DWR EXHIBIT O

City of Wichita Response to DWR Comments

December 16, 2003

EXHIBIT
PENGAD 800-631-6989
DWR "O"

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WICHITA

Water & Sewer Department

Mr. Mark Jennings, L.G.
Environmental Scientist
Division of Water Resources
Kansas Board of Agriculture
901 S. Kansas Ave., Second Floor
Topeka, KS 66612-1283

December 12, 2003

RE: Application File Nos. 45,567 through 45,576 (Equus Beds ASR Project)

Dear Mr. Jennings,

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

> 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 analysis 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. Enclosed is a compact disk that contains the model, which can be run by those with experience in this technology, and a packet describing the model and depicting the model grids and boundaries. This should allow you, your staff, or the Groundwater Management District, to use the model to assist in administering the ASR project throughout the life of the project.

> 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 through 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.

The City has previously presented information from the model to your office that demonstrates that the model can accurately predict the performance of the aquifer. Enclosed is an additional example based on the assumption that Phase I of the project was in service for the hydrologic year of 1998. The example only depicts Phase I facilities, and does not depict any withdrawals by ASR facilities. However, it does depict how water that is recharged into the aquifer (in this example only in Index Cells 2, 5, and 9) in one location moves to other locations. In this example, a total of 7,039 acre-feet of water is recharged during the year. While the water is

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recharged into only three cells, that water influences water levels in a total of 16 index cells. Enclosed is a Detailed Index Cell Water Balance (38 pages) that shows the models efforts to balance inflows and outflows from each cell. The first column shows the influence of recharge activities (depicted as "wells" in the "in" column), the second column depicts the conditions that would have taken place if the recharge project had not occurred, and the third column depicts the difference, or the impact of the recharge. The values in each of those three columns are in cubic feet per day. The box in the lower right hand corner totals the gains or losses from that cell to the adjacent cells, and provides a total change in acre-feet. The results of that water balance evaluation are summarized in the table titled "City of Wichita ASR Annual Summary, Year 1". This table lists all of the ASR credits available after the year of operation, and could be used to allocate water appropriations to recharge/recovery wells used for the project. This provides a good depiction of how water moves in the project area. For example, a total of 3,049 acre-feet of water was recharged into cell #5, but only 1,229 acre feet would be available for recovery from that cell. For the purposes of this example, if there were three recovery wells in cell #5, they would each receive an appropriation for 409.7 acre-feet for the following year.

Also included is a table that depicts the result of a calibration sensitivity exercise. The result (average of --3.73) is shown in feet. With additional inputs to the model as more data is available over time it is anticipated that the model will continue to increase its accuracy.

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.

Included in this package is 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 other 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 lessons 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 analysis and constituent balance computation supporting the fact that water pumped from bank storage wells will be derived from the Little Arkansas River and not from water stored in the Equus Beds.

During the Demonstration Project water quality was monitored in the river, in the demonstration diversion well and in monitoring wells near the diversion well. The 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 (Figure 19 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

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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 in September of 1997 and continued through December of 1997. Changes in specific conductance were also observed. Enclosed Figure III-10, from a report completed in 1996, that depicts how the specific conductance increased from approximately 550 microseimens per centimeter to over 700 microseimens per centimeters over a four-month period during the 30-day and 75 day pumping tests. Also included is Figure III-11, which shows changes in chloride levels during the same period. These graphs display why 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 conditions of the river and its constantly changing characteristics. The changes observed in the groundwater provide definitive proof that river water was being induced into the aquifer, but the concurrent dramatic changes that were observed in the river make it impossible to make any direct correlation between water quality conditions in the river and expected water quality conditions in the groundwater caused by pumping a diversion well.

It is also important to remember that the river is a drain for the aquifer system and that during base flow conditions water from the aquifer is migrating to the river where it discharges into the surface flow. If bank storage wells were in operation, once pumping stops and the river level returns to base-flow conditions, the natural subsurface flow would 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, causing dilution and reduction in chloride and specific conductance.

The ultimate factor that determines the success of a bank storage well is its impact on the aquifer, and validation that the volume of water pumped from the well does not impair existing groundwater appropriations. The validity of that concept is observable in the enclosed hydrograph from 1998. The hydrograph shows water levels in the river (at the USGS gage upstream at highway 50), and in wells 50 feet, 200 feet, and 1,700 feet from the river near the demonstration diversion well. There was a significant series of rainfall events that increased flow in the river from September through much of December. The well ran several times that year, but it had an extended time of continuous operation from September 23, 1998, until December 17, 1998. As can be seen on the hydrograph, groundwater levels rose even though the diversion well was in service, and in two instances they rose to levels even higher than the static water level. At the end of the pumping period, after pumping over 117 million gallons, groundwater levels were still three feet higher than they were at the beginning of the year, demonstrating that the bank storage diversion well had no negative impacts on the aquifer. In the 2000 Bureau report there is also a hydrograph (figure 1-36) covering a longer period of time, from January of 1998 to January of 2000, which depicts a general rise of almost five feet in groundwater levels at the project site.

- 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

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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 does not actually migrate through the clay material. This was demonstrated at the test well near Halstead and reported in a 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 enclosed figures III-3. III-4 and III-5 from the 1996 report. Modeling was also presented in the report to demonstrate the hydrogeologic setting. Enclosed are pages III-3 through III-11 from the 1996 report which provide a more detailed description of the above information and the results of the modeling completed during that period.

This information helps to point out that there is extensive variability in the hydrogeology along the Little Arkansas River. For that reason, the City is not confident that modeling is the most appropriate way to determine the capability of a bank storage well to induce water from the river at a rate adequate to replace the water pumped from the well. As an alternative to modeling, the City recommends that any permits for a bank storage well be conditioned on proving its connection to the river with a full scale well and pump tests from that 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 geologic cross sections for the Phase I wells shows the same highly variable configuration of clay lenses as found at the Halstead test site.

The pumping test for 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, performed during base flow conditions, the well saw about 1-foot of drawdown.

During the extended 75-day test with a 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 again. 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

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will 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 none-domestic wells to the proposed diversion wells are about 3,500 and 5,000 feet away. Based on the observations described above, no impacts are anticipated at 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.

Enclosed is a map labeled "Drawdown from Diversion Wells at Base Flow" that provides the estimated drawdown from the combined operation of all of the proposed wells during base-flow conditions. This would represent the "worst case" condition, as the wells will only be allowed to operate when flows in the river are above base flow. Under these conditions there would be a much smaller, or no, drawdown in the aquifer.

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

The relative elevations of the top of the proposed diversion wells and the riverbed have been measured. 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	

The riverbed elevations have also been marked on the well cross sections.

- ξ 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. The previously mentioned hydrograph from 1998 depicts the highly variable conditions in the river and in the groundwater near the river caused by bank storage events. Even though pumping occurred for 86 consecutive days, water levels and drawdowns varied substantially. 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. Recovery in the wells after pumps ceased was very rapid, less than 2 or 3

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days after pumping ceased. Because of that extensive variability, defining "equilibrium" conditions during above base-flow conditions is not achievable.

- 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 during the demonstration project and did not show impacts during pumping during above base-flow conditions. That would be a "worst case" condition. As shown in the hydrographs, there would be other occasions where there would be **no cone of depression** and, even with the wells in operation, ground water levels would be higher than during base flow conditions. No impact is expected on the two none-domestic wells located 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 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 it 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 stipulate 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 one mile south of the farthest extent of the area that could potentially be impacted by the City's proposed ASR project, and it is located on the south side of the Arkansas River, and so it 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. During the project 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. The project

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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, arsenic was detected in the bank storage well, even though it was not detected in the river. The arsenic levels in the well remained very stable even through 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 will require that the 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. The 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 every 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 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 to sampling the water that is being recharged, the City also has established an Index Well network throughout the ASR project area that will include sampling on the full spectrum of compounds once a year.

Preliminary tests on water at the 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). The source of the arsenic appears to be clays within the aquifer, and arsenic in the clay that dissolves into the groundwater. 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 violate drinking water standards, the City will construct the appropriate treatment processes 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 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.

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It is important to recognize the impacts of the "no action" alternative. The project area is currently threatened by salt-water contamination from two sources. One source is near the Burton area, which was created by the improper disposal of oil field brine. The second source is high chloride water migrating from the Arkansas River. Studies and modeling done by the USGS and the Bureau of Reclamation predict that, if there are no alterations in water usage in the project area, that chloride levels will exceed the drinking water standard of 250 ppm in most of the area by the year 2050. By recharging the aquifer using water from the Little Arkansas River those threats can be substantially mitigated.

The City hopes that the information provided above, and enclosed, helps to adequately answer the questions expressed in your letter. We are also returning the 10 original applications for further processing, as well as figures VII-24 and VII-25, which were inadvertently left out of the original submittal package.

The City continues to believe that this water resources development project is a viable way to capture water from the Little Arkansas River without impairing existing surface or groundwater appropriations, provide an additional water supply for the City, and protect the project area from salt-water contamination.

Please let me know (316) 268-4578 if you have any additional questions.

Sincerely,

CITY OF WICHITA

Gerald T. Blain

Gerald T. Blain, P.E.
Water Supply Projects Administrator

xc: David Warren, Dir. of Water and Sewer
Burns & MacDonnell

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B. Chloride concentrations in diversion well water and ground water from Halstead recharge site

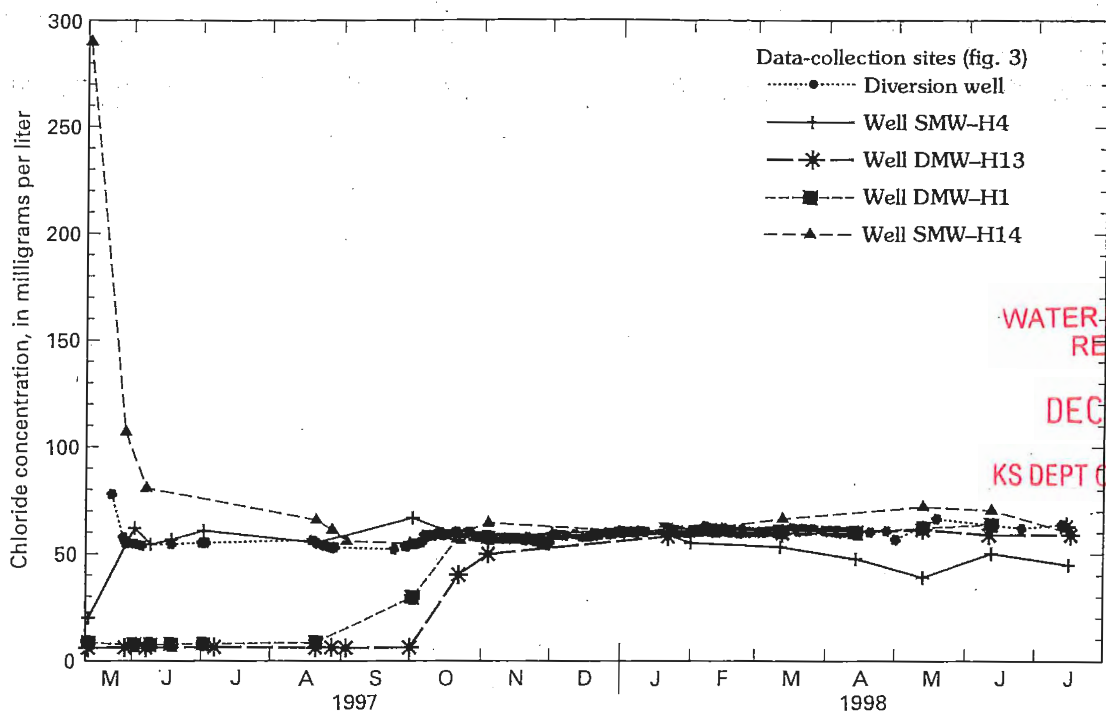

Figure 19. Comparison of chloride concentrations *(A)* in surface water and ground water from Halstead diversion well site, March 1995–July 1998, and *(B)* in diversion well water and ground water from Halstead recharge site, May 1997–July 1998. Secondary Maximum Contaminant Level from U.S. Environmental Protection Agency (1999)—Continued.

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DMW–S10, and DMW–S14) at the Sedgwick recharge site had smaller TOC concentrations during artificial recharge conditions than during baseline conditions.

From October 1997 through July 1998, total coliform bacteria in water from the Little Arkansas River near Sedgwick ranged from 30 to 27,000 col/100 mL. Total coliform bacteria ranged from less than 1 to 400 col/100 mL in treated source water diverted from the Little Arkansas River. However, densities of total coliform bacteria were not a significant concern in water from monitoring wells at the Sedgwick recharge site with only one detection (of 1 col/100 mL) after recharge began. Total coliform bacteria may become a concern during longer periods of recharge.

Atrazine, because of its frequent use on row crops in the study area and its potential effects on water quality, has been monitored frequently since February 1995 in water from the Little Arkansas River (Christensen and Ziegler, 1998a). Atrazine concentrations in surface water typically are larger in the spring and summer when herbicides are applied and when excessive rains cause greater runoff to streams (Goolsby and others, 1997). In treated source water from the Little Arkansas River, atrazine concentrations determined by ELISA ranged from less than 0.1 to 6.8 μg/L (fig. 27). The maximum atrazine concentration (determined by GC/MS) detected in water from shallow monitoring wells SMW–S11 and SMW–S13 was 0.36 μg/L, exceeding the baseline maximum concentration of 0.1 μg/L (fig. 27). Atrazine was not detected in water from the deep monitoring wells at the site. The addition of PAC to the treated source water was effective in decreasing the concentrations of atrazine to concentrations similar to baseline concentrations; therefore, concentrations of atrazine in water from nearby monitoring wells were similar to what they were prior to recharge, with the exception of atrazine concentrations in water from well SMW–S11. The seasonal variation in atrazine concentrations in water from the Little Arkansas River near Sedgwick and water from shallow monitoring wells SMW–S11 and SMW–S13 is shown in figure 28.

Documentation of the preliminary effects of artificial recharge at the Sedgwick site are important because of the large differences between constituent concentrations in the surface water and the baseline

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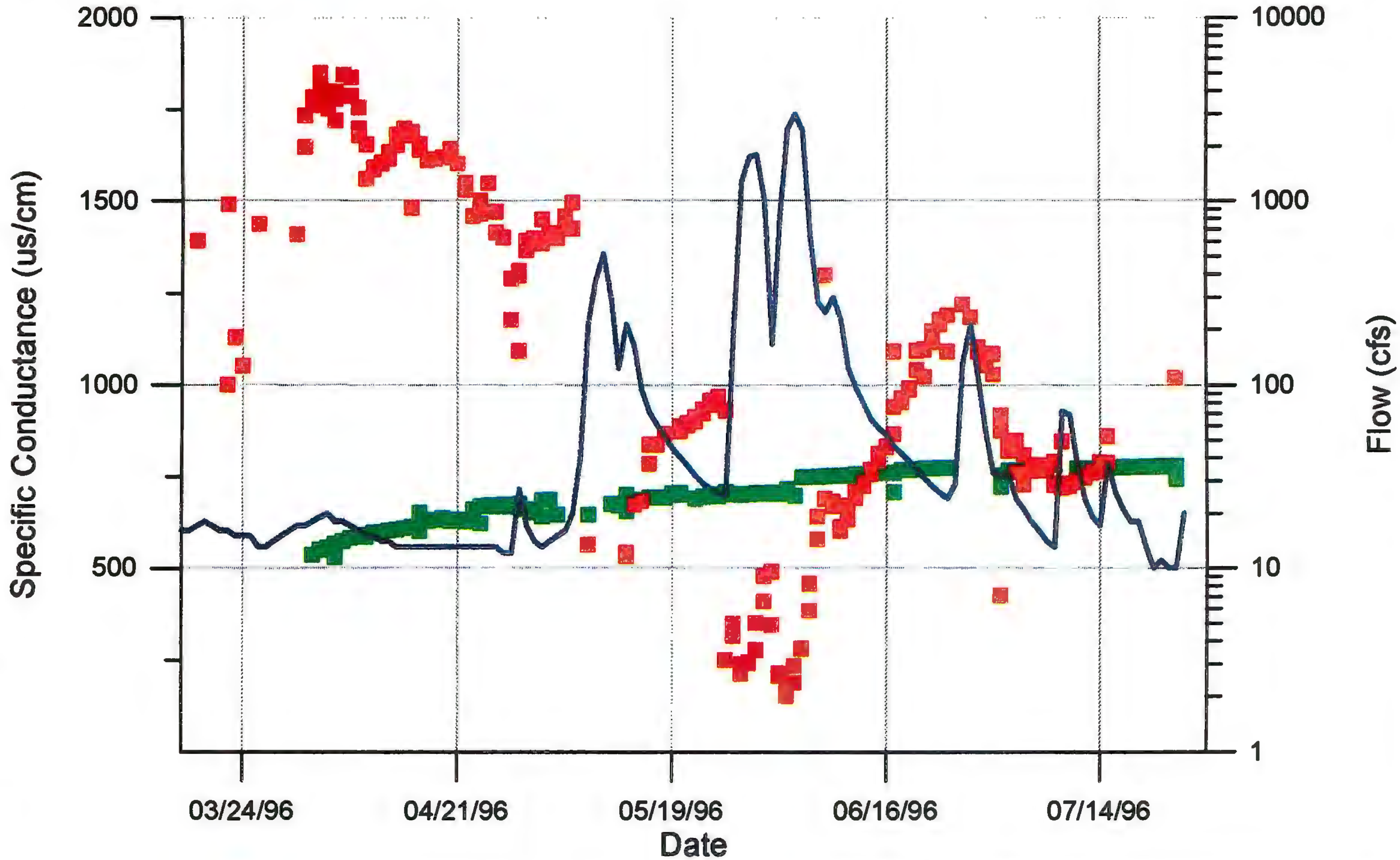

Specific Conductance - Test Well

Specific Conductance - Highway 50

Flow - Highway 50

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Figure III-10

SPECIFIC CONDUCTANCE HIGHWAY 50 & TEST WELL AT HALSTEAD, KS

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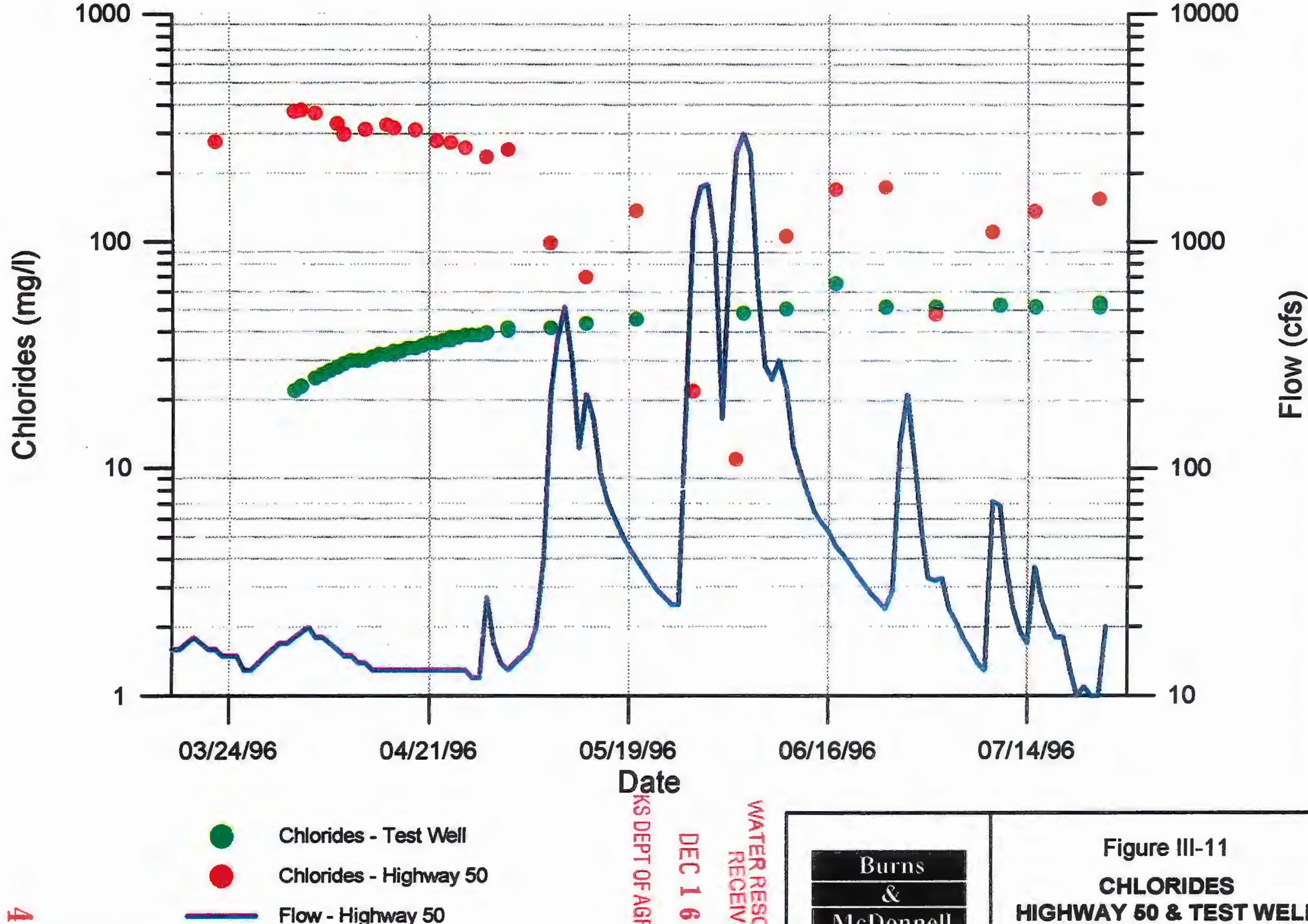

Burns & McDonnell

Figure III-11

CHLORIDES HIGHWAY 50 & TEST WELL AT HALSTEAD, KS

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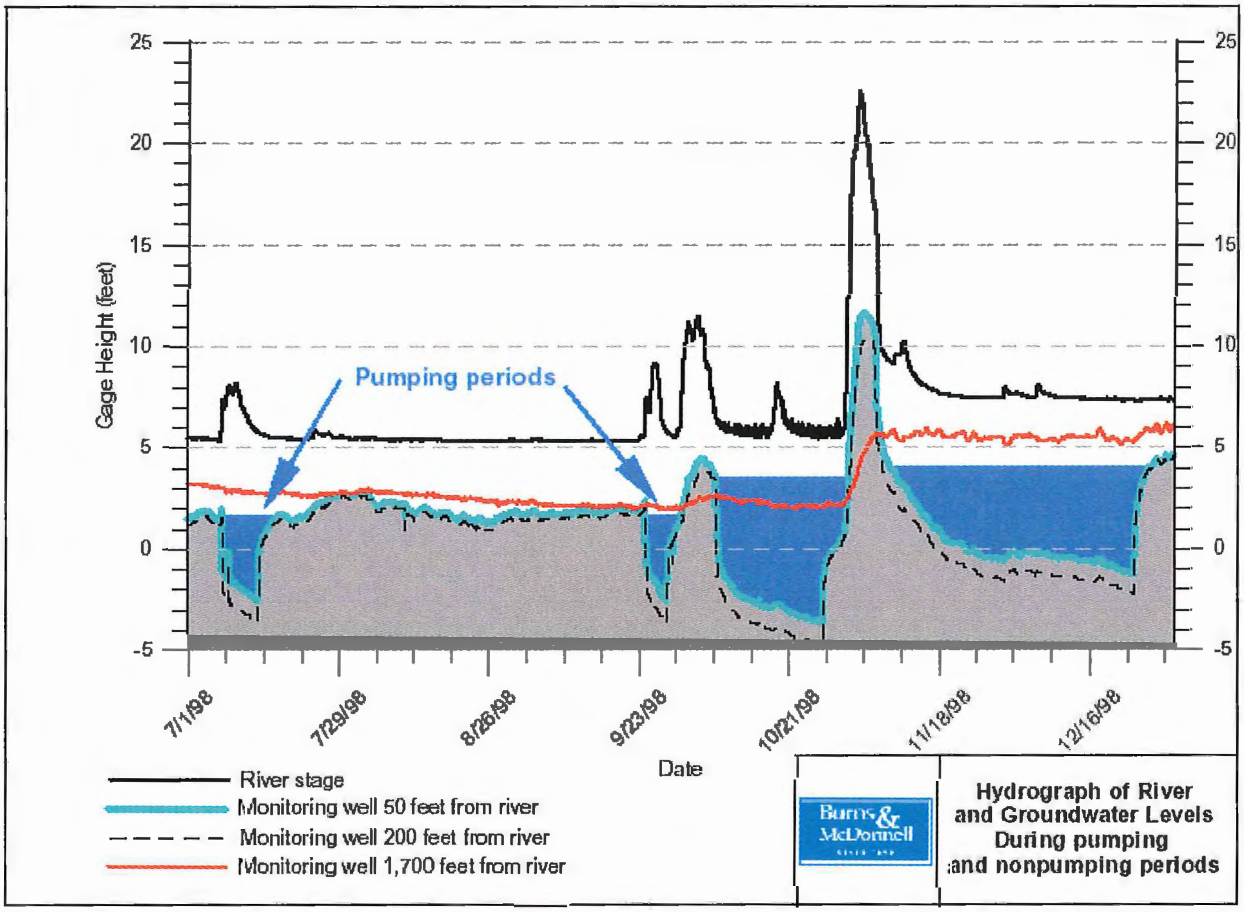
1998 Hydrograph of Little Arkansas River



Pumping was started on September 23, 1998
Pumping ended on December 17, 1998
Well pumped for 86 consecutive days
Total pumpage was 117 million gallons
Groundwater levels 3 ft. higher than before pumping started.

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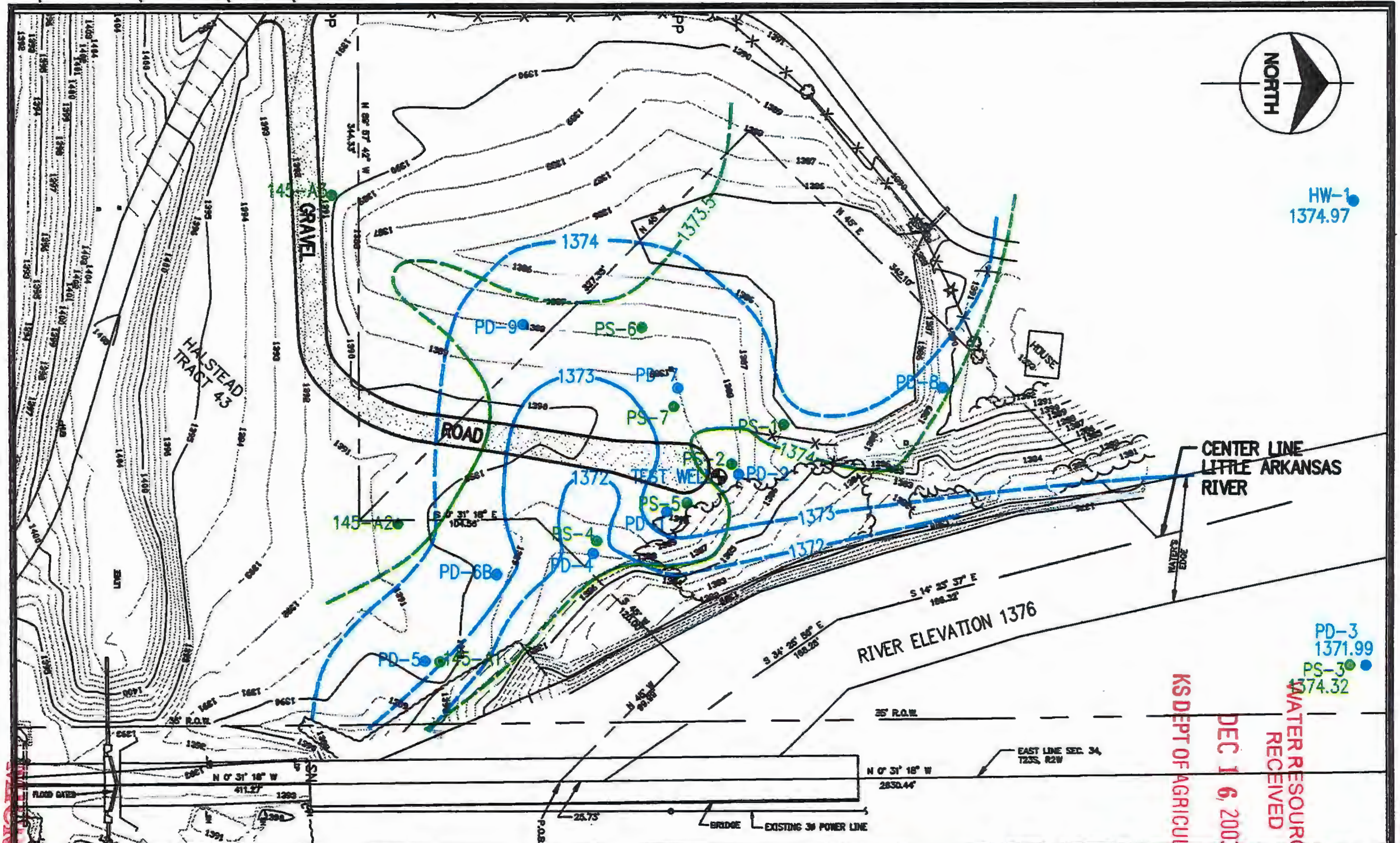
J:\WICHITA\921954\MISC\FIG2.DWG 10-18-1996 09:52 CWL



LEGEND

PS – SHALLOW PIEZOMETER

—1374— SHALLOW ZONE – GROUNDWATER EL.

PD – DEEP PIEZOMETER

—1374— DEEP ZONE – GROUNDWATER EL.

145-A1 – STRING WELL

⊕ – TEST WELL

HW – HOUSE WELL

80 0 80 160

SCALE IN FEET

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Figure III-3

POTENTIOMETRIC SURFACE MAP
STATIC WATER LEVELS
SITE TH-04

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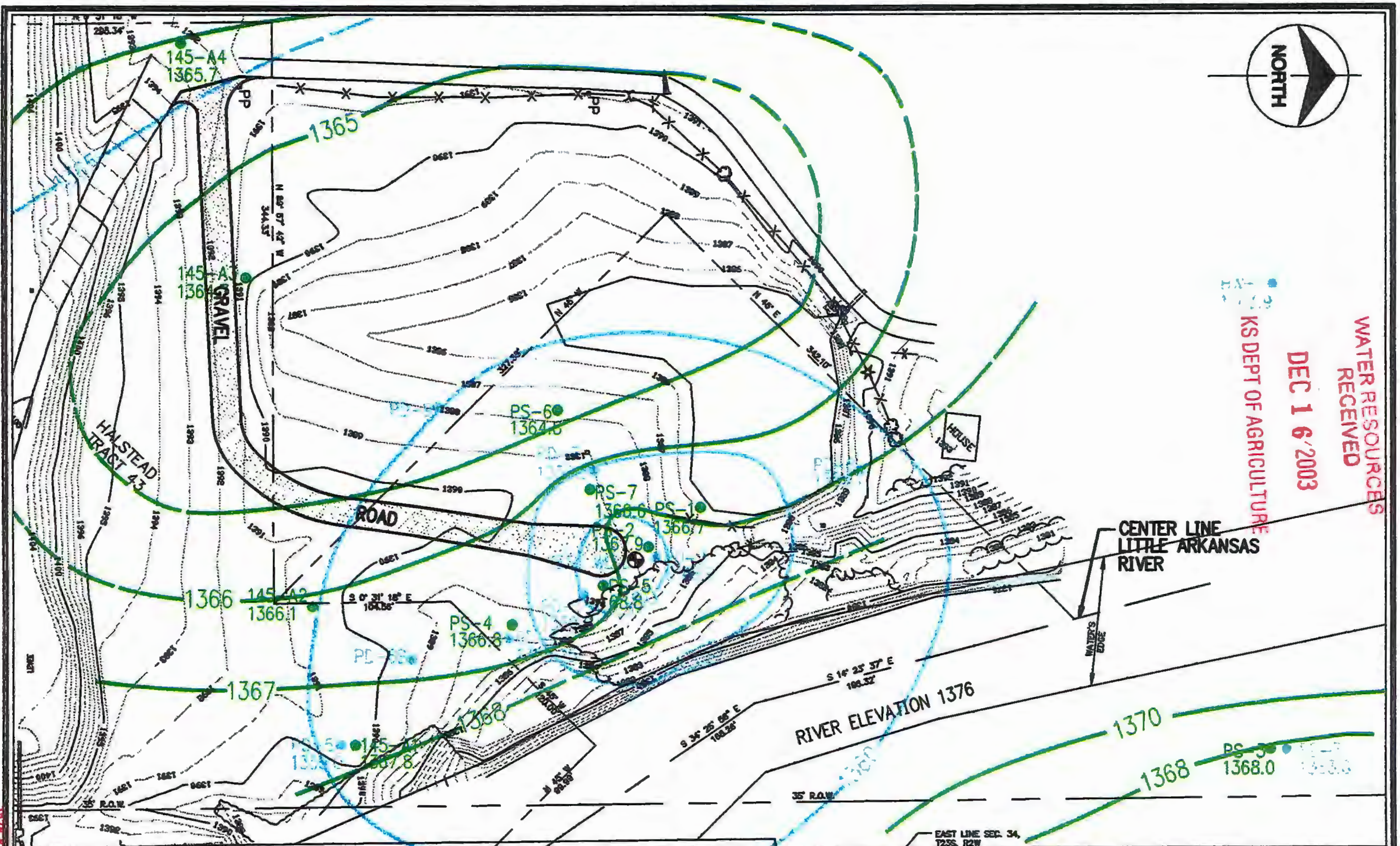
J:\WICHITA\921954\MISC\FIG3.DWG 10-18-1996 09:54 CWL



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LEGEND

PS – SHALLOW PIEZOMETER
—1374— SHALLOW ZONE – GROUNDWATER EL.
PD – DEEP PIEZOMETER
–1374– DEEP ZONE – GROUNDWATER EL.
145-A1 – STRING WELL
⊕ – TEST WELL
HW – HOUSE WELL

80 0 80 160
SCALE IN FEET

NOTE:
GROUND WATER EL. AFTER 24 DAYS OF PUMPING
Q = 863 GPM (APRIL 26, 1996)

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Figure III-4

POTENTIOMETRIC SURFACE MAP
UPPER & LOWER ZONES
DURING 30-DAY PUMP TEST

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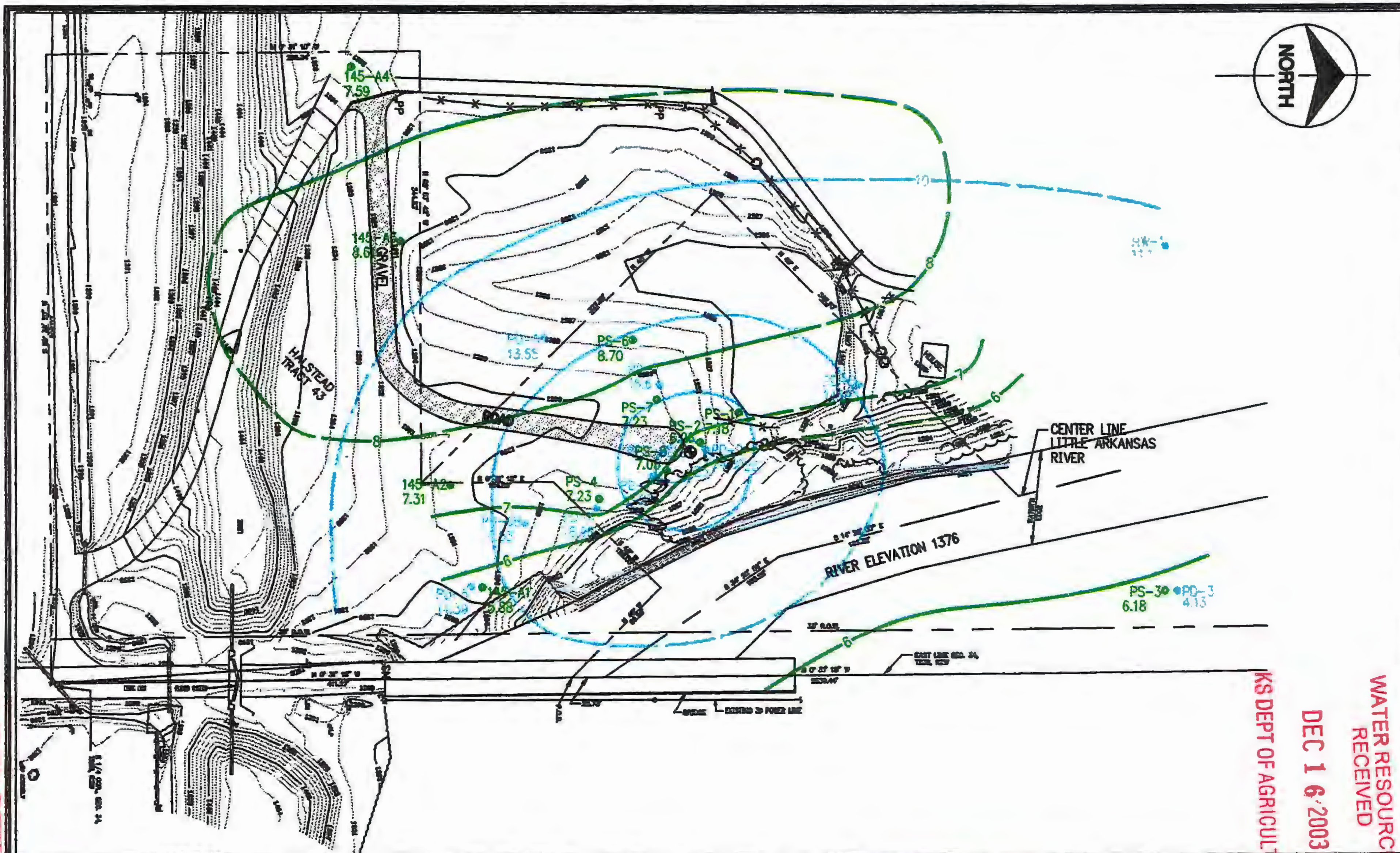

LEGEND

- 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

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Drilling conducted at the City wells for the test pit infiltration basin siting showed the soils have a variable fine-grained topsoil thicknesses that will affect design and construction of recharge basins. Generally, the fine-grained topsoil layer is thicker at the northern City wells (12 to 14 feet) and thinner in the southern and middle wells (5 to 7 feet). A clay layer is locally present at some City wells at depths of 15 to 25 feet. These clay layers, where present, may inhibit the vertical percolation of recharge water, reducing the overall recharge rate. Detailed drilling and analysis of the subsurface conditions will be required at each potential recharge basin site to help determine specific geology, suitability and design criteria for Project infiltration basin construction.

D. AQUIFER TESTING

Site TH-04, the Halstead site, was selected for the test well due to the excellent river-aquifer interaction characteristics shown by the groundwater quality responses to changes in river water quality, land availability, distance from the well site to proposed recharge area, and distance from the irrigation and domestic wells. Review of water level data shown in Figure III-1 for the string wells at Site TH-04 shows the site is influenced by tail-water effects from the low-head dam located approximately one mile downstream of the test site. River water levels are approximately 1 to 1.5 feet higher than adjacent groundwater levels in the upper aquifer zone at low flow conditions. This indicates the water flows from the river to the aquifer, thus providing recharge water to the aquifer.

1. PRETEST FINDINGS

After installation of the string wells at Site TH-04 (EB145-A1 through EB145-A5), groundwater and river stage was monitored prior to the pumping tests. Significant barometric pressure response was noted in the shallow monitoring wells possibly indicating semi-confined conditions shown in the early part of the hydrographs in Figures II-6 and III-1. After the pump was started, water levels in the upper aquifer zone declined below the bottom of the surficial silty clay

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clay layer and the barometric effects were no longer present. Through the pretest monitoring, the gradient away from the river declined slightly, probably due to regional recovery from the previous irrigation pumping season.

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2. 24-HOUR ACCEPTANCE TEST

After the test well was constructed and developed, a 24-hour acceptance test was performed to verify river-aquifer interaction, well efficiency and aquifer recovery. The 24-hour specific capacity was 31.3 gallons per minute per foot of drawdown (gpm/ft-dd). Based on distance-drawdown calculations using data from the deep zone observation wells, the apparent transmissivity is 7,240 ft^2/day and the apparent storativity is 0.0013. Based on the Theis equation, the theoretical specific capacity for the well should be 28.9 gpm/ft-dd, yielding a well efficiency over 100 percent. Based on these results, the test well appears to have been constructed and developed adequately.

3. 30-DAY AQUIFER TEST

The purpose of the 30-day aquifer test was to collect hydraulic and water quality data on the river and the aquifer to determine if the aquifer is confined, if test well water quality is acceptable for recharge and if the provisions of the term permit can be met by the test well. The static water levels in the river and string wells, prior to the 30 day test, are shown in Figure III-1. Water levels in the upper aquifer zone show a gradient away from the river due to the artificially high river stage caused by the low-head dam downstream of the test site and possible regional drawdown west of the test site due to prior irrigation pumping.

The 30-day test began at 11:45 a.m., April 2, 1996 and the pump operated at an average discharge rate of 863 gpm until May 4, 1996 when the pump shut-down. The river stage remained constant throughout the 30-day test at elevation 1376 (gage height 5 feet) and stream flow measured at the Highway 50 gage ranged from 12 to 15 cfs.

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Hydrographs of water levels during the 30-day test are also shown in Figure III-1 for the string wells and Figure III-2 for the piezometers connected to the Hermit data acquisition system. Review of Figure III-2 shows the water level curves for monitoring wells P_s1 and P_s2 cross about 12 days into the aquifer test. Both wells are screened only in the shallow zone with well P_s2 located closer to the river than well P_s1. The closer well is influenced to a greater extent by induced infiltration from the river when stabilized pumping water levels are achieved after about 15 days. Static water levels in the upper and lower aquifer zones are shown in Figure III-3. The potentiometric surface for the upper and lower aquifer zones during the 30-day pumping test are shown in Figure III-4. Drawdown for the upper and lower zone during the 30-day test is shown in Figure III-5.

Review of the hydrographs shows that groundwater levels responded very quickly to the pumping stress by the test well. Figure III-2 shows 5 to 6 feet of drawdown in the upper aquifer zone occurred rapidly after pumping began. Water levels dropped an additional 2 feet after 4 days of pumping and drawdown stabilized after approximately 16 days of pumping. Total drawdown in the string wells in the immediate test area was about 5 to 9 feet. The greatest drawdown in the upper aquifer zone was 8.7 feet in piezometer P_s6 which is about 100 feet west of the test well. A drawdown of 8.6 feet occurred in the shallow well EB145-A3, a distance of 326 feet from the river.

Review of Figure III-5 shows two cones of depression; one in the shallow zone; and one in the deep zone. The greatest drawdown in the deep zone occurred, as expected, at the test well. The greatest drawdown in the shallow zone is displaced west of the pumping well. The displacement occurs due to river influence and geologic conditions at the site. River water enters the shallow aquifer zone but must flow west of the test well to flow around a clay layer which separates the upper and lower aquifer zones at the test well. West of the test well, in the area around EB-145-A3, the clay layer is absent and water can migrate downward.

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On April 25 and 27, 1996, interference drawdown from a distant irrigation well appears to drop water levels from 0.1 to about 0.3 foot. Water levels appeared stable for the remaining seven days of the test.

4. 75-DAY AQUIFER TEST

The 75-day aquifer test was conducted to determine if atrazine contamination of the pumping well would occur with an extended test period. Since the 75-day test followed the 30-day test, a long-term 105-day test during the spring, which has the greatest opportunity for high atrazine concentrations, resulted. On May 6, 1996, two days into the extended test, the pump failed and water levels rebounded. The contractor attempted field adjustments for the pump; however, the pump failed again and was pulled for repair. The pump was repaired, reinstalled and the 75-day test resumed on May 10, 1996. The test continued until July 24, 1996. The pumping rate for the 75-day test averaged 978 gpm.

During the 75-day test, two major stream flow events occurred. The first event occurred between May 25 through May 29, 1996 and flows reached a maximum of about 1,500 cfs. The second event lasted from May 31 through June 4, 1996 and had a maximum flow rate of about 2,600 cfs. River stage respectively increased at the test site by approximately 4 and 6 feet during these two events. The aquifer responded rapidly to the change in river stage as shown in the hydrography presented in Figure III-6. Rises in groundwater levels due to the storm event respectively ranged from 2.33 to 1.21 feet for the shallow wells within 500 feet of the river and 1.34 feet for the nearby P_d5 deep monitoring wells. Well EB145-A5, 1,600 feet from the river, showed very little or no response to the storm event.

The peak groundwater responses to the high river flow were slightly retarded. Wells more distant from the river showed the most delay and the least response. Monitoring well P_d5, a deep monitoring well 50 feet from the river, showed a delayed of response of approximately

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29 hours. This is similar to EB145-A4, a shallow monitoring well located about 500 feet from the river.

The groundwater response to the river flow indicates good hydraulic communication between the river and the shallow aquifer zone. The delayed and significant response in the deep aquifer zone indicates the response is not a pressure transfer found in isolated and confined aquifers, but a hydraulic flow response.

5. ANALYSIS OF THE AQUIFER TEST

Groundwater levels initially declined very rapidly in responses to pumping stresses from the test well and then slowly declined until steady-state conditions were achieved after about 15 to 16 days as shown in Figure III-1. Because of the influence of the river, standard time-drawdown analyses are not applicable. Additionally, review of the hydrographs also show the analyses for a leaky confined aquifer is not appropriate. All available methods of analysis for leaky confined aquifers assume the water level in the zone above the confining layer remains constant throughout the test; however, water levels in the upper zone declined 6 to 8 feet immediately after pumping began, indicating a good connection between upper and lower aquifer zones. Estimates of aquifer parameters are analyzed by distance-drawdown and steady-state analysis and discussed hereafter.

6. RECOVERY

At the conclusion of each pumping test, when the pump was shut off, groundwater levels in both the shallow and deep aquifer zones immediately recovered to approximately 70 percent of their pretest levels. After the 24-hour aquifer test, recovery to prepumping water levels was complete within one day. After the 75-day test, groundwater levels continued to slowly recover during the next 14 days to a level about 2 feet below starting elevation of the 75-day test. On August 12, 1996, a short duration storm event with a peak flow greater than 2000 cfs caused a significant rise in river stage and adjacent groundwater levels. After the storm event, groundwater

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levels dropped slightly and the next long duration storm raised the water level in the monitoring wells near the river to within 1 foot of starting elevations.

After day 34 of the 75-day pumping test, the water level in EB-145-A5, about 1500 feet away, began to slowly decline. After the 75-day pumping test was completed, water levels in EB-145-A5 continued to decline for about 20 days and then began to recover starting August 20, 1996 due to the impacts of the next major storm event.

The water level data shows interference drawdown occurring between the first of June and the end of July. It appears that the water level decline in EB-145-A5 may be due to regional lowering, caused by irrigation pumping, because the well continued to decline for 20 days after test pump was stopped.

7. DISTANCE-DRAWDOWN ANALYSIS

Drawdown in the deep piezometers are plotted versus distance and are shown in Figure III-7. Wells parallel to the river and wells perpendicular to the river are shown as separate curves and test well pumping level and drawdown in the string wells are plotted. Drawdown in string well EB145-A1 and -A2, completed in the shallow zone near the river, plot above the best fit line for piezometers perpendicular to the stream. These wells are influenced by induced infiltration from the river. Drawdown in string wells EB145-A3 and -A4, completed in the shallow zone in an area of maximum drawdown, plot on the best fit line for deep piezometers perpendicular to the stream, indicating good communication between the upper and lower aquifer zones.

The theoretical distance to zero drawdown (r_0) ranged from about 2,800 to 3,000 feet for the 24-hour test. During the 30-day test, after steady-state conditions were achieved, r_0 extended to about 6,000 feet in the line of piezometers parallel to the river and is shown to be about 1,800 feet in the piezometers perpendicular to the river. The difference is due to the clay lens beneath the test site that extends

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upstream and downstream of the test well. The lens appears to thin or is absent to the west. The results of the distance-drawdown analysis are as follows:

Piezometer Test - Line	Transmissivity (ft^2/day)	Storativity (Dimensionless)
24-hour Parallel	7,240	0.0013
30-day Parallel	6,768	0.0057
Perpendicular	4,007	0.023

8. STEADY-STATE ANALYSIS

After approximately 15 or 16 days of pumping, the aquifer reached steady-state conditions where water levels remained constant during pumping, indicating that the discharged water was being replaced by recharge. Using the Theis steady-state equation, several pairs of deep piezometers can be analyzed to determine the intervening transmissivity as follows:

Piezometer Pair	Transmissivity (Ft^2/day)
P_d8 - house	7,990
P_d2 - P_d8	8,324
P_d1 - P_d4	4,058
P_d4 - P_d6	829
P_d6 - P_d5	4,365
P_d2 - P_d9	4,840

The results of the steady-state analysis confirms the initial test boring findings that the geology is variable at the test site.

9. MODELING

The subregional model was calibrated to the 30-day aquifer test conditions. Plots of the simulated drawdown in the upper and lower zones are presented in Figure III-8. Because actual spacing for some monitoring wells is less that the model grid spacing, an exact match of test drawdowns is not possible; however, the simulated contours of drawdown match actual drawdown very well.

A water budget analysis of the subregional model indicates that 95 to 98 percent of the water removed from the lower aquifer zone migrates from the upper zones and comes from the river within 6,000 feet from

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the well. A block diagram of the water budget model is shown in Figure III-9. The analysis was performed simulating the baseflow conditions that were present at the time of the 30-day test. Further analysis using the subregional (steady state) model predicts that, during above base flow conditions (river stage increased 2 feet), 100 percent of the pumped water will migrate from the upper aquifer zone within about 3,000 feet of the pumping well. The results of the water budget model for the pumping test and above base flow simulation are listed below:

	Baseflow Conditions		River Stage Plus Two Feet	
Distance (Feet)	Percent of Distance from Change in Underflow	Percent of Discharge from Upper Zones	Percent of Discharge from Change in Underflow	Percent of Discharge from Upper Zones
2,000	43.6	56.4	18.2	81.8
3,000	19.5	80.5	___	100
4,000	16.9	84.0	___	___

10. WATER QUALITY RESPONSE TO PUMPING

Test pumping the aquifer produced a notable response in water quality. Movement of water from the river through the upper aquifer zone to the lower aquifer zone complicated analysis of the test site; however, the change in water quality from the test well during the extended pumping periods was great enough to indicate significant communication between aquifer zones and the river.

Initial specific conductance of water from the test well (lower aquifer zone) was about 545 microseimens per centimeter (μs/cm). Specific conductance in the upper aquifer zone was approximately 650 μs/cm and surface water was about 1,800 μs/cm. Throughout the test, specific conductance of the well water increased to over 700 μs/cm as shown in Figure III-10. The specific conductance in well A1 (upper aquifer zone) at the start of the 75-day aquifer test was about 900 μs/cm and increased to 1390 μs/cm after 4 days of pumping. Test well conductance then varied between 700 and 1190 μs/cm for the remainder of the aquifer test due to variations in river water conductance.

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Likewise, the chloride concentration in the test well increased throughout the test from 22 to 49 mg/L as presented in Figure III-11. The river chloride concentration varied from 376 mg/L at the beginning of the 30-day aquifer test, during low flow conditions, to 22 mg/L at the end of the 30-day test when river flows increased. During the 75-day test, chloride concentrations in the river were extremely variable and ranged from 10 to 200 mg/L with variations in stream flow.

The analysis of the pumping effects on water quality are further complicated by the high tailwater resulting from the low-head dam about one mile downstream from the test site. River stage is artificially high, about 1.5 feet above static groundwater levels, causing movement of river water into the aquifer. During the test, specific conductance in shallow monitoring wells near the river increased due to the high specific conductance in the river during the low flow conditions at the beginning of the test, demonstrating hydraulic communication between the river and upper aquifer zone. Specific conductance in the pumping well increased to levels greater then the initial values in the upper zone, indicating a good hydraulic interaction between the upper and lower aquifer zones.

E. INFILTRATION TEST PITS

1. WELL NO. 4

Infiltration testing at City Well No. 4 began April 12, 1996 and ended June 6, 1996, operating about 56 days as shown in Figure III-12. Review of the figure shows infiltration rates of 60 to 80 feet per day were maintained for the first two weeks with water depths in the pit ranging from 8 to 11 feet. After 15 days, the infiltration rate dropped to about 30 feet per day, then slowly declined to about 6 feet per day. The pit maintained an infiltration rate of about 6 to 10 feet per day for over 30 days. Groundwater appeared in the adjacent piezometer 24 hours after the start of the test and ranged in depth from 5 to 9 feet below ground surface throughout the remainder of the

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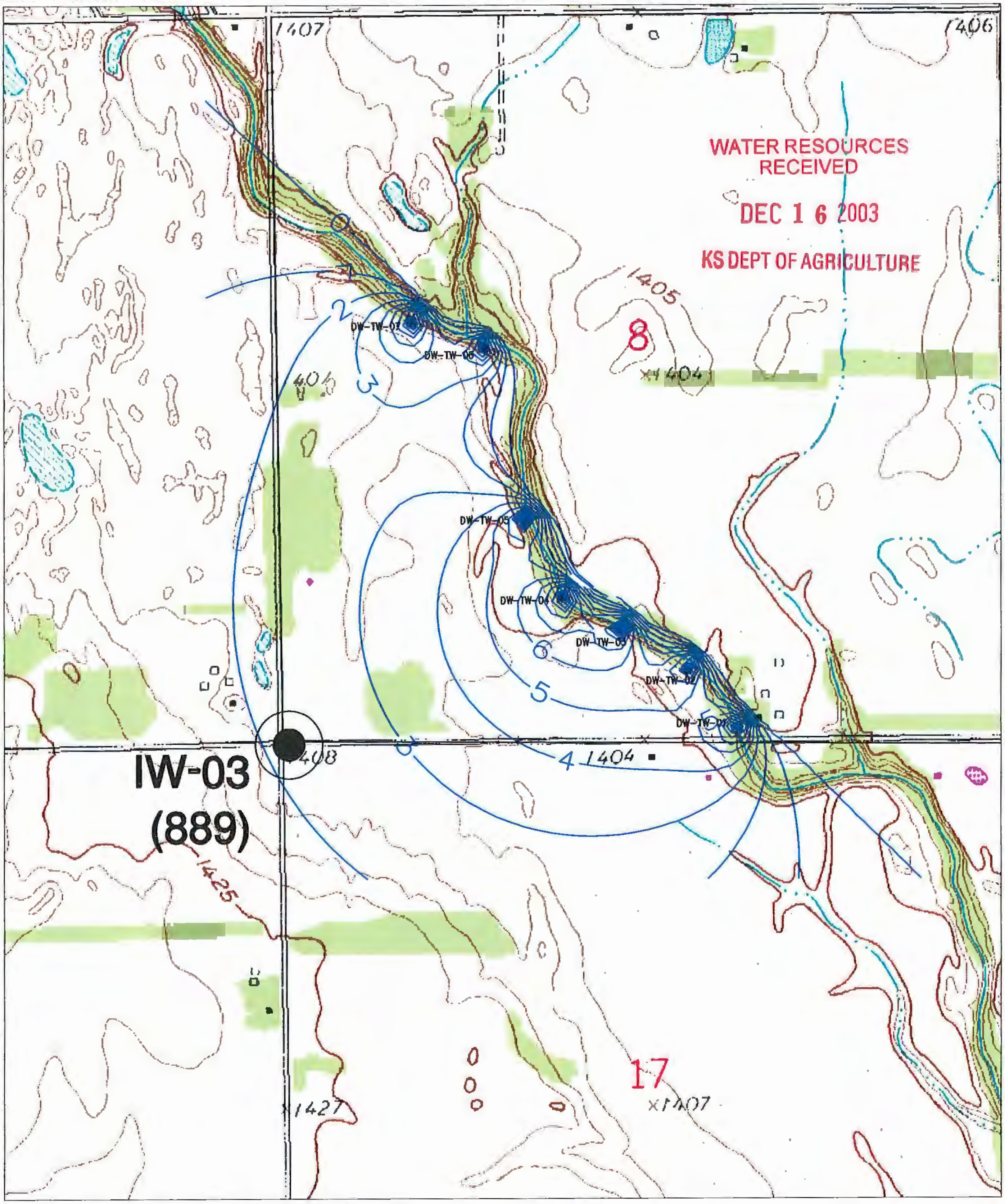

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SCALE IN FEET

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Drawdown from
DIVERSION WELLS
~~LOCATIONS~~
at Base flow

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ASR Accounting

Accounting proposed for the Wichita Equus Beds Recharge Project includes ASR credits for metered recharge that is adjusted for ASR water recovered and the amount of ASR water that enters or leaves an Index Cell through underflow or leakage to the Little Arkansas River. Movement of the ASR water is tracked using the MODFLOW model developed for the project. It is anticipated that MODFLOW runs and accounting summary will be made in the March – April time frame using the previous year's data to determine the amount of ASR water available for recovery within each Index Cell.

Accounting methodology

The basic annual accounting method is given in the following equation:

Annual account change for each index cell = ASR in – ASR out + net ASRunderflow

Where:

ASR in = metered recharge per index cell
ASR out = metered recovery per index cell

Net ASRunderflow = The Net ASRunderflow is the total <u>difference</u> between the base and ASR model runs calculated for each Index Cell. MODFLOW's cell-by-cell water budget is then processed by "Zone Budget" post-processing program.

This account change should be similar to the change in storage term in the MODFLOW budget.

Modeling Methodology

<u>MODFLOW Inputs:</u>

ASR inflow – metered annual quantity at each well and basin for each MODFLOW cell.
ASR recovered – metered annual quantity removed at each ASR well (includes pumping for maintenance.
Well pumpage – annual pumpage for each well in project area.
Precipitation – Based on monthly precipitation averaged from several stations across project area to estimate natural recharge.
River – average stream level for year.

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Accounting Runs:

Two MODFLOW runs will be made to track differences between base (no ASR) and ASR budgets. Each year will be modeled as separate stress periods. Runs will be made from base year (1993) through the currently completed year.

Model Calibration Check

In addition to the MODFLOW water budget information, a comparison of calculated water levels to measured water levels will be made to determine if additional calibration of the model is required. As actual water levels change, vertical variations in site geology may make additional model calibration necessary. If the absolute mean difference be calculated and actual water levels is greater than 5 feet, additional calibration is suggested.

Report and Documentation

The accounting report is to be submitted to DWR each April (?) for the previous year. The accounting report will consist of the following sections:

- Cover letter discussing activities and significant events of the previous year.
- The Index Cell account summary (example attached).
- ASR metered recharge and recovery (City provided).
- Well pumpage (GMD or DWR provided).
- Precipitation summary for project area.
- Average river flow levels (from USGS data).
- A detailed zone budget like report showing the Net ASRunderflow calculations.
- Calibration summary for the year.
- Water quality analyses (?).

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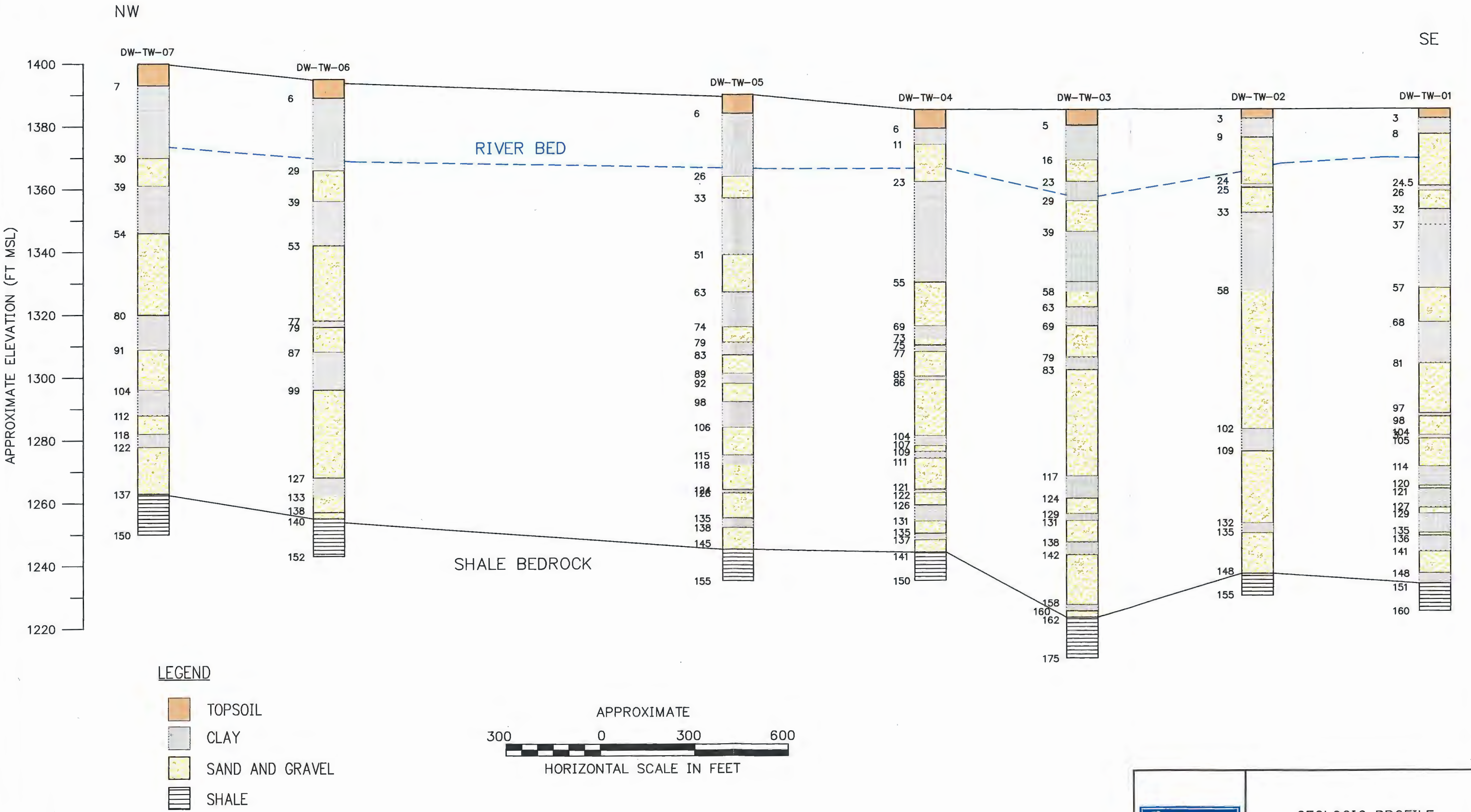

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GEOLOGIC PROFILE
DIVERSION WELL AREA

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GROUNDWATER MODELING

A. GENERAL

This part of the report describes the groundwater flow model used to evaluate aquifer flow characteristics and storage capacity in the development of conceptual design alternatives for the full-scale Equus Beds ASR Project. The basic model used in this analysis is MODFLOW, a three-dimensional, finite-difference, groundwater flow model developed by the USGS (McDonald and Harbaugh, 1988) that simulates groundwater flow, surface-water flow, and stream-aquifer interaction.

B. PREVIOUS MODELING INVESTIGATIONS

1. U.S. Geological Survey

Prior to 1988, the USGS developed a groundwater flow model to study the stream-aquifer system of the Arkansas River and the Equus Beds Aquifer which included the current study area along the Little Arkansas River. The USGS model was developed using MODFLOW for both steady state and transient simulations. Details of model construction, calibration, sensitivity analysis, and results are contained in USGS Water Resource Investigation Report (WRIR) 95-4191 (Myers et al., 1996).

The focus of the USGS study was to evaluate potential migration of high chloride water from the Arkansas River into the Equus beds Aquifer. Model simulations were also used to estimate the effects of natural and human-induced stresses on the stream-aquifer system.

Based on modeling results, the USGS concluded that two natural and three human-induced sources of chloride affect the water quality in the study area. Natural sources are the Arkansas River and the Permian-age Wellington Formation. Human-induced sources are brine from oil-fields, salt-mining, and salt refining.

Model simulations indicate that water levels in the Wichita Well Field area declined as much as 30 feet because of increasing pumpage from the aquifer. Results of simulations of hypothetical conditions during 1990-2019 indicate that streamflow losses from the Arkansas River could increase as pumpage increases because more river water would be lost to the aquifer. For the simulated period of 1990-2019, estimated chloride discharge

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from the Arkansas River to the Equus Beds Aquifer increased in proportion to increases in loss of river water.

2. U.S. Bureau of Reclamation

The Bureau of Reclamation, as part of the Arkansas River Water Management Improvement Study (1988), modified the USGS model in order to conduct a contaminant transport study. The purpose of the study was to investigate groundwater management issues regarding water quality due to migration of saline water from the Arkansas River Valley and the Burrton Oil Field area into the Equus Beds Aquifer. To improve the accuracy of the transport modeling, the Bureau of Reclamation reduced the model grid spacing and made the grid cells more square shaped. Complete details of the Bureau of Reclamation's study are given in the report titled "*Arkansas River Water Management Improvement Study, Modeling of Chloride Transport in the Equus Beds Aquifer*" (Pruitt, 1993).

Based on modeling results, hydraulic barriers and gradient control wells will restrict chloride movement from the Arkansas River, while reductions in pumpage would reduce chloride migration from both the Arkansas River and the Burrton Oil Field area. The City's ASR Project was shown to have a major impact in controlling chloride migration into the well field area.

3. Burns & McDonnell

In 1994, Burns & McDonnell completed a feasibility study for the City of Wichita's Equus Beds Groundwater Recharge Demonstration Project. For this study, the primary area of interest was the Little Arkansas River between Halstead and Valley Center, Kansas. A modified version of the USGS Equus Beds groundwater flow model (Myers, et al., 1996) was used to perform the groundwater modeling for this study. The USGS model was modified (re-gridded) in order to provide the necessary detail in the area of interest. The model was used to evaluate aquifer dynamics, including storage depletion-aquifer discharge relationships, which were used in the City's Integrated Local Water Supply (ILWS) Plan operations model.

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C. CONCEPTUAL MODEL

1. Description

The conceptual groundwater model for the Wichita Well Field study area is shown in Figure 1. A conceptual model is a visual representation of aquifer conditions, illustrating the model layers and assumed boundary conditions in the area to be modeled. Hydrostratigraphic units and system boundaries are identified and initial aquifer parameters are estimated.

The Equus Beds Aquifer has three recognized hydrogeologic units. The upper and lower units consist primarily of sand and gravel interbedded with clay and silt. The middle unit consists primarily of clay or silty clay with some sand and gravel. The block diagram in Figure 1 is the basis for the Equus Beds Aquifer model construction using the USGS MODFLOW program.

The conceptual model of the Equus Beds Aquifer used in this study has not changed from the original model created by the USGS (Myers et al., 1996). The boundary conditions, aquifer properties, sources of recharge and discharge remain the same.

2. Boundary Conditions

Boundary conditions established in the original USGS model are maintained for this study. The bottom boundary of the Equus Beds Aquifer is the shale of the Wellington Formation and the Ninnescah Shale which have low permeabilities and inhibit vertical groundwater flow. These formations are represented by a no-flow lower boundary in the model. In the areas where the aquifer extends laterally beyond the model boundaries, constant head cells are used to simulate the effects of distant parts of the aquifer as shown in Figure 2. The upper boundary of the model is represented by the water table.

3. Stream-Aquifer Interaction

The Equus Beds Aquifer model uses stream cells to simulate the interaction of the groundwater and surface water. The Arkansas and Little Arkansas Rivers and their tributaries are the major surface water bodies in the study area and are simulated as stream cells in layer 1 of the model as shown in Figure 2. The use of stream cells allows

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simulation of groundwater flow from the aquifer to the stream or, during periods of high flow, movement of water from the stream into the aquifer.

4. Aquifer Properties

Aquifer properties for the model, including horizontal and vertical hydraulic conductivity, storage coefficient, and specific yield, are presented in Attachment 1. Horizontal hydraulic conductivities from the original USGS model were modified during model calibration for this study. The vertical hydraulic conductivity is calculated by multiplying an assumed vertical-to-horizontal hydraulic conductivity ratio (K_v/Kh) of 0.005 times the horizontal hydraulic conductivity for each model cell. The MODFLOW model is set to read these values and to calculate the vertical conductance between model cells.

A specific yield of 0.15 is used for Layer 1. Storage coefficients for each cell in layers 2 and 3 are calculated by multiplying an assumed specific storage of 0.0001 ft^{-1} times the layer thickness. The calculated storage coefficients range between 0.0004 and 0.0113.

5. Recharge and Discharge

Recharge to the Equus Beds Aquifer is from subsurface inflow, precipitation, streamflow losses, and irrigation return flow. Recharge from precipitation occurs throughout the study area, except at shale outcrop formations. The amount of recharge from precipitation is the total precipitation minus surface runoff and evapotranspiration. Based on soil-moisture water balance computations, mean annual recharge values range from 0.44 to 6.02 inches (Myers et al., 1996). Recharge rates used in the model range from 0.1 to 5.5 inches per year and average 3.1 inches per year. A figure illustrating the recharge values is presented in Attachment 1.

Recharge from streams is primarily from the Arkansas River. Simulated stream flows used in the model are the same as those used in the original USGS model. Streamflows for the "starting-model" reaches of the Arkansas River and the Little Arkansas River are determined through trial and error methods. Simulated streamflow at river gages (near Hutchinson and Valley Center) approximate the estimated streamflow exceeded 70 percent of the time. Stream leakage to the aquifer is simulated by calculating a streambed conductance value based, in part, on the vertical hydraulic conductivity of the

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streambed. Vertical conductivity values used in the model are 0.5 ft/day for Emma, East Emma, West Emma, and Sand Creeks; 5 ft/day for the Little Arkansas River; 1 ft/day for Cow Creek; and 50 ft/day for the Arkansas River (Myers et al., 1996).

Discharge from the Equus Beds Aquifer is from subsurface outflow, evapotranspiration, streamflow gains, and well pumpage. Evapotranspiration components include discharge from the unsaturated zone and phreatophytic consumption of the saturated zone. Evapotranspiration of the unsaturated zone is accounted for in the values for recharge by precipitation. Phreatophytic consumption is modeled separately (Myers et al., 1996).

Well pumpage is a major source of discharge from the Equus Beds Aquifer. Groundwater is pumped from the aquifer for irrigation, municipal, and industrial use. Well pumpage data used in the model was provided by the Kansas Department of Agriculture, Division of Water Resources (DWR). Wells are simulated in Layers 1, 2, and 3 of the model; however, where Layer 3 was thin or absent, wells are simulated in Layers 1 and 2. Total pumpage for each well was distributed evenly between the layers.

D. MODEL REFINEMENTS

1. Description

For this study, the main area of interest includes the Wichita Well Field; therefore, the model used in the Burns & McDonnell 1994 study was re-gridded to provide additional detail in this area as shown in Figure 2. The current version has 84 rows, 120 columns, and 3 layers. The grid spacing ranges from 1,000 feet in the vicinity of the well field to 5,000 feet at the model edges. This model configuration is used in the conceptual design analyses.

2. Boundary Conditions

The re-gridding of the USGS model made it necessary to adjust the boundary conditions of the model to match the revised grid configuration. The boundaries are set as close as possible to boundary conditions in the USGS model. Additionally, the stream package is re-constructed to reflect the revised grid spacing. Boundary conditions for each model layer are presented in Attachment 1.

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3. Hydrogeologic Units

The top and bottom elevations of the model layers, representing the three hydrogeologic units, are updated using soil boring information obtained during the 1995 and 1998-1999 hydrogeologic investigations. Figures illustrating the top and bottom elevations are presented in Attachment 1. The addition of this information allowed the model to more realistically represent subsurface conditions in the well field area. The same methodology employed by the USGS was employed to define the top and bottom elevations of each model layer, including review of lithologic logs, gamma ray logs, electrical resistivity logs, and grain-size analyses for 95 test sites.

4. 1992 Steady State Model

For this study, the steady state model is set to represent 1992 hydrogeologic conditions. Based on historical quarterly water level measurements, the USGS has determined that the January 1993 water levels represent the lowest non-pumping levels recorded in the aquifer. The 1992 pumpage, which produced the January 1993 water levels, is simulated in a steady state model to provide reference levels for subsequent transient model simulations. During the steady state simulation, the geometry, aquifer properties, recharge, and discharge were held constant. Additionally, during steady state conditions, the aquifer-storage change was assumed to be zero.

5. Transient Model

The transient model has the same aquifer properties as the 1992 steady state model. Recharge, streamflow, and pumpage vary for each stress period to reflect actual conditions for that year. Specific yield and storage coefficient values are included in the simulations. The transient model simulates 9 stress periods, representing years 1993 through 2001. Head elevations from the 1992 steady state model are used as the starting point for the transient simulation. Pumpage is adjusted to represent data provided by the DWR. Recharge for each year is adjusted based on actual precipitation data from five recording stations (Hutchinson, Mount Hope, Newton, Sedgwick, and Wichita). Stream flows for the Arkansas and Little Arkansas rivers are adjusted based on measured stream flow data for two gaging stations (Hutchinson and Valley Center).

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E. MODEL CALIBRATION

1. Description

Calibration of the model is performed to match simulated values of hydraulic head (water levels) with observed values. During calibration, model input parameters are modified to achieve a reasonable match based on residual (observed heads minus modeled heads) statistics. Based on the calibration results, model input values are refined to produce the best representation of the aquifer system. The original model was previously calibrated by the USGS. Calibration statistics are calculated for the steady state and transient models as a check of the refined model calibration.

Another calibration parameter calculated by the model is the volumetric balance between the movement of water into and out of the aquifer. The accuracy of the volumetric water balance (or budget) is represented as the percent discrepancy between total model inflow and outflow. A budget discrepancy of less than 1 percent is considered acceptable for most modeling studies.

2. 1992 Steady State Model

For the 1992 steady state simulation, the model calculated potentiometric surface is compared to the measured January 1993 potentiometric surface. The absolute residual mean between measured heads for 38 monitoring wells (index wells) and their corresponding model calculated heads is 4.57 ft. The model calculated budget discrepancy for this steady state model is 0.01 percent. Complete calibration statistics are presented in Attachment 2.

3. Transient Model

For the transient simulation, the model calculated potentiometric surface is compared to the measured potentiometric surfaces for January for the years 1993 through 2001. These values compare favorably with the USGS calibration of the original model, which had absolute residual mean values ranging from 2.15 feet to 6.76 feet. The model calculated budget discrepancy for each stress period in the transient model is less than 1 percent. Calibration statistics for the transient model are presented in Attachment 2.

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F. SENSITIVITY ANALYSIS

Sensitivity analysis is the process of identifying model parameters that have the greatest effect on model calibration and/or model prediction. A sensitivity analysis, performed for the USGS model, included evapotranspiration, stream bed conductance, streamflow, recharge, and hydraulic conductivity. Changes in the rate of recharge and hydraulic conductivity had the most effect on the absolute residual mean (Myers et al., 1996).

As part of this study, an analysis was performed to evaluate the sensitivity of the model to changes in hydraulic conductivity, storage, specific yield, recharge, and riverbed conductivity. During the analysis, model runs were performed using multipliers of 0.5, 1, and 1.5 times the final calibrated value of each parameter. Model calculated groundwater elevations were then compared to show the effect of changing each parameter. Graphs of the sensitivity analysis results are presented in Attachment 3.

The results of the sensitivity analysis indicate that changes in hydraulic conductivity had the most effect on model results

* * * * *

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Figures

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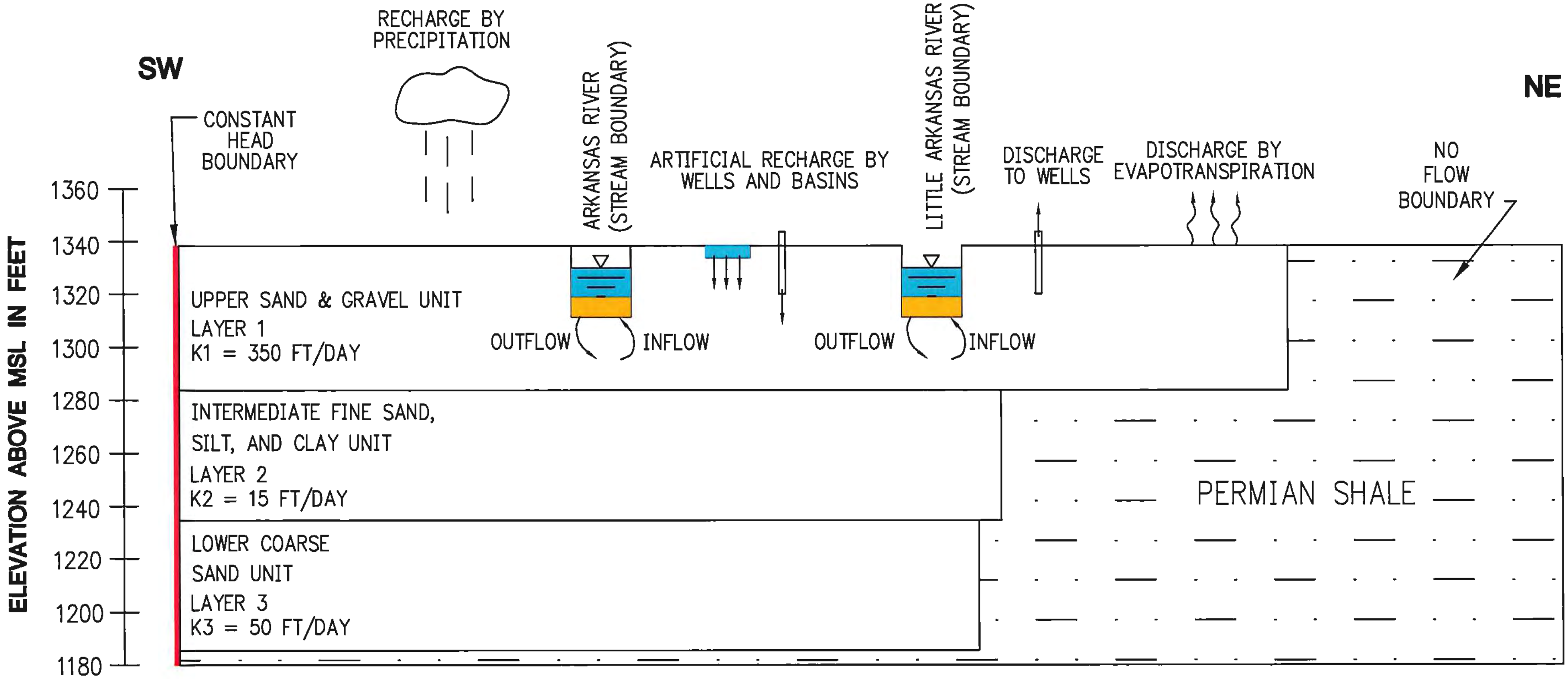

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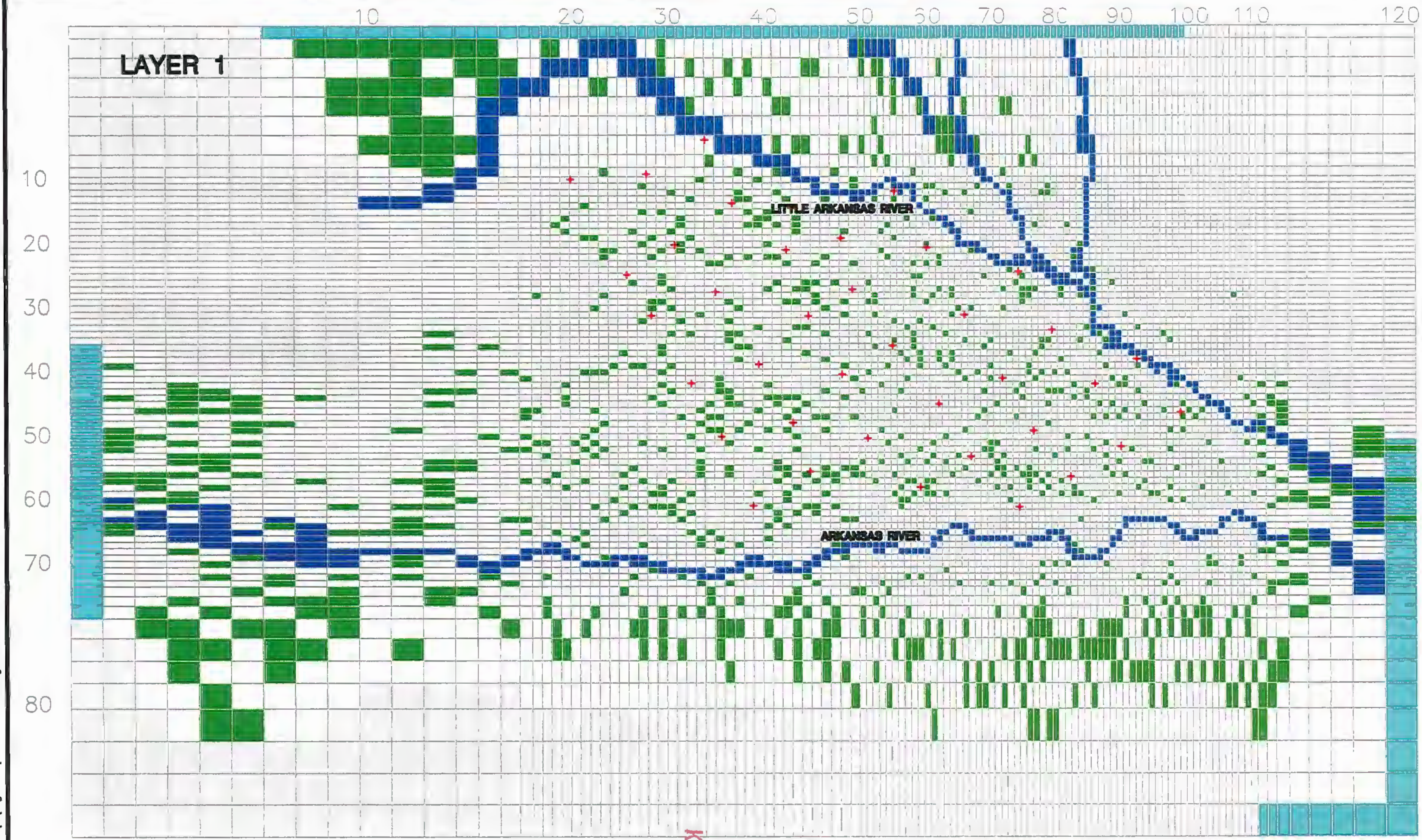
Burns & McDonnell SINCE 1898

Figure 1

WICHITA WELL FIELD CONCEPTUAL MODEL



Burns & McDonnell SINCE 1898

Figure 2
WICHITA WELL FIELD
REVISED MODEL GRID

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Attachment 1
Boundary Conditions and Model Properties

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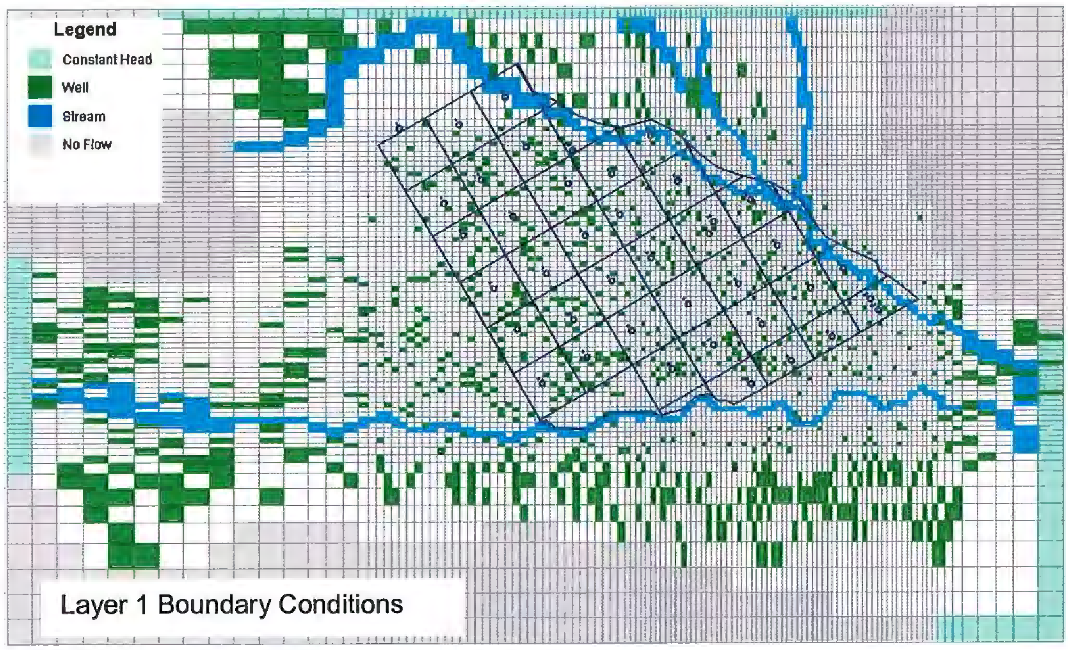

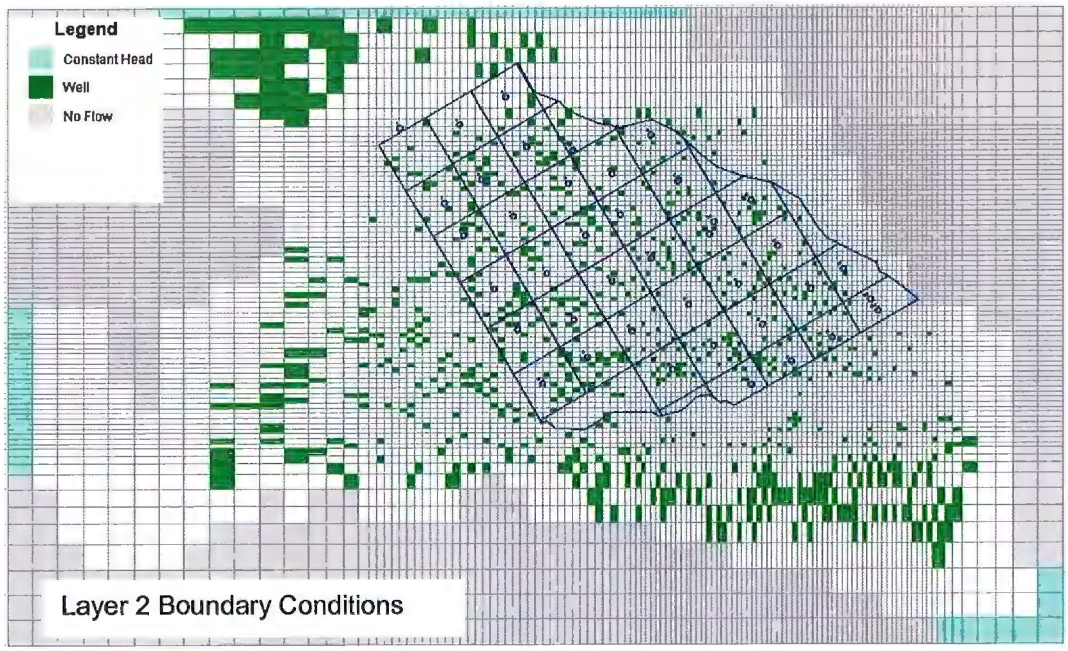

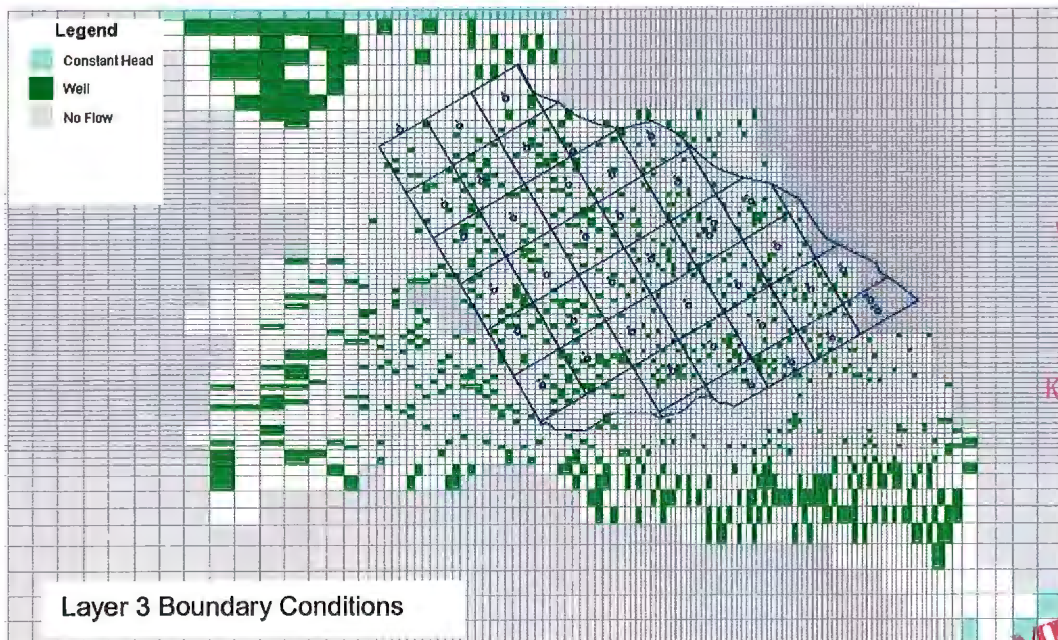

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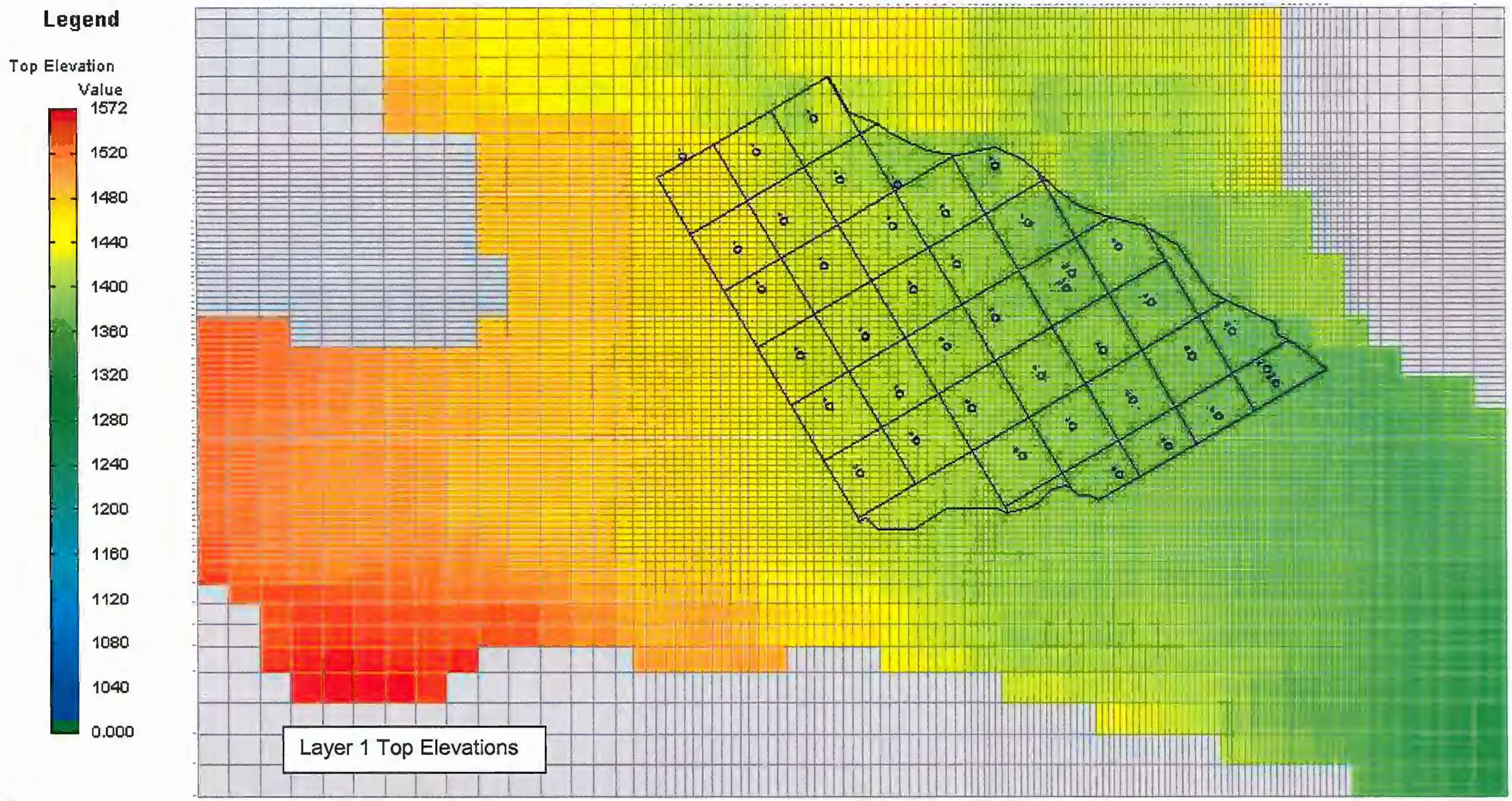

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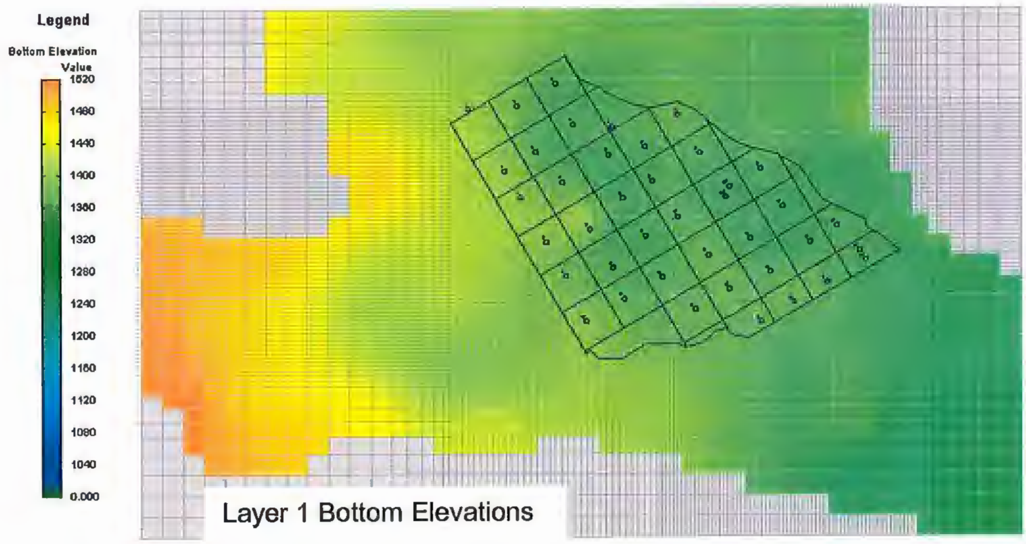
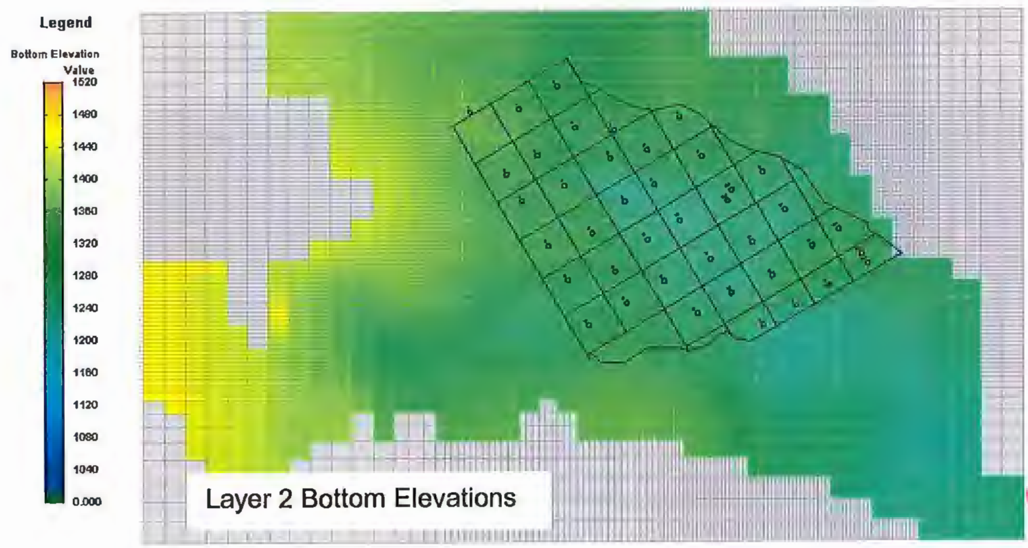


Layer 1 Bottom Elevations



Layer 2 Bottom Elevations

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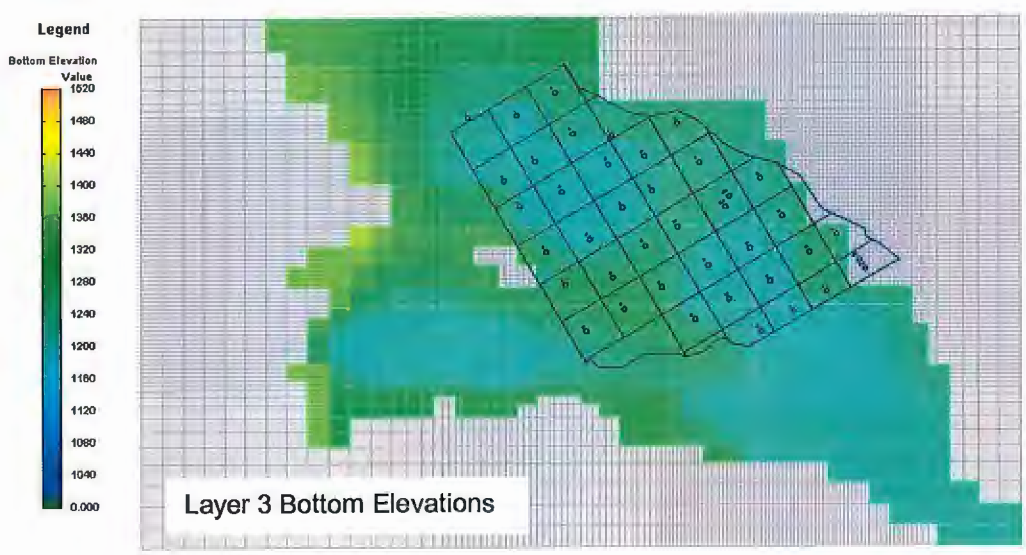

Layer 3 Bottom Elevations

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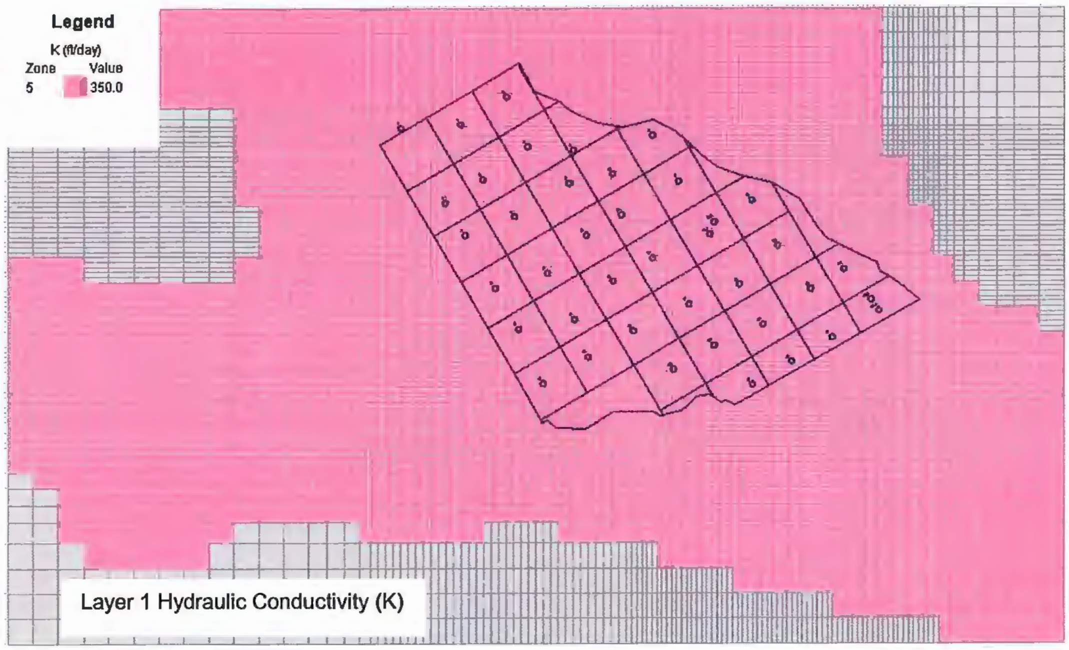

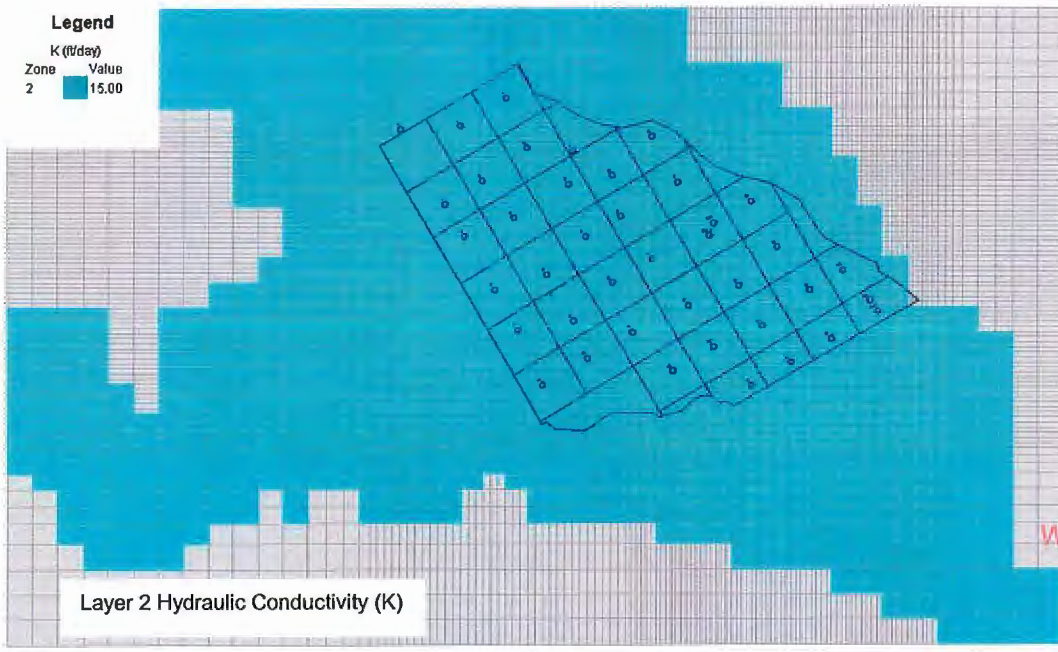

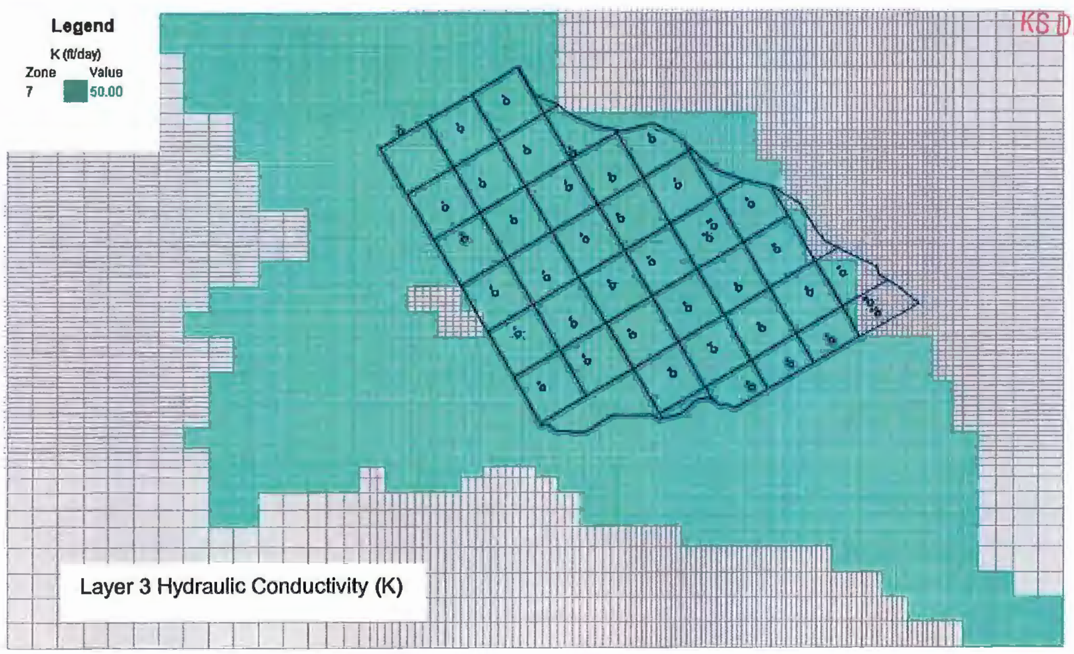

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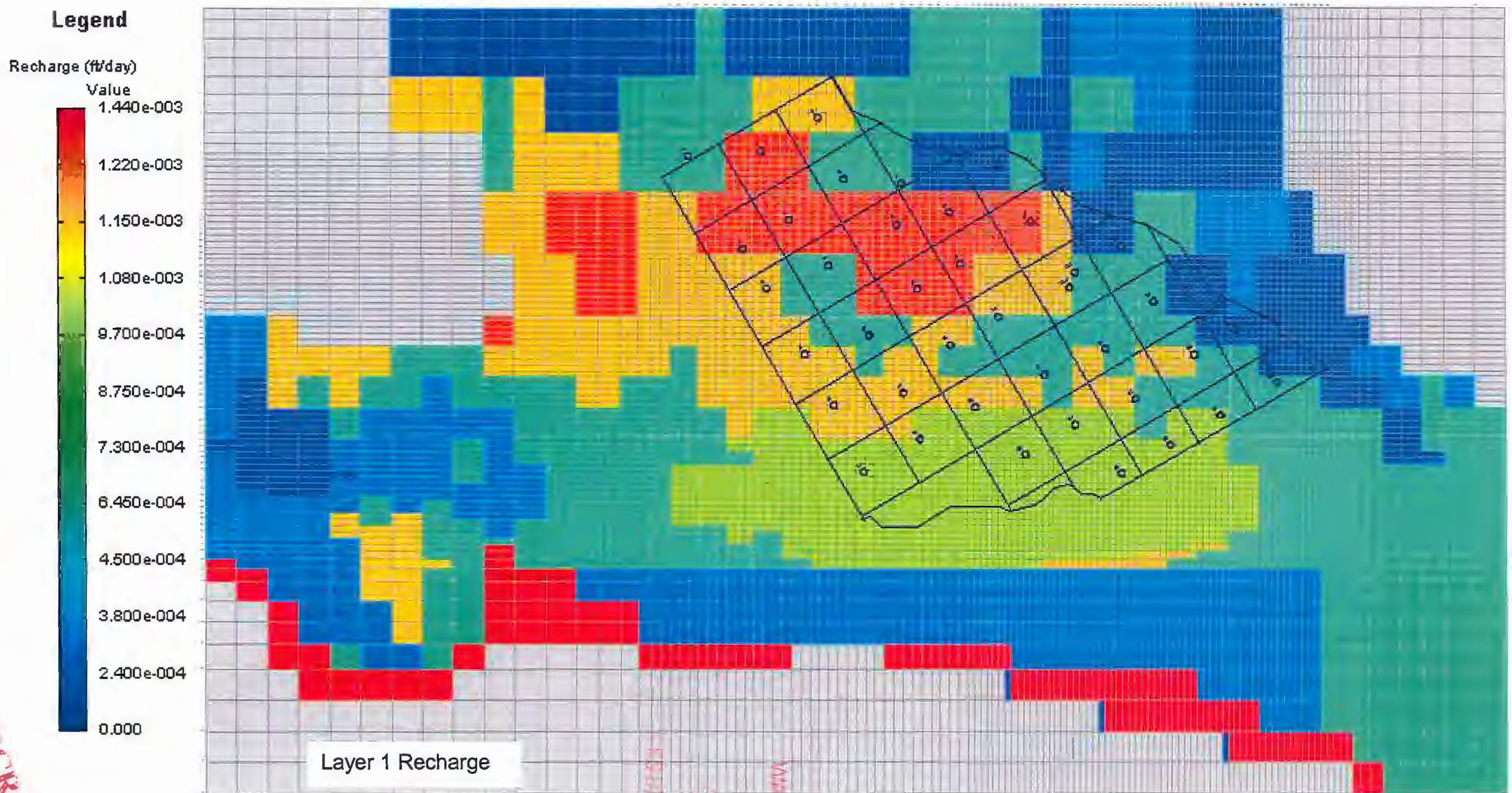

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Attachment 2
Model Calibration Statistics

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1940 Residuals

Index Well	Layer	Observed	Computed	Residual
IW1	2	1424.15	1432.14	-7.99
IW2	2	1416.80	1419.34	-2.54
IW3	2	1400.00	1403.00	-3.00
IW4	2	1431.35	1434.20	-2.85
IW5	2	1425.41	1422.87	2.54
IW6	2	1412.13	1408.87	3.26
IW7	2	1395.64	1399.54	-3.90
IW8	2	1430.97	1433.61	-2.64
IW9	2	1421.45	1420.86	0.59
IW10	2	1412.43	1406.35	6.08
IW11	2	1390.00	1396.65	-6.65
IW12	2	1370.00	1381.30	-11.30
IW13	2	1430.00	1431.34	-1.34
IW14	2	1417.50	1418.65	-1.15
IW15	2	1408.33	1409.08	-0.75
IW16	2	1398.33	1400.44	-2.11
IW17	2	1375.81	1382.55	-6.74
IW18	2	1425.68	1428.12	-2.44
IW19	2	1414.21	1416.07	-1.86
IW20	2	1404.48	1407.52	-3.04
IW21	2	1392.94	1397.56	-4.62
IW22	2	1374.75	1381.80	-7.05
IW23	2	1361.67	1368.71	-7.04
IW24	2	1421.94	1423.85	-1.91
IW25	2	1412.72	1414.24	-1.52
IW26	2	1401.19	1405.44	-4.25
IW27	2	1389.57	1392.24	-2.67
IW28	2	1376.69	1379.67	-2.98
IW29	2	1365.41	1368.46	-3.05
IW30	2	1396.86	1397.08	-0.22
IW31	2	1385.00	1387.84	-2.84
IW32	2	1374.00	1376.96	-2.96
IW33	2	1360.00	1363.65	-3.65
IW34	2	1349.26	1351.76	-2.50
IW35	2	1378.96	1380.09	-1.13
IW36	2	1370.00	1371.20	-1.20
IW37	2	1360.00	1361.19	-1.19
IW38	2	1350.00	1347.80	2.20

WATER RESOURCES
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Residual Mean	-2.65
Res. Std. Dev.	3.20
Sum of Squares	672.96
Abs. Res. Mean	3.40
Min. Residual	-11.30
Max. Residual	6.08
Head Range	86.35
Std/Head Range	0.04

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Jan. 1993 Residuals

Name	Layer	Observed	Computed	Residual
IW1	2	1413.48	1427.52	-14.04
IW2	2	1408.97	1412.35	-3.38
IW3	2	1396.62	1399.64	-3.02
IW4	2	1423.30	1423.74	-0.44
IW5	2	1407.27	1409.16	-1.89
IW6	2	1387.04	1395.12	-8.08
IW7	2	1363.97	1384.74	-20.77
IW8	2	1421.58	1421.26	0.32
IW9	2	1402.49	1400.73	1.76
IW10	2	1385.00	1383.69	1.31
IW11	2	1365.00	1377.41	-12.41
IW12	2	1369.56	1376.26	-6.70
IW13	2	1422.04	1417.88	4.16
IW14	2	1396.35	1393.13	3.22
IW15	2	1366.74	1378.86	-12.12
IW16	2	1360.00	1368.68	-8.68
IW17	2	1365.00	1369.49	-4.49
IW18	2	1420.45	1415.07	5.38
IW19	2	1401.85	1397.29	4.56
IW20	2	1380.00	1383.15	-3.15
IW21	2	1367.02	1369.26	-2.24
IW22	2	1355.00	1359.18	-4.18
IW23	2	1358.78	1361.43	-2.65
IW24	2	1418.52	1417.47	1.05
IW25	2	1407.04	1401.77	5.27
IW26	2	1390.00	1386.58	3.42
IW27	2	1371.19	1367.42	3.77
IW28	2	1351.17	1350.87	0.30
IW29	2	1351.13	1353.98	-2.85
IW30	2	1390.00	1385.04	4.96
IW31	2	1377.50	1371.65	5.85
IW32	2	1361.79	1356.76	5.03
IW33	2	1344.00	1342.68	1.32
IW34	2	1351.00	1347.67	3.33
IW35	2	1376.77	1374.85	1.92
IW36	2	1365.00	1361.62	3.38
IW37	2	1351.00	1348.36	2.64
IW38	2	1343.00	1342.44	0.56

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Residual Mean	-1.31
Res. Std. Dev.	6.01
Sum of Squares	1475.83
Abs. Res. Mean	4.57
Min. Residual	-20.77
Max. Residual	5.85
Head Range	80.30
Std/Head Range	0.07

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Jan. 1998 Residuals

Name	Layer	Observed	Computed	Residual
IW1	2	1422.99	1432.10	-9.11
IW2	2	1415.42	1416.63	-1.21
IW3	2	1400.00	1401.76	-1.76
IW4	2	1426.15	1429.29	-3.14
IW5	2	1412.96	1416.81	-3.85
IW6	2	1401.76	1403.70	-1.94
IW7	2	1381.49	1392.49	-11.00
IW8	2	1425.70	1427.26	-1.56
IW9	2	1407.83	1412.29	-4.46
IW10	2	1391.43	1395.82	-4.39
IW11	2	1376.48	1386.47	-9.99
IW12	2	1369.08	1378.72	-9.64
IW13	2	1425.35	1423.66	1.69
IW14	2	1401.43	1408.16	-6.73
IW15	2	1382.88	1395.68	-12.80
IW16	2	1372.33	1385.84	-13.51
IW17	2	1367.64	1375.42	-7.78
IW18	2	1424.29	1421.02	3.27
IW19	2	1406.50	1407.59	-1.09
IW20	2	1385.91	1396.32	-10.41
IW21	2	1370.80	1383.48	-12.68
IW22	2	1356.67	1370.83	-14.16
IW23	2	1357.47	1365.78	-8.31
IW24	2	1420.47	1420.66	-0.19
IW25	2	1409.32	1408.58	0.74
IW26	2	1390.88	1397.53	-6.65
IW27	2	1373.93	1380.86	-6.93
IW28	2	1355.50	1367.65	-12.15
IW29	2	1350.48	1362.49	-12.01
IW30	2	1392.02	1391.73	0.29
IW31	2	1379.25	1380.49	-1.24
IW32	2	1363.96	1369.03	-5.07
IW33	2	1348.91	1356.45	-7.54
IW34	2	1345.00	1349.76	-4.76
IW35	2	1377.87	1377.80	0.07
IW36	2	1365.00	1367.02	-2.02
IW37	2	1354.73	1356.56	-1.83
IW38	2	1345.27	1345.74	-0.47

Residual Mean	-5.38
Res. Std. Dev.	4.81
Sum of Squares	1976.68
Abs. Res. Mean	5.70
Min. Residual	-14.16
Max. Residual	3.27
Head Range	81.15
Std/Head Range	0.06

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Jan. 2002 Residuals

Name	Layer	Observed	Computed	Residual
IW1	2	1417.86	1429.89	-12.03
IW2	2	1412.49	1414.86	-2.37
IW3	2	1395.02	1401.87	-6.85
IW4	2	1421.42	1427.35	-5.93
IW5	2	1415.52	1415.14	0.38
IW6	2	1398.20	1402.37	-4.17
IW7	2	1382.70	1393.03	-10.33
IW8	2	1425.21	1425.49	-0.28
IW9	2	1407.44	1411.54	-4.10
IW10	2	1394.97	1396.92	-1.95
IW11	2	1378.62	1386.99	-8.37
IW12	2	1367.60	1378.98	-11.38
IW13	2	1424.09	1422.37	1.72
IW14	2	1404.39	1408.52	-4.13
IW15	2	1388.70	1396.38	-7.68
IW16	2	1380.17	1386.47	-6.30
IW17	2	1367.73	1375.60	-7.87
IW18	2	1422.96	1420.21	2.75
IW19	2	1407.63	1407.45	0.18
IW20	2	1389.03	1396.24	-7.21
IW21	2	1378.82	1382.95	-4.13
IW22	2	1364.77	1371.38	-6.61
IW23	2	1357.81	1366.15	-8.34
IW24	2	1419.76	1419.94	-0.18
IW25	2	1410.46	1407.76	2.70
IW26	2	1385.89	1396.64	-10.75
IW27	2	1376.97	1380.92	-3.95
IW28	2	1358.12	1368.99	-10.87
IW29	2	1356.80	1363.12	-6.32
IW30	2	1389.92	1390.89	-0.97
IW31	2	1369.35	1380.41	-11.06
IW32	2	1366.37	1369.61	-3.24
IW33	2	1356.11	1357.79	-1.68
IW34	2	1347.94	1350.65	-2.71
IW35	2	1373.35	1377.66	-4.31
IW36	2	1364.15	1366.87	-2.72
IW37	2	1355.24	1356.08	-0.84
IW38	2	1346.26	1345.38	0.88

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Residual Mean	-4.50
Res. Std. Dev.	4.12
Sum of Squares	1414.95
Abs. Res. Mean	4.95
Min. Residual	-12.03
Max. Residual	2.75
Head Range	78.95
Std/Head Range	0.05

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Attachment 3
Model Sensitivity Analysis

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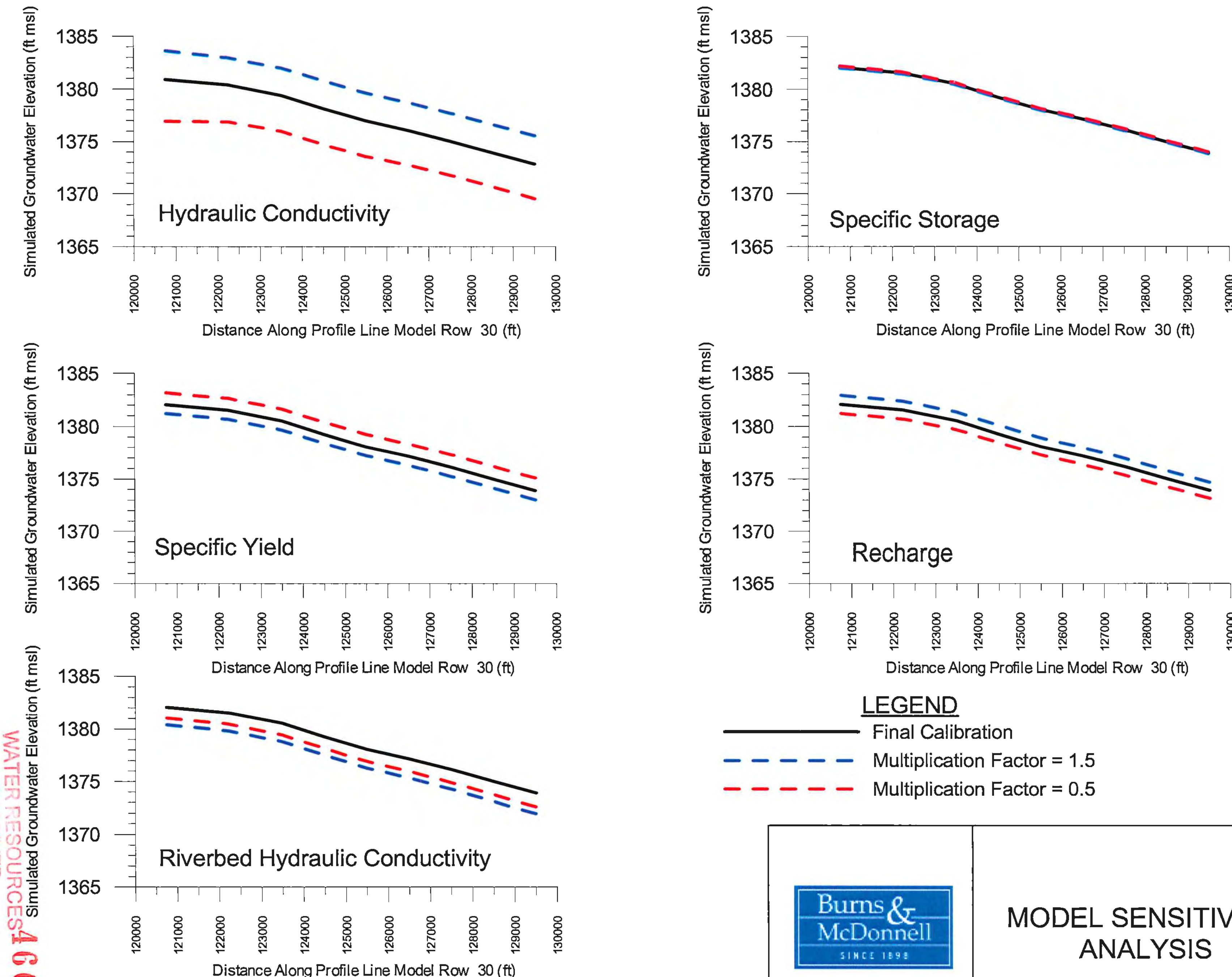

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MODEL SENSITIVITY ANALYSIS

Wsensitivity.grf 12/10/03

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Example - referred to pp 1-2 Jerry Blain's letter dated 12-12-03

City of Wichita
Equus Beds Recharge Project
Detailed Index Cell Water Balance

	Version 2.1 after program modification	Version 2 - with out proto type system			
	Flow Budget for Zone 1 at Time Step 1 of Stress Period 1	Flow Budget for Zone 1 at Time Step 1 of Stress Period 1		Net Underflow	
Budget Term	Flow (L**3/T) ft2/day *ft3/day*	Flow (L**3/T) *ft3/day*	Difference ft2/day *ft3/day*	ft2/day	AF/year
IN:					
STORAGE	334	597	-263		
CONSTANT HEAD	0	0	0		
WELLS	0	0	0		
RECHARGE	113,100	113,100	0		
ET	0	0	0		
STREAM LEAKAGE	0	0	0		
Zone 0 to 1	370,150	374,390	-4,240		
Zone 2 to 1	0	0	0		
Zone 4 to 1	101,420	103,670	-2,250		
Zone 5 to 1	12,651	13,973	-1,322		
Total IN	597,660	605,740	-8,080		
OUT:					
STORAGE	27,113	6,209	20,904		
CONSTANT HEAD	0	0	0		
WELLS	21,707	21,707	0		
RECHARGE	0	0	0		
ET	0	0	0		
STREAM LEAKAGE	0	0	0		
Zone 1 to 0	102,930	98,550	4,380	-8,620	-72.3
Zone 1 to 2	256,500	274,910	-18,410	18,410	154.4
Zone 1 to 4	127,070	132,100	-5,030	2,780	23.3
Zone 1 to 5	62,288	72,240	-9,952	8,630	72.4
Total OUT	597,610	605,710	-8,100	Total 21,200	178
IN - OUT	46	25	21		
Percent Discrepancy	0	0			

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** MDS/DWR*

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City of Wichita
Equus Beds Recharge Project
Detailed Index Cell Water Balance

Version 2.1 after program modification

Flow Budget for Zone 2 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T) ft³/day
IN:	
STORAGE	0
CONSTANT HEAD	0
WELLS	83,814
RECHARGE	139,620
ET	0
STREAM LEAKAGE	0
Zone 0 to 2	125,310
Zone 1 to 2	256,500
Zone 3 to 2	0
Zone 5 to 2	89,236
Total IN	694,480
OUT:	
STORAGE	86,529
CONSTANT HEAD	0
WELLS	35,906
RECHARGE	0
ET	7,750
STREAM LEAKAGE	0
Zone 2 to 0	77,281
Zone 2 to 1	0
Zone 2 to 3	333,480
Zone 2 to 5	153,400
Total OUT	694,340
IN - OUT	136
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 2 at Time Step 1 of Stress Period

Budget Term	Flow (L**3/T) ft³/day	ft³/day
IN:		
STORAGE	0	0
CONSTANT HEAD	0	0
WELLS	0	83,814
RECHARGE	139,620	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 0 to 2	128,400	-3,090
Zone 1 to 2	274,910	-18,410
Zone 3 to 2	0	0
Zone 5 to 2	51,658	37,578
Total IN	594,590	99,890
OUT:		
STORAGE	21,687	64,842
CONSTANT HEAD	0	0
WELLS	35,906	0
RECHARGE	0	0
ET	7,670	79
STREAM LEAKAGE	0	0
Zone 2 to 0	65,686	11,595
Zone 2 to 1	0	0
Zone 2 to 3	313,210	20,270
Zone 2 to 5	150,350	3,050
Total OUT	594,510	99,830
IN - OUT	76	59
Percent Discrepancy	0	

1

	Net Underflow	
	ft2/day	AF/year
	-14,685	-123.1
	-18,410	-154.4
	-20,270	-170.0
	34,528	289.5
Total	-18,837	-157.9

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City of Wichita
Equus Beds Recharge Project
Detailed Index Cell Water Balance

Version 2.1 after program modification — Flow Budget for Zone 3 at Time Step 1 of Stress Period 1

Version 2 - with out proto type system — Flow Budget for Zone 3 at Time Step 1 of Stress Period

Budget Term	Flow (L**3/T) Version 2.1 (ft³/day)	Flow (L**3/T) Version 2 (ft³/day)	ft³/day
IN:			
STORAGE	0	0	0
CONSTANT HEAD	0	0	0
WELLS	0	0	0
RECHARGE	113,980	113,980	0
ET	0	0	0
STREAM LEAKAGE	2,044	89	1,955
Zone 0 to 3	127,230	128,860	-1,630
Zone 2 to 3	333,480	313,210	20,270
Zone 6 to 3	33,518	23,716	9,802
Total IN	610,250	579,860	30,390
OUT:			
STORAGE	96,581	66,937	29,644
CONSTANT HEAD	0	0	0
WELLS	25,914	25,914	0
RECHARGE	0	0	0
ET	20,553	20,636	-83
STREAM LEAKAGE	112,020	122,020	-10,000
Zone 3 to 0	176,260	171,090	5,170
Zone 3 to 2	0	0	0
Zone 3 to 6	178,720	173,160	5,560
Total OUT	610,060	579,750	30,310
IN - OUT	188	110	78
Percent Discrepancy	0	0	

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	Net Underflow ft2/day	Net Underflow AF/year
	-6,800	-57.0
	20,270	170.0
	4,242	35.6
Total	17,712	148.5

WATER RESOURCES RECEIVED
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MICROFILMED 463

City of Wichita
Equus Beds Recharge Project
Detailed Index Cell Water Balance

Version 2.1 after program modification

Flow Budget for Zone 4 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	151
CONSTANT HEAD	0
WELLS	0
RECHARGE	140,200
ET	0
STREAM LEAKAGE	0
Zone 0 to 4	345,680
Zone 1 to 4	127,070
Zone 5 to 4	0
Zone 8 to 4	83,625
Zone 9 to 4	0
Total IN	696,730
OUT:	
STORAGE	49,940
CONSTANT HEAD	0
WELLS	48,734
RECHARGE	0
ET	0
STREAM LEAKAGE	0
Zone 4 to 0	0
Zone 4 to 1	101,420
Zone 4 to 5	310,140
Zone 4 to 8	156,900
Zone 4 to 9	29,484
Total OUT	696,610
IN - OUT	120
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 4 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	1,000	-849
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	140,200	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 0 to 4	348,100	-2,420
Zone 1 to 4	132,100	-5,030
Zone 5 to 4	0	0
Zone 8 to 4	95,254	-11,629
Zone 9 to 4	0	0
Total IN	716,650	-19,920
OUT:		
STORAGE	7,297	42,643
CONSTANT HEAD	0	0
WELLS	48,734	0
RECHARGE	0	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 4 to 0	0	0
Zone 4 to 1	103,670	-2,250
Zone 4 to 5	357,510	-47,370
Zone 4 to 8	162,910	-6,010
Zone 4 to 9	36,528	-7,044
Total OUT	716,650	-20,040
IN - OUT	1	119
Percent Discrepancy	0	

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	Net Underflow	
	ft2/day	AF/year
	-2,420	-20.3
	-2,780	-23.3
	47,370	397.2
	-5,619	-47.1
	7,044	59.1
Total	43,595	365.5

WATER RESOURCES RECEIVED
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City of Wichita
Equus Beds Recharge Project
Detailed Index Cell Water Balance

Version 2.1 after program modification

Flow Budget for Zone 5 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	0
CONSTANT HEAD	0
WELLS	363,650
RECHARGE	149,180
ET	0
STREAM LEAKAGE	0
Zone 1 to 5	62,288
Zone 2 to 5	153,400
Zone 4 to 5	310,140
Zone 6 to 5	0
Zone 9 to 5	64,935
Zone 10 to 5	0
Total IN	1,103,600
OUT:	
STORAGE	176,750
CONSTANT HEAD	0
WELLS	94,093
RECHARGE	0
ET	0
STREAM LEAKAGE	0
Zone 5 to 1	12,651
Zone 5 to 2	89,236
Zone 5 to 4	0
Zone 5 to 6	383,170
Zone 5 to 9	251,730
Zone 5 to 10	95,389
Total OUT	1,103,000
IN - OUT	558
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 5 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	0	0
CONSTANT HEAD	0	0
WELLS	0	363,650
RECHARGE	149,180	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 1 to 5	72,240	-9,952
Zone 2 to 5	150,350	3,050
Zone 4 to 5	357,510	-47,370
Zone 6 to 5	0	0
Zone 9 to 5	46,032	18,903
Zone 10 to 5	0	0
Total IN	775,310	328,290
OUT:		
STORAGE	30,663	146,087
CONSTANT HEAD	0	0
WELLS	94,093	0
RECHARGE	0	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 5 to 1	13,973	-1,322
Zone 5 to 2	51,658	37,578
Zone 5 to 4	0	0
Zone 5 to 6	335,350	47,820
Zone 5 to 9	164,920	86,810
Zone 5 to 10	84,589	10,800
Total OUT	775,240	327,760
IN - OUT	66	492
Percent Discrepancy	0	

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	Net Underflow	
	ft2/day	AF/year
	-8,630	-72.4
	-34,528	-289.5
	-47,370	-397.2
	-47,820	-401.0
	-67,907	-569.4
	-10,800	-90.6
Total	-217,055	-1820.0

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Equus Beds Recharge Project
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Version 2.1 after program modification

Flow Budget for Zone 6 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	378
CONSTANT HEAD	0
WELLS	0
RECHARGE	91,650
ET	0
STREAM LEAKAGE	0
Zone 0 to 6	9,862
Zone 3 to 6	178,720
Zone 5 to 6	383,170
Zone 7 to 6	825
Zone 10 to 6	57,740
Zone 11 to 6	0
Total IN	722,350
OUT:	
STORAGE	97,222
CONSTANT HEAD	0
WELLS	201,130
RECHARGE	0
ET	10,313
STREAM LEAKAGE	0
Zone 6 to 0	0
Zone 6 to 3	33,518
Zone 6 to 5	0
Zone 6 to 7	234,050
Zone 6 to 10	120,670
Zone 6 to 11	24,984
Total OUT	721,880
IN - OUT	471
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 6 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	40	338
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	91,650	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 0 to 6	9,823	40
Zone 3 to 6	173,160	5,560
Zone 5 to 6	335,350	47,820
Zone 7 to 6	832	-7
Zone 10 to 6	50,744	6,996
Zone 11 to 6	0	0
Total IN	661,590	60,760
OUT:		
STORAGE	58,546	38,676
CONSTANT HEAD	0	0
WELLS	201,130	0
RECHARGE	0	0
ET	10,521	-208
STREAM LEAKAGE	0	0
Zone 6 to 0	0	0
Zone 6 to 3	23,716	9,802
Zone 6 to 5	0	0
Zone 6 to 7	231,250	2,800
Zone 6 to 10	111,920	8,750
Zone 6 to 11	24,365	619
Total OUT	661,440	60,440
IN - OUT	155	316
Percent Discrepancy	0	

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Net Underflow

	ft2/day	AF/year
	40	0.3
	-4,242	-35.6
	47,820	401.0
	-2,807	-23.5
	-1,754	-14.7
	-619	-5.2
Total	38,438	322.3

WATER RESOURCES
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City of Wichita
Equus Beds Recharge Project
Detailed Index Cell Water Balance

Version 2.1 after program modification

Flow Budget for Zone 7 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	0
CONSTANT HEAD	0
WELLS	0
RECHARGE	30,638
ET	0
STREAM LEAKAGE	0
Zone 0 to 7	159,450
Zone 6 to 7	234,050
Zone 11 to 7	3,664
Zone 12 to 7	0
Total IN	427,800
OUT:	
STORAGE	63,509
CONSTANT HEAD	0
WELLS	27,347
RECHARGE	0
ET	24,945
STREAM LEAKAGE	146,050
Zone 7 to 0	46,962
Zone 7 to 6	825
Zone 7 to 11	99,727
Zone 7 to 12	18,205
Total OUT	427,570
IN - OUT	233
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 7 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	0	0
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	30,638	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 0 to 7	158,590	860
Zone 6 to 7	231,250	2,800
Zone 11 to 7	7,762	-4,098
Zone 12 to 7	0	0
Total IN	428,240	-440
OUT:		
STORAGE	49,296	14,213
CONSTANT HEAD	0	0
WELLS	27,347	0
RECHARGE	0	0
ET	25,918	-973
STREAM LEAKAGE	160,340	-14,290
Zone 7 to 0	46,948	14
Zone 7 to 6	832	-7
Zone 7 to 11	98,915	812
Zone 7 to 12	18,446	-241
Total OUT	428,040	-470
IN - OUT	202	32
Percent Discrepancy	0	

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	Net Underflow	
	ft2/day	AF/year
	846	7.1
	2,807	23.5
	-4,910	-41.2
	241	2.0
Total	-1,016	-8.5

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Equus Beds Recharge Project
Detailed Index Cell Water Balance

Version 2.1 after program modification

Flow Budget for Zone 8 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	95
CONSTANT HEAD	0
WELLS	0
RECHARGE	116,220
ET	0
STREAM LEAKAGE	0
Zone 0 to 8	293,380
Zone 4 to 8	156,900
Zone 9 to 8	0
Zone 13 to 8	101,720
Zone 14 to 8	0
Total IN	668,310
OUT:	
STORAGE	54,335
CONSTANT HEAD	0
WELLS	71,352
RECHARGE	0
ET	0
STREAM LEAKAGE	0
Zone 8 to 0	0
Zone 8 to 4	83,625
Zone 8 to 9	286,980
Zone 8 to 13	144,670
Zone 8 to 14	27,330
Total OUT	668,290
IN - OUT	20
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 8 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	878	-784
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	116,220	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 0 to 8	294,820	-1,440
Zone 4 to 8	162,910	-6,010
Zone 9 to 8	0	0
Zone 13 to 8	111,490	-9,770
Zone 14 to 8	0	0
Total IN	686,310	-18,000
OUT:		
STORAGE	7,100	47,235
CONSTANT HEAD	0	0
WELLS	71,352	0
RECHARGE	0	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 8 to 0	0	0
Zone 8 to 4	95,254	-11,629
Zone 8 to 9	335,090	-48,110
Zone 8 to 13	147,290	-2,620
Zone 8 to 14	30,185	-2,855
Total OUT	686,280	-17,990
IN - OUT	34	-14
Percent Discrepancy	0	

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	Net Underflow ft2/day	Net Underflow AF/year
	-1,440	-12.1
	5,619	47.1
	48,110	403.4
	-7,150	-60.0
	2,855	23.9
Total	47,994	402.4

WATER RESOURCES
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City of Wichita
Equus Beds Recharge Project
Detailed Index Cell Water Balance

Version 2.1 after program modification

Flow Budget for Zone 9 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	0
CONSTANT HEAD	0
WELLS	392,040
RECHARGE	96,525
ET	0
STREAM LEAKAGE	0
Zone 4 to 9	29,484
Zone 5 to 9	251,730
Zone 8 to 9	286,980
Zone 10 to 9	0
Zone 14 to 9	19,469
Zone 15 to 9	0
Total IN	1,076,200
OUT:	
STORAGE	266,470
CONSTANT HEAD	0
WELLS	119,260
RECHARGE	0
ET	0
STREAM LEAKAGE	0
Zone 9 to 4	0
Zone 9 to 5	64,935
Zone 9 to 8	0
Zone 9 to 10	383,260
Zone 9 to 14	207,140
Zone 9 to 15	34,716
Total OUT	1,075,800
IN - OUT	461
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 9 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	14	-14
CONSTANT HEAD	0	0
WELLS	0	392,040
RECHARGE	96,525	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 4 to 9	36,528	-7,044
Zone 5 to 9	164,920	86,810
Zone 8 to 9	335,090	-48,110
Zone 10 to 9	257	-257
Zone 14 to 9	41,804	-22,335
Zone 15 to 9	0	0
Total IN	675,140	401,060
OUT:		
STORAGE	56,151	210,319
CONSTANT HEAD	0	0
WELLS	119,260	0
RECHARGE	0	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 9 to 4	0	0
Zone 9 to 5	46,032	18,903
Zone 9 to 8	0	0
Zone 9 to 10	311,510	71,750
Zone 9 to 14	113,830	93,310
Zone 9 to 15	28,236	6,480
Total OUT	675,010	400,790
IN - OUT	126	335
Percent Discrepancy	0	

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	Net Underflow	
	ft2/day	AF/year
	-7,044	-59.1
	67,907	569.4
	-48,110	-403.4
	-72,007	-603.8
	-115,645	-969.7
	-6,480	-54.3
Total	-181,379	-1520.9

WATER RESOURCES
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Equus Beds Recharge Project
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Version 2.1 after program modification

Flow Budget for Zone 10 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	0
CONSTANT HEAD	0
WELLS	94,750
RECHARGE	144,300
ET	0
STREAM LEAKAGE	0
Zone 5 to 10	95,389
Zone 6 to 10	120,670
Zone 9 to 10	383,260
Zone 11 to 10	39,261
Zone 15 to 10	9,143
Zone 16 to 10	0
Total IN	886,770
OUT:	
STORAGE	177,290
CONSTANT HEAD	0
WELLS	189,840
RECHARGE	0
ET	0
STREAM LEAKAGE	0
Zone 10 to 5	0
Zone 10 to 6	57,740
Zone 10 to 9	0
Zone 10 to 11	215,670
Zone 10 to 15	224,130
Zone 10 to 16	21,356
Total OUT	886,020
IN - OUT	751
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 10 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	0	0
CONSTANT HEAD	0	0
WELLS	94,750	0
RECHARGE	144,300	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 5 to 10	84,589	10,800
Zone 6 to 10	111,920	8,750
Zone 9 to 10	311,510	71,750
Zone 11 to 10	37,258	2,003
Zone 15 to 10	7,773	1,371
Zone 16 to 10	0	0
Total IN	792,100	94,670
OUT:		
STORAGE	109,430	67,860
CONSTANT HEAD	0	0
WELLS	189,840	0
RECHARGE	0	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 10 to 5	0	0
Zone 10 to 6	50,744	6,996
Zone 10 to 9	257	-257
Zone 10 to 11	208,780	6,890
Zone 10 to 15	211,580	12,550
Zone 10 to 16	21,195	161
Total OUT	791,830	94,190
IN - OUT	266	485
Percent Discrepancy	0	

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	Net Underflow	
	ft2/day	AF/year
	10,800	90.6
	1,754	14.7
	72,007	603.8
	-4,887	-41.0
	-11,179	-93.7
	-161	-1.3
Total	68,334	573.0

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City of Wichita
Equus Beds Recharge Project
Detailed Index Cell Water Balance

Version 2.1 after program modification

Flow Budget for Zone 11 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	43
CONSTANT HEAD	0
WELLS	0
RECHARGE	102,150
ET	0
STREAM LEAKAGE	22,641
Zone 6 to 11	24,984
Zone 7 to 11	99,727
Zone 10 to 11	215,670
Zone 12 to 11	11,090
Zone 16 to 11	0
Total IN	476,300
OUT:	
STORAGE	117,890
CONSTANT HEAD	0
WELLS	23,275
RECHARGE	0
ET	4,387
STREAM LEAKAGE	7,116
Zone 11 to 6	0
Zone 11 to 7	3,664
Zone 11 to 10	39,261
Zone 11 to 12	156,190
Zone 11 to 16	124,110
Total OUT	475,890
IN - OUT	410
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 11 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		0
STORAGE	0	43
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	102,150	0
ET	0	0
STREAM LEAKAGE	18,614	4,027
Zone 6 to 11	24,365	619
Zone 7 to 11	98,915	812
Zone 10 to 11	208,780	6,890
Zone 12 to 11	8,590	2,500
Zone 16 to 11	0	0
Total IN	461,410	14,890
OUT:		
STORAGE	96,378	21,512
CONSTANT HEAD	0	0
WELLS	23,275	0
RECHARGE	0	0
ET	4,804	-417
STREAM LEAKAGE	10,648	-3,532
Zone 11 to 6	0	0
Zone 11 to 7	7,762	-4,098
Zone 11 to 10	37,258	2,003
Zone 11 to 12	158,970	-2,780
Zone 11 to 16	121,990	2,120
Total OUT	461,080	14,810
IN - OUT	327	83
Percent Discrepancy	0	

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	Net Underflow ft2/day	Net Underflow AF/year
	619	5.2
	4,910	41.2
	4,887	41.0
	5,280	44.3
	-2,120	-17.8
Total	13,576	113.8

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Equus Beds Recharge Project
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Version 2.1 after program modification

Flow Budget for Zone 12 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	1,439
CONSTANT HEAD	0
WELLS	0
RECHARGE	39,438
ET	0
STREAM LEAKAGE	72,359
Zone 0 to 12	114,650
Zone 7 to 12	18,205
Zone 11 to 12	156,190
Zone 16 to 12	0
Zone 17 to 12	243
Total IN	402,530
OUT:	
STORAGE	59,727
CONSTANT HEAD	0
WELLS	139,940
RECHARGE	0
ET	28,222
STREAM LEAKAGE	1,181
Zone 12 to 0	49,673
Zone 12 to 7	0
Zone 12 to 11	11,090
Zone 12 to 16	6,406
Zone 12 to 17	106,070
Total OUT	402,310
IN - OUT	220
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 12 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	226	1,213
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	39,438	0
ET	0	0
STREAM LEAKAGE	61,337	11,022
Zone 0 to 12	114,880	-230
Zone 7 to 12	18,446	-241
Zone 11 to 12	158,970	-2,780
Zone 16 to 12	0	0
Zone 17 to 12	357	-114
Total IN	393,650	8,880
OUT:		
STORAGE	50,449	9,278
CONSTANT HEAD	0	0
WELLS	139,940	0
RECHARGE	0	0
ET	28,471	-249
STREAM LEAKAGE	4,400	-3,219
Zone 12 to 0	49,454	219
Zone 12 to 7	0	0
Zone 12 to 11	8,590	2,500
Zone 12 to 16	5,966	441
Zone 12 to 17	106,190	-120
Total OUT	393,460	8,850
IN - OUT	184	35
Percent Discrepancy	0	

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	Net Underflow ft2/day	Net Underflow AF/year
	-449	-3.8
	-241	-2.0
	-5,280	-44.3
	-441	-3.7
	6	0.1
Total	-6,404	-53.7

WATER RESOURCES RECEIVED
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City of Wichita
Equus Beds Recharge Project
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Version 2.1 after program modification		Version 2 - with out proto type system		
Flow Budget for Zone 13 at Time Step 1 of Stress Period 1		Flow Budget for Zone 13 at Time Step 1 of Stress Period 1		
Budget Term	Flow (L**3/T)	Budget Term	Flow (L**3/T)	
IN:		IN:		
STORAGE	2,684	STORAGE	2,223	461
CONSTANT HEAD	0	CONSTANT HEAD	0	0
WELLS	0	WELLS	0	0
RECHARGE	116,020	RECHARGE	116,020	0
ET	0	ET	0	0
STREAM LEAKAGE	0	STREAM LEAKAGE	0	0
Zone 0 to 13	314,340	Zone 0 to 13	314,490	-150
Zone 8 to 13	144,670	Zone 8 to 13	147,290	-2,620
Zone 14 to 13	0	Zone 14 to 13	0	0
Zone 18 to 13	115,040	Zone 18 to 13	115,970	-930
Total IN	692,760	Total IN	696,000	-3,240
OUT:		OUT:		
STORAGE	21,897	STORAGE	6,429	15,468
CONSTANT HEAD	0	CONSTANT HEAD	0	0
WELLS	75,698	WELLS	75,698	0
RECHARGE	0	RECHARGE	0	0
ET	384	ET	358	25
STREAM LEAKAGE	0	STREAM LEAKAGE	0	0
Zone 13 to 0	345	Zone 13 to 0	393	-48
Zone 13 to 8	101,720	Zone 13 to 8	111,490	-9,770
Zone 13 to 14	343,720	Zone 13 to 14	354,040	-10,320
Zone 13 to 18	148,970	Zone 13 to 18	147,530	1,440
Total OUT	692,750	Total OUT	695,940	-3,190
IN - OUT	10	IN - OUT	65	-55
Percent Discrepancy	0	Percent Discrepancy	0	

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	Net Underflow	
	ft2/day	AF/year
	-103	-0.9
	7,150	60.0
	10,320	86.5
	-2,370	-19.9
Total	14,998	125.8

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WATER RESOURCES
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City of Wichita
Equus Beds Recharge Project
Detailed Index Cell Water Balance

Version 2.1 after program modification

Flow Budget for Zone 14 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	1,706
CONSTANT HEAD	0
WELLS	0
RECHARGE	94,380
ET	0
STREAM LEAKAGE	0
Zone 8 to 14	27,330
Zone 9 to 14	207,140
Zone 13 to 14	343,720
Zone 15 to 14	0
Zone 18 to 14	22,989
Zone 19 to 14	162,360
Zone 20 to 14	0
Total IN	859,630
OUT:	
STORAGE	138,540
CONSTANT HEAD	0
WELLS	245,400
RECHARGE	0
ET	0
STREAM LEAKAGE	0
Zone 14 to 8	0
Zone 14 to 9	19,469
Zone 14 to 13	0
Zone 14 to 15	262,140
Zone 14 to 18	0
Zone 14 to 19	167,690
Zone 14 to 20	26,264
Total OUT	859,500
IN - OUT	137
Percent Discrepancy	0

1

Version 2 - with out proto type system

Flow Budget for Zone 14 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)		Net Underflow ft2/day	Net Underflow AF/year
IN:				
STORAGE	1,773	-66		
CONSTANT HEAD	0	0		
WELLS	0	0		
RECHARGE	94,380	0		
ET	0	0		
STREAM LEAKAGE	0	0		
Zone 8 to 14	30,185	-2,855		
Zone 9 to 14	113,830	93,310		
Zone 13 to 14	354,040	-10,320		
Zone 15 to 14	0	0		
Zone 18 to 14	23,380	-391		
Zone 19 to 14	161,880	480		
Zone 20 to 14	0	0		
Total IN	779,460	80,170		
OUT:				
STORAGE	56,771	81,769		
CONSTANT HEAD	0	0		
WELLS	245,400	0		
RECHARGE	0	0		
ET	0	0		
STREAM LEAKAGE	0	0		
Zone 14 to 8	0	0	-2,855	-23.9
Zone 14 to 9	41,804	-22,335	115,645	969.7
Zone 14 to 13	0	0	-10,320	-86.5
Zone 14 to 15	244,810	17,330	-17,330	-145.3
Zone 14 to 18	0	0	-391	-3.3
Zone 14 to 19	164,580	3,110	-2,630	-22.1
Zone 14 to 20	25,843	421	-421	-3.5
Total OUT	779,200	80,300	Total 81,698	685.0
IN - OUT	263	-126		
Percent Discrepancy	0			

1

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Version 2.1 after program modification

Flow Budget for Zone 15 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	94
CONSTANT HEAD	0
WELLS	0
RECHARGE	144,100
ET	0
STREAM LEAKAGE	0
Zone 9 to 15	34,716
Zone 10 to 15	224,130
Zone 14 to 15	262,140
Zone 16 to 15	7,362
Zone 20 to 15	122,540
Total IN	795,080
OUT:	
STORAGE	147,850
CONSTANT HEAD	0
WELLS	302,020
RECHARGE	0
ET	0
STREAM LEAKAGE	0
Zone 15 to 9	0
Zone 15 to 10	9,143
Zone 15 to 14	0
Zone 15 to 16	214,250
Zone 15 to 20	121,300
Total OUT	794,560
IN - OUT	521
Percent Discrepancy	0

1

Version 2 - with out proto type system

Flow Budget for Zone 15 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	0	94
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	144,100	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 9 to 15	28,236	6,480
Zone 10 to 15	211,580	12,550
Zone 14 to 15	244,810	17,330
Zone 16 to 15	7,874	-511
Zone 20 to 15	117,380	5,160
Total IN	753,970	41,110
OUT:		
STORAGE	110,520	37,330
CONSTANT HEAD	0	0
WELLS	302,020	0
RECHARGE	0	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 15 to 9	0	0
Zone 15 to 10	7,773	1,371
Zone 15 to 14	0	0
Zone 15 to 16	212,210	2,040
Zone 15 to 20	120,960	340
Total OUT	753,490	41,070
IN - OUT	489	32
Percent Discrepancy	0	

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	Net Underflow	
	ft2/day	AF/year
	6,480	54.3
	11,179	93.7
	17,330	145.3
	-2,551	-21.4
	4,820	40.4
Total	37,258	312.4

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Version 2.1 after program modification

Flow Budget for Zone 16 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	55
CONSTANT HEAD	0
WELLS	0
RECHARGE	140,010
ET	0
STREAM LEAKAGE	0
Zone 10 to 16	21,356
Zone 11 to 16	124,110
Zone 12 to 16	6,406
Zone 15 to 16	214,250
Zone 17 to 16	33,749
Zone 21 to 16	19,493
Zone 22 to 16	0
Total IN	559,430
OUT:	
STORAGE	125,240
CONSTANT HEAD	0
WELLS	152,160
RECHARGE	0
ET	36
STREAM LEAKAGE	0
Zone 16 to 10	0
Zone 16 to 11	0
Zone 16 to 12	0
Zone 16 to 15	7,362
Zone 16 to 17	130,100
Zone 16 to 21	129,780
Zone 16 to 22	14,251
Total OUT	558,940
IN - OUT	494
Percent Discrepancy	0

1

Version 2 - with out proto type system

Flow Budget for Zone 16 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	0	55
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	140,010	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 10 to 16	21,195	161
Zone 11 to 16	121,990	2,120
Zone 12 to 16	5,966	441
Zone 15 to 16	212,210	2,040
Zone 17 to 16	33,042	707
Zone 21 to 16	17,648	1,845
Zone 22 to 16	0	0
Total IN	552,070	7,360
OUT:		
STORAGE	108,190	17,050
CONSTANT HEAD	0	0
WELLS	152,160	0
RECHARGE	0	0
ET	77	-41
STREAM LEAKAGE	0	0
Zone 16 to 10	0	0
Zone 16 to 11	0	0
Zone 16 to 12	0	0
Zone 16 to 15	7,874	-511
Zone 16 to 17	135,270	-5,170
Zone 16 to 21	133,390	-3,610
Zone 16 to 22	14,627	-376
Total OUT	551,580	7,360
IN - OUT	485	9
Percent Discrepancy	0	

1

	Net Underflow	
	ft2/day	AF/year
	161	1.3
	2,120	17.8
	441	3.7
	2,551	21.4
	5,877	49.3
	5,455	45.7
	376	3.2
Total	16,981	142.4

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Version 2.1 after program modification

Flow Budget for Zone 17 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	86
CONSTANT HEAD	0
WELLS	0
RECHARGE	133,700
ET	0
STREAM LEAKAGE	44,197
Zone 0 to 17	49,391
Zone 12 to 17	106,070
Zone 16 to 17	130,100
Zone 22 to 17	0
Zone 23 to 17	0
Total IN	463,540
OUT:	
STORAGE	72,373
CONSTANT HEAD	0
WELLS	95,328
RECHARGE	0
ET	32,940
STREAM LEAKAGE	0
Zone 17 to 0	82,493
Zone 17 to 12	243
Zone 17 to 16	33,749
Zone 17 to 22	138,370
Zone 17 to 23	7,729
Total OUT	463,230
IN - OUT	311
Percent Discrepancy	0

1

Version 2 - with out proto type system

Flow Budget for Zone 17 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)		Net Underflow ft2/day	Net Underflow AF/year
IN:				
STORAGE	0	86		
CONSTANT HEAD	0	0		
WELLS	0	0		
RECHARGE	133,700	0		
ET	0	0		
STREAM LEAKAGE	34,078	10,119		
Zone 0 to 17	48,715	676		
Zone 12 to 17	106,190	-120		
Zone 16 to 17	135,270	-5,170		
Zone 22 to 17	0	0		
Zone 23 to 17	0	0		
Total IN	457,950	5,590		
OUT:				
STORAGE	65,504	6,869		
CONSTANT HEAD	0	0		
WELLS	95,328	0		
RECHARGE	0	0		
ET	34,957	-2,017		
STREAM LEAKAGE	0	0		
Zone 17 to 0	83,198	-705	1,381	11.6
Zone 17 to 12	357	-114	-6	-0.1
Zone 17 to 16	33,042	707	-5,877	-49.3
Zone 17 to 22	137,310	1,060	-1,060	-8.9
Zone 17 to 23	8,014	-285	285	2.4
Total OUT	457,710	5,520	Total -5,278	-44.3
IN - OUT	241	71		
Percent Discrepancy	0			

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Version 2.1 after program modification

Flow Budget for Zone 18 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	2,808
CONSTANT HEAD	0
WELLS	0
RECHARGE	116,610
ET	0
STREAM LEAKAGE	0
Zone 0 to 18	392,030
Zone 13 to 18	148,970
Zone 14 to 18	0
Zone 19 to 18	26,244
Zone 24 to 18	165,330
Total IN	852,000
OUT:	
STORAGE	15,626
CONSTANT HEAD	0
WELLS	119,410
RECHARGE	0
ET	3,825
STREAM LEAKAGE	0
Zone 18 to 0	0
Zone 18 to 13	115,040
Zone 18 to 14	22,989
Zone 18 to 19	416,810
Zone 18 to 24	158,310
Total OUT	852,010
IN - OUT	-14
Percent Discrepancy	0

1

Version 2 - with out proto type system

Flow Budget for Zone 18 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)		Net Underflow ft2/day	Net Underflow AF/year
IN:				
STORAGE	770	2,038		
CONSTANT HEAD	0	0		
WELLS	0	0		
RECHARGE	116,610	0		
ET	0	0		
STREAM LEAKAGE	0	0		
Zone 0 to 18	391,770	260		
Zone 13 to 18	147,530	1,440		
Zone 14 to 18	0	0		
Zone 19 to 18	26,205	39		
Zone 24 to 18	164,880	450		
Total IN	847,760	4,240		
OUT:				
STORAGE	12,275	3,351		
CONSTANT HEAD	0	0		
WELLS	119,410	0		
RECHARGE	0	0		
ET	3,933	-108		
STREAM LEAKAGE	0	0		
Zone 18 to 0	0	0	260	2.2
Zone 18 to 13	115,970	-930	2,370	19.9
Zone 18 to 14	23,380	-391	391	3.3
Zone 18 to 19	414,720	2,090	-2,051	-17.2
Zone 18 to 24	158,080	230	220	1.8
Total OUT	847,770	4,240	Total 1,190	10.0
IN - OUT	-9	-5		
Percent Discrepancy	0			

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Version 2.1 after program modification

Flow Budget for Zone 19 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	952
CONSTANT HEAD	0
WELLS	0
RECHARGE	113,290
ET	0
STREAM LEAKAGE	0
Zone 14 to 19	167,690
Zone 18 to 19	416,810
Zone 20 to 19	22,000
Zone 24 to 19	27,127
Zone 25 to 19	132,630
Zone 26 to 19	31,573
Total IN	912,080
OUT:	
STORAGE	48,175
CONSTANT HEAD	0
WELLS	231,660
RECHARGE	0
ET	0
STREAM LEAKAGE	0
Zone 19 to 14	162,360
Zone 19 to 18	26,244
Zone 19 to 20	305,280
Zone 19 to 24	0
Zone 19 to 25	110,970
Zone 19 to 26	27,189
Total OUT	911,880
IN - OUT	201
Percent Discrepancy	0

1

Version 2 - with out proto type system

Flow Budget for Zone 19 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	74	878
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	113,290	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 14 to 19	164,580	3,110
Zone 18 to 19	414,720	2,090
Zone 20 to 19	21,419	581
Zone 24 to 19	26,819	308
Zone 25 to 19	130,700	1,930
Zone 26 to 19	30,923	650
Total IN	902,530	9,550
OUT:		
STORAGE	41,994	6,181
CONSTANT HEAD	0	0
WELLS	231,660	0
RECHARGE	0	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 19 to 14	161,880	480
Zone 19 to 18	26,205	39
Zone 19 to 20	302,360	2,920
Zone 19 to 24	0	0
Zone 19 to 25	110,910	60
Zone 19 to 26	27,204	-15
Total OUT	902,200	9,680
IN - OUT	323	-121
Percent Discrepancy	0	

1

	Net Underflow	
	ft2/day	AF/year
	2,630	22.1
	2,051	17.2
	-2,339	-19.6
	308	2.6
	1,870	15.7
	665	5.6
Total	5,185	43.5

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City of Wichita
Equus Beds Recharge Project
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Version 2.1 after program modification

Flow Budget for Zone 20 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	139
CONSTANT HEAD	0
WELLS	0
RECHARGE	105,950
ET	0
STREAM LEAKAGE	0
Zone 14 to 20	26,264
Zone 15 to 20	121,300
Zone 19 to 20	305,280
Zone 21 to 20	0
Zone 26 to 20	151,980
Zone 27 to 20	0
Total IN	710,920
OUT:	
STORAGE	59,848
CONSTANT HEAD	0
WELLS	66,593
RECHARGE	0
ET	0
STREAM LEAKAGE	0
Zone 20 to 14	0
Zone 20 to 15	122,540
Zone 20 to 19	22,000
Zone 20 to 21	305,870
Zone 20 to 26	107,720
Zone 20 to 27	26,258
Total OUT	710,820
IN - OUT	92
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 20 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	1	138
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	105,950	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 14 to 20	25,843	421
Zone 15 to 20	120,960	340
Zone 19 to 20	302,360	2,920
Zone 21 to 20	0	0
Zone 26 to 20	148,990	2,990
Zone 27 to 20	0	0
Total IN	704,100	6,820
OUT:		
STORAGE	58,159	1,689
CONSTANT HEAD	0	0
WELLS	66,593	0
RECHARGE	0	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 20 to 14	0	0
Zone 20 to 15	117,380	5,160
Zone 20 to 19	21,419	581
Zone 20 to 21	306,540	-670
Zone 20 to 26	107,540	180
Zone 20 to 27	26,159	99
Total OUT	703,790	7,030
IN - OUT	318	-226
Percent Discrepancy	0	

1

	Net Underflow	
	ft2/day	AF/year
	421	3.5
	-4,820	-40.4
	2,339	19.6
	670	5.6
	2,810	23.6
	-99	-0.8
Total	1,321	11.1

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Version 2.1 after program modification

Flow Budget for Zone 21 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	6,132
CONSTANT HEAD	0
WELLS	0
RECHARGE	100,750
ET	0
STREAM LEAKAGE	0
Zone 16 to 21	129,780
Zone 20 to 21	305,870
Zone 22 to 21	48,025
Zone 27 to 21	118,050
Zone 28 to 21	0
Total IN	708,610
OUT:	
STORAGE	61,728
CONSTANT HEAD	0
WELLS	368,030
RECHARGE	0
ET	0
STREAM LEAKAGE	0
Zone 21 to 16	19,493
Zone 21 to 20	0
Zone 21 to 22	135,600
Zone 21 to 27	95,590
Zone 21 to 28	27,952
Total OUT	708,390
IN - OUT	215
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 21 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	467	5,665
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	100,750	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 16 to 21	133,390	-3,610
Zone 20 to 21	306,540	-670
Zone 22 to 21	47,129	896
Zone 27 to 21	118,420	-370
Zone 28 to 21	0	0
Total IN	706,690	1,920
OUT:		
STORAGE	61,639	89
CONSTANT HEAD	0	0
WELLS	368,030	0
RECHARGE	0	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 21 to 16	17,648	1,845
Zone 21 to 20	0	0
Zone 21 to 22	136,390	-790
Zone 21 to 27	94,670	920
Zone 21 to 28	28,026	-74
Total OUT	706,410	1,980
IN - OUT	282	-68
Percent Discrepancy	0	

1

	Net Underflow	
	ft2/day	AF/year
	-5,455	-45.7
	-670	-5.6
	1,686	14.1
	-1,290	-10.8
	74	0.6
Total	-5,655	-47.4

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Version 2.1 after program modification — Version 2 - with out proto type system

Flow Budget for Zone 22 at Time Step 1 of Stress Period 1

Budget Term	Version 2.1 Flow (L**3/T)	Version 2 Flow (L**3/T)	
IN:			
STORAGE	266	1	265
CONSTANT HEAD	0	0	0
WELLS	0	0	0
RECHARGE	104,550	104,550	0
ET	0	0	0
STREAM LEAKAGE	0	0	0
Zone 16 to 22	14,251	14,627	-376
Zone 17 to 22	138,370	137,310	1,060
Zone 21 to 22	135,600	136,390	-790
Zone 23 to 22	73,003	69,717	3,286
Zone 28 to 22	4,651	4,958	-308
Zone 29 to 22	0	0	0
Total IN	470,690	467,560	3,130
OUT:			
STORAGE	70,716	70,841	-125
CONSTANT HEAD	0	0	0
WELLS	105,510	105,510	0
RECHARGE	0	0	0
ET	3,660	3,886	-227
STREAM LEAKAGE	0	0	0
Zone 22 to 16	0	0	0
Zone 22 to 17	0	0	0
Zone 22 to 21	48,025	47,129	896
Zone 22 to 23	76,679	79,091	-2,412
Zone 22 to 28	160,350	154,910	5,440
Zone 22 to 29	5,427	5,829	-402
Total OUT	470,370	467,200	3,170
IN - OUT	320	359	-40
Percent Discrepancy	0	0	

1 — 1

Net Underflow

	ft2/day	AF/year
	-376	-3.2
	1,060	8.9
	-1,686	-14.1
	5,698	47.8
	-5,748	-48.2
	402	3.4
Total	-650	-5.5

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City of Wichita
Equus Beds Recharge Project
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Version 2.1 after program modification

Flow Budget for Zone 23 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	17
CONSTANT HEAD	0
WELLS	0
RECHARGE	45,905
ET	0
STREAM LEAKAGE	158,910
Zone 0 to 23	166,550
Zone 17 to 23	7,729
Zone 22 to 23	76,679
Zone 29 to 23	4,933
Total IN	460,720
OUT:	
STORAGE	79,006
CONSTANT HEAD	0
WELLS	157,100
RECHARGE	0
ET	8,155
STREAM LEAKAGE	8,727
Zone 23 to 0	13,830
Zone 23 to 17	0
Zone 23 to 22	73,003
Zone 23 to 29	120,510
Total OUT	460,330
IN - OUT	389
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 23 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	0	17
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	45,905	0
ET	0	0
STREAM LEAKAGE	142,940	15,970
Zone 0 to 23	166,240	310
Zone 17 to 23	8,014	-285
Zone 22 to 23	79,091	-2,412
Zone 29 to 23	3,677	1,256
Total IN	445,860	14,860
OUT:		
STORAGE	66,839	12,167
CONSTANT HEAD	0	0
WELLS	157,100	0
RECHARGE	0	0
ET	8,777	-622
STREAM LEAKAGE	11,083	-2,356
Zone 23 to 0	14,936	-1,106
Zone 23 to 17	0	0
Zone 23 to 22	69,717	3,286
Zone 23 to 29	116,990	3,520
Total OUT	445,440	14,890
IN - OUT	419	-30
Percent Discrepancy	0	

1

Net Underflow		
	ft2/day	AF/year
	1,416	11.9
	-285	-2.4
	-5,698	-47.8
	-2,264	-19.0
Total	-6,831	-57.3

WATER RESOURCES
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	Version 2.1 after program modification	Version 2 - with out proto type system	
	Flow Budget for Zone 24 at Time Step 1 of Stress Period 1	Flow Budget for Zone 24 at Time Step 1 of Stress Period 1	
Budget Term	Flow (L**3/T)	Flow (L**3/T)	
IN:			
STORAGE	3,366	383	2,982
CONSTANT HEAD	0	0	0
WELLS	0	0	0
RECHARGE	121,680	121,680	0
ET	0	0	0
STREAM LEAKAGE	0	0	0
Zone 0 to 24	498,100	499,470	-1,370
Zone 18 to 24	158,310	158,080	230
Zone 19 to 24	0	0	0
Zone 25 to 24	55	83	-28
Total IN	781,510	779,690	1,820
OUT:			
STORAGE	8,175	7,850	325
CONSTANT HEAD	0	0	0
WELLS	149,910	149,910	0
RECHARGE	0	0	0
ET	16,002	16,351	-349
STREAM LEAKAGE	0	0	0
Zone 24 to 0	135,930	135,780	150
Zone 24 to 18	165,330	164,880	450
Zone 24 to 19	27,127	26,819	308
Zone 24 to 25	279,000	278,070	930
Total OUT	781,470	779,670	1,800
IN - OUT	42	21	21
Percent Discrepancy	0	0	
	1	1	

	Net Underflow	
	ft2/day	AF/year
	-1,520	-12.7
	-220	-1.8
	-308	-2.6
	-958	-8.0
Total	-3,006	-25.2

WATER RESOURCES
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Equus Beds Recharge Project
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Version 2.1 after program modification

Flow Budget for Zone 25 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	1,486
CONSTANT HEAD	0
WELLS	0
RECHARGE	116,150
ET	0
STREAM LEAKAGE	0
Zone 0 to 25	209,830
Zone 19 to 25	110,970
Zone 24 to 25	279,000
Zone 26 to 25	137
Total IN	717,580
OUT:	
STORAGE	15,490
CONSTANT HEAD	0
WELLS	135,510
RECHARGE	0
ET	1,139
STREAM LEAKAGE	0
Zone 25 to 0	82,562
Zone 25 to 19	132,630
Zone 25 to 24	55
Zone 25 to 26	350,270
Total OUT	717,660
IN - OUT	-84
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 25 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	122	1,364
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	116,150	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 0 to 25	209,340	490
Zone 19 to 25	110,910	60
Zone 24 to 25	278,070	930
Zone 26 to 25	176	-40
Total IN	714,780	2,800
OUT:		
STORAGE	16,529	-1,039
CONSTANT HEAD	0	0
WELLS	135,510	0
RECHARGE	0	0
ET	1,246	-107
STREAM LEAKAGE	0	0
Zone 25 to 0	82,604	-42
Zone 25 to 19	130,700	1,930
Zone 25 to 24	83	-28
Zone 25 to 26	348,120	2,150
Total OUT	714,780	2,880
IN - OUT	-2	-82
Percent Discrepancy	0	

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Net Underflow	ft2/day	AF/year
	532	4.5
	-1,870	-15.7
	958	8.0
	-2,190	-18.4
Total	-2,569	-21.5

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Version 2.1 after program modification — Flow Budget for Zone 26 at Time Step 1 of Stress Period 1

Version 2 - with out proto type system — Flow Budget for Zone 26 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T) (Version 2.1)	Flow (L**3/T) (Version 2)	
IN:			
STORAGE	5,582	522	5,060
CONSTANT HEAD	0	0	0
WELLS	0	0	0
RECHARGE	117,710	117,710	0
ET	0	0	0
STREAM LEAKAGE	0	0	0
Zone 0 to 26	23,262	23,081	181
Zone 19 to 26	27,189	27,204	-15
Zone 20 to 26	107,720	107,540	180
Zone 25 to 26	350,270	348,120	2,150
Zone 27 to 26	15,051	15,007	44
Zone 30 to 26	207,510	204,410	3,100
Zone 31 to 26	13,274	12,835	439
Total IN	867,580	856,430	11,150
OUT:			
STORAGE	33,321	29,664	3,657
CONSTANT HEAD	0	0	0
WELLS	317,770	317,770	0
RECHARGE	0	0	0
ET	1,574	1,687	-114
STREAM LEAKAGE	0	0	0
Zone 26 to 0	0	0	0
Zone 26 to 19	31,573	30,923	650
Zone 26 to 20	151,980	148,990	2,990
Zone 26 to 25	137	176	-40
Zone 26 to 27	222,770	219,270	3,500
Zone 26 to 30	96,434	95,808	626
Zone 26 to 31	11,818	11,824	-6
Total OUT	867,370	856,110	11,260
IN - OUT	202	318	-116
Percent Discrepancy	0	0	

1 1

	Net Underflow ft2/day	Net Underflow AF/year
	181	1.5
	-665	-5.6
	-2,810	-23.6
	2,190	18.4
	-3,456	-29.0
	2,474	20.7
	445	3.7
Total	-1,641	-13.8

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Version 2.1 after program modification

Flow Budget for Zone 27 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	264
CONSTANT HEAD	0
WELLS	0
RECHARGE	83,070
ET	0
STREAM LEAKAGE	0
Zone 20 to 27	26,258
Zone 21 to 27	95,590
Zone 26 to 27	222,770
Zone 28 to 27	14,680
Zone 31 to 27	110,400
Total IN	553,030
OUT:	
STORAGE	70,506
CONSTANT HEAD	0
WELLS	72,235
RECHARGE	0
ET	0
STREAM LEAKAGE	0
Zone 27 to 20	0
Zone 27 to 21	118,050
Zone 27 to 26	15,051
Zone 27 to 28	207,570
Zone 27 to 31	69,512
Total OUT	552,920
IN - OUT	109
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 27 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	0	264
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	83,070	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 20 to 27	26,159	99
Zone 21 to 27	94,670	920
Zone 26 to 27	219,270	3,500
Zone 28 to 27	14,548	132
Zone 31 to 27	108,290	2,110
Total IN	546,000	7,030
OUT:		
STORAGE	65,512	4,994
CONSTANT HEAD	0	0
WELLS	72,235	0
RECHARGE	0	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 27 to 20	0	0
Zone 27 to 21	118,420	-370
Zone 27 to 26	15,007	44
Zone 27 to 28	205,560	2,010
Zone 27 to 31	69,001	511
Total OUT	545,730	7,190
IN - OUT	270	-161
Percent Discrepancy	0	

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	Net Underflow ft2/day	AF/year
	99	0.8
	1,290	10.8
	3,456	29.0
	-1,878	-15.7
	1,599	13.4
Total	4,566	38.3

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Version 2.1 after program modification

Flow Budget for Zone 28 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	871
CONSTANT HEAD	0
WELLS	0
RECHARGE	84,110
ET	0
STREAM LEAKAGE	0
Zone 21 to 28	27,952
Zone 22 to 28	160,350
Zone 27 to 28	207,570
Zone 29 to 28	62,078
Zone 32 to 28	138,820
Zone 33 to 28	0
Total IN	681,750
OUT:	
STORAGE	136,230
CONSTANT HEAD	0
WELLS	397,070
RECHARGE	0
ET	0
STREAM LEAKAGE	0
Zone 28 to 21	0
Zone 28 to 22	4,651
Zone 28 to 27	14,680
Zone 28 to 29	77,782
Zone 28 to 32	45,796
Zone 28 to 33	5,077
Total OUT	681,290
IN - OUT	466
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 28 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	19	852
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	84,110	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 21 to 28	28,026	-74
Zone 22 to 28	154,910	5,440
Zone 27 to 28	205,560	2,010
Zone 29 to 28	59,480	2,598
Zone 32 to 28	139,020	-200
Zone 33 to 28	0	0
Total IN	671,140	10,610
OUT:		
STORAGE	118,880	17,350
CONSTANT HEAD	0	0
WELLS	397,070	0
RECHARGE	0	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 28 to 21	0	0
Zone 28 to 22	4,958	-308
Zone 28 to 27	14,548	132
Zone 28 to 29	82,110	-4,328
Zone 28 to 32	47,247	-1,451
Zone 28 to 33	5,656	-579
Total OUT	670,470	10,820
IN - OUT	661	-195
Percent Discrepancy	0	

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	Net Underflow	
	ft2/day	AF/year
	-74	-0.6
	5,748	48.2
	1,878	15.7
	6,926	58.1
	1,251	10.5
	579	4.9
Total	16,308	136.7

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Version 2.1 after program modification

Flow Budget for Zone 29 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	86
CONSTANT HEAD	0
WELLS.	0
RECHARGE	57,645
ET	0
STREAM LEAKAGE	26,356
Zone 0 to 29	158,470
Zone 22 to 29	5,427
Zone 23 to 29	120,510
Zone 28 to 29	77,782
Zone 33 to 29	4,809
Zone 34 to 29	0
Total IN	451,080
OUT:	
STORAGE	91,473
CONSTANT HEAD	0
WELLS	125,800
RECHARGE	0
ET	5,097
STREAM LEAKAGE	0
Zone 29 to 0	5,109
Zone 29 to 22	0
Zone 29 to 23	4,933
Zone 29 to 28	62,078
Zone 29 to 33	154,150
Zone 29 to 34	2,031
Total OUT	450,660
IN - OUT	418
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 29 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)			Net Underflow ft2/day	Net Underflow AF/year
IN:					
STORAGE	0	86			
CONSTANT HEAD	0	0			
WELLS	0	0			
RECHARGE	57,645	0			
ET	0	0			
STREAM LEAKAGE	23,907	2,449			
Zone 0 to 29	150,180	8,290			
Zone 22 to 29	5,829	-402			
Zone 23 to 29	116,990	3,520			
Zone 28 to 29	82,110	-4,328			
Zone 33 to 29	4,643	167			
Zone 34 to 29	0	0			
Total IN	441,300	9,780			
OUT:					
STORAGE	85,076	6,397			
CONSTANT HEAD	0	0			
WELLS	125,800	0			
RECHARGE	0	0			
ET	5,850	-753			
STREAM LEAKAGE	0	0			
Zone 29 to 0	6,309	-1,200		9,490	79.6
Zone 29 to 22	0	0		-402	-3.4
Zone 29 to 23	3,677	1,256		2,264	19.0
Zone 29 to 28	59,480	2,598		-6,926	-58.1
Zone 29 to 33	152,140	2,010		-1,844	-15.5
Zone 29 to 34	2,477	-446		446	3.7
Total OUT	440,810	9,850	Total	3,029	25.4
IN - OUT	495	-78			
Percent Discrepancy	0				

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Version 2.1 after program modification		Version 2 - with out proto type system		
Flow Budget for Zone 30 at Time Step 1 of Stress Period 1		Flow Budget for Zone 30 at Time Step 1 of Stress Period 1		
Budget Term	Flow (L**3/T)	Budget Term	Flow (L**3/T)	
IN:		IN:		
STORAGE	7,157	STORAGE	1,144	6,013
CONSTANT HEAD	0	CONSTANT HEAD	0	0
WELLS	0	WELLS	0	0
RECHARGE	114,400	RECHARGE	114,400	0
ET	0	ET	0	0
STREAM LEAKAGE	0	STREAM LEAKAGE	0	0
Zone 0 to 30	526,700	Zone 0 to 30	525,830	870
Zone 26 to 30	96,434	Zone 26 to 30	95,808	626
Zone 31 to 30	26,082	Zone 31 to 30	25,906	176
Total IN	770,770	Total IN	763,080	7,690
OUT:		OUT:		
STORAGE	11,402	STORAGE	9,770	1,632
CONSTANT HEAD	0	CONSTANT HEAD	0	0
WELLS	243,160	WELLS	243,160	0
RECHARGE	0	RECHARGE	0	0
ET	35,775	ET	36,196	-421
STREAM LEAKAGE	0	STREAM LEAKAGE	0	0
Zone 30 to 0	62,623	Zone 30 to 0	62,602	21
Zone 30 to 26	207,510	Zone 30 to 26	204,410	3,100
Zone 30 to 31	210,300	Zone 30 to 31	206,900	3,400
Total OUT	770,760	Total OUT	763,030	7,730
IN - OUT	9	IN - OUT	53	-45
Percent Discrepancy	0	Percent Discrepancy	0	

1 1

Net Underflow		
	ft2/day	AF/year
	849	7.1
	-2,474	-20.7
	-3,224	-27.0
Total	-4,849	-40.7

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Version 2.1 after program modification

Flow Budget for Zone 31 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	776
CONSTANT HEAD	0
WELLS	0
RECHARGE	120,640
ET	0
STREAM LEAKAGE	0
Zone 0 to 31	24,883
Zone 26 to 31	11,818
Zone 27 to 31	69,512
Zone 30 to 31	210,300
Zone 32 to 31	18,314
Zone 35 to 31	209,080
Total IN	665,320
OUT:	
STORAGE	41,444
CONSTANT HEAD	0
WELLS	157,230
RECHARGE	0
ET	3,462
STREAM LEAKAGE	0
Zone 31 to 0	0
Zone 31 to 26	13,274
Zone 31 to 27	110,400
Zone 31 to 30	26,082
Zone 31 to 32	241,500
Zone 31 to 35	71,843
Total OUT	665,230
IN - OUT	83
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 31 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	27	749
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	120,640	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 0 to 31	24,700	183
Zone 26 to 31	11,824	-6
Zone 27 to 31	69,001	511
Zone 30 to 31	206,900	3,400
Zone 32 to 31	17,820	494
Zone 35 to 31	206,540	2,540
Total IN	657,450	7,870
OUT:		
STORAGE	40,660	784
CONSTANT HEAD	0	0
WELLS	157,230	0
RECHARGE	0	0
ET	3,699	-237
STREAM LEAKAGE	0	0
Zone 31 to 0	0	0
Zone 31 to 26	12,835	439
Zone 31 to 27	108,290	2,110
Zone 31 to 30	25,906	176
Zone 31 to 32	237,710	3,790
Zone 31 to 35	70,867	976
Total OUT	657,200	8,030
IN - OUT	249	-166
Percent Discrepancy	0	

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	Net Underflow ft2/day	AF/year
	183	1.5
	-445	-3.7
	-1,599	-13.4
	3,224	27.0
	-3,296	-27.6
	1,564	13.1
Total	-369	-3.1

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Version 2.1 after program modification

Flow Budget for Zone 32 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	0
CONSTANT HEAD	0
WELLS	0
RECHARGE	102,700
ET	0
STREAM LEAKAGE	0
Zone 28 to 32	45,796
Zone 31 to 32	241,500
Zone 33 to 32	22,887
Zone 36 to 32	128,480
Zone 37 to 32	0
Total IN	541,360
OUT:	
STORAGE	94,303
CONSTANT HEAD	0
WELLS	110,820
RECHARGE	0
ET	0
STREAM LEAKAGE	0
Zone 32 to 28	138,820
Zone 32 to 31	18,314
Zone 32 to 33	132,960
Zone 32 to 36	37,842
Zone 32 to 37	8,066
Total OUT	541,130
IN - OUT	233
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 32 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	0	0
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	102,700	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 28 to 32	47,247	-1,451
Zone 31 to 32	237,710	3,790
Zone 33 to 32	22,916	-29
Zone 36 to 32	127,100	1,380
Zone 37 to 32	0	0
Total IN	537,680	3,680
OUT:		
STORAGE	84,652	9,651
CONSTANT HEAD	0	0
WELLS	110,820	0
RECHARGE	0	0
ET	1	-1
STREAM LEAKAGE	0	0
Zone 32 to 28	139,020	-200
Zone 32 to 31	17,820	494
Zone 32 to 33	137,130	-4,170
Zone 32 to 36	39,199	-1,357
Zone 32 to 37	8,514	-448
Total OUT	537,160	3,970
IN - OUT	519	-285
Percent Discrepancy	0	

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	Net Underflow	
	ft2/day	AF/year
	-1,251	-10.5
	3,296	27.6
	4,141	34.7
	2,737	22.9
	448	3.8
Total	9,371	78.6

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Version 2.1 after program modification

Flow Budget for Zone 33 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	112
CONSTANT HEAD	0
WELLS	14,782
RECHARGE	85,420
ET	0
STREAM LEAKAGE	0
Zone 28 to 33	5,077
Zone 29 to 33	154,150
Zone 32 to 33	132,960
Zone 34 to 33	45,012
Zone 37 to 33	22,051
Zone 38 to 33	328
Total IN	459,880
OUT:	
STORAGE	85,313
CONSTANT HEAD	0
WELLS	285,480
RECHARGE	0
ET	0
STREAM LEAKAGE	0
Zone 33 to 28	0
Zone 33 to 29	4,809
Zone 33 to 32	22,887
Zone 33 to 34	8,723
Zone 33 to 37	50,029
Zone 33 to 38	2,139
Total OUT	459,380
IN - OUT	505
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 33 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	0	111
CONSTANT HEAD	0	0
WELLS	14,782	0
RECHARGE	85,420	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 28 to 33	5,656	-579
Zone 29 to 33	152,140	2,010
Zone 32 to 33	137,130	-4,170
Zone 34 to 33	43,582	1,430
Zone 37 to 33	21,698	353
Zone 38 to 33	50	277
Total IN	460,460	-580
OUT:		
STORAGE	81,823	3,490
CONSTANT HEAD	0	0
WELLS	285,480	0
RECHARGE	0	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 33 to 28	0	0
Zone 33 to 29	4,643	167
Zone 33 to 32	22,916	-29
Zone 33 to 34	11,209	-2,486
Zone 33 to 37	51,533	-1,504
Zone 33 to 38	2,140	-1
Total OUT	459,740	-360
IN - OUT	715	-210
Percent Discrepancy	0	

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Net Underflow

	ft2/day	AF/year
	-579	-4.9
	1,844	15.5
	-4,141	-34.7
	3,916	32.8
	1,857	15.6
	278	2.3
Total	3,175	26.6

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Version 2.1 after program modification

Flow Budget for Zone 34 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	0
CONSTANT HEAD	0
WELLS	0
RECHARGE	19,770
ET	0
STREAM LEAKAGE	90,657
Zone 0 to 34	132,970
Zone 29 to 34	2,031
Zone 33 to 34	8,723
Zone 38 to 34	0
Total IN	254,150
OUT:	
STORAGE	73,546
CONSTANT HEAD	0
WELLS	24,103
RECHARGE	0
ET	15,142
STREAM LEAKAGE	2,274
Zone 34 to 0	33,639
Zone 34 to 29	0
Zone 34 to 33	45,012
Zone 34 to 38	59,900
Total OUT	253,620
IN - OUT	537
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 34 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	0	0
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	19,770	0
ET	0	0
STREAM LEAKAGE	78,982	11,675
Zone 0 to 34	133,190	-220
Zone 29 to 34	2,477	-446
Zone 33 to 34	11,209	-2,486
Zone 38 to 34	0	0
Total IN	245,630	8,520
OUT:		
STORAGE	65,267	8,279
CONSTANT HEAD	0	0
WELLS	24,103	0
RECHARGE	0	0
ET	15,528	-386
STREAM LEAKAGE	2,676	-403
Zone 34 to 0	33,331	308
Zone 34 to 29	0	0
Zone 34 to 33	43,582	1,430
Zone 34 to 38	60,618	-718
Total OUT	245,110	8,510
IN - OUT	524	13
Percent Discrepancy	0	

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	Net Underflow	
	ft2/day	**AF/year**
	-528	-4.4
	-446	-3.7
	-3,916	-32.8
	718	6.0
Total	-4,172	-35.0

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Version 2.1 after program modification

Flow Budget for Zone 35 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	8
CONSTANT HEAD	0
WELLS	0
RECHARGE	69,680
ET	0
STREAM LEAKAGE	0
Zone 0 to 35	345,190
Zone 31 to 35	71,843
Zone 36 to 35	21,739
Total IN	508,460
OUT:	
STORAGE	21,115
CONSTANT HEAD	0
WELLS	30,294
RECHARGE	0
ET	24,786
STREAM LEAKAGE	0
Zone 35 to 0	71,552
Zone 35 to 31	209,080
Zone 35 to 36	151,590
Total OUT	508,410
IN - OUT	48
Percent Discrepancy	0

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Version 2 - with out proto type system

Flow Budget for Zone 35 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	0	8
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	69,680	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 0 to 35	339,340	5,850
Zone 31 to 35	70,867	976
Zone 36 to 35	21,332	407
Total IN	501,220	7,240
OUT:		
STORAGE	17,287	3,828
CONSTANT HEAD	0	0
WELLS	30,294	0
RECHARGE	0	0
ET	25,547	-761
STREAM LEAKAGE	0	0
Zone 35 to 0	71,546	6
Zone 35 to 31	206,540	2,540
Zone 35 to 36	149,930	1,660
Total OUT	501,140	7,270
IN - OUT	77	-28
Percent Discrepancy	0	

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Net Underflow

	ft2/day	AF/year
	5,844	49.0
	-1,564	-13.1
	-1,253	-10.5
Total	3,027	25.4

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Version 2.1 after program modification

Flow Budget for Zone 36 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)
IN:	
STORAGE	225
CONSTANT HEAD	0
WELLS	0
RECHARGE	69,810
ET	0
STREAM LEAKAGE	0
Zone 0 to 36	154,060
Zone 32 to 36	37,842
Zone 35 to 36	151,590
Zone 37 to 36	10,449
Total IN	423,980
OUT:	
STORAGE	31,438
CONSTANT HEAD	0
WELLS	75,925
RECHARGE	0
ET	2,414
STREAM LEAKAGE	0
Zone 36 to 0	79,822
Zone 36 to 32	128,480
Zone 36 to 35	21,739
Zone 36 to 37	84,115
Total OUT	423,930
IN - OUT	49
Percent Discrepancy	0

1

Version 2 - with out proto type system

Flow Budget for Zone 36 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T)	
IN:		
STORAGE	11	214
CONSTANT HEAD	0	0
WELLS	0	0
RECHARGE	69,810	0
ET	0	0
STREAM LEAKAGE	0	0
Zone 0 to 36	152,150	1,910
Zone 32 to 36	39,199	-1,357
Zone 35 to 36	149,930	1,660
Zone 37 to 36	10,531	-82
Total IN	421,630	2,350
OUT:		
STORAGE	27,256	4,182
CONSTANT HEAD	0	0
WELLS	75,925	0
RECHARGE	0	0
ET	2,905	-491
STREAM LEAKAGE	0	0
Zone 36 to 0	80,852	-1,030
Zone 36 to 32	127,100	1,380
Zone 36 to 35	21,332	407
Zone 36 to 37	86,164	-2,049
Total OUT	421,530	2,400
IN - OUT	93	-45
Percent Discrepancy	0	

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Net Underflow

	ft2/day	AF/year
	2,940	24.7
	-2,737	-22.9
	1,253	10.5
	1,967	16.5
Total	3,423	28.7

MICROFILMED 496

WATER RESOURCES RECEIVED
DEC 16 2003
KS DEPT OF AGRICULTURE

City of Wichita
Equus Beds Recharge Project
Detailed Index Cell Water Balance

Version 2.1 after program modification

Flow Budget for Zone 37 at Time Step 1 of Stress Period 1

Version 2 - with out proto type system

Flow Budget for Zone 37 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T) Version 2.1	Flow (L**3/T) Version 2	
IN:			
STORAGE	1,926	669	1,257
CONSTANT HEAD	0	0	0
WELLS	0	0	0
RECHARGE	58,240	58,240	0
ET	0	0	0
STREAM LEAKAGE	0	0	0
Zone 0 to 37	71,965	72,106	-141
Zone 32 to 37	8,066	8,514	-448
Zone 33 to 37	50,029	51,533	-1,504
Zone 36 to 37	84,115	86,164	-2,049
Zone 38 to 37	2,057	2,041	16
Total IN	276,400	279,270	-2,870
OUT:			
STORAGE	20,321	21,708	-1,387
CONSTANT HEAD	0	0	0
WELLS	155,370	155,370	0
RECHARGE	0	0	0
ET	0	0	0
STREAM LEAKAGE	0	0	0
Zone 37 to 0	39,982	40,656	-674
Zone 37 to 32	0	0	0
Zone 37 to 33	22,051	21,698	353
Zone 37 to 36	10,449	10,531	-82
Zone 37 to 38	28,014	28,983	-969
Total OUT	276,190	278,950	-2,760
IN - OUT	208	319	-111
Percent Discrepancy	0	0	

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	Net Underflow ft2/day	Net Underflow AF/year
	533	4.5
	-448	-3.8
	-1,857	-15.6
	-1,967	-16.5
	985	8.3
Total	-2,754	-23.1

WATER RESOURCES RECEIVED
DEC 16 2003
KS DEPT OF AGRICULTURE

MICROFILMED 497

City of Wichita
Equus Beds Recharge Project
Detailed Index Cell Water Balance

Version 2.1 after program modification | Version 2 - with out proto type system

Flow Budget for Zone 38 at Time Step 1 of Stress Period 1 | Flow Budget for Zone 38 at Time Step 1 of Stress Period 1

Budget Term	Flow (L**3/T) Version 2.1	Flow (L**3/T) Version 2	
IN:			
STORAGE	0	0	0
CONSTANT HEAD	0	0	0
WELLS	0	0	0
RECHARGE	30,620	30,620	0
ET	0	0	0
STREAM LEAKAGE	12,110	10,344	1,766
Zone 0 to 38	72,190	72,567	-377
Zone 33 to 38	2,139	2,140	-1
Zone 34 to 38	59,900	60,618	-718
Zone 37 to 38	28,014	28,983	-969
Total IN	204,970	205,270	-300
OUT:			
STORAGE	45,532	44,305	1,227
CONSTANT HEAD	0	0	0
WELLS	71,621	71,621	0
RECHARGE	0	0	0
ET	10,120	10,430	-310
STREAM LEAKAGE	7,340	8,500	-1,160
Zone 38 to 0	67,552	67,879	-327
Zone 38 to 33	328	50	277
Zone 38 to 34	0	0	0
Zone 38 to 37	2,057	2,041	16
Total OUT	204,550	204,830	-280
IN - OUT	423	446	-23
Percent Discrepancy	0	0	

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	Net Underflow ft2/day	Net Underflow AF/year
	-50	-0.4
	-278	-2.3
	-718	-6.0
	-985	-8.3
Total	-2,031	-17.0

WATER RESOURCES RECEIVED
DEC 16 2003
KS DEPT OF AGRICULTURE

MICROFILMED 498

WATER RESOURCES
RECEIVED
DEC 16 2003
KS DEPT OF AGRICULTURE

ASR Operations for Year 1

	Recharge			Recovery		
	Meter Reading Begin	Meter Reading End	Amount Recharged	Meter Reading Begin	Meter Reading End	Amount Recovered
Index Cell 2						
RRW-1						
Total for Cell			702.8			
Index Cell 5						
RRW-2						
RRW-3						
RB-1				-	-	-
Total for Cell			3049.2			
Index Cell 9						
RB-2				-	-	-
Total for Cell			3287.25			
Project Total			7039.25			

499
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City of Wichita
ASR Annual Summary
Year 1

WATER RESOURCES RECEIVED
DEC 1 6 2003
KS DEPT OF AGRICULTURE

ASR Credit Summary for _____ Year 1
(acre-feet for the year)

Index Cell	Previous ASR Credit	Metered ASR in	Metered ASR out	Net Underflow	Current ASR Credit
IC-1	0.0	0.0	0	178.0	178.0
IC-2	0.0	702.8	0	-157.9	544.9
IC-3	0.0	0.0	0	148.5	148.5
IC-4	0.0	0.0	0	365.5	365.5
IC-5	0.0	3,049.2	0	-1820.0	1229.2
IC-6	0.0	0.0	0	322.3	322.3
IC-7	0.0	0.0	0	0.0	0.0
IC-8	0.0	0.0	0	402.4	402.4
IC-9	0.0	3,287.3	0	-1520.9	1766.4
IC-10	0.0	0.0	0	573.0	573.0
IC-11	0.0	0.0	0	0.0	0.0
IC-12	0.0	0.0	0	0.0	0.0
IC-13	0.0	0.0	0	125.8	125.8
IC-14	0.0	0.0	0	685.0	685.0
IC-15	0.0	0.0	0	312.4	312.4
IC-16	0.0	0.0	0	142.4	142.4
IC-17	0.0	0.0	0	0.0	0.0
IC-18	0.0	0.0	0	10.0	10.0
IC-19	0.0	0.0	0	43.5	43.5
IC-20	0.0	0.0	0	11.1	11.1
IC-21	0.0	0.0	0	0.0	0.0
IC-22	0.0	0.0	0	0.0	0.0
IC-23	0.0	0.0	0	0.0	0.0
IC-24	0.0	0.0	0	0.0	0.0
IC-25	0.0	0.0	0	0.0	0.0
IC-26	0.0	0.0	0	0.0	0.0
IC-27	0.0	0.0	0	0.0	0.0
IC-28	0.0	0.0	0	0.0	0.0
IC-29	0.0	0.0	0	0.0	0.0
IC-30	0.0	0.0	0	0.0	0.0
IC-31	0.0	0.0	0	0.0	0.0
IC-32	0.0	0.0	0	0.0	0.0
IC-33	0.0	0.0	0	0.0	0.0
IC-34	0.0	0.0	0	0.0	0.0
IC-35	0.0	0.0	0	0.0	0.0
IC-36	0.0	0.0	0	0.0	0.0
IC-37	0.0	0.0	0	0.0	0.0
IC-38	0.0	0.0	0	0.0	0.0
Total	0.0	7,039.2	0	-178.9	6860.3

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City of Wichita
ASR Calibration Information
Year 1

WATER RESOURCES
RECEIVED
DEC 1 6 2003
KS DEPT OF AGRICULTURE

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Jan. Year 1 Residuals

Name	Observed	Computed	Residual
IW1	1417.86	1419.89	-2.03
IW2	1412.49	1414.86	-2.37
IW3	1395.02	1401.87	-6.85
IW4	1421.42	1427.35	-5.93
IW5	1415.52	1415.14	0.38
IW6	1398.20	1402.37	-4.17
IW7	1382.70	1390.03	-7.33
IW8	1425.21	1425.49	-0.28
IW9	1407.44	1411.54	-4.10
IW10	1394.97	1396.92	-1.95
IW11	1378.62	1386.99	-8.37
IW12	1367.60	1372.98	-5.38
IW13	1424.09	1422.37	1.72
IW14	1404.39	1408.52	-4.13
IW15	1388.70	1396.38	-7.68
IW16	1380.17	1386.47	-6.30
IW17	1367.73	1375.60	-7.87
IW18	1422.96	1420.21	2.75
IW19	1407.63	1407.45	0.18
IW20	1389.03	1396.24	-7.21
IW21	1378.82	1382.95	-4.13
IW22	1364.77	1371.38	-6.61
IW23	1357.81	1366.15	-8.34
IW24	1419.76	1419.94	-0.18
IW25	1410.46	1407.76	2.70
IW26	1385.89	1391.64	-5.75
IW27	1376.97	1380.92	-3.95
IW28	1358.12	1368.99	-10.87
IW29	1356.80	1363.12	-6.32
IW30	1389.92	1390.89	-0.97
IW31	1369.35	1375.41	-6.06
IW32	1366.37	1369.61	-3.24
IW33	1356.11	1357.79	-1.68
IW34	1347.94	1350.65	-2.71
IW35	1373.35	1377.66	-4.31
IW36	1364.15	1366.87	-2.72
IW37	1355.24	1356.08	-0.84
IW38	1346.26	1345.38	0.88

Residual Mean	-3.74
Res. Std. Dev.	3.38

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