

MEMORANDUM



BISHOP-BROGDEN ASSOCIATES, INC.

To: File 9410.07
From: Tim Crawford and Chris Sanchez
Subject: Gilpin County Government – Justice Center Wells – Water Level Review and Summary
Job: 9410.07
Date: October 25, 2006

This memorandum presents a review of historic water levels in the Gilpin County (County) Justice Center Well Nos. JC-1 and JC-2, generally located in Section 30, Township 2 South, Range 72 West of the 6th P.M., as presented in Figure 1. This effort was performed to review trends in water levels and address concerns of neighboring well owners regarding declining water level conditions in wells, and to investigate whether or not the reported water level changes may be related to the County's well pumping. To complete this effort we reviewed water level and production data provided by the County, water level data provided by homeowners, nearby stream flow available from the State, well location information available from the State's Master Well list and information in our files. In addition, we reviewed monitoring program and pumping test data from when the JC-1 and JC-2 wells were constructed and tested, and completed an analysis of possible water level impacts between the County's wells and nearby wells.

Summary of Water Level Data and Ground Water Hydrology

We reviewed and summarized water level data provided by the County for the JC-1 and JC-2 wells, along with neighboring wells including the Peters, Duvall, Adsel and Brown wells, located as presented in Figure 1. A hydrograph, presenting the water levels in each of the wells, is presented in Figure 2. Presented below are comments regarding the water level data, the wells and hydrogeology.

- The Peters, Adsel and Brown wells are generally located approximately 4,400 feet south of the Justice Center wells. As described below, the distance between these wells and the Justice Center wells buffers any water level impacts between the wells. The Duvall well is located approximately 800 feet south of the Justice Center wells. Because of the closer proximity of the Duvall well to the Justice Center wells, there is greater potential for well-to-well interference between that well and the Justice Center wells.
- We reviewed and analyzed the water level data to identify water level changes in the County wells and the neighboring wells, as summarized below.

Well	Time period and average rate of water level decline (ft/yr)		
	1996 through 2006	1996 through 2002	2002 to 2006
JC-1 and JC-2 (Avg)	1.7	2.4	2.6
Peters	0.6	0.4	3.9
Adsel	N/A	N/A	6.7
Brown	N/A	N/A	5.0
Duvall	N/A	2.1	N/A

- A trend of declining water levels has been observed in the JC-1 and JC-2 wells and has been recorded in neighboring wells over the 12-year period of record. The values presented above are based on the average water level decline for the County's wells and neighboring wells for the designated general time periods. For example, for 1996 through 2006, an average static water level was determined for the general 1995 through 1996 timeframe, an average static water level was determined for the general 2006 timeframe, and then a decline rate was calculated between the two averages.
- Based on accepted hydraulic principles, water level declines in nearby wells resulting from County pumping must be less than those observed in the County's wells, and water level declines will decrease with distance from the pumping well. We have illustrated this principle in the attached Figure 9, a schematic diagram which was originally presented in our June, 1995 report on the testing of the wells.
- Limited water level data were available for review in nearby wells. As a result, we concentrated on the time periods presented in the table above for the purposes of comparing water level decline trends.
 - 1996 through 2006:
 - Water levels in JC-1 and JC-2 appear to have declined at a greater rate than in the Peters well.
 - This comparison is based on one data point in the Peters well which is not adequate to draw firm conclusions.
 - 1996 through 2002:
 - The water level decline rate in JC-1 and JC-2 was similar to that measured in the Duvall well, which is to be expected given the proximity of the wells.
 - Water levels in JC-1 and JC-2 appear to have declined at a greater rate than in the Peters well.
 - 2002 through 2006
 - The water level decline rate in the JC-1 and JC-2 wells was 2.6 ft/yr, whereas the water level decline rate in all other wells ranged from 3.9 to 6.7 ft/yr. The water level decline rate in all other wells was greater than the decline rate in JC-1 and JC-2. The fact that the decline rate in the nearby wells was greater than in the County wells is an indication that factors other than pumping from the County wells contributed to the water level changes in these nearby wells.
 - The 2002 to 2006 period provided the most abundant data for neighboring wells, and as a result, provides the best basis for comparison between the County wells and the neighboring wells.
 - This was a period of drought. The drought conditions very likely contributed to the recent water level declines in the neighboring wells. It is possible that the fracture system that the County's wells produce from probably receives more recharge than the neighboring wells, which makes the County's wells less sensitive to the drought conditions. This is based on relative ground water elevations and the fact that the County's wells are probably located in a more extensive fracture system.

- The 1995 data point for the Peters well may have been artificially higher than average water levels due to high streamflow (precipitation and runoff) conditions, as presented in Figure 2 and Table 1. The decline rates presented for the 1996 through 2006 and 1996 through 2006 for the Peters well may be slightly higher than the actual long-term decline because of this probable higher than average water level observed in 1995.
- During the testing of the JC-2 well in May of 1995, water levels were measured in JC-2, JC-1, and several neighboring wells (including the Peters and Duvall wells) ranging in distance from the pumping well from 640 to 6,050 feet. Although drawdown resulting from the pumping of the JC-2 well was expected to occur in neighboring wells, only a fraction of the expected drawdown was observed, and it was determined that wells located at a distance from JC-1 and JC-2 have limited hydraulic connection to JC-1 and JC-2. Projections based on data collected during the test indicate that water level drawdown in these wells would be less than two feet assuming the wells are fully connected. Because the connection between the wells appears to be minimal (as explained below), actual water level impacts are probably less.
- Several fracture systems exist in the area surrounding the Justice Center and the data indicate that pumping of the Justice Center wells minimally affects all of the fracture systems or neighboring wells in the area. Note that the County wells are completed in a defined fault zone which dominates the ground water flow to the County's wells, as presented in the attached Figure 10 from our June, 1995 report. The Peters, Adsel and Brown wells are located outside of this fault zone, which further supports the hydrogeologic separation between the wells. Additional evidence that the wells are constructed in different fracture systems includes the difference in ground water elevations and the different water level decline rates. It appears that the Duvall well is completed in the same fracture system as the County's wells and may experience water level changes resulting from the pumping of the County wells. Although water level changes may occur in the Duvall well, we are not aware of any problems with production from the well.
- No drawdown was predicted or observed in the Peters well during the original testing of the JC-2 well.
- Based on the data, the Adsel, Brown and Peters well, appear to be in a separate fracture system from the County's wells. The data suggest that interference between the County's wells and these wells is minimal.

Stream Flow Summary

- Stream flow data for North Clear Creek from the North Clear Creek Near Black Hawk, CO gage (Station ID 6718500), located approximately 6 miles from the Justice Center, indicate a correlation between ground water levels and stream flow. The streamflow provides an indication of precipitation and runoff in the basin which recharges the fractured rock aquifer. Water levels in the wells are generally higher during and immediately after periods of high discharge. During periods of low stream flow, water levels are depressed. Water level fluctuations in excess of 44 feet in the County's wells have been measured and are attributable to the natural changes that occur in the aquifer due to seasonal ground water flow changes.
- Annual North Clear Creek discharge for the water level period of record since the County's wells were installed has averaged 12,920 acre-feet. Streamflow has been less than average for the last six years, and the State has been in an on-going drought since approximately 2002. The on-going drought conditions have been a factor in the water level declines noted since the wells were

installed.

- Water levels respond to precipitation events and runoff as indicated by the streamflow data. Periods of high precipitation in the future will recharge the aquifer and result in higher water levels for a period of time, consistent with what has occurred naturally and historically.

Well Production Summary

- Based on a review of the production from the JC-1 and JC-2 wells, the wells produced higher than average volumes between July of 2004 and September of 2005. We believe this period of higher well pumping may have resulted from a leak in the County's water distribution system that went unnoticed for over a year. However, this period of relatively high pumping did not correspond with significant water level declines in the wells. The hydrograph of well pumping does show slightly more pumping in 2006 as a result of the additional uses recently implemented by the County. However, the water level data do not appear to indicate any increased water level decline as a result of the additional pumping.
- If water level impacts occurred as a result of the increased pumping in 2004 and 2005, these impacts would have been short term only. Water levels would have recovered following the period of aggressive pumping.

Local Reservoir Improvements

- We understand that changes were recently made to the storage capacity and configuration of Braeher Lake on Raltson Creek. We do not know if these changes may have changed the ground water recharge to the aquifer, but it is possible that the modifications to the reservoir altered the local ground water flow patterns. This is an item that could be investigated in more detail to determine if the changes to the lake either increased or decreased the recharge to the aquifer, which could result in water level changes in wells.

Conclusions

- No direct correlation can be made between the declines reported from neighboring wells and JC-1 and JC-2 pumping.
- Several factors have probably contributed to the slight ground water declines in the area, including:
 - On-going drought conditions
 - Pumping from new wells drilled in the area
 - Well pumping by the County and others
 - Modifications in local surface water features

It is our expectation that water levels will rebound when the drought conditions cease.

- We understand that some nearby wells have had to be re-drilled. The problems in the nearby wells, probably occurred as a result of the water level changes noted above and as a result of the wells not being drilled to adequate depths or well pumps not being set deep enough in the wells. It is also possible that these wells were simply not constructed in productive fracture systems.

- If the County's wells are causing water level changes in nearby wells, the changes are no greater than measured in the County's wells. The little water level data available from nearby wells indicate that water levels in nearby wells may be declining at greater rates than the County's wells. This indicates that factors other than the County's well pumping are contributing to the water level changes in nearby wells.
- Because of (1) the distance between the County wells and the Peters, Adsel and Brown wells, (2) the low hydraulic conductivities in the aquifer, and (3) the fact that the wells are located in separate fracture systems, it is very unlikely that the County's wells are causing significant water level changes in these wells. Projections based on data collected during the pumping test indicate that water level changes that may be induced in these wells is less than two feet.
- We understand that the County will continue to monitor water levels in their wells. Water level data from nearby wells are also helpful for the purposes of understanding local water level changes. It would be helpful if the owners of nearby wells continue to monitor water levels in their wells. We will consider additional data provided to us as part of future water level analyses for the County. We are available to provide water level monitoring guidelines for homeowners if that would be helpful.

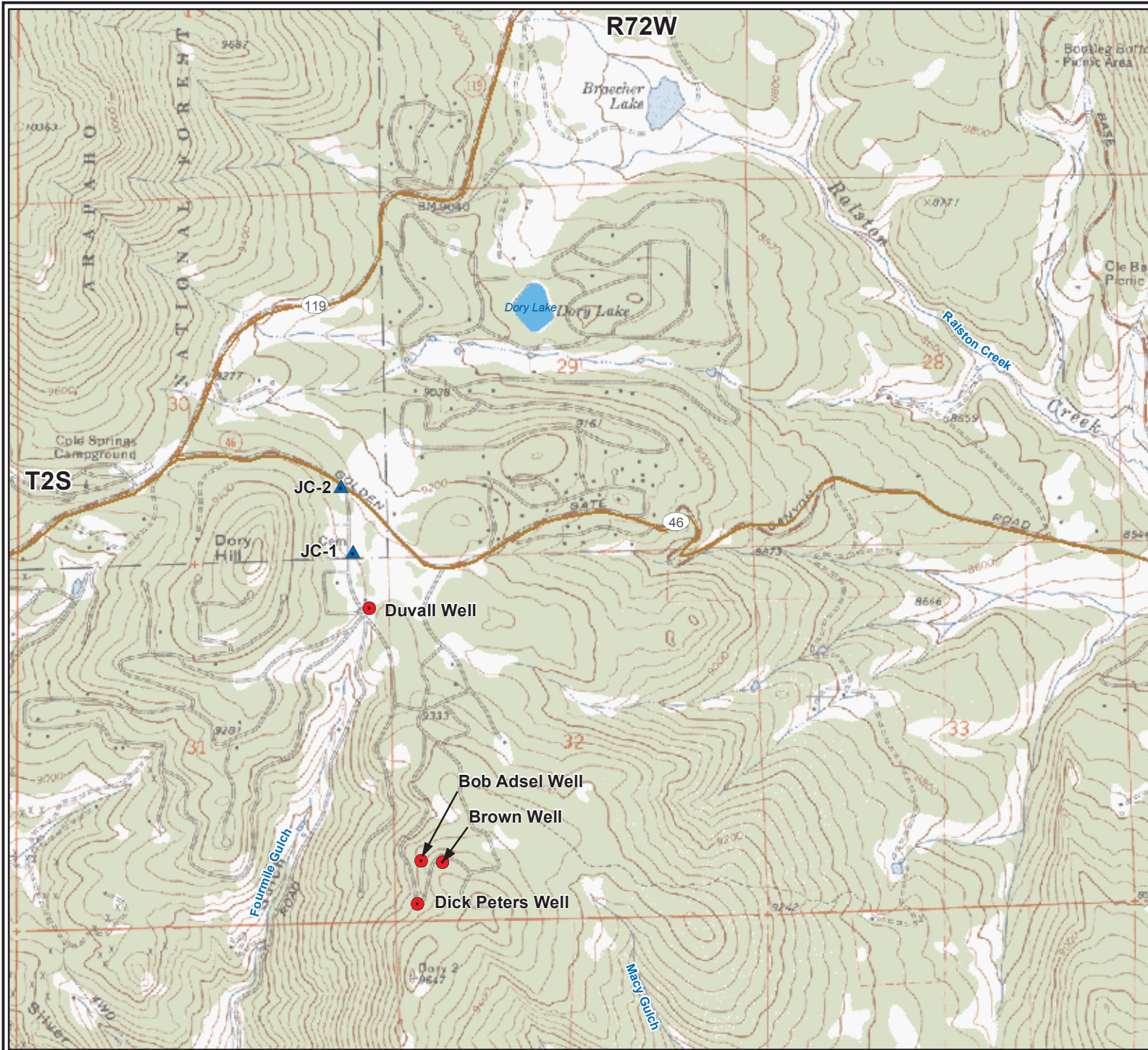


Figure 1 Gilpin County Justice Center

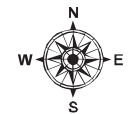
--- General Location Map



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Legend

- ▲ Justice Center Well
- Well



1 inch equals 2,000 feet

0 500 1,000 2,000 Feet

Overview Map

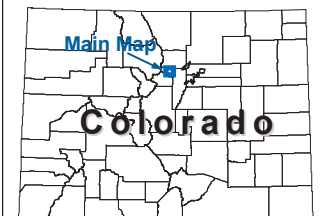
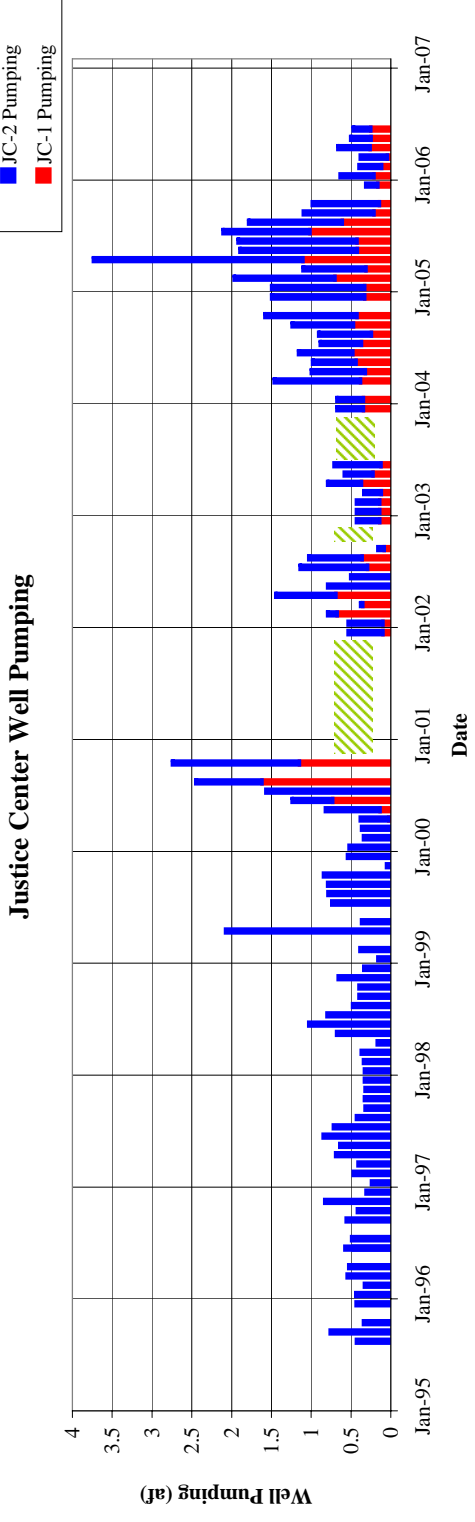
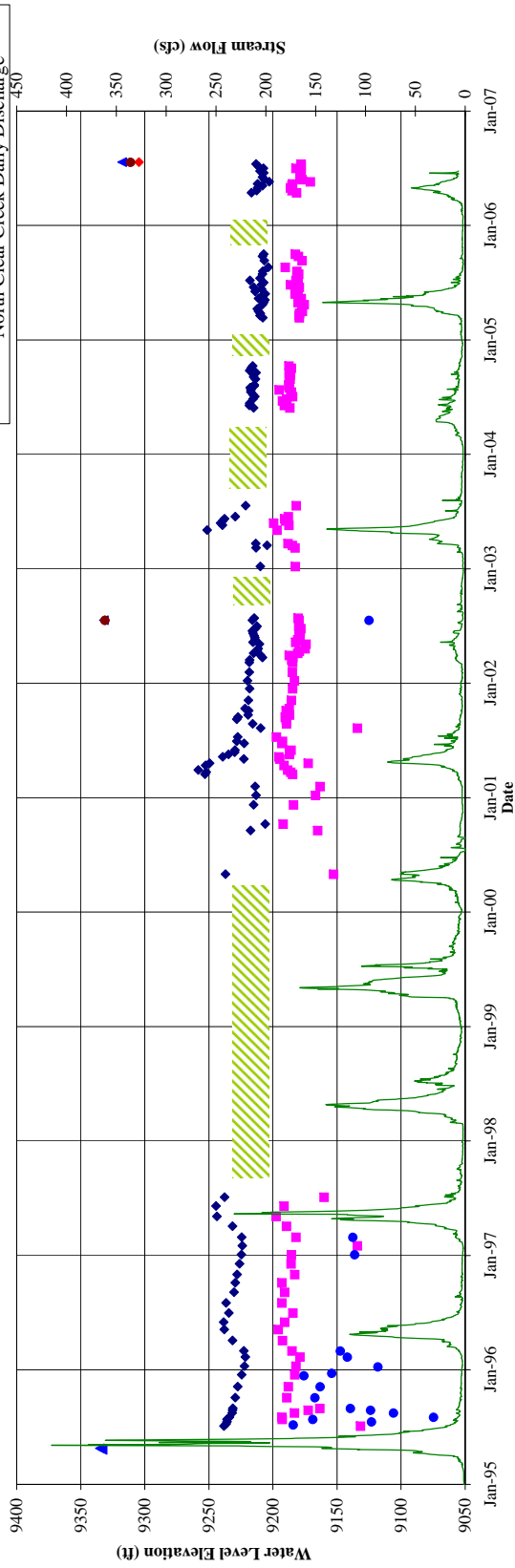
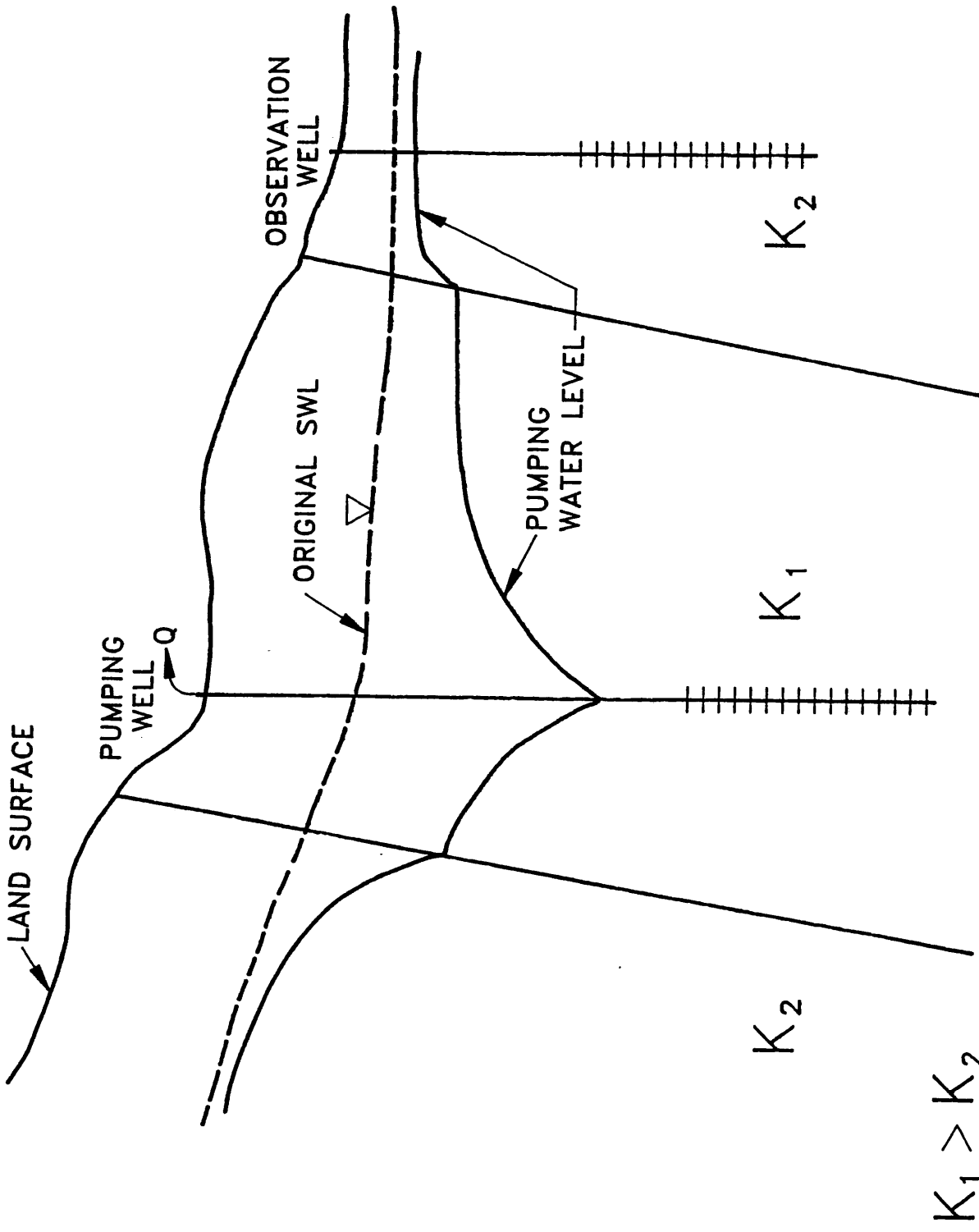


Figure 2
Gilpin County Government
Justice Center Wells



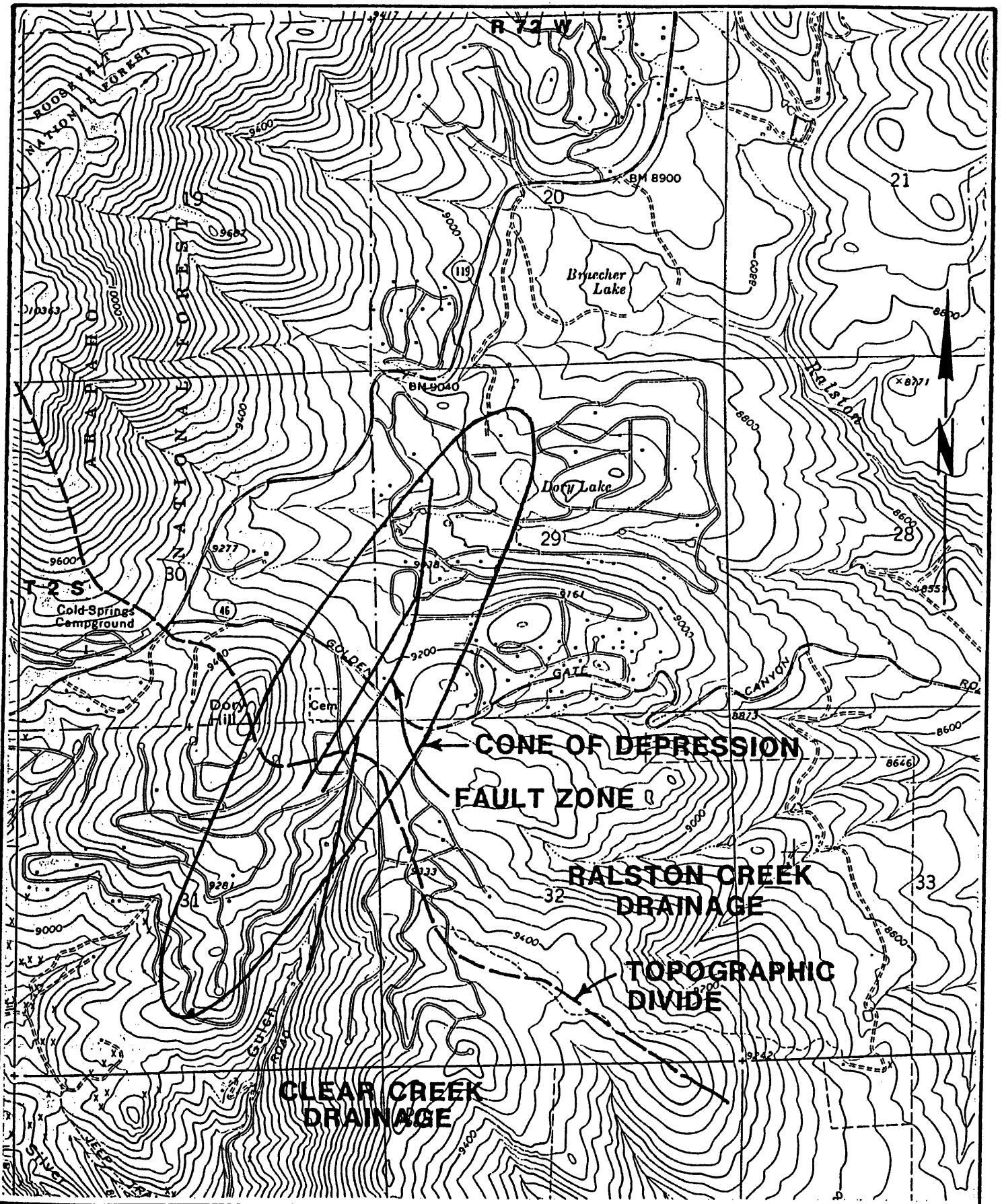
Notes:
 Information presented above based on water level and well production data provided by the client, water level data provided by concerned citizens and streamflow data available from the Division of Water Resources. It is our understanding that production data is not available for portions of 2000, 2001, 2002 and 2003. It is our understanding that the wells were not pumped for portions of 2004 and 2005 and stored water was used to meet demands in the months that do not present production data.
 As presented, water level data is not available for the entire period of record for the county wells.

- Periods during which well production or water level data were not available.



SCHMATIC CROSS SECTION
GROUND WATER SYSTEM

FIGURE 9



**POSSIBLE SHAPE OF CONE OF DEPRESSION
[FOR BASIN APPORTIONMENT ONLY]**

FIGURE 10