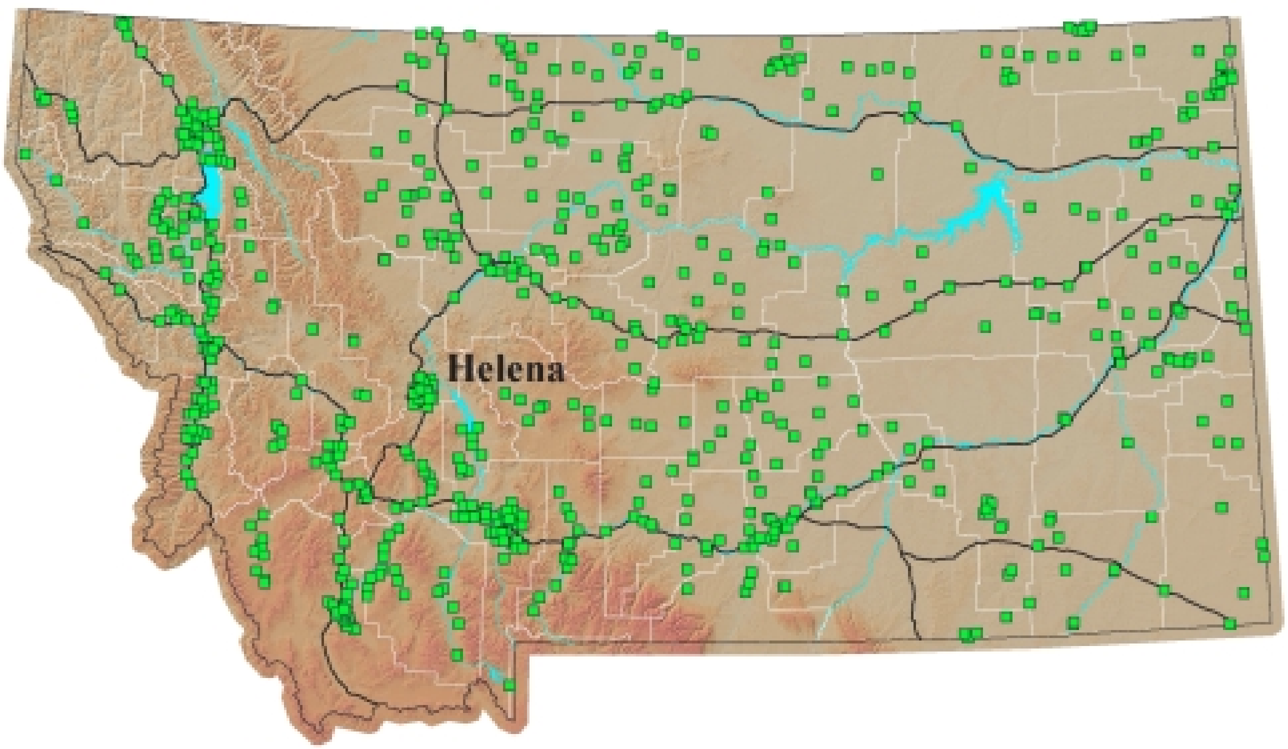
Montana Ground-Water Assessment
Statewide Monitoring Well Network



Montana Ground-Water Assessment

Water-level Monitoring and Drought: April-June 2002

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Butte, Montana

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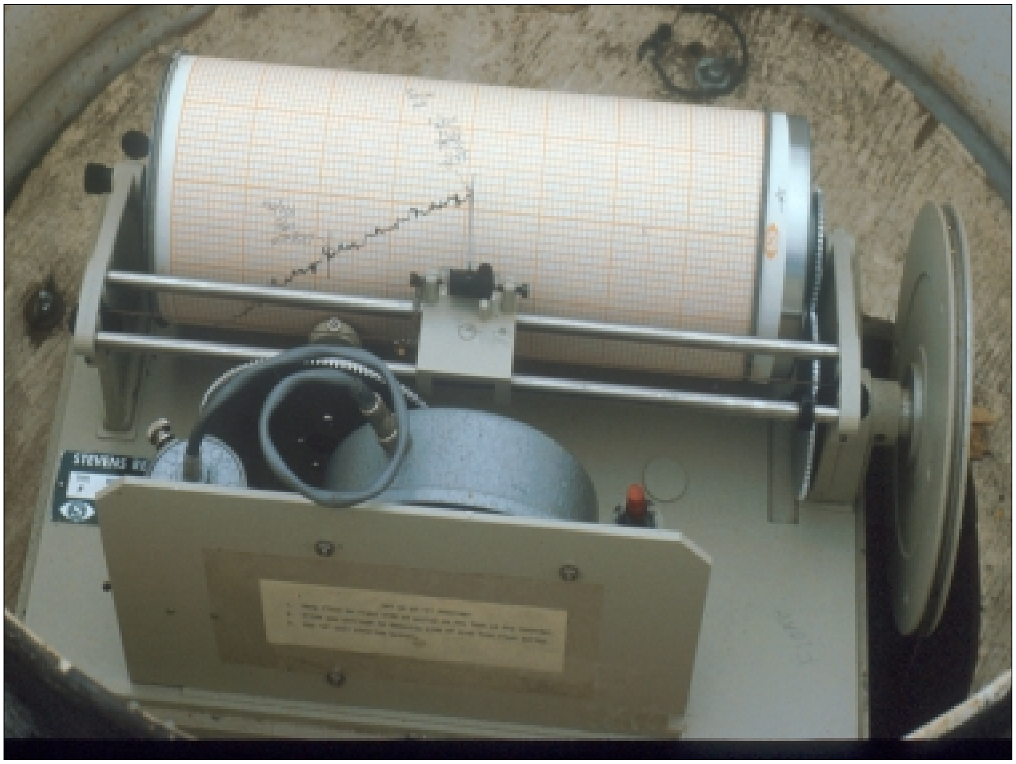
The statewide monitoring network currently contains about 830 wells. Most of the wells are measured quarterly by staff at the Montana Bureau of Mines and Geology (MBMG) but some wells in the Paradise, Helena, Gallatin, and Missoula valleys are measured by cooperators at local water-quality districts and the universities. In addition to the quarterly measurements, there are about 90 water-level recorders that provide daily water levels, 10 of which are operated by the U.S. Geological Survey under a cooperative agreement. Other cooperators include the Coal Hydrology program at MBMG that measures wells in Rosebud and Big Horn counties, the Ground-Water Characterization Program at MBMG that measures wells in active study areas, the Confederated Salish and Kootenai Tribes, and the Sheridan County Conservation District's water reservation monitoring program in northeast Montana. All of the water-level data are available through the GWIC web site at **http//:mbmggwic.mtech.edu.**

The statewide network is designed to collect water-level and water-quality data that may be used for a wide variety of purposes. Considering the current desire for information regarding the response of water wells to climatic conditions, this document focuses on how wells in the network are responding to drought.



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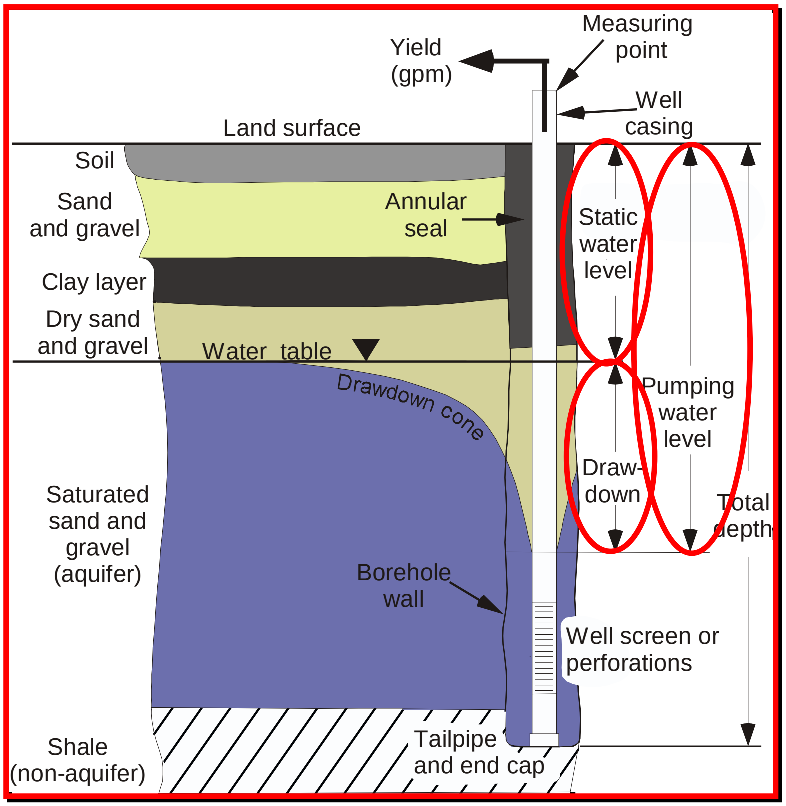
The water-level recorder shown above is one device that the Montana Bureau of Mines and Geology uses to monitor water levels in wells. The gray object in the foreground is a clock that moves a pen from left-to-right across the chart. The large pulley to the right is geared to the drum on which the chart is mounted so that as water levels in the well rise or fall, the drum rotates. The result is a line drawn on the chart that shows the change of water level with time.

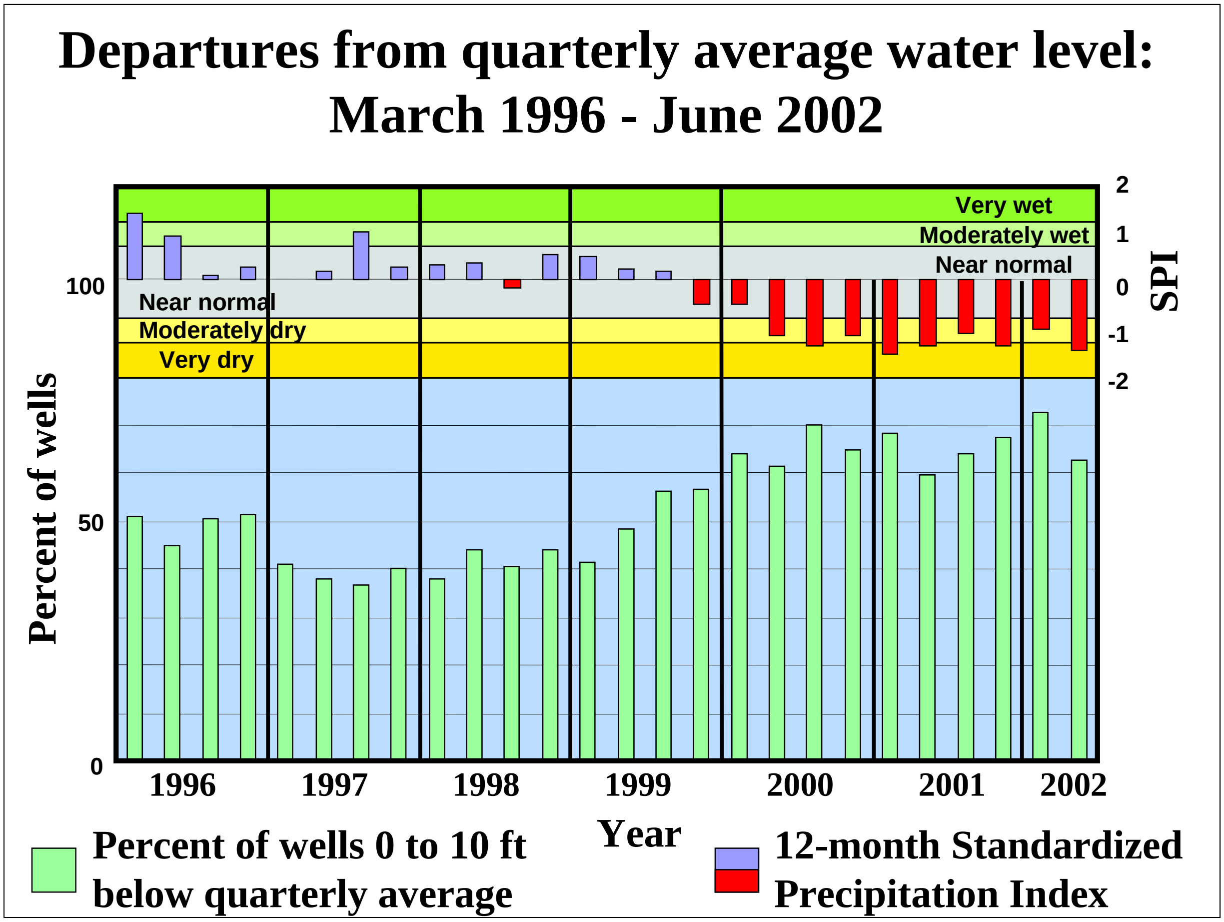


Well construction and terminology

Typical water well construction and Terminology

The **static water level** is the distance *from the land surface to the water in a well* when the well is not being pumped. A **pumping water level** is a measurement made while a well is being pumped and at a known time after pumping began. **Drawdown** is the difference between the pumping water level and the static water level at the time the pumping water level is measured. Distances to water (both static and pumping) are reported as positive numbers. Therefore a water level of 10 ft below land surface is "*higher*" than a water level of 20 ft below land surface. Increasing distances to water in wells indicates that water levels are "*declining*", decreasing distances indicate that water levels are "*rising*".

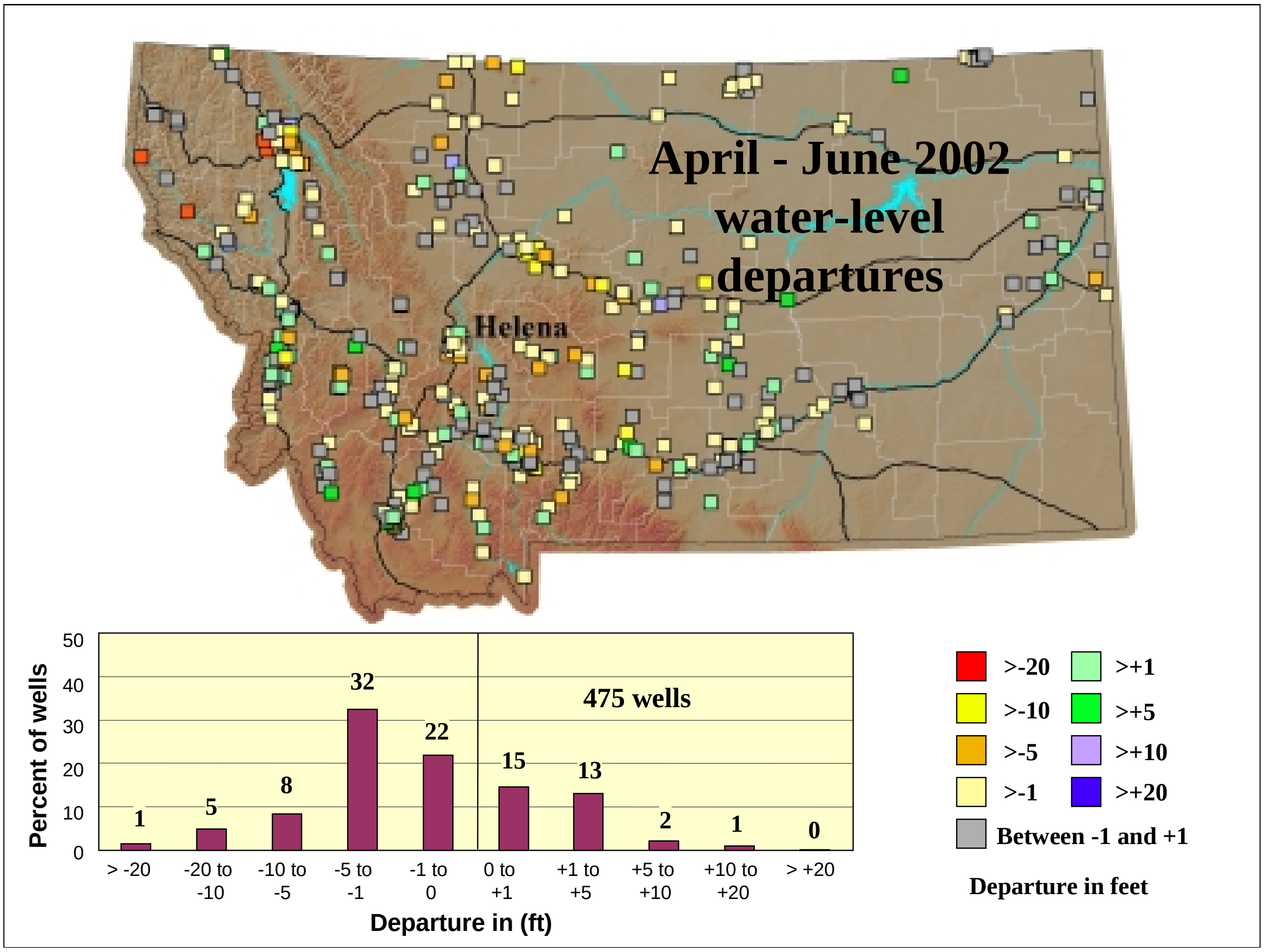
The amount of **drawdown** required to produce water from a well depends on the yield, the amount of time that the well has been pumped, and the characteristics of the aquifer. Generally, if **static water levels** in the well decline, **pumping water levels** must also so that the well can produce the amount of water desired. Because a pump in the well is at a constant depth, declining static water levels may cause pumping water levels to fall below the level of submergence required for the pump, and production from the well will be disrupted. The amount of water-level decline that can be tolerated depends on each well. For example, a shallow well that requires only inches of drawdown may continue producing while nearby deep wells that require feet of drawdown fail. Other deep wells in the same aquifer may appear unharmed because they require less drawdown to operate. However, the shallow well is relatively sensitive to the position of the water table. If the drought continues long enough and is severe, enough decline will occur so that the shallow well "dries" up even though it may have still been operating with only a few inches of water in the bottom.



Departures from quarterly average water level: March 1996-June 2002

The graph shows the percentage of wells in the statewide network that were between 0 and 10 feet below their long-term quarterly averages for each calendar quarter between January 1, 1996 and June 30, 2002. Quarterly postings of the 12-month statewide Standardized Precipitation Index (SPI) for the same time period are in the upper part of the chart. Between the quarter ending in March 1996, and the quarter ending September 1999, the SPI was mostly near, but on the wet side of normal. The percentage of wells that were below their quarterly averages dropped from about 50% to less than 40% during this period, before beginning to rise in the quarter ending June 1999. The 12-month SPI became negative in the quarter ending December 1999, became moderately dry in the quarter ending June 2000, and has continued in the moderately dry to very dry range to the present. During the dry period, the percentage of wells below their long-term quarterly averages has risen to between 60 and 70%. Some improvement in water levels within the network may have occurred because the number of wells below their long-term averages dropped from 73% to 63% between the first and second quarters of 2002. However, similar declines occurred in 2000 and 2001.

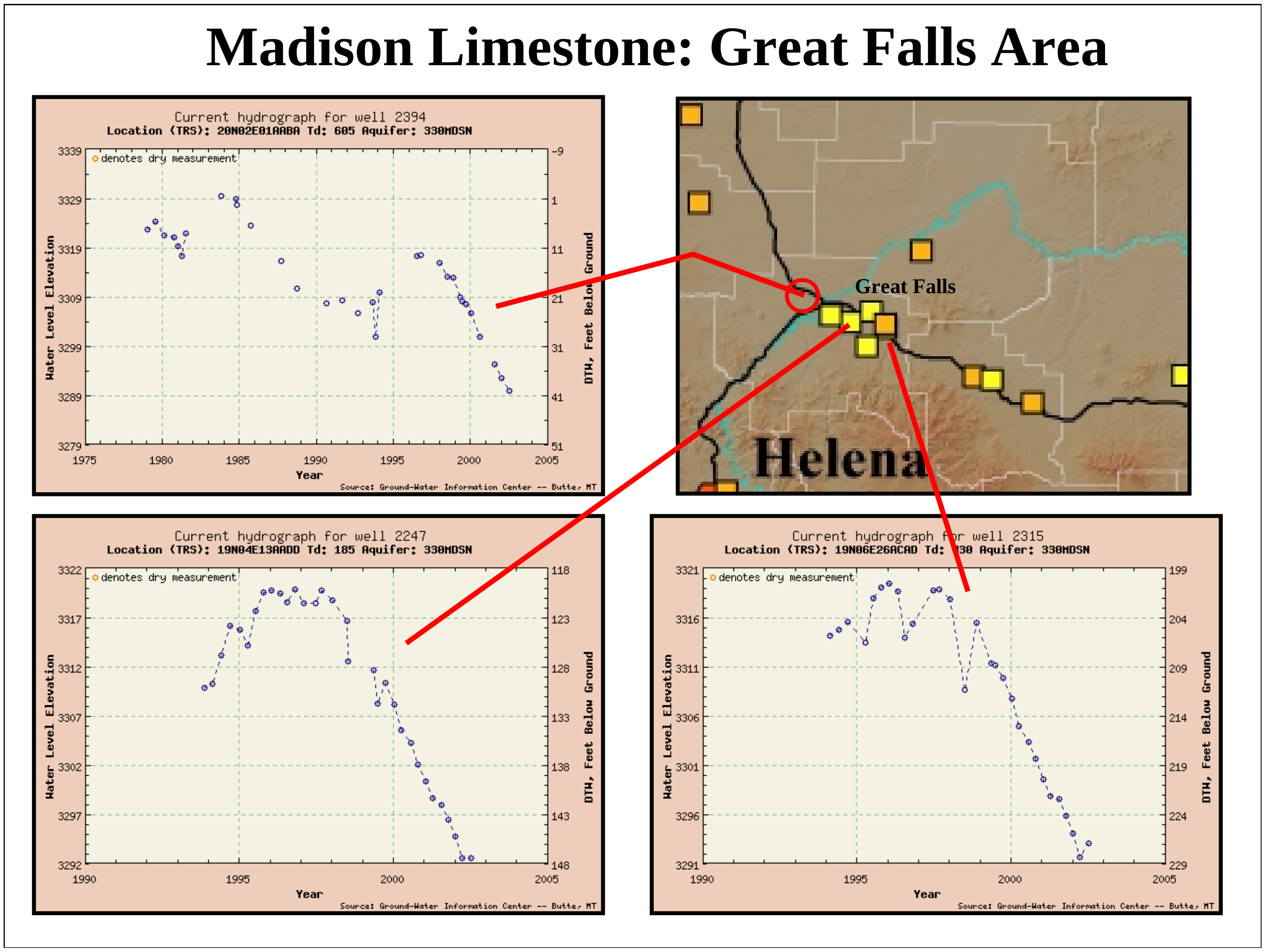
The illustration shows that although more wells are below their quarterly averages in response to the current dry climatic conditions than previously, there was a substantial percentage of wells (about 40%) that were between 0 and 10 feet below their quarterly averages even when climatic conditions were relatively wet in 1997 and 1998. It is possible that other factors are influencing water levels in these wells and examination of water-level records (hydrographs) in conjunction with climatic, pumping, and other data is essential to determine what may be happening in specific areas.



April - June 2002 seasonal water-level departures

Although the monitoring network currently contains about 830 wells, only 475 have April-June 2002 seasonal records of **more than 5 years, more than 5 measurements representing the April-June period, and have measurements made between April 1 and June 30, 2002**. Each point on the map shows the difference in feet (**departure)** between the well's most recent measurement and the average of all its measurements for the April-June period. Yellow, orange, and red points show wells in which the most recent measurement is below average. Green and blue points indicate wells where water levels are above average. Gray points show where water levels are less than 1 foot above or below average.

The histogram shows the percentage of wells that are in each departure category. About 37% of the wells have water levels within +/-1 foot of their long-term quarterly averages, although 22% of these wells are below and 15% are above their averages. Wells with water levels between 1 and 5 feet below their seasonal averages populate the largest category at 32%. About 14% of the wells were more than 5 feet below average during the April-June 2002 period while only about 3% of wells were more than 5 feet above average.



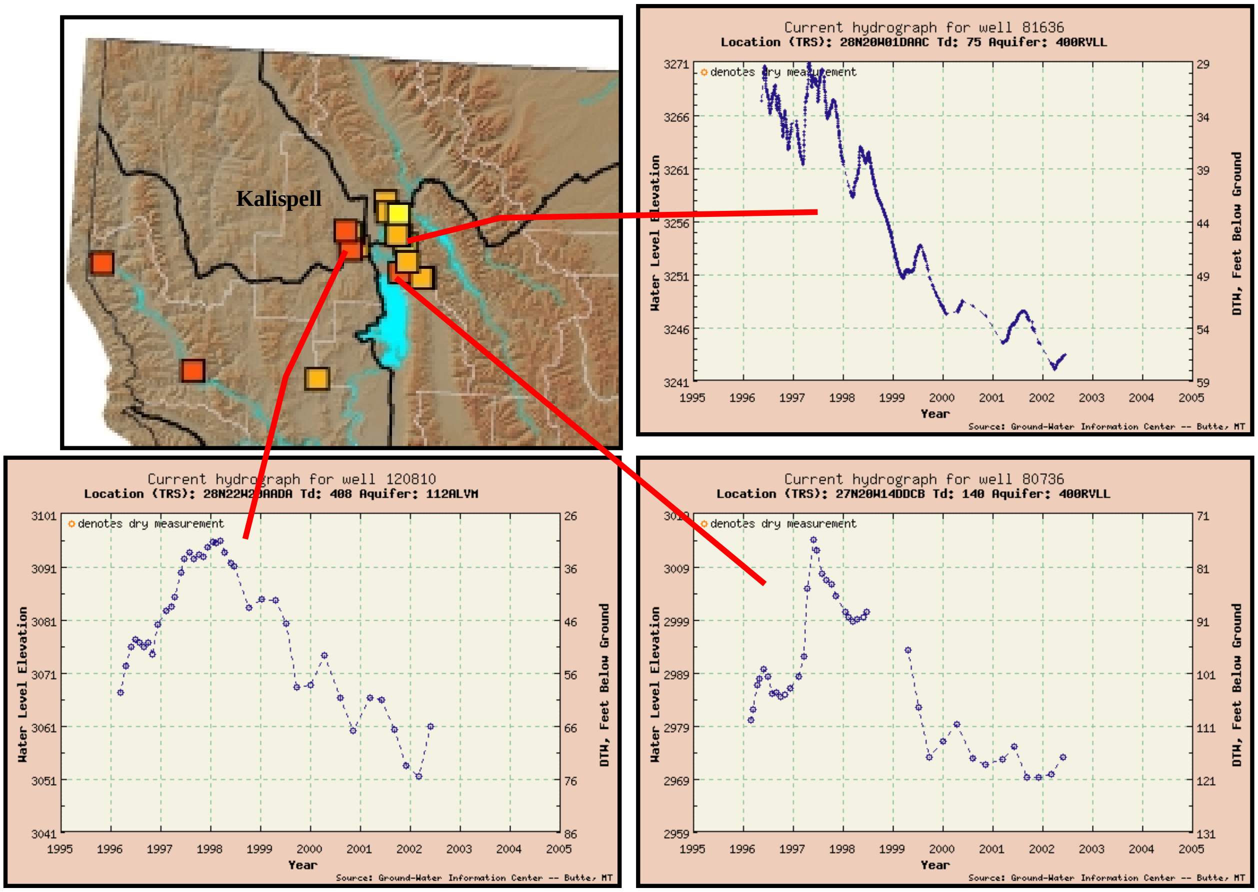
Madison Limestone: Great Falls Area

Four monitoring wells (only three shown here) completed in the Madison Limestone near Great Falls have surprisingly similar water-level records. Well 2394 is represented by a circle because muddy field conditions prevented measurement in April 2002 and its July 2002 measurement was too late to be considered in the data retrieval for the second quarter.

Well 2394 has the longest period of record and comparison of that record beginning in about 1994, to the records for wells 2247 and 2315 shows the similarity. All of the wells have steadily declined since 1997. Well 2394 has reached a new record low in July 2002, but July 10, 2002 measurements in wells 2247 and 2315 were essentially the same as and 1.4 feet above their April measurements respectively.

The Madison Limestone is at the land surface in extensive areas of the Little Belt Mountains (near the word Helena on the map above). The water-level declines likely represent lack of recharge from snow pack and run off in streams along the northern flank of the mountains.

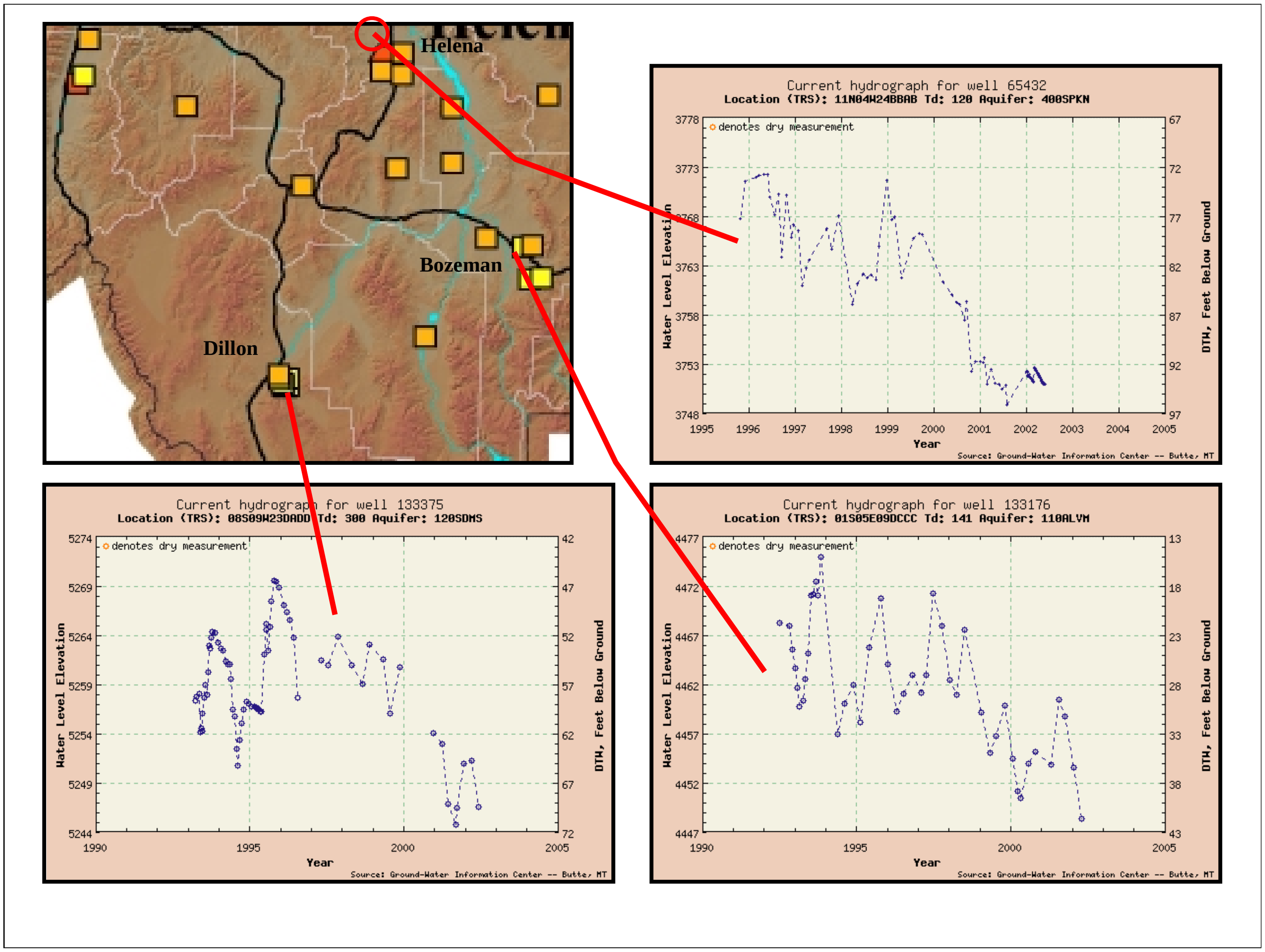
Kalispell valley: fractured bedrock



Kalispell valley: fractured bedrock

These three wells all obtain water from fractured bedrock aquifers around the perimeter of the Kalispell valley. Water levels peaked in 1997 or 1998 and have steadily fallen since. Well 81636 (upper right) is an unused 75 ft deep well located adjacent to a small stream that drains the western face of the Swan Range. Short term upward water-level movements in this well probably show recharge from snowmelt, rainfall, and stream flow in the spring and summer. The downward trend shows the impact of the recent dry years.

Wells 120810 and 80736 have slightly longer periods of record than does well 81636 and show that water levels were rising in 1996 toward peaks in 1997. Current water levels in wells 120810 and 80736 are 5-8 feet lower than water levels measured in 1996, but recently have risen from record lows measured in late 2001 and early 2002.



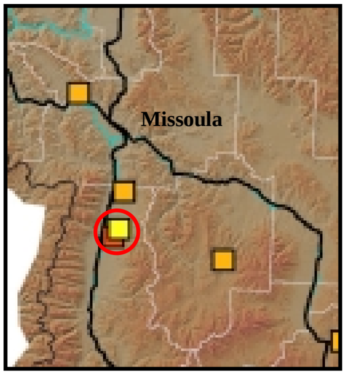
Water-level change: Helena, Bozeman, and Dillon

The hydrographs above illustrate water-level patterns in some wells in the Helena, Gallatin, and upper Beaverhead River valleys that have water-level departures from their second quarter averages of about 10 feet.

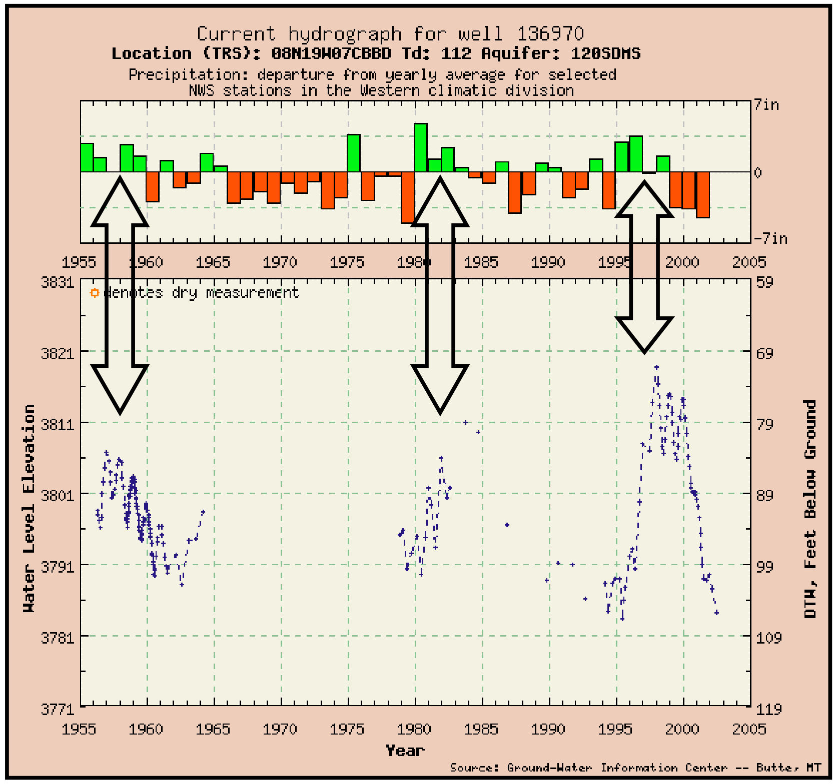
Well 65432 in the Helena Valley (current departure from second quarter average is about 9.5 feet) is represented by a circle on the map. A water-level recorder was installed on this well in late 2001 and the daily measurements in the first 6 months of 2002 overwhelm the calculation of the quarterly average causing the point to not be illustrated properly. Water-level measurements began in this well in 1996 near the peak of the last wet period.

Well 133176 in the Gallatin Valley is located near a subdivision where a number of wells have had to be deepened. Water levels began declining in late 1998 and have generally fallen since then. The most recent measurement is a new record low water level for this well and is about 2 feet lower than the previous record low which occurred in early 2000. Average water-level altitudes in 2000-2002 are about 10 feet lower than average water-level altitudes in 1992-1998.

The hydrograph for well 133375 in the Blacktail Deer Creek valley south of Dillon is typical of water-level fluctuations in that area. Water levels have fallen about 10 feet in the last 2 years and reached a new record low in late 2001. Based on the annual pattern exhibited in the hydrograph, new record lows can be expected later this year. The area is heavily dependent on surface and ground water for irrigation.

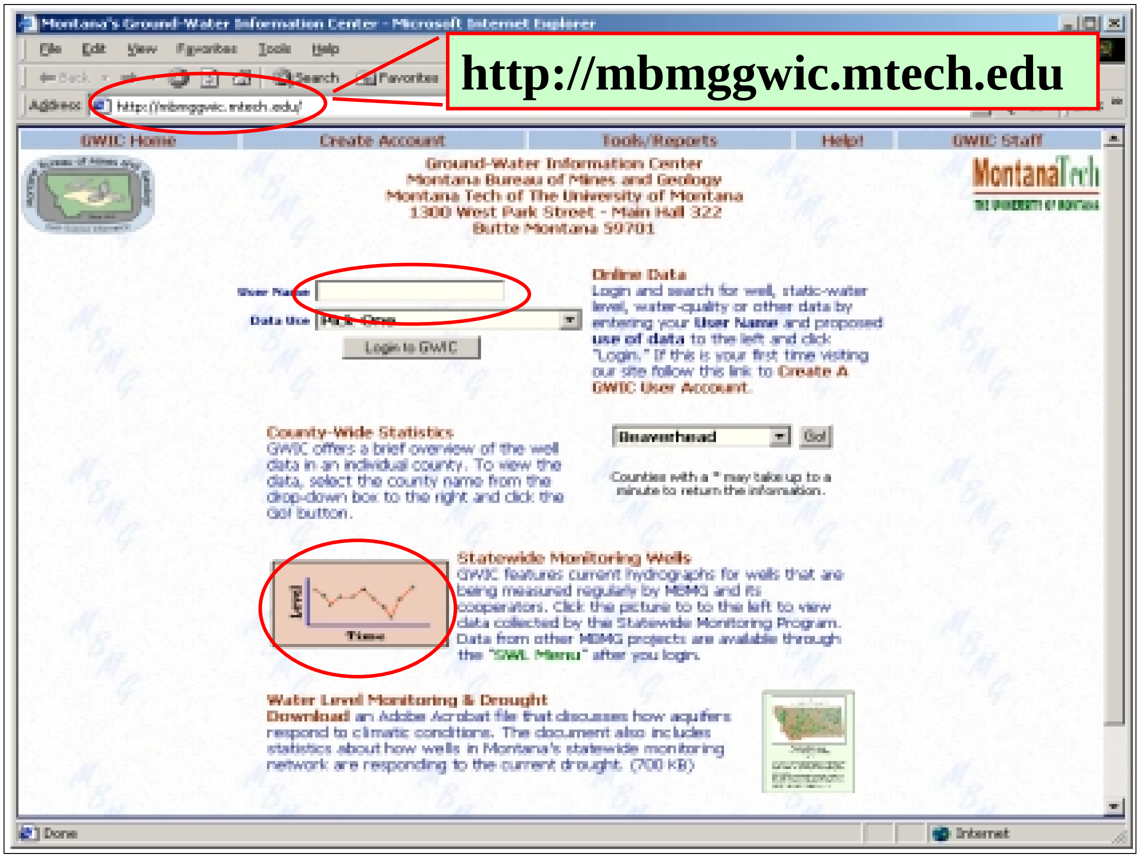


Long-term record and climate



Long-term record and climate

Water-level data from well 136970 in the Bitterroot valley seems to correlate well with precipitation data in the Western Montana Climatic Division. Peaks in water level have occurred in 1956, 1984, and 1997 during or shortly after periods of wetter than average annual precipitation. Current water levels are near, but not at record lows observed in 1995. The red square behind the yellow marker for well 136970 represents a pumping water level captured in error.

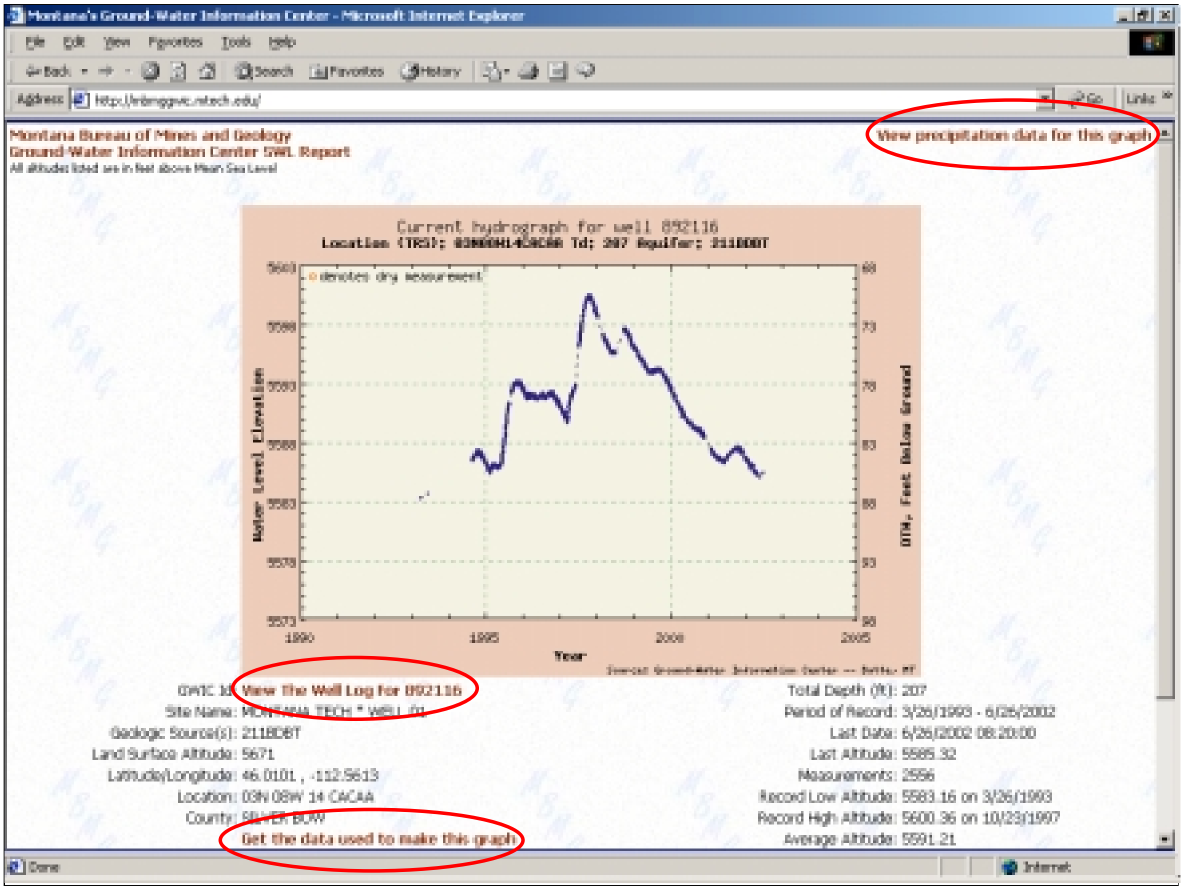


Ground-Water Information Center:

Accessing water-level information

Use your internet browser to view the the GWIC website at http://mbmggwic.mtech.edu. You can see water-level data for Ground-Water Monitoring Program statewide network wells by clicking on the hydrograph. The website will produce a map on which well locations are shown. Clicking on a well location with your computer's mouse will cause the hydrograph for that well to appear.

Water-level data for other wells being measured by other projects can be viewed by logging into the database and selecting the "*SWL Menu*" tab.



Ground-Water Information Center:

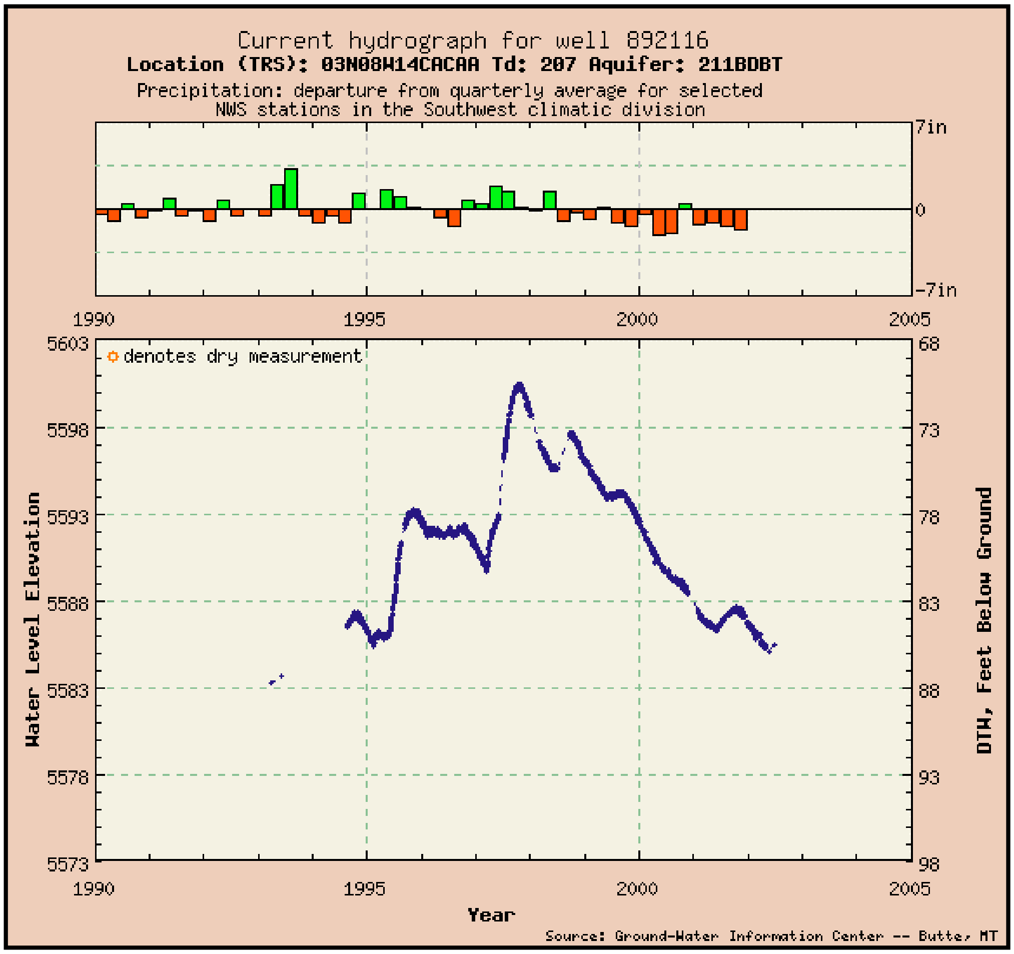
On-line hydrograph

An example hydrograph is shown above. Each hydrograph is calculated at the time of the query so the image always shows that well's most current measurements.

Below the graph, additional information such as the period of record, the depth of the well, the dates and altitudes of record lows and highs are reported. At the bottom of the web page is a link that produces the data used to make the graph. That data can be downloaded to your computer.

You can also select a link to the well log for the hydrograph and from the well log you can link to water-quality information or to the Natural Resource Information System's *Topofinder* application where you can see the well's location plotted on a topographic map or an orthophotoquad.

A new feature of the hydrograph is a link (upper right hand corner of the image) that will show precipitation data for the climatic division in which the well is located.



Ground-Water Information Center:

Precipitation data option

The hydrograph's precipitation link produces a bar graph that shows the departure in inches from monthly, quarterly, or annual averages depending on the time scale of the hydrograph. In the example above precipitation departures from long-term quarterly average are shown.

Precipitation data for about 6 stations within each climatic division are used to calculate the averages and departures. The precipitation data were downloaded from web pages at the Western Regional Climatic Center (http://www.wrcc.sage.dri.edu/summary/climsmmt.html) and each station selected had at least 30 years of precipitation record.