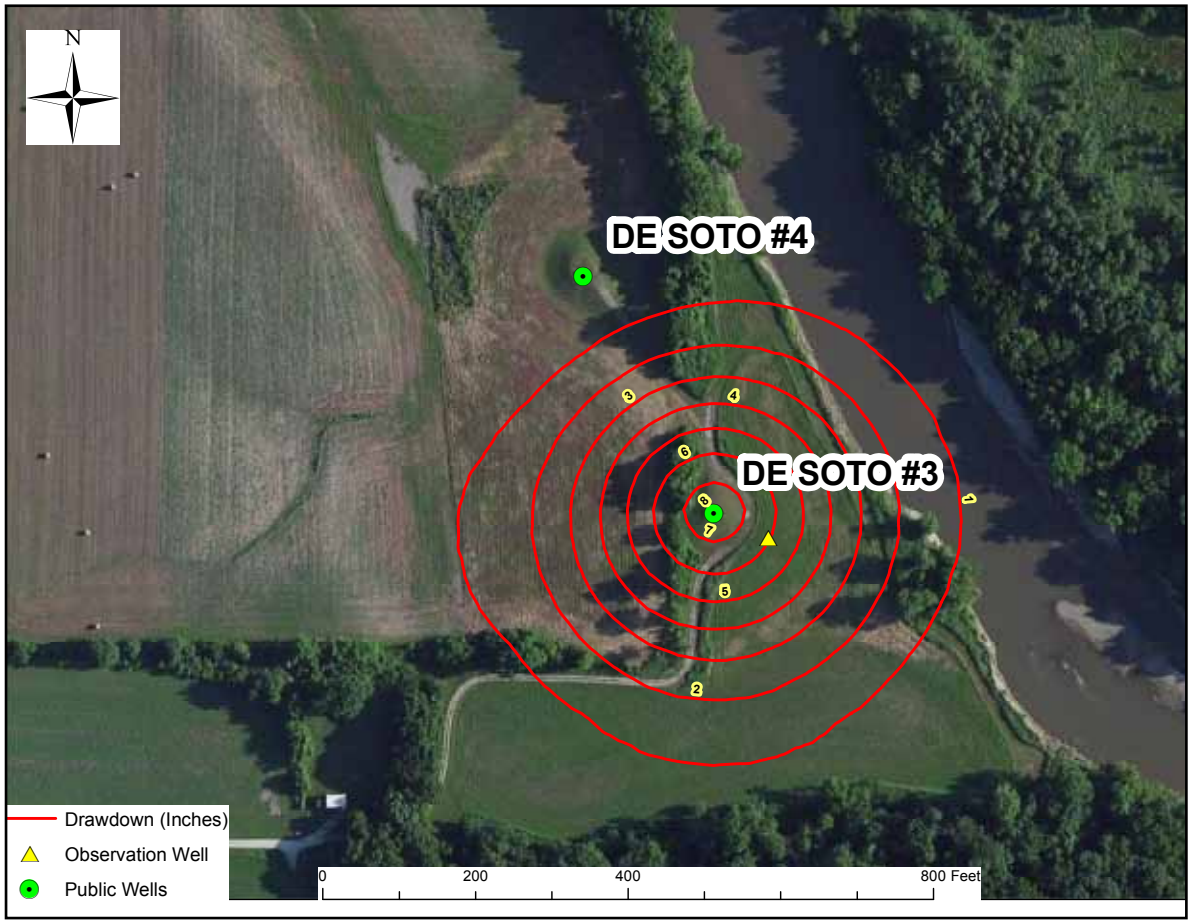



**Figure 10.** Simulated drawdown in feet for the City of De Soto pump test.

observation wells and non-pumping production wells. Table 6 compares simulated values to observed water levels. The overall error was -1.8 feet for the nine observation wells.

Local scale calibration was performed using pump test results from City of Adel Well 2, City of De Soto Well 1, and City of West Des Moines well 21 (using two observation wells). Hydraulic conductivity and specific yield values were adjusted to match the simulated water levels to the observed values. Figures 9, 10, and 11 show the simulated drawdown values. The simulated versus observed drawdowns are shown in Table 7. Figure 12 shows the simulated drawdown map for the Lower Raccoon River aquifer using data from the summer of 2012.

**Table 6.** Observed versus simulated head elevations for steady-state non-pumping conditions.

| | Observed | Simulated |
|---|---|---|
| **Well Owner** | **Head Elev. (ft)** | **Head Elev. (ft)** |
| RVG Golf Course | 881.27 | 880.91 |
| Adel Observation Well | 870.12 | 871.89 |
| Wildwood | 853.00 | 852.70 |
| De Soto Observation Well | 850.67 | 850.70 |
| Fox Creek | 833.15 | 833.55 |
| East Dallas | 819.28 | 817.90 |
| West Des Moines Soccer | 803.99 | 803.08 |
| West Des Moines #21 | 799.99 | 801.93 |
| Des Moines MET | 799.99 | 800.62 |

**Table 7.** Observed versus simulated drawdowns in feet for aquifer pump tests.

| | Observed | Simulated |
|---|---|---|
| **Well Owner** | **Drawdown (ft)** | **Drawdown (ft)** |
| Adel Observation Well | 0.27 | 0.31 |
| De Soto Observation Well | 0.67 | 0.54 |
| West Des Moines #21 OB 1 | 1.95 | 1.96 |
| West Des Moines #21 OB 2 | 0.66 | 0.95 |

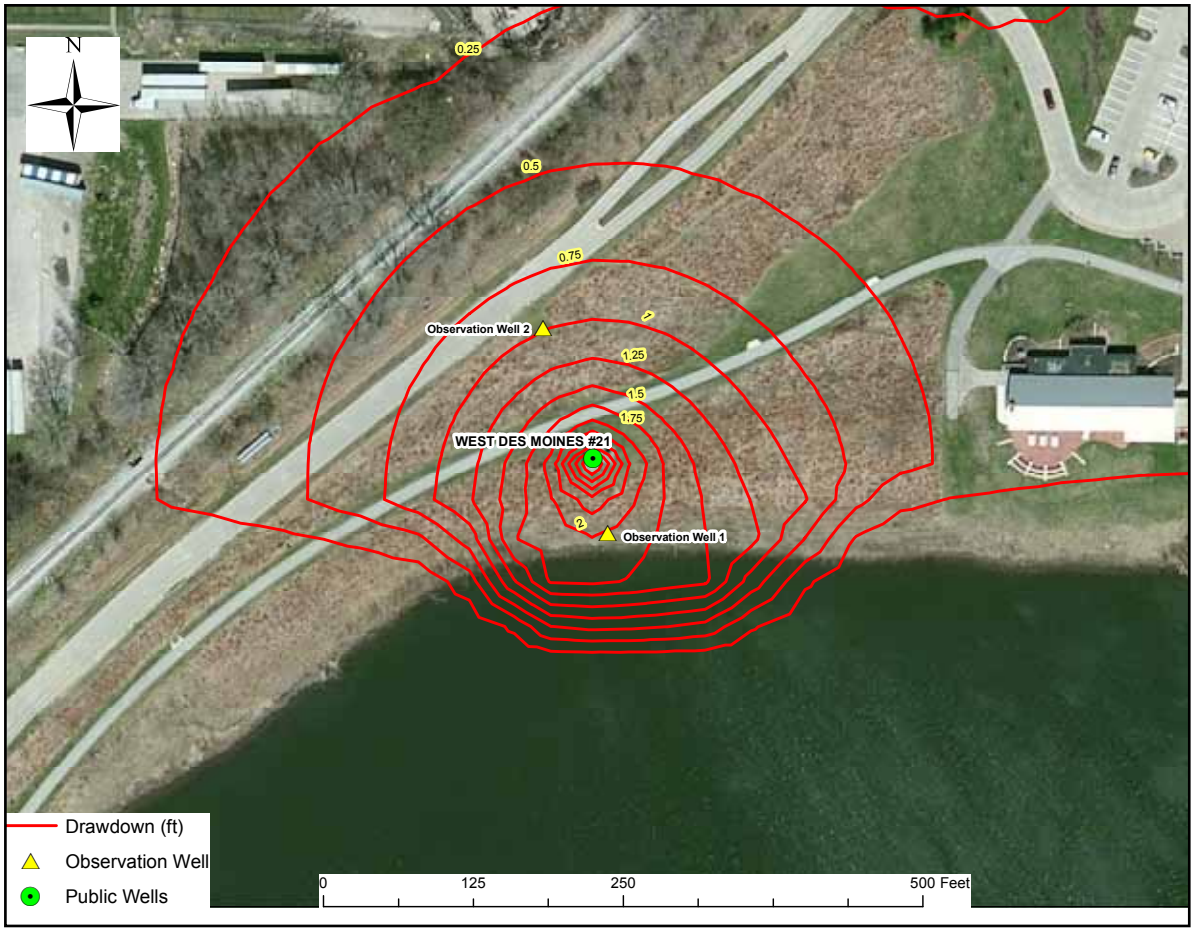



**Figure 11.** Simulated drawdown in feet for the City of West Des Moines pump test.

## MODFLOW Simulations

Following the calibration of the model, several simulations were conducted to simulate a severe drought. Pumping rates for the known public wells were obtained from city water operators, and represent the water use during the summer of 2012. The pumping rates for the irrigation wells and other water use wells were the maximum historical seasonal withdrawals listed in Table 4.

**Table 8.** Simulated source water capture zones for select public water systems

| Community | Number of Active Wells |
|---|---|
| City of Dallas Center | 4 |
| City of De Soto | 2 |
| City of Van Meter | 2 |
| Southwest Polk Water District | 3 |
| City of West Des Moines | 19 Alluvial Wells |

### Time of Travel Results

Using the particle tracking module in Visual MODFLOW, groundwater movement or travel time was simulated for the public water systems listed in Table 8. The City of Adel wells and the Des Moines Water Works radial collector wells were not modeled using particle tracking because most, if not all, of the recharge was provided by the former sand and gravel quarries and the nearby Raccoon River.

The particle tracking results can be used to evaluate the source water capture zones. The 2-, 5-, and 10-year capture zones were evaluated for

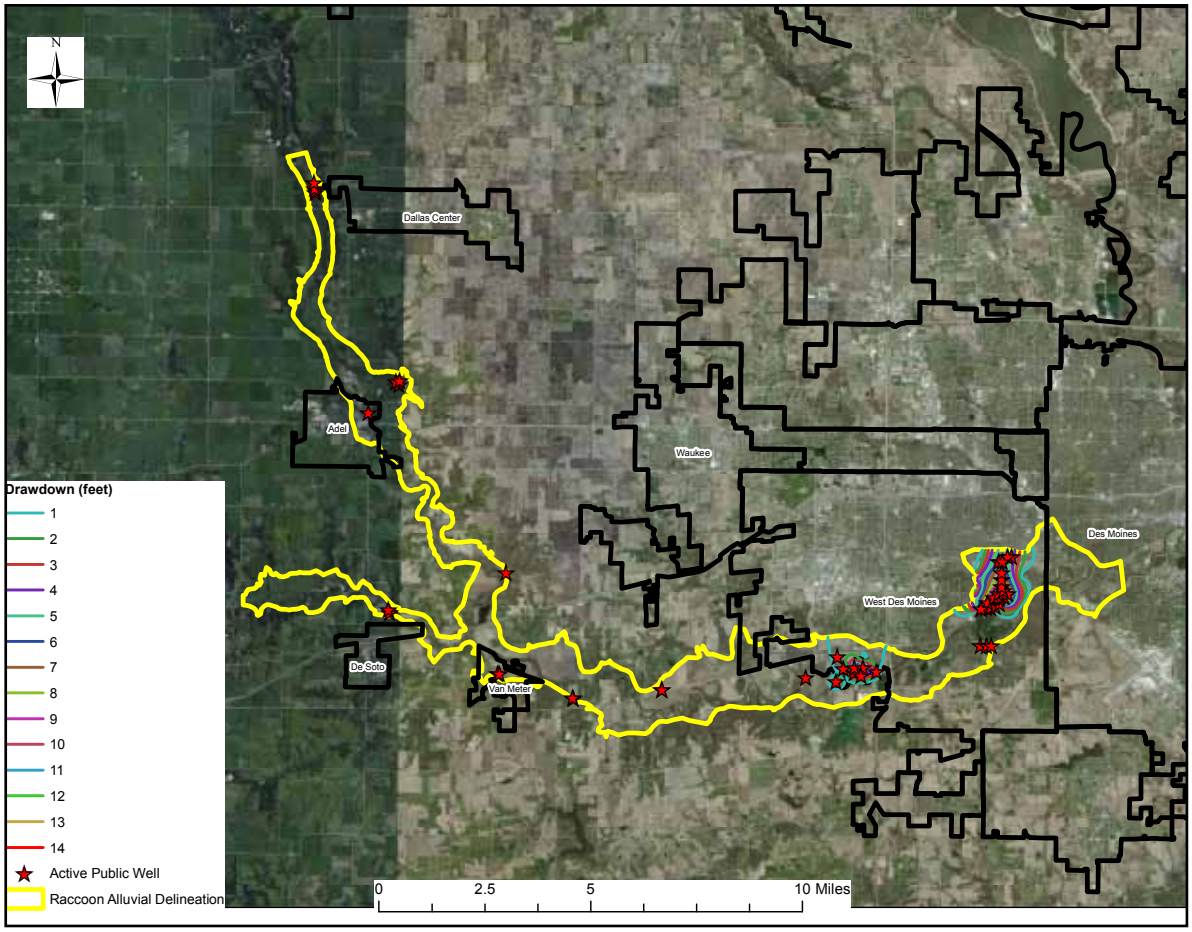



**Figure 12.** Simulated drawdown in feet for the Lower Raccoon River aquifer under drought conditions.

the public water systems listed in Table 8, and are shown in Figures 13, 14, 15, 16, and 17. The Source Water Protection program can use these capture zones to prioritize potential point and non-point sources of contamination, and implement best management practices. These best management practices have the potential to improve and/or protect an aquifer's long-term water quality. Source Water Protection is a U.S. Environmental Protection Agency program designed to improve water quality in public water supplies.

In addition to the capture zone analyses, the time of travel was used to evaluate the plume migration at the former Turbine Fuel/Delevan contaminant site (Delevan Site) located at 2250 Fuller Road, West Des Moines, Iowa (Figure 18). The time of travel analyses assumes that the contaminant plume would migrate at the same rate as the average groundwater flow velocity. It does not take into account any bio-degradation or natural attenuation. The migration of the contaminant plume also depends on the pumping schedule of the City of West Des Moines alluvial wells. When City Well 21 is not pumping, the particle tracking indicates that the contamination would make it to Well 19 in approximately 800 days or 2.2 years as shown in Figure 18. If Well 19 is not pumping, the particle tracking indicates that the contamination would make it to Well 21 in approximately 600 days or 1.6 years as shown in Figure 19. Based on information provided in the IDNR

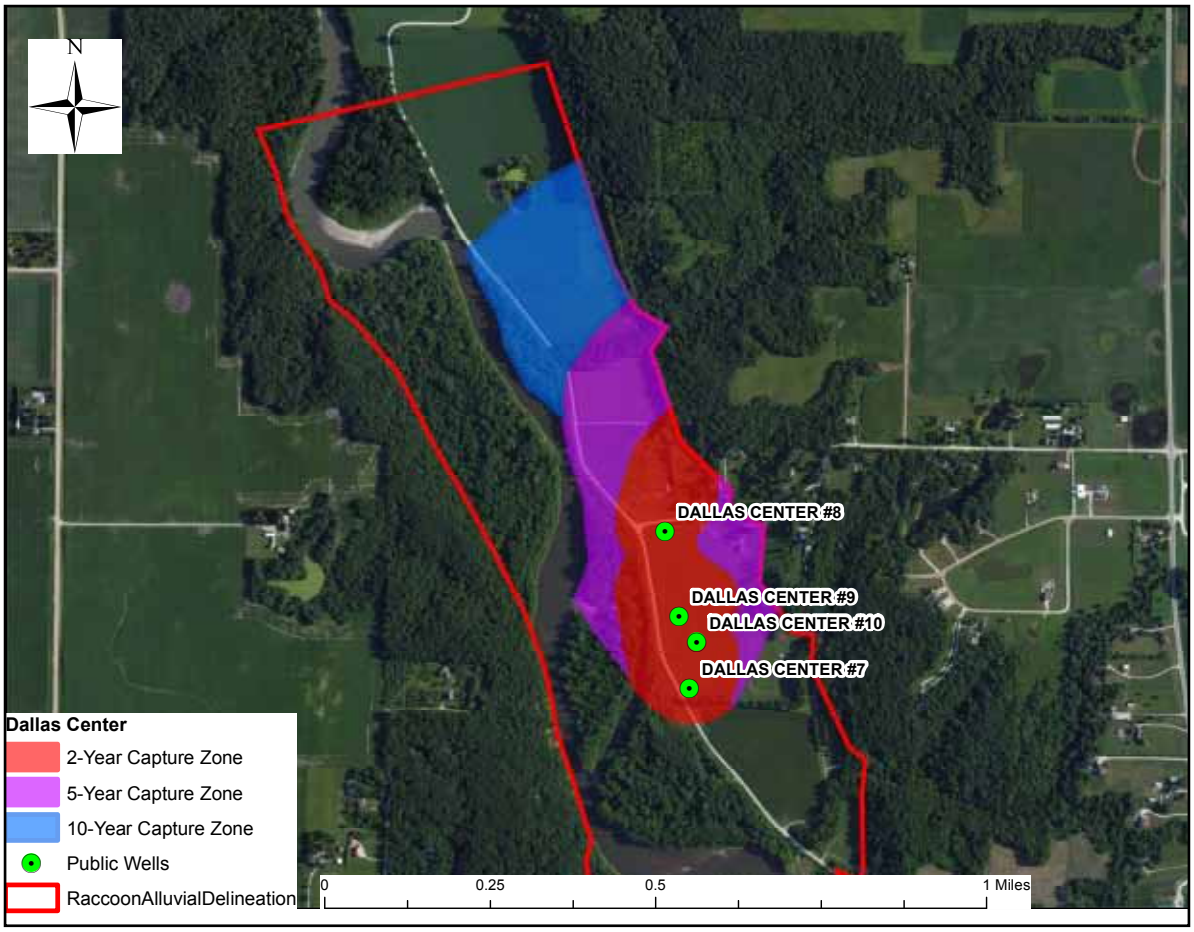



**Figure 13.** Source water capture zones for the City of Dallas Center using Visual MODFLOW particle tracker.

Contaminated Sites database, both City Wells 19 and 21 have detected contaminants associated with the Delevan Site.

### Water Balance Analysis

Based on the mass balance output from Visual MODFLOW, the percentage of water production supplied by the induced recharge from the Raccoon River during a severe drought was 52 percent, and 29 percent was supplied by induced recharge from the sand and gravel quarries. The remaining 19 percent of the water production is supplied by precipitation recharge and groundwater inflow into the model area.

The total water balance was broken down into smaller areas or zones as shown in Table 9, and the percentage of induced river recharge, induced recharge from quarries, precipitation recharge, aquifer storage, and groundwater inflow were calculated. The percentage of induced recharge varied from 0 percent at Van Meter, to 89 percent at Des Moines Water Works radial wellfield. The City of West Des Moines had the highest percentage of induced recharge from former sand and gravel quarries at 60 percent.

Based on the mass balance output from Visual MODFLOW, the induced recharge provided by the Raccoon River during a severe drought was calculated to be 11.08 mgd or 17.1 cfs. Based on data from the USGS gage station near Van Meter, the lowest average daily flow

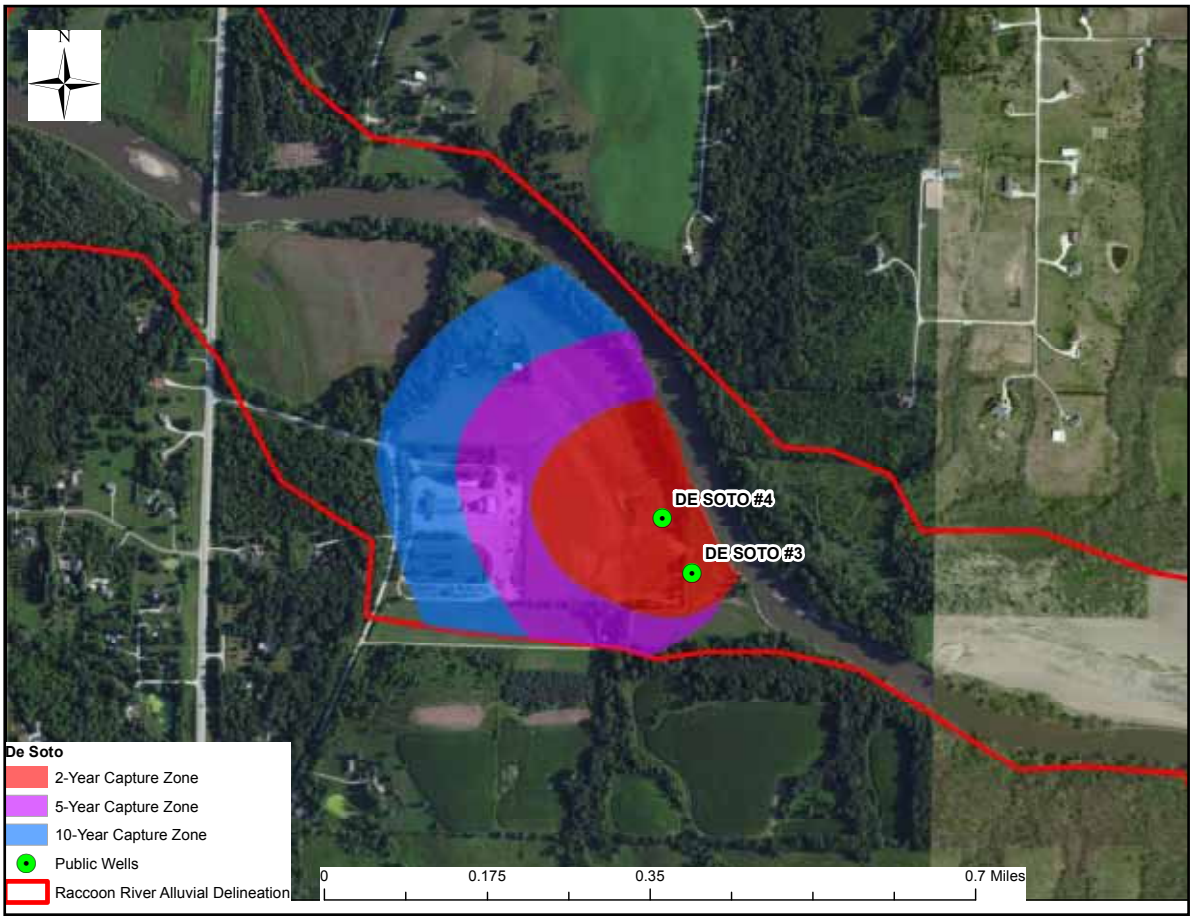



**Figure 14.** Source water capture zones for the City of De Soto using Visual MODFLOW particle tracker.

at Van Meter over the last 30 years was 65 cfs on December 11, 2000, and the lowest recorded average daily flow was 10 cfs from January 30 through February 1, 1940. Streamflow values below or approaching the 17.1 cfs value are shown in Table 10. The last time a streamflow value was below the 17.1 cfs threshold was February 4, 1940, and was 10 cfs.

In order to provide adequate streamflow downgradient of the Des Moines Water Works radial wellfield, minimum streamflow values need to be maintained at a gaging station located at Interstate 35 bridge (I-35). The I-35 gage is maintained by the USGS (5484600), and was installed on August 20, 2008. The formulas used to calculate minimum streamflow

**Table 9.** Water balance analyses using output from Visual MODFLOW.

| Budget Zone | Discharge (Q) (mgd) | Precipitation Recharge (R) (mgd) | Induced River Recharge (mgd) | Induced Quarry Recharge (mgd) | Percentage Induced Recharge | From Storage (mgd) | Inflow (mgd) |
|---|---|---|---|---|---|---|---|
| West Des Moines | 6 | 0.93 | 0.47 | 3.6 | 68% | 0.2 | 0.8 |
| Des Moines Radials | 14.4 | 0.6 | 10.2 | 2.6 | 89% | 0.2 | 0.8 |
| Van Meter | 0.1 | 0.7 | 0 | 0 | 0% | 0 | 0 |
| De Soto | 0.07 | 0.09 | 0.02 | 0 | 35% | 0 | 0 |
| Adel | 0.3 | 0.09 | 0.19 | 0.02 | 70% | 0 | 0 |
| Dallas Center | 0.16 | 0.1 | 0.06 | 0 | 38% | 0 | 0 |
| Rural Areas | 0.3 | 1.9 | 0.14 | 0 | 46% | 0 | 0 |
| | | | | | | | |
| Total | 21.33 | 4.41 | 11.08 | 6.22 | | 0.4 | 1.6 |

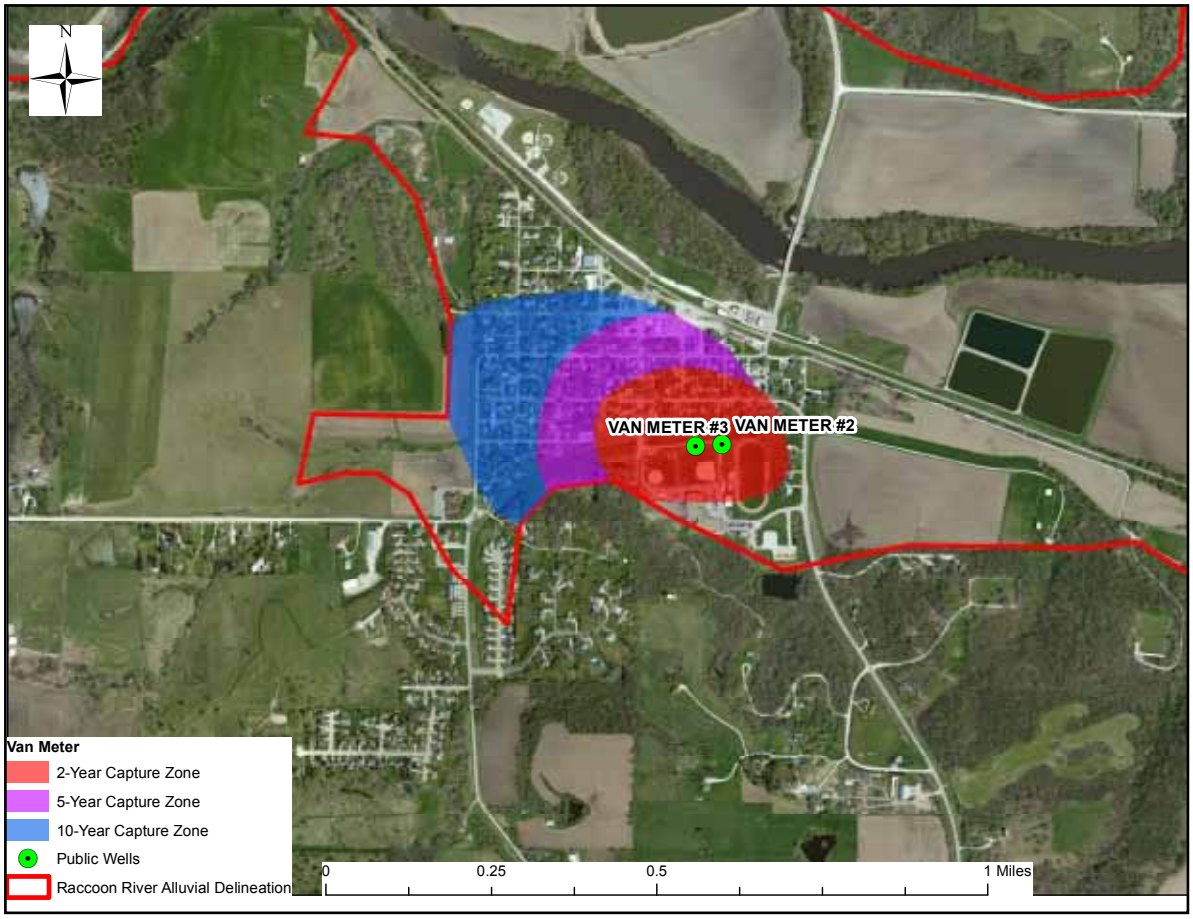



**Figure 15.** Source water capture zones for the City of Van Meter using Visual MODFLOW particle tracker.

values at the I-35 gage are shown on Table 11. The difference in streamflow values (gpd) between the Van Meter gage and the I-35 gage are shown in Table 12. The time period of September 5 to October 12, 2012, was chosen based on the lack of measurable precipitation during this period. The regulatory minimum streamflow values (using formulas in Table 11)

**Table 10.** Streamflow values at the USGS Van Meter gage station that were below or approaching the critical streamflow value of 17.1 cfs.

| Date(s) | Streamflow (cfs) | Difference from Critcal Flow (17.1 cfs) |
|---|---|---|
| October 22, 1918 | 28 | 10.9 |
| August 30, 1934 | 21 | 3.9 |
| August 30, 1936 | 17 | -0.1 |
| August 31, 1936 | 16 | -1.1 |
| January 17-19, 1937 | 18 | 0.9 |
| December 20, 1937 | 22 | 4.9 |
| September 17, 1939 | 24 | 6.9 |
| January 10 - February 4, 1940 | 10 | -7.1 |
| December 11, 2000 | 65 | 47.9 |
| January 5, 2004 | 68 | 50.9 |

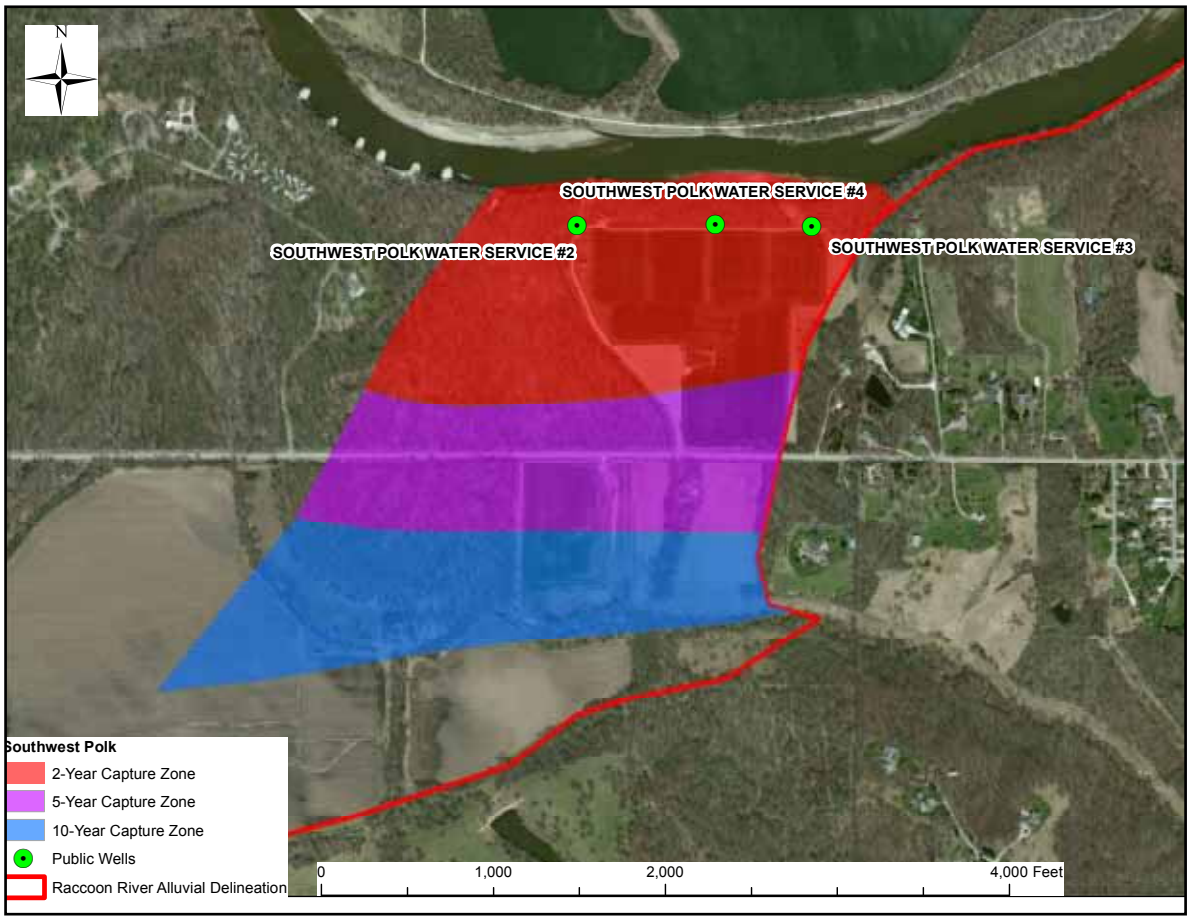



**Figure 16.** Source water capture zones for Southwest Polk Water District using Visual MODFLOW particle tracker.

that must be maintained at the I-35 gage are also listed in Table 12. All of the streamflow values measured during this time period at the I-35 gage are above the regulatory minimum.

The average difference in streamflow discharge between the Van Meter gage and the I-35 gage (Table 12) also represents the average volume of induced recharge from the Raccoon River that enters the Des Moines Water Works radial collector wells. The average difference in streamflow from September 5 to October 12, 2012, was 11.2 mgd, which is very close to our model mass balance of 10.2 mgd (Table 9). Part of this difference may be related to how much induced recharge is derived from the former quarries and how much is derived from the Raccoon River. Variability in local permeability values would influence these percentages. The Visual MODFLOW model used an average permeability value throughout the radial wellfield area.

Our model does not take into account the Des Moines Water Works Fleur Drive infiltration

**Table 11.** Formulas for calculating the minimum streamflow on the Raccoon River at the I-35 bridge based on streamflow values at Van Meter. These formulas are part of the Des Moines Water Works water-use permit.

| Actual Flow ($Q_{vm}$) at Van Meter (cfs) | Minimum Flow required I-35 Bridge (cfs) |
|---|---|
| 100 + | 53 + [0.1 x ($Q_{vm}$ - 70) |
| 70-100 | [0.5 x $Q_{vm}$] + 3 + [0.1 x ($Q_{vm}$ - 70)] |
| 6-70 | [0.5 x $Q_{vm}$] + 3 |
| 0-6 | $Q_{vm}$ |

**Table 12.** Streamflow values on the Raccoon River at Van Meter and I-35 Bridge. Minimum calculated streamflows at the I-35 gage (based on formulas from Table 11) are also included. The difference in streamflow values represents the approximate induced recharge provided to the West Des Moines radial collector wells.

| Date | Van Meter Gage (cfs) | I-35 Gage (cfs) | Regulatory | Difference Between |
|---|---|---|---|---|
| | | | Minimum (cfs) | Van Meter and I-35 (gpd) |
| 9/5/2012 | 141 | 119 | 60 | 14,217,940 |
| 9/6/2012 | 128 | 117 | 59 | 7,108,970 |
| 9/7/2012 | 114 | 110 | 57 | 2,585,080 |
| 9/8/2012 | 115 | 108 | 58 | 4,523,890 |
| 9/9/2012 | 113 | 106 | 57 | 4,523,890 |
| 9/10/2012 | 116 | 104 | 58 | 7,755,240 |
| 9/11/2012 | 112 | 104 | 57 | 5,170,160 |
| 9/12/2012 | 108 | 100 | 57 | 5,170,160 |
| 9/13/2012 | 117 | 113 | 58 | 2,585,080 |
| 9/14/2012 | 150 | 113 | 61 | 23,911,990 |
| 9/15/2012 | 155 | 128 | 62 | 17,449,290 |
| 9/16/2012 | 153 | 123 | 61 | 19,388,100 |
| 9/17/2012 | 147 | 121 | 61 | 16,803,020 |
| 9/18/2012 | 138 | 118 | 60 | 12,925,400 |
| 9/19/2012 | 141 | 114 | 60 | 17,449,290 |
| 9/20/2012 | 127 | 108 | 59 | 12,279,130 |
| 9/21/2012 | 119 | 101 | 58 | 11,632,860 |
| 9/22/2012 | 110 | 98 | 57 | 7,755,240 |
| 9/23/2012 | 104 | 95 | 56 | 5,816,430 |
| 9/24/2012 | 108 | 95 | 57 | 8,401,510 |
| 9/25/2012 | 115 | 96 | 58 | 12,279,130 |
| 9/26/2012 | 114 | 97 | 57 | 10,986,590 |
| 9/27/2012 | 108 | 90 | 57 | 11,632,860 |
| 9/28/2012 | 110 | 89 | 57 | 13,571,670 |
| 9/29/2012 | 114 | 89 | 57 | 16,156,750 |
| 9/30/2012 | 115 | 90 | 58 | 16,156,750 |
| 10/1/2012 | 113 | 118 | 57 | -3,231,350 |
| 10/2/2012 | 110 | 87 | 57 | 14,864,210 |
| 10/3/2012 | 108 | 85 | 57 | 14,864,210 |
| 10/4/2012 | 105 | 84 | 57 | 13,571,670 |
| 10/5/2012 | 97 | 83 | 54 | 9,047,780 |
| 10/6/2012 | 94 | 83 | 52 | 7,108,970 |
| 10/7/2012 | 95 | 82 | 53 | 8,401,510 |
| 10/8/2012 | 107 | 82 | 57 | 16,156,750 |
| 10/9/2012 | 103 | 83 | 56 | 12,925,400 |
| 10/10/2012 | 107 | 83 | 57 | 15,510,480 |
| 10/11/2012 | 103 | 82 | 56 | 13,571,670 |
| 10/12/2012 | 102 | 80 | 56 | 14,217,940 |
| | | | | |
| | | | Average | 11,190,675 |

gallery, which is located approximately 4 miles downstream of the West Des Moines wellfield and is outside the model study area. The Fleur Drive infiltration gallery produces on average 18.9 mgd, and approximately 17 mgd or 26.3 cfs is obtained from induced recharge from the Raccoon River. (Information provided by Des Moines Water Works.)

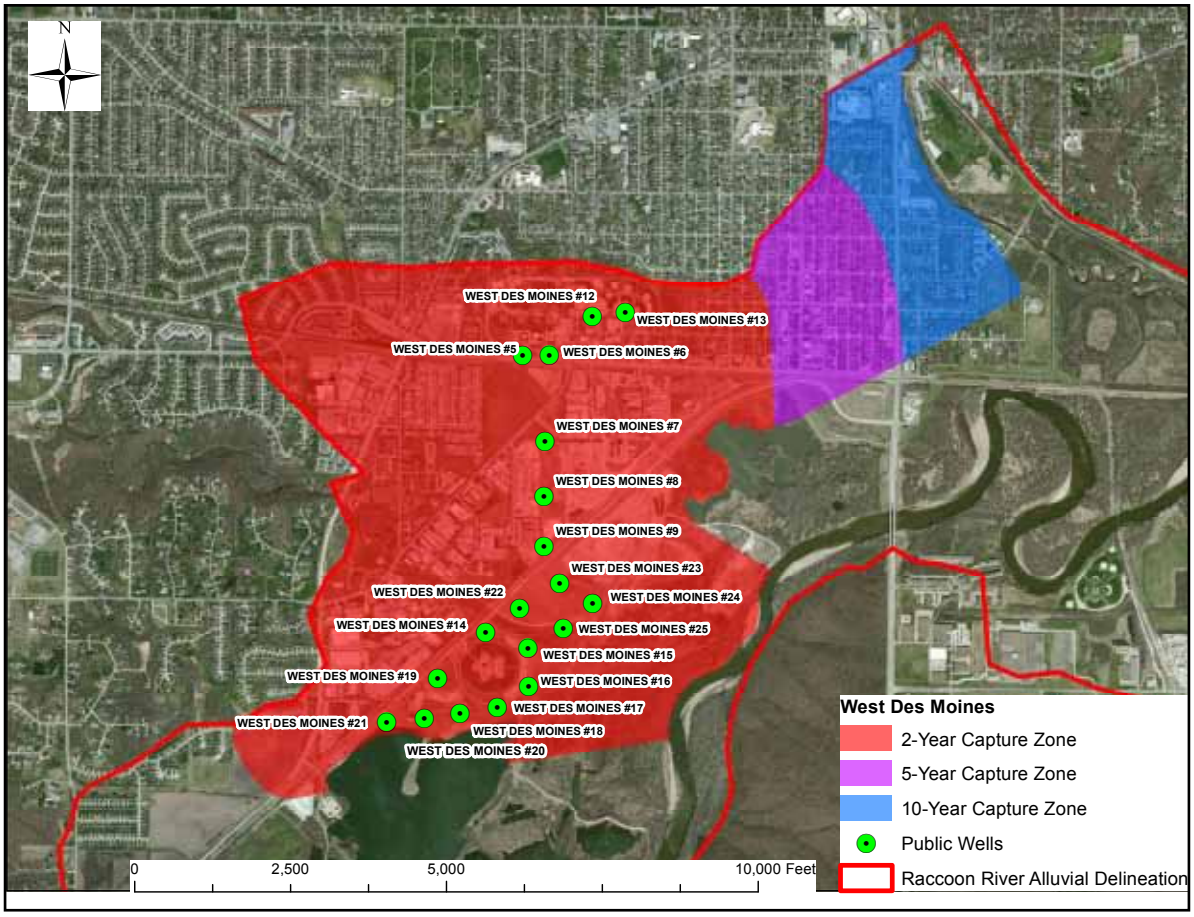



**Figure 17.** Source water capture zones for the City of West Des Moines using Visual MODFLOW particle tracker.

## Estimated Additional Pumping Capacity

Another use of a calibrated groundwater flow model is to estimate additional pumping capacity within a wellfield or budget zone. It is impossible to know the locations of proposed production wells, however, using existing infrastructure, pumping rates can be increased from the current rates until dry cells show up within the model. Using this approach, pumping rates were increased at 10 percent increments until dry cells appeared in the model. These additional pumping capacity rates are approximations and do not take into account pump settings or well specific aquifer parameters. Table 13 shows the estimated maximum pumping rates for each pumping center based on existing production wells. Based on the results from Table 13, additional pumping capacity ranges from 10 percent in the West Des Moines wellfield to over 1,000 percent at Adel. The large amount of additional pumping capacity at Adel is related to the presence of nearby former sand and gravel quarries and the proximity of the Raccoon River. Both the former sand and gravel pits and river provide tremendous induced recharge for the Adel wells. In addition to the sources of induced recharge, the sand, gravel, and boulders beneath the Adel wellfield had the highest permeability within the model area (Table 5).


**Figure 18.** Contaminant transport analysis for the former Delevan Site near West Des Moines Well 19.

## CONCLUSIONS

Based on the geologic and hydrogeologic data available in the study area, the following conclusions can be made:

- The Lower Raccoon River aquifer is one of the most intensely used aquifers in the state of Iowa. Current water use including the Fleur Drive infiltration gallery is approximately 14.6 bgy. Approximately 7.7 bgy is withdrawn from our study area.
- Transmissivity values range from 1,500 $ft^2$/day at Dallas Center, to approximately 44,000 $ft^2$/day near Adel Well 1.
- Based on several drought simulations using the groundwater flow model Visual

**Table 13.** Maximum simulated pumping rates at select wellfields along the Lower Raccoon River aquifer using Visual MODFLOW.

| Wellfield | Number of Active Wells | Current Pumping Rate (Q) (gpd) | Maximum Potential Pumping Rate (Q) (gpd) | Percent Increase in Potential Pumping Rate |
|---|---|---|---|---|
| West Des Moines | 19 | 6,000,000 | 6,600,000 | 10% |
| Des Moines Radials | 6 radial wells | 14,400,000 | 18,000,000 | 25% |
| Van Meter | 2 | 100,000 | 400,000 | 400% |
| De Soto | 2 | 126,000 | 500,000 | 400% |
| Adel | 4 | 300,000 | >3,000,000 | >1000% |
| Dallas Center | 4 | 160,000 | 640,000 | 400% |
| RVG Golf Course | 1 | 418,000 | 522,000 | 25% |


**Figure 19.** Contaminant transport analysis for the former Delevan Site near West Des Moines Well 21.

MODFLOW, additional pumping capacity ranges from 10 percent at West Des Moines radial wellfield, to over 1,000 percent at the Adel wellfield.

- Severe drought conditions during the summer and fall of 2012 caused the Des Moines Water Works to reduce the withdrawal from their Fleur Drive infiltration gallery and radial collector wellfield.
- Potential well yields greater than 500 gpm may be possible near Adel, Van Meter, and West Des Moines. The highest potential well yields occur east of Adel, and are the result of the cobble and boulder zone found at the base of the aquifer, and the abundance of induced recharge from the nearby sand and gravel quarries and the Raccoon River.
- Using the particle tracking module within the groundwater flow model, the time of travel for a known contaminant plume to reach the City of West Des Moines Well #19 is approximately 2.2 years and to reach Well #21 is 1.6 years, depending on pumping schedules.
- The calibrated groundwater flow model was used to refine the source water capture zones for the cities of Dallas Center, De Soto, Van Meter, Southwest Polk Water District, and West Des Moines.

# REFERENCES


Freeze, R.A, and Cherry, J.A., 1979, Groundwater, Prentice-Hall, Inc. Englewood Cliffs, NJ, 604 p.

Iowa Geological Survey (IGS), Groundwater resources of Dallas County, Open File County Groundwater Report No. 25, 1979, 20 p.

Iowa State University, 2012, available at http://mesonet.agron.iastate.edu/archive/data, accessed November 2012.

Thompson, C. A., Groundwater resources of Polk County, Open File County Groundwater Report No. 77, 1982, 28 p.

# APPENDIX A

# Aquifer Pump Tests
# Data and Graphs

**Contact Info**
**Address**
**Company Name**
**City, State/Province**

**Pumping Test - Water Level Data** Page 1 of 1

Project: Adel City Wellfield

Number:

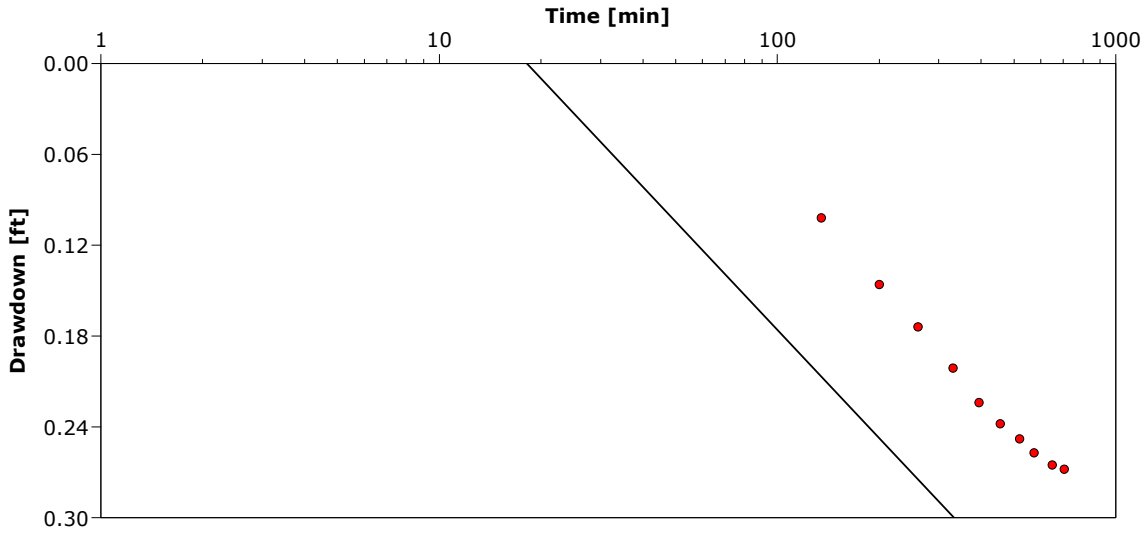
Client:

| | | |
|---|---|---|
| Location: Adel, Iowa | Pumping Test: City Well 3 | Pumping Well: Well 3 |
| Test Conducted by: Mike Gannon | Test Date: 9/10/2012 | Discharge Rate: 297 [U.S. gal/min] |
| Observation Well: OB Well 1 | Static Water Level [ft]: 14.93 | Radial Distance to PW [ft]: 50 |

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 1 | 0 | 14.931 | 0.00 |
| 2 | 135 | 15.033 | 0.102 |
| 3 | 200 | 15.077 | 0.146 |
| 4 | 260 | 15.105 | 0.174 |
| 5 | 330 | 15.132 | 0.201 |
| 6 | 395 | 15.155 | 0.224 |
| 7 | 455 | 15.169 | 0.238 |
| 8 | 520 | 15.179 | 0.248 |
| 9 | 575 | 15.188 | 0.257 |
| 10 | 650 | 15.196 | 0.265 |
| 11 | 705 | 15.199 | 0.268 |

| | | |
|---|---|---|
| | **Contact Info**<br>**Address**<br>**Company Name**<br>**City, State/Province** | **Pumping Test Analysis Report** |
| | | Project: Adel City Wellfield |
| | | Number: |
| | | Client: |

| | | |
|---|---|---|
| Location: Adel, Iowa | Pumping Test: City Well 3 | Pumping Well: Well 3 |
| Test Conducted by: Mike Gannon | | Test Date: 9/10/2012 |
| Analysis Performed by: | New analysis 4 | Analysis Date: 9/11/2012 |
| Aquifer Thickness: 30.00 ft | Discharge Rate: 297 [U.S. gal/min] | |




Calculation using COOPER & JACOB

| Observation Well | Transmissivity [ft²/d] | Hydraulic Conductivity [ft/d] | Storage coefficient | Radial Distance to PW [ft] | |
|---|---|---|---|---|---|
| OB Well 1 | $4.40 \times 10^{4}$ | $1.47 \times 10^{3}$ | $5.00 \times 10^{-1}$ | 50.0 | |

| | | |
|---|---|---|
| **Contact Info**<br>**Address**<br>**Company Name**<br>**City, State/Province** | **Pumping Test - Water Level Data** | Page 1 of 3 |
| | Project: De Soto Pump Test | |
| | Number: | |
| | Client: | |

| | | |
|---|---|---|
| Location: De Soto, Iowa | Pumping Test: Well 3 | Pumping Well: Well 3 |
| Test Conducted by: Mike Gannon | Test Date: 9/9/2012 | Discharge Rate: 150 [U.S. gal/min] |
| Observation Well: OB Well 1 | Static Water Level [ft]: 17.51 | Radial Distance to PW [ft]: 78 |

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 1 | 0 | 17.511 | 0.00 |
| 2 | 5 | 17.55 | 0.039 |
| 3 | 10 | 17.586 | 0.075 |
| 4 | 15 | 17.616 | 0.105 |
| 5 | 20 | 17.643 | 0.132 |
| 6 | 25 | 17.665 | 0.154 |
| 7 | 30 | 17.687 | 0.176 |
| 8 | 35 | 17.707 | 0.196 |
| 9 | 40 | 17.723 | 0.212 |
| 10 | 45 | 17.735 | 0.224 |
| 11 | 50 | 17.75 | 0.239 |
| 12 | 55 | 17.762 | 0.251 |
| 13 | 60 | 17.774 | 0.263 |
| 14 | 65 | 17.781 | 0.27 |
| 15 | 70 | 17.794 | 0.283 |
| 16 | 75 | 17.80 | 0.289 |
| 17 | 80 | 17.811 | 0.30 |
| 18 | 85 | 17.815 | 0.304 |
| 19 | 90 | 17.828 | 0.317 |
| 20 | 95 | 17.832 | 0.321 |
| 21 | 100 | 17.84 | 0.329 |
| 22 | 105 | 17.849 | 0.338 |
| 23 | 110 | 17.851 | 0.34 |
| 24 | 115 | 17.859 | 0.348 |
| 25 | 120 | 17.866 | 0.355 |
| 26 | 125 | 17.87 | 0.359 |
| 27 | 130 | 17.877 | 0.366 |
| 28 | 135 | 17.883 | 0.372 |
| 29 | 140 | 17.889 | 0.378 |
| 30 | 145 | 17.896 | 0.385 |
| 31 | 150 | 17.901 | 0.39 |
| 32 | 155 | 17.903 | 0.392 |
| 33 | 160 | 17.909 | 0.398 |
| 34 | 165 | 17.914 | 0.403 |
| 35 | 170 | 17.921 | 0.41 |
| 36 | 175 | 17.927 | 0.416 |
| 37 | 180 | 17.927 | 0.416 |
| 38 | 185 | 17.933 | 0.422 |
| 39 | 190 | 17.94 | 0.429 |
| 40 | 195 | 17.944 | 0.433 |
| 41 | 200 | 17.947 | 0.436 |
| 42 | 205 | 17.956 | 0.445 |
| 43 | 210 | 17.957 | 0.446 |
| 44 | 215 | 17.961 | 0.45 |
| 45 | 220 | 17.968 | 0.457 |
| 46 | 225 | 17.968 | 0.457 |
| 47 | 230 | 17.974 | 0.463 |
| 48 | 235 | 17.975 | 0.464 |
| 49 | 240 | 17.982 | 0.471 |
| 50 | 245 | 17.985 | 0.474 |
| 51 | 250 | 17.988 | 0.477 |
| 52 | 255 | 17.992 | 0.481 |
| 53 | 260 | 17.998 | 0.487 |
| 54 | 265 | 17.998 | 0.487 |
| 55 | 270 | 18.006 | 0.495 |
| 56 | 275 | 18.006 | 0.495 |
| 57 | 280 | 18.012 | 0.501 |

**Contact Info**
**Address**
**Company Name**
**City, State/Province**

**Pumping Test - Water Level Data** 

Project: De Soto Pump Test

Number:

Client:

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 58 | 285 | 18.014 | 0.503 |
| 59 | 290 | 18.019 | 0.508 |
| 60 | 295 | 18.022 | 0.511 |
| 61 | 300 | 18.026 | 0.515 |
| 62 | 305 | 18.027 | 0.516 |
| 63 | 310 | 18.033 | 0.522 |
| 64 | 315 | 18.033 | 0.522 |
| 65 | 320 | 18.037 | 0.526 |
| 66 | 325 | 18.043 | 0.532 |
| 67 | 330 | 18.044 | 0.533 |
| 68 | 335 | 18.045 | 0.534 |
| 69 | 340 | 18.054 | 0.543 |
| 70 | 345 | 18.055 | 0.544 |
| 71 | 350 | 18.054 | 0.543 |
| 72 | 355 | 18.061 | 0.55 |
| 73 | 360 | 18.063 | 0.552 |
| 74 | 365 | 18.066 | 0.555 |
| 75 | 370 | 18.069 | 0.558 |
| 76 | 375 | 18.073 | 0.562 |
| 77 | 380 | 18.076 | 0.565 |
| 78 | 385 | 18.081 | 0.57 |
| 79 | 390 | 18.083 | 0.572 |
| 80 | 395 | 18.085 | 0.574 |
| 81 | 400 | 18.087 | 0.576 |
| 82 | 405 | 18.09 | 0.579 |
| 83 | 410 | 18.094 | 0.583 |
| 84 | 415 | 18.10 | 0.589 |
| 85 | 420 | 18.099 | 0.588 |
| 86 | 425 | 18.107 | 0.596 |
| 87 | 430 | 18.103 | 0.592 |
| 88 | 435 | 18.11 | 0.599 |
| 89 | 440 | 18.112 | 0.601 |
| 90 | 445 | 18.114 | 0.603 |
| 91 | 450 | 18.115 | 0.604 |
| 92 | 455 | 18.121 | 0.61 |
| 93 | 460 | 18.122 | 0.611 |
| 94 | 465 | 18.124 | 0.613 |
| 95 | 470 | 18.128 | 0.617 |
| 96 | 475 | 18.131 | 0.62 |
| 97 | 480 | 18.132 | 0.621 |
| 98 | 485 | 18.131 | 0.62 |
| 99 | 490 | 18.134 | 0.623 |
| 100 | 495 | 18.14 | 0.629 |
| 101 | 500 | 18.137 | 0.626 |
| 102 | 505 | 18.14 | 0.629 |
| 103 | 510 | 18.143 | 0.632 |
| 104 | 515 | 18.146 | 0.635 |
| 105 | 520 | 18.146 | 0.635 |
| 106 | 525 | 18.147 | 0.636 |
| 107 | 530 | 18.148 | 0.637 |
| 108 | 535 | 18.154 | 0.643 |
| 109 | 540 | 18.152 | 0.641 |
| 110 | 545 | 18.153 | 0.642 |
| 111 | 550 | 18.152 | 0.641 |
| 112 | 555 | 18.155 | 0.644 |
| 113 | 560 | 18.159 | 0.648 |
| 114 | 565 | 18.157 | 0.646 |
| 115 | 570 | 18.159 | 0.648 |
| 116 | 575 | 18.163 | 0.652 |
| 117 | 580 | 18.159 | 0.648 |
| 118 | 585 | 18.161 | 0.65 |
| 119 | 590 | 18.163 | 0.652 |
| 120 | 595 | 18.165 | 0.654 |

**Contact Info**
**Address**
**Company Name**
**City, State/Province**

**Pumping Test - Water Level Data** 

Project: De Soto Pump Test

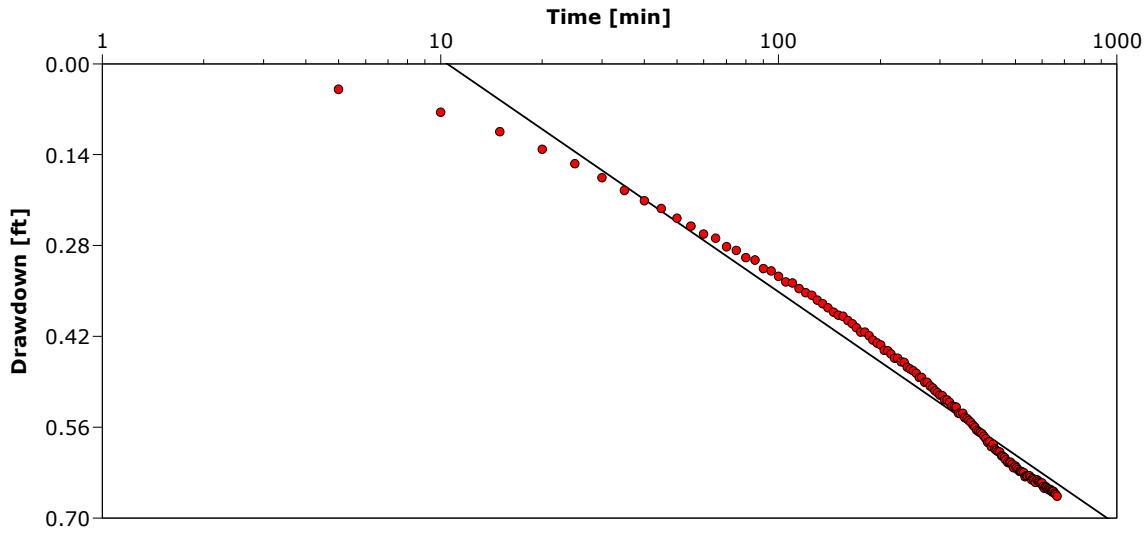
Number:

Client:

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 121 | 600 | 18.164 | 0.653 |
| 122 | 605 | 18.169 | 0.658 |
| 123 | 610 | 18.172 | 0.661 |
| 124 | 615 | 18.169 | 0.658 |
| 125 | 620 | 18.171 | 0.66 |
| 126 | 625 | 18.173 | 0.662 |
| 127 | 630 | 18.175 | 0.664 |
| 128 | 635 | 18.174 | 0.663 |
| 129 | 640 | 18.176 | 0.665 |
| 130 | 645 | 18.178 | 0.667 |
| 131 | 650 | 18.177 | 0.666 |
| 132 | 655 | 18.18 | 0.669 |
| 133 | 660 | 18.182 | 0.671 |
| 134 | 665 | 18.185 | 0.674 |

| | | |
|---|---|---|
| | **Contact Info**<br>**Address**<br>**Company Name**<br>**City, State/Province** | **Pumping Test Analysis Report**<br>Project: De Soto Pump Test<br>Number:<br>Client: |

| | | |
|---|---|---|
| Location: De Soto, Iowa | Pumping Test: Well 3 | Pumping Well: Well 3 |
| Test Conducted by: Mike Gannon | | Test Date: 9/9/2012 |
| Analysis Performed by: | New analysis 3 | Analysis Date: 9/11/2012 |
| Aquifer Thickness: 31.00 ft | Discharge Rate: 150 [U.S. gal/min] | |




Calculation using COOPER & JACOB

| Observation Well | Transmissivity [ft²/d] | Hydraulic Conductivity [ft/d] | Storage coefficient | Radial Distance to PW [ft] | |
|---|---|---|---|---|---|
| OB Well 1 | $1.47 \times 10^{4}$ | $4.75 \times 10^{2}$ | $3.96 \times 10^{-2}$ | 78.0 | |

| | | |
|---|---|---|
| **Contact Info**<br>**Address**<br>**Company Name**<br>**City, State/Province** | **Pumping Test - Water Level Data** | Page 1 of 15 |
| | Project: West Des Moines Pump Test | |
| | Number: | |
| | Client: | |

| | | |
|---|---|---|
| Location: West Des Moines, Iowa | Pumping Test: Well 21 | Pumping Well: Well 21 |
| Test Conducted by: | Test Date: 9/11/2012 | Discharge Rate: 243 [U.S. gal/min] |
| Observation Well: 0B1 | Static Water Level [ft]: 9.99 | Radial Distance to PW [ft]: 63 |

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 1 | 0 | 9.986 | 0.00 |
| 2 | 5 | 10.125 | 0.139 |
| 3 | 10 | 10.283 | 0.297 |
| 4 | 15 | 10.345 | 0.359 |
| 5 | 20 | 10.403 | 0.417 |
| 6 | 25 | 10.446 | 0.46 |
| 7 | 30 | 10.491 | 0.505 |
| 8 | 35 | 10.527 | 0.541 |
| 9 | 40 | 10.563 | 0.577 |
| 10 | 45 | 10.599 | 0.613 |
| 11 | 50 | 10.631 | 0.645 |
| 12 | 55 | 10.667 | 0.681 |
| 13 | 60 | 10.691 | 0.705 |
| 14 | 65 | 10.714 | 0.728 |
| 15 | 70 | 10.739 | 0.753 |
| 16 | 75 | 10.77 | 0.784 |
| 17 | 80 | 10.793 | 0.807 |
| 18 | 85 | 10.806 | 0.82 |
| 19 | 90 | 10.832 | 0.846 |
| 20 | 95 | 10.851 | 0.865 |
| 21 | 100 | 10.864 | 0.878 |
| 22 | 105 | 10.888 | 0.902 |
| 23 | 110 | 10.899 | 0.913 |
| 24 | 115 | 10.921 | 0.935 |
| 25 | 120 | 10.948 | 0.962 |
| 26 | 125 | 10.95 | 0.964 |
| 27 | 130 | 10.963 | 0.977 |
| 28 | 135 | 10.983 | 0.997 |
| 29 | 140 | 10.991 | 1.005 |
| 30 | 145 | 11.008 | 1.022 |
| 31 | 150 | 11.034 | 1.048 |
| 32 | 155 | 11.019 | 1.033 |
| 33 | 160 | 11.03 | 1.044 |
| 34 | 165 | 11.053 | 1.067 |
| 35 | 170 | 11.053 | 1.067 |
| 36 | 175 | 11.068 | 1.082 |
| 37 | 180 | 11.087 | 1.101 |
| 38 | 185 | 11.087 | 1.101 |
| 39 | 190 | 11.097 | 1.111 |
| 40 | 195 | 11.119 | 1.133 |
| 41 | 200 | 11.12 | 1.134 |
| 42 | 205 | 11.129 | 1.143 |
| 43 | 210 | 11.151 | 1.165 |
| 44 | 215 | 11.147 | 1.161 |
| 45 | 220 | 11.148 | 1.162 |
| 46 | 225 | 11.163 | 1.177 |
| 47 | 230 | 11.176 | 1.19 |
| 48 | 235 | 11.165 | 1.179 |
| 49 | 240 | 11.183 | 1.197 |
| 50 | 245 | 11.195 | 1.209 |
| 51 | 250 | 11.198 | 1.212 |
| 52 | 255 | 11.208 | 1.222 |
| 53 | 260 | 11.214 | 1.228 |
| 54 | 265 | 11.215 | 1.229 |
| 55 | 270 | 11.225 | 1.239 |
| 56 | 275 | 11.231 | 1.245 |
| 57 | 280 | 11.24 | 1.254 |

**Contact Info**
**Address**
**Company Name**
**City, State/Province**

**Pumping Test - Water Level Data** 

Project: West Des Moines Pump Test

Number:

Client:

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 58 | 285 | 11.248 | 1.262 |
| 59 | 290 | 11.254 | 1.268 |
| 60 | 295 | 11.259 | 1.273 |
| 61 | 300 | 11.271 | 1.285 |
| 62 | 305 | 11.276 | 1.29 |
| 63 | 310 | 11.279 | 1.293 |
| 64 | 315 | 11.288 | 1.302 |
| 65 | 320 | 11.288 | 1.302 |
| 66 | 325 | 11.291 | 1.305 |
| 67 | 330 | 11.298 | 1.312 |
| 68 | 335 | 11.307 | 1.321 |
| 69 | 340 | 11.315 | 1.329 |
| 70 | 345 | 11.319 | 1.333 |
| 71 | 350 | 11.319 | 1.333 |
| 72 | 355 | 11.336 | 1.35 |
| 73 | 360 | 11.33 | 1.344 |
| 74 | 365 | 11.336 | 1.35 |
| 75 | 370 | 11.35 | 1.364 |
| 76 | 375 | 11.345 | 1.359 |
| 77 | 380 | 11.349 | 1.363 |
| 78 | 385 | 11.349 | 1.363 |
| 79 | 390 | 11.354 | 1.368 |
| 80 | 395 | 11.363 | 1.377 |
| 81 | 400 | 11.365 | 1.379 |
| 82 | 405 | 11.369 | 1.383 |
| 83 | 410 | 11.375 | 1.389 |
| 84 | 415 | 11.38 | 1.394 |
| 85 | 420 | 11.383 | 1.397 |
| 86 | 425 | 11.387 | 1.401 |
| 87 | 430 | 11.386 | 1.40 |
| 88 | 435 | 11.401 | 1.415 |
| 89 | 440 | 11.389 | 1.403 |
| 90 | 445 | 11.396 | 1.41 |
| 91 | 450 | 11.409 | 1.423 |
| 92 | 455 | 11.401 | 1.415 |
| 93 | 460 | 11.428 | 1.442 |
| 94 | 465 | 11.403 | 1.417 |
| 95 | 470 | 11.408 | 1.422 |
| 96 | 475 | 11.436 | 1.45 |
| 97 | 480 | 11.445 | 1.459 |
| 98 | 485 | 11.433 | 1.447 |
| 99 | 490 | 11.438 | 1.452 |
| 100 | 495 | 11.407 | 1.421 |
| 101 | 500 | 11.438 | 1.452 |
| 102 | 505 | 11.426 | 1.44 |
| 103 | 510 | 11.461 | 1.475 |
| 104 | 515 | 11.444 | 1.458 |
| 105 | 520 | 11.455 | 1.469 |
| 106 | 525 | 11.441 | 1.455 |
| 107 | 530 | 11.46 | 1.474 |
| 108 | 535 | 11.456 | 1.47 |
| 109 | 540 | 11.463 | 1.477 |
| 110 | 545 | 11.463 | 1.477 |
| 111 | 550 | 11.473 | 1.487 |
| 112 | 555 | 11.463 | 1.477 |
| 113 | 560 | 11.477 | 1.491 |
| 114 | 565 | 11.481 | 1.495 |
| 115 | 570 | 11.48 | 1.494 |
| 116 | 575 | 11.482 | 1.496 |
| 117 | 580 | 11.481 | 1.495 |
| 118 | 585 | 11.487 | 1.501 |
| 119 | 590 | 11.49 | 1.504 |
| 120 | 595 | 11.49 | 1.504 |

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 121 | 600 | 11.49 | 1.504 |
| 122 | 605 | 11.493 | 1.507 |
| 123 | 610 | 11.496 | 1.51 |
| 124 | 615 | 11.501 | 1.515 |
| 125 | 620 | 11.504 | 1.518 |
| 126 | 625 | 11.513 | 1.527 |
| 127 | 630 | 11.511 | 1.525 |
| 128 | 635 | 11.513 | 1.527 |
| 129 | 640 | 11.517 | 1.531 |
| 130 | 645 | 11.514 | 1.528 |
| 131 | 650 | 11.518 | 1.532 |
| 132 | 655 | 11.529 | 1.543 |
| 133 | 660 | 11.529 | 1.543 |
| 134 | 665 | 11.53 | 1.544 |
| 135 | 670 | 11.528 | 1.542 |
| 136 | 675 | 11.53 | 1.544 |
| 137 | 680 | 11.536 | 1.55 |
| 138 | 685 | 11.539 | 1.553 |
| 139 | 690 | 11.542 | 1.556 |
| 140 | 695 | 11.545 | 1.559 |
| 141 | 700 | 11.548 | 1.562 |
| 142 | 705 | 11.546 | 1.56 |
| 143 | 710 | 11.554 | 1.568 |
| 144 | 715 | 11.549 | 1.563 |
| 145 | 720 | 11.558 | 1.572 |
| 146 | 725 | 11.56 | 1.574 |
| 147 | 730 | 11.564 | 1.578 |
| 148 | 735 | 11.565 | 1.579 |
| 149 | 740 | 11.564 | 1.578 |
| 150 | 745 | 11.565 | 1.579 |
| 151 | 750 | 11.57 | 1.584 |
| 152 | 755 | 11.57 | 1.584 |
| 153 | 760 | 11.575 | 1.589 |
| 154 | 765 | 11.578 | 1.592 |
| 155 | 770 | 11.576 | 1.59 |
| 156 | 775 | 11.578 | 1.592 |
| 157 | 780 | 11.583 | 1.597 |
| 158 | 785 | 11.583 | 1.597 |
| 159 | 790 | 11.586 | 1.60 |
| 160 | 795 | 11.585 | 1.599 |
| 161 | 800 | 11.588 | 1.602 |
| 162 | 805 | 11.592 | 1.606 |
| 163 | 810 | 11.595 | 1.609 |
| 164 | 815 | 11.595 | 1.609 |
| 165 | 820 | 11.597 | 1.611 |
| 166 | 825 | 11.601 | 1.615 |
| 167 | 830 | 11.598 | 1.612 |
| 168 | 835 | 11.60 | 1.614 |
| 169 | 840 | 11.603 | 1.617 |
| 170 | 845 | 11.606 | 1.62 |
| 171 | 850 | 11.606 | 1.62 |
| 172 | 855 | 11.609 | 1.623 |
| 173 | 860 | 11.61 | 1.624 |
| 174 | 865 | 11.615 | 1.629 |
| 175 | 870 | 11.616 | 1.63 |
| 176 | 875 | 11.612 | 1.626 |
| 177 | 880 | 11.617 | 1.631 |
| 178 | 885 | 11.62 | 1.634 |
| 179 | 890 | 11.62 | 1.634 |
| 180 | 895 | 11.622 | 1.636 |
| 181 | 900 | 11.621 | 1.635 |
| 182 | 905 | 11.625 | 1.639 |
| 183 | 910 | 11.627 | 1.641 |

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 184 | 915 | 11.628 | 1.642 |
| 185 | 920 | 11.635 | 1.649 |
| 186 | 925 | 11.633 | 1.647 |
| 187 | 930 | 11.631 | 1.645 |
| 188 | 935 | 11.634 | 1.648 |
| 189 | 940 | 11.637 | 1.651 |
| 190 | 945 | 11.639 | 1.653 |
| 191 | 950 | 11.639 | 1.653 |
| 192 | 955 | 11.638 | 1.652 |
| 193 | 960 | 11.643 | 1.657 |
| 194 | 965 | 11.645 | 1.659 |
| 195 | 970 | 11.645 | 1.659 |
| 196 | 975 | 11.647 | 1.661 |
| 197 | 980 | 11.65 | 1.664 |
| 198 | 985 | 11.652 | 1.666 |
| 199 | 990 | 11.649 | 1.663 |
| 200 | 995 | 11.655 | 1.669 |
| 201 | 1000 | 11.655 | 1.669 |
| 202 | 1005 | 11.657 | 1.671 |
| 203 | 1010 | 11.655 | 1.669 |
| 204 | 1015 | 11.659 | 1.673 |
| 205 | 1020 | 11.659 | 1.673 |
| 206 | 1025 | 11.664 | 1.678 |
| 207 | 1030 | 11.662 | 1.676 |
| 208 | 1035 | 11.668 | 1.682 |
| 209 | 1040 | 11.663 | 1.677 |
| 210 | 1045 | 11.665 | 1.679 |
| 211 | 1050 | 11.668 | 1.682 |
| 212 | 1055 | 11.669 | 1.683 |
| 213 | 1060 | 11.668 | 1.682 |
| 214 | 1065 | 11.672 | 1.686 |
| 215 | 1070 | 11.672 | 1.686 |
| 216 | 1075 | 11.676 | 1.69 |
| 217 | 1080 | 11.677 | 1.691 |
| 218 | 1085 | 11.681 | 1.695 |
| 219 | 1090 | 11.678 | 1.692 |
| 220 | 1095 | 11.68 | 1.694 |
| 221 | 1100 | 11.683 | 1.697 |
| 222 | 1105 | 11.679 | 1.693 |
| 223 | 1110 | 11.684 | 1.698 |
| 224 | 1115 | 11.687 | 1.701 |
| 225 | 1120 | 11.689 | 1.703 |
| 226 | 1125 | 11.688 | 1.702 |
| 227 | 1130 | 11.691 | 1.705 |
| 228 | 1135 | 11.691 | 1.705 |
| 229 | 1140 | 11.689 | 1.703 |
| 230 | 1145 | 11.693 | 1.707 |
| 231 | 1150 | 11.696 | 1.71 |
| 232 | 1155 | 11.693 | 1.707 |
| 233 | 1160 | 11.695 | 1.709 |
| 234 | 1165 | 11.699 | 1.713 |
| 235 | 1170 | 11.70 | 1.714 |
| 236 | 1175 | 11.701 | 1.715 |
| 237 | 1180 | 11.702 | 1.716 |
| 238 | 1185 | 11.702 | 1.716 |
| 239 | 1190 | 11.699 | 1.713 |
| 240 | 1195 | 11.707 | 1.721 |
| 241 | 1200 | 11.707 | 1.721 |
| 242 | 1205 | 11.708 | 1.722 |
| 243 | 1210 | 11.708 | 1.722 |
| 244 | 1215 | 11.709 | 1.723 |
| 245 | 1220 | 11.708 | 1.722 |
| 246 | 1225 | 11.712 | 1.726 |

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 247 | 1230 | 11.713 | 1.727 |
| 248 | 1235 | 11.715 | 1.729 |
| 249 | 1240 | 11.717 | 1.731 |
| 250 | 1245 | 11.715 | 1.729 |
| 251 | 1250 | 11.721 | 1.735 |
| 252 | 1255 | 11.717 | 1.731 |
| 253 | 1260 | 11.717 | 1.731 |
| 254 | 1265 | 11.719 | 1.733 |
| 255 | 1270 | 11.719 | 1.733 |
| 256 | 1275 | 11.719 | 1.733 |
| 257 | 1280 | 11.722 | 1.736 |
| 258 | 1285 | 11.726 | 1.74 |
| 259 | 1290 | 11.724 | 1.738 |
| 260 | 1295 | 11.725 | 1.739 |
| 261 | 1300 | 11.727 | 1.741 |
| 262 | 1305 | 11.731 | 1.745 |
| 263 | 1310 | 11.728 | 1.742 |
| 264 | 1315 | 11.731 | 1.745 |
| 265 | 1320 | 11.734 | 1.748 |
| 266 | 1325 | 11.733 | 1.747 |
| 267 | 1330 | 11.73 | 1.744 |
| 268 | 1335 | 11.739 | 1.753 |
| 269 | 1340 | 11.738 | 1.752 |
| 270 | 1345 | 11.738 | 1.752 |
| 271 | 1350 | 11.741 | 1.755 |
| 272 | 1355 | 11.737 | 1.751 |
| 273 | 1360 | 11.742 | 1.756 |
| 274 | 1365 | 11.74 | 1.754 |
| 275 | 1370 | 11.743 | 1.757 |
| 276 | 1375 | 11.748 | 1.762 |
| 277 | 1380 | 11.745 | 1.759 |
| 278 | 1385 | 11.75 | 1.764 |
| 279 | 1390 | 11.746 | 1.76 |
| 280 | 1395 | 11.749 | 1.763 |
| 281 | 1400 | 11.752 | 1.766 |
| 282 | 1405 | 11.752 | 1.766 |
| 283 | 1410 | 11.747 | 1.761 |
| 284 | 1415 | 11.753 | 1.767 |
| 285 | 1420 | 11.754 | 1.768 |
| 286 | 1425 | 11.756 | 1.77 |
| 287 | 1430 | 11.756 | 1.77 |
| 288 | 1435 | 11.756 | 1.77 |
| 289 | 1440 | 11.76 | 1.774 |
| 290 | 1445 | 11.759 | 1.773 |
| 291 | 1450 | 11.761 | 1.775 |
| 292 | 1455 | 11.766 | 1.78 |
| 293 | 1460 | 11.764 | 1.778 |
| 294 | 1465 | 11.765 | 1.779 |
| 295 | 1470 | 11.768 | 1.782 |
| 296 | 1475 | 11.776 | 1.79 |
| 297 | 1480 | 11.775 | 1.789 |
| 298 | 1485 | 11.771 | 1.785 |
| 299 | 1490 | 11.769 | 1.783 |
| 300 | 1495 | 11.779 | 1.793 |
| 301 | 1500 | 11.771 | 1.785 |
| 302 | 1505 | 11.773 | 1.787 |
| 303 | 1510 | 11.768 | 1.782 |
| 304 | 1515 | 11.776 | 1.79 |
| 305 | 1520 | 11.766 | 1.78 |
| 306 | 1525 | 11.77 | 1.784 |
| 307 | 1530 | 11.78 | 1.794 |
| 308 | 1535 | 11.77 | 1.784 |
| 309 | 1540 | 11.778 | 1.792 |

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 310 | 1545 | 11.779 | 1.793 |
| 311 | 1550 | 11.775 | 1.789 |
| 312 | 1555 | 11.782 | 1.796 |
| 313 | 1560 | 11.773 | 1.787 |
| 314 | 1565 | 11.78 | 1.794 |
| 315 | 1570 | 11.782 | 1.796 |
| 316 | 1575 | 11.775 | 1.789 |
| 317 | 1580 | 11.779 | 1.793 |
| 318 | 1585 | 11.78 | 1.794 |
| 319 | 1590 | 11.783 | 1.797 |
| 320 | 1595 | 11.793 | 1.807 |
| 321 | 1600 | 11.787 | 1.801 |
| 322 | 1605 | 11.788 | 1.802 |
| 323 | 1610 | 11.788 | 1.802 |
| 324 | 1615 | 11.794 | 1.808 |
| 325 | 1620 | 11.788 | 1.802 |
| 326 | 1625 | 11.788 | 1.802 |
| 327 | 1630 | 11.776 | 1.79 |
| 328 | 1635 | 11.796 | 1.81 |
| 329 | 1640 | 11.786 | 1.80 |
| 330 | 1645 | 11.789 | 1.803 |
| 331 | 1650 | 11.791 | 1.805 |
| 332 | 1655 | 11.786 | 1.80 |
| 333 | 1660 | 11.798 | 1.812 |
| 334 | 1665 | 11.783 | 1.797 |
| 335 | 1670 | 11.796 | 1.81 |
| 336 | 1675 | 11.782 | 1.796 |
| 337 | 1680 | 11.797 | 1.811 |
| 338 | 1685 | 11.796 | 1.81 |
| 339 | 1690 | 11.798 | 1.812 |
| 340 | 1695 | 11.776 | 1.79 |
| 341 | 1700 | 11.795 | 1.809 |
| 342 | 1705 | 11.798 | 1.812 |
| 343 | 1710 | 11.784 | 1.798 |
| 344 | 1715 | 11.801 | 1.815 |
| 345 | 1720 | 11.799 | 1.813 |
| 346 | 1725 | 11.795 | 1.809 |
| 347 | 1730 | 11.798 | 1.812 |
| 348 | 1735 | 11.793 | 1.807 |
| 349 | 1740 | 11.785 | 1.799 |
| 350 | 1745 | 11.809 | 1.823 |
| 351 | 1750 | 11.80 | 1.814 |
| 352 | 1755 | 11.795 | 1.809 |
| 353 | 1760 | 11.803 | 1.817 |
| 354 | 1765 | 11.798 | 1.812 |
| 355 | 1770 | 11.798 | 1.812 |
| 356 | 1775 | 11.803 | 1.817 |
| 357 | 1780 | 11.818 | 1.832 |
| 358 | 1785 | 11.807 | 1.821 |
| 359 | 1790 | 11.797 | 1.811 |
| 360 | 1795 | 11.805 | 1.819 |
| 361 | 1800 | 11.808 | 1.822 |
| 362 | 1805 | 11.81 | 1.824 |
| 363 | 1810 | 11.814 | 1.828 |
| 364 | 1815 | 11.807 | 1.821 |
| 365 | 1820 | 11.815 | 1.829 |
| 366 | 1825 | 11.823 | 1.837 |
| 367 | 1830 | 11.808 | 1.822 |
| 368 | 1835 | 11.809 | 1.823 |
| 369 | 1840 | 11.817 | 1.831 |
| 370 | 1845 | 11.817 | 1.831 |
| 371 | 1850 | 11.822 | 1.836 |
| 372 | 1855 | 11.802 | 1.816 |

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 373 | 1860 | 11.812 | 1.826 |
| 374 | 1865 | 11.819 | 1.833 |
| 375 | 1870 | 11.824 | 1.838 |
| 376 | 1875 | 11.813 | 1.827 |
| 377 | 1880 | 11.819 | 1.833 |
| 378 | 1885 | 11.817 | 1.831 |
| 379 | 1890 | 11.813 | 1.827 |
| 380 | 1895 | 11.817 | 1.831 |
| 381 | 1900 | 11.813 | 1.827 |
| 382 | 1905 | 11.813 | 1.827 |
| 383 | 1910 | 11.82 | 1.834 |
| 384 | 1915 | 11.812 | 1.826 |
| 385 | 1920 | 11.812 | 1.826 |
| 386 | 1925 | 11.821 | 1.835 |
| 387 | 1930 | 11.828 | 1.842 |
| 388 | 1935 | 11.81 | 1.824 |
| 389 | 1940 | 11.816 | 1.83 |
| 390 | 1945 | 11.812 | 1.826 |
| 391 | 1950 | 11.814 | 1.828 |
| 392 | 1955 | 11.806 | 1.82 |
| 393 | 1960 | 11.808 | 1.822 |
| 394 | 1965 | 11.813 | 1.827 |
| 395 | 1970 | 11.813 | 1.827 |
| 396 | 1975 | 11.817 | 1.831 |
| 397 | 1980 | 11.822 | 1.836 |
| 398 | 1985 | 11.816 | 1.83 |
| 399 | 1990 | 11.818 | 1.832 |
| 400 | 1995 | 11.824 | 1.838 |
| 401 | 2000 | 11.823 | 1.837 |
| 402 | 2005 | 11.828 | 1.842 |
| 403 | 2010 | 11.83 | 1.844 |
| 404 | 2015 | 11.826 | 1.84 |
| 405 | 2020 | 11.825 | 1.839 |
| 406 | 2025 | 11.825 | 1.839 |
| 407 | 2030 | 11.823 | 1.837 |
| 408 | 2035 | 11.824 | 1.838 |
| 409 | 2040 | 11.822 | 1.836 |
| 410 | 2045 | 11.822 | 1.836 |
| 411 | 2050 | 11.826 | 1.84 |
| 412 | 2055 | 11.821 | 1.835 |
| 413 | 2060 | 11.827 | 1.841 |
| 414 | 2065 | 11.825 | 1.839 |
| 415 | 2070 | 11.831 | 1.845 |
| 416 | 2075 | 11.829 | 1.843 |
| 417 | 2080 | 11.829 | 1.843 |
| 418 | 2085 | 11.826 | 1.84 |
| 419 | 2090 | 11.826 | 1.84 |
| 420 | 2095 | 11.835 | 1.849 |
| 421 | 2100 | 11.832 | 1.846 |
| 422 | 2105 | 11.827 | 1.841 |
| 423 | 2110 | 11.831 | 1.845 |
| 424 | 2115 | 11.836 | 1.85 |
| 425 | 2120 | 11.834 | 1.848 |
| 426 | 2125 | 11.835 | 1.849 |
| 427 | 2130 | 11.831 | 1.845 |
| 428 | 2135 | 11.833 | 1.847 |
| 429 | 2140 | 11.833 | 1.847 |
| 430 | 2145 | 11.841 | 1.855 |
| 431 | 2150 | 11.84 | 1.854 |
| 432 | 2155 | 11.843 | 1.857 |
| 433 | 2160 | 11.839 | 1.853 |
| 434 | 2165 | 11.845 | 1.859 |
| 435 | 2170 | 11.84 | 1.854 |

**Contact Info**
**Address**
**Company Name**
**City, State/Province**



Project: West Des Moines Pump Test

Number:

Client:

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 436 | 2175 | 11.844 | 1.858 |
| 437 | 2180 | 11.843 | 1.857 |
| 438 | 2185 | 11.848 | 1.862 |
| 439 | 2190 | 11.844 | 1.858 |
| 440 | 2195 | 11.851 | 1.865 |
| 441 | 2200 | 11.848 | 1.862 |
| 442 | 2205 | 11.845 | 1.859 |
| 443 | 2210 | 11.846 | 1.86 |
| 444 | 2215 | 11.849 | 1.863 |
| 445 | 2220 | 11.848 | 1.862 |
| 446 | 2225 | 11.845 | 1.859 |
| 447 | 2230 | 11.853 | 1.867 |
| 448 | 2235 | 11.853 | 1.867 |
| 449 | 2240 | 11.848 | 1.862 |
| 450 | 2245 | 11.853 | 1.867 |
| 451 | 2250 | 11.844 | 1.858 |
| 452 | 2255 | 11.851 | 1.865 |
| 453 | 2260 | 11.849 | 1.863 |
| 454 | 2265 | 11.847 | 1.861 |
| 455 | 2270 | 11.852 | 1.866 |
| 456 | 2275 | 11.848 | 1.862 |
| 457 | 2280 | 11.856 | 1.87 |
| 458 | 2285 | 11.849 | 1.863 |
| 459 | 2290 | 11.849 | 1.863 |
| 460 | 2295 | 11.851 | 1.865 |
| 461 | 2300 | 11.857 | 1.871 |
| 462 | 2305 | 11.85 | 1.864 |
| 463 | 2310 | 11.852 | 1.866 |
| 464 | 2315 | 11.857 | 1.871 |
| 465 | 2320 | 11.856 | 1.87 |
| 466 | 2325 | 11.853 | 1.867 |
| 467 | 2330 | 11.855 | 1.869 |
| 468 | 2335 | 11.855 | 1.869 |
| 469 | 2340 | 11.851 | 1.865 |
| 470 | 2345 | 11.855 | 1.869 |
| 471 | 2350 | 11.858 | 1.872 |
| 472 | 2355 | 11.858 | 1.872 |
| 473 | 2360 | 11.856 | 1.87 |
| 474 | 2365 | 11.858 | 1.872 |
| 475 | 2370 | 11.858 | 1.872 |
| 476 | 2375 | 11.857 | 1.871 |
| 477 | 2380 | 11.863 | 1.877 |
| 478 | 2385 | 11.858 | 1.872 |
| 479 | 2390 | 11.859 | 1.873 |
| 480 | 2395 | 11.861 | 1.875 |
| 481 | 2400 | 11.86 | 1.874 |
| 482 | 2405 | 11.861 | 1.875 |
| 483 | 2410 | 11.865 | 1.879 |
| 484 | 2415 | 11.867 | 1.881 |
| 485 | 2420 | 11.863 | 1.877 |
| 486 | 2425 | 11.86 | 1.874 |
| 487 | 2430 | 11.863 | 1.877 |
| 488 | 2435 | 11.863 | 1.877 |
| 489 | 2440 | 11.862 | 1.876 |
| 490 | 2445 | 11.86 | 1.874 |
| 491 | 2450 | 11.86 | 1.874 |
| 492 | 2455 | 11.862 | 1.876 |
| 493 | 2460 | 11.864 | 1.878 |
| 494 | 2465 | 11.861 | 1.875 |
| 495 | 2470 | 11.864 | 1.878 |
| 496 | 2475 | 11.862 | 1.876 |
| 497 | 2480 | 11.862 | 1.876 |
| 498 | 2485 | 11.865 | 1.879 |

**Contact Info**
**Address**
**Company Name**
**City, State/Province**



Project: West Des Moines Pump Test

Number:

Client:

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 499 | 2490 | 11.868 | 1.882 |
| 500 | 2495 | 11.867 | 1.881 |
| 501 | 2500 | 11.865 | 1.879 |
| 502 | 2505 | 11.864 | 1.878 |
| 503 | 2510 | 11.867 | 1.881 |
| 504 | 2515 | 11.87 | 1.884 |
| 505 | 2520 | 11.866 | 1.88 |
| 506 | 2525 | 11.865 | 1.879 |
| 507 | 2530 | 11.869 | 1.883 |
| 508 | 2535 | 11.866 | 1.88 |
| 509 | 2540 | 11.869 | 1.883 |
| 510 | 2545 | 11.871 | 1.885 |
| 511 | 2550 | 11.869 | 1.883 |
| 512 | 2555 | 11.871 | 1.885 |
| 513 | 2560 | 11.867 | 1.881 |
| 514 | 2565 | 11.871 | 1.885 |
| 515 | 2570 | 11.873 | 1.887 |
| 516 | 2575 | 11.87 | 1.884 |
| 517 | 2580 | 11.867 | 1.881 |
| 518 | 2585 | 11.87 | 1.884 |
| 519 | 2590 | 11.873 | 1.887 |
| 520 | 2595 | 11.872 | 1.886 |
| 521 | 2600 | 11.87 | 1.884 |
| 522 | 2605 | 11.875 | 1.889 |
| 523 | 2610 | 11.867 | 1.881 |
| 524 | 2615 | 11.872 | 1.886 |
| 525 | 2620 | 11.874 | 1.888 |
| 526 | 2625 | 11.874 | 1.888 |
| 527 | 2630 | 11.871 | 1.885 |
| 528 | 2635 | 11.877 | 1.891 |
| 529 | 2640 | 11.875 | 1.889 |
| 530 | 2645 | 11.873 | 1.887 |
| 531 | 2650 | 11.879 | 1.893 |
| 532 | 2655 | 11.878 | 1.892 |
| 533 | 2660 | 11.875 | 1.889 |
| 534 | 2665 | 11.877 | 1.891 |
| 535 | 2670 | 11.877 | 1.891 |
| 536 | 2675 | 11.877 | 1.891 |
| 537 | 2680 | 11.876 | 1.89 |
| 538 | 2685 | 11.877 | 1.891 |
| 539 | 2690 | 11.879 | 1.893 |
| 540 | 2695 | 11.877 | 1.891 |
| 541 | 2700 | 11.876 | 1.89 |
| 542 | 2705 | 11.88 | 1.894 |
| 543 | 2710 | 11.882 | 1.896 |
| 544 | 2715 | 11.881 | 1.895 |
| 545 | 2720 | 11.88 | 1.894 |
| 546 | 2725 | 11.886 | 1.90 |
| 547 | 2730 | 11.881 | 1.895 |
| 548 | 2735 | 11.881 | 1.895 |
| 549 | 2740 | 11.879 | 1.893 |
| 550 | 2745 | 11.88 | 1.894 |
| 551 | 2750 | 11.884 | 1.898 |
| 552 | 2755 | 11.881 | 1.895 |
| 553 | 2760 | 11.881 | 1.895 |
| 554 | 2765 | 11.883 | 1.897 |
| 555 | 2770 | 11.887 | 1.901 |
| 556 | 2775 | 11.883 | 1.897 |
| 557 | 2780 | 11.88 | 1.894 |
| 558 | 2785 | 11.886 | 1.90 |
| 559 | 2790 | 11.882 | 1.896 |
| 560 | 2795 | 11.887 | 1.901 |
| 561 | 2800 | 11.89 | 1.904 |

**Contact Info**
**Address**
**Company Name**
**City, State/Province**



Project: West Des Moines Pump Test

Number:

Client:

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 562 | 2805 | 11.885 | 1.899 |
| 563 | 2810 | 11.89 | 1.904 |
| 564 | 2815 | 11.89 | 1.904 |
| 565 | 2820 | 11.895 | 1.909 |
| 566 | 2825 | 11.889 | 1.903 |
| 567 | 2830 | 11.89 | 1.904 |
| 568 | 2835 | 11.887 | 1.901 |
| 569 | 2840 | 11.891 | 1.905 |
| 570 | 2845 | 11.889 | 1.903 |
| 571 | 2850 | 11.89 | 1.904 |
| 572 | 2855 | 11.891 | 1.905 |
| 573 | 2860 | 11.89 | 1.904 |
| 574 | 2865 | 11.894 | 1.908 |
| 575 | 2870 | 11.89 | 1.904 |
| 576 | 2875 | 11.892 | 1.906 |
| 577 | 2880 | 11.893 | 1.907 |
| 578 | 2885 | 11.897 | 1.911 |
| 579 | 2890 | 11.895 | 1.909 |
| 580 | 2895 | 11.895 | 1.909 |
| 581 | 2900 | 11.896 | 1.91 |
| 582 | 2905 | 11.90 | 1.914 |
| 583 | 2910 | 11.896 | 1.91 |
| 584 | 2915 | 11.897 | 1.911 |
| 585 | 2920 | 11.895 | 1.909 |
| 586 | 2925 | 11.897 | 1.911 |
| 587 | 2930 | 11.898 | 1.912 |
| 588 | 2935 | 11.899 | 1.913 |
| 589 | 2940 | 11.895 | 1.909 |
| 590 | 2945 | 11.902 | 1.916 |
| 591 | 2950 | 11.903 | 1.917 |
| 592 | 2955 | 11.90 | 1.914 |
| 593 | 2960 | 11.897 | 1.911 |
| 594 | 2965 | 11.898 | 1.912 |
| 595 | 2970 | 11.901 | 1.915 |
| 596 | 2975 | 11.906 | 1.92 |
| 597 | 2980 | 11.904 | 1.918 |
| 598 | 2985 | 11.903 | 1.917 |
| 599 | 2990 | 11.889 | 1.903 |
| 600 | 2995 | 11.898 | 1.912 |
| 601 | 3000 | 11.896 | 1.91 |
| 602 | 3005 | 11.903 | 1.917 |
| 603 | 3010 | 11.893 | 1.907 |
| 604 | 3015 | 11.908 | 1.922 |
| 605 | 3020 | 11.914 | 1.928 |
| 606 | 3025 | 11.89 | 1.904 |
| 607 | 3030 | 11.901 | 1.915 |
| 608 | 3035 | 11.901 | 1.915 |
| 609 | 3040 | 11.90 | 1.914 |
| 610 | 3045 | 11.898 | 1.912 |
| 611 | 3050 | 11.898 | 1.912 |
| 612 | 3055 | 11.893 | 1.907 |
| 613 | 3060 | 11.89 | 1.904 |
| 614 | 3065 | 11.898 | 1.912 |
| 615 | 3070 | 11.893 | 1.907 |
| 616 | 3075 | 11.899 | 1.913 |
| 617 | 3080 | 11.909 | 1.923 |
| 618 | 3085 | 11.901 | 1.915 |
| 619 | 3090 | 11.904 | 1.918 |
| 620 | 3095 | 11.904 | 1.918 |
| 621 | 3100 | 11.899 | 1.913 |
| 622 | 3105 | 11.915 | 1.929 |
| 623 | 3110 | 11.907 | 1.921 |
| 624 | 3115 | 11.889 | 1.903 |

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 625 | 3120 | 11.908 | 1.922 |
| 626 | 3125 | 11.905 | 1.919 |
| 627 | 3130 | 11.896 | 1.91 |
| 628 | 3135 | 11.898 | 1.912 |
| 629 | 3140 | 11.905 | 1.919 |
| 630 | 3145 | 11.904 | 1.918 |
| 631 | 3150 | 11.897 | 1.911 |
| 632 | 3155 | 11.901 | 1.915 |
| 633 | 3160 | 11.90 | 1.914 |
| 634 | 3165 | 11.90 | 1.914 |
| 635 | 3170 | 11.901 | 1.915 |
| 636 | 3175 | 11.902 | 1.916 |
| 637 | 3180 | 11.901 | 1.915 |
| 638 | 3185 | 11.903 | 1.917 |
| 639 | 3190 | 11.905 | 1.919 |
| 640 | 3195 | 11.904 | 1.918 |
| 641 | 3200 | 11.905 | 1.919 |
| 642 | 3205 | 11.899 | 1.913 |
| 643 | 3210 | 11.90 | 1.914 |
| 644 | 3215 | 11.899 | 1.913 |
| 645 | 3220 | 11.902 | 1.916 |
| 646 | 3225 | 11.909 | 1.923 |
| 647 | 3230 | 11.897 | 1.911 |
| 648 | 3235 | 11.908 | 1.922 |
| 649 | 3240 | 11.917 | 1.931 |
| 650 | 3245 | 11.911 | 1.925 |
| 651 | 3250 | 11.906 | 1.92 |
| 652 | 3255 | 11.914 | 1.928 |
| 653 | 3260 | 11.903 | 1.917 |
| 654 | 3265 | 11.91 | 1.924 |
| 655 | 3270 | 11.907 | 1.921 |
| 656 | 3275 | 11.904 | 1.918 |
| 657 | 3280 | 11.911 | 1.925 |
| 658 | 3285 | 11.901 | 1.915 |
| 659 | 3290 | 11.911 | 1.925 |
| 660 | 3295 | 11.894 | 1.908 |
| 661 | 3300 | 11.907 | 1.921 |
| 662 | 3305 | 11.901 | 1.915 |
| 663 | 3310 | 11.911 | 1.925 |
| 664 | 3315 | 11.904 | 1.918 |
| 665 | 3320 | 11.90 | 1.914 |
| 666 | 3325 | 11.916 | 1.93 |
| 667 | 3330 | 11.901 | 1.915 |
| 668 | 3335 | 11.908 | 1.922 |
| 669 | 3340 | 11.901 | 1.915 |
| 670 | 3345 | 11.909 | 1.923 |
| 671 | 3350 | 11.903 | 1.917 |
| 672 | 3355 | 11.908 | 1.922 |
| 673 | 3360 | 11.908 | 1.922 |
| 674 | 3365 | 11.911 | 1.925 |
| 675 | 3370 | 11.911 | 1.925 |
| 676 | 3375 | 11.905 | 1.919 |
| 677 | 3380 | 11.91 | 1.924 |
| 678 | 3385 | 11.902 | 1.916 |
| 679 | 3390 | 11.904 | 1.918 |
| 680 | 3395 | 11.905 | 1.919 |
| 681 | 3400 | 11.90 | 1.914 |
| 682 | 3405 | 11.902 | 1.916 |
| 683 | 3410 | 11.901 | 1.915 |
| 684 | 3415 | 11.903 | 1.917 |
| 685 | 3420 | 11.901 | 1.915 |
| 686 | 3425 | 11.909 | 1.923 |
| 687 | 3430 | 11.908 | 1.922 |

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 688 | 3435 | 11.907 | 1.921 |
| 689 | 3440 | 11.912 | 1.926 |
| 690 | 3445 | 11.913 | 1.927 |
| 691 | 3450 | 11.913 | 1.927 |
| 692 | 3455 | 11.911 | 1.925 |
| 693 | 3460 | 11.909 | 1.923 |
| 694 | 3465 | 11.903 | 1.917 |
| 695 | 3470 | 11.905 | 1.919 |
| 696 | 3475 | 11.905 | 1.919 |
| 697 | 3480 | 11.907 | 1.921 |
| 698 | 3485 | 11.904 | 1.918 |
| 699 | 3490 | 11.905 | 1.919 |
| 700 | 3495 | 11.908 | 1.922 |
| 701 | 3500 | 11.907 | 1.921 |
| 702 | 3505 | 11.913 | 1.927 |
| 703 | 3510 | 11.909 | 1.923 |
| 704 | 3515 | 11.911 | 1.925 |
| 705 | 3520 | 11.915 | 1.929 |
| 706 | 3525 | 11.911 | 1.925 |
| 707 | 3530 | 11.911 | 1.925 |
| 708 | 3535 | 11.912 | 1.926 |
| 709 | 3540 | 11.907 | 1.921 |
| 710 | 3545 | 11.91 | 1.924 |
| 711 | 3550 | 11.91 | 1.924 |
| 712 | 3555 | 11.912 | 1.926 |
| 713 | 3560 | 11.912 | 1.926 |
| 714 | 3565 | 11.918 | 1.932 |
| 715 | 3570 | 11.914 | 1.928 |
| 716 | 3575 | 11.913 | 1.927 |
| 717 | 3580 | 11.917 | 1.931 |
| 718 | 3585 | 11.915 | 1.929 |
| 719 | 3590 | 11.915 | 1.929 |
| 720 | 3595 | 11.916 | 1.93 |
| 721 | 3600 | 11.916 | 1.93 |
| 722 | 3605 | 11.918 | 1.932 |
| 723 | 3610 | 11.918 | 1.932 |
| 724 | 3615 | 11.918 | 1.932 |
| 725 | 3620 | 11.924 | 1.938 |
| 726 | 3625 | 11.918 | 1.932 |
| 727 | 3630 | 11.919 | 1.933 |
| 728 | 3635 | 11.92 | 1.934 |
| 729 | 3640 | 11.923 | 1.937 |
| 730 | 3645 | 11.918 | 1.932 |
| 731 | 3650 | 11.922 | 1.936 |
| 732 | 3655 | 11.92 | 1.934 |
| 733 | 3660 | 11.923 | 1.937 |
| 734 | 3665 | 11.922 | 1.936 |
| 735 | 3670 | 11.921 | 1.935 |
| 736 | 3675 | 11.924 | 1.938 |
| 737 | 3680 | 11.92 | 1.934 |
| 738 | 3685 | 11.922 | 1.936 |
| 739 | 3690 | 11.921 | 1.935 |
| 740 | 3695 | 11.921 | 1.935 |
| 741 | 3700 | 11.92 | 1.934 |
| 742 | 3705 | 11.923 | 1.937 |
| 743 | 3710 | 11.927 | 1.941 |
| 744 | 3715 | 11.926 | 1.94 |
| 745 | 3720 | 11.925 | 1.939 |
| 746 | 3725 | 11.925 | 1.939 |
| 747 | 3730 | 11.924 | 1.938 |
| 748 | 3735 | 11.929 | 1.943 |
| 749 | 3740 | 11.924 | 1.938 |
| 750 | 3745 | 11.928 | 1.942 |

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 751 | 3750 | 11.927 | 1.941 |
| 752 | 3755 | 11.923 | 1.937 |
| 753 | 3760 | 11.923 | 1.937 |
| 754 | 3765 | 11.926 | 1.94 |
| 755 | 3770 | 11.925 | 1.939 |
| 756 | 3775 | 11.926 | 1.94 |
| 757 | 3780 | 11.926 | 1.94 |
| 758 | 3785 | 11.925 | 1.939 |
| 759 | 3790 | 11.925 | 1.939 |
| 760 | 3795 | 11.929 | 1.943 |
| 761 | 3800 | 11.926 | 1.94 |
| 762 | 3805 | 11.926 | 1.94 |
| 763 | 3810 | 11.926 | 1.94 |
| 764 | 3815 | 11.928 | 1.942 |
| 765 | 3820 | 11.926 | 1.94 |
| 766 | 3825 | 11.928 | 1.942 |
| 767 | 3830 | 11.926 | 1.94 |
| 768 | 3835 | 11.929 | 1.943 |
| 769 | 3840 | 11.926 | 1.94 |
| 770 | 3845 | 11.929 | 1.943 |
| 771 | 3850 | 11.928 | 1.942 |
| 772 | 3855 | 11.93 | 1.944 |
| 773 | 3860 | 11.929 | 1.943 |
| 774 | 3865 | 11.925 | 1.939 |
| 775 | 3870 | 11.929 | 1.943 |
| 776 | 3875 | 11.932 | 1.946 |
| 777 | 3880 | 11.931 | 1.945 |
| 778 | 3885 | 11.931 | 1.945 |
| 779 | 3890 | 11.933 | 1.947 |
| 780 | 3895 | 11.929 | 1.943 |
| 781 | 3900 | 11.929 | 1.943 |
| 782 | 3905 | 11.93 | 1.944 |
| 783 | 3910 | 11.926 | 1.94 |
| 784 | 3915 | 11.93 | 1.944 |
| 785 | 3920 | 11.935 | 1.949 |
| 786 | 3925 | 11.93 | 1.944 |
| 787 | 3930 | 11.932 | 1.946 |
| 788 | 3935 | 11.932 | 1.946 |
| 789 | 3940 | 11.931 | 1.945 |
| 790 | 3945 | 11.929 | 1.943 |
| 791 | 3950 | 11.93 | 1.944 |
| 792 | 3955 | 11.931 | 1.945 |
| 793 | 3960 | 11.932 | 1.946 |
| 794 | 3965 | 11.931 | 1.945 |
| 795 | 3970 | 11.934 | 1.948 |
| 796 | 3975 | 11.934 | 1.948 |
| 797 | 3980 | 11.934 | 1.948 |
| 798 | 3985 | 11.931 | 1.945 |
| 799 | 3990 | 11.932 | 1.946 |
| 800 | 3995 | 11.934 | 1.948 |
| 801 | 4000 | 11.935 | 1.949 |
| 802 | 4005 | 11.932 | 1.946 |
| 803 | 4010 | 11.932 | 1.946 |
| 804 | 4015 | 11.936 | 1.95 |
| 805 | 4020 | 11.936 | 1.95 |
| 806 | 4025 | 11.934 | 1.948 |
| 807 | 4030 | 11.936 | 1.95 |
| 808 | 4035 | 11.937 | 1.951 |
| 809 | 4040 | 11.933 | 1.947 |
| 810 | 4045 | 11.934 | 1.948 |
| 811 | 4050 | 11.94 | 1.954 |
| 812 | 4055 | 11.936 | 1.95 |
| 813 | 4060 | 11.939 | 1.953 |

**Contact Info**
**Address**
**Company Name**
**City, State/Province**

**Pumping Test - Water Level Data** 

Project: West Des Moines Pump Test

Number:

Client:

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 814 | 4065 | 11.937 | 1.951 |
| 815 | 4070 | 11.936 | 1.95 |
| 816 | 4075 | 11.937 | 1.951 |
| 817 | 4080 | 11.935 | 1.949 |
| 818 | 4085 | 11.933 | 1.947 |
| 819 | 4090 | 11.936 | 1.95 |
| 820 | 4095 | 11.937 | 1.951 |
| 821 | 4100 | 11.94 | 1.954 |
| 822 | 4105 | 11.936 | 1.95 |
| 823 | 4110 | 11.942 | 1.956 |
| 824 | 4115 | 11.933 | 1.947 |
| 825 | 4120 | 11.937 | 1.951 |
| 826 | 4125 | 11.938 | 1.952 |
| 827 | 4130 | 11.941 | 1.955 |
| 828 | 4135 | 11.937 | 1.951 |
| 829 | 4140 | 11.934 | 1.948 |
| 830 | 4145 | 11.938 | 1.952 |
| 831 | 4150 | 11.935 | 1.949 |
| 832 | 4155 | 11.94 | 1.954 |
| 833 | 4160 | 11.942 | 1.956 |
| 834 | 4165 | 11.941 | 1.955 |
| 835 | 4170 | 11.94 | 1.954 |
| 836 | 4175 | 11.939 | 1.953 |
| 837 | 4180 | 11.94 | 1.954 |
| 838 | 4185 | 11.945 | 1.959 |
| 839 | 4190 | 11.944 | 1.958 |
| 840 | 4195 | 11.94 | 1.954 |
| 841 | 4200 | 11.939 | 1.953 |
| 842 | 4205 | 11.942 | 1.956 |
| 843 | 4210 | 11.943 | 1.957 |
| 844 | 4215 | 11.941 | 1.955 |
| 845 | 4220 | 11.943 | 1.957 |
| 846 | 4225 | 11.943 | 1.957 |
| 847 | 4230 | 11.946 | 1.96 |
| 848 | 4235 | 11.939 | 1.953 |
| 849 | 4240 | 11.939 | 1.953 |
| 850 | 4245 | 11.939 | 1.953 |
| 851 | 4250 | 11.938 | 1.952 |
| 852 | 4255 | 11.942 | 1.956 |
| 853 | 4260 | 11.94 | 1.954 |
| 854 | 4265 | 11.935 | 1.949 |
| 855 | 4270 | 11.94 | 1.954 |
| 856 | 4275 | 11.937 | 1.951 |
| 857 | 4280 | 11.941 | 1.955 |
| 858 | 4285 | 11.935 | 1.949 |
| 859 | 4290 | 11.934 | 1.948 |
| 860 | 4295 | 11.942 | 1.956 |
| 861 | 4300 | 11.935 | 1.949 |
| 862 | 4305 | 11.935 | 1.949 |
| 863 | 4310 | 11.937 | 1.951 |
| 864 | 4315 | 11.941 | 1.955 |
| 865 | 4320 | 11.943 | 1.957 |
| 866 | 4325 | 11.942 | 1.956 |
| 867 | 4330 | 11.943 | 1.957 |
| 868 | 4335 | 11.945 | 1.959 |
| 869 | 4340 | 11.945 | 1.959 |
| 870 | 4345 | 11.948 | 1.962 |
| 871 | 4350 | 11.946 | 1.96 |
| 872 | 4355 | 11.941 | 1.955 |
| 873 | 4360 | 11.942 | 1.956 |
| 874 | 4365 | 11.946 | 1.96 |
| 875 | 4370 | 11.945 | 1.959 |
| 876 | 4375 | 11.941 | 1.955 |

**Contact Info**
**Address**
**Company Name**
**City, State/Province**



Project: West Des Moines Pump Test

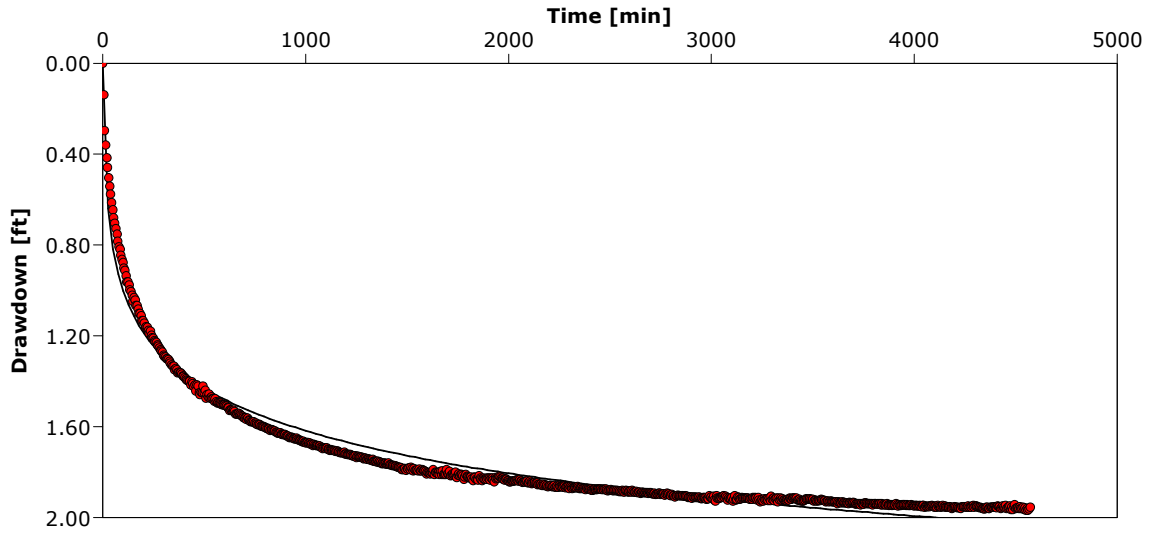
Number:

Client:

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 877 | 4380 | 11.94 | 1.954 |
| 878 | 4385 | 11.94 | 1.954 |
| 879 | 4390 | 11.942 | 1.956 |
| 880 | 4395 | 11.937 | 1.951 |
| 881 | 4400 | 11.942 | 1.956 |
| 882 | 4405 | 11.943 | 1.957 |
| 883 | 4410 | 11.936 | 1.95 |
| 884 | 4415 | 11.938 | 1.952 |
| 885 | 4420 | 11.939 | 1.953 |
| 886 | 4425 | 11.947 | 1.961 |
| 887 | 4430 | 11.944 | 1.958 |
| 888 | 4435 | 11.936 | 1.95 |
| 889 | 4440 | 11.942 | 1.956 |
| 890 | 4445 | 11.944 | 1.958 |
| 891 | 4450 | 11.934 | 1.948 |
| 892 | 4455 | 11.945 | 1.959 |
| 893 | 4460 | 11.944 | 1.958 |
| 894 | 4465 | 11.938 | 1.952 |
| 895 | 4470 | 11.936 | 1.95 |
| 896 | 4475 | 11.951 | 1.965 |
| 897 | 4480 | 11.942 | 1.956 |
| 898 | 4485 | 11.951 | 1.965 |
| 899 | 4490 | 11.937 | 1.951 |
| 900 | 4495 | 11.931 | 1.945 |
| 901 | 4500 | 11.946 | 1.96 |
| 902 | 4505 | 11.943 | 1.957 |
| 903 | 4510 | 11.943 | 1.957 |
| 904 | 4515 | 11.946 | 1.96 |
| 905 | 4520 | 11.938 | 1.952 |
| 906 | 4525 | 11.946 | 1.96 |
| 907 | 4530 | 11.947 | 1.961 |
| 908 | 4535 | 11.94 | 1.954 |
| 909 | 4540 | 11.951 | 1.965 |
| 910 | 4545 | 11.944 | 1.958 |
| 911 | 4550 | 11.955 | 1.969 |
| 912 | 4555 | 11.946 | 1.96 |
| 913 | 4560 | 11.955 | 1.969 |
| 914 | 4565 | 11.948 | 1.962 |
| 915 | 4570 | 11.94 | 1.954 |

| | | |
|---|---|---|
| **Contact Info**<br>**Address**<br>**Company Name**<br>**City, State/Province** | **Pumping Test Analysis Report** | |
| | Project: West Des Moines Pump Test | |
| | Number: | |
| | Client: | |

| | | |
|---|---|---|
| Location: West Des Moines, Iowa | Pumping Test: Well 21 | Pumping Well: Well 21 |
| Test Conducted by: | | Test Date: 9/11/2012 |
| Analysis Performed by: | New analysis 5 | Analysis Date: 9/21/2012 |
| Aquifer Thickness: 20.00 ft | Discharge Rate: 243 [U.S. gal/min] | |




Calculation using Theis

| Observation Well | Transmissivity [ft²/d] | Hydraulic Conductivity [ft/d] | Storage coefficient | Radial Distance to PW [ft] | |
|---|---|---|---|---|---|
| 0B1 | $1.37 \times 10^{4}$ | $6.86 \times 10^{2}$ | $1.38 \times 10^{-2}$ | 63.0 | |

| | | |
|---|---|---|
| **Contact Info**<br>**Address**<br>**Company Name**<br>**City, State/Province** | **Pumping Test - Water Level Data** | Page 1 of 5 |
| | Project: West Des Moines Pump Test | |
| | Number: | |
| | Client: | |

| | | |
|---|---|---|
| Location: West Des Moines, Iowa | Pumping Test: Well 21 | Pumping Well: Well 21 |
| Test Conducted by: | Test Date: 9/11/2012 | Discharge Rate: 243 [U.S. gal/min] |
| Observation Well: OB2 | Static Water Level [ft]: 22.61 | Radial Distance to PW [ft]: 115 |

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 1 | 0 | 22.611 | 0.001 |
| 2 | 5 | 22.63 | 0.02 |
| 3 | 10 | 22.636 | 0.026 |
| 4 | 15 | 22.641 | 0.031 |
| 5 | 20 | 22.648 | 0.038 |
| 6 | 25 | 22.653 | 0.043 |
| 7 | 30 | 22.661 | 0.051 |
| 8 | 35 | 22.667 | 0.057 |
| 9 | 40 | 22.67 | 0.06 |
| 10 | 45 | 22.678 | 0.068 |
| 11 | 50 | 22.68 | 0.07 |
| 12 | 55 | 22.691 | 0.081 |
| 13 | 60 | 22.695 | 0.085 |
| 14 | 65 | 22.698 | 0.088 |
| 15 | 70 | 22.702 | 0.092 |
| 16 | 75 | 22.711 | 0.101 |
| 17 | 80 | 22.712 | 0.102 |
| 18 | 85 | 22.718 | 0.108 |
| 19 | 90 | 22.726 | 0.116 |
| 20 | 95 | 22.73 | 0.12 |
| 21 | 100 | 22.732 | 0.122 |
| 22 | 105 | 22.736 | 0.126 |
| 23 | 110 | 22.744 | 0.134 |
| 24 | 115 | 22.748 | 0.138 |
| 25 | 120 | 22.751 | 0.141 |
| 26 | 125 | 22.758 | 0.148 |
| 27 | 130 | 22.763 | 0.153 |
| 28 | 135 | 22.764 | 0.154 |
| 29 | 140 | 22.77 | 0.16 |
| 30 | 145 | 22.77 | 0.16 |
| 31 | 150 | 22.776 | 0.166 |
| 32 | 155 | 22.781 | 0.171 |
| 33 | 160 | 22.783 | 0.173 |
| 34 | 165 | 22.785 | 0.175 |
| 35 | 170 | 22.794 | 0.184 |
| 36 | 175 | 22.796 | 0.186 |
| 37 | 180 | 22.801 | 0.191 |
| 38 | 185 | 22.805 | 0.195 |
| 39 | 190 | 22.81 | 0.20 |
| 40 | 195 | 22.814 | 0.204 |
| 41 | 200 | 22.816 | 0.206 |
| 42 | 205 | 22.821 | 0.211 |
| 43 | 210 | 22.823 | 0.213 |
| 44 | 215 | 22.826 | 0.216 |
| 45 | 220 | 22.83 | 0.22 |
| 46 | 225 | 22.835 | 0.225 |
| 47 | 230 | 22.838 | 0.228 |
| 48 | 235 | 22.843 | 0.233 |
| 49 | 240 | 22.842 | 0.232 |
| 50 | 245 | 22.848 | 0.238 |
| 51 | 250 | 22.852 | 0.242 |
| 52 | 255 | 22.859 | 0.249 |
| 53 | 260 | 22.859 | 0.249 |
| 54 | 265 | 22.864 | 0.254 |
| 55 | 270 | 22.864 | 0.254 |
| 56 | 275 | 22.872 | 0.262 |
| 57 | 280 | 22.875 | 0.265 |

**Contact Info**
**Address**
**Company Name**
**City, State/Province**

**Pumping Test - Water Level Data** 

Project: West Des Moines Pump Test

Number:

Client:

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 58 | 285 | 22.879 | 0.269 |
| 59 | 290 | 22.884 | 0.274 |
| 60 | 295 | 22.879 | 0.269 |
| 61 | 300 | 22.885 | 0.275 |
| 62 | 305 | 22.887 | 0.277 |
| 63 | 310 | 22.89 | 0.28 |
| 64 | 315 | 22.898 | 0.288 |
| 65 | 320 | 22.898 | 0.288 |
| 66 | 325 | 22.903 | 0.293 |
| 67 | 330 | 22.901 | 0.291 |
| 68 | 335 | 22.908 | 0.298 |
| 69 | 340 | 22.914 | 0.304 |
| 70 | 345 | 22.917 | 0.307 |
| 71 | 350 | 22.916 | 0.306 |
| 72 | 355 | 22.92 | 0.31 |
| 73 | 360 | 22.923 | 0.313 |
| 74 | 365 | 22.925 | 0.315 |
| 75 | 370 | 22.931 | 0.321 |
| 76 | 375 | 22.931 | 0.321 |
| 77 | 380 | 22.936 | 0.326 |
| 78 | 385 | 22.938 | 0.328 |
| 79 | 390 | 22.938 | 0.328 |
| 80 | 395 | 22.942 | 0.332 |
| 81 | 400 | 22.944 | 0.334 |
| 82 | 405 | 22.947 | 0.337 |
| 83 | 410 | 22.953 | 0.343 |
| 84 | 415 | 22.951 | 0.341 |
| 85 | 420 | 22.954 | 0.344 |
| 86 | 425 | 22.959 | 0.349 |
| 87 | 430 | 22.96 | 0.35 |
| 88 | 435 | 22.961 | 0.351 |
| 89 | 440 | 22.966 | 0.356 |
| 90 | 445 | 22.967 | 0.357 |
| 91 | 450 | 22.969 | 0.359 |
| 92 | 455 | 22.972 | 0.362 |
| 93 | 460 | 22.979 | 0.369 |
| 94 | 465 | 22.982 | 0.372 |
| 95 | 470 | 22.982 | 0.372 |
| 96 | 475 | 22.982 | 0.372 |
| 97 | 480 | 22.984 | 0.374 |
| 98 | 485 | 22.989 | 0.379 |
| 99 | 490 | 22.99 | 0.38 |
| 100 | 495 | 22.995 | 0.385 |
| 101 | 500 | 22.996 | 0.386 |
| 102 | 505 | 22.997 | 0.387 |
| 103 | 510 | 23.005 | 0.395 |
| 104 | 515 | 22.999 | 0.389 |
| 105 | 520 | 23.004 | 0.394 |
| 106 | 525 | 23.005 | 0.395 |
| 107 | 530 | 23.008 | 0.398 |
| 108 | 535 | 23.013 | 0.403 |
| 109 | 540 | 23.015 | 0.405 |
| 110 | 545 | 23.017 | 0.407 |
| 111 | 550 | 23.016 | 0.406 |
| 112 | 555 | 23.021 | 0.411 |
| 113 | 560 | 23.021 | 0.411 |
| 114 | 565 | 23.023 | 0.413 |
| 115 | 570 | 23.025 | 0.415 |
| 116 | 575 | 23.028 | 0.418 |
| 117 | 580 | 23.033 | 0.423 |
| 118 | 585 | 23.032 | 0.422 |
| 119 | 590 | 23.033 | 0.423 |
| 120 | 595 | 23.037 | 0.427 |

**Contact Info**
**Address**
**Company Name**
**City, State/Province**

**Pumping Test - Water Level Data** 

Project: West Des Moines Pump Test

Number:

Client:

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 121 | 600 | 23.038 | 0.428 |
| 122 | 605 | 23.041 | 0.431 |
| 123 | 610 | 23.043 | 0.433 |
| 124 | 615 | 23.046 | 0.436 |
| 125 | 620 | 23.048 | 0.438 |
| 126 | 625 | 23.051 | 0.441 |
| 127 | 630 | 23.052 | 0.442 |
| 128 | 635 | 23.052 | 0.442 |
| 129 | 640 | 23.054 | 0.444 |
| 130 | 645 | 23.055 | 0.445 |
| 131 | 650 | 23.057 | 0.447 |
| 132 | 655 | 23.062 | 0.452 |
| 133 | 660 | 23.062 | 0.452 |
| 134 | 665 | 23.063 | 0.453 |
| 135 | 670 | 23.065 | 0.455 |
| 136 | 675 | 23.065 | 0.455 |
| 137 | 680 | 23.074 | 0.464 |
| 138 | 685 | 23.071 | 0.461 |
| 139 | 690 | 23.074 | 0.464 |
| 140 | 695 | 23.073 | 0.463 |
| 141 | 700 | 23.078 | 0.468 |
| 142 | 705 | 23.079 | 0.469 |
| 143 | 710 | 23.078 | 0.468 |
| 144 | 715 | 23.079 | 0.469 |
| 145 | 720 | 23.081 | 0.471 |
| 146 | 725 | 23.083 | 0.473 |
| 147 | 730 | 23.087 | 0.477 |
| 148 | 735 | 23.087 | 0.477 |
| 149 | 740 | 23.093 | 0.483 |
| 150 | 745 | 23.093 | 0.483 |
| 151 | 750 | 23.092 | 0.482 |
| 152 | 755 | 23.095 | 0.485 |
| 153 | 760 | 23.096 | 0.486 |
| 154 | 765 | 23.101 | 0.491 |
| 155 | 770 | 23.10 | 0.49 |
| 156 | 775 | 23.10 | 0.49 |
| 157 | 780 | 23.101 | 0.491 |
| 158 | 785 | 23.102 | 0.492 |
| 159 | 790 | 23.108 | 0.498 |
| 160 | 795 | 23.108 | 0.498 |
| 161 | 800 | 23.109 | 0.499 |
| 162 | 805 | 23.111 | 0.501 |
| 163 | 810 | 23.11 | 0.50 |
| 164 | 815 | 23.115 | 0.505 |
| 165 | 820 | 23.115 | 0.505 |
| 166 | 825 | 23.117 | 0.507 |
| 167 | 830 | 23.117 | 0.507 |
| 168 | 835 | 23.119 | 0.509 |
| 169 | 840 | 23.122 | 0.512 |
| 170 | 845 | 23.121 | 0.511 |
| 171 | 850 | 23.121 | 0.511 |
| 172 | 855 | 23.125 | 0.515 |
| 173 | 860 | 23.13 | 0.52 |
| 174 | 865 | 23.128 | 0.518 |
| 175 | 870 | 23.132 | 0.522 |
| 176 | 875 | 23.131 | 0.521 |
| 177 | 880 | 23.132 | 0.522 |
| 178 | 885 | 23.136 | 0.526 |
| 179 | 890 | 23.137 | 0.527 |
| 180 | 895 | 23.142 | 0.532 |
| 181 | 900 | 23.142 | 0.532 |
| 182 | 905 | 23.14 | 0.53 |
| 183 | 910 | 23.139 | 0.529 |

**Contact Info**
**Address**
**Company Name**
**City, State/Province**

**Pumping Test - Water Level Data** 

Project: West Des Moines Pump Test

Number:

Client:

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 184 | 915 | 23.141 | 0.531 |
| 185 | 920 | 23.145 | 0.535 |
| 186 | 925 | 23.145 | 0.535 |
| 187 | 930 | 23.149 | 0.539 |
| 188 | 935 | 23.147 | 0.537 |
| 189 | 940 | 23.15 | 0.54 |
| 190 | 945 | 23.153 | 0.543 |
| 191 | 950 | 23.152 | 0.542 |
| 192 | 955 | 23.153 | 0.543 |
| 193 | 960 | 23.159 | 0.549 |
| 194 | 965 | 23.158 | 0.548 |
| 195 | 970 | 23.156 | 0.546 |
| 196 | 975 | 23.16 | 0.55 |
| 197 | 980 | 23.162 | 0.552 |
| 198 | 985 | 23.161 | 0.551 |
| 199 | 990 | 23.165 | 0.555 |
| 200 | 995 | 23.166 | 0.556 |
| 201 | 1000 | 23.164 | 0.554 |
| 202 | 1005 | 23.168 | 0.558 |
| 203 | 1010 | 23.167 | 0.557 |
| 204 | 1015 | 23.169 | 0.559 |
| 205 | 1020 | 23.171 | 0.561 |
| 206 | 1025 | 23.171 | 0.561 |
| 207 | 1030 | 23.172 | 0.562 |
| 208 | 1035 | 23.175 | 0.565 |
| 209 | 1040 | 23.177 | 0.567 |
| 210 | 1045 | 23.176 | 0.566 |
| 211 | 1050 | 23.181 | 0.571 |
| 212 | 1055 | 23.181 | 0.571 |
| 213 | 1060 | 23.178 | 0.568 |
| 214 | 1065 | 23.181 | 0.571 |
| 215 | 1070 | 23.183 | 0.573 |
| 216 | 1075 | 23.182 | 0.572 |
| 217 | 1080 | 23.187 | 0.577 |
| 218 | 1085 | 23.185 | 0.575 |
| 219 | 1090 | 23.189 | 0.579 |
| 220 | 1095 | 23.188 | 0.578 |
| 221 | 1100 | 23.186 | 0.576 |
| 222 | 1105 | 23.189 | 0.579 |
| 223 | 1110 | 23.189 | 0.579 |
| 224 | 1115 | 23.196 | 0.586 |
| 225 | 1120 | 23.194 | 0.584 |
| 226 | 1125 | 23.197 | 0.587 |
| 227 | 1130 | 23.194 | 0.584 |
| 228 | 1135 | 23.196 | 0.586 |
| 229 | 1140 | 23.197 | 0.587 |
| 230 | 1145 | 23.198 | 0.588 |
| 231 | 1150 | 23.199 | 0.589 |
| 232 | 1155 | 23.203 | 0.593 |
| 233 | 1160 | 23.20 | 0.59 |
| 234 | 1165 | 23.199 | 0.589 |
| 235 | 1170 | 23.205 | 0.595 |
| 236 | 1175 | 23.203 | 0.593 |
| 237 | 1180 | 23.208 | 0.598 |
| 238 | 1185 | 23.206 | 0.596 |
| 239 | 1190 | 23.209 | 0.599 |
| 240 | 1195 | 23.21 | 0.60 |
| 241 | 1200 | 23.21 | 0.60 |
| 242 | 1205 | 23.211 | 0.601 |
| 243 | 1210 | 23.214 | 0.604 |
| 244 | 1215 | 23.212 | 0.602 |
| 245 | 1220 | 23.215 | 0.605 |
| 246 | 1225 | 23.219 | 0.609 |

**Contact Info**
**Address**
**Company Name**
**City, State/Province**

**Pumping Test - Water Level Data** 

Project: West Des Moines Pump Test

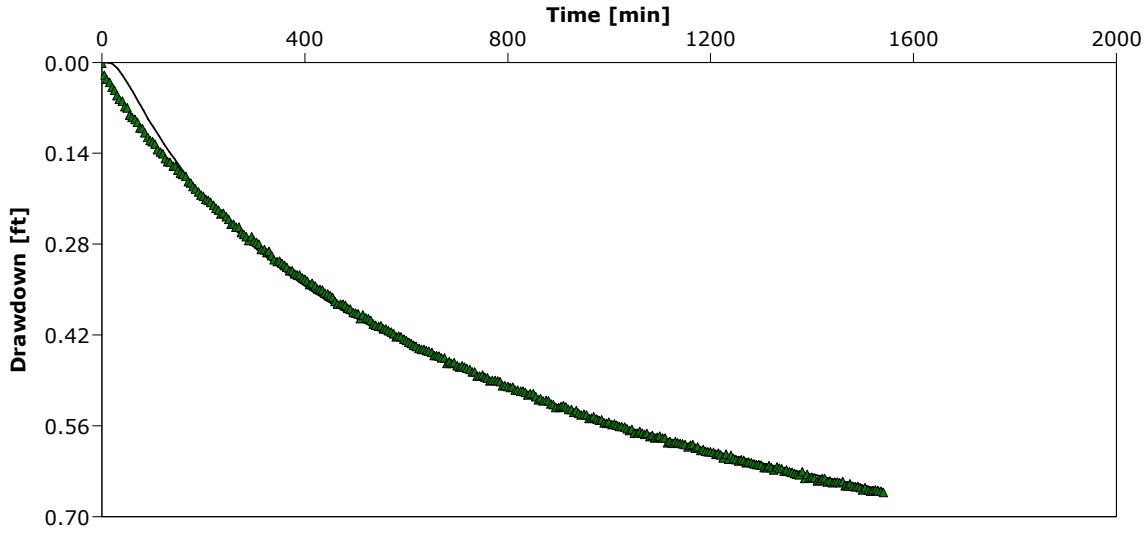
Number:

Client:

| | Time [min] | Water Level [ft] | Drawdown [ft] |
|---|---|---|---|
| 247 | 1230 | 23.214 | 0.604 |
| 248 | 1235 | 23.221 | 0.611 |
| 249 | 1240 | 23.216 | 0.606 |
| 250 | 1245 | 23.22 | 0.61 |
| 251 | 1250 | 23.222 | 0.612 |
| 252 | 1255 | 23.224 | 0.614 |
| 253 | 1260 | 23.222 | 0.612 |
| 254 | 1265 | 23.223 | 0.613 |
| 255 | 1270 | 23.227 | 0.617 |
| 256 | 1275 | 23.226 | 0.616 |
| 257 | 1280 | 23.227 | 0.617 |
| 258 | 1285 | 23.229 | 0.619 |
| 259 | 1290 | 23.23 | 0.62 |
| 260 | 1295 | 23.23 | 0.62 |
| 261 | 1300 | 23.231 | 0.621 |
| 262 | 1305 | 23.234 | 0.624 |
| 263 | 1310 | 23.234 | 0.624 |
| 264 | 1315 | 23.232 | 0.622 |
| 265 | 1320 | 23.234 | 0.624 |
| 266 | 1325 | 23.238 | 0.628 |
| 267 | 1330 | 23.233 | 0.623 |
| 268 | 1335 | 23.235 | 0.625 |
| 269 | 1340 | 23.236 | 0.626 |
| 270 | 1345 | 23.24 | 0.63 |
| 271 | 1350 | 23.238 | 0.628 |
| 272 | 1355 | 23.241 | 0.631 |
| 273 | 1360 | 23.242 | 0.632 |
| 274 | 1365 | 23.244 | 0.634 |
| 275 | 1370 | 23.245 | 0.635 |
| 276 | 1375 | 23.246 | 0.636 |
| 277 | 1380 | 23.241 | 0.631 |
| 278 | 1385 | 23.251 | 0.641 |
| 279 | 1390 | 23.245 | 0.635 |
| 280 | 1395 | 23.25 | 0.64 |
| 281 | 1400 | 23.249 | 0.639 |
| 282 | 1405 | 23.25 | 0.64 |
| 283 | 1410 | 23.255 | 0.645 |
| 284 | 1415 | 23.254 | 0.644 |
| 285 | 1420 | 23.251 | 0.641 |
| 286 | 1425 | 23.251 | 0.641 |
| 287 | 1430 | 23.257 | 0.647 |
| 288 | 1435 | 23.255 | 0.645 |
| 289 | 1440 | 23.258 | 0.648 |
| 290 | 1445 | 23.257 | 0.647 |
| 291 | 1450 | 23.257 | 0.647 |
| 292 | 1455 | 23.258 | 0.648 |
| 293 | 1460 | 23.256 | 0.646 |
| 294 | 1465 | 23.262 | 0.652 |
| 295 | 1470 | 23.262 | 0.652 |
| 296 | 1475 | 23.26 | 0.65 |
| 297 | 1480 | 23.263 | 0.653 |
| 298 | 1485 | 23.264 | 0.654 |
| 299 | 1490 | 23.263 | 0.653 |
| 300 | 1495 | 23.265 | 0.655 |
| 301 | 1500 | 23.269 | 0.659 |
| 302 | 1505 | 23.265 | 0.655 |
| 303 | 1510 | 23.269 | 0.659 |
| 304 | 1515 | 23.271 | 0.661 |
| 305 | 1520 | 23.27 | 0.66 |
| 306 | 1525 | 23.269 | 0.659 |
| 307 | 1530 | 23.27 | 0.66 |
| 308 | 1535 | 23.271 | 0.661 |
| 309 | 1540 | 23.273 | 0.663 |

| | | |
|---|---|---|
| **Contact Info**<br>**Address**<br>**Company Name**<br>**City, State/Province** | **Pumping Test Analysis Report** | |
| | Project: West Des Moines Pump Test | |
| | Number: | |
| | Client: | |

| | | |
|---|---|---|
| Location: West Des Moines, Iowa | Pumping Test: Well 21 | Pumping Well: Well 21 |
| Test Conducted by: | | Test Date: 9/11/2012 |
| Analysis Performed by: | New analysis 6 | Analysis Date: 11/30/2012 |
| Aquifer Thickness: 20.00 ft | Discharge Rate: 243 [U.S. gal/min] | |




Calculation using Theis

| Observation Well | Transmissivity [ft²/d] | Hydraulic Conductivity [ft/d] | Storage coefficient | Radial Distance to PW [ft] | |
|---|---|---|---|---|---|
| OB2 | $1.46 \times 10^{4}$ | $7.28 \times 10^{2}$ | $2.11 \times 10^{-1}$ | 115.0 | |

**Iowa Department of Natural Resources**
**Geological and Water Survey**
**109 Trowbridge Hall**
**Iowa City, Iowa 52242-1319**
**(319) 335-1575**
**www.igsb.uiowa.edu**