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NATIONAL PERSPECTIVE ON SALINE AQUIFERS

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Good morning and thank you for the invitation to speak at this year's conference. Today I'm going to give an overview of the U.S. Geological Survey's (USGS) activities related to saline-water resources in the United States.

My presentation today will consist of five parts. We'll start with a discussion to put into context fresh and saline waters across the world and then within the U.S. Next, I'll talk about the distribution of saline ground water, the chemical characteristics of saline-water resources, tools the USGS has developed for evaluation of the effects of saline ground-water extraction on subsurface waters, and I would like to end by talking about current USGS activities and future opportunities to investigate this valuable and important resource.

Figure 1 addresses the first topic for discussion: where is the Earth's water located and in what form does it exist?

The distribution of the Earth's water is illustrated by these three columns. The first column shows the breakdown between fresh and saline water on Earth. Only 3 percent of the Earth's water is fresh. Next, if you take that portion of fresh water and break it into its components, you'll see that 68 percent of the fresh water is captured in the world's ice caps and glaciers leaving this component of fresh water unavailable for our use. The next largest portion of fresh water, 31 percent, is ground water.

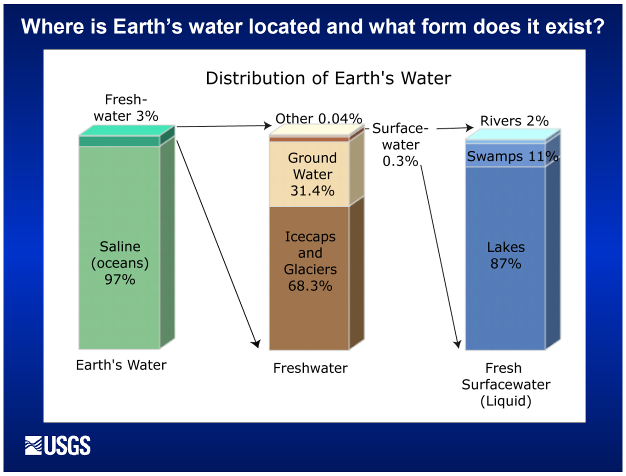

Figure 1.

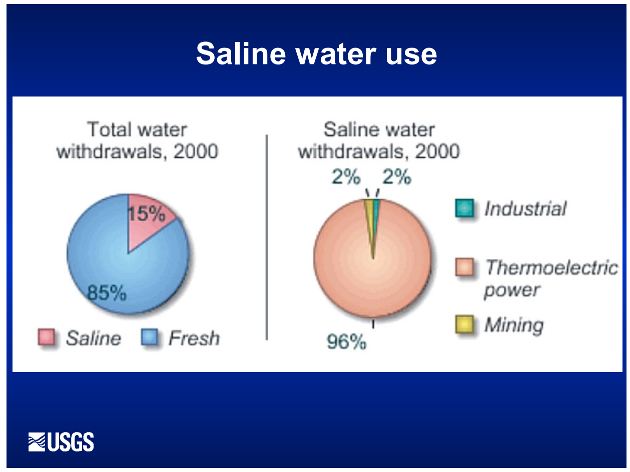

Figure 2.

The world's surface water accounts for only 0.3 percent of the available fresh water. The last column provides the breakdown of the surface water component of Earth's water. The fresh surface water component is composed of lakes, swamps, and rivers, with rivers accounting for only 2 percent of the available fresh surface water supply.

We rely heavily across the world on surface-water resources and it clearly constitutes a very small portion of the available fresh-water supplies. I think this highlights just how precious and limited surface water in rivers and streams is on a worldwide basis.

Another way to look at the Earth's fresh-water resources is by asking, "how much of the Earth's water is usable by humans?" Of all the Earth's water, only 0.3 percent is usable by humans. The largest usable component of that 0.3 percent is the ground-water share of the usable water supply. Although some of that ground water is deep and not very accessible, in comparison to rivers, it still greatly surpasses the quantity of fresh-water supplies on Earth but remains a very small part of the Earth's total water supply.

However, rivers are what this country and the world have traditionally relied on for most of our fresh-water supplies. This conference is evidence to the fact that we are starting to look at ground-water resources to meet the present water needs.

Let's change our perspective from the Earth, big picture, to the scale of the United States. Surface water accounted for 79 percent of the total water withdrawals in the U.S. during 2000. The remaining 21 percent of total water withdrawals was from ground water, with only 1 percent of the total ground-water withdrawals being saline.

Figure 2 illustrates that saline water was primarily used for thermoelectric power generation in 2000.

Figure 3 shows a map of the U.S. on which the relative quantities of saline-water withdrawals are shown by state. California and Florida account for 40 percent of the total saline-water withdrawals in the U.S. New Mexico reported zero saline-water withdrawals in 2000. That may or may not be totally true, but does reflect what was reported.

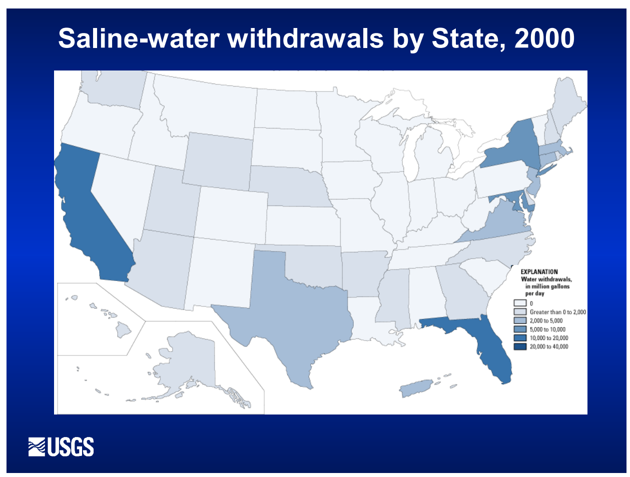

Figure 3.

Let's now look at some trends in total fresh- and saline-water withdrawals. Figure 4 uses blue bars to represent fresh water and red bars for saline-water withdrawals. From 1950 to 1980, there was a steady increase in total fresh-water withdrawals in the U.S. and that is also reflected in the saline-water withdrawals. After 1980, you will note a decline in fresh-water withdrawals that is likely a result of stabilization of technologies related to irrigation and thermoelectric power usage. Fresh-water withdrawals have remained level with a slight increase in 2000. However, if you look at the saline-water withdrawals, you will see a gentle decline.

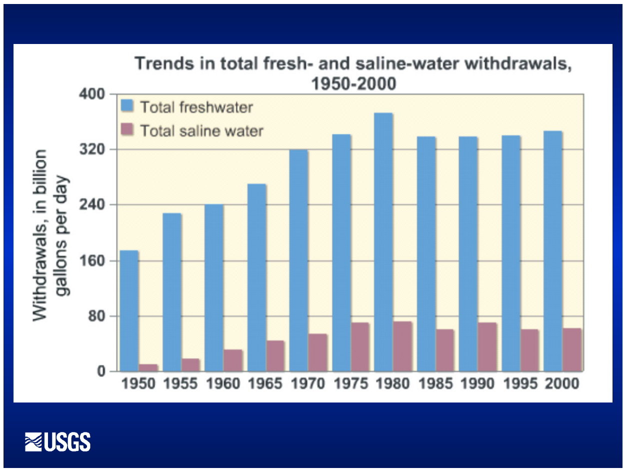

Figure 4.

The facts and numbers I am presenting are from a USGS publication recently released entitled, *Estimated Use of Water in the United States in 2000* (Circular 1268). The publication is available to you in hardcopy from USGS Information Services and on the web at: http://pubs.water.usgs.gov/cir1268.

Other factors affect water demand and are potentially important to the development of saline resources. Demographic changes in the U.S. during the last 10-year period are shown in Figure 5. It shows the percent change in the resident population in the 50 states. Darker colored states indicate a larger percent change in population. You can see that the greatest changes are in the West and Southeast. The U.S. population is migrating and with that migration comes additional demand for water.

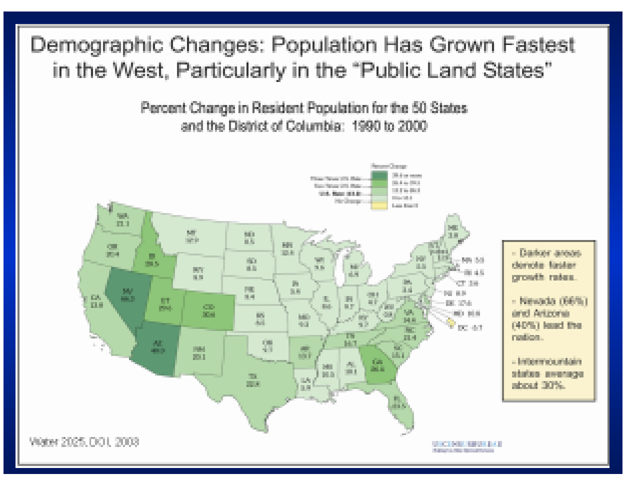

Figure 5.

Figure 6 is a plot showing trends in ground-water withdrawals over a 50-year period along with population trends. What can be seen is that population does not waiver very much as it continues an upward climb. However, recent ground-water withdrawals appear to be on a slight upswing after about a 15-year period of nearly level withdrawals. My contention is that the most recent withdrawals are using ground water to meet the growing population demand.

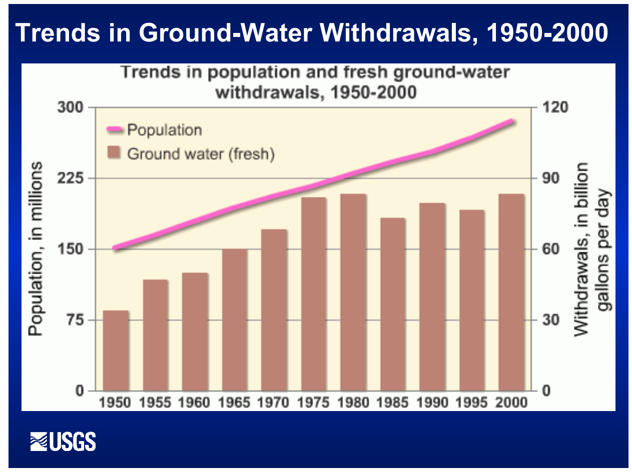

Figure 6.

Surface water resources, specifically in the West, are typically fully appropriated, and in the East, it is much the same story. This also points to the fact that rural water use is predominantly taken from ground-water sources and when cities grow, bands of land develop around cities where people often do not have access to public drinking-water supplies and therefore must develop their own domestic supplies from ground water.

Another important factor to consider when looking at the sustainability of water supplies concerns understanding stresses on those supplies. Figure 7 shows streamflow conditions in the U.S. during the summer of 2002. The dots indicate the location of USGS streamflow stations and illustrates how streamflow varies from normal conditions. I am sure you remember that two years ago, many of the streams in the West and the Southeast were experiencing severe drought. Drought compounds an already difficult situation with more demand than supply from surface water, so additional ground-water supplies need to be developed to meet current demand. If traditional ground-water resources are not available, alternative sources of water will need to be identified, including saline-water resources.

The bottom line is that our fresh-water resources are precious and limited. Total water use remains stable, however, the percentage of ground-water withdrawals may be increasing. Ninety-six percent of the saline-water withdrawals were used for thermoelectric power generation. In 2002, ground

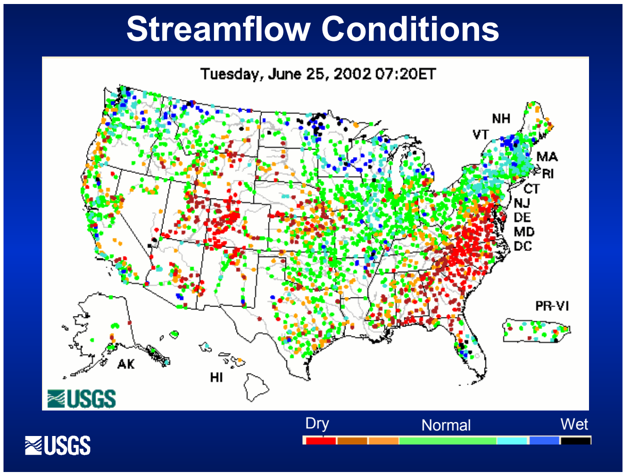

Figure 7.

water was used by more than 35 percent of the U.S. population as a source for public-water supply. Over 15 percent of the U.S. population relied on self-supplied ground water.

As previously stated, rural areas are highly dependent on ground water for their drinking-water supplies. Population growth is occurring faster in the arid West than other parts of the country. Climate change can exacerbate inadequate water supplies. For example, the severe drought of 2002 resulted in Rio Grande flows in New Mexico falling to 13 percent of normal, an indication that the Rio Grande was being substantially stressed.

The reality of limited fresh-water supplies and the increasing demands from a growing population points to the necessity to find alternative supplies. The USGS is well poised to address this problem. To aid in the next part of my presentation let's take a few minutes to look at some definitions. What is saline water? We classify saline water as water having greater than 1000 mg/L or ppm of total dissolved solids or salts. To give you a point of reference, ocean water is about 35,000 mg/L total dissolved solids. The U.S. EPA has established a nonenforceable drinking water standard of 500 mg/L. But in many rural communities people are consuming water with higher concentrations than the U.S. EPA drinking-water standard. When water gets up to about 3000 mg/L, it is probably at the point of being too salty to drink.

Now I would like to give an overview of the work the USGS has done in locating certain saline ground-water resources. First, I'd like to talk about several national studies. The first study was by Krieger and others that was published in 1957. That was a preliminary survey of saline waters in the U.S. It was not as comprehensive as the next study by Feth and others in 1965, which produced a generalized map with a depth to and quality of saline ground water in the U.S. This map is currently being used to show where saline waters are located in the U.S.

The USGS has more recently been involved in similar inventory type studies like the Professional Paper Series 813, a generalized analysis of ground-water resources within 21 Water Resource Regions of the U.S. This series provided general water chemistry information on total dissolved solids and a few selected ions. This study was a generalized broad-scale analysis of selected US water resources.

The first effort to look at U.S. ground-water resources in a detailed manner was the Regional Aquifer-System Analysis (RASA) Program in the 1980s and 1990s. It is obvious that before we look at alternative supplies, we need to characterize our existing fresh-water supplies. The RASA Program characterized the hydrogeologic framework, hydrology, and some general geochemistry for 25 different principal aquifers in the U.S.

The work was important but only looked at fresh-water resources. The most recent national study produced the publication, *Ground-Water Atlas of U.S.* in 2000. This publication was a compilation of existing information, therefore no new information was collected as part of the study.

Figure 8 is the Feth and others map of saline-water resources for the U.S. published in 1965. As I pointed out earlier, this is the map we still use today. However, the map is only a two-dimensional representation of the saline-water resources and therefore does not define the resource vertically with depth.

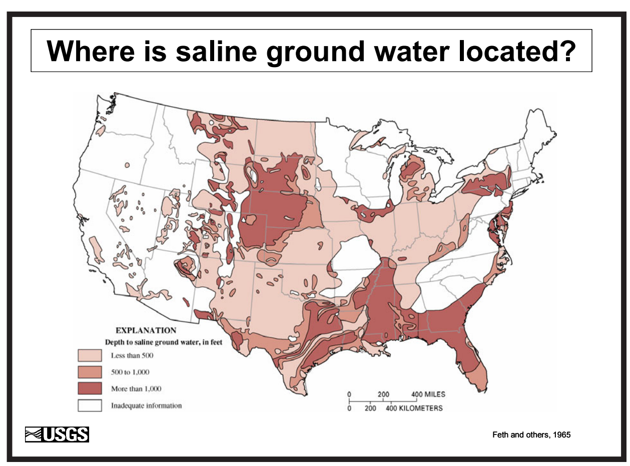

Figure 8.

In addition to USGS national efforts, we have also conducted investigations at the state level through our local District offices. Rick Huff will give a presentation later this morning detailing activities the USGS and others have conducted on a state basis, primarily in New Mexico.

I also want to acknowledge that state agencies are conducting studies of saline-water resources. They are conducting investigations alongside USGS and on their own.

The next topic I want to discuss is, what do we know about the chemical characteristics of the saline ground-water resources in the U.S.? Most of the national investigations focused on fresh-water resources. The USGS has done relatively little research on the geochemistry of saline-water resources. The USGS has been involved in studying the disposal of various industrial wastes as well as brines in deep saline aquifers. But there has been no consistent effort across the nation to study these type of activities.

Another question the USGS has addressed is, how do we examine the effects of saline ground-water withdrawals on the remaining fresh-water resource? I think this is where the USGS has made a substantial contribution. The USGS has developed numerical models to quantify the movement of inland saline-water resources to aid in the understanding of the impacts of using these resources in different hydrologic environments. Two examples are the SEAWAT and SUTRA models. SEAWAT is a combined flow (MODFLOW) and transport (MT3DMS) model. It simulates transient or stress related activities in the ground-water system. The model can also simulate variable-density ground-water flow in three dimensions. It is a very powerful tool. Another attractive aspect is that SEAWAT continues to be updated and compatible with new releases of MODFLOW and MT3DMS. This tool can be used to assess what would happen to ground-water reservoirs once withdrawals are made from either fresh or saline ground waters.

The other numerical model I mentioned that was developed by USGS is SUTRA. This model will simulate transient density-dependent saturated or unsaturated ground-water flow. It will simulate transport of solute or energy in ground water in two and three dimensions. The USGS will continue to support the development of these models.

For the last part of my talk, I want to go into some detail about the current status and future direction of USGS investigations on saline-water resources. In 2001, the USGS was given a Congressional directive to prepare a report describing the scope and magnitude of the effort needed to provide periodic assessments of the status and trends in the availability and use of fresh-water resources.

The USGS completed the analysis and delivered the report to Congress in 2002 (*Concepts for National Assessment of Water Availability and Use* - Circular 1223). The report is accessible on the web at URL: http://water.usgs.gov/pubs/circ/circ1223/.

After submitting the report, the USGS was asked by Congress to develop an implementation plan for such a national assessment. The implementation plan was developed to answer this question: "What is the availability of water resources in the nation and how does this availability relate to demand, source, and geographic location?" This question was asked by Congressman Ralph Regula of Ohio.

The products of the assessment include: data, GIS coverages, and a series of succinct reports that describe hydrologic conditions and trends in water availability on a regional and national scale. The topics that will be reported on include: 1) surface water, 2) historic trends in ground-water levels and updates of ground-water storage change, 3) identification and estimation of undeveloped potential water resources (the subject of this conference), and 4) documentation of surface- and ground-water withdrawals.

Finally, where are we now? We are awaiting passage of the federal budget for fiscal year 2005. The House of Representatives report for the 2005 USGS budget includes increases in funding over the Administration request for initiation of a Water Availability and Use pilot program. If that effort is funded as described in the House report, we would begin the pilot plan in the Great Lakes. In the future, under full implementation, the program would evolve and conduct similar investigations in the remaining aquifer systems across the country. A component of the initiative is to also synthesize existing information. That is when a new effort on saline-water resources will likely take place. If the complete pilot plan is funded, the USGS will likely start the synthesis in the West, and perhaps in New Mexico. The full Senate still must vote on the present recommendations in the report and then the House and Senate must meet in conference to iron out their differences.

I'd like to end by saying the USGS recognizes the need to study saline-water resources. It is evident from my presentation how important those resources will be, especially in certain parts of the country. My hope is that the Water Availability and Use Initiative is fully funded so we can proceed with the pilot study. I appreciate your attention, thank you.