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Sub-Sub File Name Wichita

Year (calendar) 2003

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Wichita responses to DWR questions

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Wichita ASR Project 11-24-2003

Wichita: Blain

Burn&Mac: Stous, Klein

KDHE: Waldo, Cocharan

DWR: Huntzinger, Gilliland, Jennings, Bagley

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1. Discussion of draft responses (from Blain) to DWR's 10-30-2003 letter

A. Model documentation

B. DWR needs examples, maps, model files on CD.
Zone Budget Program (currently the basis of the acctg system)
↳ Worked out examples - with MODFLOW output to substantiate.

B. Final Report - April 2000 (DWR ck to see if present in office)

C. WQ analysis and constituent balance computations.
Fig III-10 from April 2000 report
Can't do mass balance on constituents because there is too much variation in the concentrations in the stream.

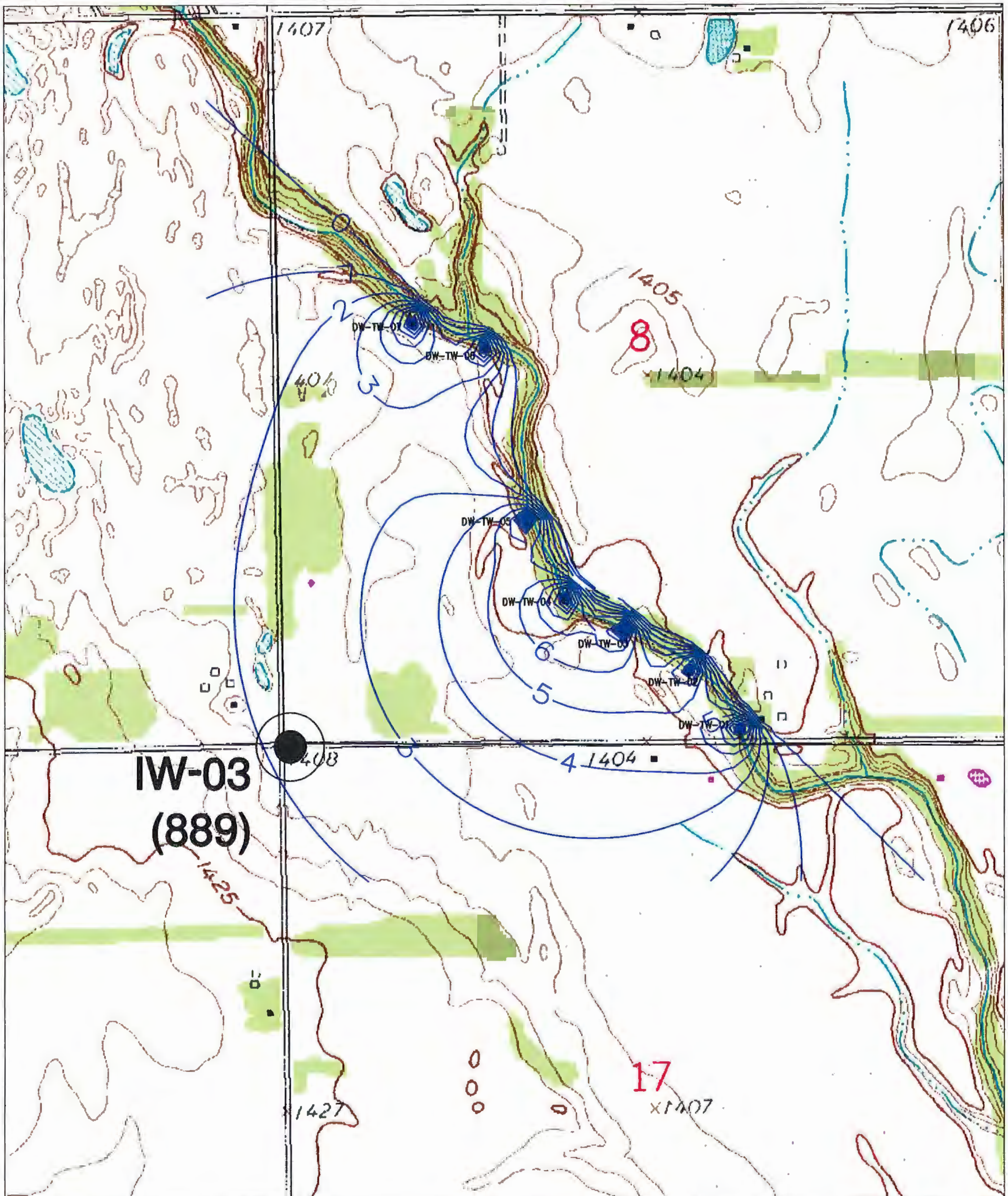
D. Clay zones
Not a continuous confining layer; clay lense - water flows around, not thru.
See Fig III-5 (Handed out) Largest DD in upper layer is ~150' W of well indicating water moves west before it goes down to get around clay layer.

A full scale test is necessary to prove this point at each site. [This may suggest a condition on the permit] Testholes could be instrumented to document response to changes in the streamflow.

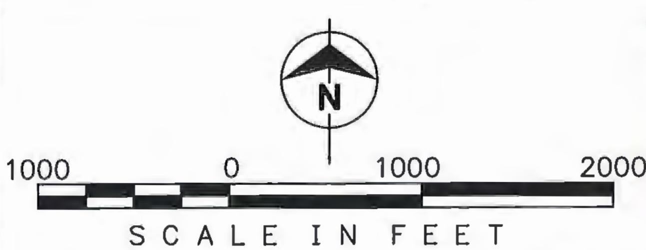
See also (handout) "Diversion Well Locations" (Theis analysis).

7-day recovery period is good for regulatory purposes. If recovery doesn't occur within that time, then there isn't enough of a connection between the river and the well.

11-24-2003



Under Baseflow Conditions (Theis w/ image wells)



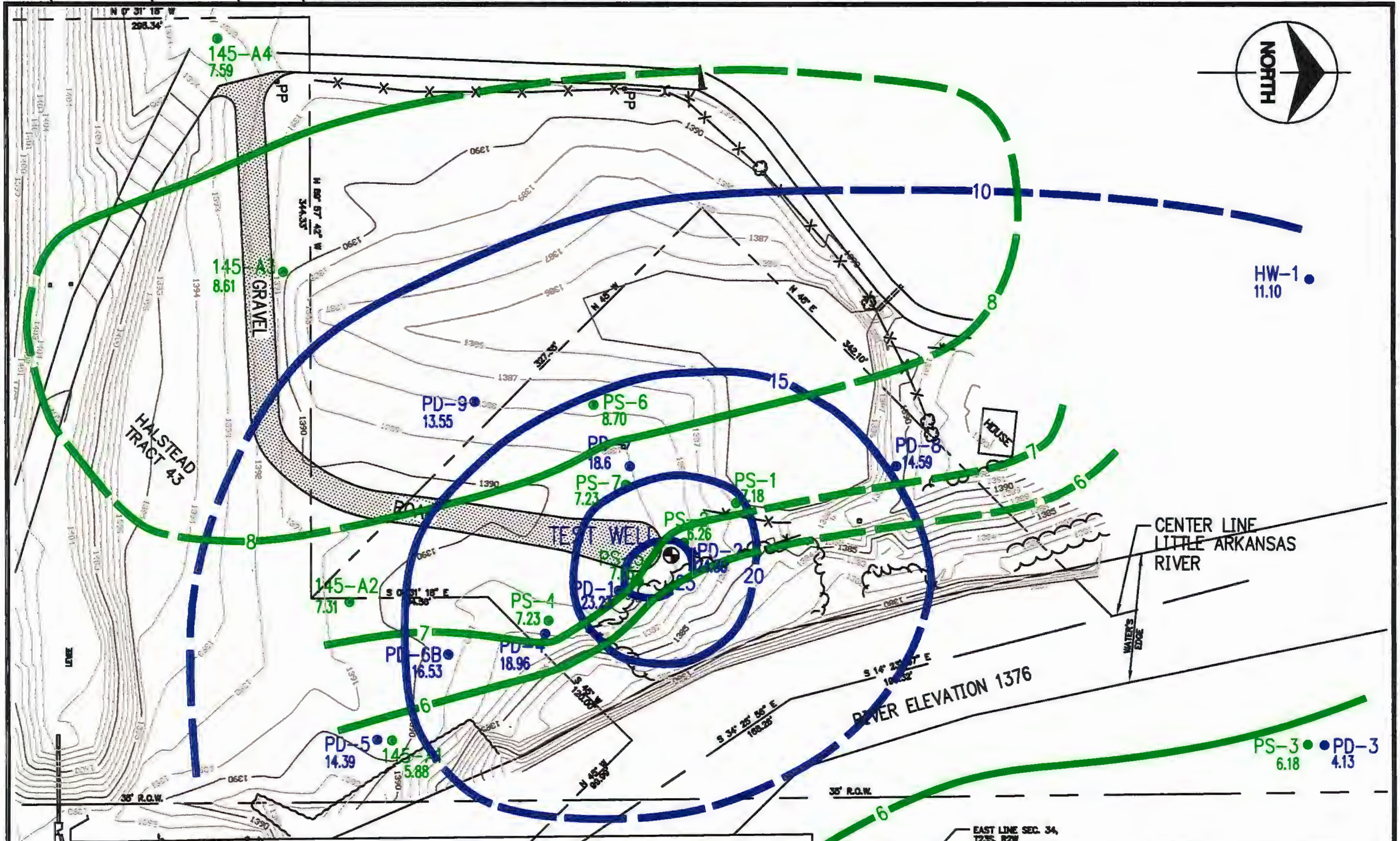
Burns & McDonnell SINCE 1898

DIVERSION WELL LOCATIONS

DIVERSION2.DWG 11/20/03

11-24-2003

J:\WICHITA\restore\MISC\FIG1.DWG 11-20-2003 16:13 AAO



LEGEND

PS – SHALLOW PIEZOMETER
—7.0— SHALLOW ZONE – DRAWDOWN
PD – DEEP PIEZOMETER
—20— DEEP ZONE – DRAWDOWN
145-A1 – STRING WELL
⊕ – TEST WELL
HW – HOUSE WELL

80 0 80 160

SCALE IN FEET

NOTE:

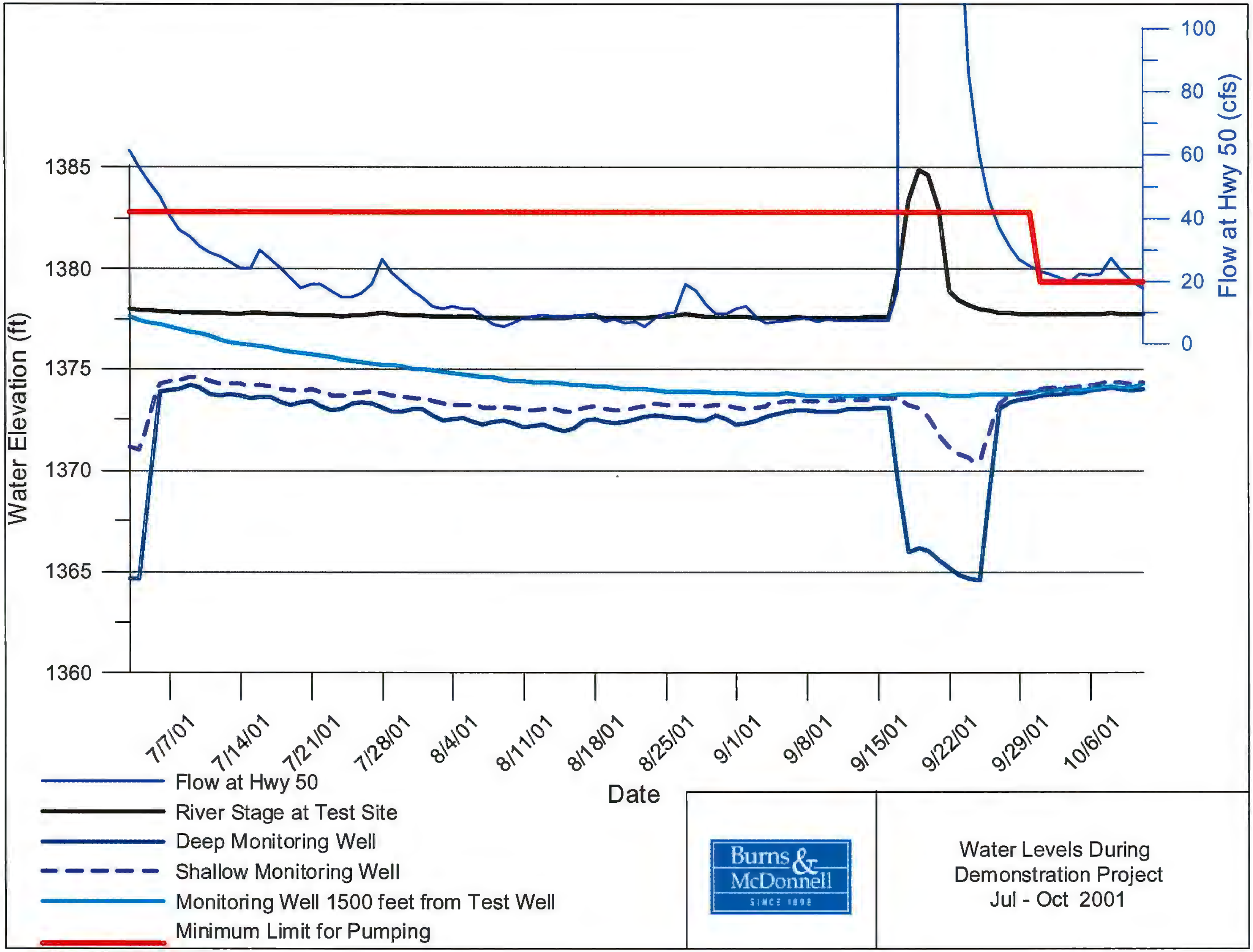
DRAWDOWN AFTER 24 DAYS OF PUMPING
Q = 863 GPM (APRIL 26, 1996)

Burns & McDonnell

Figure III-5

DRAWDOWN
UPPER AND LOWER ZONES
SITE TH-04

11-24-2003



Water Levels During
Demonstration Project
Jul - Oct 2001

2001 water levels.grf 11/19/03 14:28:51

11-24-2003

Responses to DWR letter of 10-30-03

The City acknowledges your letter of October 30, 2003, and we hope that this correspondence helps to answer the questions posed in your letter:

> In your cover letter included with the referenced applications, on page 4 you offered to submit to DWR a copy of the aquifer model that has been developed for the aquifer for the ASR project. Please submit a copy of the model, along with supporting information on the modeling technique, assumptions made in setting up the model, how the model was calibrated, data on any sensitivity analyses run on the model. The computer code for the model does not need to be submitted at this time.

The Wichita Equus Beds aquifer groundwater water flow model is set up for the USGS MODFLOW program using "Groundwater Vistas" pre and post processing software. The model is currently configured in a transient mode making the electronic files relatively large, however they can be loaded on a compact disk. Documentation of the model is described in several reports. Please clarify the model data, information and format you desire and we will be happy to package the information in a way that will be most useful to you.

> Along with the model, please submit worked-out examples of how the proposed accounting method will track the quantity and location of recharge credit water stored in the model cells through time, as it moves though the aquifer system. The examples should clearly show how the recharge credits assigned to each cell are determined, and tracked from cell to cell, such that it is known at all times how much recharge credit is available for diversion from each cell.

Several examples were presented during several of our previous meetings with DWR to discuss various alternatives for accounting methodology. Our examples illustrated accounting in several index cells during the period of 1993 to 1997 assuming that the phase I system was in place. The illustration basically uses the water balance report from MODFLOW to give year-end changes. We have included an example that assumes three years of operation of the Phase I system, and then where the water would be in year four, and how it can be allocated to the recovery wells in the Phase I system. We feel this example is indicative of how the model can be used for the scale project for administration of the ASR project.

> In your cover letter on page 3, reference is made to the results of the Recharge Demonstration Project, stating that the project has "proved that bank storage wells will capture bank storage water and will induce water from the Little Arkansas River". Please provide a copy of the final report documenting the findings of the project.

We have included a copy of the "Final Report on the Equus Beds Groundwater Recharge Demonstration Project" prepared for the Bureau of Reclamation in 2000. During the course of the Demonstration Project a number of reports were generated that offered very detailed data and analysis on the various components of the project. This report offers a good summary of those detailed reports and information on lessens learned during the project.

> If not already included in the final report on the Recharge Demonstration Project, the following information is required regarding the proposed bank storage wells:
>
> - Data, such as water quality analyses and constituent balance computations, supporting the fact that the water pumped from bank storage wells will be derived from the Little Arkansas River and not from water stored in the Equus Beds aquifer.

During the Demonstration Project water quality was monitored in the river and in the demonstration diversion well and the monitoring wells near the diversion well. That monitoring program observed that the water quality in the aquifer adjacent to the river changed as the diversion well was pumped. Enclosed is a graph (taken from USGS Report on Baseline Water Quality and Preliminary Effects of Artificial Recharge on Groundwater, South-Central Kansas 1995-98) that depicts the change in chloride levels in deep monitoring wells adjacent to the diversion well. While chloride levels in the river change as the flow in the river changes, they usually tend to be higher than the native chloride levels in the Equus Beds at this site. The graph depicts that chloride levels in the two deep monitoring wells rose from approximately 15 ppm to approximately 50 to 80 ppm after the well started extensive pumping. That there were also changes in specific conductance. Figure III-10, from the 1998 depicts how the specific conductance increased from approximately 550 microseimens per centimeter to over 700 microseimens per centimeters. While it is impossible to show a quantitative relationship between the changes in water quality in the groundwater with the water quality in the river because of the dynamic character of the river and its constantly changing characteristics, the changes that were observed provide definitive proof that that river water was being induced into the aquifer.

It is also important to remember that the river is a drain for the aquifer system and that water from the aquifer is migrating to the river where it discharges into the surface flow. Once pumping stops, the natural subsurface flow again returns to the river. Slowly, the induced “river water” remaining in the aquifer beneath the channel bed is returned to the river as up gradient aquifer water flows toward the river.

Based on average USGS data at the diversion well test site during the demonstration project, an increase in chlorides in the diversion well and nearby shallow monitoring wells demonstrates the hydraulic communication between the river and underlying aquifer materials.

- Data to show that the proposed bank storage wells, which are proposed to be screened below a clay zone, are able to induce flow from the stream through the clay zone to the well screen, at rates sufficient to support the rate of diversion requested for the bank storage wells. Supporting information should be in the form of computer modeling or engineering calculations. Data on the transmissivity of the confining layer should be provided to show that water may be induced to migrate from bank storage to the lower zone of the aquifer at a sufficient rate to satisfy the rate of diversion requested for the wells.

The clay "zones" shown in the boring logs are not continuous confining layers but are discontinuous lenses. The majority of the water reaching the well flows around these lenses and do not migrate through the clay material. This was demonstrated at the test well near Halstead and reported in the 1996 report. Drawdown in the upper sand layer was greatest at the western edge of the clay lens (100 to 200 feet west of the pumping well). See the attached figures from the report. Modeling was also presented in the report to demonstrating the hydrogeologic setting. **See pages ___ of the report.**

We also constructed a physical model of the geologic setting that was shown at several public meetings to demonstrate the migration of water from the river to the well.

- A map or other data must be provided showing the areal extent of the difference in head required to be developed by pumping the bank storage well in order to induce flow through the confining layer to the well screen. Include information on whether or not the drawdown caused by pumping the bank storage wells extends far enough into the aquifer to affect existing wells.

As discussed above, water moves around the clay lenses and is not moving through the clay lenses. The attached geologic cross section for the Phase I wells shows the same highly variable configuration of clay lenses as found at the Halstead test site.

The pumping test prior to the demonstration project included monitoring water levels from a number of wells that were installed perpendicular to the river. The most inland well, A5, was approximately 1,500 feet from the test well. During the initial 24-hour acceptance test at a pumping rate of 923 gpm, there was no discernable drawdown at that well. For the 30-day test, with base flow conditions, the well saw about 1-foot of drawdown.

During the extended 75-day test with pumping rate of 978 gpm, a high flow event occurred during the initial part of the test. During this approximately 30 day time period, there was no observed drawdown in the A5 well. After the river returned to base flow, drawdown of about 1 to 1½ feet developed. These observations reinforce that if the diversion wells are pumped only during above base-flow events that they will induce river water into the aquifer at a rate that replace the water pumped from the wells, and that there will be no impact on pre-existing groundwater levels near the wells.

The two closest permitted wells to the proposed diversion wells are about 3,500 and 5,000 feet away. Based on the observations described above, no impacts are expected to these wells, even if the diversion wells are pumped during base flow conditions. However, these applications require that these wells only be pumped during above base flow conditions, which makes an even greater margin of safety that nearby wells will be impacted.

- Information on the location and the elevation of the bed of the Little Arkansas River as it relates to the well log provided for each proposed bank storage well.

We have measured the relative elevations of the top of the proposed diversion wells and the riverbed. Those differences are as follows:

DW 1 – 15.50 feet	DW 5 – 23.44 feet
DW 2 – 17.31 feet	DW 6 – 25.42 feet
DW 3 – 28.73 feet	DW 7 – 26.02 feet
DW 4 – 18.66 feet	

- Provide calculations determining the point in time when equilibrium conditions are reached, wherein the water induced from the river equals the pumping rate of the bank storage well. What is the time lag from commencement of pumping to the time this equilibrium is reached?

Equilibrium conditions are difficult to determine because the well(s) will only be pumping during changing river conditions. During the 30-day test with base flow conditions, equilibrium was reached approximately 14-days after pumping began.

However, these wells will be permitted to operate only during above base-flow events, which are highly dynamic events. We have attached two other examples from the demonstration project are included to shown several aspects of the hydrogeological system. Daily USGS value are used to graph river discharge, river stage, and groundwater level at various locations at the diversion well test site.

The first example is from January through May 2001. A very large storm event created flows high enough for the project to operate (20 cfs April through September and 42 cfs October through March). The event allowed pumping for approximately eleven weeks. At the termination of pumping, groundwater levels were **higher** than before pumping began. During the pumping period, water levels in a well about 1,500 feet away increased in elevation.

The second example from the USGS data is from July to October 2001.

1) The graph shows termination of pumping near the early part of July.
2) Groundwater levels drop in response to lower river levels and assumed dry weather with up gradient irrigation pumping.

3) Pumping begins with a high flow event in mid September. During pumping, groundwater levels change (shallow and deep wells near the river) with changes in river flow demonstrating near equilibrium conditions.
4) There is no apparent change in water levels in the monitoring well about 1,500 feet away.
5) Recovery to pre pumping groundwater levels was rapid (less than 2 to 3 days) after pumping stopped.

- Until equilibrium is reached, what is the extent of the cone of depression out into the aquifer, and what is its effect on surrounding wells?

As discussed above, the cone of depression extended to about 1,500 during pumping at base flow conditions and did not show impacts during pumping for the demonstration project. That would be a "worse case" condition. As shown in the hydrographs, there would be other occasions there might actually be **no cone of depression**, and even with the well in operation ground water levels would be higher than during base flow conditions. No impact is expected on the two wells 3,500 and 5,000 feet away from the Phase 1 wells when pumping during above base flow conditions.

- What is the time frame in which the aquifer will recover to normal conditions after pumping the bank storage well has ceased?

As discussed above, recovery to pre pumping water levels has been shown to be rapid. Recovery times will vary with site specific geologic conditions but in all cases is expected to be fairly short. In areas where water has to travel greater distances around clay lenses, recovery times may take slightly longer. However it is reasonable to assume that recovery will not exceed seven days if a suitable connection exists between the river and the diversion well.

- To what extent, if any, will the proposed reactivation of the Bentley Reserve Field wells have on the ASR project? Has this pumping been incorporated into the aquifer model?

The City of Wichita is proposing to install six diversion wells on the right bank of the Arkansas River south of Bentley. These wells are intended to induce water primarily from the Arkansas River. Modeling performed by the US Bureau of Reclamation indicates that over 70% of the water obtained from these wells will be obtained directly from the Arkansas River. The site of this wellfield is over a mile south of the farthest extent of the area that could potentially be impacted by the City's proposed ASR project, and it is also located on the south side of the Arkansas River, and so that project will have no impact on the ASR project.

In page 6 of your cover letter, reference is made to the City's commitment to compliance with applicable water quality standards regarding water used for artificial recharge. Please provide detailed information on how the city plans to monitor the quality of water used for recharge, and what treatment methods, if any, will be used to ensure recharged water meets quality standards.

Water quality monitoring was a major component of the Demonstration Project, and over 4,200 water samples were collected and analyzed. The compounds that most directly affected water quality in the river were turbidity, chlorides, and atrazine. That project determined that water quality in the river changes substantially at various flow levels and seasons of the year. However, the water obtained from the bank storage well remained relatively stable for the constituents of concern in the river. It appeared that almost all of the atrazine and turbidity was removed from the water through the filtration process of the riverbank. However, we also detected arsenic in the bank storage well, even though we did not detect it in the river. The arsenic levels in the well remained very stable even during extended pumping periods.

The Kansas Department of Health and Environment will require the City to obtain Class V permits to put water back into the aquifer. Those permits require that all water discharged into the aquifer must meet all drinking water standards.

To assure that all water recharged into the aquifer meets drinking water standards the City will work with KDHE to establish an approved sampling program. That program will require a sampling and testing protocol that has not yet been fully established. However, the City would suggest that:

- Water samples be collected prior to the first recharge site (a blended water sample from all of the diversion wells in service at that time).
- That the frequency of that sampling initially be once very seven days of operation.
- That the samples be tested, at a minimum, for bacteria, arsenic, chlorides, and atrazine.
- The City will also install monitoring wells at each recharge site, and those monitoring wells will be sampled every quarter to determine any changes in groundwater quality.
- After one year of operation, the sampling program will be reviewed, and a determination be made on changing the sampling frequency. If all of the constituents of concern are very stable, a less frequent sampling program may be considered.
- In addition sampling the water that is being recharged, the City also has established an index well monitoring network throughout the ASR project area that will include sampling on the full spectrum of compounds once per year.

Preliminary tests on water at sites of the proposed diversion wells indicate that there is a potential that some of the wells may withdraw water that exceeds the future water quality standard for arsenic (10 parts per billion). If the City is not able to provide water that meets that standard, the City is prepared to construct and operate a treatment system that will reduce the arsenic to drinking water standards. If any other constituents are detected after the wells are constructed that exceed their drinking water standards, the City will construct the appropriate treatment protocols needed to address those constituents. It is also important to note that baseline water sampling from the index well network by the USGS has revealed that at over 60% of the sites tested in the ASR project area that the existing groundwater fails to meet one or more of the drinking water standards, so in much of the project area water quality will probably improve over the existing conditions.