Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Groundwater and Soil Salinity Monitoring Network in Support of Long-term Irrigation and Salt Management of MSCP Restoration Areas

Agreement No. R10AP30003

U.S. Department of the Interior
Bureau of Reclamation

September 2011

Lower Colorado River Multi-Species Conservation Program
Steering Committee Members

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Bureau of Reclamation
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National Park Service
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Lower Colorado River
Multi-Species Conservation Program

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Prepared by:

GeoSystems Analysis, Inc.
2015 N. Forbes Blvd, Suite 105
Tucson, Arizona 85745

Lower Colorado River
Multi-Species Conservation Program
Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada
http://www.lcrmscp.gov

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1.0 INTRODUCTION

Through Grant R10AP30003: Soil and Groundwater Monitoring, GeoSystems Analysis, Inc. (GSA) is assisting the Bureau of Reclamation (Reclamation) Lower Colorado River (LCR) Multi-Species Conservation Program (MSCP) in the analysis of salinity conditions, impacts on vegetation, and potential mitigation measures for restoration programs. As a portion of this project (Task 2 and Task 3), GSA is characterizing groundwater conditions at Beal Lake Restoration Site (Beal Lake), Palo Verde Ecological Reserve (PVER), and Cibola National Wildlife Refuge (NWR) Farm Unit #1 (Cibola) for the three-year project base period (2010 through 2012).

This report satisfies Subtask 2f, which consists of documentation of the groundwater monitoring network design and implementation, presentation of aquifer testing methods and results, and presentation of preliminary monitoring data. Three project subtasks are addressed:

- *Subtask 2a*—Design of groundwater salinity monitoring networks for the three sites.
- *Subtask 2c*—Installation of piezometers for monitoring of groundwater elevations, groundwater salinity, and shallow aquifer properties (see Subtask 2e).
- *Subtask 2e*—Aquifer testing in selected piezometers at each site to determine the saturated hydraulic conductivity of the upper portion of the shallow alluvial aquifer.

1.1 Groundwater Monitoring Overview

At each site, a grid of piezometers was designed and installed to allow determination of groundwater depth and elevation, groundwater gradients and flow direction, groundwater salinity (specific conductance [EC]), and the spatial distribution of these parameters. Previously-installed piezometers, where available, were incorporated into the monitoring network. A subset of new and previously-installed piezometers was utilized for aquifer testing.

For this project, there were three major objectives of piezometer installation and monitoring:

1. Determination/observation of groundwater depth and elevation over time: GSA will determine groundwater depth/elevation and groundwater gradients across the monitored restoration sites. Groundwater depth determines the availability of ground water to satisfy a portion of evapotranspirative demand. Changes in groundwater elevation can indicate groundwater recharge (percolation), plant water availability, and/or changes in surface water (Colorado River mainstem) or backwater (e.g. Topock Marsh and Beal Lake) elevations, or intentional flooding of normally dry land (e.g. California Department

of Fish and Game (CDFG) field at PVER, Loafing Pond adjacent to the Nature Trail at Cibola NWR). Finally, groundwater elevation gradients indicate the direction of groundwater flow.

2. Determination of aquifer properties: GSA measured the hydraulic conductivity of aquifer materials, which governs the rate of groundwater flow in the direction of groundwater gradients. Additionally, conductivity can determine the ability of the aquifer to support a groundwater mound—lower conductivity would reduce groundwater flow rates and dissipation rates of percolated irrigation water and retain water for subsequent root extraction, whereas high conductivity would increase groundwater flow rates and promote rapid dispersal of water in the direction of groundwater gradients.
3. Monitoring of groundwater quality: GSA will monitor groundwater EC in established piezometers. If groundwater salinity is greater than tolerances of native phreatophytes, it will be unavailable for evapotranspirative demand regardless of depth below ground surface. Groundwater salinity evapoconcentration would occur where near-surface groundwater in evaporated or transpired, leaving behind evapoconcentrated, salty water. However, freshwater inputs to include percolation from irrigation and precipitation, or subsurface inflow, could reduce groundwater salinity. The goal of monitoring groundwater quality is to observe groundwater salinity levels over time and determine underlying processes for variation in groundwater quality.

For Objective 1, a simple, screened piezometer allows for groundwater depth observations. Assuming an unconfined aquifer, the depth of screening does not affect groundwater depth observations. The primary consideration for piezometer design is to ensure that the piezometer depth exceeds the groundwater depth for the period of monitoring.

For Objective 2, the length and depth of the screen in relation to the phreatic surface (depth of groundwater) can constrain the types of testing that can be conducted. Additionally, the material type (texture and structure) through which the screen passes is crucial, as these characteristics determine hydraulic properties. Finally, the borehole diameter is an important parameter for calculations of hydraulic properties.

For Objective 3, the screened interval is an important consideration. Assuming no irrigation percolation and that plant water extraction and/or evaporation is occurring from the upper aquifer, groundwater salinity would be greatest at and near the phreatic surface. In this case screening across this interval allows observation of the poorest quality water, and also the water which would be available to phreatophyte roots. Having the screened interval entirely below the phreatic surface would allow observation of underlying aquifer water quality, with reduced effects of evapotranspiration on water quality. Screening across the phreatic surface would potentially allow observation of changes in groundwater quality due to periodic flooding events. Finally, nested piezometers allow screening of separate depth intervals. Having a screened interval both across the phreatic surface and entirely below allows observation of variations in EC with depth in the shallow alluvial aquifer and determination of vertical hydraulic gradients.

Because groundwater depth varies throughout the year due to several factors, including irrigation management, evapotranspirative demand, and river elevations, groundwater elevations in relation to the screened interval cannot be guaranteed for the long-term. For the piezometer installations, current groundwater elevations were used as a guide, with the assumption of modest seasonal changes. When seasonal and long-term groundwater depth changes are uncertain, wells should be installed deeper to ensure water presence in the well throughout the year.

2.0 PIEZOMETER INSTALLATION, DEVELOPMENT, AND GROUNDWATER MONITORING METHODS

2.1 Well Installation

The three piezometer installation methods used for the current project were driven piezometer points, hand-augered piezometers, and hollow-stemmed auger piezometers:

1. Driven Piezometer Points: Where shallow groundwater was predicted, stainless steel drive points were hand driven using a post driver. A guide hole was augered to the depth of saturation using a 1-½” diameter auger. Once the phreatic surface was reached the auger was removed and the piezometer drive point was driven into the groundwater to the desired level. Annular space around the piezometer was re-packed with cutting material, and a concrete seal was used to secure an above-ground monument. A schematic of this type of piezometer installation is provided in Figure 1. GSA has previously used this method for installation of piezometers to greater than twenty feet below ground surface (GSA 2008). However, penetration resistance increases with greater depth, and other methods are needed for piezometers of depth greater than twenty feet below ground surface (bgs). Additionally, drive point installation was difficult for this project due to the prevalence of flowing sand at the field sites (refer to Section 3.0). Once the screened interval was driven below the phreatic surface, sand began intruding the piezometer. Thus, a hand-augering method was developed (as detailed below) and used for subsequent piezometer installations at Beal Lake and Cibola NWR.

2. Hand-augered Casing Advancement: As an alternative to driven piezometers, GSA used hand-augering for installation of piezometers in areas with shallow groundwater. This method allowed for placement of sand packs around piezometer screens to reduce sediment intrusion. A 4" auger bucket was used to create a borehole to the depth of saturation. The auger was removed from the hole, and a 3 inch PVC internal threaded pipe was inserted into the hole. A 2.5 inch auger was used to auger inside the 3-inch casing, advancing the casing as the hole was drilled. When the desired depth was reached, (about 3 feet below the water table), a 1.25 inch slotted piezometer was inserted. Silica sand (8-12 Colorado Silica Sand) was placed in the annulus between the piezometer and outer casing as the outer casing was removed. Care was taken to always have 4 to 12 inches of silica sand inside the casing to prevent caving until the bottom of the casing was above the water table. A six to ten inch bentonite layer was placed in the hole at about 6 inches above the top of the slotted screen. Soil was placed above the bentonite to a depth of 2 feet bgs. A six inch surface monument was placed over the piezometer and sealed with concrete. A typical hand-augered piezometer schematic is shown in Figure 2.
3. Hollow-stem Augered Piezometers: Where groundwater depth was greater than could be achieved with hand driven or hand-augered piezometers, a hollow-stemmed auger (HSA) drill rig was used. In addition to allowing piezometer installations at greater depths, mechanical drilling allowed for larger boreholes, leaving room for multiple completions, or "nested" piezometers, whereby more than one piezometer tube was inserted. The borehole was drilled into the subsurface to the desired depth below the phreatic surface. After the final drilling depth was reached, the drill stem was removed and a wood plug was placed in the end of the hollow stem and the hole was re-drilled. At final depth water was added to the drill stem, the plug was driven out and the piezometers were installed through the drill stem. This procedure was used to prevent sand from flowing back into the drill stem. The annulus between the piezometers and drill stem was backfilled with sand, bentonite and parent material during removal of the drill stem. The intervals of backfill material placement are described in detail in Section 3.0. Concrete was placed on the surface to seal the piezometer and secure the surface monument. A typical HSA-augered nested piezometer is shown in Figure 3.

For Beal Lake, depth to groundwater ranged from approximately 3 to 8 feet bgs. For Cibola NWR, depth to groundwater ranged from approximately 7 to 10 feet bgs. The relatively shallow groundwater depths at Beal Lake and Cibola NWR allowed installation of hand-driven piezometers and hand-augered piezometers. Deeper groundwater at PVER (i.e. between 12 and 18 feet bgs) necessitated installation using HSAs.

2.2 Geologic Logging

During June, 2010 extensive soil sampling was conducted by GSA at depths of up to six feet bgs; this analysis will be delivered to Reclamation as part of the year-one soil salinity analysis report. For this reason, supplemental sampling was not conducted during piezometer installation at Cibola NWR and Beal Lake except where hand-augered piezometers were installed. At these locations, soil texture of the aquifer material was estimated by hand.

HSA drilling at PVER was advanced to 30 feet bgs, thus penetrating much deeper than year-one soil sampling (six feet bgs). Because of the deeper extent, HSA drill cuttings were sampled this year over 2.5 ft. depth intervals. Texture was estimated in the field using the visual-manual soil classification method ASTM D 2488-93 (1996). Samples were placed in double-sealed freezer bags and transported to the GSA laboratory. Samples collected down to the depth of saturation were tested for gravimetric water content and 1:1 soil to water weight ratio extract EC (Rhoades 1986). Because water was added during the drilling process once groundwater was reached (Section 3.1), laboratory testing was not performed on samples collected from below the phreatic surface. An intact sample was collected every 10 feet with a 2-in diameter, 18-inch split-spoon sampler to allow potential laboratory determination of hydraulic conductivity as needed to supplement aquifer testing. These samples were also analyzed for water content and 1:1 extract EC. To estimate saturated-paste extract EC, the 1:1 extract EC was multiplied by two.

2.3 Piezometer Development

Piezometers were developed to remove sediment which intruded into during installation. For driven piezometers, water was pumped into the piezometers through a piece of PVC pipe to suspend and discharge sediment through the top of the piezometer. In several cases, the capacity of the water pump was insufficient to keep the borehole full. In these cases, sediment-laden water was bailed from the piezometer using a 5/8-inch, stainless steel bailer. If three feet of water could not be established in driven piezometers, the piezometer was removed and later re-installed via the hand-augering casing advancement method.

For hand-augered monitoring piezometers, a 5/8-inch stainless steel bailer was used repeatedly until the piezometer was clear to the bottom PVC cap in the piezometer. For hollow-stem augered piezometers, stainless steel bailers attached to the drill rig were used to purge the piezometers.

2.3 Groundwater Monitoring, Sampling, and Analysis

Desired observations from the groundwater monitoring network include groundwater depth, elevation, and gradients, and groundwater quality. Piezometers were instrumented with either a Rugged LevelTroll 100 or AquaTroll 200 sensor and data logger system (In-Situ, Inc., Fort Collins, CO) for automated measurement of groundwater depth. Both systems include a pressure transducer which measures the absolute pressure at the sensor location and a thermistor to measure water temperature. The gage pressure at the sensor is determined by correcting for atmospheric pressure, measured at one piezometer per restoration site using a barometric pressure sensor (BaroTroll 100, In-Situ, Inc.). Gage pressure is then converted to a depth of water by dividing by the density of water. In addition to measurement of pressure and temperature, the AquaTroll 200 sensor measures and records EC of groundwater within the piezometer. This sensor was placed in a subset (i.e. two per site) of piezometers for automated measurement of EC. All data loggers were programmed to record groundwater elevation and EC on four-hour intervals (i.e. six times per day at 0000, 0400, 0800, 1200, 1600, and 2000 hours).

Piezometers were, and continue to be, visited quarterly to download data, check battery status, and confirm that all sensors are functioning and correctly calibrated to report water depths. Groundwater depth measurement is manually confirmed using an electronic sounder (Solinst Model 101 Water Level Meter, Georgetown ON Canada) inserted into the piezometer. During each quarterly visit, piezometers are purged with a bailer for a minimum of three piezometer volumes and the final bailed sample is tested for EC using a field EC meter (HYDAC Digital Conductivity/Temperature/pH Tester, On-Site Instruments LLC, Lewis Center, OH).

All groundwater depth and groundwater quality data are being accumulated in Microsoft Excel spreadsheets. Preliminary data are discussed in Section 5.0. Data will be provided to the Reclamation COR after subsequent data downloads and groundwater quality sampling. Over the remaining project period, spatial and temporal trends will be analyzed in detail, and integrated with models of groundwater elevations, water budgets, and soil and groundwater salinity. To date, piezometer datum elevations have not been surveyed. Datum elevations are required to determine groundwater elevation and groundwater gradients. It is anticipated that surveys will occur prior to the end of Q1 2012.

2.4 Aquifer Testing

The Bouwer and Rice (1976) slug test method was conducted in selected piezometers at each restoration site to determine the saturated hydraulic conductivity of the screened interval below the groundwater table. In total, seven piezometers each at Cibola NWR and Beal, and four piezometers at PVER were tested.

Slug tests were implemented by rapidly adding or removing a volume of water from a piezometer and monitoring recovery of water levels to the initial elevation. A pressure transducer was placed in the piezometer and connected to a CR 1000 data logger (Campbell Scientific, Inc., Logan, UT) for automated measurement of water level recovery. A solid metal rod was inserted into the piezometer, initially raising the water level within. The rod remained in the piezometer until the water level returned to the initial level. The rod was then rapidly removed, resulting in an immediate decline in the piezometer water level below that of the surrounding aquifer. The rise of water within the piezometer was then measured on one-second intervals until the water level returned to initial elevations. The data were analyzed using a spreadsheet to determine saturated hydraulic conductivity, with standard units of feet per day.

It was previously anticipated that a groundwater pumping test might be possible at the restoration sites. Available well databases for Arizona and California were searched for the presence of an existing irrigation supply well or equivalent within or near the restoration sites. No wells were located within a reasonable distance from installed piezometers. Therefore, a pumping test is not feasible at this time.

3.0 PIEZOMETER INSTALLATION DETAIL

Tables 1 through 3 summarize for each site the piezometers being monitoring, installation method used, and the number of piezometers with data loggers at each restoration site. Information in this table is described further in the following sections.

3.1 Piezometer Installation at Palo Verde Ecological Reserve

Piezometers were installed at eight locations at Palo Verde Ecological Reserve (PVER) between December 12 and 17, 2010. The installation locations are shown in Figure 4. Piezometer locations were moved from those proposed (GSA 2010) due to high density of vegetation and the inability of the drill rig to traverse soil checks used to manage irrigation.

3.1.1 Installation Detail

Boreholes were drilled to a depth of 30 feet by Yellow Jacket Drilling (Phoenix, AZ) using a HSA rig (Figure 5). Two piezometers were installed in each borehole. The deeper, 2-inch PVC piezometer was placed at 30 feet bgs and had a 10-foot screened section. A shallower, 1-inch PVC piezometer was placed to span the water table and had a 7-foot screened section. For all but one borehole (PZ-5) the bottom of the hole was 33 feet bgs. 8-12 Colorado Silica Sand was placed in the hole to the 30 foot depth. A ten foot length of 2-inch Schedule 40 PVC pipe with

0.020 inch slots was placed at approximately 30 feet bgs (i.e. a screened interval was installed from approximately 20 to 30 feet bgs). 8-12 Colorado Silica sand was then backfilled to 18 to 19 feet bgs as the auger flights were removed. A 0.6 to 3-foot layer of time release bentonite pellets was added to seal the hole between piezometers. Sand was placed on top of the pellets and the shallow piezometer installed. Bentonite chips were added from approximately 8 feet to 5 feet bgs. Drill cuttings were placed from 5 to 2 feet bgs. A five foot section of six-inch diameter surface casing with locking lid was placed around the piezometers. The casing was placed 2 feet in the ground with a concrete surface seal (Figures 6 and 7).

A schematic of the completed PVER piezometers is shown in Figure 3. As-built piezometer dimensions as referenced in Figure 3 are detailed in Table 1. Rugged LevelTroll 100 level transducers (Figure 8) were placed in all 2-inch piezometers except PZ-3. An In-Situ Aqua Troll 200 transducer, which measures salinity, temperature and water depth, was placed in the 1-inch piezometer at PZ-3. The AquaTroll 200 was moved to the 1-inch piezometer in PZ-2 on 2/10/2011 and a Rugged LevelTroll 100 transducer was placed in the PZ-3 2-inch piezometer. Another AquaTroll 200 was added to the 1-inch piezometer at PZ-6 on 2/25/2011. The depths and locations of the transducers as of June, 2011 are shown in Table 1.

3.1.2 Geologic Logging and Laboratory Analysis

Detailed geologic log sheets for the eight boreholes are provided in Appendix 1. Laboratory results (water content and EC) and summarized soil textures and soil EC to the depth of groundwater are shown in Table 4. The top 2.5 to 5 feet consisted mostly of silty sand. PZ-3 and PZ-6 holes had some silty clay. For all boreholes, except PZ-8, the rest of the profile consisted of sand and medium sand to 30 feet bgs. PZ-8 had sand to 10 feet bgs and sandy silt and silt to 27.5 feet bgs. Below 27.5 feet bgs was again sand.

Gravimetric water content and estimated saturated-paste extract EC for samples retrieved from the eight boreholes down to 20 feet bgs are provided in Table 4. Because irrigation does not occur at the site in December, water content was lower than would be typical for the growing season. Gravimetric water content for fine-textured material (sandy silt, silt, silty clay) averaged 0.24 g/g, with a range of 0.17 to 0.31 g/g. Gravimetric water content for coarser materials (fine sand, sand, medium sand, and silty sand) averaged 0.10 g/g, with a range of 0.01 to 0.27 g/g. The higher average gravimetric water content of fine material indicates the ability of these soil types to retain moisture. Sandy samples with higher gravimetric water content tended to be deeper, and therefore adjacent to or within the capillary fringe, where moisture content is directly affected by upward movement of groundwater into the vadose zone.

EC averaged 0.94 dS/m for all samples up to 20 feet below ground surface, with a range of 0.36 to 4.01 dS/m. EC for fine-textured material averaged 1.82 dS/m with a range of 0.83 to 4.01 dS/m. EC for coarse-textured material averaged 0.77 dS/m with a range of 0.36 to 2.17 dS/m. The significantly higher average salinity of fine-textured material ($P<0.005$, Student's t-test) is likely due to the poorer drainage of finer materials and resultant evapoconcentration of salts.

3.2 Piezometer Installation at Beal Lake Restoration Site

At Beal Lake, 13 piezometers were previously installed by Reclamation. To fill in gaps in coverage by the current piezometers, GSA installed five additional piezometers across the center and western portion of the restoration site. In addition, one new piezometer was installed between the restoration plots and the Colorado River, on the south side of Beal Lake proper. The resultant piezometer locations are shown in Figure 9.

3.2.1 Installation Detail

Two different methods of piezometer installation were used: driven piezometers and hand augered casing advancement. The driven piezometers consisted of a 5 foot length of 1.25 inch stainless steel screened pipe and additional lengths of stainless steel or galvanized pipe attached above. For this method a hole was hand augered to the water table which was typically about 5 feet bgs. The stainless steel was used near the water table. The piezometer was driven to approximately 3 feet below the water table, adding lengths of pipe as needed. A five foot steel monument with locking cap was placed over the piezometer and secured with concrete. After installation, several piezometer volumes were removed by bailing. Sediment was removed by flushing with a tube placed at the bottom on the piezometer. Data loggers were suspended near the bottom of the screened section. A schematic of the driven piezometer is shown in Figure 1.

A considerable amount of sediment was observed in the screened section when the driven piezometers were tested. Thus, the hand-augered casing advancement method was used to install the remaining piezometers. For hand-augered casing advancement piezometers, bailing alone was sufficient to clean sediment from the piezometer. A data logger was suspended near the bottom of the piezometer. A schematic of the completed casing-advance piezometer is shown in Figure 2. The piezometer depth as-built specification data referenced in Figures 1 and 2 are shown in Table 2.

Two of the new piezometers at Beal Lake were instrumented with an AquaTroll 200, and the remaining four new piezometers were instrumented with a Rugged LevelTroll 100. Additionally, five pre-existing piezometers were instrumented with Rugged LevelTroll 100s.

Data logger types for each piezometer are detailed in Table 2.

3.2.2 Geologic Logging

As described in Section 2.2, additional soil sampling was not conducted at Beal Lake during piezometer installation. However, manual texturing during piezometer installation indicated that soils at all piezometer locations were primarily sand, with minor layers of loamy sand. No clayey material, gravel or cobbles were observed at Beal Lake.

3.3 Piezometer Installation at Cibola National Wildlife Refuge Farm Unit #1

At Cibola NWR, ten piezometers were installed by GSA under a previous contract. For the current study, GSA is utilizing seven of these existing piezometers for groundwater elevation monitoring, and supplementing coverage with eleven additional piezometers throughout the Crane's Roost, Mass Transplanting Demonstration, and, The Nature Trail. Figure 10 shows locations for both pre-existing and new piezometers.

3.3.1 Installation Detail

As for Beal Lake, piezometers were installed with either driven piezometer points or hand-augered casing advancement. Installation methods for each piezometer at Cibola are shown in Table 3. The piezometer depth as-built specification data referenced in Figures 1 and 2 are shown in Table 3.

Two of the new piezometers were instrumented with an AquaTroll 200. The remaining new piezometers and four existing piezometers were instrumented with Rugged LevelTroll 100s. The other three previously-installed piezometers were already instrumented with WL16 Water Level Loggers (Global Water Instrumentation, Inc., Gold River, CA) which will be left in place for the current study.

3.3.2 Geologic Logging

As described in Section 2.2, additional soil sampling was not conducted at Cibola NWR during piezometer installation. However, as observed during previous soil sampling, manual texturing during piezometer installation indicated that near-surface soils were dominated by silty loam. Intermediate depths (i.e. 1.5 to 4 feet bgs) are consistently composed of thin strata of various soil types ranging from sand to clay. No gravel or cobbles have been observed. At depths greater than five feet, soils were primarily sand. However, PZ-11-C was dominated by loamy soils throughout the drilling profile, including within groundwater. Additionally, extremely low hydraulic conductivity of the aquifer material at PZ-4-C (refer to Section 4.0) suggests that the aquifer at this location is dominated by fine-grained material (no cutting samples were available because this was a driven piezometer).

4.0 HYDRAULIC TESTING

Results for hydraulic testing of all piezometers are shown in Table 5. The data analysis is presented in Appendix 2. Saturated hydraulic conductivity at PVER piezometer locations ranged between 16 and 61 feet per day, with a geometric mean of 27 feet per day. For Beal Lake, values ranged from 17 to 36 feet per day, with a geometric mean of 25 feet per day. For Cibola, saturated hydraulic conductivity ranged from 0.00037 feet per day to 8.8 feet per day. The low value of 0.00037 feet per day observed for PZ-4-C was due to the presence of fine-grained material not observed at other well locations at either of the three restoration sites. With the low value at PZ-4-C omitted as an outlier, the geometric mean for Cibola was 3.1 feet per day.

5.0 PRELIMINARY MONITORING RESULTS

Extensive presentation and analysis of groundwater depth, gradients, and salinity over time will be presented to Reclamation via annual reports. Below is a presentation of preliminary observations for February and May groundwater sampling trips, during which all piezometers, instrumented or not, were sounded to determine depth to groundwater. Additionally, groundwater EC was determined for piezometers which could be bailed.

5.1 Groundwater Depth

Two field sampling and data downloading trips have been conducted as of June 30, 2011. The first was in February, 2011, and the second was in May, 2011. Groundwater depth bgs for PVER on February 10, 2011, is shown in Figure 11. Groundwater depth ranged between 12.48 and 18.04 feet bgs. Groundwater was generally deeper closer to the Colorado River. Groundwater depth for PVER on May 19, 2011, is shown in Figure 12. Groundwater depth ranged between 8.52 and 17.25 feet with a similar general trend of deeper groundwater near the Colorado River. Because the fields used for restoration are laser-leveled, this trend indicates higher groundwater elevations further from the river. A well survey will be required to confirm this and allow additional analysis and quantification of groundwater elevation gradients.

Groundwater depth bgs for Beal Lake on February 9, 2011, is shown in Figure 13. Groundwater depth within the fields ranged between 4.25 and 7.61 feet bgs. Groundwater was shallower for piezometer NN2 (3.16 feet bgs), as would be anticipated because this piezometer is in a depression between Beal Lake and Topock Marsh (i.e. lower ground surface elevation). Groundwater depth for Beal Lake on May 20, 2011, is shown in Figure 14. Groundwater depth within the fields ranged between 3.17 and 6.47 feet, with shallower groundwater again present adjacent to Topock Marsh.

Groundwater depth bgs for Cibola NWR on February 10, 2011, is shown in Figure 15. Groundwater depth ranged between 6.93 and 9.50 feet bgs. Groundwater was generally deeper at the Crane's roost than near the Loafing Pond and seed feasibility study field. Groundwater depth for Cibola NWR on May 18, 2011, is shown in Figure 16. Groundwater depth ranged between 5.63 and 8.29 feet. Again, groundwater was generally shallower in the northeast section of the study area, with deeper groundwater in the Crane's Roost.

5.2 Groundwater Salinity

Groundwater EC for PVER on February 10, 2011, is shown in Figure 17. EC ranged between 0.87 and 2.38 dS/m. Generally, groundwater EC was similar in both piezometers (shallow and deep) at a given monitoring well. However, the EC of the shallow piezometer at PZ-3 was less than half that of the deep piezometer. The field east of PZ-3, managed by the CDFG, was being flooded for waterfowl. EC of the water in this field was measured as 0.89 dS/m and was likely contributing to the lower EC observed in the shallow piezometer. Deep piezometer groundwater EC was generally higher on the eastern portion of the monitoring area. EC for water collected from the drainage ditch on the west side of PVER Phase 2 was measured as 2.00 dS/m. Groundwater EC for PVER on May 19, 2011, is shown in Figure 18. EC ranged between 0.98 and 2.57 dS/m. Again, groundwater EC was similar in shallow and deep piezometers with the exception of PZ-3. However, the difference between shallow and deep EC was not as great in May as observed in February. Spatial trends were not apparent during May, except that EC was greater in the northeast corner of the monitoring area (PZ-6). No consistent trend was observed for groundwater EC between February and May.

Groundwater EC for Beal Lake on February 9, 2011, is shown in Figure 19. Within the restoration fields, groundwater EC ranged between 1.46 and 5.47 dS/m. EC of groundwater outside the restoration fields was as high as 15.92 dS/m (PZ-4-BL south of Beal Lake). Groundwater EC trends within the restoration fields are not apparent. The EC of water in the canal connecting Topock Marsh to Beal Lake (Beal Lake Canal, i.e. the irrigation water source) was 2.4 dS/m during this sampling event. Groundwater EC for Beal Lake on May 20, 2011, is shown in Figure 20. Within the restoration fields, groundwater EC ranged between 1.33 and 4.22 dS/m. Groundwater EC trends within the restoration fields are not apparent, and for most of the site were between 2.00 and 4.30 dS/m. However, EC of groundwater near Topock Marsh (the east portion of the site) was less 2.00 dS/m. In May, the EC within the Beal Lake Canal was

1.87 dS/m, and the EC of water in the Topock Marsh was measured as 1.99 dS/m. PZ-4 was not sampled in February due to a lack of site access.

Groundwater EC for Cibola NWR on February 10, 2011, is shown in Figure 21. Groundwater EC ranged between 1.21 and 8.23 dS/m, with generally lower EC close to the Loafing Pond and higher EC in the Crane's Roost. The Loafing Pond was flooded, as was Danner Lake (east of the Nature Trail). No other fields in the area were being irrigated during this visit. Groundwater EC for Cibola NWR on May 18 and 19, 2011, is shown in Figure 22. EC values ranged between 1.17 and 8.57 dS/m. Groundwater EC was again generally lower near the Loafing Pond. However, high EC was measured on the east side of the nature trail (piezometers not available for sampling in February, 2011). During this visit, EC of irrigation water traveling the main ditch was measured as 0.88 dS/m. The field north of the Crane's Roost (North 160 area) was being flooded during the May visit, with measured EC of standing water in that field being 12.17 dS/m. EC for water collected from the drainage ditch on the east side of the Crane's Roost was measured as 4.88 dS/m.

6.0 SUMMARY AND CONCLUSIONS

6.1 Piezometer Installation, Development, and Instrumentation

Installation of driven piezometers at Cibola NWR and Beal was largely unsuccessful due to the prevalence of flowing sands intruding well screens. The hand-augering installation method proved effective, with the added benefit of reduced material costs for piezometer completion, due primarily because PVC screens and blank extensions could be used in lieu of stainless steel.

Hollow-stemmed auger piezometer installation and development at PVER was also highly successful. Costs of this installation method are greater than those for driven and hand augered piezometers, however, the larger feasible auger diameter compared to hand augering allows for nested piezometers.

To date, BaroTroll, LevelTroll, and AquaTroll sensors have performed as anticipated. However, steel cable used for suspension of loggers in the piezometers proved unsuccessful. Galvanized wire rope disintegrated at Beal Lake after less than one month of use. Wire rope at Beal Lake and Cibola NWR was replaced with braided nylon rope. This replacement appears to be durable. However, sensor depth must be recalibrated during each field visit due to stretching of the rope that occurs during logger removal for data downloads. Larger-diameter (3/8 inch), vinyl-coated wire rope was installed at PVER. This material also appears to be durable, but cannot be installed in piezometers with a diameter smaller than 2 inches. The condition of suspension rope will be checked during each field visit.

6.2 Geologic Logging

Logging of well cuttings at PVER indicates near-surface (less than 5 feet bgs) materials consisting primarily of silty sands, with predominance of sand between 5 and 30 feet bgs. However, at one piezometer (PZ-8-C) sandy silt and silt was present between 10 and 27.5 feet bgs. Logging of hand-auger cuttings at Beal Lake indicates predominance of sand in both the surface and shallow aquifer. Logging of hand-auger cuttings at Cibola NWR indicates predominance of silty loam in the near surface (0 to 1.5 feet bgs), underlain by strata of coarse and fine-grained material. At greater than 4 feet bgs, soils were primarily sands. Finer-grained material was present at one piezometer (PZ-4-C).

Comparison between restoration sites indicates variability in near-surface soil texture, ranging from sands to silty loam. In the near-surface aquifer, sand is the dominant texture. However, some piezometers indicated the presence of fine-grained material. This heterogeneity can be expected at sites throughout the historic floodplain.

6.3 Hydraulic Testing

Saturated hydraulic conductivity of aquifer materials at Beal Lake and PVER averaged 25 and 27 feet per day, respectively. These are relatively high values typical for sandy materials. Conversely, saturated hydraulic conductivity of aquifer materials at Cibola NWR averaged 3.1 feet per day, with an outlier of 0.00037 feet per day at a piezometer installed in fine-grained soils. Thus, subsurface drainage at Beal Lake and PVER is expected to occur much more readily than at Cibola NWR. Additionally, given similar hydraulic gradients, groundwater flow would be much greater at Beal Lake and PVER. As a result, reduced groundwater mounding would be anticipated at these sites compared to Cibola NWR. The ease of salt leaching is expected to be greater at Beal Lake and PVER. However, rapid dissipation of groundwater mounds might decrease water availability to tap roots at PVER, where groundwater is greater than ten feet bgs. Conversely, shallow groundwater at Beal Lake is likely always within the rooting zone of phreatophyte riparian trees.

6.4 Preliminary Monitoring Results

Groundwater depth varied in time and space for all study areas. For all restoration sites, groundwater was generally shallower in May, 2011 than February, 2011. This is probably due to a combination of higher flow in the Colorado River mainstem, higher surface water elevations in Topock Marsh, and more frequent irrigation at all sites. As anticipated, shallow groundwater was observed at Beal Lake (generally less than seven feet bgs), deeper groundwater was observed at PVER (generally greater than ten feet bgs), with the depth to groundwater at Cibola intermediate between these other sites. Preliminary trends indicate the following:

- For PVER, groundwater was generally deeper near the Colorado River.
- At Beal Lake, groundwater was generally shallower toward the north and northeast portions of the site (i.e. adjacent to Topock Marsh). High percolation rates of irrigation water through the soil profile have been observed to create mounded groundwater during irrigation events. Thus, analysis of instrumentation data is required to provide additional insights to spatial and temporal groundwater trends at this site.
- At Cibola, groundwater tended to be shallower near the northeast portion of the study area.

Further time-series analysis will be conducted for annual monitoring reports. Instrument data on groundwater levels will provide enhanced temporal resolution. Additionally, surveys of wells must be completed to determine groundwater elevations, gradients, and groundwater flow rates.

Early groundwater salinity monitoring indicates lowest EC of groundwater at PVER with an average EC of approximately 1.5 dS/m in May, 2011. EC was intermediate at Beal Lake, with an average value within the restoration site of approximately 2.7 dS/m in May, 2011. Higher groundwater EC was generally observed at Cibola NWR, with an average EC of approximately 3.3 dS/m observed in May, 2011. Groundwater EC at PVER and Beal Lake is generally within the tolerances of desired native riparian trees. However, higher groundwater EC at Cibola NWR is likely to cause some level of stress within trees, according to published data (GSA, 2011).

At PVER, spatial trends of groundwater EC were not apparent. EC of water sampled from shallow and deep piezometers was generally similar. However, lower EC was observed in the shallow piezometer of PZ-3 in February. This is likely due to mounding of high quality water being applied by CDFG in the adjacent field.

At Beal Lake, trends were not apparent within restoration fields. However, high salinity of groundwater was observed in a non-irrigated area (PZ-4 south of Beal Lake). EC of water in the Beal Lake Canal was greater for the February sampling event than for the May sampling event.

At Cibola, groundwater EC tended to be higher in the Crane's roost, and low near the Loafing Pond. This may be due to continuous irrigation of the Loafing Pond during the winter months for waterfowl. Monitoring during May indicates elevated groundwater EC in the center and east portions of the Nature Trail. Additionally, Groundwater EC greater than 5 dS/m was observed in portions of the Crane's Roost. Elevated salinity in May on the northern edge of the Crane's Roost might be a result of infiltration of poor quality water in the "North 160" fields.

7.0 ACKNOWLEDGMENTS

We thank the Multi-Species Conservation Program and the Reclamation Lower Colorado Regional office for its funding and guidance for this project. Additionally, we thank the Fish and Wildlife Service management and staff at Cibola NWR and Havasu NWR for their assistance at the field sites, and California Fish and Game personnel for their assistance at PVER.

8.0 REFERENCES

ASTM D-2488-93. 1996. Standard Practice for the Description and Identification of Soils (Visual Manual Procedure). In: 1996 Annual Book of ASTM Standards, Vol.04.08, American Society for Testing and Materials.

Bouwer, H., and R.C. Rice. 1976. A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research 12:423-428.

GeoSystems Analysis, Inc. 2008. Site Characterization: Cibola National Wildlife Refuge Field 51. Prepared for Bureau of Reclamation, Lower Colorado Region, May 6, 2008.

GeoSystems Analysis, Inc. 2010. 2010 Groundwater Monitoring Plan. Prepared for Bureau of Reclamation, Lower Colorado Region, May 3, 2010.

GeoSystems Analysis, Inc. 2011. Review of Salinity and Sodicity, Monitoring, and Remediation for Riparian Restoration Areas. Prepared for Bureau of Reclamation, Lower Colorado Region, May 17, 2011.

GSA, see GeoSystems Analysis, Inc.

Rhoades, J.D. 1986. Soluble salts. Methods of Soil Analysis, Part 2. A.L. Page (ed.). American Society of Agronomy, Madison, WI, pp. 167-179.

TABLES

Table 1. Installation specifications for piezometers installed at Palo Verde Ecological Reserve. UTM in meters, all other measurements in English units (feet).

Piezometer	UTM Easting	UTM Northing	A[1]	B[1]	C[1]	D[1]	E[1]	F[1]	G[1]	H[1]	I[1]	J[1]	K[1]	L[1]	M[1]	N 2" PVC	N 1" PVC	Data Logger Type
PZ-1-PVER	728865	3729643	30	10	33	19.2	18.6	18.6	7	18.6	7.5	5	2.69	2.43	2.49	29.58	NA	Level Troll
PZ-2-PVER	728651	3730080	30	10	33	19	17	15.4	7	17	8	5	2.56	1.91	2.40	29.5	17.92 [2]	Aqua Troll
PZ-3-PVER	729040	3730063	30	10	33	18.6	17	16.3	7	17	8	5	2.50	2.19	2.15	29.77 [2]	17.50 [3]	Level Troll
PZ-4-PVER	728396	3730074	30	10	33	18	16.5	15.9	7	16.5	8.1	5	2.69	2.41	2.38	29.5	NA	Level Troll
PZ-5-PVER	728303	3730412	29	10	29	18.4	15.5	15.5	7	15.5	8	5	2.72	2.23	2.23	29.58	NA	Level Troll
PZ-6-PVER	729001	3730460	30	10	33	19	16.7	16	7	16.7	7.5	5	2.73	2.35	2.27	29.58	NA	Aqua Troll
PZ-7-PVER	728619	3730481	30	10	33	19	16.9	16	7	16.9	8	5	2.94	2.58	2.72	29.5	NA	Level Troll
PZ-8-PVER	728413	3729629	30	10	33	19	17.2	16.5	7	17.2	8	5	2.82	2.39	2.32	29.75	NA	Level Troll

[1]Notation from Figure 3. [2]Added 2/10/2011. [3]Removed 2/10/2011. NA = Not Applicable. NM = Not Measured.

Table 2. Installation specifications for piezometers installed at Beal Lake National Wildlife Refuge. UTM in meters, other measurements in English units (feet) unless otherwise noted.

Piezometer	UTM Easting	UTM Northing	Type and Material[1]	Diameter, inches	A[2]	B[2]	C[2]	D[2]	E[2]	F[2]	G[2]	H[2]	Data Logger Type
PZ-1 BL	725313	3850818	Steel, D	1.38	8.1	5.33	6.4	2.77	NA	NA	2.40	2.77	Level Troll
PZ-2 BL	725777	3850891	PVC, CA	1	9.25	4.66	9.16	4.59	3.75	3.25	2.10	2.83	Aqua Troll
PZ-3 BL	725639	3850671	Steel, D	1.28	7.15	4.83	6.65	2.32	2.1	1.2	1.73	2.75	Level Troll
PZ-4 BL	725550	3849528	Steel, D	1.38	7.63	3	7.25	4.63	NA	NA	2.59	2.86	Level Troll
PZ-5 BL	726037	3850996	PVC, CA	1	9	4.83	7.94	4.17	3.5	2.92	2.30	2.92	Aqua Troll
PZ-6 BL	725552	3850921	SS, CA	1.38	9.03	5.33	8.69	3.69	2.75	2	1.63	2.93	Level Troll
PZ-A BL	726258	3850945	PVC, EX	2.06	23	10	NA	8	NA	NA	1.97	NM	None
PZ-C BL	726053	3850666	PVC, EX	2.06	18	10	15.55	8	NA	NA	3.02	NM	Level Troll
PZ-D BL	725932	3850519	PVC, EX	2.06	18	10	12.18	8	NA	NA	2.96	NM	Level Troll
PZ-E BL	725847	3850413	PVC, EX	2.06	18	10	NA	8	NA	NA	3.5	NM	None
PZ-EE4 BL	725679	3851216	PVC, EX	2.06	18.5	10	12.28	8.5	NA	NA	2.14	NM	Level Troll
PZ-EE2 BL	725826	3851131	PVC, EX	2.06	18.5	10	14.98	8.5	NA	NA	1.95	NM	Level Troll
PZ-NN1 BL	726275	3850957	PVC, EX	2.06	18	10	15.19	8.5	NA	NA	2.43	NM	Level Troll

[1]Abbreviations indicated casing advance (CA), driven (D), or existing (EX). [2]Notation from Figure 1 (driven) or Figure 2 (casing advance). NA = Not Applicable. NM = Not Measured.

Table 3. Installation specifications for piezometers installed at Cibola National Wildlife Refuge. UTM in meters, other measurements in English units (feet) unless otherwise noted.

Piezometer	UTM Easting	UTM Northing	Type and Material[1]	Diameter, inches	A[2]	B[2]	C[2]	D[2]	E[2]	F[2]	G[2]	H[2]	Data Logger Type
PZ-1 C	716173	3694559	PVC, CA	1.28	10.9	4.63	9.72	6.27	5.05	3.75	1.75	2.85	Level Troll
PZ-2 C	715788	3694156	Steel, D	1.38	11.92	5.33	9.01	6.58	NA	NA	2.72	3.04	Level Troll
PZ-3 C	715348	3694113	PVC, CA	1.28	11.81	4.65	9.68	7.17	6.64	6.04	2.31	2.80	Aqua Troll
PZ-4 C	714936	3693873	Steel, D	1.38	12.35	5.33	11.3	7.02	NA	NA	2.39	2.95	Level Troll
PZ-5 C	715005	3693578	Steel, D	1.38	12.21	5.33	11.3	6.88	NA	NA	2.64	3.13	Aqua Troll
PZ-6 C	714662	3694107	Steel, D	1.38	12.75	5.33	11.6	7.42	NA	NA	2.36	2.90	Level Troll
PZ-7 C	715633	3694266	PVC, CA	1.28	10.98	4.63	10.1	6.35	5.56	4.56	2.26	2.92	Level Troll
PZ-8 C	716001	3694376	PVC, CA	1.28	10.88	4.65	8.56	6.23	5.08	3.83	2.33	2.85	Level Troll
PZ-9 C	716162	3694171	PVC, CA	1.28	10.03	4.63	9.36	5.41	4.93	2.93	2.48	2.88	Level Troll
PZ-10 C	714672	3693336	PVC, CA	1.28	13.35	4.67	11.9	8.69	7.92	7.27	2.30	2.82	Level Troll
PZ-11 C	715279	3693366	PVC, CA	1.28	13.32	4.65	12.9	8.68	8.06	6.81	2.26	2.81	Level Troll
PZ-NE	715794	3694556	Steel, EX	1.28	14.1	5.33	NA	8.77	NA	NA	0.54	2.10	None
PZ-SE	715799	3694360	Steel, EX	1.28	18.1	5.33	11.9	12.7	NA	NA	0.64	2.17	WL16
PZ-C	715617	3694451	Steel, EX	1.28	16.4	5.33	10.1	11.0	NA	NA	1.59	2.46	Level Troll
PZ-NW	715428	3694543	Steel, EX	1.28	14.1	5.33	NA	8.77	NA	NA	NM	2.50	None
PZ-SW	715430	3694352	Steel, EX	1.28	17.1	5.33	8.99	11.7	NA	NA	0.81	2.84	Level Troll
PZ-SSN	715775	3694493	Steel, EX	1.28	11.19	5.33	10.7	5.86	NA	NA	0.13	2.54	Level Troll
PZ-SSC	715812	3694450	Steel, EX	1.28	10.25	5.33	NA	4.92	NA	NA	1.27	2.71	None
PZ-SSS	715776	3694411	Steel, EX	1.28	11.31	5.33	8.88	5.98	NA	NA	0.02	2.51	WL16
PZ-SAGON	715732	3694486	Steel, EX	1.28	10.08	5.33	9.75	4.75	NA	NA	1.31	2.50	WL16
PZ-SAGOS	715730	3694435	Steel, EX	1.28	NM	5.33	NA	NM	NA	NA	0.97	2.36	None

[1]Abbreviations indicated casing advance (CA), driven (D), or existing (EX). [2]Notation from Figure 1 (driven) or Figure 2 (casing advance). NA = Not Applicable. NM = Not Measured.

Table 4. Summarized soil texture, water content, and specific conductance (EC) for Palo Verde Ecological Reserve drilling samples.

Piezometer	Depth Interval, feet bgs	Soil Texture	Gravimetric Water Content, g/g	Saturated Paste Extract EC, dS/m
PZ-1	0-2.5	Sandy silt	0.20	0.98
	2.5-5.0	Fine sand	0.10	0.65
	5.0-7.5	Fine sand	0.20	0.97
	7.5-10.0	Sand	0.13	0.71
	10.0-12.5	Sand	0.08	0.52
	12.5-15.0	Sand	0.07	0.55
	15.0-17.5	Medium sand	0.06	0.48
	17.5-20	Medium sand	0.05	0.48
PZ-2	0-2.5	Silty sand	0.11	0.95
	2.5-5.0	Fine sand	0.09	0.77
	5.0-7.5	Fine sand	0.07	0.75
	7.5-10.0	Fine sand	0.06	0.69
	10.0-12.5	Sand	0.05	0.49
	12.5-15.0	Sand	0.08	0.53
	15.0-17.5	Sand	0.17	0.74
	17.5-20.0	Sand	0.22	0.87
PZ-3	0-2.5	Silt	0.23	2.70
	2.5-5.0	Silty clay	0.31	4.01
	5.0-7.5	Sand	NM	NM
	7.5-10.0	Sand	NM	NM
	10.0-12.5 A	Sand	0.08	1.29
	10.0-12.5 B	Sand	0.08	1.28
	12.5-15.0 A	Sand	0.06	0.94
	15.0-17.5	Sand	0.07	0.99
	17.5-20	Sand	0.19	0.87
PV-4	0-2.5	Silty sand	0.08	0.97
	2.5-5.0	Fine sand	0.10	0.64
	5.0-7.5	Sand	0.08	0.59
	7.5-10.0	Sand	0.07	0.53
	10.0-12.5	Sand	0.05	0.52
	12.5-15.0	Sand	0.12	0.65
	15.0-17.5	Sand	NM[1]	NM[1]
	17.5-20.0	Sand	NM[1]	NM[1]
PZ-5	0-2.5	Silty sand	0.10	0.74
	2.5-5.0	Fine sand	0.11	0.54
	5.0-7.5	Sand	0.06	0.50
	7.5-10.0	Sand	0.06	0.41
	10.0-12.5	Sand	0.05	0.40
	12.5-15.0	Sand	0.15	0.60
	15.0-17.5	Sand	0.17	0.63
	17.5-20.0	Sand	0.17	0.68
PZ-6	0-2.5	Silt	0.18	1.56
	2.5-5.0	Silty clay	0.27	2.14
	5.0-7.5	Silty clay, less clay	0.28	1.79
	7.5-10.0	Fine sand	0.09	1.02

Table **4**, continued.

Piezometer	Depth Interval, feet bgs	Soil Texture	Gravimetric Water Content, g/g	Saturated Paste Extract EC, dS/m
PZ-6	10.0-12.5	Sand	0.07	0.79
	12.5-15.0	Sand	0.11	1.00
	15.0-17.5	Sand	0.20	1.70
	17.5-20	Sand	0.27	2.17
PZ-7	0-2.5	Fine sand	0.01	1.23
	2.5-5.0	Fine sand	0.01	1.15
	5.0-7.5	Fine sand	0.02	0.61
	7.5-10.0	Fine sand	0.05	0.46
	10.0-12.5	Fine sand	0.03	0.54
	12.5-15.0	Sand	0.11	0.36
	15.0-17.5	Sand	0.13	0.68
	17.5-20.0	Sand	0.16	0.61
PZ-8	0-2.5	Silty sand	0.11	0.93
	2.5-5.0	Sand	0.09	0.64
	5.0-7.5	Sand	0.08	0.57
	7.5-10.0	Sand	0.10	0.70
	10.0-12.5	Sandy silt	0.17	0.83
	12.5-15.0	Sandy silt	0.28	0.91
	15.0-17.5	Sandy silt	0.27	1.14
	17.5-20.0	Sandy silt	0.24	2.15

NM = Not Measured.
[1]Samples within saturated zone.

Table 5. Aquifer saturated hydraulic conductivity results for all restoration sites.

Location	Piezometer	Saturated Hydraulic Conductivity, feet per day
PVER	PZ-3-PVER	28
	PZ-4-PVER	16
	PZ-5-PVER	20
	PZ-8-PVER	61
Geometric Mean		**27**
Beal Lake	NN-1	23
	EE-4	24
	EE-2	32
	D	31
	C	36
	PZ-1-BL	17
	PZ-6-BL	17
Geometric mean		**25**
Cibola NWR	PZ-1-C	1.6
	PZ-3-C	4.5
	PZ-6-C	8.8
	PZ-9-C	1.6
	PZ-10-C	2.3
	PZ-SW	3.9
Geometric Mean		**3.1**
Cibola NWR	PZ-4-C[1]	0.00037

[1]Omitted from geometric mean calculation as an outlier (refer to Section 4.0).

FIGURES

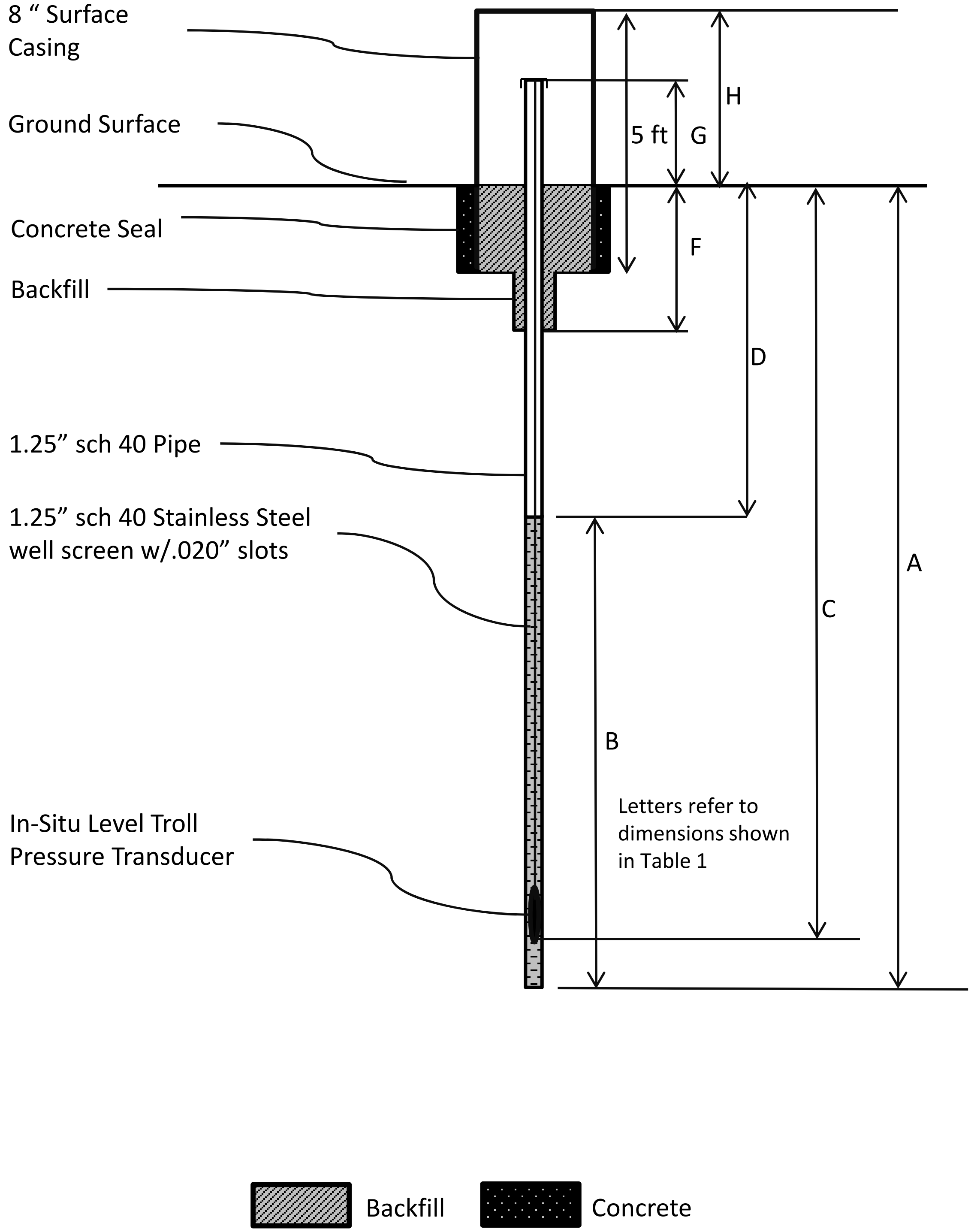


Figure 1
As-built schematic diagram of driven well point piezometers

Prepared for:

Lower Colorado River Multi-Species Conservation Program

Prepared by:

GSA GeoSystems Analysis, Inc.

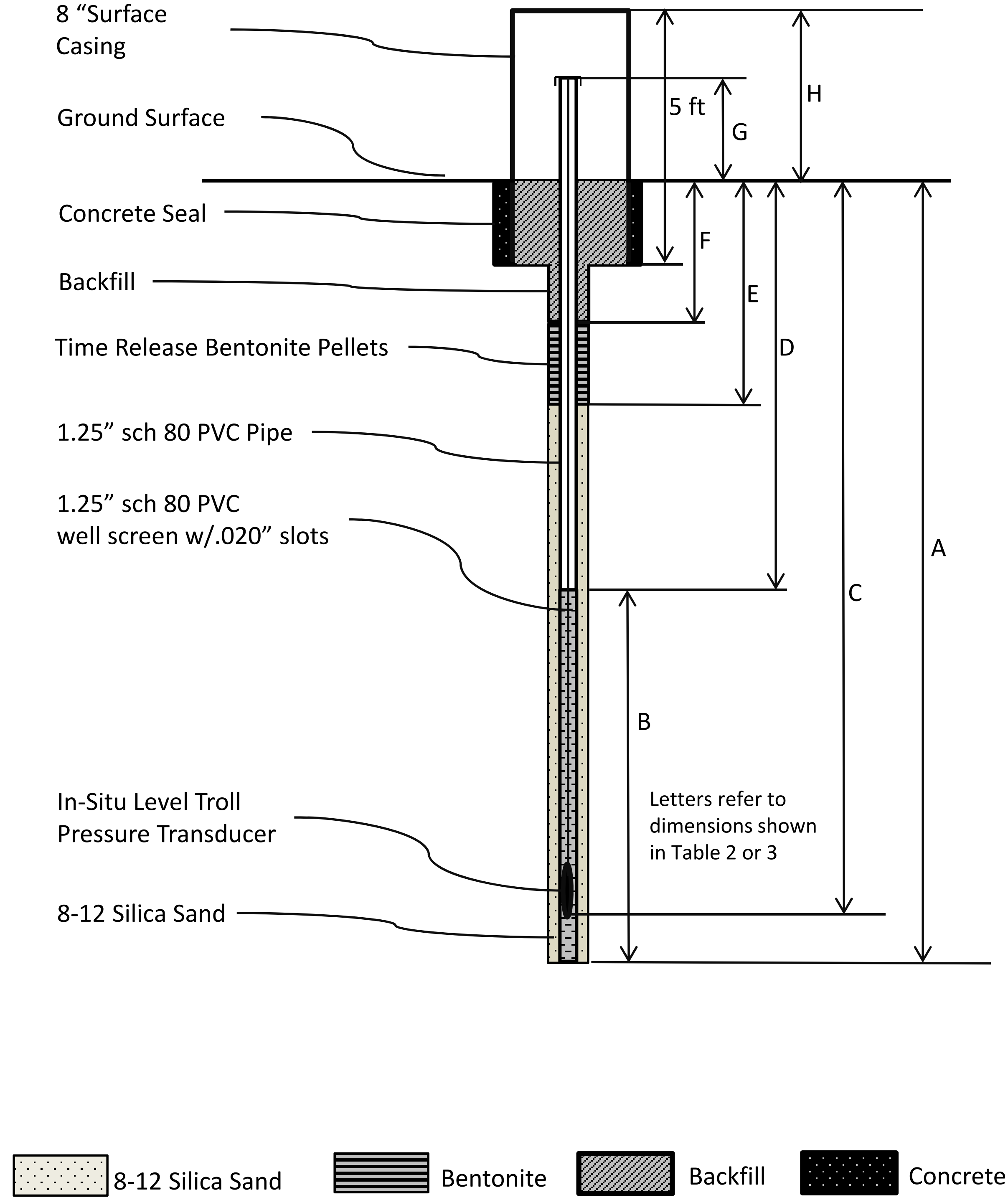


Figure 2
As-built schematic diagram of hand-augered casing advancement piezometers

Prepared for:

Lower Colorado River Multi-Species Conservation Program

Prepared by:

GSA GeoSystems Analysis, Inc.

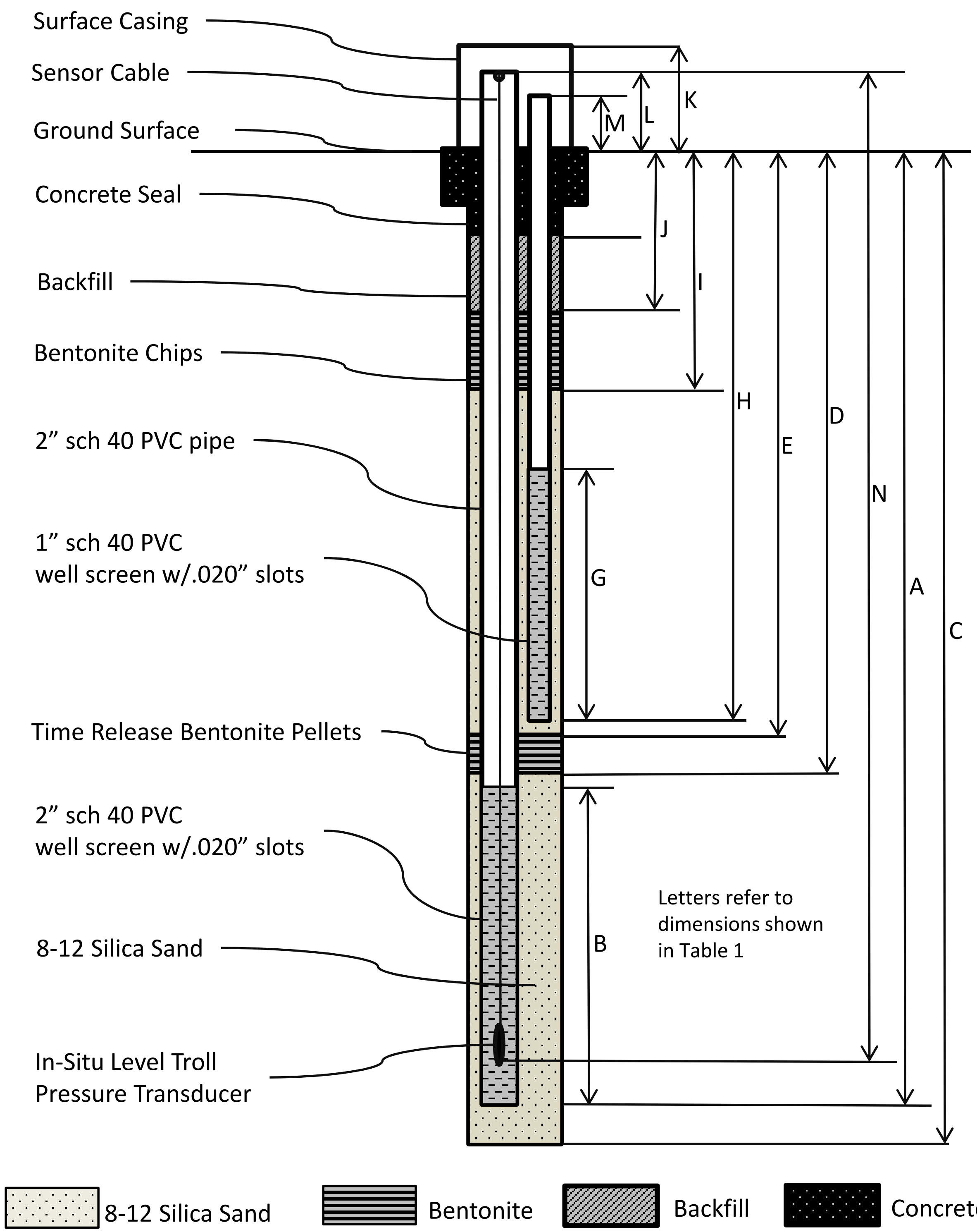


Figure 3
As-built schematic diagram of nested piezometers installed with a hollow-stemmed auger

Prepared for:

Prepared by:

Legend

Piezometer

Instrument Location

Field Border

N

0 200 400 600 800 1,000 Feet

Figure 4

Location of piezometers at PVER

Drawn	Date
RK	07/31/2011
Checked	Job Number
MG	0923
Approved	File
MM	E:\jobs\0923...\Groundwater Monitoring\Figure 4.mxd

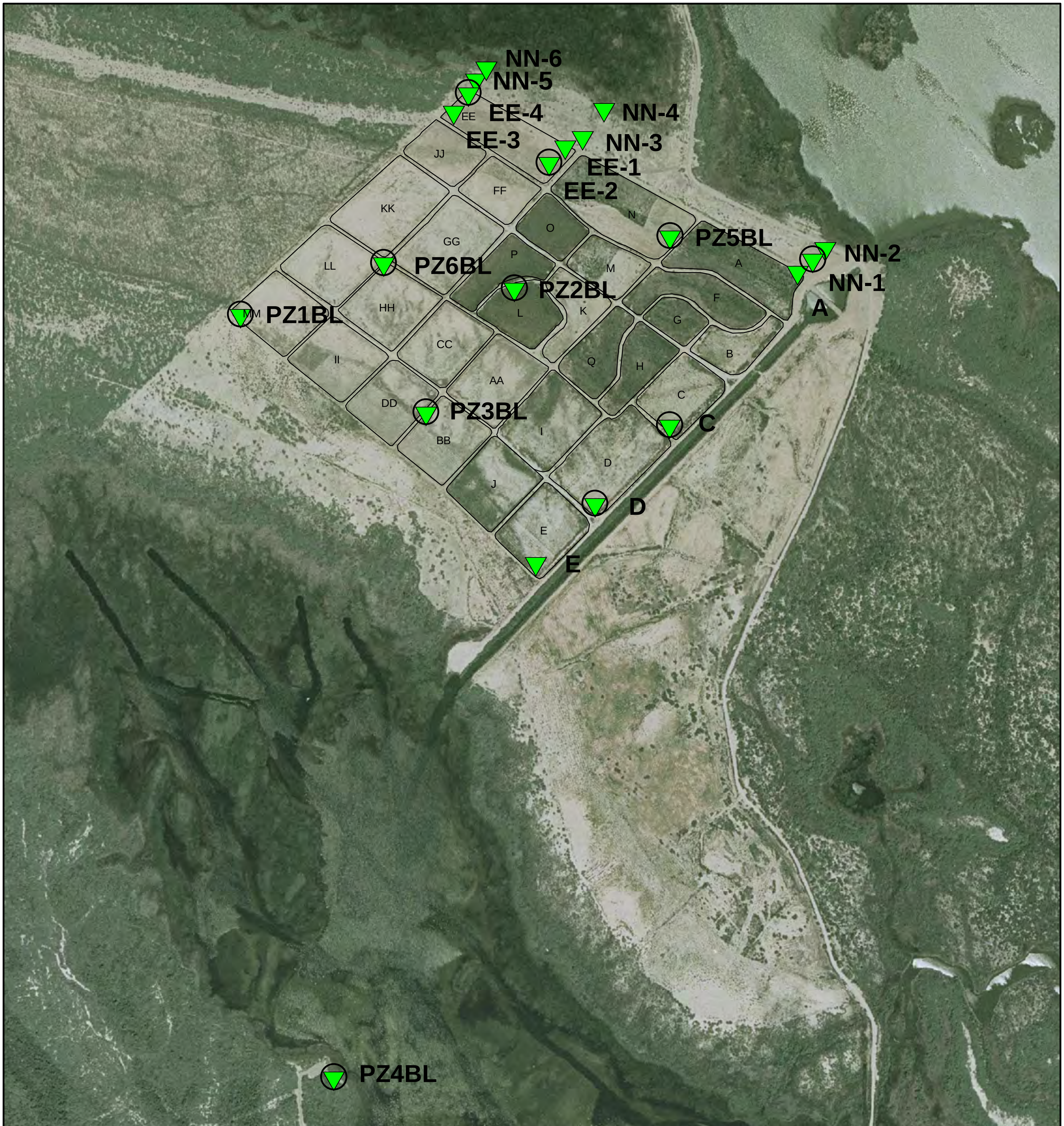
GSA GeoSystems Analysis, Inc.

Figure 5. Hollow stem auger drill rig.

Figure 6. Completed piezometer monument.

Figure 7. Completed nested piezometers.

Figure 8. In-Situ Rugged LevelTroll 100 level transducer and data logger.



Legend

Piezometer

Instrument Locations

Field Border

N

0 450 900 1,350 1,800 2,250 Feet

Figure 9

Piezometer locations at Beal Lake Restoration Site

Drawn	Date
RK	07/31/2011
Checked	Job Number
MG	0923
Approved	File
MM	E:\jobs\0923...\Groundwater Monitoring\Figure 9.mxd

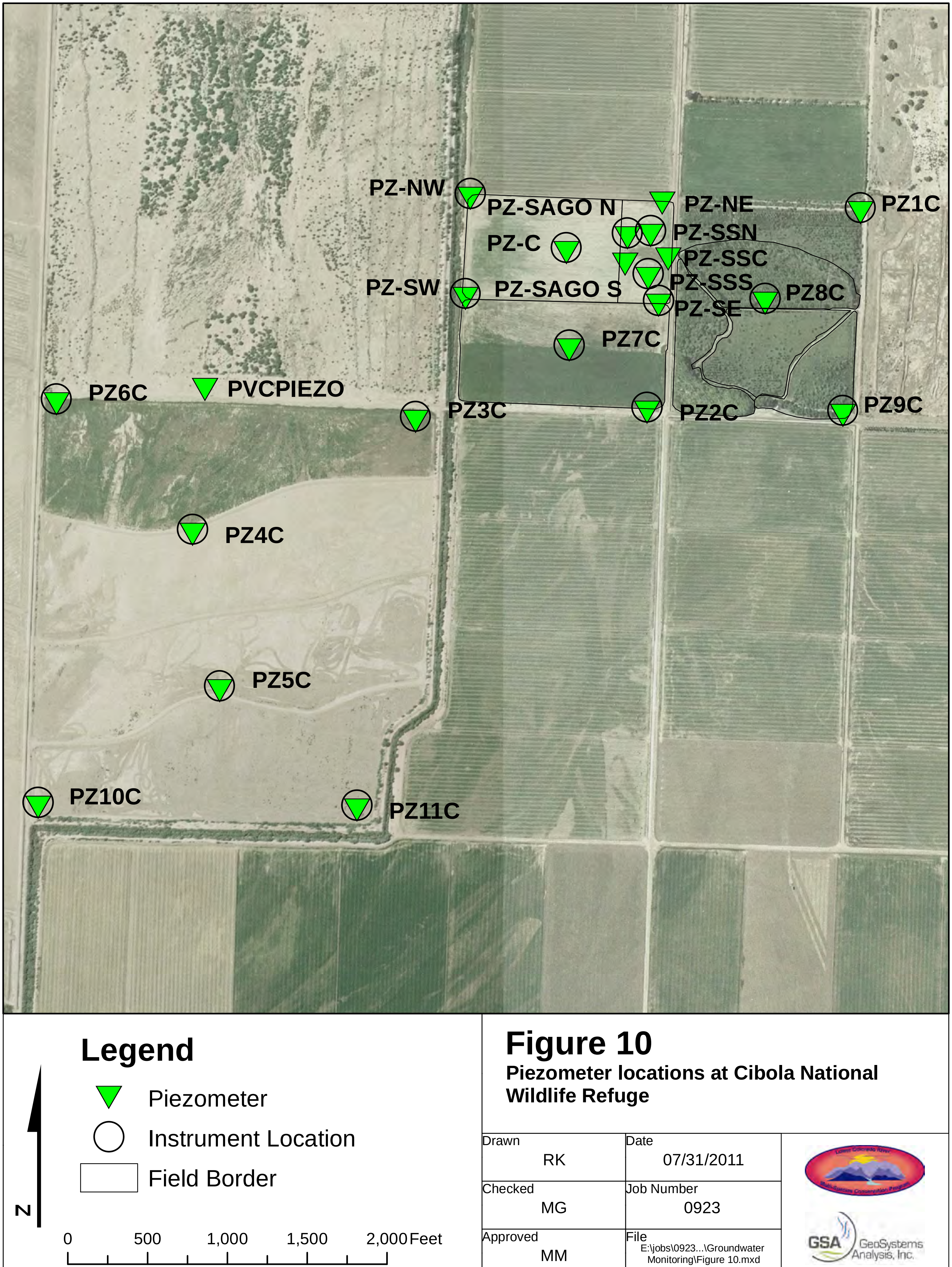
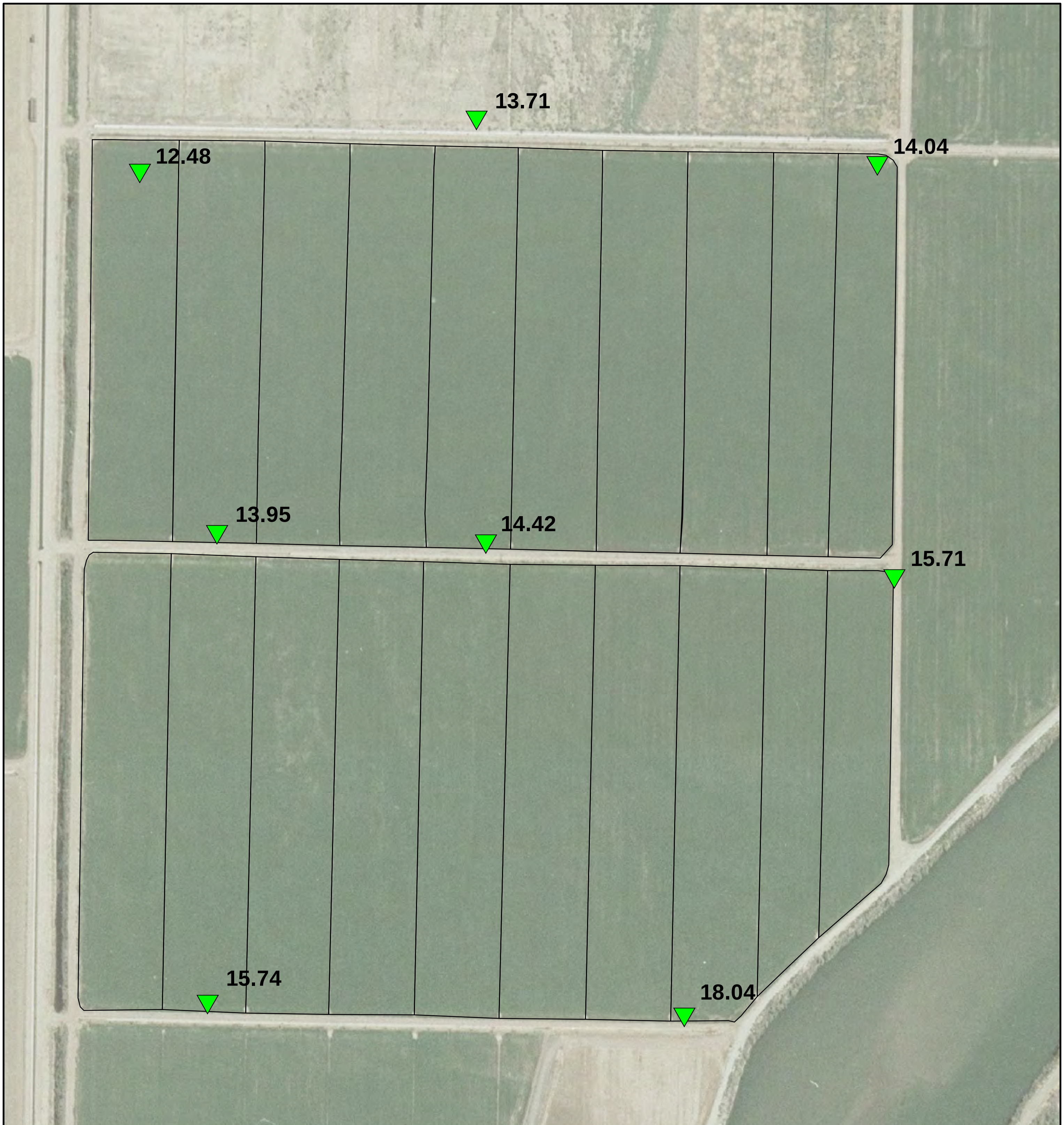


Figure 10

Piezometer locations at Cibola National Wildlife Refuge

Drawn	Date
RK	07/31/2011
Checked	Job Number
MG	0923
Approved	File
MM	E:\jobs\0923...\Groundwater Monitoring\Figure 10.mxd

GSA GeoSystems Analysis, Inc.



Legend

Piezometer

Field Border

N

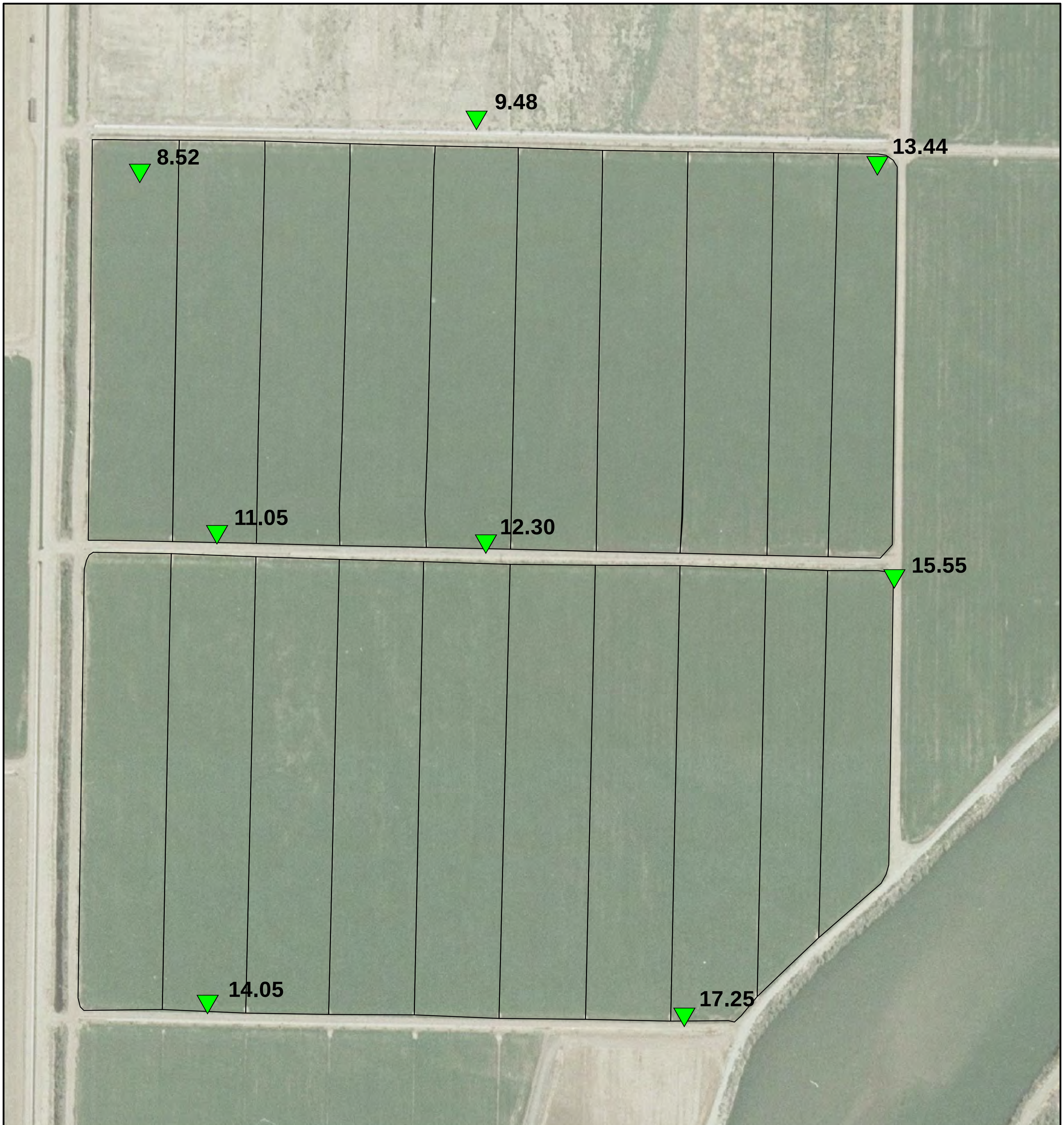
0 200 400 600 800 1,000 Feet

Figure 11

Depth to groundwater at Palo Verde Ecological Reserve on February 10, 2011, feet below ground surface

Drawn	Date
RK	07/31/2011
Checked	Job Number
MG	0923
Approved	File
MM	E:\jobs\0923...\Groundwater Monitoring\Figure 11.mxd

GSA GeoSystems Analysis, Inc.



Legend

Piezometer

Field Border

N

0 200 400 600 800 1,000 Feet

Figure 12

Depth to groundwater at Palo Verde Ecological Reserve on May 19, 2011, feet below ground surface

Drawn	Date
RK	07/31/2011
Checked	Job Number
MG	0923
Approved	File
MM	E:\jobs\0923...\Groundwater Monitoring\Figure 12.mxd

GSA GeoSystems Analysis, Inc.

Legend

No Data

Piezometer

Field Border

N

0 500 1,000 1,500 2,000 2,500 Feet

Figure 13

Depth to groundwater at Beal Lake Restoration Site on February 9, 2011, feet below ground surface

Drawn RK	Date 07/31/2011
Checked MG	Job Number 0923
Approved MM	File E:\jobs\0923...\Groundwater Monitoring\Figure 13.mxd

GSA GeoSystems Analysis, Inc.

Legend

Piezometer

Field Border

N

0 500 1,000 1,500 2,000 2,500 Feet

Figure 14

Depth to groundwater at Beal Lake Restoration Site on May 20, 2011, feet below ground surface

Drawn	Date
RK	07/31/2011
Checked	Job Number
MG	0923
Approved	File
MM	E:\jobs\0923...\Groundwater Monitoring\Figure 14.mxd

GSA GeoSystems Analysis, Inc.

Legend

No Data

Piezometer

Field Border

N

0 500 1,000 1,500 2,000 Feet

Figure 15

Depth to groundwater at Cibola National Wildlife Refuge Farm Unit #1 on February 10, 2011, feet below ground surface

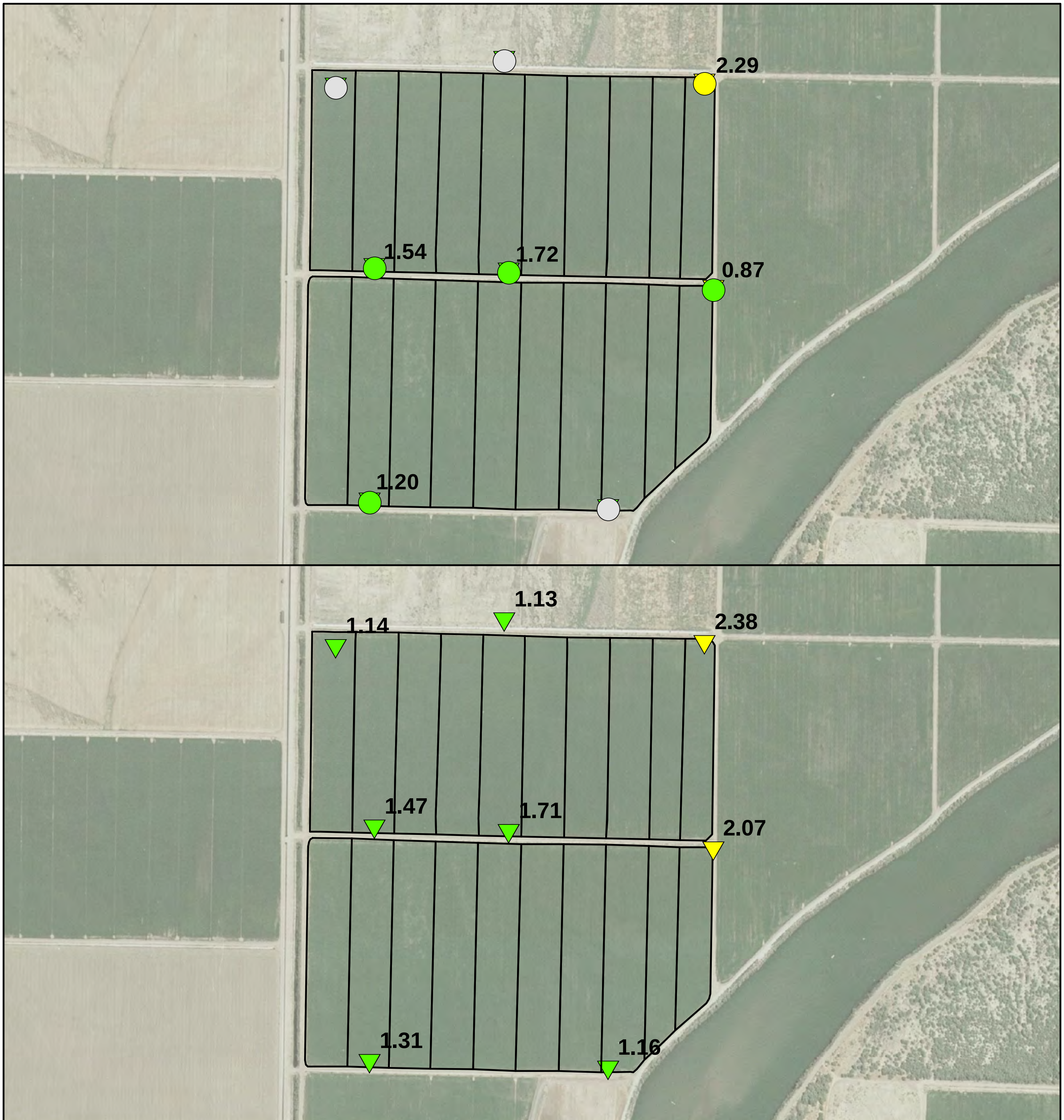
Drawn	Date
RK	07/31/2011
Checked	Job Number
MG	0923
Approved	File
MM	E:\jobs\0923...\Groundwater Monitoring\Figure 15.mxd

GSA GeoSystems Analysis, Inc.

Figure 16

Depth to groundwater at Cibola National Wildlife Refuge Farm Unit #1 on May 18 and 19, 2011, feet below ground surface

Drawn RK	Date 07/31/2011	
Checked MG	Job Number 0923	
Approved MM	File E:\jobs\0923...\Groundwater Monitoring\Figure 16.mxd	GSA GeoSystems Analysis, Inc.



Legend

Shallow Piezometer
- No Data
- 0-2 dS/m Low
- 2-5 dS/m Moderate

Deep Piezometer
- No Data
- 0-2 dS/m Low
- 2-5 dS/m Moderate

Field Border

N

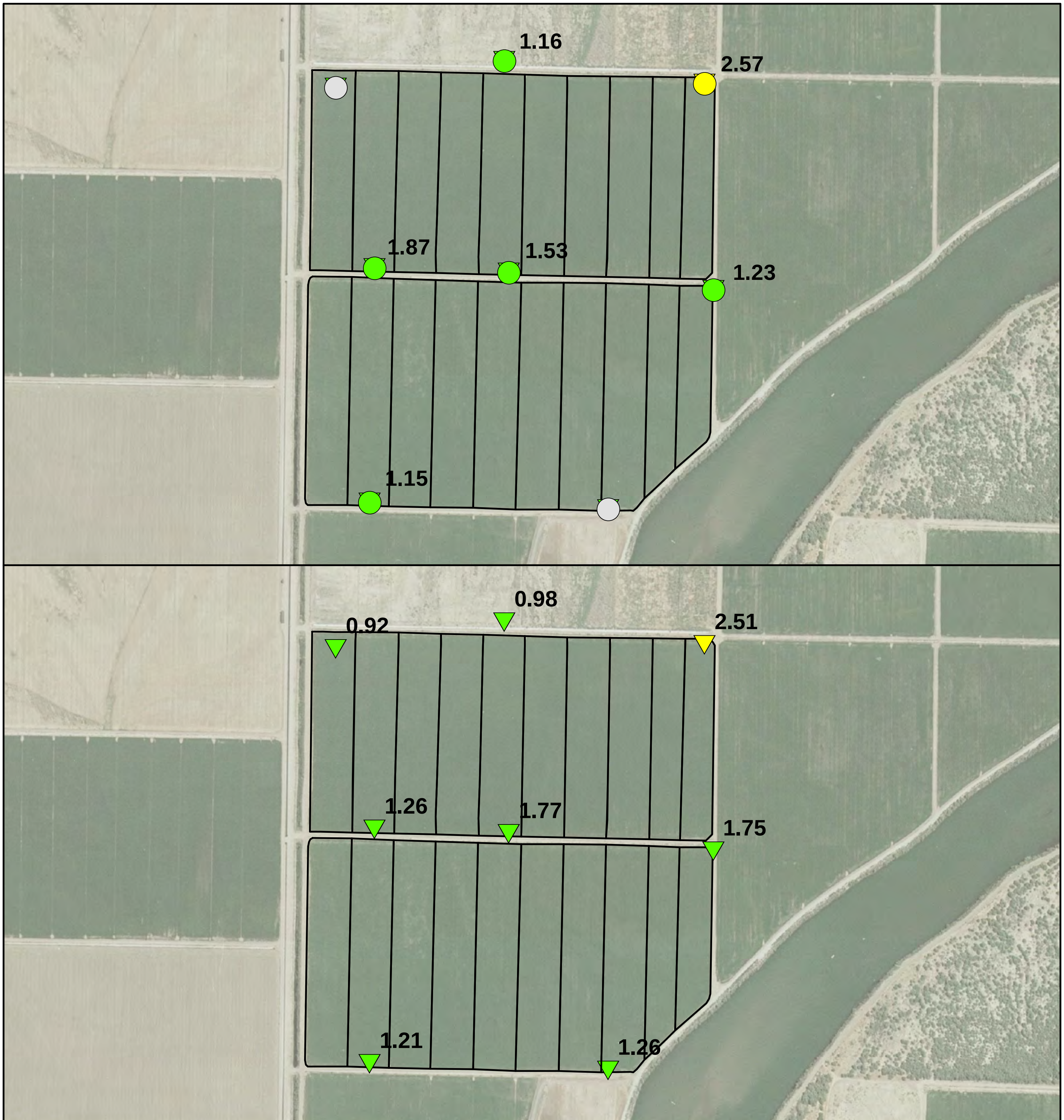
0 400 800 1,200 1,600 2,000 Feet

Figure 17

Groundwater specific conductance (EC) at Palo Verde Ecological Reserve on February 10, 2011

Drawn	Date
RK	08/02/2011
Checked	Job Number
MG	0923
Approved	File
MM	E:\jobs\0923...\Groundwater Monitoring\Figure 17.mxd

GSA GeoSystems Analysis, Inc.



Legend

Shallow Piezometer
- No Data
- 0-2 dS/m Low
- 2-5 dS/m Moderate

Deep Piezometer
- 0-2 dS/m Low
- 2-5 dS/m Moderate
- Field Border

N

0 400 800 1,200 1,600 2,000 Feet

Figure 18

Groundwater specific conductance (EC) at Palo Verde Ecological Reserve on May 19, 2011

Drawn	Date
RK	08/02/2011
Checked	Job Number
MG	0923
Approved	File
MM	E:\jobs\0923...\Groundwater Monitoring\Figure 18.mxd

GSA GeoSystems Analysis, Inc.

Legend

▽	No Data	▽	5-10 dS/m High
▽	0-2 dS/m Low	▽	10+ dS/m Extreme
▽	2-5 dS/m Moderate	▭	Field Border

N

0 500 1,000 1,500 2,000 2,500 Feet

Figure 19

Groundwater specific conductance (EC) at Beal Lake Restoration Site on February 9, 2011

Drawn: RK	Date: 08/02/2011
Checked: MG	Job Number: 0923
Approved: MM	File: E:\jobs\0923...\Groundwater Monitoring\Figure 19.mxd

GSA GeoSystems Analysis, Inc.

Legend

- No Data
- 0-2 dS/m Low
- 2-5 dS/m Moderate
- 5-10 dS/m High
- Field Border

N

0 500 1,000 1,500 2,000 2,500 Feet

Figure 20

Groundwater specific conductance (EC) at Beal Lake Restoration Site on May 20, 2011

Drawn RK	Date 08/02/2011
Checked MG	Job Number 0923
Approved MM	File E:\jobs\0923...\Groundwater Monitoring\Figure 20.mxd

Legend

- No Data
- 0-2 dS/m Low
- 2-5 dS/m Moderate
- 5-10 dS/m High
- Field Border

N

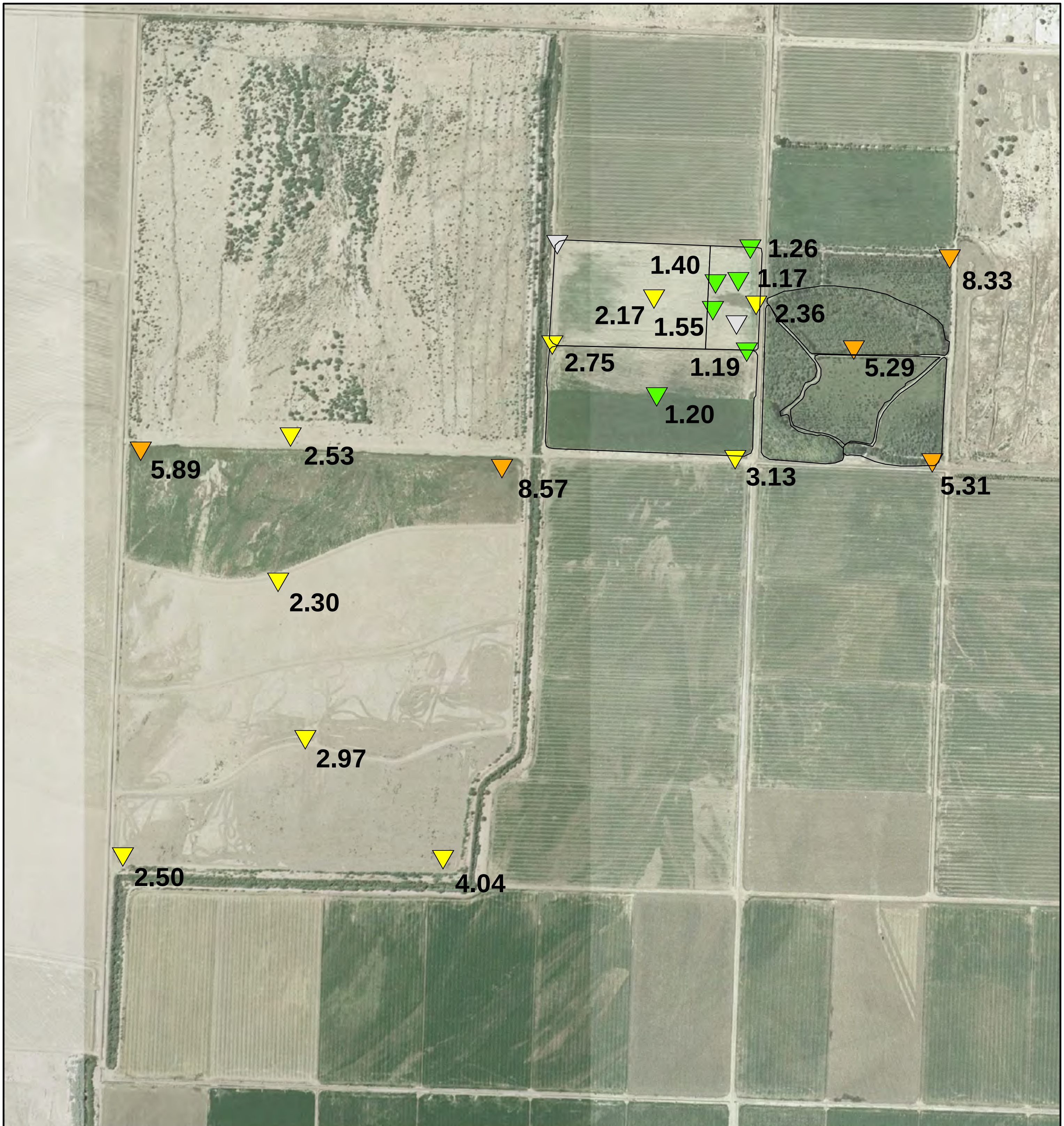
0 500 1,000 1,500 2,000 Feet

Figure 21

Groundwater specific conductance (EC) at Cibola National Wildlife Refuge Farm Unit #1 on February 10, 2011

Drawn	Date
RK	08/02/2011
Checked	Job Number
MG	0923
Approved	File
MM	E:\jobs\0923...\Groundwater Monitoring\Figure 21.mxd

GSA GeoSystems Analysis, Inc.



Legend

- No Data
- 0-2 dS/m Low
- 2-5 dS/m Moderate
- 5-10 dS/m High
- Field Border

N

0 500 1,000 1,500 2,000 Feet

Figure 22

Groundwater specific conductance (EC) at Cibola National Wildlife Refuge Farm Unit #1 on May 18 and 19, 2011

Drawn	Date
RK	08/02/2011
Checked	Job Number
MG	0923
Approved	File
MM	E:\jobs\0923...\Groundwater Monitoring\Figure 22.mxd

GSA GeoSystems Analysis, Inc.

Appendix I:
Geologic Log Sheets

Geologic Log Sheet

Client	**BOR**	Logged By	**Rice**
Project No.	**923**	**Drilling Company**	**Yellow Jacket**
		Operator	**Sean**
Borehole	**PZ-1-PVER**	**Location**	Palo Verde Ecological Reserve

Date Logged	Depth Interval (ft)		Samples	Moisture Content				Particle Size Distribution				Grading	Sand Fraction			Plasticity				USCS Group Symbol/Name	
	From	To	g=grab, c=core	Dry	Slightly Moist	Moist	Wet	% Gravel	% Sand	% Silt	% Clay	W= Well, P= Poor	Fine	Medium	Coarse	None	Low	Medium	High		Comments
12/14/2010	0	2.5	g			x			70	25	5	W	x			x				SM	Sandy silt
12/14/2010	2.5	5	g			x			95	5		W	x			x				SW	Fine sand
12/14/2010	5	7.5	g			x			95	5		W	x			x				SW	Fine sand
12/14/2010	7.5	10	g			x			100			W	x	x		x				SW	Sand
12/14/2010	10	11..5	c			x			100			W	x	x		x				SW	Sand
12/14/2010	10	12.5	g			x			100			W	x	x		x				SW	Sand
12/14/2010	12.5	15	g			x			100			W	x	x		x				SW	Sand
12/14/2010	15	17.5	g			x			100			W	x	x		x				SW	Medium sand
12/14/2010	17.5	20	g				x		100			W		x		x				SW	Medium sand
12/14/2010	20	21.5	c				x		100			W		x		x				SW	Medium sand
12/14/2010	20	22.5	g				x		100			W		x		x				SW	Medium sand
12/14/2010	22.5	25	g				x		100			W		x		x				SW	Medium sand
12/14/2010	25	27.5	g				x		100			W		x		x				SW	Medium sand
12/14/2010	27.5	30	g				x		100			W		x		x				SW	Medium sand
12/14/2010	30	31.5	c				x		100			W		x		x				SW	Medium sand

Geologic Log Sheet

Client	**BOR**	Logged By	**Rice**		
Project No.	**923**	**Drilling Company**	**Yellow Jacket**	**Operator**	**Sean**
Borehole	**PZ-2-PVER**	**Location**	Palo Verde Ecological Reserve		

Date Logged	Depth Interval (ft)		Samples	Moisture Content				Particle Size Distribution				Grading	Sand Fraction			Plasticity				USCS Group Symbol/Name	Comments
	From	To	g=grab, c=core	Dry	Slightly Moist	Moist	Wet	% Gravel	% Sand	% Silt	% Clay	W= Well, P= Poor	Fine	Medium	Coarse	None	Low	Medium	High		
12/15/2010	0	2.5	g			x			85	12	3	W	x			x				SM	Silty sand
12/15/2010	2.5	5	g			x			90	10		W	x			x				SW-SC	Fine sand
12/15/2010	5	7.5	g			x			95	5		W	x			x				SW	Fine sand
12/15/2010	7.5	10	g			x			95	5		W	x			x				SW	Fine sand
12/15/2010	10	11..5	c			x			95	5		W	x			x				SW	Fine sand
12/15/2010	10	12.5	g			x			97	3		W	x			x				SW	Sand
12/15/2010	12.5	15	g			x			97	3		W	x			x				SW	Sand
12/15/2010	15	17.5	g			x			97	3		W	x			x				SW	Sand
12/15/2010	17.5	20	g			x			97	3		W	x			x				SW	Sand
12/15/2010	20	21.5	c				x		100			W	x			x				SW	Sand
12/15/2010	20	22.5	g				x		100			W	x	x		x				SW	Sand
12/15/2010	22.5	25	g				x		100			W	x	x		x				SW	Sand
12/15/2010	25	27.5	g				x		100			W	x	x		x				SW	Sand
12/15/2010	27.5	30	g				x		100			W	x	x		x				SW	Medium sand
12/15/2010	30	31.5	c				x		100			W		x	x	x				SW	Coarse sand at 31.5 feet

Geologic Log Sheet

Client	BOR	Logged By	Rice	
Project No.	923	Drilling Company	Yellow Jacket Operator	Sean
Borehole	PZ-3-PVER	Location	Palo Verde Ecological Reserve	

Date Logged	Depth Interval (ft) From	Depth Interval (ft) To	Samples g=grab, c=core	Moisture Content Dry	Moisture Content Slightly Moist	Moisture Content Moist	Moisture Content Wet	Particle Size Distribution % Gravel	% Sand	% Silt	% Clay	Grading W= Well, P= Poor	Sand Fraction Fine	Sand Fraction Medium	Sand Fraction Coarse	Plasticity None	Plasticity Low	Plasticity Medium	Plasticity High	USCS Group Symbol/Name	Comments
12/15/2010	0	2.5	g			x			65	30	5	W	x				x			ML	Silt
12/15/2010	2.5	5	g			x			45	35	20	W	x						x	CL	Silty clay
12/15/2010	5	7.5	g			x			97	3		W	x			x				SW	Sand
12/15/2010	7.5	10	g			x			97	3		W	x			x				SW	Sand
12/15/2010	10	11..5	c			x			100			W	x			x				SW	Sand
12/15/2010	10	12.5	g			x			97	3		W	x	x		x				SW	Sand
12/15/2010	12.5	15	g			x			97	3		W	x	x		x				SW	Sand
12/15/2010	15	17.5	g			x			97	3		W	x	x		x				SW	Sand
12/15/2010	17.5	20	g				x		97	3		W	x	x		x				SW	Sand
12/15/2010	20	21.5	c				x		97	3		W	x	x		x				SW	Sand
12/15/2010	20	22.5	g				x		97	3		W	x	x		x				SW	Sand
12/15/2010	22.5	25	g				x		97	3		W	x	x		x				SW	Sand
12/15/2010	25	27.5	g				x		97	3		W	x	x		x				SW	Sand
12/15/2010	27.5	30	g				x		97	3		W	x	x		x				SW	Sand
																					No core at 30 ft.

Geologic Log Sheet

Client	BOR	Logged By	Rice		
Project No.	923	Drilling Company	Yellow Jacket	Operator	Sean
Borehole	PZ-4-PVER		Location	Palo Verde Ecological Reserve	

Date Logged	Depth Interval (ft)		Samples	Moisture Content				Particle Size Distribution				Grading	Sand Fraction			Plasticity				USCS Group Symbol/Name	Comments
	From	To	g=grab, c=core	Dry	Slightly Moist	Moist	Wet	% Gravel	% Sand	% Silt	% Clay	W= Well, P= Poor	Fine	Medium	Coarse	None	Low	Medium	High		Comments
12/14/2010	0	2.5	g			x			85	13	2	W	x			x				SM	Silty sand
12/14/2010	2.5	5	g			x			95	5		W	x			x				SW	Fine sand
12/14/2010	5	7.5	g			x			95	5		W	x			x				SW	Sand
12/14/2010	7.5	10	g			x			100			W	x	x		x				SW	Sand
12/14/2010	10	11..5	c			x			100			W	x	x		x				SW	Sand
12/14/2010	10	12.5	g			x			100			W	x	x		x				SW	Sand
12/14/2010	12.5	15	g			x			100			W	x	x		x				SW	Sand
12/14/2010	15	17.5	g			x			100			W	x	x		x				SW	Sand
12/14/2010	17.5	20	g			x			100			W	x	x		x				SW	Sand
12/14/2010	20	21.5	c				x		100			W	x	x		x				SW	Sand
12/14/2010	20	22.5	g				x		100			W		x		x				SW	Medium sand
12/14/2010	22.5	25	g				x		100			W		x		x				SW	Medium sand
12/14/2010	25	27.5	g				x		100			W		x		x				SW	Medium sand
12/14/2010	27.5	30	g				x		100			W		x		x				SW	Medium sand
12/14/2010	30	31.5	c				x		100			W		x		x				SW	Medium sand

Geologic Log Sheet

Client	BOR	Logged By	Rice	
Project No.	923	Drilling Company	Yellow Jacket	Operator: Sean
Borehole	PZ-5-PVER	Location	Palo Verde Ecological Reserve	

Date Logged	Depth Interval (ft) From	Depth Interval (ft) To	Samples g=grab, c=core	Moisture Content: Dry	Slightly Moist	Moist	Wet	Particle Size Distribution: % Gravel	% Sand	% Silt	% Clay	Grading W= Well, P= Poor	Sand Fraction: Fine	Medium	Coarse	Plasticity: None	Low	Medium	High	USCS Group Symbol/Name	Comments
12/14/2010	0	2.5	g		x				90	8	2	W	x			x				SW-SM	Silty sand
12/14/2010	2.5	5	g		x				98	2		W	x			x				SW	Fine sand
12/14/2010	5	7.5	g		x				100			W	x			x				SW	Sand
12/14/2010	7.5	10	g		x				100			W	x			x				SW	Sand
12/14/2010	10	11..5	c		x				100			W	x			x				SW	Sand
12/14/2010	10	12.5	g		x				100			W	x			x				SW	Sand
12/14/2010	12.5	15	g			x			100			W	x			x				SW	Sand
12/14/2010	15	17.5	g			x			100			W	x			x				SW	Sand
12/14/2010	17.5	20	g			x			100			W	x			x				SW	Sand
12/14/2010	20	21.5	c				x		100			W	x			x				SW	Sand
12/14/2010	20	22.5	g				x		100			W	x			x				SW	Sand
12/14/2010	22.5	25	g				x		100			W	x			x				SW	Sand
12/14/2010	25	27.5	g				x		100			W	x			x				SW	Sand
12/14/2010	27.5	30	g				x		100			W	x			x				SW	Sand
12/14/2010	30	31.5	c				x		100			W	x			x				SW	Sand

Geologic Log Sheet

Client	**BOR**	Logged By	**Rice**		
Project No.	**923**	**Drilling Company**	**Yellow Jacket**	**Operator**	**Sean**
Borehole	**PZ-6-PVER**	**Location**	Palo Verde Ecological Reserve		

Date Logged	Depth Interval (ft)		Samples	Moisture Content				Particle Size Distribution				Grading	Sand Fraction			Plasticity				USCS Group Symbol/Name	Comments
	From	To	g=grab, c=core	Dry	Slightly Moist	Moist	Wet	% Gravel	% Sand	% Silt	% Clay	W= Well, P= Poor	Fine	Medium	Coarse	None	Low	Medium	High		
12/14/2010	0	2.5	g			x			60	35	5	W	x				x			SC	Silt
12/14/2010	2.5	5	g			x			40	45	15	W	x						x	ML	Silty clay
12/14/2010	5	7.5	g			x			50	45	10	W	x						x	ML	Silty clay, less clay
12/14/2010	7.5	10	g			x			100			W	x				x			SW	Fine sand
12/14/2010	10	11..5	c			x			100			W	x				x			SW	Fine sand
12/14/2010	10	12.5	g			x			100			W	x	x			x			SW	Sand
12/14/2010	12.5	15	g			x			100			W	x	x			x			SW	Sand
12/14/2010	15	17.5	g				x		100			W	x	x			x			SW	Sand
12/14/2010	17.5	20	g				x		100			W	x	x			x			SW	Sand
12/14/2010	20	21.5	c				x		100			W	x	x			x			SW	Sand, only one core
12/14/2010	20	22.5	g				x		100			W		x			x			SW	Medium sand
12/14/2010	22.5	25	g				x		100			W		x			x			SW	Medium sand
12/14/2010	25	27.5	g				x		100			W		x			x			SW	Medium sand
12/14/2010	27.5	30	g				x		100			W		x			x			SW	Medium sand
12/14/2010																				SW	No core

Geologic Log Sheet

Client	**BOR**	Logged By	**Rice**		
Project No.	**923**	**Drilling Company**	**Yellow Jacket**	**Operator**	**Sean**
Borehole	**PZ-7-PVER**	**Location**	Palo Verde Ecological Reserve		

Date Logged	Depth Interval (ft)		Samples	Moisture Content				Particle Size Distribution				Grading	Sand Fraction			Plasticity				USCS Group Symbol/Name	
	From	To	g=grab, c=core	Dry	Slightly Moist	Moist	Wet	% Gravel	% Sand	% Silt	% Clay	W= Well, P= Poor	Fine	Medium	Coarse	None	Low	Medium	High		Comments
12/14/2010	0	2.5	g	x					95	5		W	x			x				SW	Fine sand
12/14/2010	2.5	5	g	x					95	5		W	x			x				SW	Fine sand
12/14/2010	5	7.5	g	x					95	5		W	x			x				SW	Fine sand
12/14/2010	7.5	10	g		x				95	5		W	x			x				SW	Fine sand, Large hole at 10' on backfill
12/14/2010	10	11..5	c		x				100			W	x			x				SW	Fine sand
12/14/2010	10	12.5	g			x			100			W	x			x				SW	Fine sand
12/14/2010	12.5	15	g			x			100			W	x	x		x				SW	Sand
12/14/2010	15	17.5	g				x		100			W	x	x		x				SW	Sand
12/14/2010	17.5	20	g				x		100			W	x	x		x				SW	Sand
12/14/2010	20	21.5	c				x		100			W	x	x		x				SW	Sand
12/14/2010	20	22.5	g				x		100			W	x	x		x				SW	Sand
12/14/2010	22.5	25	g				x		100			W		x		x				SW	Medium sand
12/14/2010	25	27.5	g				x		100			W		x		x				SW	Medium sand
12/14/2010	27.5	30	g				x		100			W		x		x				SW	Medium sand
12/14/2010	30	31.5	c				x		100			W		x		x				SW	Medium sand

Geologic Log Sheet

Client	BOR	Logged By	Rice
Project No.	923	Drilling Company	Yellow Jacket
Operator	Sean		
Borehole	PZ-8-PVER	Location	Palo Verde Ecological Reserve

Date Logged	Depth Interval (ft)		Samples	Moisture Content				Particle Size Distribution				Grading	Sand Fraction			Plasticity				USCS Group Symbol/Name	Comments
	From	To	g=grab, c=core	Dry	Slightly Moist	Moist	Wet	% Gravel	% Sand	% Silt	% Clay	W= Well, P= Poor	Fine	Medium	Coarse	None	Low	Medium	High		
12/14/2010	0	2.5	g			x			85	12	3	W	x			x				SM	Silty sand
12/14/2010	2.5	5	g			x			95	5		W	x			x				SW	Sand
12/14/2010	5	7.5	g			x			95	5		W	x			x				SW	Sand
12/14/2010	7.5	10	g			x			95	5		W	x			x				SW	Sand
12/14/2010	10	11..5	c			x			95	5		W	x			x				SW	Sand
12/14/2010	10	12.5	g			x			85	15		W	x			x				SM	Sandy silt
12/14/2010	12.5	15	g			x			80	15	5	W	x			x				SM	Sandy silt
12/14/2010	15	17.5	g				x		75	20	5	W	x				x			SM	Sandy silt
12/14/2010	17.5	20	g				x		75	20	5	W	x				x			SM	Sandy silt
12/14/2010	20	21.5	c				x		75	20	5	W	x				x			SM	Sandy silt
12/14/2010	20	22.5	g				x		40	50	10	W	x				x			SM	Silt
12/14/2010	22.5	25	g				x		40	50	10	W	x				x			SM	Silt
12/14/2010	25	27.5	g				x		40	50	10	W	x				x			SM	Silt
12/14/2010	27.5	30	g				x		40	50	10	W	x				x			SM	Silt
12/14/2010	30	31.5	c				x		90	10		W	x			x				SW	Sand

Appendix II:
Slug Test Results

WELL ID: PVER

Local ID: PZ-3-PV
Date: 3/16/2011
Time: 2:25:00 PM

INPUT

Construction:

Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	10	Inch
Screen Length (L)	10.00	Feet

Depths to:

water level (DTW)	18.36	Feet
top of screen (TOS)	20.00	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Coarse Sand
above screen -- Bentonite

Aquifer Material -- Medium Sand

COMPUTED

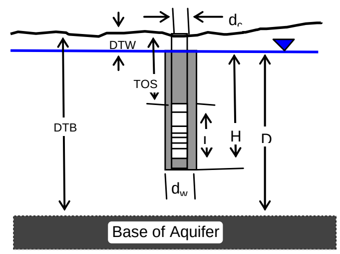
L_{wetted}	10	Feet
D =	31.64	Feet
H =	11.64	Feet
L/r_w =	24.00	
$y_{0\text{-DISPLACEMENT}}$ =	0.36	Feet
$y_{0\text{-SLUG}}$ =	0.34	Feet

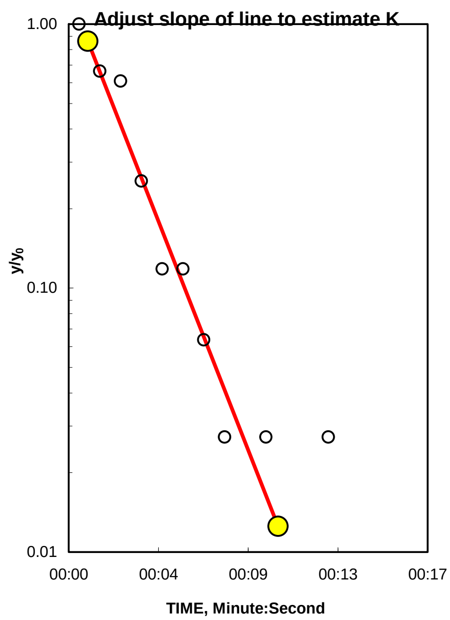
From look-up table using L/r_w

Partial penetrate A =	2.334	
B =	0.376	
ln(Re/rw) =	2.048	
Re =	3.23	Feet
Slope =	0.200581	$\log_{10}$/sec
$t_{90\%}$ recovery =	5	sec

Input is consistent.

K = 28 Feet/Day





Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	125.70
2	0:00:02.0	122.00
3	0:00:03.0	121.40
4	0:00:04.0	117.50
5	0:00:05.0	116.00
6	0:00:06.0	116.00
7	0:00:07.0	115.40
8	0:00:08.0	115.00
9	0:00:09.0	114.70
10	0:00:10.0	115.00
11	0:00:11.0	114.70
12	0:00:12.0	114.70
13	0:00:13.0	115.00
14	0:00:14.0	114.70
15	0:00:15.0	114.70
16	0:00:16.0	114.70

REMARKS:

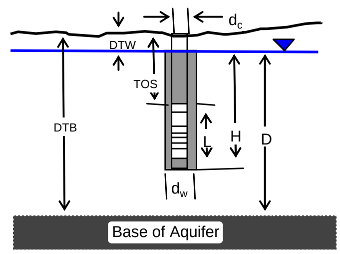
Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: PVER

Local ID: PZ-4-PV
Date: 3/16/2011
Time: 11:05:00 AM

INPUT

Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	10	Inch
Screen Length (L)	10.00	Feet
Depths to:		
water level (DTW)	16.47	Feet
top of screen (TOS)	20.00	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen --	Coarse Sand	
above screen --	Bentonite	
Aquifer Material --	Medium Sand	



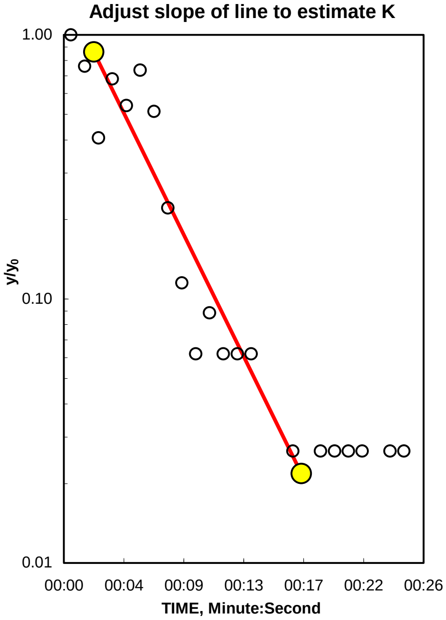
COMPUTED

L_{wetted}	10	Feet
D =	33.53	Feet
H =	13.53	Feet
L/r_w =	24.00	
$y_{0\text{-DISPLACEMENT}}$ =	0.37	Feet
$y_{0\text{-SLUG}}$ =	0.38	Feet
From look-up table using L/r_w		
Partial penetrate A =	2.334	
B =	0.376	
ln(Re/rw) =	2.110	
Re =	3.44	Feet
Slope =	0.106776	$\log_{10}$/sec
$t_{90\%}$ recovery =	9	sec

Input is consistent.

K =	16	Feet/Day

Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	150.40
2	0:00:02.0	147.70
3	0:00:03.0	143.70
4	0:00:04.0	146.80
5	0:00:05.0	145.20
6	0:00:06.0	147.40
7	0:00:07.0	144.90
8	0:00:08.0	141.60
9	0:00:09.0	140.40
10	0:00:10.0	139.80
11	0:00:11.0	140.10
12	0:00:12.0	139.80
13	0:00:13.0	139.80
14	0:00:14.0	139.80
15	0:00:15.0	139.10
16	0:00:16.0	139.10
17	0:00:17.0	139.40
18	0:00:18.0	139.10
19	0:00:19.0	139.40
20	0:00:20.0	139.40
21	0:00:21.0	139.40
22	0:00:22.0	139.40
23	0:00:23.0	139.10
24	0:00:24.0	139.40
25	0:00:25.0	139.40

K= 16 is less than likely minimum of 20 for Medium Sand

REMARKS: Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: PVER

Local ID: PZ-5-PV
Date: 3/17/2011
Time: 7:50:00 AM

INPUT

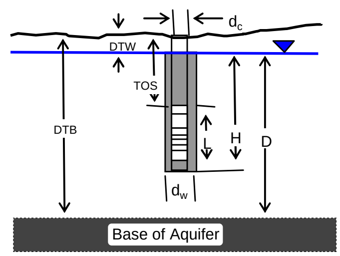
Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	10	Inch
Screen Length (L)	10.00	Feet
Depths to:		
water level (DTW)	14.75	Feet
top of screen (TOS)	19.00	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen --	Coarse Sand	
above screen --	Bentonite	
Aquifer Material --	Medium Sand	

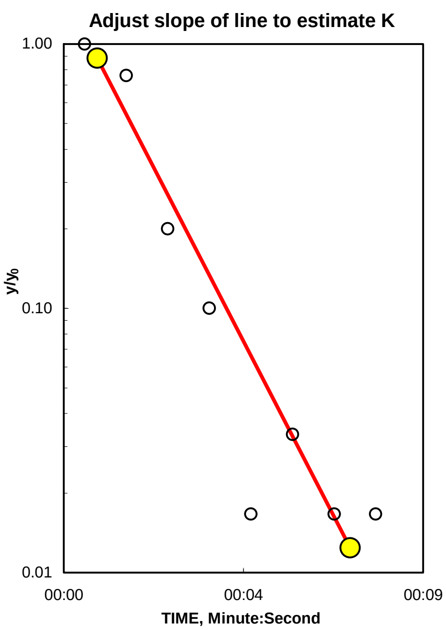
COMPUTED

L_{wetted}	10	Feet
D =	35.25	Feet
H =	14.25	Feet
L/r_w =	24.00	
$y_{0\text{-DISPLACEMENT}}$ =	0.59	Feet
$y_{0\text{-SLUG}}$ =	0.56	Feet
From look-up table using L/r_w		
Partial penetrate A =	2.334	
B =	0.376	
ln(Re/rw) =	2.127	
Re =	3.50	Feet
Slope =	0.304641	log_{10}/sec
$t_{90\%}$ recovery =	3	sec

Input is consistent.

K =	45	Feet/Day





Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	163.50
2	0:00:02.0	167.80
3	0:00:03.0	177.90
4	0:00:04.0	179.70
5	0:00:05.0	181.20
6	0:00:06.0	180.90
7	0:00:07.0	181.20
8	0:00:08.0	181.20
9	0:00:09.0	181.50
10	0:00:10.0	181.50

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: PVER

Local ID: PZ-5-PV-2
Date: 3/16/2011
Time: 8:00:00 AM

INPUT

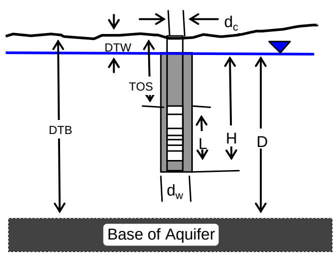
Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	10	Inch
Screen Length (L)	10.00	Feet
Depths to:		
water level (DTW)	14.75	Feet
top of screen (TOS)	19.00	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen --	Coarse Sand	
above screen --	Bentonite	
Aquifer Material --	Medium Sand	

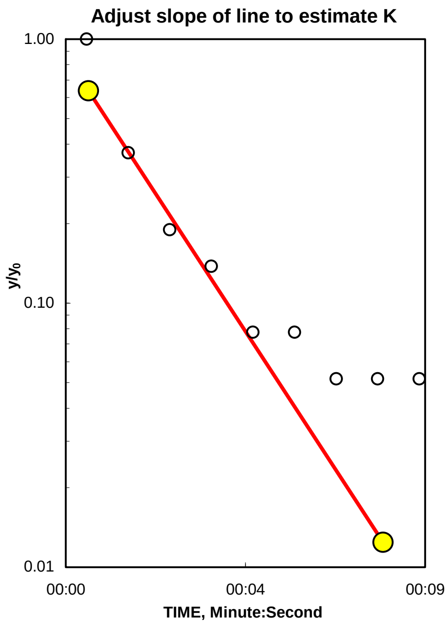
COMPUTED

L_{wetted}	10	Feet
D =	35.25	Feet
H =	14.25	Feet
L/r_w =	24.00	
$y_{0\text{-DISPLACEMENT}}$ =	0.38	Feet
$y_{0\text{-SLUG}}$ =	0.34	Feet
From look-up table using L/r_w		
Partial penetrate A =	2.334	
B =	0.376	
ln(Re/rw) =	2.127	
Re =	3.50	Feet
Slope =	0.241362	log_{10}/sec
$t_{90\%}$ recovery =	4	sec

Input is consistent.

K =	**35**	**Feet/Day**





Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	193.10
2	0:00:02.0	185.80
3	0:00:03.0	183.70
4	0:00:04.0	183.10
5	0:00:05.0	182.40
6	0:00:06.0	182.40
7	0:00:07.0	182.10
8	0:00:08.0	182.10
9	0:00:09.0	182.10
10	0:00:10.0	182.10
11	0:00:11.0	182.10
12	0:00:12.0	181.80

REMARKS:

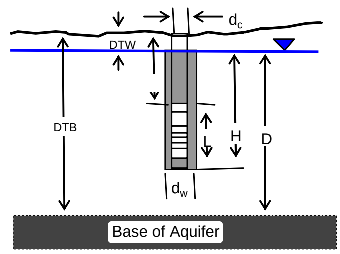
Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: PVER

Local ID: PZ-5-PV-3
Date: 3/16/2011
Time: 0:00

INPUT

Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	10	Inch
Screen Length (L)	10.00	Feet
Depths to:		
water level (DTW)	14.75	Feet
top of screen (TOS)	19.00	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen --	Coarse Sand	
above screen --	Bentonite	
Aquifer Material --	Medium Sand	



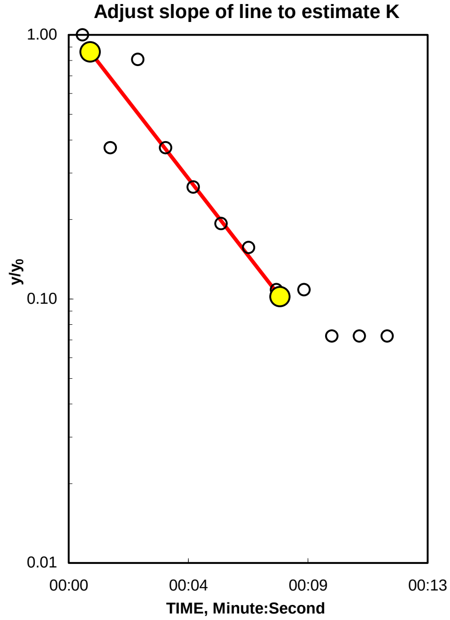
COMPUTED

L_{wetted}	10	Feet
D =	35.25	Feet
H =	14.25	Feet
L/r_w =	24.00	
$y_{0\text{-DISPLACEMENT}}$ =	0.27	Feet
$y_{0\text{-SLUG}}$ =	0.23	Feet
From look-up table using L/r_w		
Partial penetrate A =	2.334	
B =	0.376	
ln(Re/rw) =	2.127	
Re =	3.50	Feet
Slope =	0.135298	$\log_{10}$/sec
$t_{90\%}$ recovery =	7	sec

Input is consistent.

K =	20	Feet/Day

Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	189.80
2	0:00:02.0	184.60
3	0:00:03.0	188.20
4	0:00:04.0	184.60
5	0:00:05.0	183.70
6	0:00:06.0	183.10
7	0:00:07.0	182.80
8	0:00:08.0	182.40
9	0:00:09.0	182.40
10	0:00:10.0	182.10
11	0:00:11.0	182.10
12	0:00:12.0	182.10

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: PVER

Local ID: PZ-8-PV
Date: 3/16/2011
Time: 12:05:00 PM

INPUT

Construction:

Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	10	Inch
Screen Length (L)	10.00	Feet

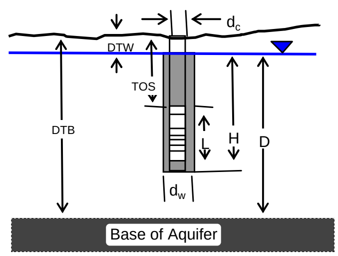
Depths to:

water level (DTW)	17.97	Feet
top of screen (TOS)	20.00	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Coarse Sand
above screen -- Bentonite

Aquifer Material -- Medium Sand



COMPUTED

L_{wetted}	10	Feet
D =	32.03	Feet
H =	12.03	Feet
L/r_w =	24.00	
$y_{0\text{-DISPLACEMENT}}$ =	0.70	Feet
$y_{0\text{-SLUG}}$ =	0.75	Feet

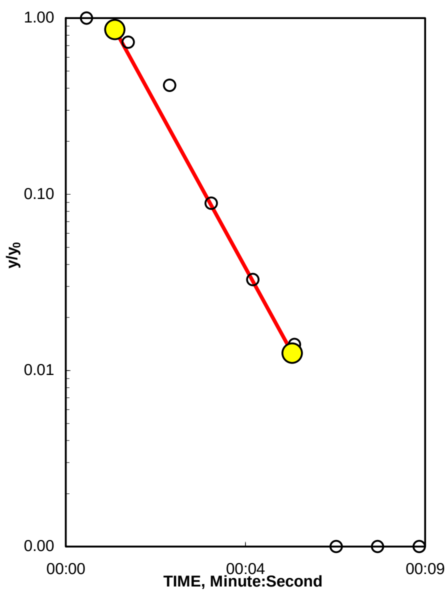
From look-up table using L/r_w

Partial penetrate A =	2.334	
B =	0.376	
ln(Re/rw) =	2.061	
Re =	3.27	Feet
Slope =	0.431269	$\log_{10}$/sec
$t_{90\%}$ recovery =	2	sec

Input is consistent.

K =	61	Feet/Day

Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	150.10
2	0:00:02.0	155.90
3	0:00:03.0	162.60
4	0:00:04.0	169.60
5	0:00:05.0	170.80
6	0:00:06.0	171.20
7	0:00:07.0	171.50
8	0:00:08.0	171.50
9	0:00:09.0	171.50
10	0:00:10.0	171.50

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: PVER

Local ID: PZ-8-PV-2
Date: 3/16/2011
Time: 0:00

INPUT

Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	10	Inch
Screen Length (L)	10.00	Feet
Depths to:		
water level (DTW)	17.97	Feet
top of screen (TOS)	20.00	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen --	Coarse Sand	
above screen --	Bentonite	
Aquifer Material --	Medium Sand	

COMPUTED

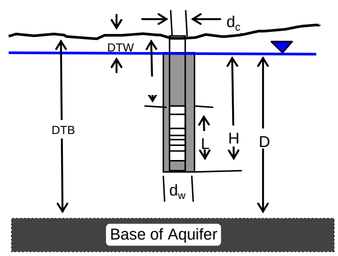
L_{wetted}	10	Feet
D =	32.03	Feet
H =	12.03	Feet
L/r_w =	24.00	
$y_{0\text{-DISPLACEMENT}}$ =	0.49	Feet
$y_{0\text{-SLUG}}$ =	0.56	Feet

From look-up table using L/r_w

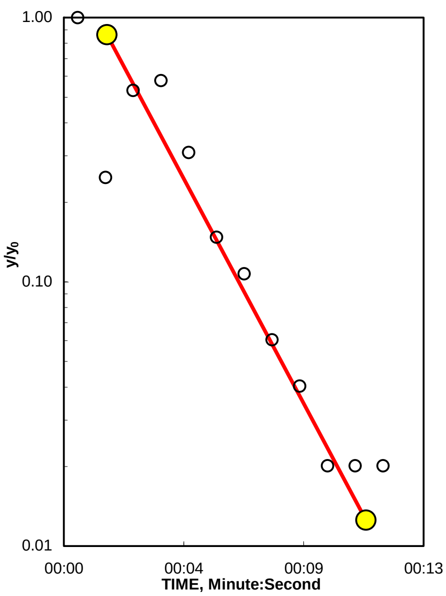
Partial penetrate A =	2.334	
B =	0.376	
ln(Re/rw) =	2.061	
Re =	3.27	Feet
Slope =	0.196866	log_{10}/sec
$t_{90\%}$ recovery =	5	sec

Input is consistent.

K =	28	Feet/Day



Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	108.00
2	0:00:02.0	96.80
3	0:00:03.0	101.00
4	0:00:04.0	101.70
5	0:00:05.0	97.70
6	0:00:06.0	95.30
7	0:00:07.0	94.70
8	0:00:08.0	94.00
9	0:00:09.0	93.70
10	0:00:10.0	93.40
11	0:00:11.0	93.40
12	0:00:12.0	93.40
13	0:00:13.0	93.10
14	0:00:14.0	93.10
15	0:00:15.0	93.10

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: Beal Lake

Local ID: PZ-1-BL
Date: 3/17/2011
Time: 0:00

INPUT

Construction:

Casing dia. (d_c)	1.38	Inch
Annulus dia. (d_w)	1.63	Inch
Screen Length (L)	5.33	Feet

Depths to:

water level (DTW)	5.16	Feet
top of screen (TOS)	5.46	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Coarse Sand
above screen -- Bentonite

Aquifer Material -- Fine Sand

COMPUTED

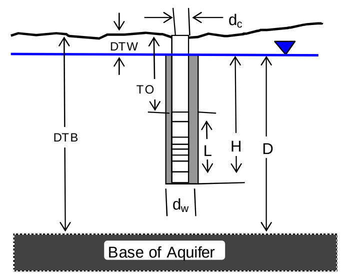
L_{wetted}	5.33	Feet
D =	44.8375	Feet
H =	5.625	Feet
L/r_w =	78.48	
$y_{0\text{-DISPLACEMENT}}$ =	1.34	Feet
$y_{0\text{-SLUG}}$ =	1.58	Feet

From look-up table using L/r_w

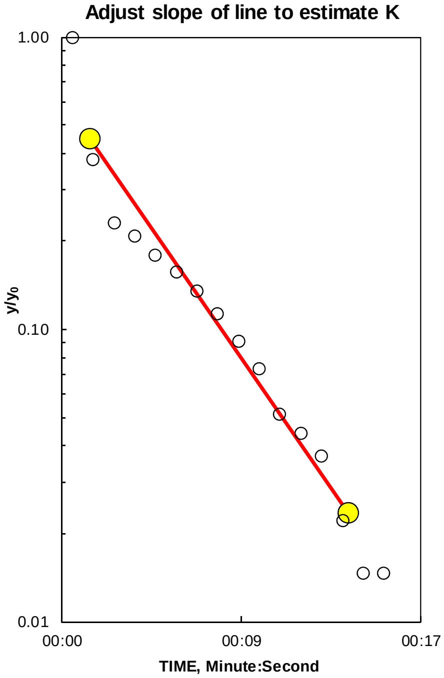
Partial penetrate A =	3.939	
B =	0.650	
ln(Re/rw) =	2.866	
Re =	1.19	Feet
Slope =	0.10264	log_{10}/sec
$t_{90\%}$ recovery =	10	sec

Input is consistent.

K = 18 Feet/Day



Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	48.10
2	0:00:02.0	73.37
3	0:00:03.0	79.46
4	0:00:04.0	80.40
5	0:00:05.0	81.60
6	0:00:06.0	82.50
7	0:00:07.0	83.40
8	0:00:08.0	84.30
9	0:00:09.0	85.20
10	0:00:10.0	85.90
11	0:00:11.0	86.80
12	0:00:12.0	87.10
13	0:00:13.0	87.40
14	0:00:14.0	88.00
15	0:00:15.0	88.30
16	0:00:16.0	88.30
17	0:00:17.0	88.60
18	0:00:18.0	88.90
19	0:00:19.0	88.90

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: Beal Lake

Local ID: PZ-1-BL-2
Date: 3/17/2011
Time: 0:00

INPUT

Construction:

Casing dia. (d_c)	1.38	Inch
Annulus dia. (d_w)	1.63	Inch
Screen Length (L)	5.33	Feet

Depths to:

water level (DTW)	5.16	Feet
top of screen (TOS)	5.46	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Coarse Sand
above screen -- Bentonite

Aquifer Material -- Fine Sand

COMPUTED

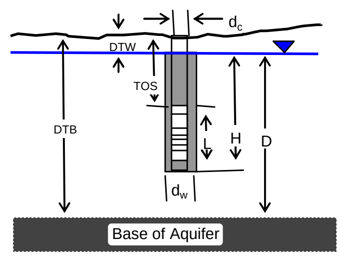
L_{wetted}	5.33	Feet
D =	44.8375	Feet
H =	5.625	Feet
L/r_w =	78.48	
$y_{0\text{-DISPLACEMENT}}$ =	0.84	Feet
$y_{0\text{-SLUG}}$ =	0.89	Feet

From look-up table using L/r_w

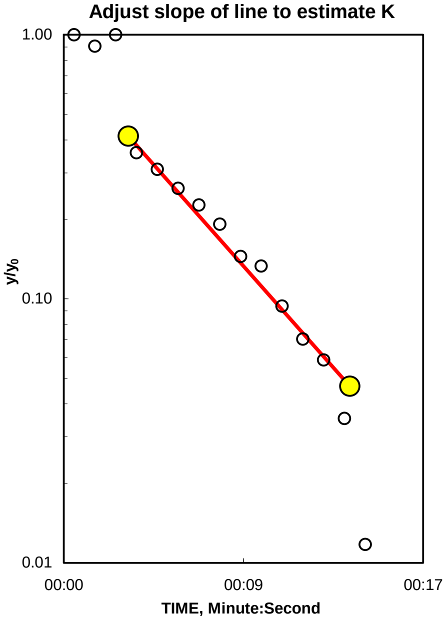
Partial penetrate A =	3.939	
B =	0.650	
ln(Re/rw) =	2.866	
Re =	1.19	Feet
Slope =	0.088894	$\log_{10}$/sec
$t_{90\%}$ recovery =	11	sec

Input is consistent.

K = 16 Feet/Day



Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	63.32
2	0:00:02.0	65.75
3	0:00:03.0	63.32
4	0:00:04.0	79.76
5	0:00:05.0	81.00
6	0:00:06.0	82.20
7	0:00:07.0	83.10
8	0:00:08.0	84.00
9	0:00:09.0	85.20
10	0:00:10.0	85.50
11	0:00:11.0	86.50
12	0:00:12.0	87.10
13	0:00:13.0	87.40
14	0:00:14.0	88.00
15	0:00:15.0	88.60
16	0:00:16.0	88.90
17	0:00:17.0	89.20
18	0:00:18.0	89.20
19	0:00:19.0	89.50
20	0:00:20.0	89.50
21	0:00:21.0	89.50
22	0:00:22.0	89.80

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Slug test was conducted in surficial aquifer, central Florida, which is mostly medium and fine sand.

Thanks to Hannu Etelämäki for identifying bugs in the unit conversion.

WELL ID: Beal Lake

Local ID:	PZ-6-BL
Date:	3/17/2011
Time:	0:00

INPUT

Construction:

Casing dia. (d_c)	1.38	Inch
Annulus dia. (d_w)	3.4	Inch
Screen Length (L)	5.33	Feet

Depths to:

water level (DTW)	5.63	Feet
top of screen (TOS)	5.37	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Coarse Sand
above screen -- Bentonite

Aquifer Material -- Fine Sand

COMPUTED

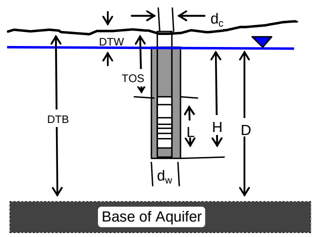
L_{wetted}	5.078	Feet
D =	44.37	Feet
H =	5.078	Feet
L/r_w =	35.84	
$y_{0\text{-DISPLACEMENT}}$ =	0.35	Feet
$y_{0\text{-SLUG}}$ =	0.39	Feet

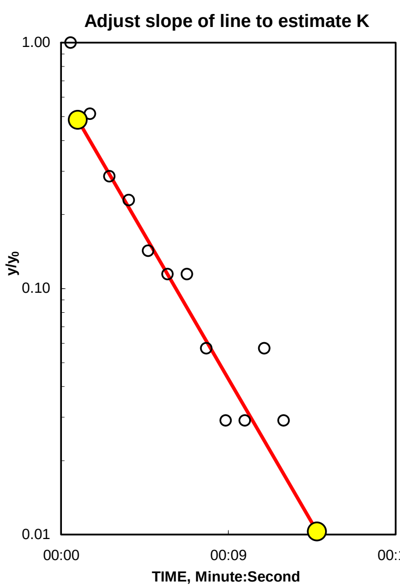
From look-up table using L/r_w

Partial penetrate A =	2.716	
B =	0.442	
ln(Re/rw) =	2.210	
Re =	1.29	Feet
Slope =	0.13549	log_{10}/sec
$t_{90\%}$ recovery =	7	sec

Input is consistent.

K = 19 Feet/Day





Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	52.65
2	0:00:02.0	57.83
3	0:00:03.0	60.26
4	0:00:04.0	60.87
5	0:00:05.0	61.79
6	0:00:06.0	62.09
7	0:00:07.0	62.09
8	0:00:08.0	62.70
9	0:00:09.0	63.00
10	0:00:10.0	63.00
11	0:00:11.0	62.70
12	0:00:12.0	63.00
13	0:00:13.0	63.31
14	0:00:14.0	63.31
15	0:00:15.0	63.31
16	0:00:16.0	63.31
17	0:00:17.0	63.31

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: Beal Lake

Local ID: PZ-6-BL-2
Date: 3/17/2011
Time: 0:00

INPUT

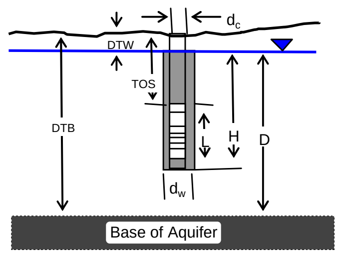
Construction:		
Casing dia. (d_c)	1.38	Inch
Annulus dia. (d_w)	3.4	Inch
Screen Length (L)	5.33	Feet
Depths to:		
water level (DTW)	5.63	Feet
top of screen (TOS)	5.37	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen --	Coarse Sand	
above screen --	Bentonite	
Aquifer Material --	Fine Sand	

COMPUTED

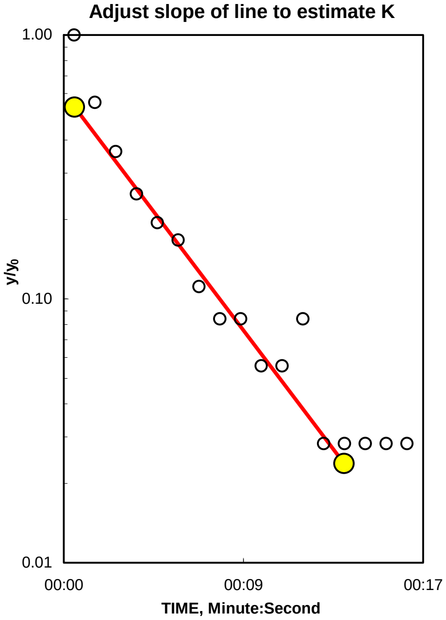
L_{wetted}	5.078	Feet
D =	44.37	Feet
H =	5.078	Feet
L/r_w =	35.84	
$y_{0\text{-DISPLACEMENT}}$ =	0.36	Feet
$y_{0\text{-SLUG}}$ =	0.39	Feet
From look-up table using L/r_w		
Partial penetrate A =	2.716	
B =	0.442	
ln(Re/rw) =	2.210	
Re =	1.29	Feet
Slope =	0.104244	$\log_{10}$/sec
$t_{90\%}$ recovery =	10	sec

Input is consistent.

K =	15	Feet/Day



Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	55.09
2	0:00:02.0	59.96
3	0:00:03.0	62.09
4	0:00:04.0	63.31
5	0:00:05.0	63.92
6	0:00:06.0	64.22
7	0:00:07.0	64.83
8	0:00:08.0	65.13
9	0:00:09.0	65.13
10	0:00:10.0	65.44
11	0:00:11.0	65.44
12	0:00:12.0	65.13
13	0:00:13.0	65.74
14	0:00:14.0	65.74
15	0:00:15.0	65.74
16	0:00:16.0	65.74
17	0:00:17.0	65.74
18	0:00:18.0	66.05
19	0:00:19.0	65.44
20	0:00:20.0	66.05

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: Beal Lake

Local ID: PZ-C-BL
Date: 3/18/2011
Time: 0:00

INPUT

Construction:

Casing dia. (d_c)	2.06	Inch
Annulus dia. (d_w)	2.375	Inch
Screen Length (L)	10.00	Feet

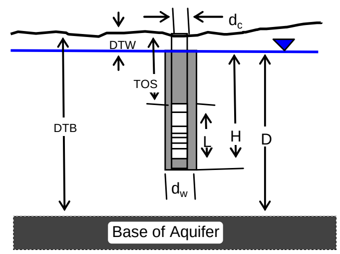
Depths to:

water level (DTW)	5.50	Feet
top of screen (TOS)	14.97	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Medium Sand
above screen -- Backfill

Aquifer Material -- Medium Sand



COMPUTED

L_{wetted}	10	Feet
D =	44.5	Feet
H =	19.47	Feet
L/r_w =	101.05	
$y_{0\text{-DISPLACEMENT}}$ =	2.37	Feet
$y_{0\text{-SLUG}}$ =	2.65	Feet

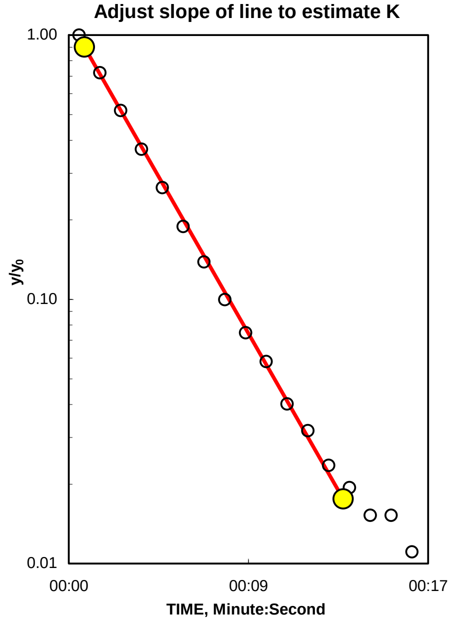
From look-up table using L/r_w

Partial penetrate A =	4.497	
B =	0.761	
ln(Re/rw) =	3.397	
Re =	2.96	Feet
Slope =	0.137442	$\log_{10}$/sec
$t_{90\%}$ recovery =	7	sec

Input is consistent.

K = 34 Feet/Day

Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	112.80
2	0:00:02.0	133.00
3	0:00:03.0	147.60
4	0:00:04.0	158.30
5	0:00:05.0	165.90
6	0:00:06.0	171.40
7	0:00:07.0	175.00
8	0:00:08.0	177.80
9	0:00:09.0	179.60
10	0:00:10.0	180.80
11	0:00:11.0	182.10
12	0:00:12.0	182.70
13	0:00:13.0	183.30
14	0:00:14.0	183.60
15	0:00:15.0	183.90
16	0:00:16.0	183.90
17	0:00:17.0	184.20
18	0:00:18.0	184.20
19	0:00:19.0	184.20
20	0:00:20.0	184.20
21	0:00:21.0	184.50
22	0:00:22.0	184.50
23	0:00:23.0	184.50
24	0:00:24.0	184.50
25	0:00:25.0	184.50

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: Beal Lake

Local ID: PZ-C-BL-2
Date: 3/18/2011
Time: 0:00

INPUT

Construction:

Casing dia. (d_c)	2.06	Inch
Annulus dia. (d_w)	2.375	Inch
Screen Length (L)	10.00	Feet

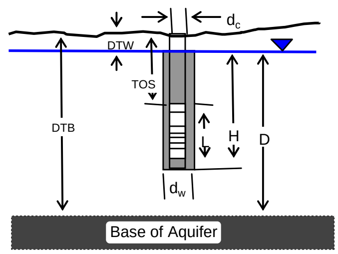
Depths to:

water level (DTW)	5.50	Feet
top of screen (TOS)	14.97	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Medium Sand
above screen -- Backfill

Aquifer Material -- Medium Sand



COMPUTED

L_{wetted}	10	Feet
D =	44.5	Feet
H =	19.47	Feet
L/r_w =	101.05	
$y_{0\text{-DISPLACEMENT}}$ =	2.38	Feet
$y_{0\text{-SLUG}}$ =	2.65	Feet

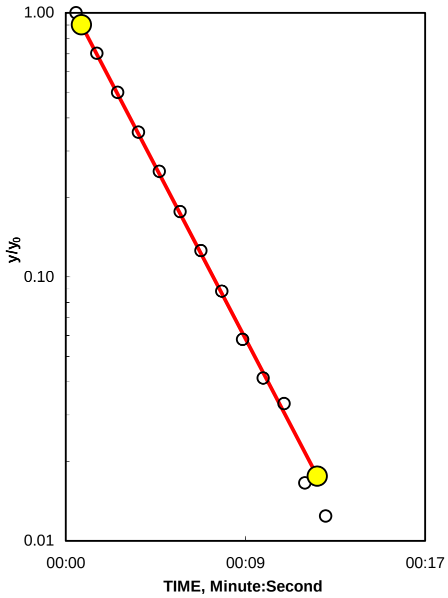
From look-up table using L/r_w

Partial penetrate A =	4.497	
B =	0.761	
ln(Re/rw) =	3.397	
Re =	2.96	Feet
Slope =	0.150736	$\log_{10}$/sec
$t_{90\%}$ recovery =	7	sec

Input is consistent.

K =	37	Feet/Day

Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	112.50
2	0:00:02.0	134.10
3	0:00:03.0	148.80
4	0:00:04.0	159.40
5	0:00:05.0	166.80
6	0:00:06.0	172.20
7	0:00:07.0	175.90
8	0:00:08.0	178.60
9	0:00:09.0	180.80
10	0:00:10.0	182.00
11	0:00:11.0	182.60
12	0:00:12.0	183.80
13	0:00:13.0	184.10
14	0:00:14.0	184.40
15	0:00:15.0	184.70
16	0:00:16.0	184.70
17	0:00:17.0	185.00
18	0:00:18.0	185.00
19	0:00:19.0	185.00
20	0:00:20.0	185.30
21	0:00:21.0	185.30

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: Beal Lake

Local ID: PZ-D-BL
Date: 3/18/2011
Time: 0:00

INPUT

Construction:

Casing dia. (d_c)	2.06	Inch
Annulus dia. (d_w)	2.375	Inch
Screen Length (L)	10.00	Feet

Depths to:

water level (DTW)	6.17	Feet
top of screen (TOS)	10.96	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Medium Sand
above screen -- Backfill

Aquifer Material -- Medium Sand

COMPUTED

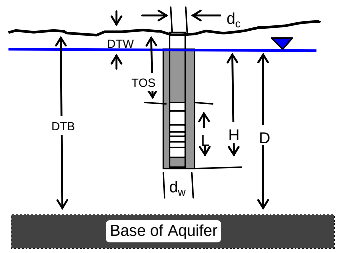
L_{wetted}	10	Feet
D =	43.83	Feet
H =	14.79	Feet
L/r_w =	101.05	
$y_{0\text{-DISPLACEMENT}}$ =	2.48	Feet
$y_{0\text{-SLUG}}$ =	2.65	Feet

From look-up table using L/r_w

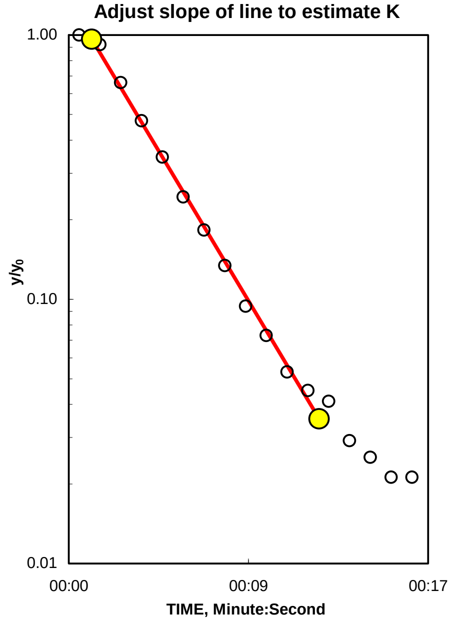
Partial penetrate A =	4.497	
B =	0.761	
ln(Re/rw) =	3.258	
Re =	2.57	Feet
Slope =	0.131374	log_{10}/sec
$t_{90\%}$ recovery =	8	sec

Input is consistent.

K =	31	Feet/Day



Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	108.60
2	0:00:02.0	114.70
3	0:00:03.0	134.20
4	0:00:04.0	148.30
5	0:00:05.0	158.00
6	0:00:06.0	165.60
7	0:00:07.0	170.20
8	0:00:08.0	173.90
9	0:00:09.0	176.90
10	0:00:10.0	178.50
11	0:00:11.0	180.00
12	0:00:12.0	180.60
13	0:00:13.0	180.90
14	0:00:14.0	181.80
15	0:00:15.0	182.10
16	0:00:16.0	182.40
17	0:00:17.0	182.40
18	0:00:18.0	182.70
19	0:00:19.0	182.70
20	0:00:20.0	182.70
21	0:00:21.0	183.00
22	0:00:22.0	183.00
23	0:00:23.0	182.70
24	0:00:24.0	183.00
25	0:00:25.0	183.00

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: Beal Lake

Local ID: PZ-D-BL-2
Date: 3/18/2011
Time: 0:00

INPUT

Construction:

Casing dia. (d_c)	2.06	Inch
Annulus dia. (d_w)	2.375	Inch
Screen Length (L)	10.00	Feet

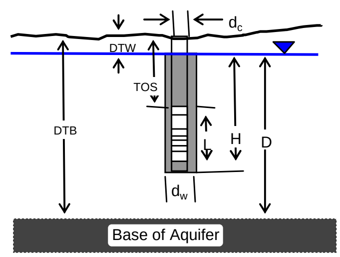
Depths to:

water level (DTW)	6.17	Feet
top of screen (TOS)	10.96	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Medium Sand
above screen -- Backfill

Aquifer Material -- Medium Sand



COMPUTED

L_{wetted}	10	Feet
D =	43.83	Feet
H =	14.79	Feet
L/r_w =	101.05	
$y_{0\text{-DISPLACEMENT}}$ =	2.57	Feet
$y_{0\text{-SLUG}}$ =	2.65	Feet

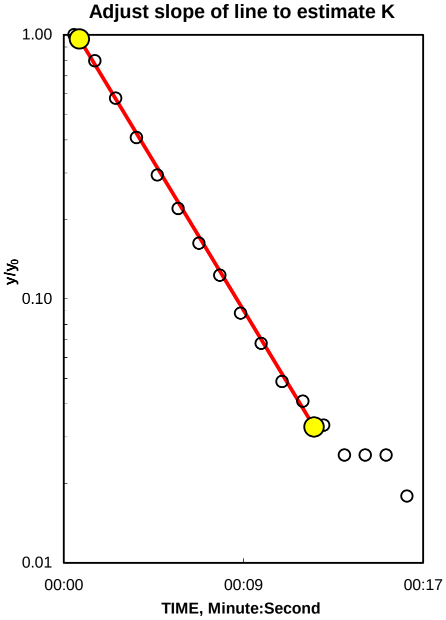
From look-up table using L/r_w

Partial penetrate A =	4.497	
B =	0.761	
ln(Re/rw) =	3.258	
Re =	2.57	Feet
Slope =	0.130275	$\log_{10}$/sec
$t_{90\%}$ recovery =	8	sec

Input is consistent.

K = 31 Feet/Day

Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	106.80
2	0:00:02.0	122.60
3	0:00:03.0	140.00
4	0:00:04.0	153.10
5	0:00:05.0	162.00
6	0:00:06.0	167.80
7	0:00:07.0	172.30
8	0:00:08.0	175.40
9	0:00:09.0	178.10
10	0:00:10.0	179.70
11	0:00:11.0	181.20
12	0:00:12.0	181.80
13	0:00:13.0	182.40
14	0:00:14.0	183.00
15	0:00:15.0	183.00
16	0:00:16.0	183.00
17	0:00:17.0	183.60
18	0:00:18.0	183.30
19	0:00:19.0	183.90
20	0:00:20.0	183.90
21	0:00:21.0	183.60
22	0:00:22.0	183.60
23	0:00:23.0	183.90
24	0:00:24.0	183.90
25	0:00:25.0	184.20
26	0:00:26.0	184.20
27	0:00:27.0	184.20
28	0:00:28.0	183.90
29	0:00:29.0	184.20
30	0:00:30.0	184.20
31	0:00:31.0	184.20
32	0:00:32.0	183.90
33	0:00:33.0	184.20
34	0:00:34.0	184.20
35	0:00:35.0	183.90
36	0:00:36.0	183.90
37	0:00:37.0	184.20
38	0:00:38.0	184.20

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: Beal Lake

Local ID: PZ-EE2-BL
Date: 3/17/2011
Time: 0:00

INPUT

Construction:

Casing dia. (d_c)	2.06	Inch
Annulus dia. (d_w)	2.375	Inch
Screen Length (L)	10.00	Feet

Depths to:

water level (DTW)	4.92	Feet
top of screen (TOS)	10.45	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Coarse Sand
above screen -- Bentonite

Aquifer Material -- Medium Sand

COMPUTED

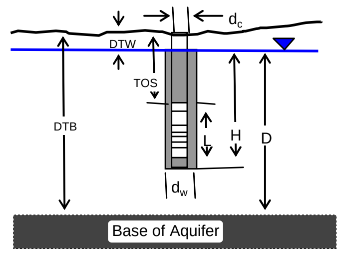
L_{wetted}	10	Feet
D =	45.08	Feet
H =	15.53	Feet
L/r_w =	101.05	
$y_{0\text{-DISPLACEMENT}}$ =	2.71	Feet
$y_{0\text{-SLUG}}$ =	3.18	Feet

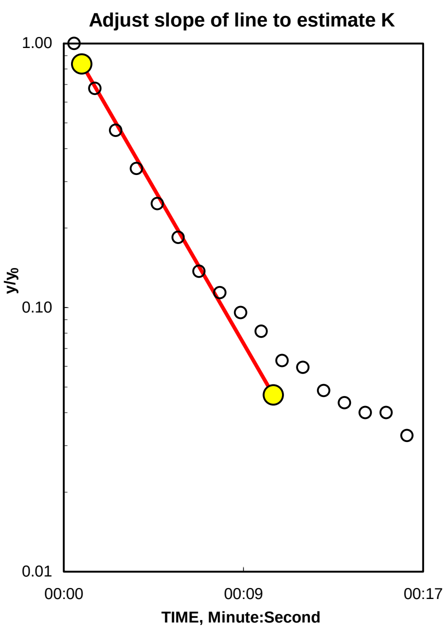
From look-up table using L/r_w

Partial penetrate A =	4.497	
B =	0.761	
ln(Re/rw) =	3.279	
Re =	2.63	Feet
Slope =	0.135917	$\log_{10}$/sec
$t_{90\%}$ recovery =	7	sec

Input is consistent.

K = 33 Feet/Day





Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	105.10
2	0:00:02.0	131.90
3	0:00:03.0	148.90
4	0:00:04.0	159.90
5	0:00:05.0	167.20
6	0:00:06.0	172.40
7	0:00:07.0	176.30
8	0:00:08.0	178.20
9	0:00:09.0	179.70
10	0:00:10.0	180.90
11	0:00:11.0	182.40
12	0:00:12.0	182.70
13	0:00:13.0	183.60
14	0:00:14.0	184.00
15	0:00:15.0	184.30
16	0:00:16.0	184.30
17	0:00:17.0	184.90
18	0:00:18.0	184.60
19	0:00:19.0	184.60
20	0:00:20.0	184.60
21	0:00:21.0	185.20
22	0:00:22.0	184.90
23	0:00:23.0	185.50
24	0:00:24.0	185.20
25	0:00:25.0	185.20
26	0:00:26.0	185.20

REMARKS:

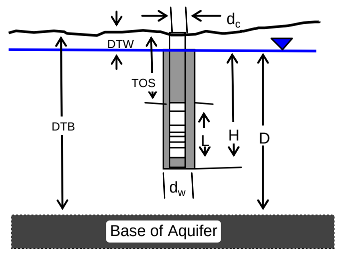
Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: Beal Lake

Local ID: PZ-EE2-BL-2
Date: 3/17/2011
Time: 0:00

INPUT

Construction:		
Casing dia. (d_c)	2.06	Inch
Annulus dia. (d_w)	2.375	Inch
Screen Length (L)	10.00	Feet
Depths to:		
water level (DTW)	4.92	Feet
top of screen (TOS)	10.45	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen --	Coarse Sand	
above screen --	Bentonite	
Aquifer Material --	Medium Sand	



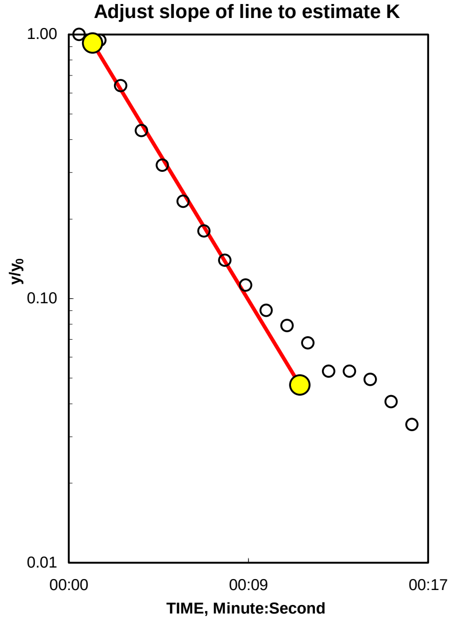
COMPUTED

L_{wetted}	10	Feet
D =	45.08	Feet
H =	15.53	Feet
L/r_w =	101.05	
$y_{0\text{-DISPLACEMENT}}$ =	2.66	Feet
$y_{0\text{-SLUG}}$ =	3.18	Feet
From look-up table using L/r_w		
Partial penetrate A =	4.497	
B =	0.761	
ln(Re/rw) =	3.279	
Re =	2.63	Feet
Slope =	0.129782	log_{10}/sec
$t_{90\%}$ recovery =	8	sec

Input is consistent.

K =	31	Feet/Day

Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	106.60
2	0:00:02.0	110.60
3	0:00:03.0	135.80
4	0:00:04.0	152.60
5	0:00:05.0	161.70
6	0:00:06.0	168.70
7	0:00:07.0	173.00
8	0:00:08.0	176.30
9	0:00:09.0	178.50
10	0:00:10.0	180.30
11	0:00:11.0	181.20
12	0:00:12.0	182.10
13	0:00:13.0	183.30
14	0:00:14.0	183.30
15	0:00:15.0	183.60
16	0:00:16.0	184.30
17	0:00:17.0	184.90
18	0:00:18.0	184.60
19	0:00:19.0	184.60
20	0:00:20.0	184.60
21	0:00:21.0	184.90
22	0:00:22.0	184.90
23	0:00:23.0	185.20
24	0:00:24.0	185.20
25	0:00:25.0	185.20
26	0:00:26.0	185.20

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Slug test was conducted in surficial aquifer, central Florida, which is mostly medium and fine sand.

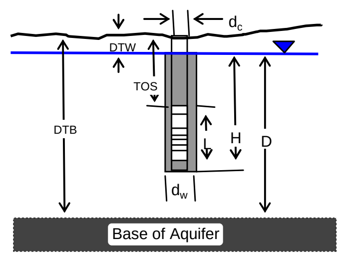
Thanks to Hannu Etelämäki for identifying bugs in the unit conversion.

WELL ID: Beal Lake

Local ID: PZ-EE4-BL
Date: 3/17/2011
Time: 0:00

INPUT

Construction:		
Casing dia. (d_c)	2.06	Inch
Annulus dia. (d_w)	2.375	Inch
Screen Length (L)	10.00	Feet
Depths to:		
water level (DTW)	4.10	Feet
top of screen (TOS)	11.20	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen --	Medium Sand	
above screen --	Backfill	
Aquifer Material --	Medium Sand	



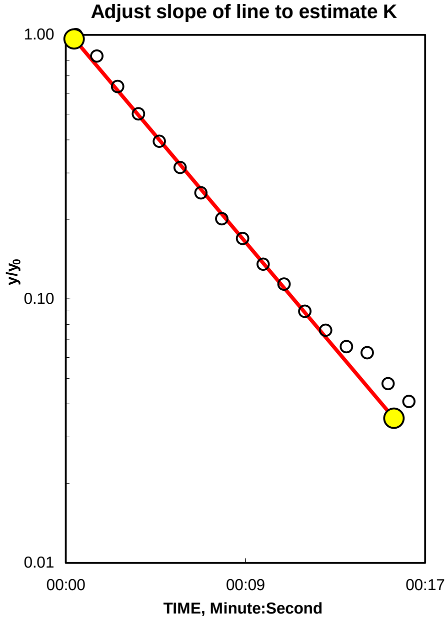
COMPUTED

L_{wetted}	10	Feet
D =	45.9	Feet
H =	17.1	Feet
L/r_w =	101.05	
$y_{0\text{-DISPLACEMENT}}$ =	2.89	Feet
$y_{0\text{-SLUG}}$ =	3.18	Feet
From look-up table using L/r_w		
Partial penetrate A =	4.497	
B =	0.761	
ln(Re/rw) =	3.325	
Re =	2.75	Feet
Slope =	0.093438	$\log_{10}$/sec
$t_{90\%}$ recovery =	11	sec

Input is consistent.

K = 23 Feet/Day

Adjust slope of line to estimate K



REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:06.0	99.50
2	0:00:07.0	114.40
3	0:00:08.0	131.50
4	0:00:09.0	143.40
5	0:00:10.0	152.80
6	0:00:11.0	159.90
7	0:00:12.0	165.40
8	0:00:13.0	169.90
9	0:00:14.0	172.70
10	0:00:15.0	175.70
11	0:00:16.0	177.60
12	0:00:17.0	179.70
13	0:00:18.0	180.90
14	0:00:19.0	181.80
15	0:00:20.0	182.10
16	0:00:21.0	183.40
17	0:00:22.0	184.00
18	0:00:23.0	184.30
19	0:00:24.0	184.30
20	0:00:25.0	185.20
21	0:00:26.0	185.20
22	0:00:27.0	185.20
23	0:00:28.0	185.20
24	0:00:29.0	185.80
25	0:00:30.0	185.80
26	0:00:31.0	185.80
27	0:00:32.0	185.80
28	0:00:33.0	186.10
29	0:00:34.0	186.10
30	0:00:35.0	186.40
31	0:00:36.0	186.40
32	0:00:37.0	186.10
33	0:00:38.0	186.40
34	0:00:39.0	186.40
35	0:00:40.0	186.40
36	0:00:41.0	186.40
37	0:00:42.0	186.40
38	0:00:43.0	186.10
39	0:00:44.0	186.70
40	0:00:45.0	186.40
41	0:00:46.0	186.40
42	0:00:47.0	186.70
43	0:00:48.0	186.70
44	0:00:49.0	186.40
45	0:00:50.0	186.40

WELL ID: Beal Lake

Local ID: PZ-EE4-BL
Date: 3/17/2011
Time: 0:00

INPUT

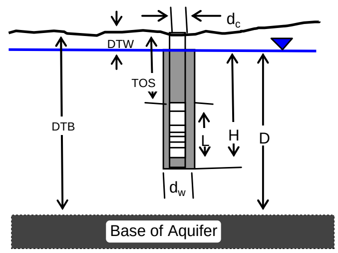
Construction:		
Casing dia. (d_c)	2.06	Inch
Annulus dia. (d_w)	2.375	Inch
Screen Length (L)	10.00	Feet
Depths to:		
water level (DTW)	4.10	Feet
top of screen (TOS)	11.20	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen --	Medium Sand	
above screen --	Backfill	
Aquifer Material --	Medium Sand	

COMPUTED

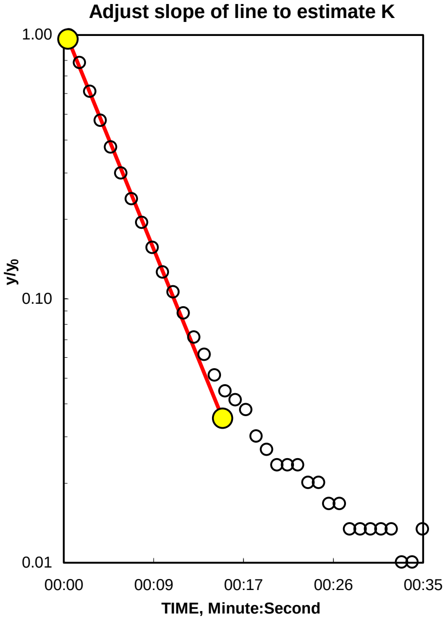
L_{wetted}	10	Feet
D =	45.9	Feet
H =	17.1	Feet
L/r_w =	101.05	
$y_{0\text{-DISPLACEMENT}}$ =	2.94	Feet
$y_{0\text{-SLUG}}$ =	3.18	Feet
From look-up table using L/r_w		
Partial penetrate A =	4.497	
B =	0.761	
ln(Re/rw) =	3.325	
Re =	2.75	Feet
Slope =	0.096697	$\log_{10}$/sec
$t_{90\%}$ recovery =	10	sec

Input is consistent.

K =	24	Feet/Day



Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:06.0	98.20
2	0:00:07.0	117.40
3	0:00:08.0	133.00
4	0:00:09.0	145.20
5	0:00:10.0	154.00
6	0:00:11.0	160.80
7	0:00:12.0	166.20
8	0:00:13.0	170.20
9	0:00:14.0	173.60
10	0:00:15.0	176.30
11	0:00:16.0	178.10
12	0:00:17.0	179.70
13	0:00:18.0	181.20
14	0:00:19.0	182.10
15	0:00:20.0	183.00
16	0:00:21.0	183.60
17	0:00:22.0	183.90
18	0:00:23.0	184.20
19	0:00:24.0	184.90
20	0:00:25.0	185.20
21	0:00:26.0	185.50
22	0:00:27.0	185.50
23	0:00:28.0	185.50
24	0:00:29.0	185.80
25	0:00:30.0	185.80
26	0:00:31.0	186.10
27	0:00:32.0	186.10
28	0:00:33.0	186.40
29	0:00:34.0	186.40
30	0:00:35.0	186.40
31	0:00:36.0	186.40
32	0:00:37.0	186.40
33	0:00:38.0	186.70
34	0:00:39.0	186.70
35	0:00:40.0	186.40
36	0:00:41.0	186.40
37	0:00:42.0	186.70

REMARKS:

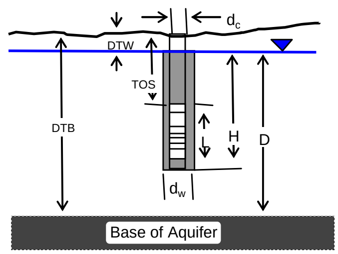
Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: Beal Lake

Local ID: PZ-NN!-BL
Date: 3/14/2011
Time: 0:00

INPUT

Construction:		
Casing dia. (d_c)	2.06	Inch
Annulus dia. (d_w)	2.375	Inch
Screen Length (L)	10.00	Feet
Depths to:		
water level (DTW)	4.65	Feet
top of screen (TOS)	10.43	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen --	Coarse Sand	
above screen --	Bentonite	
Aquifer Material --	Medium Sand	



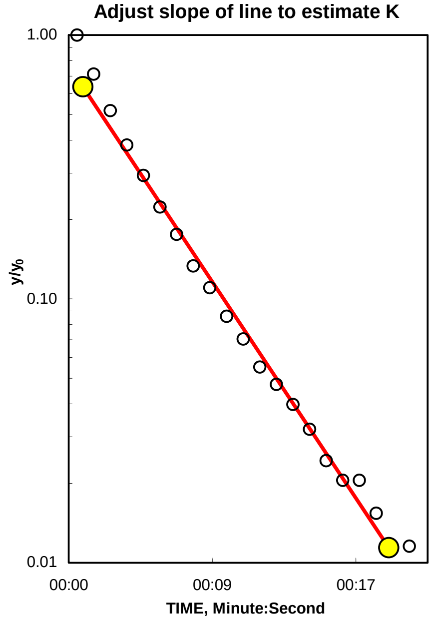
COMPUTED

L_{wetted}	10	Feet
D =	45.35	Feet
H =	15.78	Feet
L/r_w =	101.05	
$y_{0\text{-DISPLACEMENT}}$ =	2.56	Feet
$y_{0\text{-SLUG}}$ =	2.65	Feet
From look-up table using L/r_w		
Partial penetrate A =	4.497	
B =	0.761	
ln(Re/rw) =	3.286	
Re =	2.65	Feet
Slope =	0.094929	$\log_{10}$/sec
$t_{90\%}$ recovery =	11	sec

Input is consistent.

K =	23	Feet/Day

Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	100.30
2	0:00:02.0	122.80
3	0:00:03.0	138.00
4	0:00:04.0	148.40
5	0:00:05.0	155.40
6	0:00:06.0	160.90
7	0:00:07.0	164.60
8	0:00:08.0	167.90
9	0:00:09.0	169.70
10	0:00:10.0	171.60
11	0:00:11.0	172.80
12	0:00:12.0	174.00
13	0:00:13.0	174.60
14	0:00:14.0	175.20
15	0:00:15.0	175.80
16	0:00:16.0	176.40
17	0:00:17.0	176.70
18	0:00:18.0	176.70
19	0:00:19.0	177.10
20	0:00:20.0	177.40
21	0:00:21.0	177.40
22	0:00:22.0	177.70
23	0:00:23.0	177.70
24	0:00:24.0	177.70
25	0:00:25.0	177.70
26	0:00:26.0	177.70
27	0:00:27.0	178.00
28	0:00:28.0	178.00
29	0:00:29.0	178.00
30	0:00:30.0	178.30
31	0:00:31.0	178.00
32	0:00:32.0	178.30
33	0:00:33.0	178.30
34	0:00:34.0	178.30
35	0:00:35.0	178.30

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: Beal Lake

Local ID: PZ-NN1-BL-2
Date: 3/14/2011
Time: 0:00

INPUT

Construction:

Casing dia. (d_c)	2.06	Inch
Annulus dia. (d_w)	2.375	Inch
Screen Length (L)	10.00	Feet

Depths to:

water level (DTW)	4.65	Feet
top of screen (TOS)	10.43	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Coarse Sand
above screen -- Bentonite

Aquifer Material -- Medium Sand

COMPUTED

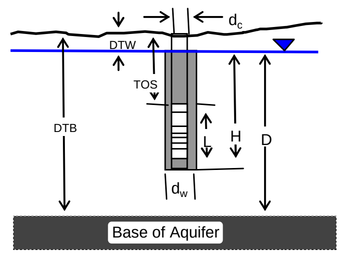
L_{wetted}	10	Feet
D =	45.35	Feet
H =	15.78	Feet
L/r_w =	101.05	
$y_{0\text{-DISPLACEMENT}}$ =	3.74	Feet
$y_{0\text{-SLUG}}$ =	3.18	Feet

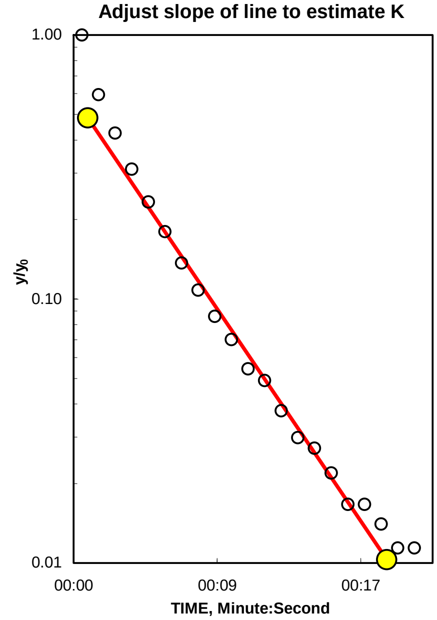
From look-up table using L/r_w

Partial penetrate A =	4.497	
B =	0.761	
ln(Re/rw) =	3.286	
Re =	2.65	Feet
Slope =	0.093149	$\log_{10}$/sec
$t_{90\%}$ recovery =	11	sec

Input is consistent.

K = 22 Feet/Day





Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	64.28
2	0:00:02.0	110.60
3	0:00:03.0	129.80
4	0:00:04.0	142.90
5	0:00:05.0	151.70
6	0:00:06.0	157.80
7	0:00:07.0	162.70
8	0:00:08.0	166.00
9	0:00:09.0	168.50
10	0:00:10.0	170.30
11	0:00:11.0	172.10
12	0:00:12.0	172.70
13	0:00:13.0	174.00
14	0:00:14.0	174.90
15	0:00:15.0	175.20
16	0:00:16.0	175.80
17	0:00:17.0	176.40
18	0:00:18.0	176.40
19	0:00:19.0	176.70
20	0:00:20.0	177.00
21	0:00:21.0	177.00
22	0:00:22.0	177.30
23	0:00:23.0	177.30
24	0:00:24.0	177.60
25	0:00:25.0	177.60
26	0:00:26.0	177.60
27	0:00:27.0	177.60
28	0:00:28.0	177.30
29	0:00:29.0	177.60
30	0:00:30.0	177.90
31	0:00:31.0	177.90
32	0:00:32.0	177.90
33	0:00:33.0	177.90
34	0:00:34.0	177.90
35	0:00:35.0	178.20
36	0:00:36.0	177.90
37	0:00:37.0	177.90
38	0:00:38.0	178.20

REMARKS:

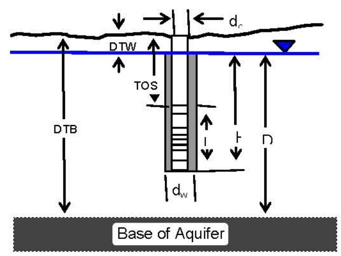
Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: CIBOLA

Local ID: PZ-1-C
Date: 3/14/2011
Time: 1:37:00 PM

INPUT

Construction:	
Casing dia. (d_c)	1.25 Inch
Annulus dia. (d_w)	3.5 Inch
Screen Length (L)	4.63 Feet
Depths to:	
water level (DTW)	4.86 Feet
top of screen (TOS)	6.27 Feet
Base of Aquifer (DTB)	50 Feet
Annular Fill:	
across screen -- Coarse Sand	
above screen -- Bentonite	
Aquifer Material -- Fine Sand	

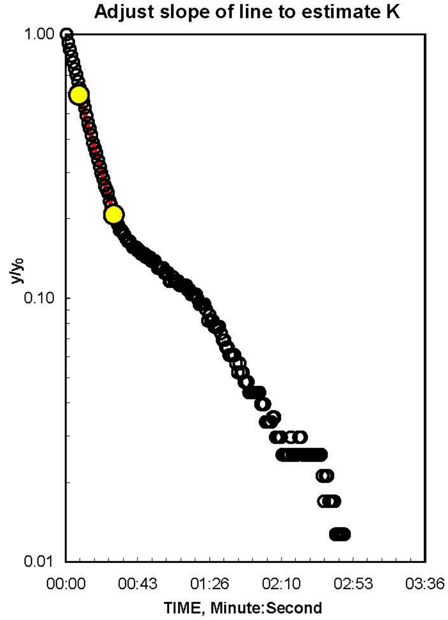


COMPUTED

L_{wetted}	4.63 Feet
D =	45.14 Feet
H =	6.04 Feet
L/r_w =	31.75
$y_{0\text{-DISPLACEMENT}}$ =	2.32 Feet
$y_{0\text{-SLUG}}$ =	2.56 Feet
From look-up table using L/r_w	
Partial penetrate A =	2.578
B =	0.423
ln(Re/rw) =	2.217
Re =	1.34 Feet
Slope =	0.02162 $\log_{10}$/sec
$t_{90\%}$ recovery =	46 sec

Input is consistent.

K =	2.8 Feet/Day



K= 2.8 is less than likely minimum of 3 for Fine Sand

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Reduced Data

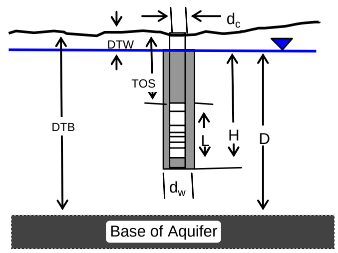
Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	192.00
2	0:00:05.0	176.80
3	0:00:09.0	165.50
4	0:00:13.0	156.10
5	0:00:17.0	148.70
6	0:00:21.0	143.60
7	0:00:25.0	139.60
8	0:00:29.0	136.50
9	0:00:33.0	134.10
10	0:00:37.0	133.20
11	0:00:41.0	132.30
12	0:00:45.0	132.00
13	0:00:49.0	131.40
14	0:00:53.0	131.10
15	0:00:57.0	130.50
16	0:01:01.0	130.10
17	0:01:05.0	129.80
18	0:01:09.0	129.20
19	0:01:13.0	129.20
20	0:01:17.0	128.60
21	0:01:21.0	128.00
22	0:01:25.0	127.70
23	0:01:29.0	127.10
24	0:01:33.0	126.80
25	0:01:37.0	125.90
26	0:01:41.0	125.60
27	0:01:45.0	125.30
28	0:01:49.0	124.70
29	0:01:53.0	124.40
30	0:01:57.0	124.40
31	0:02:01.0	123.70
32	0:02:05.0	123.80
33	0:02:09.0	123.40
34	0:02:13.0	123.10
35	0:02:17.0	123.10
36	0:02:21.0	123.40
37	0:02:25.0	123.10
38	0:02:29.0	123.10
39	0:02:33.0	123.10
40	0:02:37.0	122.80
41	0:02:41.0	122.50
42	0:02:45.0	122.20
43	0:02:49.0	121.90
44	0:02:53.0	121.90
45	0:02:57.0	121.90

WELL ID: CIBOLA

Local ID: PZ-3-C
Date: 3/15/2011
Time: 8:50:00 AM

INPUT

Construction:		
Casing dia. (d_c)	1.25	Inch
Annulus dia. (d_w)	3.5	Inch
Screen Length (L)	4.65	Feet
Depths to:		
water level (DTW)	7.92	Feet
top of screen (TOS)	7.17	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen --	Coarse Sand	
above screen --	Bentonite	
Aquifer Material --	Fine Sand	



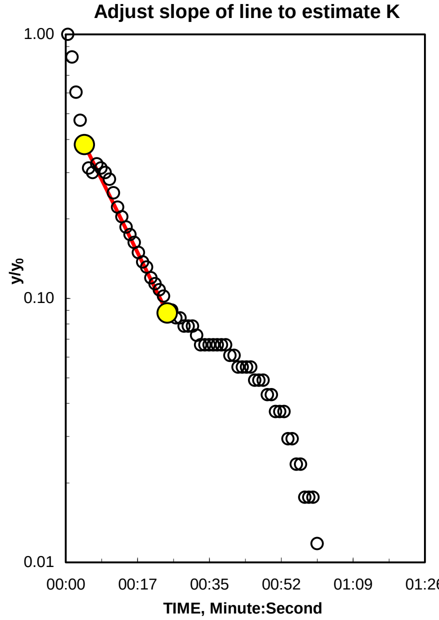
COMPUTED

L_{wetted}	3.896	Feet
D =	42.08333	Feet
H =	3.896	Feet
L/r_w =	26.72	
$y_{0\text{-DISPLACEMENT}}$ =	1.67	Feet
$y_{0\text{-SLUG}}$ =	1.92	Feet
From look-up table using L/r_w		
Partial penetrate A =	2.412	
B =	0.395	
ln(Re/rw) =	1.971	
Re =	1.05	Feet
Slope =	0.031957	log_{10}/sec
$t_{90\%}$ recovery =	31	sec

Input is consistent.

K = 4.4 Feet/Day

Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	149.80
2	0:00:02.0	140.60
3	0:00:03.0	129.60
4	0:00:04.0	122.90
5	0:00:05.0	118.30
6	0:00:06.0	114.70
7	0:00:07.0	114.10
8	0:00:08.0	115.30
9	0:00:09.0	114.70
10	0:00:10.0	114.10
11	0:00:11.0	113.20
12	0:00:12.0	111.60
13	0:00:13.0	110.10
14	0:00:14.0	109.20
15	0:00:15.0	108.30
16	0:00:16.0	107.70
17	0:00:17.0	107.10
18	0:00:18.0	106.40
19	0:00:19.0	105.80
20	0:00:20.0	105.50
21	0:00:21.0	104.90
22	0:00:22.0	104.60
23	0:00:23.0	104.30
24	0:00:24.0	104.00
25	0:00:25.0	103.40
26	0:00:26.0	103.40
27	0:00:27.0	103.10
28	0:00:28.0	103.10
29	0:00:29.0	102.80
30	0:00:30.0	102.80
31	0:00:31.0	102.80
32	0:00:32.0	102.50
33	0:00:33.0	102.20
34	0:00:34.0	102.20
35	0:00:35.0	102.20
36	0:00:36.0	102.20
37	0:00:37.0	102.20
38	0:00:38.0	102.20
39	0:00:39.0	102.20
40	0:00:40.0	101.90
41	0:00:41.0	101.90
42	0:00:42.0	101.60
43	0:00:43.0	101.60
44	0:00:44.0	101.60
45	0:00:45.0	101.60

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: CIBOLA

Local ID: PZ-4-C
Date: 3/15/2011
Time: 10:10

INPUT

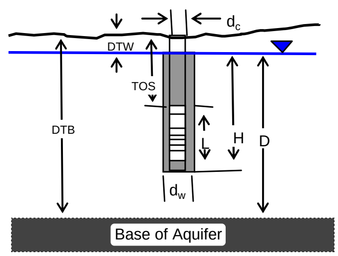
Construction:		
Casing dia. (d_c)	1.38	Inch
Annulus dia. (d_w)	1.63	Inch
Screen Length (L)	4.67	Feet
Depths to:		
water level (DTW)	8.68	Feet
top of screen (TOS)	8.25	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen --	Coarse Sand	
above screen --	Bentonite	
Aquifer Material --	Clay	

COMPUTED

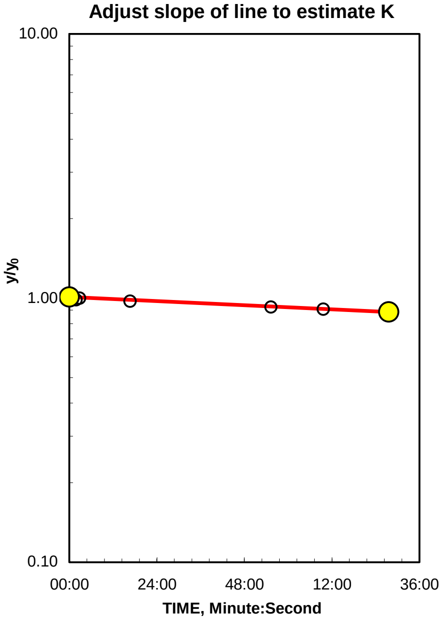
L_{wetted}	4.24	Feet
D =	41.32333	Feet
H =	4.24	Feet
L/r_w =	62.43	
$y_{0\text{-DISPLACEMENT}}$ =	3.27	Feet
$y_{0\text{-SLUG}}$ =	3.15	Feet
From look-up table using L/r_w		
Partial penetrate A =	3.481	
B =	0.564	
ln(Re/rw) =	2.660	
Re =	0.97	Feet
Slope =	1.81E-06	log_{10}/sec
$t_{90\%}$ recovery =	553123	sec

Input is consistent.

K =	0.00037	Feet/Day



Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	10:10:00.0	13.99
2	10:21:00.0	13.94
3	10:27:00.0	13.99
4	11:50:00.0	13.90
5	15:42:00.0	13.74
6	17:08:00.0	13.69

K= 0.00037 is greater than likely maximum of 0.0001 for Clay

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: Cibola

Local ID: PZ-6-C
Date: 3/14/2011
Time: 0:00

INPUT

Construction:

Casing dia. (d_c)	1.38	Inch
Annulus dia. (d_w)	1.63	Inch
Screen Length (L)	5.33	Feet

Depths to:

water level (DTW)	8.04	Feet
top of screen (TOS)	7.17	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Coarse Sand
above screen -- Bentonite

Aquifer Material -- Fine Sand

COMPUTED

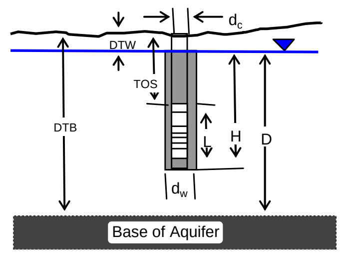
L_{wetted}	4.46	Feet
D =	41.96	Feet
H =	4.46	Feet
L/r_w =	65.67	
$y_{0\text{-DISPLACEMENT}}$ =	0.73	Feet
$y_{0\text{-SLUG}}$ =	0.76	Feet

From look-up table using L/r_w

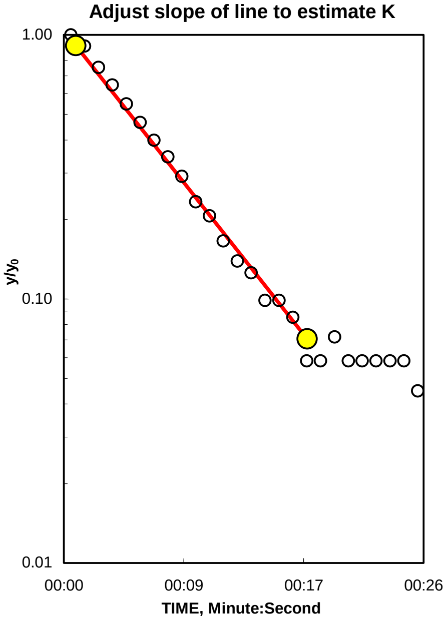
Partial penetrate A =	3.565	
B =	0.578	
ln(Re/rw) =	2.703	
Re =	1.01	Feet
Slope =	0.066566	log_{10}/sec
$t_{90\%}$ recovery =	15	sec

Input is consistent.

K = 13 Feet/Day



Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	84.00
2	0:00:02.0	86.10
3	0:00:03.0	89.50
4	0:00:04.0	91.90
5	0:00:05.0	94.10
6	0:00:06.0	95.90
7	0:00:07.0	97.40
8	0:00:08.0	98.60
9	0:00:09.0	99.80
10	0:00:10.0	101.10
11	0:00:11.0	101.70
12	0:00:12.0	102.60
13	0:00:13.0	103.20
14	0:00:14.0	103.50
15	0:00:15.0	104.10
16	0:00:16.0	104.10
17	0:00:17.0	104.40
18	0:00:18.0	105.00
19	0:00:19.0	105.00
20	0:00:20.0	104.70
21	0:00:21.0	105.00
22	0:00:22.0	105.00
23	0:00:23.0	105.00
24	0:00:24.0	105.00
25	0:00:25.0	105.00
26	0:00:26.0	105.30
27	0:00:27.0	105.30

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: Cibola

Local ID: PZ-6-C-2
Date: 3/15/2011
Time: 3:20:00 PM

INPUT

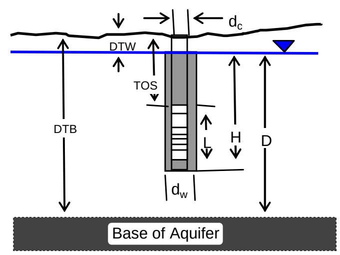
Construction:		
Casing dia. (d_c)	1.38	Inch
Annulus dia. (d_w)	1.63	Inch
Screen Length (L)	5.33	Feet
Depths to:		
water level (DTW)	8.04	Feet
top of screen (TOS)	7.17	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen --	Coarse Sand	
above screen --	Bentonite	
Aquifer Material --	Fine Sand	

COMPUTED

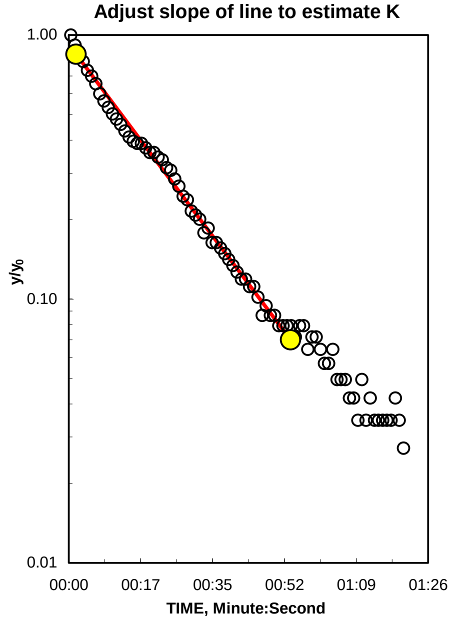
L_{wetted}	4.46	Feet
D =	41.96	Feet
H =	4.46	Feet
L/r_w =	65.67	
$y_{0\text{-DISPLACEMENT}}$ =	1.33	Feet
$y_{0\text{-SLUG}}$ =	1.58	Feet
From look-up table using L/r_w		
Partial penetrate A =	3.565	
B =	0.578	
ln(Re/rw) =	2.703	
Re =	1.01	Feet
Slope =	0.020977	log_{10}/sec
$t_{90\%}$ recovery =	48	sec

Input is consistent.

K =	4.2	Feet/Day



Adjust slope of line to estimate K



REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Reduced Data

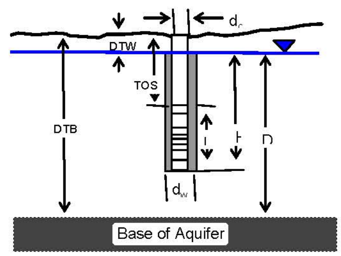
Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	146.70
2	0:00:02.0	143.30
3	0:00:03.0	140.90
4	0:00:04.0	138.40
5	0:00:05.0	136.00
6	0:00:06.0	134.50
7	0:00:07.0	132.70
8	0:00:08.0	130.50
9	0:00:09.0	129.00
10	0:00:10.0	127.80
11	0:00:11.0	126.60
12	0:00:12.0	125.70
13	0:00:13.0	124.80
14	0:00:14.0	123.80
15	0:00:15.0	122.90
16	0:00:16.0	122.30
17	0:00:17.0	122.00
18	0:00:18.0	122.00
19	0:00:19.0	121.40
20	0:00:20.0	120.80
21	0:00:21.0	120.80
22	0:00:22.0	120.20
23	0:00:23.0	119.90
24	0:00:24.0	119.00
25	0:00:25.0	118.70
26	0:00:26.0	117.80
27	0:00:27.0	117.10
28	0:00:28.0	116.20
29	0:00:29.0	115.90
30	0:00:30.0	115.00
31	0:00:31.0	114.70
32	0:00:32.0	114.40
33	0:00:33.0	113.50
34	0:00:34.0	113.80
35	0:00:35.0	112.90
36	0:00:36.0	112.90
37	0:00:37.0	112.60
38	0:00:38.0	112.30
39	0:00:39.0	112.00
40	0:00:40.0	111.70
41	0:00:41.0	111.40
42	0:00:42.0	111.10
43	0:00:43.0	111.10
44	0:00:44.0	110.80
45	0:00:45.0	110.80

WELL ID: CIBOLA

Local ID: PZ-9-C
Date: 3/14/2011
Time: 4:45:00 PM

INPUT

Construction:	
Casing dia. (d_c)	1.25 Inch
Annulus dia. (d_w)	3.5 Inch
Screen Length (L)	4.63 Feet
Depths to:	
water level (DTW)	4.86 Feet
top of screen (TOS)	6.27 Feet
Base of Aquifer (DTB)	50 Feet
Annular Fill:	
across screen --	Coarse Sand
above screen --	Bentonite
Aquifer Material --	Fine Sand



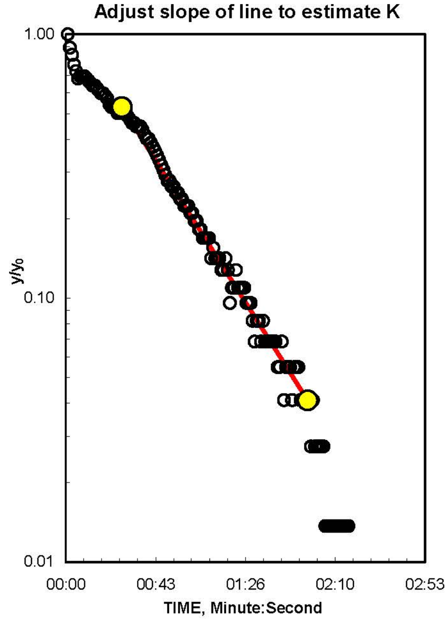
COMPUTED

L_{wetted}	4.63 Feet
D =	45.14 Feet
H =	6.04 Feet
L/r_w =	31.75
$y_{0\text{-DISPLACEMENT}}$ =	0.72 Feet
$y_{0\text{-SLUG}}$ =	0.64 Feet
From look-up table using L/r_w	
Partial penetrate A =	2.578
B =	0.423
ln(Re/rw) =	2.217
Re =	1.34 Feet
Slope =	0.012441 $\log_{10}$/sec
$t_{90\%}$ recovery =	80 sec

Input is consistent.

K =	1.6 Feet/Day

Adjust slope of line to estimate K



K= 1.6 is less than likely minimum of 3 for Fine Sand

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	143.80
2	0:00:04.0	138.70
3	0:00:07.0	137.10
4	0:00:10.0	136.80
5	0:00:13.0	135.90
6	0:00:16.0	135.30
7	0:00:19.0	134.70
8	0:00:22.0	133.50
9	0:00:25.0	132.90
10	0:00:28.0	132.90
11	0:00:31.0	132.30
12	0:00:34.0	131.70
13	0:00:37.0	131.40
14	0:00:40.0	130.70
15	0:00:43.0	129.80
16	0:00:46.0	128.90
17	0:00:49.0	128.00
18	0:00:52.0	127.70
19	0:00:55.0	127.10
20	0:00:58.0	126.80
21	0:01:01.0	126.50
22	0:01:04.0	125.90
23	0:01:07.0	125.60
24	0:01:10.0	125.00
25	0:01:13.0	125.00
26	0:01:16.0	124.70
27	0:01:19.0	124.00
28	0:01:22.0	124.70
29	0:01:25.0	124.30
30	0:01:28.0	124.00
31	0:01:31.0	123.40
32	0:01:34.0	123.40
33	0:01:37.0	123.40
34	0:01:40.0	123.40
35	0:01:43.0	123.10
36	0:01:46.0	123.10
37	0:01:49.0	122.80
38	0:01:52.0	123.10
39	0:01:55.0	122.80
40	0:01:58.0	122.50
41	0:02:01.0	122.50
42	0:02:04.0	122.50
43	0:02:07.0	122.20
44	0:02:10.0	122.20
45	0:02:13.0	122.20

WELL ID: CIBOLA

Local ID: PZ-9-C-2
Date: 3/14/2011
Time: 0:00

INPUT

Construction:

Casing dia. (d_c)	1.25	Inch
Annulus dia. (d_w)	3	Inch
Screen Length (L)	4.63	Feet

Depths to:

water level (DTW)	5.98	Feet
top of screen (TOS)	5.41	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Coarse Sand
above screen -- Bentonite

Aquifer Material -- Fine Sand

COMPUTED

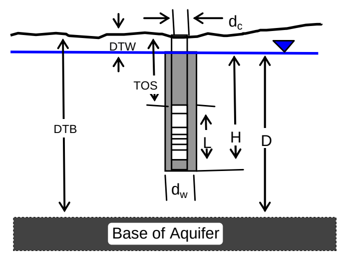
L_{wetted}	4.05	Feet
D =	44.01667	Feet
H =	4.05	Feet
L/r_w =	32.40	
$y_{0\text{-DISPLACEMENT}}$ =	2.32	Feet
$y_{0\text{-SLUG}}$ =	2.56	Feet

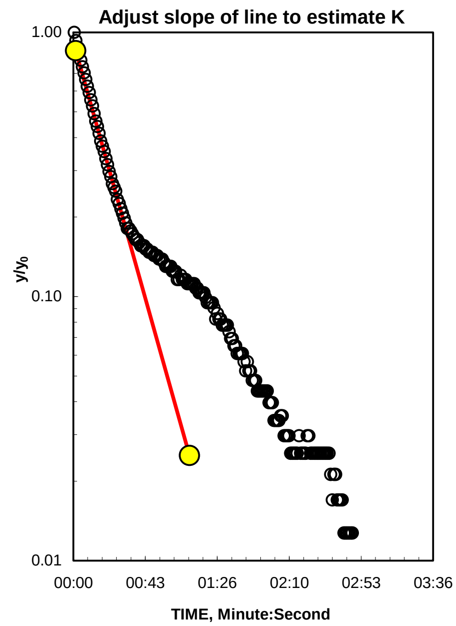
From look-up table using L/r_w

Partial penetrate A =	2.601	
B =	0.426	
ln(Re/rw) =	2.117	
Re =	1.04	Feet
Slope =	0.022432	log_{10}/sec
$t_{90\%}$ recovery =	45	sec

Input is consistent.

K = 3.2 Feet/Day





REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Reduced Data

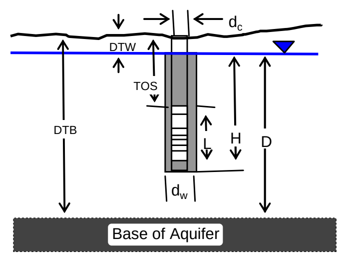
Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	192.00
2	0:00:05.0	176.80
3	0:00:09.0	165.50
4	0:00:13.0	156.10
5	0:00:17.0	148.70
6	0:00:21.0	143.60
7	0:00:25.0	139.60
8	0:00:29.0	136.50
9	0:00:33.0	134.10
10	0:00:37.0	133.20
11	0:00:41.0	132.30
12	0:00:45.0	132.00
13	0:00:49.0	131.40
14	0:00:53.0	131.10
15	0:00:57.0	130.50
16	0:01:01.0	130.10
17	0:01:05.0	129.80
18	0:01:09.0	129.20
19	0:01:13.0	129.20
20	0:01:17.0	128.60
21	0:01:21.0	128.00
22	0:01:25.0	127.70
23	0:01:29.0	127.10
24	0:01:33.0	126.80
25	0:01:37.0	125.90
26	0:01:41.0	125.60
27	0:01:45.0	125.30
28	0:01:49.0	124.70
29	0:01:53.0	124.40
30	0:01:57.0	124.40
31	0:02:01.0	123.70
32	0:02:05.0	123.80
33	0:02:09.0	123.40
34	0:02:13.0	123.10
35	0:02:17.0	123.10
36	0:02:21.0	123.40
37	0:02:25.0	123.10
38	0:02:29.0	123.10
39	0:02:33.0	123.10
40	0:02:37.0	122.80
41	0:02:41.0	122.50
42	0:02:45.0	122.20
43	0:02:49.0	121.90
44	0:02:53.0	121.90
45	0:02:57.0	121.90

WELL ID: CIBOLA

Local ID: PZ-10-C
Date: 3/15/2011
Time: 11:20:00 AM

INPUT

Construction:		
Casing dia. (d_c)	1.25	Inch
Annulus dia. (d_w)	3.5	Inch
Screen Length (L)	4.67	Feet
Depths to:		
water level (DTW)	8.68	Feet
top of screen (TOS)	8.25	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen --	Coarse Sand	
above screen --	Bentonite	
Aquifer Material --	Fine Sand	

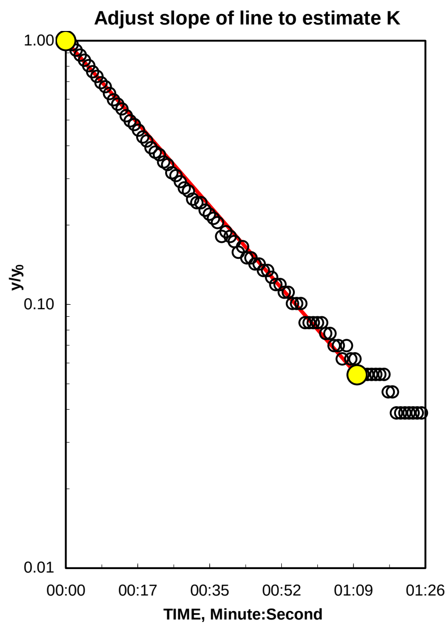


COMPUTED

L_{wetted}	4.24	Feet
D =	41.32333	Feet
H =	4.24	Feet
L/r_w =	29.07	
$y_{0\text{-DISPLACEMENT}}$ =	1.27	Feet
$y_{0\text{-SLUG}}$ =	1.28	Feet
From look-up table using L/r_w		
Partial penetrate A =	2.479	
B =	0.409	
ln(Re/rw) =	2.042	
Re =	1.12	Feet
Slope =	0.018109	$\log_{10}$/sec
$t_{90\%}$ recovery =	55	sec

Input is consistent.

K =	2.4	Feet/Day



K= 2.4 is less than likely minimum of 3 for Fine Sand

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	189.40
2	0:00:03.0	186.30
3	0:00:05.0	183.30
4	0:00:07.0	180.20
5	0:00:09.0	177.50
6	0:00:11.0	175.10
7	0:00:13.0	172.90
8	0:00:15.0	170.80
9	0:00:17.0	169.30
10	0:00:19.0	167.40
11	0:00:21.0	165.90
12	0:00:23.0	165.00
13	0:00:25.0	163.80
14	0:00:27.0	162.60
15	0:00:29.0	161.40
16	0:00:31.0	160.40
17	0:00:33.0	160.10
18	0:00:35.0	159.20
19	0:00:37.0	158.60
20	0:00:39.0	158.00
21	0:00:41.0	157.40
22	0:00:43.0	157.10
23	0:00:45.0	156.50
24	0:00:47.0	156.20
25	0:00:49.0	155.90
26	0:00:51.0	155.30
27	0:00:53.0	155.00
28	0:00:55.0	154.60
29	0:00:57.0	154.60
30	0:00:59.0	154.00
31	0:01:01.0	154.00
32	0:01:03.0	153.70
33	0:01:05.0	153.40
34	0:01:07.0	153.10
35	0:01:09.0	153.10
36	0:01:11.0	152.80
37	0:01:13.0	152.80
38	0:01:15.0	152.80
39	0:01:17.0	152.80
40	0:01:19.0	152.50
41	0:01:21.0	152.20
42	0:01:23.0	152.20
43	0:01:25.0	152.20
44	0:01:27.0	152.20
45	0:01:29.0	151.90

WELL ID: CIBOLA

Local ID: PZ-10-C-2
Date: 3/15/2011
Time: 11:20:00 AM

INPUT

Construction:

Casing dia. (d_c)	1.28	Inch
Annulus dia. (d_w)	3.5	Inch
Screen Length (L)	4.67	Feet

Depths to:

water level (DTW)	7.67	Feet
top of screen (TOS)	8.25	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Coarse Sand
above screen -- Bentonite

Aquifer Material -- Fine Sand

COMPUTED

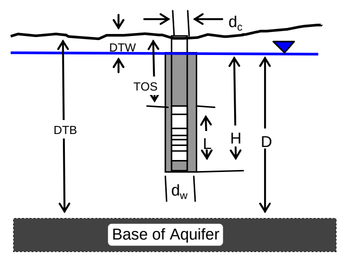
L_{wetted}	4.666667	Feet
D =	42.33333	Feet
H =	5.25	Feet
L/r_w =	32.00	
$y_{0\text{-DISPLACEMENT}}$ =	1.27	Feet
$y_{0\text{-SLUG}}$ =	1.22	Feet

From look-up table using L/r_w

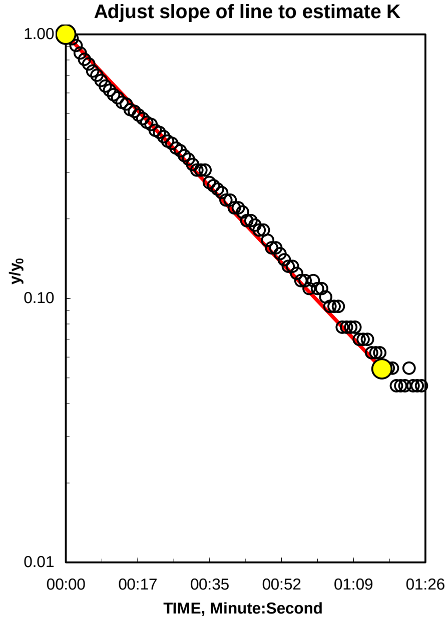
Partial penetrate A =	2.587	
B =	0.424	
ln(Re/rw) =	2.168	
Re =	1.27	Feet
Slope =	0.016679	log_{10}/sec
$t_{90\%}$ recovery =	60	sec

Input is consistent.

K =	2.2	Feet/Day



Adjust slope of line to estimate K



K= 2.2 is less than likely minimum of 3 for Fine Sand

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Reduced Data

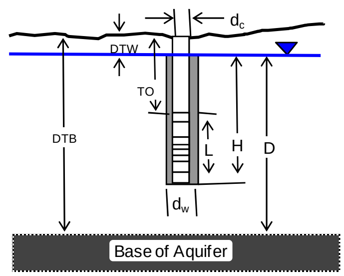
Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	189.30
2	0:00:03.0	185.70
3	0:00:05.0	181.70
4	0:00:07.0	178.70
5	0:00:09.0	176.50
6	0:00:11.0	174.40
7	0:00:13.0	172.90
8	0:00:15.0	171.70
9	0:00:17.0	170.40
10	0:00:19.0	169.20
11	0:00:21.0	168.30
12	0:00:23.0	167.10
13	0:00:25.0	165.90
14	0:00:27.0	165.00
15	0:00:29.0	164.10
16	0:00:31.0	163.10
17	0:00:33.0	162.50
18	0:00:35.0	161.30
19	0:00:37.0	160.70
20	0:00:39.0	159.80
21	0:00:41.0	159.20
22	0:00:43.0	158.90
23	0:00:45.0	158.30
24	0:00:47.0	157.70
25	0:00:49.0	157.10
26	0:00:51.0	156.70
27	0:00:53.0	156.10
28	0:00:55.0	155.80
29	0:00:57.0	155.20
30	0:00:59.0	154.90
31	0:01:01.0	154.90
32	0:01:03.0	154.60
33	0:01:05.0	154.30
34	0:01:07.0	153.70
35	0:01:09.0	153.70
36	0:01:11.0	153.40
37	0:01:13.0	153.40
38	0:01:15.0	153.10
39	0:01:17.0	152.80
40	0:01:19.0	152.80
41	0:01:21.0	152.50
42	0:01:23.0	152.80
43	0:01:25.0	152.50
44	0:01:27.0	152.20
45	0:01:29.0	152.20

WELL ID: CIBOLA

Local ID: PZ-SW-C
Date: 3/15/2011
Time: 12:55:00 PM

INPUT

Construction:		
Casing dia. (d_c)	1.28	Inch
Annulus dia. (d_w)	1.63	Inch
Screen Length (L)	5.33	Feet
Depths to:		
water level (DTW)	8.75	Feet
top of screen (TOS)	11.00	Feet
Base of Aquifer (DTB)	50	Feet
Annular Fill:		
across screen -- Coarse Sand		
above screen -- Bentonite		
Aquifer Material -- Fine Sand		



COMPUTED

L_{wetted}	5.333333	Feet
D =	41.25	Feet
H =	7.58	Feet
L/r_w =	78.53	
$y_{0\text{-DISPLACEMENT}}$ =	0.84	Feet
$y_{0\text{-SLUG}}$ =	0.78	Feet

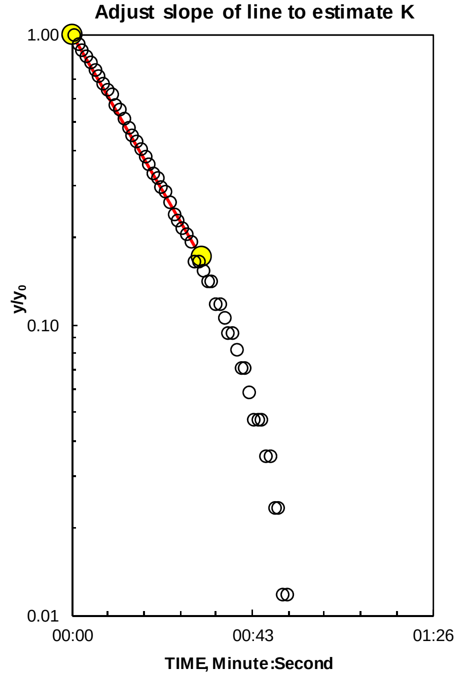
From look-up table using L/r_w

Partial penetrate A =	3.940	
B =	0.650	
ln(Re/rw) =	3.002	
Re =	1.37	Feet
Slope =	0.024824	log_{10}/sec
$t_{90\%}$ recovery =	40	sec

Input is consistent.

K =	3.9 Feet/Day

Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	149.80
2	0:00:02.0	151.60
3	0:00:03.0	152.80
4	0:00:04.0	154.00
5	0:00:05.0	154.90
6	0:00:06.0	156.10
7	0:00:07.0	157.10
8	0:00:08.0	158.00
9	0:00:09.0	158.90
10	0:00:10.0	159.50
11	0:00:11.0	160.70
12	0:00:12.0	161.30
13	0:00:13.0	162.20
14	0:00:14.0	163.10
15	0:00:15.0	163.80
16	0:00:16.0	164.40
17	0:00:17.0	165.00
18	0:00:18.0	165.60
19	0:00:19.0	166.20
20	0:00:20.0	166.80
21	0:00:21.0	167.10
22	0:00:22.0	167.70
23	0:00:23.0	168.00
24	0:00:24.0	168.60
25	0:00:25.0	169.20
26	0:00:26.0	169.50
27	0:00:27.0	169.80
28	0:00:28.0	170.10
29	0:00:29.0	170.40
30	0:00:30.0	171.10
31	0:00:31.0	171.10
32	0:00:32.0	171.40
33	0:00:33.0	171.70
34	0:00:34.0	171.70
35	0:00:35.0	172.30
36	0:00:36.0	172.30
37	0:00:37.0	172.60
38	0:00:38.0	172.90
39	0:00:39.0	172.90
40	0:00:40.0	173.20
41	0:00:41.0	173.50
42	0:00:42.0	173.50
43	0:00:43.0	173.80
44	0:00:44.0	174.10
45	0:00:45.0	174.10

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

WELL ID: Cibola

Local ID: PZ-SW-C-2
Date: 3/15/2011
Time: 12:55:00 PM

INPUT

Construction:

Casing dia. (d_c)	1.28	Inch
Annulus dia. (d_w)	1.63	Inch
Screen Length (L)	5.33	Feet

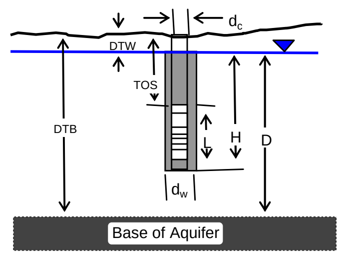
Depths to:

water level (DTW)	8.75	Feet
top of screen (TOS)	11.00	Feet
Base of Aquifer (DTB)	50	Feet

Annular Fill:

across screen -- Coarse Sand
above screen -- Bentonite

Aquifer Material -- Fine Sand



COMPUTED

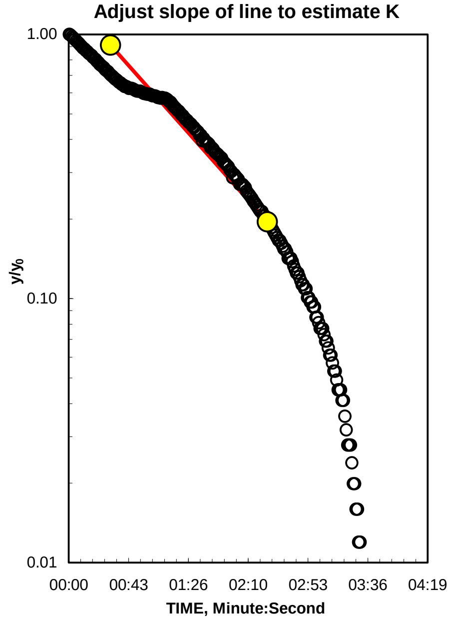
L_{wetted}	5.333333	Feet
D =	41.25	Feet
H =	7.58	Feet
L/r_w =	78.53	
$y_{0\text{-DISPLACEMENT}}$ =	2.48	Feet
$y_{0\text{-SLUG}}$ =	2.64	Feet

From look-up table using L/r_w

Partial penetrate A =	3.940	
B =	0.650	
ln(Re/rw) =	3.002	
Re =	1.37	Feet
Slope =	0.005911	$\log_{10}$/sec
$t_{90\%}$ recovery =	169	sec

Input is consistent.

K =	0.94	Feet/Day



K= 0.94 is less than likely minimum of 3 for Fine Sand

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:01.0	180.00
2	0:00:05.0	176.70
3	0:00:09.0	173.30
4	0:00:13.0	170.00
5	0:00:17.0	167.30
6	0:00:21.0	164.20
7	0:00:25.0	161.50
8	0:00:29.0	159.00
9	0:00:33.0	156.30
10	0:00:37.0	154.20
11	0:00:41.0	152.40
12	0:00:45.0	151.70
13	0:00:49.0	150.80
14	0:00:53.0	150.20
15	0:00:57.0	149.30
16	0:01:01.0	148.70
17	0:01:05.0	148.10
18	0:01:09.0	147.80
19	0:01:13.0	146.60
20	0:01:17.0	144.50
21	0:01:21.0	142.60
22	0:01:25.0	140.50
23	0:01:29.0	139.00
24	0:01:33.0	137.10
25	0:01:37.0	134.40
26	0:01:41.0	133.80
27	0:01:45.0	132.30
28	0:01:49.0	130.80
29	0:01:53.0	129.20
30	0:01:57.0	127.70
31	0:02:01.0	126.50
32	0:02:05.0	125.00
33	0:02:09.0	123.80
34	0:02:13.0	122.60
35	0:02:17.0	121.30
36	0:02:21.0	120.10
37	0:02:25.0	118.90
38	0:02:29.0	118.00
39	0:02:33.0	117.10
40	0:02:37.0	116.20
41	0:02:41.0	115.30
42	0:02:45.0	114.00
43	0:02:49.0	113.10
44	0:02:53.0	112.20
45	0:02:57.0	111.60