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## **Congressional Testimony**

### **Dr. Gene Whitney, before the Subcommittee on Energy and Mineral Resources, Committee on Resources, U.S. House of Representatives, September 6, 2001**

Submitted by [USGS Congressional Liaison Office](#)

**Dr. Gene Whitney, Supervisory Geologist, U.S. Geological Survey before the Subcommittee on Energy and Mineral Resources, Committee on Resources, U.S. House of Representatives**

**September 6, 2001**

Madam Chairman and distinguished Members of the Subcommittee, thank you for the opportunity to participate in this hearing and to present the results of the U.S. Geological Survey's (USGS) assessment of coalbed methane resources of the U.S. This assessment of undiscovered coalbed methane resources is a fundamental part of the USGS National Oil and Gas Assessment, completed in 1995, which has now been updated with recent assessments of the Uinta-Piceance Basin, Colorado and Utah and the Powder River Basin, Wyoming and Montana.

#### THE NATURE OF COALBED METHANE

Coal is the most abundant fossil fuel, with global reserves estimated to be several trillion tons. In addition to minable reserves, coal is considered to be a source of fluid hydrocarbons, in particular the lightest hydrocarbon gas, methane. Methane is the dominant component in natural gas. The methane that forms in coal is produced by chemical reactions that proceed as a consequence of increasing temperature during the burial of the coal in a sedimentary basin, or may be produced by the action of bacteria that derive their nutrition from the coal and generate methane as a by-product.

Although coal is a solid, it is quite porous, and the pores and fractures in coal may hold enormous volumes of methane. The methane in coal is generally held in the pore spaces by water pressure. As long as water is present, the methane remains in the coal. When the water pressure is reduced, the methane is released and may flow through the fractures in the coal to the surface or to a well bore.

The buildup of methane gas in coal mines during the mining process was recognized very early in coal mining history. The fires or explosions that tragically proved the presence of the methane gas have historically posed chronic coal production problems and danger to human life. Only within the last few decades has methane in coal beds been recognized as a significant untapped energy resource that might be produced.

Not all types of coal may be suitable for producing coalbed methane, however. If coal is too deep in a basin, it becomes effectively sealed and the gas cannot be released from the coal. In addition, deep coal would require deep drilling and the low productivity of coalbed methane wells (small volumes of gas per well per day compared to conventional natural gas wells) generally requires shallower, less

expensive, development. Also, coal is highly variable in its chemical composition and physical structure. Certain types of organic matter are more prone to form methane, and the porosity of the coal must permit movement of the gas once it is released. Therefore, only certain coal beds, and perhaps in certain zones, are highly prospective for coalbed methane production.

## DISTRIBUTION, ASSESSMENT, AND DEVELOPMENT OF COALBED METHANE RESOURCES

The USGS has, as a major part of its mission, the responsibility to estimate, or assess, the amounts of undiscovered oil and natural gas remaining in all onshore areas of the U.S. and in state-owned waters. These assessments are estimates of the quantities of oil and natural gas that have not yet been discovered, but which might be added to the reserves of the United States in the future. These assessments are based on the identification of favorable geologic conditions for the formation and accumulation of oil and gas. Assessments are conducted by teams of geoscientists who possess a thorough understanding of the geologic processes and environments that produce oil and natural gas. The USGS periodically releases updated estimates of oil and gas based on the latest available data and the most refined assessment methodologies. An important component of the ongoing USGS National Oil and Gas Assessment is an estimate of the technically recoverable coalbed methane resources in the United States.

The goal of the USGS National Oil and Gas Assessment is to anticipate the occurrence of undiscovered volumes of natural gas, including coalbed methane, and to estimate the volume of gas left to be discovered and recovered. By conducting geologic studies of the basins within the U.S., these assessments provide some indication of the future supplies of natural gas that may be produced within the next generation or so. The results of the coalbed methane assessment conducted in 1995 are shown in the table 1, and key basins are being updated on an ongoing basis.

**Table 1.** Technically recoverable (not constrained by cost of production) undiscovered resources of gas estimated for continuous-type plays in coal beds, onshore United States. All data from the USGS National Oil and Gas Assessment, 1995. [Mean value totals may not be equal to the sums of the component means given elsewhere because numbers have been independently rounded. Fractile values (F95, F5) are not additive. F95 represents a 19 in 20 chance and F5 represents a 1 in 20 chance of the occurrence of at least the amount tabulated.]

Province name	(trillion cubic feet)		
	F95	F5	Mean
<b>Region 2--Pacific Coast</b>			
Bellingham (WA, OR)	0	0.09	0.04
West Cascade (WA, OR)	0	1.20	0.66
<b>Total, Region 2</b>	<b>0.26</b>	<b>1.30</b>	<b>0.70</b>
<b>Region 3--Colorado Plateau and Basin and Range</b>			
Uinta Basin (UT, CO)	1.86	4.82	3.21
Piceance Basin (CO, UT)	5.47	10.09	7.49
San Juan Basin (NM, CO)	5.76	9.67	7.53
<b>Total, Region 3</b>	<b>15.00</b>	<b>21.88</b>	<b>18.24</b>
<b>Region 4--Rocky Mountains and Northern Great Plains</b>			
Powder River Basin (WY, MT)	0.32	2.90	1.11
Wind River Basin (WY)	0.22	0.72	0.43
S.W. Wyoming (WY, UT, CO)	0.83	7.66	3.89
Raton Basin (CO, NM)	1.39	2.23	1.78
<b>Total, Region 4</b>	<b>3.97</b>	<b>11.71</b>	<b>7.20</b>
<b>Region 7--Mid-continent</b>			
Forest City Basin (KS, MO, IA, NE)	0	1.44	0.45

Cherokee Platform (KS, OK)	1.07	3.08	1.91
Arkoma Basin (OK, AR)	1.87	3.58	2.64
<b>Total, Region 7</b>	<b>3.57</b>	<b>6.76</b>	<b>5.01</b>
<b>Region 8--Eastern</b>			
Illinois Basin (IL, IN, KY)	0.84	2.77	1.63
Warrior Basin (AL, MS)	1.49	3.43	2.30
North Appalachian (PA, NY, OH)	7.68	16.36	11.48
Central Appalachian (PA, OH, KY, WV, VA)	1.88	4.64	3.07
Cahaba (TN, AL, GA)	0.14	0.54	0.29
<b>Total, Region 8</b>	<b>14.34</b>	<b>24.00</b>	<b>18.78</b>
<b>TOTAL, lower 48 States</b>	<b>42.89</b>	<b>57.63</b>	<b>49.91</b>

The USGS has reassessed two important coalbed-methane bearing basins in the Rocky Mountains: the Uinta-Piceance Basin in Utah and Colorado and the Powder River Basin in Wyoming and Montana. We estimate that the Uinta and Piceance Basins contain, at the mean, 2.32 trillion cubic feet (tcf) of undiscovered, technically-recoverable coalbed methane (Table 2). This new estimate is a substantial reduction from our 1995 estimate of 10.70 tcf (Table 1).

In contrast, our estimate of undiscovered coalbed methane in the Powder River Basin has increased substantially. The USGS now estimates the Powder River Basin contains 14.26 tcf of undiscovered, technically-recoverable coalbed methane (Table 2), compared with 1.11 tcf reported in the 1995 National Oil and Gas Assessment (Table 1).

New estimates of undiscovered, technically-recoverable coalbed methane resources reflect new information about the geology of the basin and the extent of the resources made available from recent exploration and drilling activity in these basins, combined with advances in gas recovery technology in the shallow deposits of the Powder River Basin.

**Table 2.** Updated (2001) assessment values (trillion cubic feet) for undiscovered, technically-recoverable coalbed methane resources in the Uinta-Piceance Basin and the Powder River Basin.

<b>F<sub>95</sub></b>	<b>Basin</b>	<b>F<sub>5</sub></b>	<b>Mean</b>
1.16	Uinta-Piceance Basin (CO, UT)	4.07	2.32
8.24	Powder River Basin (WY, MT)	22.42	14.26

Nationally, the major coalbed methane provinces coincide with the major coal provinces. The geology of coalbed methane is based upon the geology of the coal in which it forms and accumulates. The USGS has also conducted regional assessments of coal resources, including detailed research on the accumulation, burial, and subsequent uplift of coal that occurs across the U.S. Although coalbed methane is a form of natural gas, its accurate assessment rests upon the assessment of coal in U.S. basins; coal assessment provides an ideal basis for the subsequent assessment of coalbed methane. Although the presence of abundant coal does not guarantee that coalbed methane will be economically recoverable, the presence of coal is an obvious prerequisite for coalbed methane formation and accumulation in economic deposits. Therefore, the major coal provinces, such as the Appalachian Basin, the Texas Gulf Coast, the Colorado Plateau, and the Tertiary basins of the Northern Rockies and Great Plains, provide the most prospective areas for coalbed methane production (see map).

In addition to the undiscovered, technically recoverable coalbed methane volumes reported in Table 1, coalbed methane also comprises part of current U.S. natural gas reserves and production. Nationally, coalbed methane accounts for approximately 8% of total natural gas reserves and 7% of total natural gas production. Historically, the San Juan Basin has been the most productive coalbed methane basin in the U.S., accounting for approximately two-thirds of the known reserves and approximately 80% of the coalbed methane production (source, Energy Information Administration,

(EIA), 2000). The second most productive area of the country, Warrior Basin in Alabama, accounts for approximately 8% of total coalbed methane reserves and 9% of U.S. coalbed methane production. (Table 3, EIA, 2000)

**Table 3. U.S. Coalbed Methane Proved Reserves and Production, 1989-1999**

(Billion Cubic Feet at 14.73 pounds per square inch atmospheric pressure (psia) and 60° Fahrenheit)

Year	Alabama		Colorado		New Mexico		Others <sup>a</sup>		Total	
	Reserves	Production	Reserves	Production	Reserves	Production	Res.	Prod.	Reserves	Production
1989	537	23	1,117	12	2,022	56	0	0	<b>3,676</b>	<b>91</b>
1990	1,224	36	1,320	26	2,510	133	33	1	<b>5,087</b>	<b>196</b>
1991	1,714	68	2,076	48	4,206	229	167	3	<b>8,163</b>	<b>348</b>
1992	1,968	89	2,716	82	4,724	358	626	10	<b>10,034</b>	<b>539</b>
1993	1,237	103	3,107	125	4,775	486	1,065	18	<b>10,184</b>	<b>752</b>
1994	976	108	2,913	179	4,137	530	1,686	34	<b>9,712</b>	<b>851</b>
1995	972	109	3,461	226	4,299	574	1,767	47	<b>10,499</b>	<b>956</b>
1996	823	98	3,711	274	4,180	575	1,852	56	<b>10,566</b>	<b>1,003</b>
1997	1,077	111	3,890	312	4,351	597	2,144	70	<b>11,462</b>	<b>1,090</b>
1998	1,029	123	4,211	401	4,232	571	2,707	99	<b>12,179</b>	<b>1,194</b>
<b>1999</b>	<b>1,060</b>	<b>108</b>	<b>4,826</b>	<b>432</b>	<b>4,080</b>	<b>582</b>	<b>3,263</b>	<b>130</b>	<b>13,229</b>	<b>1,252</b>

<sup>a</sup>Includes Oklahoma, Pennsylvania, Utah, Virginia, West Virginia, and Wyoming.

**Source:** Energy Information Administration, Office of Oil and Gas, U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves:1999 Annual Report, 2000

This picture is changing, however, with the emergence of other western U.S. coalbed methane basins. In the Rocky Mountain region, the Powder River Basin in Wyoming is experiencing a coalbed methane production boom. The thick coals of the Powder River Basin in Wyoming and Montana are proving to be fertile areas for coalbed methane exploration and production. Coal beds with producible methane are often shallow in this basin, so wells are inexpensive to drill and operate. Although highly variable in thickness, the Tertiary coals in the Powder River Basin are commonly quite thick, reaching 300 feet thick in parts of the basin.

Exploration and production activity in the Powder River Basin began to increase geometrically once coalbed methane developers understood the production techniques necessary to successfully produce the gas. In May of 1994, there were 110 coalbed methane wells in the basin, producing 6.5 million cubic feet of gas per day, as well as 949,637 gallons of water per day. In May of 2001, seven years later, there were 5,446 wells producing 642 million cubic feet of coalbed methane per day and 61,141,720 gallons of water per day. The large volumes of water are produced because it is the water that holds the methane in the pores of the coal, and water must be removed in order for the gas to be released. Therefore, the first stage of production in a coalbed methane well in the Powder River Basin is the removal of sufficient water to release the gas so that it can be produced.

#### IMPACTS AND ISSUES OF COALBED METHANE DEVELOPMENT

As a result of this water production, one of the major concerns associated with coalbed methane production in the Powder River Basin has been disposal of the co-produced water (water produced as a byproduct of the gas production). The coal beds in this basin are significant aquifers because of their high porosity and highly fractured character. Many local residents have historically taken their water supply from coal beds. However, the ground water table must be drawn down during coalbed methane production for the methane to be released from the coal. This draw-down requires many closely-spaced wells, sometimes pumping at high rates.

The water within the coals in the southeastern quadrant of the Powder River Basin in east central Wyoming

is high quality water, suitable for drinking and agriculture, but the water in coals elsewhere in the basin may not be of such high quality. In these cases, the water must undergo treatment if it is to be disposed of on the surface, or it must be re-injected into a deep formation so that it does not contaminate the surface or ground water. Even some highly dilute waters may be undesirable because of salts that may be concentrated during evaporation if surface disposal is used. Therefore, it is essential to understand the chemistry of waters co-produced with coalbed methane and to dispose of those waters appropriately.

In the San Juan Basin, the water is rarely of sufficiently high quality that it can be disposed of on the surface. This is the situation in most other basins in the U.S. In addition, many states require that all co-produced fluids be re-injected into subsurface formations, regardless of the quality of the fluid. The production of large volumes of water and the need to develop appropriate methods for its disposal strongly affect the economic viability of coalbed methane wells. Because coalbed methane wells generally produce at lower rates than conventional natural gas wells, the expense of disposing of the co-produced waters may be economically prohibitive and could render the well uneconomic.

In areas where the co-produced water is high quality, such as in portions of the Powder River Basin, the main issue may be the effect of surface disposal of large volumes of water. Even though the water is clean, it affects the environment in this semi-arid climate. Co-produced water from coalbed methane development is presently discharged either directly into existing surface waters or to drainages. It is expected that surface disposal of co-produced water may result in erosion or drowning of drainages and associated vegetation within the area. Several companies have been experimenting with reinjecting the co-produced water into sandstones and coal beds in the Wasatch and Fort Union Formations. One company is reinjecting water into an aquifer used by the city of Gillette, Wyoming.

Ground water withdrawal from aquifers is a particularly sensitive issue to landowners who "beneficially use" ground water for their livestock and for irrigation (in addition to drinking water). Generally, methane operators have cooperated with landowners by diverting co-produced water from coalbed methane wells into stock tanks or other holding areas for their livestock. Another impact of coalbed methane development is the affect on local coal mining operations of ground water withdrawal from the coal. Although this does not affect the amount of coal that is produced, it reduces the available water for coal mining operations and accelerates oxidation of the coal, which may reduce its heat content and energy potential. In addition, because surface mining activities involve the drawing down of the water table, reservoir pressures can be reduced, resulting in the liberation of the methane from the coal, which may escape along the active face of the mine. For example, there are 18 large surface coal mines along the eastern part of the Campbell County and the northernmost part of Converse County, Wyoming. Last year, these coal mines produced about 300 million short tons from the Wyodak-Anderson coal zone. The Wyodak-Anderson coal zone is also being explored and developed for coalbed methane by about 80 methane operators basin wide. The coal produced from these mines made up about 30 percent of the total U.S. coal production in 2000 and was shipped to more than 140 electric-power generating plants in the western, mid-western, southern, and southeastern U.S.

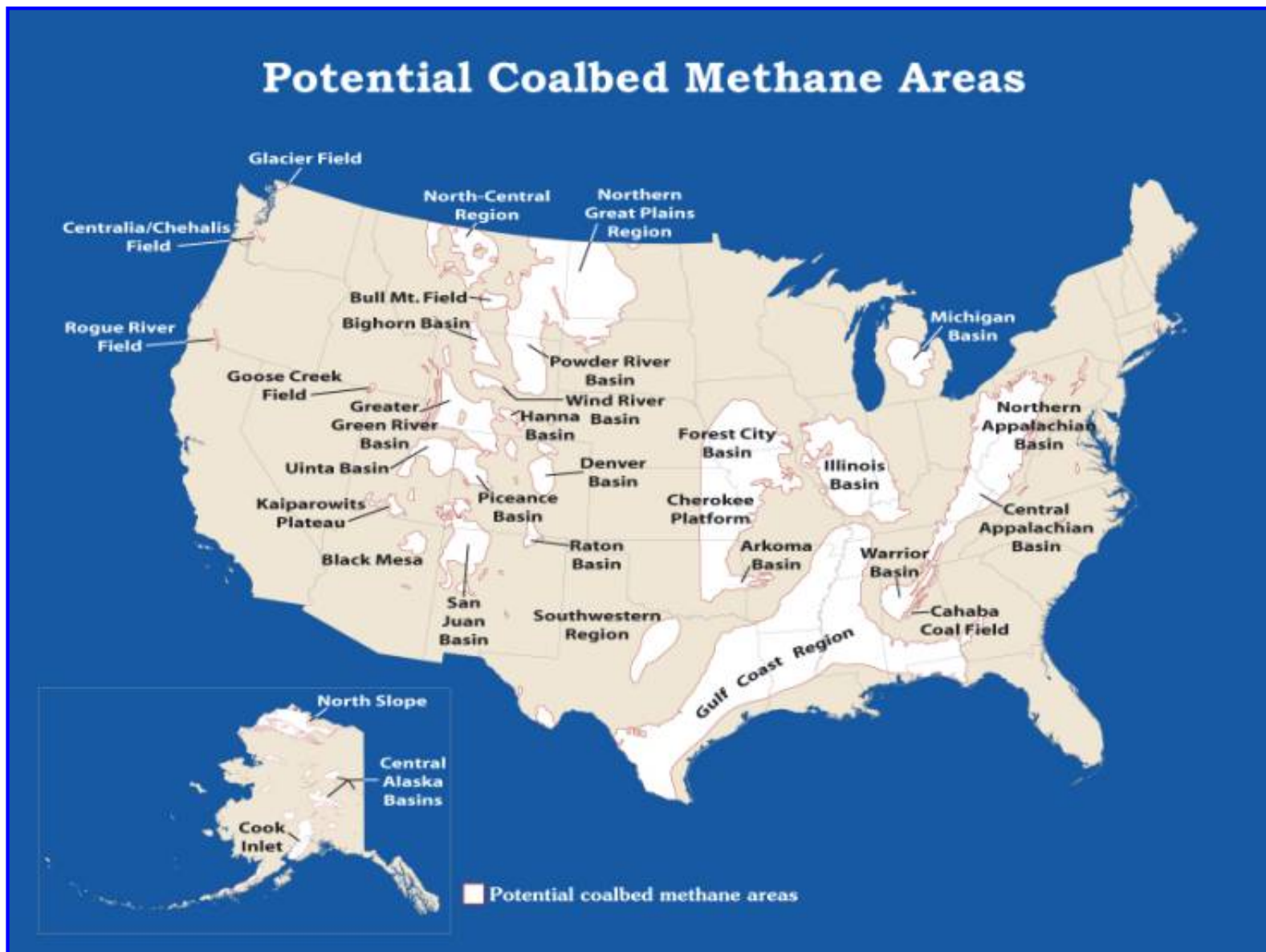
More than half of the lands in the Powder River Basin contain mineral rights owned by the Federal government, yet the majority of the surface in the basin is privately owned. As a result, the majority of coalbed methane wells are on state and private surface lands; only 14 percent of the wells are on Federally-owned surface lands. Coalbed methane development on Federal lands creates impacts in the basin resulting from associated drilling, facilities, methane gathering systems (e.g., pipeline networks), access roads, and withdrawal and disposal of co-produced water from coalbed methane wells. The Bureau of Land Management (BLM) assesses the land-use management and impacts of drilling coalbed methane wells on lands where mineral rights are controlled by the Federal government.

The BLM and the USGS initiated a cooperative project to collect technical data for analysis and evaluation of coalbed methane resources and reservoirs in the Powder River Basin, primarily from coal cores provided by cooperating coalbed methane operators. BLM and USGS use this opportunity for additional information and analyses of the coalbed methane resources to accomplish their agencies' respective resource evaluation and management missions. The agencies have different, but complementary, goals and information needs. Their joint study also addresses public need for data regarding Powder River Basin coalbed methane resources.

## SUMMARY

Coalbed methane is different from other types of natural gas deposits in its distribution, in its production methods, and in its environmental impact. Coalbed methane occurs in coal, is economically producible where it is shallow, and requires dewatering of the coal prior to production. Water co-produced prior to and during gas production must be re-injected into a deep formation or, if the water is sufficiently good quality, disposed of on the surface. Consequences of surface disposal of fresh water include some potential chemical effects after evaporation, the introduction of water into a semi-arid environment, and potential ground water depletion.

Madam Chairman, this concludes my remarks. I would be happy to respond to questions Members of the Committee may have.







## Congressional Testimony

### Statement of Timothy L. Miller Before the House Subcommittee on Environment and Hazardous Materials, May 21, 2002

Submitted by [USGS Congressional Liaison Office](#)

**Statement of Timothy L. Miller, Chief, National Water-Quality Assessment Program, U.S. Geological Survey, U.S. Department of the Interior Before the United States House of Representatives Committee on Energy and Commerce, Subcommittee on Environment and Hazardous Materials**

**May 21, 2002**

Mr. Chairman and subcommittee members, I appreciate the opportunity to appear before the Subcommittee on Environment and Hazardous Materials to testify on the findings of U. S. Geological Survey (USGS) studies on water-quality issues related to methyl tertiary-butyl ether, commonly referred to as MTBE.

As you may know, the mission of the USGS is to assess the quantity and the quality of the earth's resources and to provide information that will assist resource managers and policy makers at the Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and research on the fate and transport of pollutants in water are important parts of the overall mission of the USGS.

USGS studies over the past 8 years have shown that MTBE typically is present at very low concentrations in shallow ground water within areas where MTBE is used. Our studies also suggest that MTBE levels do not appear to be increasing over time and are almost always below levels of concern from aesthetic and public health standpoints. The few locations in our database with high concentrations of MTBE may be associated with leaking underground storage tanks.

Based on comparisons with the U.S. Environmental Protection Agency's (USEPA) drinking water advisory, the health threat to water supplies is small compared to other water-related issues. MTBE is primarily an aesthetic (taste and odor) problem. However, we believe it may be prudent to continue our monitoring and research within available resources so that we can verify that the threat remains low and to further the understanding of this chemical to contribute to effective strategies to protect our Nation's water supplies and to efficiently remediate those ground waters that have become contaminated.

The results I will present today come from about a decade of sampling and study of MTBE and other Volatile Organic Compounds (VOCs). MTBE is one of about 60 VOCs that we measure on a routine basis in our water-quality studies.

The single largest study we have made of MTBE is part of our National Water Quality Assessment (NAWQA) Program. Based on initial monitoring data for wells sampled in 1993-94 in the NAWQA Program, we published a report on the occurrence of MTBE in shallow ground water in urban and agricultural areas. At that time our data set was fairly small—about 200 randomly selected wells in urban areas and 500 randomly selected wells in agricultural areas. We reported finding MTBE in about 25 percent of urban wells and 1 percent of agricultural wells. Many of the MTBE detections were low concentrations. In fact, only 3 percent of the urban wells exceeded 20 micrograms per liter, the lower limit of USEPA's consumer advisory for taste and odor. Also, many of the urban wells that contained MTBE were located in Denver, Colorado, and in New England, both areas with extensive use of MTBE prior to our sampling. At the time, MTBE was a chemical for which usage had increased dramatically in recent years and we knew it moved in the subsurface differently from other gasoline components. Thus, even though it was detected in few wells and at very low levels, we believed it would be prudent to continue studying it at many locations and over a period of several years to learn more about its national distribution and fate.

Since our first report in 1995, we have sampled additional wells in the NAWQA Program. This now gives us much better coverage of aquifers across the Nation. For the period 1993-2000, we sampled 4,260 wells (or springs) for MTBE and a wide range of other compounds. Of this total, 396 are public water-supply wells; 1,847 are domestic wells; and 2,017 are monitoring wells (or other wells not used for drinking water). At a reporting level of 0.2 micrograms per liter (a level that is one one-hundredth of the USEPA advisory level), we detected MTBE in 5.2 percent of the wells sampled. Most of the MTBE detections are low concentrations. None of the public water-supply wells and only one domestic well had MTBE at a concentration above the lower limit of USEPA's advisory. Through our interpretations of this large data set we have also determined that low-levels of MTBE are detected in about 1 out of 5 wells in MTBE high-use areas. Although we do not expect to see a great change in these results over time, we recognize that there may be a delay in the detection of MTBE in some wells—particularly those that are deeper and may be farther from the source of contamination. MTBE is the second most frequently detected volatile organic compound (VOC). Chloroform, a drinking-water disinfection by-product and a commercial solvent, is the most frequently detected VOC.

Based on our NAWQA findings and interests of other agencies, we have undertaken two allied, large-scale studies to further our understanding of the occurrence of MTBE and other VOCs. We have completed a study in cooperation with the USEPA's Office of Ground Water and Drinking Water. For the period 1993-98, we have compiled information on the occurrence of MTBE and other VOCs in drinking water supplied by Community Water Systems in 12 States in the Northeast and Mid-Atlantic Regions of the United States. Parts of these Regions are designated Reformulated Gasoline (RFG) Areas and, in general, these RFG Areas have used MTBE in gasoline in large amounts for many years. USGS obtained the MTBE/VOC data from each State's drinking-water program. We then randomly selected about 20 percent of the almost 11,000 Community Water Systems in the study area for our analysis. States with MTBE data included Connecticut, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont, and Virginia. Data for MTBE were not available for Delaware and Pennsylvania, at the time the study was completed.

At a reporting level of one microgram per liter, about 9 percent of the Community Water Systems had detectable MTBE in their drinking water; however, most of the detections were low concentrations. Ten Community Water Systems had MTBE concentrations that equaled or exceeded the lower limit of the USEPA advisory, or about 1 percent of all Community Water Systems with MTBE data. We also confirmed that MTBE was detected more frequently in RFG Areas than elsewhere in the two Regions. Furthermore, larger Community Water Systems located in urban centers had a larger incidence of MTBE detections.

We are also working with the Metropolitan Water District of Southern California, and the Oregon Graduate Institute of Science and Technology, to complete a study of MTBE, other ether gasoline oxygenates, and other VOCs in select reservoirs, rivers, and wells that supply Community Water Systems. This study was partly funded through the American Water Works Association Research Foundation (AWWARF). We are in the final year of this 4-year project.

For this study, we tested the source water of 954 randomly selected Community Water Systems, including 579 wells, 171 rivers, and 204 reservoirs. Samples were collected in all 50 States and Puerto Rico, and varied sizes of systems were included. All sampling for this project is completed; however, some of our intended interpretations and report writing are not yet completed and peer reviewed. Initial findings, which were reported on June 20, 2001, at the Annual Conference of the American Water Works Association, were similar to our findings noted earlier in this statement. Specifically, when detected in source waters, the concentrations of MTBE were almost always below the USEPA advisory. However, MTBE was found in about 9 percent of all sources sampled (at a reporting level of 0.2 micrograms per liter), and it was the second most frequently detected VOC. A larger detection frequency of MTBE was found in surface-water sources (14 percent), than ground-water sources (5 percent). In general, the detection of MTBE increased with increasing size of the Community Water Systems. MTBE was detected in about 4 percent of Community Water Systems serving less than 10,000 people, and in nearly 15 percent of systems serving greater than 50,000 people. Many of the surface-water sources sampled in the AWWARF study were large rivers and reservoirs that had recreational watercraft

usage. Older models of watercraft motors are known to release a fraction of non-combusted gasoline to water and this, in part, may explain the larger occurrence of MTBE in surface-water sources.

We also conduct research on the fate and transport of MTBE in ground water and surface water through the USGS Toxic Substances Hydrology Program. In this program, we explore the range of geochemical and microbiological processes that determine how MTBE will behave when it enters soil, ground water or surface water. This research is demonstrating that MTBE does biodegrade under a wide range of environmental settings although at slower rates than many of the components of traditionally formulated gasoline. These ongoing studies have important implications for predicting the future concentrations of MTBE in water, where contamination has already occurred. These results are also important for the design and selection of remediation plans.

As part of the Toxic Substances Hydrology Program research, USGS scientists have demonstrated that naturally occurring microorganisms can biodegrade MTBE in many hydrologic environments, and in some cases, to harmless by-products. In some situations, however, biodegradation may be incomplete and tert-butyl alcohol (TBA) can be formed. Especially noteworthy are the observations that MTBE biodegrades in ground water and soil where sufficient oxygen is present and in bed sediments of streams, lakes, wetlands, and estuaries where MTBE-contaminated ground water can ultimately discharge. Essentially, these environments can be considered to be natural sinks for MTBE removal. As noted earlier, MTBE is expected to degrade slower in ground water than gasoline hydrocarbons of traditional gasoline formations. The length of time required to complete this removal is currently a topic of ongoing investigation.

The USGS has actively participated in two previous Federal reviews of MTBE and other oxygenates in gasoline. A Blue Ribbon Panel was appointed by the Administrator of the USEPA to investigate the air-quality benefits and water-quality concerns associated with oxygenates in gasoline, and to provide independent advice and recommendations on ways to maintain air quality while protecting water quality. In 1998-1999, Dr. John Zogorski of the USGS served as a water-quality consultant to the Blue Ribbon Panel and three USGS scientists testified before the Panel. An important finding of the Blue Ribbon Panel is that the major source of MTBE ground-water contamination appears to be releases from underground gasoline storage systems. Many of these tanks have been removed permanently or upgraded in the 1990s, and thus this source is likely to diminish in the coming years. Other major sources of water contamination were stated to be from small and large gasoline spills and from recreational watercraft, especially those with older model 2-cycle motors. USGS has documented low levels of MTBE in urban air, urban precipitation, and urban stormwater, and these sources may cause low concentrations of MTBE in surface water and ground water. MTBE has also been found in spills of home fuel oil in Northeastern States.

During 1995-96, at the request of the USEPA and the Office of Science and Technology Policy (OSTP), the USGS co-chaired an interagency panel to summarize what was known and unknown about the water-quality implications of the production, distribution, storage,

and use of fuel. Our efforts were published in 1997 as a chapter in a report entitled "Interagency Assessment of Oxygenated Fuels" prepared by the National Science and Technology Council, Committee on Environment and Natural Resources. The chapter summarizes the scientific literature and data on the sources, occurrences, concentrations, behavior, and the fate of fuel oxygenates in ground water and surface water. We also discussed the implications for drinking water and aquatic life, and made recommendations of information needed to better characterize the occurrence of MTBE and other oxygenates in the Nation's drinking-water supplies.

Furthermore, last year, USGS and Oregon Graduate Institute scientists co-authored a feature article in the journal *Environmental Science and Technology*, a publication of the American Chemical Society. A salient part of the article summarized important information about MTBE including: growth in production; solubility, transport and degradation in ground water; releases from leaking underground fuel tanks; and the effect of select factors, such as aquifer recharge, the presence of low permeability stratum, and water utility pumping rates. This information helped to determine the likelihood of MTBE reaching community water-supply wells. Based on available but admittedly incomplete data for 31 States, the authors determined that about 9,000 community wells may have one or more leaking underground storage tanks nearby (i.e., within 1-km radius of the well). Because detailed information on the community wells, storage tanks, and hydrogeology were not available, the authors could not determine the number of wells at risk.

Unfortunately, some of the press coverage of this article inaccurately stated that 9,000 drinking-water wells were contaminated with MTBE. As stated in the journal publication, not all community wells with gasoline releases nearby are at risk because not all gasoline releases contain MTBE, and not all MTBE-gasoline releases are sufficiently large to pollute a nearby well. Also, many wells draw water from the deeper zones of aquifers and many wells are largely isolated from land-surface contamination by low permeability stratum, technically called aquitards. Based on these factors, data from the studies mentioned previously, and a recent survey by others, we would estimate that the number of community wells contaminated is far lower than 9,000 for 31 States.

In summary, the USGS has not found widespread, high-level MTBE contamination in rivers, reservoirs, and ground water that are actively used as the sources for Community Water Systems. Furthermore, we have not found such contamination in public wells and domestic wells sampled in our NAWQA Program, or in the drinking water of Community Water Systems in 10 Northeastern and Mid-Atlantic States. We have, however, identified MTBE (and some other VOCs) fairly frequently in ground water, source water, and drinking water at concentrations below USEPA's advisory. We also conclude that the frequency of detection of MTBE is larger in RFG Areas, in comparison to other areas of the Nation. Approximately 85 million people reside in RFG areas that use MTBE extensively, and drinking water in these areas is provided almost equally from surface water and ground water.

There are multiple strategies for dealing with situations where MTBE contamination of ground water has taken place and these should include strategies that take maximum

advantage of the natural attenuation that we observe in our research. Within available resources, more research would be helpful to provide guidance on the most cost-effective strategies for protecting drinking water sources in those areas that have become contaminated.

I appreciate the opportunity to testify on the results of USGS assessments and research on MTBE. I am happy to try to respond to any questions of the Subcommittee.

## **Congressional Testimony**

### **Statement of Charles G. Groat Before the House Committee on Resources, May 16, 2002**

Submitted by [USGS Congressional Liaison Office](#)

**Statement of Charles G. Groat, Director, U.S. Geological Survey, U.S. Department of the Interior Before the Subcommittee on Forests and Forest Health, and the Subcommittee on Fisheries, Conservation, Wildlife and Oceans, Committee on Resources, U.S. House of Representatives Joint Oversight Hearing on Chronic Wasting Disease**

**May 16, 2002**

Mr. Chairmen and Members of the Subcommittees, thank you for this opportunity to provide the Department of the Interior's (Department) views regarding the emerging issue of Chronic Wasting Disease (CWD) in deer and elk. The Department is very concerned about the potential effects this disease could have on captive and free-roaming deer and elk and on the economies of affected areas of our country. The Administration believes that meaningful cooperation and coordination with the states is vital to addressing this matter.

In addition, the Administration believes that it is critical for the federal agencies involved to work in concert on this important issue. It is important that we work together to protect wildlife resources and maintain healthy wild populations of these animals. The Department has the skills and expertise to assist the states in the conduct of research to detect and characterize this unusual disease, to provide research and monitoring facilities, and to assist in other appropriate ways. Only through coordination, communication, and cooperation within the federal family, with the states, and with stakeholders will we succeed in managing this issue.

CWD is a disease known to be found in mule deer, elk, and white-tailed deer. CWD is fatal



to both deer and elk. The disease's cause, transmission route, and treatment methodologies are unknown, although associated with altered protein structures (called prions) in the lymphatic system and brain. The recent detection of CWD in wild white-tailed deer in Wisconsin, the first known occurrence east of the Mississippi, increases the urgency in investigating and controlling this disease. Chronic Wasting Disease is not known to occur in humans or domestic cattle or sheep.

The Department recognizes that states have primary responsibility for management of cervids and other resident species within their borders, including mule deer, elk, and white-tailed deer. With particular reference to hunting and harvesting, for instance, states set deer and elk hunting regulations — length of season, harvest methods, and limits — and have established wildlife management programs, generally housed within state fish and game or natural resource agencies.

The Department manages roughly one in every five acres of land in the United States and has stewardship responsibilities for natural resources on these lands. Through the National Park Service, Fish and Wildlife Service, Bureau of Land Management, and Bureau of Indian Affairs, the Department provides assistance to, cooperates with and, in some cases, co-manages with states to ensure healthy, viable wildlife populations. Free-roaming wildlife do not recognize jurisdictional boundaries. The Department shares thousands of miles of coterminous boundaries with state, private, and other federal lands. To successfully combat this disease we must employ an approach in the wild and in captive herds that respects the varied roles of federal and state agencies, as well as affected landowners, while also bringing the strengths of each respective entity to bear on the challenge we face.

Populations of deer and elk in a number of states and Canada have tested positive for CWD. Many states, like Colorado and Wisconsin, are in urgent need of basic information about CWD transmission and methods for control and prevention.

The U.S. Geological Survey (USGS) is the principal science and research agency for the Department. The USGS National Wildlife Health Center (the Madison Center) is the only federal research facility specializing in wildlife disease research and is uniquely positioned to work with state fish and wildlife agencies, as well as federal land management agencies. Since 1975, the Center has provided research, training, and technical assistance to states and other federal agencies related to the diagnosis, prevention, and management of wildlife diseases in naturally occurring populations. Through the Madison Center, the USGS has coordinated activities with states and other federal agencies on critical disease outbreaks such as West Nile Virus, Newcastle disease, avian cholera, botulism, and others.

The Department stands ready to assist with research, monitoring, information, and technical assistance roles in combating this disease in free-ranging deer and elk with our state partners. As more states detect CWD in their wild herds, they will need reliable information in a timely manner. As research reveals more clues about the disease, that information needs to be available rapidly to benefit state and federal efforts in controlling the disease. The Department can and does develop, utilize and share research knowledge and assist nationally in monitoring and surveillance programs to help ensure that the most

appropriate response strategies are shared among wildlife managers in state and federal agencies. The Department, through the National Wildlife Health Center, can establish a forum for technical information, including issues such as depopulating procedures, non-lethal testing procedures, disposal of infected carcasses, and worker safety.

The Department and the Department of Agriculture have agreed to form a Joint Federal CWD Working Group. The Working Group's mission will be to assist the states in a cooperative and coordinated manner. Leadership will be comprised of one person each from the Departments of Interior and Agriculture and key officials from each bureau or agency within those two Departments.

Currently, the Department is working with Colorado, Wisconsin, and other state fish and wildlife agencies in developing cooperative and synergistic research and control programs that are urgently needed for Chronic Wasting Disease. For instance, although a new diagnostic technique using tonsil tissue instead of brain tissue has been developed for live deer, this technique is not applicable to elk. Currently, this technique is best suited to captive animals. The Department proposes to participate with the state wildlife agencies to assist in a national program for the detection and management of CWD in wild herds of deer and elk.

The Department's land management bureaus can contribute to the application of science in the cooperative management of federal lands under their control. The National Park Service, which manages more than 84 million acres contained in 385 park units, is extremely concerned about CWD and the potential impacts this disease could have upon the wildlife resources of the parks and adjacent lands and the ability of park visitors to view wildlife. To date, Rocky Mountain National Park is the only unit of the National Park System that is known to have elk and deer infected with the disease. However, Wind Cave National Park in South Dakota, and Agate Fossil Beds and Scotts Bluff National Monuments in Nebraska are at high risk of infection because the disease was recently detected in nearby wild deer and elk or in nearby facilities for captive rearing deer and elk.

Chronic wasting disease, which is not endemic to Rocky Mountain National Park, was first discovered in the park in 1981. The prevalence of infection for deer, based on samples taken in the park is about 5-6%, the same for animals outside the park. The prevalence of the disease in elk, less than 1%, is believed to be the same for elk outside the park. For the past seven years, both the Colorado Division of Wildlife (CDOW) and the National Park Service have been collaborating on research projects, conducting surveillance of deer and elk movements, cooperating on capturing deer to obtain tonsillar biopsies for CWD testing, removing infected animals, and developing joint strategies for management of the disease. Recently the CDOW was asked to work with the park as a cooperator developing a chronic wasting disease management plan and environmental impact statement for the Rocky Mountain National Park area. Federal and state funds will be used to support this effort.

This week, the National Park Service has approved for funding three projects related to CWD in two national parks. Two projects will be conducted in Rocky Mountain National Park. One of those projects will develop a management plan, and the other will implement

interim management actions. In Wind Cave National Park, a study is planned to detect the occurrence and transmission of the disease in deer within and near the park. Animals will be monitored for movement patterns, including dispersal and migration, and other factors relevant to CWD.

To date, there are no known cases of CWD on National Wildlife Refuge lands. Regardless, the U.S. Fish and Wildlife Service and the CDOW recently agreed to jointly address CWD if, and when, it occurs on National Wildlife Refuge lands. This will include survey, testing, and active management, including any necessary efforts to depopulate infected herds.

The Department's stewardship role and cooperative relationship with states dictate that it step forward to help address this problem. Without coordination of information collected by federal and state agencies, information provided by new research, and the means to rapidly disseminate that information to state agencies and federal land managers, this disease could further impact wild deer and elk populations and have an impact on local economies.

Mr. Chairmen, this concludes my written statement and I will be pleased to respond to any questions you might have.

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## Congressional Testimony

### Statement of Dr. P. Patrick Leahy Before the House Subcommittee on Energy and Mineral Resources, March 14, 2002

Submitted by [USGS Congressional Liaison Office](#)

**Statement of Dr. P. Patrick Leahy, Associate Director for Geology, U.S. Geological Survey Before The Subcommittee on Energy and Mineral Resources, Committee on Resources, U.S. House of Representatives On the 2003 Budget Request For the U.S. Geological Survey**

**March 14, 2002**

Madam Chairman, and Members of the Subcommittee. I come before you today to present the Administration's proposal for the budget of the U.S. Geological Survey (USGS) for fiscal year 2003. The proposed budget requests \$904 million, including \$37 million for a government-wide legislative proposal to shift to agencies the full cost of the Civil Service Retirement System (CSRS) and the Federal Employee Health Benefits Program for current employees. Without the legislative proposal, the request is \$867 million, a decrease of \$47 million from the fiscal year 2002 enacted level. Although less than the 2002 enacted level, this request will enable us to maintain our core science and monitoring programs to continue to provide the Nation with relevant and impartial scientific information.

Before I begin, Madam Chairman, I would like to thank the Subcommittee for its strong support of the USGS over the years. Your support for the scientific programs of the Survey has provided a wealth of valuable information to assist the citizens of this Nation in making sound decisions on environmental, resource, economic, agricultural, and social issues.

The Survey's 123-year history of excellence in the earth and biological sciences is a solid foundation from which we provide scientific solutions to many national issues. The USGS, through its scientific activities – long-term monitoring and data collection, innovative

research and process understanding, and informative assessments and interpretive studies – is well poised to provide the natural science information that society demands to address critical issues, such as

- mitigating the impacts of earthquakes,
- developing strategies to detect and control harmful invasive species,
- developing a better knowledge base for the sustained development of the Nation's water resources, and
- providing information on the availability, quality, and development impacts of energy and mineral resources.

As the science bureau of the Department of the Interior, USGS provides information and technologies that are critical to achieving the missions of the Department's land and resource management bureaus. Scientific support from the USGS to these bureaus ensures that the increasingly complex management decisions for Interior's vast resources are informed by relevant, impartial, credible science.

Let me take just a moment to share a few of our accomplishments over the past year, which show that the taxpayer investment in the science and monitoring programs of the USGS has paid sound dividends for the Nation.

After the September 11 attacks on America, USGS staff provided critical geospatial data and coordination to many State and Federal agencies, helping them respond to the crisis; well over 100,000 maps were distributed. The USGS topographic maps are the only complete, nation-wide coverage of the Nation's land surface and infrastructure. As part of the process of modernizing these topographic data, we are conducting eight National Map pilot projects in Delaware, Florida, the Lake Tahoe area, Missouri, Pennsylvania, Texas, Utah, and Washington-Idaho. These pilots are the foundation upon which future partnerships for data sharing and maintenance will be built.

Our science is respected and valued. In the December issue of *Environmental Science and Technology*, 10 papers were selected for high impact in the field of environmental research over the past 35 years. I am proud that three of those papers were authored by scientists who currently work at the USGS in our hydrology programs.

We are using the Internet to maximize the availability of our information, so that taxpayers have easy access to the scientific results of their investment in our research and monitoring. The new National Water Information System online database provides 14 gigabytes of real-time and historical streamflow, ground-water, and water-quality data collected from 1.5 million sites in all 50 States, Puerto Rico, and the District of Columbia. Since the online database was formally launched last July, the number of pages served has continued to grow, and we have received many compliments praising USGS for the usefulness of this site. Furthermore, the website was selected as one of only 25 finalists in the Federal Chief Information Officers Council Excellence.Gov Awards.

Partnerships remain an essential component of how we do business, to ensure cost-

effective operations. In the Tampa Bay region, USGS worked with the National Oceanographic and Atmospheric Administration to develop a seamless merged topographic/bathymetric elevation model of the Tampa Bay region. The new model is proving very useful to local planning, natural resource, and regulatory agencies. We continued to work with the Centers for Disease Control and other public health entities to provide biological and geospatial data about the spread of West Nile Virus. By the end of summer 2001, this disease had been found in birds in most States east of the Mississippi River. In addition, USGS research demonstrated that the disease can be transmitted bird-to-bird, rather than only through mosquito bites. This is a critical advance in understanding how the disease moves between birds, mosquitoes, and humans.

In Nevada, a team of hydrologists has been conducting an intensive re-study of the ground water in the Fallon area, where 16 children have been diagnosed with two forms of leukemia and 2 have died since 1997--a rate 100 times higher than expected for a community of this size. Earlier USGS reports document a broad spectrum of metals, organic compounds, and radioisotopes in the ground water; the samples collected this past summer indicated 10% of the samples have arsenic concentrations greater than 500  $\mu\text{g/L}$  (a maximum concentration of 2,900  $\mu\text{g/L}$  has been observed) and some uranium activities are greater than 200 pCi/L. The USGS Nevada District office has worked closely with State agencies and the CDC to design the study, and results are expected soon.

Finally, the Nisqually earthquake did NOT cause widespread death and destruction in the Seattle area. One reason certainly was the depth of the earthquake--30 miles below the surface--but another is the 15 years of work by USGS scientists to assess the seismic hazard in the region and provide the information to local officials in ways that they could use to protect and prepare communities for such events. USGS scientists have worked closely with the University of Washington, the Federal Emergency Management Agency, and others to raise awareness of the earthquake risk among local businesses--including Boeing, Microsoft, and Bank of America--and the general public, so people can take effective action to mitigate their risk. The earthquake also provided the first major test of the 20 Advanced National Seismic System stations that had been recently installed in and around Seattle. All 20 instruments provided valuable information for immediate data analysis and damage assessments, as well as information on the effects of local soil conditions and geologic structures.

The 2003 budget request focuses resources on our core mission programs of geology, mapping, biology, and water. The budget preserves a number of significant program increases received in recent years that provide science support to Interior land- and resource-management bureaus and other high priorities. In the area of hazards, the request preserves the 2002 funding increase for continued implementation of the Advanced National Seismic System, which provides both immediate information on the intensity of ground shaking, for use by emergency responders, and high-quality data on building response, used by engineers to improve building safety. The request also includes funding to address Administration priorities. The USGS will continue to provide the scientific information that is vital to the President's national strategy for a sound energy policy. In addition to ongoing national assessments of coal, oil, and natural gas, and other energy and mineral commodities, the 2003 budget request proposes an increase of \$2.7

million for USGS to step up its efforts in support of the National Energy Policy and the overall goal of increasing domestic energy production. Of that \$2.7 million, \$1.2 million will enable USGS to more fully implement the requirements of section 604 of the Energy Act of 2000, which requires USGS to conduct estimates of undiscovered oil and natural gas resources on Federal lands in the continental United States. During 2002, with reimbursable funding provided by the Bureau of Land Management, the USGS will estimate volumes of oil and gas resources on Federal lands in five study areas in the Rocky Mountains. The 2003 increase will enable USGS to expand this work beyond the initial five study areas. The budget includes an additional \$1.0 million to produce digital base maps in Alaska, with work focused initially on potential lease areas in the National Petroleum Reserve. The mapping effort will provide resource managers with information they need to make timely and environmentally sound resource and management decisions. The USGS budget proposal supports alternative, non-fossil fuel energy development as well, with \$500,000 for USGS to begin the process of updating geothermal energy assessments. The USGS will initiate this effort in the Great Basin region.

Besides these energy-related budget increases, USGS is also proposing a \$1.0 million initiative to utilize its core mission expertise to study the relationship between environmental change and human health issues in the U.S.–Mexico border region. The border area is a significant contributor to our economic vitality and encompasses important natural resources. In partnership with the National Institute of Environmental Health Sciences, USGS will bring its expertise in geologic, geochemical, and hydrologic processes to bear on these issues. The proposal aims to improve the understanding of naturally occurring and introduced disease-causing agents in the environment — like radiation, pesticides, and pathogens — and their specific exposure pathways in water, air, and soil. For example, USGS will produce geologic maps showing the distribution of rock types likely to produce elevated levels of potentially toxic elements such as mercury, arsenic, and selenium.

The budget maintains recent funding increases that have enabled USGS to undertake a multi-disciplinary coastal initiative, as requested by the Congress. Coastal regions are under enormous pressure due to population growth, and USGS science will lead to a better understanding of the impacts of natural and human-induced change on the coastal environment. In 2003, the current USGS pilot study in Tampa Bay, Florida, will focus on developing a comprehensive understanding of coastal and marine systems. The study will provide Internet-accessible data and decision support systems to inform the responsible use and management of the Nation's coastal and offshore resources.

The budget proposes a \$4.0 million increase for the Critical Ecosystems Science Initiative for the Everglades. This will enable USGS to provide the long-term science, analysis, monitoring, modeling, and decision support systems needed for the adaptive implementation of the Comprehensive Everglades Restoration Plan. The budget retains increases appropriated in 2001 and 2002 for base USGS biological science center operations and high-priority tactical science support for the Fish and Wildlife Service. It also retains funding increases that have accelerated the pace of the biological Gap Analysis Program and expanded the National Biological Information Infrastructure. These programs develop and disseminate data that are beneficial to land and resource managers at all

levels of government.

The 2003 budget also retains funding increases provided in FY 2001 that expanded the Ground-Water Resources Program, in response to the Nation's growing reliance on these resources. There is a recognized need for more sophisticated knowledge to support sustainable development of complex aquifers and to protect inter-related surface waters and riparian habitat.

The net funding decrease for FY 2003 reflects the elimination of unrequested funding increases, many of which were for short-duration projects that are completed, and reductions to lower priority programs. The budget includes a 10% reduction to the National Water Quality Assessment Program. The budget proposes to offset this decrease with funding contributions from NAWQA customers and beneficiaries. Finally, the budget reflects a transfer of \$10 million in Toxic Substances Hydrology Program funding to the National Science Foundation, where it will be used for a water-quality research grants program. This transfer reflects the Administration's goal of realigning the Federal Government's investment in research and development to give greater support and emphasis to competitive research.

In closing, Madam Chairman, I know that the USGS will do its best to remain strong, dynamic, and ready to meet the science needs of the Nation. I will be pleased to respond to any questions you may have.

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## **Congressional Testimony**

### **Statement of Robert M. Hirsch Before the House Subcommittee Water and Power, March 7, 2002**

Submitted by [USGS Congressional Liaison Office](#)

**Statement of Robert M. Hirsch, Associate Director for Water, U.S. Geological Survey, U.S. Department of the Interior Before the Subcommittee Water and Power, House Committee on Resources on H.R. 3480**

**March 7, 2002**

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to provide the views of the Department of the Interior (DOI) on H.R. 3480, the "Upper Mississippi River Basin Protection Act of 2001." The Administration agrees with the goals of H.R. 3480; we especially appreciate the bi-partisan efforts of the sponsors of the bill to address this important issue and emphasis within the bill on the need for reliance on sound science. The Administration has concerns about the financial resources that would be required for the United States Geological Survey (USGS) to carry out this bill in the context of the availability of resources overall for Administration programs. Further, some provisions of the bill may be duplicative of existing Federal and State programs.

The bill directs the Secretary of the Interior, acting through the United States Geological Survey, to provide a scientific basis for the management of sediment and nutrient loss in the Upper Mississippi River. This would be accomplished through establishing a sediment and nutrient monitoring network that builds on existing monitoring activities; conducting research and modeling that relates sediment and nutrient losses to landscape, land use and land management characteristics; providing technical assistance regarding use of consistent and reliable methods for data collection; and instituting a program to disseminate new information to managers, scientists and the public.

The role identified for DOI in this bill is consistent with USGS's leadership role in

monitoring, interpretation, research, and assessment of the health and status of the water and biological resources of the Nation. As the Nation's largest water, earth, and biological science, and civilian mapping agency, USGS conducts the largest single non-regulatory ambient water-quality monitoring activity in the Nation. Furthermore, the USGS has been active in a number of programs and investigations that involve the Upper Mississippi River Basin (UMRB) specifically.

The USGS is an active participant in the Mississippi River, Gulf of Mexico Watershed Nutrient Task Force. This Task Force, which has representation from Federal agencies, and State and Tribal governments in the basin, is charged with fulfilling requirements of The Harmful Algal Bloom and Hypoxia Research and Control Act of 1998, by preparing a plan for controlling hypoxia in the Northern Gulf of Mexico, and shares a common goal of improving water-quality conditions in the Mississippi River Basin.

The USGS also has had a lead role in the preparation of a science report that uses available water-quality information to define a recent baseline condition for nutrient sources and loads in the Mississippi River Basin – a baseline from which future water-quality trends and improvements will be measured. This report identifies those parts of the Upper Mississippi River Basin that have the highest nutrient yields.

The USGS has offices in each of the five Upper Mississippi River Basin States. These offices have a long history of conducting water-quantity and water-quality monitoring and assessment activities within the basin. Existing USGS programs include the National Water-Quality Assessment Program, the National Stream Quality Accounting Network, the National Streamflow Information Program, the Toxic Substances Hydrology Program, the Water Resources Research Act Program, and the Cooperative Water Program, as well as reimbursable programs we operate, such as the Long-Term Resource Monitoring Program funded by the U.S. Army Corps of Engineers. These programs currently provide information on nutrients and sediment within the basin.

For the past 20 years, the USGS Upper Midwest Environmental Sciences Center (UMESC) in La Crosse, Wisconsin has provided research support in the Upper Mississippi River Basin to Department of the Interior agencies and the U.S. Army Corps of Engineers to address complex issues of navigation, contaminants, and other natural resource concerns. More recently, this Center has developed an active partnership with the USDA Natural Resources Conservation Service on sediment and nutrient concerns of the agencies. For 15 years, the UMESC has provided the scientific and management leadership for the Long-term Resource Monitoring Program of the U.S. Army Corps of Engineer's Environmental Management Program for the Upper Mississippi River Basin main stem rivers. This monitoring program of water quality, fisheries, vegetation, land use, and other critical indicators of river health is the largest main stem river assessment program in the Nation.

The USGS conducts monitoring activities in cooperation with many States and local governments in the Upper Mississippi River Basin. The USGS is also active in hydrologic and water-quality studies in the Lower Mississippi River Basin. The continuity of research is important from the standpoint of developing a complete assessment of the entire

Mississippi River basin. To this end, the USGS has begun a partnership this year with the Long-term Estuary Assessment Group, centered at Tulane University.

H.R. 3480 acknowledges the need to use all existing monitoring and science programs of the USGS and others while identifying information needs in the Upper Mississippi River Basin. Existing programs and development of models are tools for defining how water-quality conditions are affected by human activities and natural climatic variations and how management actions may best improve water-quality conditions at a wide range of scales from small watersheds to the Mississippi River Basin.

Furthermore, the bill would authorize integration of activities conducted in cooperation with other Federal partners and would emphasize and expand the existing USGS coordination and assistance to State monitoring programs. For example, the U.S. Fish and Wildlife Service's (FWS) Partners for Fish and Wildlife Program restores wetland habitat in watersheds across the country, including the Upper Mississippi River Basin. The FWS is available to apply its expertise to the reduction of sediment and nutrient loss in the basin through participation in demonstration projects, technical assistance, and working groups. We recognize the need to ensure that future monitoring activities complement and do not duplicate State monitoring activities.

The provisions of H.R. 3480 are consistent with Gulf of Mexico Watershed Nutrient Task Force recommendations with regard to science and management activities. The proposed legislation describes a program consistent with current USGS activities to support protection of the UMRB.

In summary, the goals of the bill are commendable, and the bill contains provisions that are within the scope and expertise of the USGS, and that may be met by other on-going programs. However, funding for the activities in H.R. 3480 is not included in the fiscal year 2003 President's Budget proposal and would remain subject to available resources. Also, there are several provisions of the bill with which we have concerns. We believe that the cost-sharing provisions of this bill should conform with other similar programs, such as the USGS Cooperative Water Program which requires a dollar for dollar match of Federal and non-Federal funds.

We welcome the opportunity to discuss with the Committee the matters of concern to us and ways to best achieve the important purposes of the bill. Thank you, Mr. Chairman, for the opportunity to present this testimony. I will be pleased to answer questions you and other members of the Subcommittee might have.

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## Congressional Testimony

### Statement of Robert M. Hirsch Before the Senate Subcommittee on Fisheries, Wildlife, and Water, February 28, 2002

Submitted by [USGS Congressional Liaison Office](#)

**Statement of Robert M. Hirsch, Associate Director for Water, U.S. Geological Survey, Department of the Interior Before the Subcommittee on Fisheries, Wildlife, and Water, Committee on Environment and Public Works, United States Senate on S.1961, "THE WATER INVESTMENT ACT OF 2002"**

**February 28, 2002**

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to testify today on S.1961, "The Water Investment Act of 2002." As you know, the mission of the U. S. Geological Survey (USGS) is to provide scientific information to support decision-making on issues of resources, environmental quality, and natural hazards. Information about water has been a central part of our agency's mission throughout our 123-year history. My remarks will be limited to Title IV of the bill, which relates to USGS. EPA has provided the Administration's views on the remainder of the bill.

As such, we agree that the role defined in Title IV of the bill is an appropriate one for the USGS and that it could improve Federal coordination of water information, but we would welcome an opportunity to work with the Committee on the bill language to assure that the tasks are feasible and clearly defined and that they are appropriate for the USGS as a Federal scientific agency. Let me begin by providing some general context for my remarks.

Competition for water to meet the needs of homes, cities, farms, and industries in many parts of the country is increasing, as are requirements to leave water in the streams and rivers to meet environmental and recreational needs. Information on water resources is needed at many levels to address these issues. Included among these is information to help shed light on overall changing conditions of scarcity, use, and competition for water

to help inform discussions about potential changes in policies and investment plans related to water.

In this regard, the USGS received a directive from Congress as part of the report on the fiscal year (FY) 2002 Appropriations for Interior and Related Agencies (House Committee on Appropriations) to prepare a report describing the scope and magnitude of the efforts needed to provide periodic assessments of the status and trends in the availability and use of freshwater resources.

Our efforts over the past six months in preparing that report have provided us with some insight that may be useful to this Subcommittee as it considers this legislation. In preparing our report to Congress, the USGS has solicited input from many individuals and organizations involved in issues of water availability and use. We asked them what types of decisions and policy issues would benefit from improved water facts today and in the future, how to build on existing efforts, and where to expand collaborative opportunities. In response to our request, we received nearly 100 responses from the water-management and policy communities.

There were several clear messages. First, there was consensus that a better set of facts is needed for informed decisions related to water availability and use. National organizations, in particular, noted the need for consistent indicators of water availability across the country. However, individuals representing State and local governments reminded us that many States have conducted extensive planning to quantify water availability now and in the future, and that the availability and use of water is a State, local, or tribal issue in most respects.

Our report to the House Appropriations Committee is in the final stages of review at the present time. Based on the comments we received from others, we believe that the critical need is for regular reporting on indicators of the status and trends in storage volumes, flow rates, and uses of water nationwide. This information is not available in an up-to-date, nationally comprehensive and integrated form.

Water availability is a function of the total flow of water through a basin, its quality, and the structures, laws, regulations, and institutions that control its use. Information is currently synthesized about the Nation's water quality by the USGS National Water-Quality Assessment (NAWQA) program -- A program that has recently been reviewed by the National Research Council (NRC) after completing its first decade. The NRC/NAWQA review committee stated "NAWQA is providing key national leadership, reporting, and assessing the quality of surface water and groundwater resources across the nation. Furthermore, NAWQA is playing a vital role in balancing its good science with responsiveness to policy and regulatory needs. This is a vital function." The assessment required by this bill could be used with water-quality information from NAWQA and other existing water-quality programs to provide a more complete national picture of both the quantity and quality aspects of water availability.

Data that are germane to issues of water availability include population statistics, land

uses, water costs and pricing, climate data, and instream-flow requirements for aquatic habitats. These data are compiled by State and local agencies, by universities and water-resource organizations, and by several Federal agencies.

## **Indicators of Water Availability and Use**

An assessment, such as called for in this bill, would need to rely on up-to-date, nationally consistent indicators that would reflect the status and trends in water availability and use nationwide, for surface-water flows and storage, ground-water levels and storage, and water use.

### **Surface Water**

Currently, the USGS provides a number of assessment-type streamflow products at daily, weekly, and monthly time scales. These products, such as the online *WaterWatch* Internet site, are useful to emergency managers, public officials, and others tracking floods and droughts and to private citizens planning recreational activities. The USGS will continue to produce these types of information on daily to monthly conditions through our existing programs. Indicators that support longer-term water-availability decisions, however, require compilation of streamflow information at longer time scales.

### **Ground Water**

Long-term, systematic measurements of ground-water levels provide essential data needed to evaluate changes in ground-water storage over time. The density of existing monitoring wells varies considerably from State-to-State, and even more so among major aquifers, with very limited monitoring in many aquifers. Thus, an inventory of existing water-level networks for major aquifer systems would be useful to identify data gaps across the Nation and determine the detail to which we can provide this information.

### **Water Use**

Tracking water use is an important part of understanding water availability. The USGS has compiled and disseminated estimates of water use for the Nation at 5-year intervals since 1950. The National Research Council (NRC) recently reviewed the USGS program for water-use information and will be making a number of recommendations for improvement of the program to address inconsistencies in the availability of water-use data from State to State. This NRC report will be released within the next few months. We would encourage the Committee to seek their input on this important component of the water resource equation. Valid and consistent water-use data are as vital as river flow or ground-water data and are often even more difficult to acquire. An assessment such as is envisioned by this legislation depends on water-use data. The responsibility for collecting and analyzing these data must be shared by the States and the Federal Government.

## **Summary**

In summary, in response to the directive from Congress and with input from many others, the USGS has developed concepts for a national assessment of freshwater availability and use. The proposed assessment would develop and report on indicators of the status and trends in storage volumes, flow rates, and uses of water nationwide. Currently, this information is not available in an up-to-date, nationally comprehensive and integrated form. The development and reporting of national indicators of water availability and use would be analogous to the task of other Federal statistical programs that produce and regularly update indicator variables that describe economic, demographic, or health conditions of the Nation. Any such effort would comply with the Office of Management and Budget's (OMB) recently issued Information Quality Guidelines.

The assessment would be highly collaborative, involving the USGS along with Federal and State agencies, Indian tribes, universities, and non-governmental interests. Collaboration across agency boundaries would ensure that information produced by the USGS could be aggregated with other types of physical, social, economic, and environmental data that affect water availability.

In regard to section 403(b) on water resource research priorities we would note that we are currently engaged in contracting with the National Research Council, at the direction of Congress, to conduct a study of the priorities for, and best means of organizing, water research across the Federal Government. We would suggest that this National Research Council effort may provide very valuable inputs to help carry out the objectives of this section.

In regard to section 403(c) on information delivery systems, the objectives defined here are very much in concert with the existing charge to the USGS under OMB Memorandum 92-01 on "Coordination of Water Resources Information." This section would reinforce our ongoing role of coordination of water information across the Federal Government.

In closing, again, we agree that the role defined in the bill is an appropriate one for the USGS, but we would welcome an opportunity to work with the Committee on the language of Title IV, to assure that the tasks are clear and feasible and that they are appropriate for the USGS as a Federal scientific agency. For example, the bill directs the USGS to identify areas of the United States that are at risk for water shortages or surpluses. However, long range predictions of water supplies cannot be determined solely by physical science but are heavily dependent on human decisions to invest in infrastructure, restrict use, change water laws, etc., which are largely State decisions. The USGS makes a significant contribution to these issues by regularly providing indicators of the changing status of the Nation's water resources derived from long-term monitoring.

We appreciate this opportunity to discuss USGS capabilities and I welcome any questions you may have.

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## Congressional Testimony

### Statement of Robert M. Hirsch Before the Senate Subcommittee on Fisheries, Wildlife, and Water, November 14, 2001

Submitted by [USGS Congressional Liaison Office](#)

**Statement of Robert M. Hirsch, Associate Director for Water, U.S. Geological Survey, Department of the Interior Before the Subcommittee on Fisheries, Wildlife, and Water, Senate Committee on Environment and Public Works, United States Senate**

**November 14, 2001**

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to report on the status of water conditions in the United States as monitored by the U.S. Geological Survey (USGS).

The USGS is a science agency within the Department of the Interior with a history of 122 years of providing scientific information needed for the wise management of our Nation's natural resources. The study of water goes back to our very early years and the work of our second Director, John Wesley Powell, who focused much attention on the availability of water resources for the economic development of the West. The USGS of today consists of four major program areas: Geology, Geography, Biology, and Water. The USGS strives to combine these four disciplinary areas to provide more complete information and analysis regarding the resource and environmental issues facing our Nation.

Hydrologically, conditions across the country are quite varied at the present time. The West is a mixture of above-normal flows in southern and coastal California, normal flows in Washington State, and below-normal flows in the northern and central Rockies, northern California and Oregon. Although the interagency *U.S. Drought Monitor*, which incorporates USGS streamflow information, continues to depict much of the Northwest as being in moderate to extreme drought, streamflows have moderated in some areas (such as

Washington State) during the past four to six weeks. In the central third of the Nation, rivers and streams are generally flowing in the normal range, with above normal flows throughout Indiana, southern Michigan, and eastern North Dakota. Indeed, intense and persistent rains in October brought very high flows and flooding to much of the southern Great Lakes and northern Ohio Valley from the middle of October to early November. The East, however, is a different story. Streams in the coastal states from Maine to Florida are reporting very low flows for this time of year, with many setting new daily and weekly records.

The USGS water resources program provides reliable, impartial, timely information that is needed to understand the Nation's water resources.

We operate about 7000 streamgages, which monitor the flow of water in our Nation's rivers and streams, and we freely provide the current and historical data to a wide range of users. This information is used for purposes that include: water supply planning, flood risk assessment, water quality management (including calculation of Total Maximum Daily Loads under the Environmental Protection Agency's Clean Water Act Program), water supply operations, streamflow forecasting (done primarily by the National Weather Service, the Army Corps of Engineers, and the Natural Resources Conservation Service), habitat assessments, and personal planning of river-based recreational activities. Currently, we are in a process of modernizing the streamgage network. At the present time, about 5000 of these stations have satellite telemetry that enables us to provide near-real-time data to all users via the Internet.

Using these data, and information from other agencies, I will describe the current surface-water situation across the Nation, as well as variations and changes that have occurred in recent weeks. To do this I will rely on an illustration that we create daily and place on the USGS website. It is based on conditions for the preceding week at all USGS streamgaging stations that have 30 or more years of record and have telemetry systems. Each dot on the map represents an individual gage. They are color coded with red indicating that flows for the week were the lowest ever recorded for that time of year, brown indicating that flow was below the 10th percentile, orange was between the 10th and 25th percentile, green indicates "normal" (25th to 75th percentile), light blue is 75th to 90th percentile, dark blue is above the 90th percentile, and black represents record high flows for this time of year.

Figure 1. AVERAGE STREAMFLOW FOR THE WEEK ENDING NOVEMBER 12.

Map showing Average Weekly Streamflow for the Week Ending Monday, November 12, 2001.

The lowest flows currently are occurring in southern Virginia and western North Carolina. During the past several weeks, more than three-dozen streamgages have reported new record daily and weekly low-flows in this area. This pattern is also reflected in groundwater declines as monitored at a few USGS wells that report in real-time in this region. Other areas experiencing record low flows for this time of year include South Carolina, the Delaware River basin, and parts of New England.

What's interesting about the pattern of dryness in the East is that, although it seems to have just recently appeared, it has actually been lurking around since early summer. Along the entire Eastern Seaboard, except for South Florida, flows have been varying between normal and below normal since July. There were no persistent rainy periods, particularly those associated with tropical storm systems, to produce and maintain elevated flows and, when below-normal to much below-normal precipitation occurred throughout the coastal States during October, the region was poised to experience fairly rapid streamflow declines. Although the reservoirs serving some metropolitan areas are at normal to above-normal levels for this time of year, such as those feeding the Potomac River upstream of Washington, D.C., other systems are already showing signs of stress. Just last week, for example, storage in the Upper Delaware River Basin reservoirs declined to drought warning levels, triggering reductions in Delaware River flow targets and water diversions to New York City and New Jersey.

I would like to focus for a moment on the Delaware River Basin, which encompasses more than 13,000 square miles in Delaware, New Jersey, New York, and Pennsylvania. As major river systems go, the Delaware River Basin is a small watershed – covering only about 0.4 percent of the U.S. land area. Despite its small size, the Basin provides water to about 20

million people, about 7 percent of the U.S. population. Although not physically in the basin, New York City obtains about one-half its water supply from three reservoirs in the Upper Delaware Basin. As I mentioned previously, water supplies in the Delaware River Basin are showing signs of stress. On November 1, 2001, combined storage in the Upper Delaware Basin reservoirs was 98 billion gallons, or 36 percent of capacity, and continues to decline. This is 57 percent lower than the level of storage that existed a year ago. As a result of these abnormally dry conditions, New Jersey, New York, and Pennsylvania have recently declared some level of drought alert for counties in the basin. Voluntary conservation measures are being requested in these areas. If storage continues to decline at the present rate, the Delaware River Basin could be in a drought-emergency condition by early December, resulting in the imposition of mandatory in-basin conservation measures and restrictions.

The precipitation outlook for November to January, issued recently by NOAA, indicates normal conditions across most of the United States. The Southern Plains may receive above-normal rainfall, and parts of the Southeast below-normal rainfall. If such conditions were to occur, the water resources situation in South Carolina, Georgia, and northern Florida could only get worse. However, it is worth noting that we are now entering the time of the year when water demand goes down. Evaporation is reduced, and people will not be watering lawns, washing cars, or irrigating crops as during the summer months. So declines in streams and aquifers will be less noticeable to the average citizen now than in the late spring or summer. Still, normal rainfall would not be sufficient to restore deficient stream- and aquifer-levels to normal. It would take above-normal precipitation over a period of weeks to months to do that. Thus, given current hydrologic conditions, the East Coast will need to average above-normal precipitation over the coming four to five months to ensure that normal water supplies are available next spring and summer; particularly in those areas already experiencing shortages.

The streamgaging network, that measures the "pulse" of the Nation's rivers (and enables us to produce a "snapshot" of conditions such as I have used here), is a priority for the USGS. We have worked closely with the Congress over the last 3 years and thanks to your support, and the support of hundreds of State, local, and tribal agencies, we have made good progress in modernizing and stabilizing the network. We are working with our partners in an effort to assure that these vital data continue to be available to water resource management.

I should also briefly mention the importance of ground water as an indicator of drought and as an important aspect of the mechanisms available to communities, agriculture, and industry as insurance against drought. While our ground-water level monitoring networks have not been modernized to a level where we can provide the same kind of synoptic view of ground-water conditions as we presented for surface water, we anticipate improvements in the next few years. We believe that the science of ground-water hydrology is crucial to water management not only in arid regions, but nationwide. Conjunctive use of surface and ground water has great potential for making water supplies more drought resistant. Ground water is crucial to sustaining streamflow for habitat and for water supply. More and more we find that our partners are interested in the role that ground water plays in maintaining adequate flow and temperature conditions in rivers.

We also find that emerging technologies such as artificial recharge, aquifer storage and recovery, and recharge of reclaimed wastewater are pivotal parts of the water management equation. The science to support the use of these new technologies is a part of our strategic plan for the future of USGS ground-water science.

I thank the Subcommittee for this opportunity to testify and would be pleased to respond to any questions you might have.

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## **Congressional Testimony**

### **Statement of Robert M. Hirsch before the House Subcommittee on Oversight and Investigations, October 18, 2001**

Submitted by [USGS Congressional Liaison Office](#)

**Statement of Robert M. Hirsch, Associate Director for Water, U.S. Geological Survey, U.S. Department of the Interior Before the United States House of Representatives Committee on Energy and Commerce Subcommittee on Oversight and Investigations**

**October 18, 2001**

Chairman Greenwood and other committee members, I appreciate the opportunity to appear before the Subcommittee on Oversight and Investigations to testify on the findings of U.S. Geological Survey (USGS) studies on water-quality issues related to methyl tertiary-butyl ether, commonly referred to as MTBE.

As you may know, the mission of the USGS is to assess the quantity and the quality of the earth's resources and to provide information that will assist resource managers and policy makers at the Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and research on the fate and transport of pollutants in water are important parts of the overall mission of the USGS.

USGS studies over the past 8 years have shown that MTBE typically is present at very low concentrations in shallow ground water within areas where MTBE is used. Our studies also suggest that MTBE levels do not appear to be increasing over time and are almost always below levels of concern from aesthetic and public health standpoints. The few locations in our database with high concentrations of MTBE may be associated with leaking underground storage tanks.

Based on comparisons with the U.S. Environmental Protection Agency's (USEPA) drinking water advisory, the health threat to water supplies is small compared to other water-related issues. MTBE is primarily an aesthetic (taste and odor) problem. However, we believe it may be prudent to continue our monitoring and research within available resources so that we can verify that the threat remains low and to further the understanding of this chemical to contribute to effective strategies to protect our Nation's water supplies and to efficiently remediate those ground waters that have become contaminated.

The results I will present today come from about a decade of sampling and study of MTBE and other Volatile Organic Compounds (VOCs). MTBE is one of about 60 VOCs that we measure on a routine basis in our water-quality studies.

The single largest study we have made of MTBE is part of our National Water Quality Assessment (NAWQA) Program. Based on initial monitoring data for wells sampled in 1993-94 in the NAWQA Program, we published a report on the occurrence of MTBE in shallow ground water in urban and agricultural areas. At that time our data set was fairly small--about 200 randomly selected wells in urban areas and 500 randomly selected wells in agricultural areas. We reported finding MTBE in about 25 percent of urban wells and 1 percent of agricultural wells. Many of the MTBE detections were low concentrations. In fact, only 3 percent of the urban detections exceeded 20 micrograms per liter, the lower limit of USEPA's consumer advisory for taste and odor. Also, many of the urban wells that contained MTBE were located in Denver, Colorado, and in New England, both areas with extensive use of MTBE prior to our sampling. At the time, MTBE was a chemical for which usage had increased dramatically in recent years and we knew it moved in the subsurface differently from other gasoline components. Thus, even though it was detected in few wells and at very low levels, we believed it would be prudent to continue studying it at many locations and over a period of several years to learn more about its national distribution and fate.

Since our first report in 1995, we have sampled additional wells in the NAWQA Program. This now gives us much better coverage of aquifers across the Nation. For the period 1993-2000, we sampled 4,260 wells (or springs) for MTBE and a wide range of other compounds. Of this total, 396 are public water-supply wells; 1,847 are domestic wells; and 2,017 are monitoring wells (or other wells not used for drinking water). At a reporting level of 0.2 micrograms per liter (a level that is one one-hundredth of the USEPA advisory level), we detected MTBE in 5.2 percent of the wells sampled. Most of the MTBE detections are low concentrations. None of the public water-supply wells and only one domestic well had MTBE at a concentration above the lower limit of USEPA's advisory. Through our interpretations of this large data set we have also determined that low-levels of MTBE are detected in about 1 out of 5 wells in MTBE high-use areas. Although we do not expect to see a great change in these results over time, we recognize that there may be a delay in the detection of MTBE in some wells—particularly those that are deeper and may be farther from the source of contamination. MTBE is the second most frequently detected volatile organic compound (VOC). Chloroform, a drinking-water disinfection by-product and a commercial solvent, is the most frequently detected VOC.



Based on our NAWQA findings and interests of other agencies, we have undertaken two allied, large-scale studies to further our understanding of the occurrence of MTBE and other VOCs. We have completed a study in cooperation with the USEPA's Office of Ground Water and Drinking Water. For the period 1993-98, we have compiled information on the occurrence of MTBE and other VOCs in drinking water supplied by Community Water Systems in 12 States in the Northeast and Mid-Atlantic Regions of the United States. Parts of these Regions are designated Reformulated Gasoline (RFG) Areas and, in general, these RFG Areas have used MTBE in gasoline in large amounts for many years. USGS obtained the MTBE/VOC data from each State's drinking-water program. We then randomly selected about 20 percent of the almost 11,000 Community Water Systems in the study area for our analysis. States with MTBE data included Connecticut, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont, and Virginia. Data for MTBE were not available for Delaware and Pennsylvania, at the time the study was completed.

At a reporting level of one microgram per liter, about 9 percent of the Community Water Systems had detectable MTBE in their drinking water; however, most of the detections were low concentrations. Ten Community Water Systems had MTBE concentrations that equaled or exceeded the lower limit of the USEPA advisory, or about 1 percent of all Community Water Systems with MTBE data. We also confirmed that MTBE was detected more frequently in RFG Areas than elsewhere in the two Regions. Furthermore, larger Community Water Systems located in urban centers had a larger incidence of MTBE detections.

We are also working with the Metropolitan Water District of Southern California, and the Oregon Graduate Institute of Science and Technology, to complete a study of MTBE, other ether gasoline oxygenates, and other VOCs in select reservoirs, rivers, and wells that supply Community Water Systems. This study was partly funded through the American Water Works Association Research Foundation (AWWARF). We are in the final year of this 4-year project.

For this study, we tested the source water of 954 randomly selected Community Water Systems, including 579 wells, 171 rivers, and 204 reservoirs. Samples were collected in all 50 States and Puerto Rico, and varied sizes of systems were included. All sampling for this project is completed; however, some of our intended interpretations and report writing are not yet completed and peer reviewed. Initial findings, which were reported on June 20, 2001, at the Annual Conference of the American Water Works Association, were similar to our findings noted earlier in this statement. Specifically, when detected in source waters, the concentrations of MTBE were almost always below the USEPA advisory. However, MTBE was found in about 9 percent of all sources sampled (at a reporting level of 0.2 micrograms per liter), and it was the second most frequently detected VOC. A larger detection frequency of MTBE was found in surface-water sources (14 percent), than ground-water sources (5 percent). In general, the detection of MTBE increased with increasing size of the Community Water Systems. MTBE was detected in about 4 percent of Community Water Systems serving less than 10,000 people, and in nearly 15 percent of systems serving greater than 50,000 people. Many of the surface-water sources sampled in the AWWARF study were large rivers and reservoirs that had recreational watercraft

usage. Older models of watercraft motors are known to release a fraction of non-combusted gasoline to water and this, in part, may explain the larger occurrence of MTBE in surface-water sources.

We also conduct research on the fate and transport of MTBE in ground water and surface water through the USGS Toxic Substances Hydrology Program. In this program, we explore the range of geochemical and microbiological processes that determine how MTBE will behave when it enters soil, ground water or surface water. This research is demonstrating that MTBE does biodegrade under a wide range of environmental settings although at slower rates than many of the components of traditionally formulated gasoline. These ongoing studies have important implications for predicting the future concentrations of MTBE in water, where contamination has already occurred. These results are also important for the design and selection of remediation plans.

As part of the Toxic Substances Hydrology Program research, USGS scientists have demonstrated that naturally occurring microorganisms can biodegrade MTBE in many hydrologic environments, and in some cases, to harmless by-products. In some situations, however, biodegradation may be incomplete and tert-butyl alcohol (TBA) can be formed. Especially noteworthy are the observations that MTBE biodegrades in ground water and soil where sufficient oxygen is present and in bed sediments of streams, lakes, wetlands, and estuaries where MTBE-contaminated ground water can ultimately discharge. Essentially, these environments can be considered to be natural sinks for MTBE removal. As noted earlier, MTBE is expected to degrade slower in ground water than gasoline hydrocarbons of traditional gasoline formations. The length of time required to complete this removal is currently a topic of ongoing investigation.

The USGS has actively participated in two previous Federal reviews of MTBE and other oxygenates in gasoline. A Blue Ribbon Panel was appointed by the Administrator of the USEPA to investigate the air-quality benefits and water-quality concerns associated with oxygenates in gasoline, and to provide independent advice and recommendations on ways to maintain air quality while protecting water quality. In 1998-1999, Dr. John Zogorski of the USGS served as a water-quality consultant to the Blue Ribbon Panel and three USGS scientists testified before the Panel. An important finding of the Blue Ribbon Panel is that the major source of MTBE ground-water contamination appears to be releases from underground gasoline storage systems. Many of these tanks have been removed permanently or upgraded in the 1990s, and thus this source is likely to diminish in the coming years. Other major sources of water contamination were stated to be from small and large gasoline spills and from recreational watercraft, especially those with older model 2-cycle motors. USGS has documented low levels of MTBE in urban air, urban precipitation, and urban stormwater, and these sources may cause low concentrations of MTBE in surface water and ground water. MTBE has also been found in spills of home fuel oil in Northeastern States.

During 1995-96, at the request of the USEPA and the Office of Science and Technology Policy (OSTP), the USGS co-chaired an interagency panel to summarize what was known and unknown about the water-quality implications of the production, distribution, storage,

and use of fuel. Our efforts were published in 1997 as a chapter in a report entitled "Interagency Assessment of Oxygenated Fuels" prepared by the National Science and Technology Council, Committee on Environment and Natural Resources. The chapter summarizes the scientific literature and data on the sources, occurrences, concentrations, behavior, and the fate of fuel oxygenates in ground water and surface water. We also discussed the implications for drinking water and aquatic life, and made recommendations of information needed to better characterize the occurrence of MTBE and other oxygenates in the Nation's drinking-water supplies.

Furthermore, last year, USGS and Oregon Graduate Institute scientists co-authored a feature article in the journal *Environmental Science and Technology*, a publication of the American Chemical Society. A salient part of the article summarized important information about MTBE including: growth in production; solubility, transport and degradation in ground water; releases from leaking underground fuel tanks; and the effect of select factors, such as aquifer recharge, the presence of low permeability stratum, and water utility pumping rates. This information helped to determine the likelihood of MTBE reaching community water-supply wells. Based on available but admittedly incomplete data for 31 States, the authors determined that about 9,000 community wells may have one or more leaking underground storage tanks nearby (i.e., within 1-km radius of the well). Because detailed information on the community wells, storage tanks, and hydrogeology were not available, the authors could not determine the number of wells at risk.

Unfortunately, some of the press coverage of this article inaccurately stated that 9,000 drinking-water wells were contaminated with MTBE. As stated in the journal publication, not all community wells with gasoline releases nearby are at risk because not all gasoline releases contain MTBE, and not all MTBE-gasoline releases are sufficiently large to pollute a nearby well. Also, many wells draw water from the deeper zones of aquifers and many wells are largely isolated from land-surface contamination by low permeability stratum, technically called aquitards. Based on these factors, data from the studies mentioned previously, and a recent survey by others, we would estimate that the number of community wells contaminated is far lower than 9,000 for 31 States.

In summary, the USGS has not found widespread, high-level MTBE contamination in rivers, reservoirs, and ground water that are actively used as the sources for Community Water Systems. Furthermore, we have not found such contamination in public wells and domestic wells sampled in our NAWQA Program, or in the drinking water of Community Water Systems in 10 Northeastern and Mid-Atlantic States. We have, however, identified MTBE (and some other VOCs) fairly frequently in ground water, source water, and drinking water at concentrations below USEPA's advisory. We also conclude that the frequency of detection of MTBE is larger in RFG Areas, in comparison to other areas of the Nation. Approximately 85 million people reside in RFG areas that use MTBE extensively, and drinking water in these areas is provided almost equally from surface water and ground water.

There are multiple strategies for dealing with situations where MTBE contamination of ground water has taken place and these should include strategies that take maximum

advantage of the natural attenuation that we observe in our research. Within available resources, more research would be helpful to provide guidance on the most cost-effective strategies for protecting drinking water sources in those areas that have become contaminated.

I appreciate the opportunity to testify on the results of USGS assessments and research on MTBE. I am happy to try to respond to any questions of the Subcommittee.

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## Congressional Testimony

### Statement of Dr. Charles Groat before the House Subcommittee on Interior Appropriations, March 7, 2002

Submitted by [Congressional Liaison Office](#)

### Statement of Dr. Charles Groat, Director, U.S. Geological Survey Before The Subcommittee on Interior Appropriations, U.S. House of Representatives On the 2003 Budget Request For the U.S. Geological Survey March 7, 2002

Good morning, Mr. Chairman, and Members of the Subcommittee. I come before you today to present the Administration's proposal for the budget of the U.S. Geological Survey (USGS) for fiscal year 2003. The proposed budget requests \$904 million, including \$37 million for a government-wide legislative proposal to shift to agencies the full cost of the Civil Service Retirement System (CSRS) and the Federal Employee Health Benefits Program for current employees. Without the legislative proposal, the request is \$867 million, a decrease of \$47 million from the fiscal year 2002 enacted level. Although less than the 2002 enacted level, this request will enable us to maintain our core science and monitoring programs to continue to provide the Nation with relevant and impartial scientific information.

Before I begin, Mr. Chairman, I would like to thank the Subcommittee for its strong support of the USGS over the years. Your support for the scientific programs of the Survey has provided a wealth of valuable information to assist the citizens of this Nation in making sound decisions on environmental, resource, economic, agricultural, and social issues.

The Survey's 123-year history of excellence in the earth and biological sciences is a solid foundation from which we provide scientific solutions to many national issues. The USGS, through its scientific activities – long-term monitoring and data collection, innovative research and process understanding, and informative assessments and interpretive studies

– is well poised to provide the natural science information that society demands to address critical issues, such as

- mitigating the impacts of earthquakes,
- developing strategies to detect and control harmful invasive species,
- developing a better knowledge base for the sustained development of the Nation's water resources, and
- providing information on the availability, quality, and development impacts of energy and mineral resources.

As the science bureau of the Department of the Interior, USGS provides information and technologies that are critical to achieving the missions of the Department's land and resource management bureaus. Scientific support from the USGS to these bureaus ensures that the increasingly complex management decisions for Interior's vast resources are informed by relevant, impartial, credible science.

Let me take just a moment to share a few of our accomplishments over the past year, which show that the taxpayer investment in the science and monitoring programs of the USGS has paid sound dividends for the Nation.

After the September 11 attacks on America, USGS staff provided critical geospatial data and coordination to many State and Federal agencies, helping them respond to the crisis; well over 100,000 maps were distributed. The USGS topographic maps are the only complete, nation-wide coverage of the Nation's land surface and infrastructure. As part of the process of modernizing these topographic data, we are conducting eight National Map pilot projects in Delaware, Florida, the Lake Tahoe area, Missouri, Pennsylvania, Texas, Utah, and Washington-Idaho. These pilots are the foundation upon which future partnerships for data sharing and maintenance will be built.

Our science is respected and valued. In the December issue of Environmental Science and Technology, 10 papers were selected for high impact in the field of environmental research over the past 35 years. I am proud that three of those papers were authored by scientists who currently work at the USGS in our hydrology programs.

We are using the Internet to maximize the availability of our information, so that taxpayers have easy access to the scientific results of their investment in our research and monitoring. The new National Water Information System online database provides 14 gigabytes of real-time and historical streamflow, ground-water, and water-quality data collected from 1.5 million sites in all 50 States, Puerto Rico, and the District of Columbia. Since the online database was formally launched last July, the number of pages served has continued to grow, and we have received many compliments praising USGS for the usefulness of this site. Furthermore, the website was selected as one of only 25 finalists in the Federal Chief Information Officers Council Excellence.Gov Awards.

Partnerships remain an essential component of how we do business, to ensure cost-effective operations. In the Tampa Bay region, USGS worked with the National

Oceanographic and Atmospheric Administration to develop a seamless merged topographic/bathymetric elevation model of the Tampa Bay region. The new model is proving very useful to local planning, natural resource, and regulatory agencies. We continued to work with the Centers for Disease Control and other public health entities to provide biological and geospatial data about the spread of West Nile Virus. By the end of summer 2001, this disease had been found in birds in most States east of the Mississippi River. In addition, USGS research demonstrated that the disease can be transmitted bird-to-bird, rather than only through mosquito bites. This is a critical advance in understanding how the disease moves between birds, mosquitoes, and humans.

In Nevada, a team of hydrologists has been conducting an intensive re-study of the ground water in the Fallon area, where 16 children have been diagnosed with two forms of leukemia and 2 have died since 1997--a rate 100 times higher than expected for a community of this size. Earlier USGS reports document a broad spectrum of metals, organic compounds, and radioisotopes in the ground water; the samples collected this past summer indicated 10% of the samples have arsenic concentrations greater than 500 µg/L (a maximum concentration of 2,900 µg/L has been observed) and some uranium activities are greater than 200 pCi/L. The USGS Nevada District office has worked closely with State agencies and the CDC to design the study, and results are expected soon.

Finally, the Nisqually earthquake did NOT cause widespread death and destruction in the Seattle area. One reason certainly was the depth of the earthquake--30 miles below the surface--but another is the 15 years of work by USGS scientists to assess the seismic hazard in the region and provide the information to local officials in ways that they could use to protect and prepare communities for such events. USGS scientists have worked closely with the University of Washington, the Federal Emergency Management Agency, and others to raise awareness of the earthquake risk among local businesses--including Boeing, Microsoft, and Bank of America--and the general public, so people can take effective action to mitigate their risk. The earthquake also provided the first major test of the 20 Advanced National Seismic System stations that had been recently installed in and around Seattle. All 20 instruments provided valuable information for immediate data analysis and damage assessments, as well as information on the effects of local soil conditions and geologic structures.

The 2003 budget request focuses resources on our core mission programs of geology, mapping, biology, and water. The budget preserves a number of significant program increases received in recent years that provide science support to Interior land- and resource-management bureaus and other high priorities. In the area of hazards, the request preserves the 2002 funding increase for continued implementation of the Advanced National Seismic System, which provides both immediate information on the intensity of ground shaking, for use by emergency responders, and high-quality data on building response, used by engineers to improve building safety. The request also includes funding to address Administration priorities. The USGS will continue to provide the scientific information that is vital to the President's national strategy for a sound energy policy. In addition to ongoing national assessments of coal, oil, and natural gas, and other energy and mineral commodities, the 2003 budget request proposes an increase of \$2.7 million for USGS to step up its efforts in support of the National Energy Policy and the

overall goal of increasing domestic energy production. Of that \$2.7 million, \$1.2 million will enable USGS to more fully implement the requirements of section 604 of the Energy Act of 2000, which requires USGS to conduct estimates of undiscovered oil and natural gas resources on Federal lands in the continental United States. During 2002, with reimbursable funding provided by the Bureau of Land Management, the USGS will estimate volumes of oil and gas resources on Federal lands in five study areas in the Rocky Mountains. The 2003 increase will enable USGS to expand this work beyond the initial five study areas. The budget includes an additional \$1.0 million to produce digital base maps in Alaska, with work focused initially on potential lease areas in the National Petroleum Reserve. The mapping effort will provide resource managers with information they need to make timely and environmentally sound resource and management decisions. The USGS budget proposal supports alternative, non-fossil fuel energy development as well, with \$500,000 for USGS to begin the process of updating geothermal energy assessments. The USGS will initiate this effort in the Great Basin region. Besides these energy-related budget increases, USGS is also proposing a \$1.0 million initiative to utilize its core mission expertise to study the relationship between environmental change and human health issues in the U.S.–Mexico border region. The border area is a significant contributor to our economic vitality and encompasses important natural resources. In partnership with the National Institute of Environmental Health Sciences, USGS will bring its expertise in geologic, geochemical, and hydrologic processes to bear on these issues. The proposal aims to improve the understanding of naturally occurring and introduced disease-causing agents in the environment — like radiation, pesticides, and pathogens — and their specific exposure pathways in water, air, and soil. For example, USGS will produce geologic maps showing the distribution of rock types likely to produce elevated levels of potentially toxic elements such as mercury, arsenic, and selenium.

The budget maintains recent funding increases that have enabled USGS to undertake a multi-disciplinary coastal initiative, as requested by the Congress. Coastal regions are under enormous pressure due to population growth, and USGS science will lead to a better understanding of the impacts of natural and human-induced change on the coastal environment. In 2003, the current USGS pilot study in Tampa Bay, Florida, will focus on developing a comprehensive understanding of coastal and marine systems. The study will provide Internet-accessible data and decision support systems to inform the responsible use and management of the Nation's coastal and offshore resources.

The budget proposes a \$4.0 million increase for the Critical Ecosystems Science Initiative for the Everglades. This will enable USGS to provide the long-term science, analysis, monitoring, modeling, and decision support systems needed for the adaptive implementation of the Comprehensive Everglades Restoration Plan. The budget retains increases appropriated in 2001 and 2002 for base USGS biological science center operations and high-priority tactical science support for the Fish and Wildlife Service. It also retains funding increases that have accelerated the pace of the biological Gap Analysis Program and expanded the National Biological Information Infrastructure. These programs develop and disseminate data that are beneficial to land and resource managers at all levels of government. The 2003 budget also retains funding increases provided in FY 2001 that expanded the Ground-Water Resources Program, in response to the Nation's growing reliance on these resources. There is a recognized need for more sophisticated knowledge



to support sustainable development of complex aquifers and to protect inter-related surface waters and riparian habitat.

The net funding decrease for FY 2003 reflects the elimination of unrequested funding increases, many of which were for short-duration projects that are completed, and reductions to lower priority programs. The budget includes a 10% reduction to the National Water Quality Assessment Program. The budget proposes to offset this decrease with funding contributions from NAWQA customers and beneficiaries. Finally, the budget reflects a transfer of \$10 million in Toxic Substances Hydrology Program funding to the National Science Foundation, where it will be used for a water-quality research grants program. This transfer reflects the Administration's goal of realigning the Federal Government's investment in research and development to give greater support and emphasis to competitive research.

In closing, Mr. Chairman, I know that the Survey will do its best to remain strong, dynamic, and ready to meet the science needs of the Nation. I will be pleased to respond to any questions you may have.

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## Congressional Testimony

### Statement of Charles C. Groat before the Senate Committee on Appropriations May 29, 2001

Submitted by [Congressional Liaison Office](#)

Statement of Charles C. Groat, Director, U.S. Geological Survey, Department of the Interior before the Committee on Appropriations, United States Senate on Climate Change and Its Impact on the Arctic Region and Alaska

May 29, 2001

#### Introduction

Mr. Chairman and Members of the Committee, thank you for this opportunity to present testimony on behalf of the U.S. Geological Survey (USGS) regarding scientific research being conducted on climate change in the Arctic region and how climate change is impacting that region, with special emphasis on Alaska.

Within the Arctic region, Alaska hosts some of the most important hydrologic, biologic, mineral and energy resources of the Nation and is subject to a wide variety of natural hazards, particularly earthquakes, volcanic eruptions, and landslides. Rich in pristine wilderness and natural resources, Alaska has some of the largest tracts of federally owned land in the country. Some of the "crown jewels" of the National Park Service and the National Wildlife Refuge System occur in Alaska. The Department of the Interior (DOI) is responsible for the management of more than 218 million acres of Alaska, an area larger than the entire State of Texas. More than 50 percent of the lands that Interior manages are in Alaska. More than 40 percent of the Nation's freshwater supply and more coastline than the rest of the States combined are found in Alaska. More than 3100 miles of designated rivers in the Wild and Scenic River System are in Alaska. Of the national total, nearly 70 percent of designated Wilderness areas -- more than 57 million acres, roughly the size of Oregon -- are in Alaska. Areas classified as wetlands total 170 million acres,

more than all other States combined.

As the principal science agency of the DOI, the USGS provides understanding of past and contemporary Alaskan environments and is positioning the region to better anticipate and prepare for what may happen in the future. The stewardship mission of the Department must be informed by an integrated scientific understanding of how climate changes may interact with other natural and human-induced environmental stresses. To advance that critical understanding, the USGS sponsored an assessment of the potential consequences of climate variability and change to Alaska with the University of Alaska, Fairbanks (UAF). The 1997 workshop, which received funding from DOI, was one of a series of regional workshops that the U.S. Global Change Research Program (USGCRP) sponsored as part of its national assessment of the potential consequences of climate change. The workshops brought together researchers, governmental agencies, industry, non-governmental agencies, and the public to assess the potential impacts of climate change on Alaska. The attached assessment report, "Preparing For A Changing Climate," addresses the following four questions:

- What are the current environmental stresses and issues that will form a backdrop for potential additional impacts of climate change?
- How might climate variability and change exacerbate or ameliorate existing problems?
- What are the priority research and information needs that can better inform decision making and the policy process?
- What coping options exist that can build resilience to current environmental stresses, and also possibly lessen the impacts of climate change?

This report is available online at <http://www.besis.uaf.edu/regional-report/regional-report.html>

## **Impacts of Climate Change on Alaska**

Current climate studies indicate that high-latitude regions of North America, especially Alaska and northwestern Canada, are presently experiencing some of the most dramatic warming in the world. Alaska has experienced the greatest warming of any State in the Nation over the past 50 years; this trend is consistent with model predictions that show increased temperatures at higher latitudes. USGS pioneered scientific studies of climate that showed some of the earliest evidence for warming in Alaska.

Alaska, like many other areas of the world, experienced a shift to warmer temperatures in the late 1970s. The following are some of the major climate-related trends in Alaska that scientists have observed:

- Air temperatures in Alaska have increased an average of 4° F since the 1950s, 7° F in the interior in winter, with much of the warming sparked by a large-scale arctic atmosphere and ocean regime shift in 1977.

- The 30-year air temperature record shows that increases are greatest in winter and spring and in the interior of Alaska and north of the Brooks Range.
- Recent reports suggest that summer sea ice has decreased about 3 percent per decade since the 1970s, multi-year sea ice has decreased by 14 percent since 1978, while sea ice has thinned at a rate of 4 inches per year from 1993-1997. These decreases in sea ice have affected subsistence hunting patterns and increased the danger of hunting on the ice.
- Boreholes reveal that permafrost temperatures in northern Alaska have increased 2-4° C (3.5-7° F) above temperatures 50-110 years ago; permafrost has thawed in some places to a point where it is discontinuous, resulting in increased road maintenance costs and ruining traditional ice cellars of some northern villages.
- Precipitation has increased about 30 percent for most of Alaska west of the 141 degrees West Longitude between 1968 and 1990; exceptions are the southeastern part of the State and summer precipitation in the interior, particularly around Fairbanks.
- Warmer conditions have allowed insects to thrive when cooler summers and colder winters would have normally destroyed or limited their extent; the spruce bark beetle has destroyed over 3 million acres of forest.
- The growing season in Alaska has lengthened by 13 days since 1950.

The 1997 UAF/DOI-sponsored Alaska workshop that was part of the "Preparing for a Changing Climate" assessment attracted people from within as well as outside of the State to discuss current and potential issues associated with the State's forests, tundra, coastal systems, permafrost, marine resources, wildlife, subsistence economy, and human systems (such as transportation, energy, and land use), under changing climate scenarios. With further warming in Alaska, a variety of consequences are possible. The location, volume, and species mix of fish catches could change, causing stress as the industry deals with relocation of harvesters and processors. While the permafrost is melting, the maintenance cost for pipelines could increase, but construction costs could be lower in areas where it has melted. The loss of sea ice could reduce costs for offshore oil and gas exploration and production and improve shipping, but coastal erosion could increase due to higher relative sea levels and increased storm intensity with concomitant impacts on coastal communities.

A longer growing season could improve agriculture and forestry yields, but warmer temperatures, increased summer drying, and disease-stressed trees could increase flammable vegetation, thus increasing the potential for forest fires.

Engineering must account for impacts of future thaw on existing infrastructure (highways, railroads, military and commercial airfields, buildings and the oil pipeline). For example, planning for future energy resources extraction and construction of the proposed natural gas pipeline will need to take into account the changing properties of soils that are experiencing permafrost thawing.

Fisheries may be at risk from climate change. For instance, sockeye salmon in this region support a long-established fishery, generating millions of dollars annually and providing

thousands of jobs. They also play a critical role in Alaska's sensitive coastal ecosystems. Adult sockeye salmon returning to Bristol Bay's tributaries provide food for killer whales, grizzly bears, eagles, and other predators. Eggs deposited in the streams and rivers feed many other species of fish throughout the system. Even in death after spawning, tons of decaying salmon flesh contributes marine-derived nutrients used by both plants and animals along Alaska's rivers. Ongoing USGS studies are measuring historical patterns of sockeye growth in marine and freshwater environments and identifying linkages between growth rates and climatic conditions. These USGS studies, which will generate preliminary results in 2003, will provide a thorough analysis of the effects of climate change on sockeye salmon production in Bristol Bay during the freshwater and early marine life stages that are most likely to be sensitive to fluctuations in climate.

Preliminary research suggests climate change may be implicated in the annual greening of vegetation earlier in the year. Studies by USGS scientists indicate that during the 1990s the period of time when the active layer of permafrost begins to warm to when it refreezes again has increased by more than 30 days at several sites on the Alaskan North Slope. Studies of past geologic periods by USGS geologists show that forest replaces tundra during warm climatic intervals.

New studies by USGS researchers are showing that the coastal rain forest of the Tongass National Forest in southeastern Alaska has a complex and dynamic history. This forest, which did not exist in Alaska during the last ice age, is still expanding. Some of Alaska's National Parks may see a shift in the type of vegetation that dominates their landscapes as this forest continues to migrate northward. Policy and land management decisions by the National Park Service and the U.S. Forest Service depend on understanding the dynamic nature of this ecosystem.

USGS monitoring revealed that glaciers receded in the last decade of the 20th century at the highest rates of the 30-year monitoring record; recently de-glaciated terrains are rebounding, sometimes rising centimeters per year through both glacial rebound and tectonic forces; and ranges of plants and animals are changing and expanding northward. One of the major attractions for many of Alaska's National Parks (Denali, Wrangell-St. Elias, Glacier Bay, and Kenai Fjords) is the stunning array of glaciers that have shaped, and continue to shape, the rugged Alaskan mountain landscape. USGS researchers have used satellite imagery to make precise maps of these glaciers and to monitor their changes over time.

### **Natural Resources at Risk and Research Priorities for USGS**

USGS is studying the effects of climate on Alaska's resources. These efforts are in close alignment with the USGCRP. The USGS acquires, manages, and makes available a treasure of remotely sensed data used by Alaskan, Federal, and State land management agencies for mapping, monitoring, and modeling vegetation, hydrology, and geologic processes; monitoring fires, volcanoes, and floods; and characterizing the landscape in support of the scientific and management communities. An example of the application of these data and tools is the Interagency Consortium Program, which is designed to produce

a consistent, comprehensive, and flexible land cover database for the State (the Multi-Resolution Land Characterization 2000 Program). The membership of this Federal consortium includes DOI bureaus (National Park Service, Bureau of Land Management, U. S. Fish and Wildlife Service, and USGS), Department of Agriculture (U.S. Forest Service), NOAA, NASA, and the U.S. Environmental Protection Agency. The consortium's objective is to provide repetitive coverage of satellite data that can be used to document and explain changes in land use and land cover. The Program is new to Alaska, and state-of-the-art land cover mapping and data analysis methodologies are being developed through research at the USGS Alaska Science Center.

The USGS is the developer and manager of the Internet-based Alaska Geographic Data Committee's (AGDC) Geospatial Data Clearinghouse. The AGDC's Clearinghouse serves as the Alaska Gateway to the data holdings of its members, over 40 Federal and State agencies, borough and municipal governments, Tribal Organizations, universities, and private companies within Alaska. The AGDC Gateway provides public access to everything from legal land status to detailed historical mining reports, USGS topographic maps, virtual visits to national parks, archives of remotely sensed data, and real-time stream-gage information. While its primary focus is on information that has a geographic context, the AGDC Clearinghouse also links to a broader range of environmental data through its Arctic Environmental Data Directory, which provides connections to the entire circumpolar Arctic international scientific community. Alaska agencies, native organizations, and the private sector are involved in analyzing and responding to critical issues that include hazard prevention, land conveyance, resource exploration and development, legal access and public safety, public use and resource assessment, and community and economic development.

Other ongoing USGS studies related to climate change in the Arctic include monitoring the Yukon River to document a 5-year baseline of water, sediment, and chemical loading delivered to the Bering Sea. Data will provide a baseline to compare changes that may occur in the Yukon over the next 20 to 50 years. This effort will focus on measuring the carbon and nitrogen in the river that are fundamental to the health of the ecosystem. USGS will also measure contaminants in air, water, sediment, and fish tissue that may affect people and wildlife.

USGS is measuring and modeling carbon cycling and nutrient storage as they relate to climate, permafrost, and fire. Partnerships with other scientific agencies allow USGS to contribute and interact with scientific experts of all disciplines on issues of carbon and nutrient cycling. USGS scientists play a key role in providing field-based data on soil, peat, wetlands, and water and gas chemistry. USGS also develops and applies mathematical modeling of the effects of climate on vegetation, soils, water, fire, and ecosystems. USGS monitors the permafrost temperatures in 21 deep boreholes in the National Petroleum Reserve, Alaska. Analysis of temperature profiles in the deep boreholes provided some of the first evidence that the Alaskan Arctic warmed 2-4° C (3.5-7° F) during the 20th century. Analysis of all the boreholes is being conducted under the Global Terrestrial Network - Permafrost in collaboration with other agencies and other countries.

USGS is providing information and research findings to resource managers, policymakers, and the public to support sound management of biological resources and ecosystems in Alaska. This includes studies of the role of Arctic and subarctic environments in maintaining wild stocks of nationally important marine and anadromous fish species and nationally important migratory bird populations; the ecology of marine mammals and their role and effect as top-end consumers in Arctic and subarctic marine environments; the role of Arctic and sub-arctic environments in maintaining the ecology of terrestrial mammals, and the role of top herbivores and carnivores in the dynamics of Arctic and subarctic terrestrial systems.

USGS is providing records of past climates and vegetation groups that existed in Alaska, which are key to understanding the likely consequences of future climate changes in high-latitude ecosystems. Current USGS work on the fossil record and climate history of Alaska suggests that future periods of cooler, drier climate would result in shrinkage of forest boundaries, lowering of the altitude-limited tree line, and expansion of tundra vegetation into lower elevations. A future change to warmer, moister climates would result in expansion of Alaska's forests into areas now occupied by tundra. Measuring and modeling climate-land interactions will provide a basis for resource planning for Alaska lands.

Plant fossils, such as leaves, wood, cones, pollen, and seeds, provide important evidence of how Alaska's vegetation has responded to climate changes over time periods of centuries to millions of years. USGS studies of the Alaskan fossil record of plants include data from many natural exposures and sediment cores. These data provide the basis for reconstructing the record of past vegetation changes over millions of years of Earth history. The fossil record shows that dramatic changes in high-latitude vegetation have occurred many times in the past, primarily in response to global climate changes.

USGS monitoring of volcanoes is providing information on the processes that trigger eruptions, generate volcanic ash clouds and result in volcanic emissions. The latter can impact climate (for example, the sulfur-rich 1991 eruption of Pinatubo volcano in the Philippines caused temporary global cooling.) Studies of eruption dynamics, down-slope transport of lava and volcanic debris, and the history of past eruptions contribute to an understanding that goes beyond the question of "when" to also address the question of "what to expect" when a sleeping volcano wakes up. The issue of volcanic ash and aviation safety is another aspect of USGS volcano monitoring. The world's busiest air traffic corridors pass over hundreds of volcanoes capable of sudden, explosive eruptions. Airborne ash can diminish visibility, damage flight control systems, and cause jet engines to fail. The Alaska Volcano Observatory, a cooperative effort of USGS, UAF, and Alaska Division of Geologic and Geophysical Surveys, plays a major role in the effort to reduce the risk posed to aircraft by volcanic eruptions.

The USGS has provided critical information for Alaska's development decisions, through our scientific studies of permafrost, gas and oil resources, mineral resources, fish and wildlife populations and their habitats, and the impacts of petroleum exploration, development, pollution, and climate change on terrestrial and marine mammals, migratory birds, anadromous fishes, and marine invertebrates. USGS leadership in technical review

and advice during the planning and permitting of the Trans-Alaska pipeline is an example. This role included a significant contribution toward designing the pipeline to withstand disturbance associated with permafrost.

In the past, Bristol Bay, Alaska, has produced more wild-caught sockeye salmon (*Oncorhynchus nerka*) than any other region in the world, with record runs exceeding 50 million fish annually. Recently, however, adult sockeye runs in Bristol Bay have declined 78 percent, even though counts of both juvenile fish leaving the rivers for the ocean and adults returning to the rivers to spawn have indicated strong sockeye salmon production in the freshwater tributaries to the Bay.

Recent developments have demonstrated that western Alaska salmon stocks are also in serious trouble. The returns of summer-run chum (*Oncorhynchus keta*) and chinook (*O. tshawytscha*) salmon over much of western Alaska during 2000 were the worst ever recorded. The weak returns of chinook (a 75 percent decrease) and chum (62 percent decrease) salmon into the Yukon and Kuskokwim Rivers have prompted regulatory actions by both the State and Federal fisheries managers that have resulted in the closure of subsistence harvests, and restrictions on commercial and sport fishing. The Yukon River pink salmon, which are not harvested, had a 90 percent decline in 2000. The USGS is conducting research addressing critical information gaps concerning the spawning ecology of Yukon River salmon. These studies will allow for long-term comparisons of salmon production in relation to significant shifts in the physical environments of the North Pacific leading to accelerated declines in species assemblages, including a marked decline in salmon runs returning to Alaska.

Polar bears live in the ice-covered portions of the Bering, Chukchi and Beaufort Seas adjacent to Alaska. Their dependence upon drifting ice makes polar bears an important indicator of global warming and its effects in the Arctic. Ongoing USGS research is investigating interactions between bears, their principal prey, ringed seals, and the changing sea ice that supports both of them.

USGS coordinates Arctic research with the Arctic Research Council and the Interagency Arctic Research Policy Committee (IARPC). Through this coordination, we ensure that USGS research complements, rather than duplicates, research of other agencies. IARPC, through an interagency working group, is coordinating a multi-agency research program, "Study of Environmental Arctic Change" (SEARCH). Planning for SEARCH involves the Departments of the Interior, Agriculture, Defense, and Energy and the National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, and National Science Foundation.

Geologic maps are used by land, water, and natural resource managers at all levels of the government and by the private sector to achieve the most efficient use of Earth resources in a way that is sustainable and economically viable. Economic growth is driven largely by access to the Earth's resources. Geologic maps provide the spatial framework to locate these resources. Unlike topographic maps, which show the elevation of the Earth's surface, geologic maps display the array of soils, sediments, and rocks that are present at and



below the Earth's surface. These maps are essential for a complete characterization of materials mobility in ecosystems. Detailed geologic maps are useful for mineral and petroleum exploration, for hazard assessment, and/or for land and natural resource planning.

USGS is well positioned to contribute to meeting the challenges facing Alaska. USGS' long-term study of the biological, geological, hydrologic, and energy and mineral resource systems of Alaska have addressed not only the location and utility of the resources but also their origin, sensitivity to climate and disturbance, and the fate of these resources in the future.

Mr. Chairman, this concludes my testimony. Thank you for the invitation to present testimony on this important topic. I would be happy to respond to any questions Members of the Committee may have.

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## Congressional Testimony

### Statement of Dr. Suzanne D. Weedman Before the Energy Subcommittee of the Science Committee May 3, 2001

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Submitted by [Congressional Liaison Office](#)

#### Statement of Dr. Suzanne D. Weedman, Energy Resources Program Coordinator, U.S. Geological Survey, U.S. Department of the Interior Before the Energy Subcommittee of the Science Committee, U.S. House of Representatives, May 3, 2001

Mr. Chairman and Members of the Subcommittee, thank you for this opportunity to present this statement regarding U.S. Geological Survey assessments of national and global energy resources.

#### Background

Within the Federal Government, the U.S. Geological Survey (USGS) is responsible for assessing undiscovered oil and gas resources of all onshore and State offshore areas of the Nation as well as coal and coal bed methane resources. The Geothermal Energy Research, Development and Demonstration Act of 1974 assigned responsibility for the evaluation and assessment of geothermal resources to the USGS through the U.S. Department of the Interior (DOI). The Minerals Management Service (MMS) is responsible for estimating the undiscovered oil and natural gas resources of the Outer Continental Shelf (OCS).

Because the Subcommittee requested a comprehensive overview of the U.S. Energy picture, we will also include a brief overview of U.S. uranium resources.

#### Oil and Natural Gas Resources

The USGS 1995 National Oil and Gas Assessment. In February 1995, the USGS released the *National Assessment of United States Oil and Gas Resources*. Currently, we are updating that assessment in selected regions thought to have high potential for undiscovered natural gas, including coal-bed methane. This update will be completed in 2004, with interim products available in early 2002. The updated assessment will include allocations of undiscovered oil and gas resources to Federal lands.

The 1995 USGS assessment of the Nation's onshore undiscovered oil and gas was published in digital format on a CD-ROM (USGS Digital Data Series-30) and in a non-technical summary, as USGS Circular 1118. The Assessment was conducted in collaboration with State Geological Surveys, MMS, and industry geologists working under the auspices of the American Association of Petroleum Geologists. Additional cooperation with the Bureau of Land Management, National Park Service, U.S. Forest Service, and Bureau of Indian Affairs was essential for USGS to generate information regarding oil and gas resources on Federal lands. The current update of the 1995 assessment involves many of the same partners.

Assuming existing technology, there are approximately 112 billion barrels of technically recoverable oil onshore and in State waters, according to USGS's most recent assessment. This volume includes both conventional and unconventional resources. Technically recoverable resources are those that may be recoverable using current technology without regard to economic feasibility. This includes measured (proved) reserves, future additions to reserves in existing fields (reserve growth), and undiscovered conventional resources.

The technically recoverable conventional resources of natural gas in measured (proved) reserves,

future additions to reserves in existing fields (reserve growth), and undiscovered conventional accumulations equal approximately 716 trillion cubic feet of gas. In addition to conventional gas resources, USGS has assessed technically recoverable resources in continuous-type (largely unconventional) accumulations. We estimate about 308 TCFG (trillion cubic feet of gas) of technically recoverable natural gas in continuous-type deposits in sandstones, shales, and chalks, and almost 50 TCFG of technically recoverable gas in coal beds. The total technically recoverable oil and gas resource base onshore and in State waters of the United States is displayed in Table 1.

Table 1. Results of the USGS 1995 National Oil and Gas Assessment

	<b>Oil (billion barrels)</b>	<b>Gas (trillion cu. ft.)</b>	<b>Natural Gas Liquids (billion barrels)</b>
<i>Resource Category</i>	1995	1995	1995
Undiscovered resources			
Conventional Accumulations	30	259	7
Unconventional Accumulations			
Sedimentary reservoirs	2	308	2
Coal-bed methane	NA	50	NA
Anticipated Reserve Growth	60	322	13
<i>Total</i>	92	939	22
Measured (Proved) Reserves (in 1994)	20	135	7
<i>Total</i>	112	1,074	29

The estimates presented in this statement reflect USGS understanding as of January 1, 1994. They are intended to capture the range of uncertainty, to provide indicators of the relative potential of various petroleum provinces, and to provide a useful guide in considering possible effects of future oil- and gas-related activities within the United States.

The geographic information system (GIS) coverages contained in this assessment and related databases provide the capability to estimate oil and gas resource potential on specific tracts of land, including those managed by the Federal Government. This process is called allocation, based on expert opinion, and is accomplished using a methodology that takes into consideration all geologic information available about a particular basin.

1995 National Oil and Gas Assessment and Onshore Federal Lands (1998). In January 1998, USGS published an Open-File Report (OFR 95-0075-N) that reported estimates of volumes of undiscovered oil and gas on Federal lands. Estimates of oil in undiscovered conventional fields range from 4.4 to 12.8 billion barrels (BBO), with a mean value of 7.5 BBO. Estimates of technically recoverable gas in undiscovered conventional fields range from 34.0 to 96.8 trillion cubic feet (TCF), with a mean value of 57.9 TCF. Almost 85 percent of the assessed natural gas in undiscovered conventional accumulations was non-associated gas, that is, gas in gas fields rather than gas in oil fields. Estimates of technically recoverable resources in unconventional (continuous type) accumulations for oil are from 0.2 to 0.6 BBO, with a mean value of 0.3 BBO, and for gas, from 72.3 to 202.4 TCF, with a mean value of 127.1 TCF. These ranges of estimates correspond to 95-percent probability (19 in 20 chance) and 5-percent probability (1 in 20 chance) respectively, of a least those amounts occurring.

An economic evaluation was applied to these technically recoverable estimates. Our study concluded that at \$30 per barrel for oil and \$3.34 per thousand cubic feet of gas, 3.3 BBO oil and 13.6 TCF in undiscovered conventional fields could be found, developed, and produced. In addition, at these estimated prices, 0.2 BBO oil and 11.4 TCF in continuous-type accumulations and 11.8 TCF of coalbed gas can be developed.

Estimated volumes of undiscovered oil, gas, and natural gas liquids in onshore Federal lands, as of January 1994 are displayed in Table 2.

Table 2. Results of the USGS 1998 National Oil and Gas Assessment and Onshore Federal Lands

	Technically Recoverable			Economically Recoverable*	
	F <sub>95</sub>	Mean	F <sub>05</sub>	\$18/bbl \$2/mcf	\$30/bbl \$3.34/ mcf
Conventional					
Oil (BBO)**	4.4	7.5	12.8	1.6	3.3
Gas (TCF)	34.0	57.9	96.8	9.7	13.6
NGL (BBL)	1.1	1.8	2.7	0.7	0.9
Unconventional					
Oil (BBO)	0.2	0.3	0.6	0.1	0.1
Gas (TCF)	72.4	127.1	202.4	6.1	11.4
NGL (BBL)	0.1	1.5	2.6	0.0	0.1
Coalbed Methane (TCF)	13.0	16.1	19.6	7.0	11.8

\* Includes cost of finding, developing, and producing the resource. Based on mean values of technically recoverable estimate.

\*\* BBO = billion barrels oil; TCF = trillion cubic feet; BBL = billion barrels liquid; bbl = barrel; mcf = thousand cubic feet.

The results of the USGS National Oil and Gas Resource Assessment have been used by the Energy Information Administration (EIA) for its *Annual Energy Outlook*, by the California Energy Commission and Canadian Energy Board to model inter-regional natural gas supply and demand and the resulting economic impacts, and by numerous petroleum companies as a basis for evaluating risk associated with exploration and development of domestic oil and gas resources.

Many Federal agencies use the information in the USGS National Oil and Gas Assessment for land-use planning, energy policy formulation, and economic forecasting. Customers include the Department of the Interior, Bureau of Land Management, National Park Service, U.S. Forest Service, Bureau of Indian Affairs, Energy Information Administration, and the Department of Energy (DOE), among others. In addition, most State Geological Surveys and/or State Divisions of Oil and Gas use the USGS assessment for regional and local resource evaluation and lease planning purposes. Many private sector organizations also use the digital oil and gas assessment results, including environmental protection advocacy groups, petroleum exploration companies, and utility companies (including natural gas and electricity utilities).

Sec. 604 Energy Act of 2000. The Secretary of the Interior is charged with conducting an inventory of energy resources and the restrictions and impediments to their development on Federal Lands in Section 604 of the Energy Act of 2000, signed into law on November 9, 2000.

It is our understanding that the role of USGS will be to assess the oil and gas resources of oil- and

gas-bearing basins that have federally managed lands, consistent with the USGS assessment and allocation methodology. Then, USGS geologists will allocate resource estimates to those specific land parcels managed by the Federal government. The USGS resource estimates will be combined with reserve volumes from the Energy Information Administration (EIA) of the Department of Energy (DOE), and will be incorporated into a geographic information system (GIS) to show the spatial distribution of those potential resources and known reserves. The resource and reserve information will be integrated with information on restrictions and impediments provided by the Bureau of Land Management (BLM) and the Forest Service.

The USGS will use resource estimates from the 1995 National Oil and Gas Assessment for areas where there are no significant new data and will update resource estimates for the gas-prone areas of the country where new data are available.

The Minerals Management Service's 2000 OCS Resource Assessment. As background, MMS's mission consists of two major programs: Offshore Minerals Management and Minerals Revenue Management. The leasing and oversight of mineral operations on the Outer Continental Shelf (OCS) and all mineral revenue management functions for Federal (onshore and offshore) and American Indian lands are centralized within the bureau. In 2000, OCS oil and natural gas production accounted for roughly 25 and 26 percent, respectively, of our nation's domestic energy production – oil production was over 500 million barrels and natural gas production was over 5 trillion cubic feet. The amount of oil and natural gas production in 2000 was the most ever produced on the OCS. In addition, in fiscal year 2000, MMS collected and distributed about \$7.8 billion in mineral leasing revenues from Federal and American Indian lands.

In its role as manager of the Nation's OCS energy and non-energy mineral resources, MMS is responsible for assessing those resources; determining if they can be developed in an environmentally sound manner; and if leased, regulating activities to ensure safety and environmental protection. An integral element in that mission is to identify the most promising areas of the OCS for the occurrence of crude oil and natural gas accumulations and to quantify the amounts of oil and natural gas that may exist in these areas.

Since its creation in 1982, MMS has completed four systematic assessments of Federal OCS undiscovered oil and natural gas resources, including its most recent assessment. The 2000 resource assessment was done to support staff work and analysis needed in formulating the next 5-Year Oil and Gas Leasing Program covering the timeframe 2002-2007. It should be noted that the methodology for the 2000 assessment has not changed significantly from that used in the previous 1995 assessment.

The 2000 assessment presents the updated assessment results since the 1995 assessment for the Alaska, Atlantic, and Gulf of Mexico OCS Regions. In the Alaska Region only the Beaufort and Chukchi Seas, Hope Basin, and Cook Inlet areas were updated, as there were no new data or other changes since the last assessment. The Pacific OCS Region was not updated for the same reasons. The Atlantic OCS Region was re-evaluated to reflect recent exploration results offshore Nova Scotia, current exploration and production technologies, and to make the water depth divisions compatible with the ones now being used in the Gulf of Mexico.

The MMS has recently made public the 2000 assessment, and I have included a copy of the assessment with my written statement for the hearing record. MMS estimates that the total mean undiscovered, conventionally recoverable resources for the United States OCS are 75.0 billion barrels of oil and 362.2 trillion cubic feet of natural gas. Within that total, MMS determined that the undiscovered conventionally recoverable resources foregone by the 1998 moratoria (i.e., the President's June 1998 OCS decision) would be approximately 16 billion barrels of oil and 62 trillion cubic feet of gas.

The total mean undiscovered economically recoverable resources for the United States OCS are 26.6 billion barrels of oil and 116.8 trillion cubic feet of gas at prices of \$18 per barrel and \$2.11 per thousand cubic feet, respectively, and 46.7 billion barrels of oil and 168.1 trillion cubic feet of gas at prices of \$30 per barrel and \$3.52 per thousand cubic feet, respectively.

USGS 2000 World Petroleum Assessment. In March 2000, USGS released the *World Petroleum Assessment 2000*. This assessment is a five-year project that was extensively reviewed by members of the World Energy Consortium. The project assessed recoverable undiscovered conventional oil and gas resources of the world, exclusive of the United States, for a 30-year time frame (1995–2025). This is a geologically based assessment and resources were allocated to individual countries, allocated to onshore and offshore, and allocated to OPEC, OECD, and other countries not part of OPEC or OECD. For the first time, our world assessment contains an estimate of the amount of reserve growth expected in the next 30 years. All the products are digital and available on CD-ROM and via the Web.

The assessment provides estimates of the quantities of conventional oil, gas, and natural gas liquids that have the potential to be added to global reserves in the next 30 years. The mean (expected) volumes of undiscovered resources are 649 billion barrels of oil (BBO), 4,669 trillion cubic feet of gas (TCFG), and 207 billion barrels of natural gas liquids (BBNGL). The estimated mean additions to reserves from discovered fields (potential reserve growth) are 612 BBO, 3,305 TCFG, and 42 BBNGL.

The potential additions to reserves from reserve growth are nearly as large as the estimated undiscovered resource volumes. These estimates imply that 75 percent of the world's grown conventional oil endowment (see Table 3 for explanation of grown endowment) and 66 percent of the world's grown conventional gas endowment have already been discovered in the areas assessed (exclusive of the U.S.). Additionally, for these areas, 20 percent of the world's grown conventional oil endowment and 7 percent of the world's grown conventional gas endowment had been produced as of the end of 1995.

This assessment is based on extensive geologic studies rather than a statistical projection. The petroleum assessed occurs in fields exceeding a stated minimum size, which varies between 1 and 20 million barrels of oil equivalent in different areas, and in accumulation categories judged to be viable in a 30-year forecast span.

Compared to the last USGS world petroleum assessment (Masters and others, 1994, 1997), undiscovered volumes from this world assessment are 20 percent greater for oil, 14 percent smaller for gas, and 130 percent greater for natural gas liquids. The large estimated volumes of oil, gas, and natural gas liquids from reserve growth in this assessment represent a resource category not quantitatively assessed previously for the world by the USGS.

The volume of undiscovered oil estimated in this assessment is larger than that of the 1994 assessment, due in part to larger estimates for the Middle East and Atlantic offshore portions of South America and Africa. However, in some areas the estimated volumes of undiscovered oil were smaller, particularly for Mexico and China.

The volume of undiscovered gas estimated in this assessment is smaller than that of the previous world assessment mainly because of smaller estimates for arctic areas of the Former Soviet Union, some basins in China, and the Alberta Basin of Canada. The volume of undiscovered NGL estimated in this assessment is much larger than that of the previous assessment because of more detailed analysis, coupled with the incorporation of co product ratios into the assessment calculations.

Areas assessed in the World Petroleum Assessment 2000 that contain the greatest volumes of undiscovered conventional oil include the Middle East, northeast Greenland Shelf, the West Siberian and Caspian areas of the Former Soviet Union, and the Niger and Congo delta areas of Africa. Significant new undiscovered oil resource potential was identified in a number of areas with no significant production history, such as northeast Greenland and offshore Suriname.

Areas that contain the greatest volumes of undiscovered conventional gas include the West Siberia Basin, Barents and Kara Seas shelves of the Former Soviet Union, the Middle East, and offshore Norwegian Sea. A number of areas were identified that may contain significant additional undiscovered gas resources where large discoveries have been made but remain undeveloped. Examples include East Siberia and the Northwest Shelf of Australia.

Table 3. Results from the USGS World Energy Assessment 2000 compared with U.S. domestic resources.

Category of Resources	Oil (Billions of Barrrels)			Natural Gas (Trillions of Cubic Feet)		
	Mean World Oil	Mean U.S. Oil	U.S. % of World	Mean World Gas	Mean U.S. Gas	U.S. % of World
Undiscovered Resources	649 <sup>a</sup>	83 <sup>c,d</sup>	11%	4,669 <sup>a</sup>	527 <sup>c</sup>	10%
Reserve Growth	612 <sup>a</sup>	76 <sup>c,d</sup>	11%	3,305 <sup>a</sup>	355 <sup>c</sup>	10%
Reserves	859 <sup>b</sup>	32	4%	4,621 <sup>b</sup>	172	4%

Cumulative Production	539 <sup>b</sup>	171	24%	898 <sup>b</sup>	854	49%
Column Totals	2,659	362	12%	13,493	1,908	12%
Total "Grown" Petroleum Endowment	3,021 Billion Barrels			15,401 Trillion Cubic Feet		

Mean values are the average or expected values

Grown Petroleum Endowment is the sum of the known petroleum volume (cumulative production plus remaining reserves), the mean of the undiscovered volume, and additions to reserves by reserve growth

a = Data from USGS World Petroleum Assessment, 2000

b = Data from Petroconsultants, 1996, and NRG Associates, 1995

c = Data from USGS National Oil and Gas Assessment, 1995, and from Minerals Management Service, 1996.

d = Mean U.S. Oil amounts include natural gas liquids

### Coal Resources

The USGS is completing a National Coal Resource Assessment (NCRA) during 2001. To date, two coal resource assessments have been released, the Colorado Plateau and the Northern Rocky Mountains and Great Plains. Coal resource assessments of the Appalachian and Illinois Basins, and Gulf Coast Region will be available later in 2001. The USGS coal assessments also identify volumes of coal under federally owned lands, and of federally owned coal under privately owned lands, where present.

The NCRA is a multi-year effort by the USGS to identify, characterize, and assess the coal resources that are expected to supply a major part of the Nation's energy needs during the 21st century. Products from NCRA include publicly available stratigraphic, geochemical, and GIS databases to answer a variety of questions of importance to government, industry and public decision makers and interpretive geologic and geochemical information for the primary coal resources of the Nation. Five priority regions were assessed: the Appalachian Basin, Illinois Basin, Gulf Coast, Colorado Plateau, and Northern Rocky Mountains and Great Plains. The NCRA is a cooperative effort between the USGS and a number of State geological surveys in these coal-bearing regions. Volumes of coal resources on Federal lands were also identified.

The results of the USGS National Coal Resource Assessment are important because they provide an impartial assessment of the Nation's coal resources. The USGS NCRA provides information that can be used to; (1) evaluate and minimize environmental impacts related to extraction, production, and use of energy resources; (2) manage resources on Federal lands; (3) address issues of energy and environmental policy and strategy; (4) determine the potential for coalbed gas resources and development of the United States; (5) determine the availability and recoverability of coal resources throughout the U.S; (6) determine potential areas of future coal development; and (7) assess the potential of coal to act as a storage site to sequester carbon dioxide.

The reported coal resource estimates for the five regions refer to coal resources in the ground and are quite large and should not be confused with available or minable and recoverable coal (often referred to as 'reserves') in these regions. There are trillions of tons of coal in the United States. However, total resources are also important because they are still potential resources, should technologic, societal, political, or economic needs change resulting in presently unminable coal becoming usable. For example, results from the two finalized assessment regions estimate resources of approximately 550 billion short tons of remaining coal in the Colorado Plateau and 660 billion short tons of coal in the Northern Rocky Mountains and Great Plains region. Not all of this coal is available for mining or economically recoverable. Studies in the Appalachian and Illinois Basins indicate that only 50 to 60 percent of the coal is usually available for mining after land use and technological restrictions are applied to the data, and only 11 to 38 percent is economically recoverable. Furthermore, coal quality affects coal usage greatly. Current Clean Air Act regulations limit the amount of sulfur dioxide that power plants may emit. These regulations limit the amount of sulfur in the coal that may be burned, unless the power plants install certain smoke stack equipment.

In addition to the resources assessed in the five priority regions, a resource assessment of coal on Federal land was also conducted. The Federal Government manages vast amounts of coal resources. The U.S. Government held 91.7 billion short tons of coal in reserve in 1998-1999. Approximately one-third of the Nation's coal production comes from coal on Federal lands; in 1997, approximately 1.1 billion short tons of coal were produced in the United States and approximately 330 million tons of that coal originated from Federal lands. More than a quarter of a billion dollars in royalties are generated

annually from production of coal on Federal lands, of which about half is disbursed to the States from which the coal was mined.

Federal coal and land ownership is a much more important issue in the western United States where many coal fields occur on Federally managed lands. The majority of relatively high quality coal reserves in Wyoming, Utah, Montana, Colorado and New Mexico occur on federally managed lands. Approximately 50 percent of the coal in the Colorado Plateau assessment region underlies land that is administered by Federal agencies including the Bureau of Land Management, the National Park Service, and the U. S. Forest Service; the Colorado Plateau also contains coal underlying Tribal, State, and private lands. Approximately 32 percent of the coal in the Northern Rocky Mountains and Great Plains assessment region occurs beneath land surface managed by Federal agencies, however, Federal coal resources underlie approximately 80 percent of this area.

An important issue in Federal land management is the interrelationship between surface ownership and coal ownership. Often ownership of the coal and ownership of the surface land is not the same. This is strikingly illustrated when comparing land ownership versus federal coal ownership in the assessed units of the Colorado Plateau and the Northern Rocky Mountains and Great Plains. In the Powder River Basin, Wyoming and Montana, where more than a third of the country's coal is produced, almost all of the coal is Federally managed, yet most of the surface rights are privately held. In the Colorado Plateau, the majority of the coal is also federally managed, yet the majority of surface ownership is nonfederal (either State, Tribal, or private).

Because federally managed coal plays a major role in the energy supply of the United States, National Coal Resource Assessment developed digital databases of information on Federal coal resources. These databases identify areas where surface ownership is different from mineral ownership and can help policy makers, land-use planners, land managers, and mineral developers make informed decisions regarding Federal land use while maintaining a healthy domestic energy industry. At this time, these databases only contain information for the conterminous United States, because digital information on coal ownership in Alaska is not presently available.

This work represents the first time that resource estimates have been calculated for Federal coal. More than 360 billion short tons of Federal coal exists in Utah, Colorado, and New Mexico and more than 520 billion short tons of Federal coal exists in Wyoming, Montana, and North Dakota.

### Geothermal Resources

Assessment efforts initiated under the Geothermal Energy Research, Development, and Demonstration Act of 1974 led to the publication of USGS Circular 726, *Assessment of Geothermal Resources of the United States—1975* and USGS Circular 790, *Assessment of Geothermal Resources of the United States—1978*. These reports established the methodology for geothermal resource assessments and provided estimates of potential electric power generation that have guided geothermal energy research and development for the past 22 years.

Today, the United States has an installed capacity of approximately 2,860 Megawatts (MW) of electrical power production from geothermal plants located in California, Hawaii, Nevada, and Utah. This constitutes 0.4% of our total electricity generation capacity. Geothermal energy is derived from the earth's internal heat and can be manifested as volcanoes, hot springs, and other thermal features. Large portions of the western U.S. are characterized by abnormally high heat flow as a result of active faulting and volcanism and all of the existing geothermal power plants fall within these regions.

Geothermal reservoirs are classified according to their temperature and whether the reservoir fluid occurs as liquid water or as steam. Geothermal power is obtained from steam produced directly from the ground, from steam flashed and separated from hot water, or from binary systems involving closed-loop heat exchange between hot water and organic fluids with low boiling temperatures.

High temperature geothermal systems have temperatures greater than 150°C (302°F) with the reservoir fluid comprising hot water and/or steam. These systems are typically the best candidates for electricity generation and power plants exploiting these systems typically flash the hot water to drive steam turbines.

Intermediate temperature systems have temperatures between 90 and 150°C (194 and 302°F) and generally require the use of binary power plants with closed-loop heat exchange technology that allows transfer of the heat in the geothermal fluid to a second fluid that vaporizes at lower temperature.



Low temperature systems are those with temperatures less than 90°C (194°F) and are generally considered appropriate for direct use applications (space heating, agricultural process heat, spas). In this statement I will concentrate on the nature and abundance of intermediate and high temperature geothermal systems in the United States. A general overview of all aspects of geothermal energy can be found in USGS Circular 1125, *Tapping the Earth's Natural Heat*.

The last nationwide geothermal resource assessment (USGS Circular 790) was published in 1978, and a comparison of its findings with the current state of knowledge and development highlights some important points.

(a) Nine western states (Alaska, Arizona, California, Hawaii, Idaho, Nevada, New Mexico, Oregon and Utah) have potential for at least 100 MW of electrical power generation per state from identified geothermal systems.

(b) The total identified high temperature geothermal resource in these nine states was estimated at approximately 22,000 MW. On a state-by-state basis, only California has realized a significant fraction (22%) of this potential (2,600 out of 12,000 MW). Estimates of undiscovered resources ranged from 72,000 to 127,000 MW.

(c) The Great Basin region, which lies mostly in Nevada and Utah but also encompasses parts of California, Oregon, and Idaho, has the lowest percentage of developed power with respect to the Circular 790 estimates. Only about 500 MW are produced in the Great Basin compared with an estimated high-temperature resource of about 7,500 MW.

Table 4 summarizes the results of the state-by-state comparison for the nine states highlighted in the 1978 resource assessment and the installed electrical power generating capacity as of 1998 (Source - Energy Information Administration (EIA)).

Table 4. State-by-state comparison of estimated geothermal resource, installed geothermal capacity, and total installed capacity from all sources.

State	Estimated Geothermal Resource-1978 (MW)	Installed Capacity -Geothermal (MW)	Installed Capacity -All Sources (MW)	Percentage of Geothermal Power
Alaska	250	0	2,093	0
Arizona	1,000	0	15,254	0
California	12,000	2,600	52,349	4.9%
Hawaii	250	30	2,353	1.3%
Idaho	540	0	3,001	0
Nevada	2,000	200	6,389	3.1%
New Mexico	2,700	0	5,531	0
Oregon	2,200	0	11,344	0
Utah	1,350	33	5,206	0.6%
Total	22,290	2,863	103,520	2.8%

If the entire estimated resource for these nine states could be exploited as electrical power, it would equal 21.5% of the electrical power generated from all other sources. The possible reasons for the large difference between the estimated geothermal resource and installed capacity are varied and, in the absence of another systematic resource assessment, difficult to quantify.

Among the factors limiting geothermal resource development are the following.

- Economics – Until recently, the 5- to 8-cent per kilowatt-hour (kwh) cost of geothermal energy was not competitive with fossil fuel-generated power costing as little as 3 cents/kwh.
- Water – Reservoirs exploited with flash-steam power plants lose a significant fraction of the produced water from their cooling towers. In many western states water for reinjection into geothermal reservoirs is either unavailable or in short supply.
- Remote Locations – Many geothermal systems, particularly those in the Great Basin, are dispersed in relatively remote locations with limited access to electric power transmission lines and other facilities.
- Validation of the Resource – Because geothermal reservoir development requires drilling, it has often proven difficult for power companies to obtain financing in the absence of up to date resource assessments.
- Uncertainties in the Circular 790 Assessment – The state of knowledge about geothermal resources has advanced dramatically in the past 20 years, and there is evidence that Circular 790 may have overstated the abundance of high temperature resources in the western U.S.

There are also a number of technical reasons why geothermal resource development could approximate some of the estimates contained in Circular 790.

- Binary Power Plants - The maturation of binary power plant technology has provided a means of exploiting geothermal reservoirs with little or no loss of water. In addition, binary power plants have enabled the development of intermediate temperature systems not included in the Circular 790 estimate.
- Reclaimed Water – Effluent pipelines carrying reclaimed water from urban areas have become a cost-effective and environmentally sound means of providing water for reinjection into declining or depleted geothermal reservoirs. For example, reclaimed water is now being used to replenish The Geysers geothermal field in California, which produces approximately 1,200 MW of electricity.
- Enhanced Geothermal Systems – With DOE support, scientists and engineers have been developing a geothermal reservoir stimulation technique known as Enhanced Geothermal Systems (EGS). Through the hydraulic fracturing of the hot but impermeable rock surrounding geothermal reservoirs, power companies will be able to increase the amount of hot rock available to heat geothermal fluid, increasing the capacity and extending the lifetime of existing geothermal systems.
- Exploration Technology – Improved geochemical and geophysical tools for geothermal exploration, together with targeted test drilling, have allowed power companies to more accurately predict the productivity of a specific geothermal resource before embarking on an expensive program of production drilling.

Recent efforts to incorporate some or all of these developments in updated assessments have led to widely varying results. According to a 1999 report prepared by the Geothermal Energy Association (GEA) and the DOE (*Geothermal Energy, The Potential for Clean Power from the Earth*), the domestic geothermal energy potential ranges from 6,520 MW with existing technology to 18,880 MW with enhanced technology. A geothermal industry consultant's re-examination of the Circular 790 assessment with the addition of potential Enhanced Geothermal System sources gives a range of values between 6,300 and 27,400 MW (J. Sass, unpublished report). The Strategic Plan for the DOE Office of Power Technologies has a goal for geothermal energy to provide 10% of the electric power requirements of western states by the year 2020. This would require more than 10,000 MW of additional geothermal power, and a review by the National Research Council (NRC) suggests this goal is unlikely to be met (*Renewable Power Pathways: A Review of the U.S. Department of Energy's Renewable Energy Programs*, NRC, 2000). By contrast, the Energy Information Administration of DOE estimates an installed geothermal power capacity of 4,140 MW by 2011 (*EIA Annual Energy Outlook 2001* - [http://www.eia.doe.gov/oiaf/aeo/aeotab\\_17.htm](http://www.eia.doe.gov/oiaf/aeo/aeotab_17.htm)).

### Uranium Resources

The first and only national uranium assessment was the National Uranium Resource Evaluation (NURE) program, completed by the U.S. Department of Energy in 1980. The NURE program mapped and tabulated uranium deposits by county and various energy regions in the United States. Energy Information Administration still uses this assessment of uranium endowment to make annual calculations of the economic portion of the 1980 resources and of the few new identified endowments.

Uranium first became a fuel for commercial generation of electricity in 1953; today, 22 percent of our electricity comes from nuclear generating plants. According to EIA statistics, the U.S. nuclear power industry achieved its second year of record power generation levels in 2000.

Also according to the EIA, in 1999, U.S. utilities received a total of 47.9 million pounds U<sub>3</sub>O<sub>8</sub>e (equivalent), at an average price of \$11.63 per pound. Compared with 1998, the quantity of uranium received increased 12 percent and the price decreased 4 percent. Foreign-origin uranium

accounted for 36.5 million pounds (76 percent) of the deliveries at an average price of \$11.47 per pound. Approximately 26 percent of all uranium purchased by U.S. utilities was of Canadian origin, while 24 percent was of U.S. origin. In rank order, the next five foreign countries of origin were Australia (15 percent), Russia (13 percent), South Africa (6 percent), Uzbekistan (5 percent), and Ukraine (4 percent).

Since 1980 in the U.S., new resource areas have been developed, new types of deposits have been discovered, new mining methods have become available, and new resource-estimating methodologies have been developed. Because of these new discoveries, the original assessment is significantly out of date.

Mr. Chairman, this concludes my remarks. I would be happy to respond to questions you or Members of the Subcommittee may have.

## Congressional Testimony

### Statement of Dr. Colin F. Williams Before the Subcommittee on Energy and Mineral Resources, May 3, 2001

Submitted by [Congressional Liaison Office](#)

### Statement of Dr. Colin F. Williams, Supervisory Geophysicist, U.S. Geological Survey, Before the Subcommittee on Energy and Mineral Resources, Committee on Resources, U.S. House of Representatives, May 3, 2001

Madam Chairman and distinguished Members of the Subcommittee, thank you for this opportunity to present, on behalf of the U.S. Geological Survey, this statement regarding our assessment of the location, extent and nature of geothermal resources in the United States.

#### Background

The Geothermal Energy Research, Development and Demonstration Act of 1974 (P.L. 93-410) assigned responsibility for the evaluation and assessment of geothermal resources to the USGS through the U.S. Department of the Interior (DOI). The assessment efforts initiated under this Act led to the publication of USGS Circular 726, *Assessment of Geothermal Resources of the United States - 1975* and USGS Circular 790, *Assessment of Geothermal Resources of the United States - 1978*. These reports established the methodology for geothermal resource assessments and provided estimates of potential electric power generation that have guided geothermal energy research and development for the past 22 years.

In this statement I will summarize the current state of geothermal energy in the United States and provide information on the evolution of geothermal science and technology as it relates to the resource assessments of the 1970s.

#### The Current State

Today, the United States has an installed capacity of approximately 2,860 Megawatts (MW) of electrical power production from geothermal plants located in California, Hawaii, Nevada, and Utah. This constitutes 0.4% of our total electricity generation capacity and is the Nation's largest source of non-hydroelectric renewable electrical power.

### Classification, Location and Development of Geothermal Resources

The Earth's internal heat drives many geologic processes and, where it is locally concentrated, this heat can be manifested as volcanoes, hot springs, and other thermal features. Large portions of the western U.S. are characterized by abnormally high heat flow as a result of active faulting and volcanism. All of the existing geothermal power plants fall within these regions. The Earth's heat can be exploited at various temperatures to provide a source of geothermal energy.

Geothermal reservoirs are classified according to their temperature and whether the reservoir fluid occurs as liquid water or as steam. Geothermal power is obtained from steam produced directly from the ground, from steam flashed and separated from hot water, or from binary systems involving closed-loop heat exchange between hot water and organic fluids with low boiling temperatures.

High temperature geothermal systems have temperatures greater than 150°C (302°F) with the reservoir fluid comprising hot water and/or steam. These systems are typically the best candidates for electricity generation and power plants exploiting these systems typically flash the hot water to drive steam turbines.

Intermediate temperature systems have temperatures between 90 and 150°C (194 and 302°F) and generally require the use of binary power plants with closed-loop heat exchange technology that allows transfer of the heat in the geothermal fluid to a second fluid that vaporizes at lower temperature.

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The last nationwide geothermal resource assessment (USGS Circular 790) was published in 1978, and a comparison of its findings with the current state of knowledge and development highlights some important points.

- Circular 790 identified nine western states (Alaska, Arizona, California, Hawaii, Idaho, Nevada, New Mexico, Oregon and Utah) with the potential for at least 100 MW of electrical power generation per state from identified geothermal systems.

- The total identified high temperature geothermal resource in these nine states was estimated at approximately 22,000 MW. On a state-by-state basis, only California has realized a significant fraction (22%) of this potential (2,600 out of 12,000 MW). Estimates of undiscovered resources ranged from 72,000 to 127,000 MW.
- The Great Basin region, which lies mostly in Nevada and Utah but also encompasses parts of California, Oregon, and Idaho, has the lowest percentage of developed power with respect to the Circular 790 estimates. Only about 500 MW are produced in the Great Basin compared with an estimated high-temperature resource of about 7,500 MW.

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Hawaii	250	30	2,353	1.3%
Idaho	540	0	3,001	0
Nevada	2,000	200	6,389	3.1%
New Mexico	2,700	0	5,531	0
Oregon	2,200	0	11,344	0
Utah	1,350	33	5,206	0.6%
Total	22,290	2,863	103,520	2.8%

If the entire estimated resource for these nine states could be exploited as electrical power, it would equal 21.5% of the electrical power generated from all other sources. The possible reasons for the large difference between the estimated geothermal resource and installed capacity are varied and, in the absence of another systematic resource

assessment, difficult to quantify.

Among the factors limiting geothermal resource development are the following.

- Economics – Until recently, the 5- to 8-cent per kilowatt-hour (kwh) cost of geothermal energy was not competitive with fossil fuel-generated power costing as little as 3 cents/kwh.
- Water – Reservoirs exploited with flash-steam power plants lose a significant fraction of the produced water from their cooling towers. In many western states water for reinjection into geothermal reservoirs is either unavailable or in short supply.
- Remote Locations – Many geothermal systems, particularly those in the Great Basin, are dispersed in relatively remote locations with limited access to electric power transmission lines and other facilities.
- Validation of the Resource – Because geothermal reservoir development requires drilling, it has often proven difficult for power companies to obtain financing in the absence of up to date resource assessments.
- Uncertainties in the Circular 790 Assessment – The state of knowledge about geothermal resources has advanced dramatically in the past 20 years, and there is evidence that Circular 790 may have overstated the abundance of undiscovered high temperature resources in the western U.S.

There are also a number of technical reasons why geothermal resource development could approximate some of the estimates contained in Circular 790.

- Binary Power Plants - The maturation of binary power plant technology has provided a means of exploiting geothermal reservoirs with little or no loss of water. In addition, binary power plants have enabled the development of intermediate temperature systems not included in the Circular 790 estimate.
- Reclaimed Water – Effluent pipelines carrying reclaimed water from urban areas have become a cost-effective and environmentally sound means of providing water for reinjection into declining or depleted geothermal reservoirs. For example, reclaimed water is now being used to replenish The Geysers geothermal field in California, which produces approximately 1,200 MW of electricity.
- Enhanced Geothermal Systems – With DOE support, scientists and engineers have been developing a geothermal reservoir stimulation technique known as Enhanced Geothermal Systems (EGS). Through the hydraulic fracturing of the hot but impermeable rock surrounding geothermal reservoirs, power companies will be able to increase the amount of hot rock available to heat geothermal fluid, increasing the capacity and extending the lifetime of existing geothermal systems.
- Exploration Technology – Improved geochemical and geophysical tools for geothermal exploration, together with targeted test drilling, have allowed power companies to more accurately predict the productivity of a specific geothermal resource before embarking on an expensive program of production drilling.

Recent efforts to incorporate some or all of these developments in updated assessments have led to widely varying results. According to a 1999 report prepared by the Geothermal

Energy Association (GEA) and the DOE (*Geothermal Energy, The Potential for Clean Power from the Earth*), the domestic geothermal energy potential ranges from 6,520 MW with existing technology to 18,880 MW with enhanced technology. A geothermal industry consultant's re-examination of the Circular 790 assessment with the addition of potential Enhanced Geothermal System sources gives a range of values between 6,300 and 27,400 MW (J. Sass, unpublished report). The Strategic Plan for the DOE Office of Power Technologies has a goal for geothermal energy to provide 10% of the electric power requirements of western states by the year 2020. This would require more than 10,000 MW of additional geothermal power, and a review by the National Research Council (NRC) suggests this goal is unlikely to be met (*Renewable Power Pathways: A Review of the U.S. Department of Energy's Renewable Energy Programs*, NRC, 2000). By contrast, the Energy Information Administration of DOE estimates an installed geothermal power capacity of 4,140 MW by 2011 (*EIA Annual Energy Outlook 2001* - [http://www.eia.doe.gov/oiaf/aeo/aeotab\\_17.htm](http://www.eia.doe.gov/oiaf/aeo/aeotab_17.htm)).

### Future Directions for Research and Development

Along with the need to reduce the uncertainties in the assessment of domestic geothermal resources, there are many active research efforts in geothermal science and technology that could benefit the geothermal power industry in the near term.

- Exploration and Drilling - Although the technology of power generation is well advanced, new geothermal systems can be hard to locate and expensive to develop. Advances in exploration and drilling technology can cut costs and increase the probability of success.
- Enhanced Geothermal Systems - Techniques for expanding and sustaining geothermal reservoirs are in their infancy, and EGS experiments proposed for the next few years could greatly expand the existing resource base.
- Integrated Geological Studies - In order to accurately assess the geothermal resources of the western U.S., significant progress needs to be made on understanding the processes responsible for the formation of geothermal systems, particularly in the Great Basin. Recent investigations of the interrelationships among heat flow, ground-water circulation, active faulting, volcanism, and geochemical fluid-rock interactions suggest that the Earth Science community is on the verge of developing a new, comprehensive understanding of geothermal systems. The resulting models for the nature and extent of geothermal systems would not only improve the accuracy of any new assessment but also enable the development of more economical exploration and development strategies for geothermal energy.

Madam Chairman, this concludes my remarks. I would be happy to respond to questions Members of the Committee may have.

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## Congressional Testimony

### Statement of Jill S. Baron Before the House Committee on Science, May 3, 2001

Submitted by [Congressional Liason Office](#)

Mr. Chairman and distinguished Members of the Committee, thank you for this opportunity to present, on behalf of the U.S. Geological Survey, this statement regarding sources, transport, and fate of atmospheric deposition in the Western United States.

I am an ecologist with the U.S. Geological Survey (USGS). In 1981, I began research into the susceptibility of Rocky Mountain National Park lakes to acidic atmospheric deposition. I, and my colleagues, now have over 20 years in understanding alpine and sub-alpine ecological processes and the influence of atmospheric deposition on these natural environments. The USGS has been quite active in studying the ecological and biogeochemical influences of airborne pollutants throughout the United States, and has produced cutting-edge science from our long-term watershed research and monitoring efforts. I am confident of the results I will present to you today regarding atmospheric deposition and ecological effects for the specific areas we have studied. The response to atmospheric nitrogen deposition in Southern California has been pronounced, and it is well documented by scientists working there. In Colorado, we see significant changes from nitrogen deposition that tell us our ecosystems are just beginning to respond, and our results are also well-documented in the scientific literature. However, the West is very large, and our studies and monitoring are limited in geographic scope. There is also a great amount we do not yet know about combined interactions between many environmental stresses and the plants, animals, and microbes that make up our ecosystems.

#### Definition of the Issue

The history of atmospheric deposition to the Western United States beyond the 100th Meridian (hereafter referred to as West) differs from that in the Eastern half of the

country. Because the West has been settled more recently than the East, it has not experienced emissions of sulfur and nitrogen oxides for as long. Although population in the West is increasing rapidly, human density is still far below much of the rest of the country. This has resulted in a lower density of power plants and industrial facilities that have been a large source of air pollutants elsewhere. Compared to the East, the West is fortunate to have energy sources that generally do not emit high amounts of sulfur dioxide, one of the major precursors to acid rain. Low sulfur coal, hydropower, nuclear, and solar and wind energy have helped the West suffer less the effects of atmospheric deposition to ecosystems and historical structures common to the East. The major sources of sulfur oxide emissions in the Intermountain West were refineries and smelters for metals such as copper, and many of these smelters have closed over the past 20 years. As they have closed, both emissions and atmospheric deposition of sulfur compounds have decreased significantly (Epstein and Oppenheimer 1986). A final important difference between West and East is that the complex topography and localized arid climates of the West combine to create places where most atmospheric deposition occurs as dry particles and aerosols, such as in Southern California and in the deserts of the Southwest.

Emissions and atmospheric deposition of nitrogen oxides and ammonium, however, are increasing rapidly and significantly in the West, creating their own set of environmental concerns (Lynch et al. 1995, Campbell, unpub. data). While we consistently find acid rain, especially in the summer, in Rocky Mountain National Park, it has not yet had a measurable effect on lake chemistry in the Park (NADP/NTN 2000, Baron et al. 2000, Campbell et al. 1995).

The major anthropogenic source of nitrogen oxides is combustion of fuels at high temperatures. Combustion sources include automobiles, trucks, trains, and heavy farm and construction machinery, the utility and industrial sectors, and increasingly, energy development from coal-bed methane, natural gas. Additional nitrogen comes from agricultural emissions, both from fertilized croplands and from large manure piles of confined animal feeding operations. These are regionally important, and in some areas, such as the Colorado Front Range, account for more than 20 percent of the nitrogen emissions (Baron and Mosier, in prep).

### Where are the Regions of Elevated Wet Nitrogen Deposition?

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) provides our best coverage of precipitation chemistry in the United States, and its records began in 1978. As measured at NADP/NTN sites, wet deposition of nitrogen in the West is lower on an annual average than other more industrialized parts of the world, such as Europe and the Northeast United States (NADP/NTN 2000). Nevertheless, there are hotspots of elevated wet nitrogen deposition in Southern California and along the Colorado Front Range when compared with the rest of the West (Fenn et al. 1998). These are regions of high population and agricultural activity, and sufficient precipitation to receive the deposition in rain and snow. Wet deposition measurements in Southern California reflect only 10 percent of the total atmospheric nitrogen deposition (Bytnerowicz et al. 1998). Because of its Mediterranean climate, most deposition occurs as dry deposits in

Southern California, and is not measured by the NADP/NTN network. Wet deposition to the high mountain areas of the Colorado Front Range are perhaps an order of magnitude lower than those from California, but they are high enough to have caused chemical and ecological change, as described below (Baron et al. 2000, Fenn et al. 1998, NADP/NTN 2000). Other parts of the West, such as near Tucson, Phoenix, and Las Vegas, may also have high nitrogen deposition, but it falls as dry deposition due to the arid climate.

### Chemical and Ecological Responses to Elevated Nitrogen Deposition

Nitrogen is an essential fertilizer, and atmospheric nitrogen deposition is a boon to croplands and commercial forests around the world. In natural forests and parks, however, it can affect both plant communities and aquatic environments. Some species are better able to use nitrogen for enhanced growth, allowing them to out-compete their neighbors. This can lead to changes in plant and animal community structure. In many parts of the world with long histories of nitrogen additions, grasses now dominate meadows and fields that once had much greater species diversity (Vitousek et al. 1998). This is well-documented in England and the Netherlands, in experimental plots in the Great Plains, and increasingly, in native coastal sage scrub vegetation of Southern California (Padgett and Allen 1999). Experiments have shown that nitrogen additions have the same effect on alpine tundra (Bowman et al. 1993, 1998, 2000), enhancing grass production at the expense of the wildflowers.

Trees grow and respond to nitrogen additions at a slower pace, and there are few forest species that can out-compete those adapted to harsh western environments. At high elevations of the Rocky Mountains all plants live a hard life, and the cold, short growing season, and limited water help to create a situation called nitrogen saturation, with excess nitrogen flushing into streams and lakes. As nitrogen moves through soils, chemicals essential for forest fertility are stripped into the water, enhancing lake and stream acidification (Driscoll et al. 2001).

Before acidification occurs there will be lake fertilization effects. Many high elevation lakes do not get enough nitrogen for algal growth, so additions from atmospheric deposition cause increased productivity and changes in community composition (Morris and Lewis 1992, Elser et al. 1990). Excess nitrogen deposition influences plant growth and community composition. Leaching of nitrate through watersheds leads to eutrophication of lakes and streams, and ultimately, to acidification.

In summary, the best evidence for effects of nitrogen deposition occur in Southern California and the Colorado Front Range. In Southern California, ozone damage, eutrophication of streams, and loss of soil fungi essential to endangered species are evident. On the Colorado Front Range, terrestrial plant communities and algal lake communities are altered and increased nitrogen cycling is poised to create acidification similar to that in the East.

### Examples of the Effects of Nitrogen Deposition in the West

### *Southern California:*

- Wet plus dry deposition in Southern California is very high, around 35 kilograms per hectare per year (comparable to deposition in northern Europe and the eastern United States, Bytnerowicz et al. 1999). It, combined with high concentrations of ozone in the San Bernardino Mountains, has caused ponderosa pine growth to be severely reduced (Fenn et al. 1998, Grulke et al. 1999, Arbaugh et al. 1999).
- Perennial streams in the San Bernardino Mountains have average concentrations greater than 10 milligrams of nitrate-N per liter. This average concentration is greater than U.S. Environmental Protection Agency drinking water standards (Fenn and Poth 1999).
- The coastal sage scrub is a unique environment with a great number of native species, many of them sensitive or listed as threatened or endangered. Researchers have found a direct relationship between the increase of nitrogen deposition and the loss of soil microorganisms such as fungi and bacteria. These microorganisms are essential to the sage scrub community, in that they enhance nutrient uptake by plants, and help decompose dead material (Edgerton-Warburton and Allen 2000). Without them, native species are weaker and open to invasion by non-native grasses. The non-native annual grasses perpetuate themselves by providing the fuel for frequent fires (Callaway and Davis 1993). Increased fire, perhaps helped along by the nitrogen deposition, poses risk to people and property as well as the native ecosystem.

### *Colorado Front Range:*

- Alpine tundra with added nitrogen shows a shift in plant community composition that favors grasses over flowering plants (Bowman et al. 2000, 1998, and 1993).
- In the harsh high elevation environments of the Rockies, nitrogen deposition has significantly increased rates of forest and soil nitrogen cycling--the first stage of expected effects on the road toward nitrogen saturation (Baron et al. 2000, Rueth and Baron, accepted).
- Alpine lakes in areas with elevated nitrogen deposition have significantly higher nitrate concentrations than lakes in low deposition areas--another indication of expected effects from excess nitrogen deposition (Baron et al. 2000, Baron, 1992).
- Lake algal communities have changed significantly in the past 50 years. These microscopic plants are the base of the lake food chain. Algae in some alpine lakes is more abundant, and now dominated by species representative of pollution. These species have been shown to dominate in lakes all over the world that have been fertilized or otherwise disturbed, and their presence indicates a profound change in their environment. The communities now found in these remote and otherwise undisturbed lakes are different than any other throughout lake history (Baron et al. 2000, Wolfe et al. 2001).

I would like to spend the remainder of my time emphasizing the need to develop better research and monitoring information throughout the West.

## Research and Monitoring Needs

### *Monitoring:*

- There are hundreds of square miles in the West without any wet deposition monitoring, so our knowledge of atmospheric deposition is incomplete. High elevation regions, especially, are under-represented, but this is where the greatest amount of wet deposition occurs.
- Dry deposition monitoring is even more sparse, but dominates deposition through much of the West.
- Long-term monitoring of chemical and biological trends in watersheds is greatly needed. There are only a handful of long-term study areas in the West, operated by the U.S. Geological Survey, the National Science Foundation Long-Term Ecological Research program, USDA Forest Service, and some universities. In a region undergoing rapid change in population and energy development, we are very poorly set up to detect the consequences. Managers of public lands depend greatly on objective scientific reports of the condition of their resources. Long-term monitoring is highly effective at detecting trends, and when coupled with research, give early indications of the causes of change.

### *Research:*

- Our confidence in atmospheric transport models is poor in the West, where the complex topography makes modeling extremely difficult. More effort in this area would yield great benefits in understanding source-receptor relationships.
- The mechanisms of dry deposition are still not well-understood; more research into transport and deposition mechanisms is needed.
- Our understanding of the complex ecological interactions that occur with nitrogen deposition is incomplete. Communities that evolved with low nitrogen availability are changing in novel ways that we do not understand. More research is needed to tell us about possible effects on disturbance regimes such as fire, changes in nutrient cycling and leaching, increased opportunities for invasions and insect outbreaks, and how much nitrogen causes acidification in Western watersheds. Better understanding of ecosystem functions will help managers of public lands, and regulatory agencies make decisions on critical thresholds of ecological change.

Mr. Chairman, this concludes my remarks. I am happy to respond to questions Members of the Committee may have.

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## Congressional Testimony

### **Statement of Dr. P. Patrick Leahy Before the Committee on Energy and Natural Resources, April 3, 2001**

Submitted by [Congressional Liason Office](#)

### **Statement of Dr. P. Patrick Leahy, Associate Director for Geology, U.S. Geological Survey, U. S. Department of the Interior, Before the Committee on Energy and Natural Resources, United States Senate, April 3, 2001**

Mr. Chairman and Members of the Committee, thank you for this opportunity to present, on behalf of the U.S. Geological Survey (USGS), testimony regarding our national assessment of onshore oil and natural gas resources. Additionally, the Committee has requested that we include information recently provided by the Minerals Management Service (MMS) to the Congress concerning estimates of the undiscovered oil and natural gas resources of the Outer Continental Shelf (OCS).

Within the Federal Government, the USGS is responsible for assessing undiscovered oil and gas resources of all onshore and State offshore areas of the Nation. In February 1995, the USGS released the *National Assessment of United States Oil and Gas Resources*. Currently, we are updating that assessment in selected regions thought to have high potential for undiscovered natural gas, including coal-bed methane and gas hydrate. This update will be completed in 2004, with interim products available in early 2002. The updated assessment will include allocations of undiscovered oil and gas resources to Federal lands. Additionally, the USGS is completing a National Coal Resource Assessment during 2001. To date, coal resource assessments of the Colorado Plateau and of the Northern Rocky Mountains and Great Plains have been released, and coal resource assessments of the Appalachian and Illinois Basins, and Gulf Coast Region will be available later in 2001. USGS coal assessments also identify volumes of coal under Federally owned lands, and of Federally owned coal under privately owned lands, where present.

MMS is responsible for developing estimates of Federal offshore crude oil and natural gas

resources. The most recent MMS resource assessment was completed in 2000, and I will discuss some of the highlights of that assessment later in my testimony. I would also like to submit for the record a copy of the testimony MMS presented on its most recent resource assessment before the House Resources Subcommittee on Energy and Mineral Resources on March 22, 2001.

### **USGS 1995 National Assessment of United States Oil and Gas Resources**

The 1995 USGS assessment of the Nation's onshore undiscovered oil and gas was published in digital format on a CD-ROM (USGS Digital Data Series-30) and in a non-technical summary, as USGS Circular 1118. The Assessment was conducted in collaboration with State Geological Surveys, with MMS, and with industry geologists under the auspices of the American Association of Petroleum Geologists. Additional cooperation with the Bureau of Land Management, National Park Service, U.S. Forest Service, and Bureau of Indian Affairs was essential for the USGS to generate information regarding oil and gas resources on Federal lands. The current update of the 1995 assessment is being conducted with many of the same partners.

Assuming existing technology, there are approximately 112 billion barrels of technically recoverable oil onshore and in State waters, according to the USGS's most recent assessment. Technically recoverable resources are those that may be recoverable using current technology without regard to cost. Economically recoverable resources are that part of the technically recoverable resource for which economic factors are included and which can be recovered at a given market price. This includes measured (proved) reserves, future additions to reserves in existing fields (reserve growth), and undiscovered resources. The technically recoverable conventional resources of natural gas in measured reserves, future additions to reserves in existing fields, and undiscovered accumulations equal approximately 716 trillion cubic feet of gas.

In addition to conventional gas resources, the USGS has made an assessment of technically recoverable resources in continuous-type (largely unconventional) accumulations. We estimate about 308 TCFG (trillion cubic feet of gas) of technically recoverable natural gas in continuous-type deposits in sandstones, shales, and chinks, and almost 50 TCFG of technically recoverable gas in coal beds. The total technically recoverable oil and gas resource base onshore and in State waters of the United States is displayed in the table below.

### **Results of the USGS 1995 National Oil and Gas Assessment**

Below is a table of the results of the USGS 1995 assessment:

<b>Resource Category</b>	<b>---- OIL ----</b>	<b>---- GAS ----</b>	<b>-- Natural Gas</b>
	<b>(billion barrels)</b>	<b>(trillion cu. ft.)</b>	<b>Liquids --</b>
	<b>1995</b>	<b>1995</b>	<b>(billion barrels)</b>
Undiscovered resources			1995

Conventional Accumulations	30	259	7
Unconventional Accumulations			
Sedimentary reservoirs	2	308	2
Coal-bed methane	NA	50	NA
<b>Anticipated Reserve Growth</b>	60	322	13
TOTAL	92	939	22
<b>Proved Reserves (in 1994)</b>	20	135	7
TOTAL	112	1,074	29

The estimates presented in this testimony reflect USGS understanding as of January 1, 1994. They are intended to capture the range of uncertainty, to provide indicators of the relative potential of various petroleum provinces, and to provide a useful guide in considering possible effects of future oil- and gas-related activities within the United States.

The geographic information system (GIS) coverages contained in this assessment and related databases provide the capability to estimate oil and gas resource potential on specific tracts of land, including those owned and/or managed by the Federal Government. This process is called allocation, based on expert opinion, and is accomplished using a methodology that takes into consideration all geologic information available about the basin.

### **1995 National Oil and Gas Assessment and Onshore Federal Lands (1998)**

In January 1998, the USGS published an Open-File Report (OFR 95-0075-N) that reported estimates of volumes of undiscovered oil and gas on Federal lands. Estimates of oil in undiscovered conventional fields range from 4.4 to 12.8 billion barrels (BBO), with a mean value of 7.5 BBO. Estimates of technically recoverable gas in undiscovered conventional fields range from 34.0 to 96.8 trillion cubic feet (TCF), with a mean value of 57.9 TCF. Almost 85 percent of the assessed natural gas in undiscovered conventional accumulations was non-associated gas, that is, gas in gas fields rather than gas in oil fields. Estimates of technically recoverable resources in conventional (continuous type) accumulations for oil are from 0.2 to 0.6 BBO, with a mean value of 0.3 BBO, and for gas, from 72.3 to 202.4 TCF, with a mean value of 127.1 TCF. These ranges of estimates correspond to 95 percent probability (19 in 20 chance) and 5 percent probability (1 in 20 chance) respectively, of at least those amounts occurring.

An economic evaluation was applied to these technically recoverable estimates. Our study concluded that at \$30 per barrel for oil and \$3.34 per thousand cubic feet of gas, 3.3 BBO oil and 13.6 TCF in undiscovered conventional fields can be found, developed, and produced. In addition, at these estimated prices, 0.2 BBO oil and 11.4 TCF in continuous-type accumulations and 11.8 TCF of coalbed gas can be developed.

Estimated volumes of undiscovered oil, gas, and natural gas liquids in onshore Federal lands, as of January 1994 are displayed in the table below.

	Technically Recoverable			<u>Economically Recoverable*</u>	
	F95	Mean	F05	\$18/bbl \$2/mcf	\$30/bbl \$3.34/mcf
Conventional					
Oil ( <u>BBO</u> )**	4.4	7.5	12.8	1.6	3.3
Gas ( <u>TCF</u> )	34.0	57.9	96.8	9.7	13.6
NGL ( <u>BBL</u> )	1.1	1.8	2.7	0.7	0.9
Unconventional					
Oil ( <u>BBO</u> )	0.2	0.3	0.6	0.1	0.1
Gas ( <u>TCF</u> )	72.4	127.1	202.4	6.1	11.4
NGL ( <u>BBL</u> )	0.1	1.5	2.6	0.0	0.1
Coalbed methane ( <u>TCF</u> )	13.0	16.1	19.6	7.0	11.8

\* Includes cost of finding, developing, and producing the resource. Based on mean values of technically recoverable estimate.

\*\* BBO = billion barrels oil; TCF = trillion cubic feet; BBL = billion barrels liquid; mcf = thousand cubic feet.

### **Applications of the USGS 1995 National Oil and Gas Resource Assessment**

The results of the USGS National Oil and Gas Resource Assessment have been used by the Energy Information Administration for its Annual Energy Outlook, by the California Energy Commission and Canadian Energy Board to model inter-regional natural gas supply and demand and the resulting economic impacts, and by numerous petroleum companies as a basis for evaluating risk associated with exploration and development of domestic oil and gas resources.

Many Federal agencies use the information in the USGS National Oil and Gas Assessment for land-use planning, energy policy formulation, and economic forecasting. Customers include the Department of the Interior, Bureau of Land Management, National Park Service, U.S. Forest Service, Bureau of Indian Affairs, Energy Information Administration, and the Department of Energy, among others. In addition, most State Geological Surveys and/or State Divisions of Oil and Gas use the USGS assessment for regional and local resource evaluation and lease planning purposes. Many private sector organizations also use the digital oil and gas assessment results, including environmental protection advocacy groups, petroleum exploration companies, and utility companies (including

natural gas and electricity utilities).

## **Sec. 604 Energy Act of 2000**

The Secretary of the Interior is charged with conducting an inventory of energy resources and the restrictions and impediments to their development on Federal Lands in Section 604 of the Energy Act of 2000, signed into law on November 9, 2000. The exact text is given below:

### **SEC. 604. SCIENTIFIC INVENTORY OF OIL AND GAS RESERVES.**

**IN GENERAL.**--The Secretary of the Interior, in consultation with the Secretaries of Agriculture and Energy, shall conduct an inventory of all onshore Federal lands. The inventory shall identify--

(1) the United States Geological Survey reserve estimates of the oil and gas resources underlying these lands; and

(2) the extent and nature of any restrictions or impediments to the development of such resources.

(b) **REGULAR UPDATE.**--Once completed the USGS reserve estimates and the surface availability data as provided in subsection (a)(2) shall be regularly updated and made publicly available.

(c) **INVENTORY.**--The inventory shall be provided to the Committee on Resources of the House of Representatives and to the Committee on Energy and Natural Resources of the Senate within 2 years after the date of the enactment of this section.

(d) **AUTHORIZATION OF APPROPRIATIONS.**--There are authorized to be appropriated such sums as may be necessary to implement this section.

It is our understanding that the role of the USGS will be to assess the oil and gas resources of oil and gas-bearing basins with Federal land ownership, consistent with the USGS assessment and allocation methodology. Then, USGS geologists will allocate resource estimates to those specific land parcels owned by the Federal government. The USGS resource estimates will be combined with reserve volumes from the DOE/EIA, and will be incorporated into a geographic information system (GIS) that shows the spatial distribution of those potential resources and known reserves. The resource and reserve GIS will be integrated with a GIS of restrictions and impediments constructed by BLM and USFS. The USGS has met several times with representatives of the Bureau of Land Management (BLM), the US Forest Service, the US Department of Energy and their Energy Information Administration and the staff of this committee to discuss plans to produce this inventory.

The USGS intends to use some of the resource estimates from the 1995 National Oil and Gas Assessment, for which there are not significant new data, and will update resource estimates for the gas-prone areas of the country for which we have new data and are developing improved assessment methods.

### **The Minerals Management Service's 2000 OCS Resource Assessment**

As background, MMS's mission consists of two major programs: Offshore Minerals Management and Minerals Revenue Management. The leasing and oversight of mineral operations on the Outer Continental Shelf (OCS) and all mineral revenue management functions for Federal (onshore and offshore) and American Indian lands are centralized within the bureau. In 2000, OCS oil and natural gas production accounted for roughly 25 and 26 percent, respectively, of our nation's domestic energy production -- oil production was over 500 million barrels and natural gas production was over 5 trillion cubic feet. The amount of oil and natural gas production in 2000 was the most ever produced on the OCS. In addition, in fiscal year 2000, MMS collected and distributed about \$7.8 billion in mineral leasing revenues from Federal and American Indian lands.

In its role as manager of the Nation's OCS energy and non-energy mineral resources, MMS is responsible for assessing those resources; determining if they can be developed in an environmentally sound manner; and if leased, regulating activities to ensure safety and environmental protection. An integral element in that mission is to identify the most promising areas of the OCS for the occurrence of crude oil and natural gas accumulations and to quantify the amounts of oil and natural gas that may exist in these areas.

Since its creation in 1982, MMS has completed four systematic assessments of Federal OCS undiscovered oil and natural gas resources, including its most recent assessment. The 2000 resource assessment was done to support staff work and analysis needed in formulating the next 5-Year Oil and Gas Leasing Program covering the timeframe 2002-2007. It should be noted that the methodology for the 2000 assessment has not changed significantly from that used in the previous 1995 assessment.

The 2000 assessment presents the updated assessment results since the 1995 assessment for the Alaska, Atlantic, and Gulf of Mexico OCS Regions. In the Alaska Region only the Beaufort and Chukchi Seas, Hope Basin, and Cook Inlet areas were updated, as other planning areas lacked new data and changes since the last assessment. The Pacific OCS Region was not updated for the same reasons. The Atlantic OCS Region was re-evaluated to reflect recent exploration results offshore Nova Scotia, current exploration and production technologies, and to make the water depth divisions compatible with the ones now being used in the Gulf of Mexico.

The MMS has recently made public the 2000 assessment, and I have included a copy of the assessment with my written testimony for the hearing record. MMS estimates that the total mean undiscovered, conventionally recoverable resources for the United States OCS are 75.0 billion barrels of oil and 362.2 trillion cubic feet of natural gas. Within that total, MMS determined that the undiscovered conventionally recoverable resources foregone by

the 1998 moratoria (i.e., the President's June 1998 OCS decision) would be approximately 16 billion barrels of oil and 62 trillion cubic feet of gas.

The total mean undiscovered economically recoverable resources for the United States OCS are 26.6 billion barrels of oil and 116.8 trillion cubic feet of gas at prices of \$18 per barrel and \$2.11 per thousand cubic feet, respectively, and 46.7 billion barrels of oil and 168.1 trillion cubic feet of gas at prices of \$30 barrel and \$3.52 per thousand cubic feet, respectively.

Mr. Chairman, this concludes my remarks. However, I would be happy to respond to any questions Members of the Committee may have.

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## Congressional Testimony

### **Statement of Robert M. Hirsch Before the Subcommittee on Water and Power, March 27, 2001**

Submitted by [Congressional Liason Office](#)

**Statement of Robert M. Hirsch, Associate Director for Water, U.S. Geological Survey, Department of the Interior, Before the Subcommittee on Water and Power, House Committee on Resources, United States House of Representatives, March 27, 2001**

Good afternoon, Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to report on the status of water conditions in the Western United States as monitored by the U.S. Geological Survey (USGS). Because this is the first appearance of the USGS before this Subcommittee in the new Congress and before you as Chairman, allow me to start with a few preliminary thoughts about the role of the USGS.

The USGS is a science agency within the Department of the Interior with a history of 122 years of providing scientific information needed for the wise management of our Nation's natural resources. The study of water goes back to our very early years and the work of our second Director John Wesley Powell who focused much attention on the availability of water resources for the economic development of the West. The USGS of today consists of four major program areas: Geology, Mapping, Biology, and Water. The USGS strives to combine these four disciplinary areas to provide a more complete data and analysis of the resource and environmental issues that our Nation faces today.

The USGS water resources program provides reliable, impartial, timely information that is needed to understand the Nation's water resources.

It is crucial to note that the USGS provides unbiased science to resource and regulatory decision makers. We work closely with local, State, tribal, and Federal agencies, and the private sector to provide them with the information they need to make informed decisions.

Of particular interest to the Committee may be our Cooperative Water Program, through which we partner with over 1300 non-Federal agencies to carry out data collection and hydrologic studies.

For over a century the USGS has played the key role in monitoring the flow of our Nation's rivers. We operate about 7000 streamgages, which monitor the flow of water in our Nation's rivers and streams, and we freely provide the current and historical data to a wide range of users. This information is used for purposes that include: water supply planning, flood risk assessment, water quality management (including calculation of Total Maximum Daily Loads), water supply operations, streamflow forecasting (done primarily by the National Weather Service and the Natural Resources Conservation Service), habitat assessments, and personal planning of river-based recreational activities. Currently, we are in a process of modernizing this network. At the present time, about 5000 of these stations have satellite telemetry that enables us to provide near-real-time data to all users via the Internet.

Using these data, and information from other agencies, I will describe the current Western surface-water situation, variations and changes that have occurred in recent weeks and also place this in a national context. To do this I will rely on an illustration that we create daily and place on the USGS website. It is based on conditions for the preceding week at all USGS streamgaging stations that have 30 or more years of record and have telemetry systems. Each dot on the map represents an individual gage. They are color coded with red indicating that flows for the week were the lowest ever recorded for that time of year, brown indicating that flow was below the 10th percentile, orange was between the 10th and 25th percentile, green indicates "normal" (25th to 75th percentile), light blue is 75th to 90th percentile, dark blue is above the 90th percentile, and black represents record high flows for this time of year.

Figure 1. AVERAGE STREAMFLOW FOR THE WEEK ENDING MARCH 18

Figure 1 - Average streamflow for the week ending March 18.

Hydrologically, conditions in the West are quite varied at the present time. The Southwest is having relatively normal conditions, a pattern that we have been observing since last November. Most of the Great Plains, from the Dakotas to Texas are experiencing normal to above-normal streamflows; also a persistent pattern during recent months. In eastern Texas, a number of rivers and streams have recorded new daily high flows during the past month, while flood flows have been observed at many others.

In contrast, the Pacific Northwest is experiencing below-normal streamflows in response to winter season precipitation that has averaged only 25 to 75 percent of normal. Currently, 75 percent of USGS real-time streamgages in this region are reporting below-normal flows.

The most serious low flow conditions are occurring in Washington and Oregon. Notably, below normal streamflows were recorded at 90 percent of our real-time stations in Oregon last week and at 75 percent of the gages in Washington. The snowpack in river basins in these States is generally less than 60 percent of average. There are also significant deficiencies in reservoir storage. Statewide, the useable contents of reservoirs in Washington are about 50 percent of average, while those in Oregon are only slightly better at 75 percent of average. The low seasonal precipitation and the currently low reservoir storage have resulted in spring and summer streamflow forecasts of less than 70 percent of average for most areas in Washington and Oregon. The outlook for Idaho is even worse, with nearly the entire State forecast to have spring and summer flows of less than 70 percent of average.

Nearby States, such as Montana and Wyoming are also experiencing reduced streamflows, snowpack, and soil moisture, although the dryness is less severe than in the Pacific Northwest. Indeed, although the useable contents of reservoirs in Montana are about 60 percent of average, those in Wyoming are actually above average. Still, more than 60

percent of the real-time streamgages in both States are reporting below-normal flows. Northern California, particularly the Northern Sierra Nevada, had relatively dry conditions and low streamflows earlier in the winter, but has recovered considerably during the past month. Currently, reservoir contents are about normal statewide, as are daily and weekly average streamflows.

It is worth noting that, unlike the current situation in Florida and western North Carolina where drought has persisted for more than two years and enormous moisture deficits of more than two feet have accrued, the dryness in the Northwest is only four months old. Admittedly, it came at the worst possible time of year since the region depends upon winter season precipitation and snowpack to meet the spring and summer water demand. Even so, the current situation would have been much worse had there not been normal to above-normal hydroclimatic conditions during the preceding 18 months.

The streamgaging network, that measures the "pulse" of the Nation's rivers (and enables us to produce a "snapshot" of conditions such as I have used here), is a high priority for the USGS. We have worked closely with the Congress over the last 3 years to explore the issues relating to the modernization and stability of the network.

I should also briefly mention the importance of ground water as an indicator of drought and as an important aspect of the mechanisms available to communities, agriculture, and industry as insurance against drought. While our ground-water level monitoring networks have not been modernized to a level where we can provide the same kind of synoptic view of ground-water conditions as we presented for surface water, we anticipate improvements in the next few years. We believe that the science of ground-water hydrology is crucial to water management in the West and nationwide. Conjunctive use of surface and ground water has great potential for making water supplies more drought resistant. Ground water is crucial to sustaining streamflow for habitat and for water supply. More and more we find that our partners are interested in the role that ground water plays in maintaining adequate flow and temperature conditions in rivers.

We also find that emerging technologies such as artificial recharge, aquifer storage and recovery, and recharge of reclaimed wastewater are pivotal parts of the water management equation. The science to support the use of these new technologies is a part of our strategic plan for the future of USGS ground-water science.

I thank the Subcommittee for this opportunity to testify and I look forward to answering your questions today and working with you over the coming months and years.

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## Congressional Testimony

### Statement of Dr. P. Patrick Leahy Before the Subcommittee on Energy and Minerals, March 22, 2001

Submitted by [Congressional Liason Office](#)

**Statement of Dr. P. Patrick Leahy, Associate Director for Geology, U.S. Geological Survey, U. S. Department of the Interior, Before the Subcommittee on Energy and Minerals, Committee on Resources, United States House of Representatives, March 22, 2001**

Madame Chairman and members of the subcommittee, thank you for this opportunity to present, on behalf of the U.S. Geological Survey (USGS), testimony regarding our assessment of oil and gas resources nationally, in the 1002 Area of the Arctic National Wildlife Refuge, and of Federal lands as called for in the recently enacted Energy Act of 2000. My testimony will address these subjects in this order.

Within the Federal Government, the USGS is responsible for assessing undiscovered oil and gas resources of all onshore and State offshore areas of the Nation. The Minerals Management Service (MMS) provides estimates for Federal offshore crude oil and natural gas resources. In February 1995, the USGS released the *National Assessment of United States Oil and Gas Resources*. Currently, we are updating that assessment in selected regions thought to have high potential for undiscovered natural gas, including coal-bed methane and gas hydrate. This update will be completed in 2004, with interim products available in early 2002. The updated assessment will include allocations of undiscovered oil and gas resources to Federal lands. Additionally, the USGS is completing a National Coal Resource Assessment during 2001. To date, coal resource assessments of the Colorado Plateau and of the Northern Rocky Mountains and Great Plains have been released, and coal resource assessments of the Appalachian and Illinois Basins, and Gulf Coast Region will be available later in 2001. USGS coal assessments also identify volumes of coal under Federally owned lands, and of Federally owned coal under privately owned lands, where present.

## 1995 National Assessment of United States Oil and Gas Resources

The 1995 USGS assessment of the Nation's undiscovered oil and gas was published in digital format on a CD-ROM (USGS Digital Data Series-30) and in a non-technical summary, as USGS Circular 1118. The Assessment was conducted in collaboration with State Geological Surveys, with MMS, and with industry geologists under the auspices of the American Association of Petroleum Geologists. Additional cooperation with the Bureau of Land Management, National Park Service, U.S. Forest Service, and Bureau of Indian Affairs was essential for the USGS to generate information regarding oil and gas resources on Federal lands. The current update of the 1995 assessment is being conducted with many of the same partners.

Assuming existing technology, there are approximately 112 billion barrels of technically recoverable oil onshore and in State waters, according to the USGS's most recent assessment. Technically recoverable resources are those that may be recoverable using current technology without regard to cost. Economically recoverable resources are that part of the technically recoverable resource for which economic factors are included and which can be recovered at a given market price. This includes measured (proved) reserves, future additions to reserves in existing fields (reserve growth), and undiscovered resources. The technically recoverable conventional resources of natural gas in measured reserves, future additions to reserves in existing fields, and undiscovered accumulations equal approximately 716 trillion cubic feet of gas.

In addition to conventional gas resources, the USGS has made an assessment of technically recoverable resources in continuous-type (largely unconventional) accumulations. We estimate about 308 TCFG (trillion cubic feet of gas) of technically recoverable natural gas in continuous-type deposits in sandstones, shales, and chalks, and almost 50 TCFG of technically recoverable gas in coal beds. The total technically recoverable oil and gas resource base onshore and in State waters of the United States is displayed in the table below.

### Results of the USGS 1995 National Oil and Gas Assessment

Below is a table of the results of the USGS 1995 assessment:

Resource Category	---- OIL ----	---- GAS ----	-- Natural Gas
	(billion barrels)	(trillion cu. ft.)	Liquids -- (billion barrels)
	1995	1995	1995
Undiscovered resources			
Conventional Accumulations	30	259	7
Unconventional Accumulations			
Sedimentary reservoirs	2	308	2
Coal-bed methane	NA	50	NA

<b>Anticipated Reserve Growth</b>	60	322	13
TOTAL	92	939	22
<b>Proved Reserves (in 1994)</b>	20	135	7
TOTAL	112	1,074	29

The estimates presented in this testimony reflect USGS understanding as of January 1, 1994, and are shown on a map of the United States in Figure 1. They are intended to capture the range of uncertainty, to provide indicators of the relative potential of various petroleum provinces, and to provide a useful guide in considering possible effects of future oil- and gas-related activities within the United States.

The geographic information system (GIS) coverages contained in this assessment and related databases provide the capability to estimate oil and gas resource potential on specific tracts of land, including those owned and/or managed by the Federal Government. This process is called allocation, based on expert opinion, and is accomplished using a methodology that takes into consideration all geologic information available about the basin.

### **1995 National Oil and Gas Assessment and Onshore Federal Lands (1998)**

In January 1998, the USGS published an Open-File Report (OFR 95-0075-N) that reported estimates of volumes of undiscovered oil and gas on Federal lands. Estimates of oil in undiscovered conventional fields range from 4.4 to 12.8 billion barrels (BBO), with a mean value of 7.5 BBO. Estimates of technically recoverable gas in undiscovered conventional fields range from 34.0 to 96.8 trillion cubic feet (TCF), with a mean value of 57.9 TCF. Almost 85 percent of the assessed natural gas in undiscovered conventional accumulations was non-associated gas, that is, gas in gas fields rather than gas in oil fields. Estimates of technically recoverable resources in conventional (continuous type) accumulations for oil are from 0.2 to 0.6 BBO, with a mean value of 0.3 BBO, and for gas, from 72.3 to 202.4 TCF, with a mean value of 127.1 TCF. These ranges of estimates correspond to 95 percent probability (19 in 20 chance) and 5 percent probability (1 in 20 chance) respectively, of at least those amounts occurring.

An economic evaluation was applied to these technically recoverable estimates. Our study concluded that at \$30 per barrel for oil and \$3.34 per thousand cubic feet of gas, 3.3 BBO oil and 13.6 TCF in undiscovered conventional fields can be found, developed, and produced. In addition, at these estimated prices, 0.2 BBO oil and 11.4 TCF in continuous-type accumulations and 11.8 TCF of coalbed gas can be developed.

Estimated volumes of undiscovered oil, gas, and natural gas liquids in onshore Federal lands, as of January 1994 are displayed in the table below.

**Technically Recoverable**    **Economically Recoverable\***



	F95	Mean	F05	\$18/bbl \$2/mcf	\$30/bbl \$3.34/mcf
Conventional					
Oil ( <u>BBO</u> )**	4.4	7.5	12.8	1.6	3.3
Gas ( <u>TCF</u> )	34.0	57.9	96.8	9.7	13.6
NGL ( <u>BBL</u> )	1.1	1.8	2.7	0.7	0.9
Unconventional					
Oil ( <u>BBO</u> )	0.2	0.3	0.6	0.1	0.1
Gas ( <u>TCF</u> )	72.4	127.1	202.4	6.1	11.4
NGL ( <u>BBL</u> )	0.1	1.5	2.6	0.0	0.1
Coalbed methane ( <u>TCF</u> )	13.0	16.1	19.6	7.0	11.8

\* Includes cost of finding, developing, and producing the resource. Based on mean values of technically recoverable estimate.

\*\* BBO = billion barrels oil; TCF = trillion cubic feet; BBL = billion barrels liquid; mcf = thousand cubic feet.

### **Applications of the USGS 1995 National Oil and Gas Resource Assessment**

The results of the USGS National Oil and Gas Resource Assessment have been used by the Energy Information Administration for its Annual Energy Outlook, by the California Energy Commission and Canadian Energy Board to model inter-regional natural gas supply and demand and the resulting economic impacts, and by numerous petroleum companies as a basis for evaluating risk associated with exploration and development of domestic oil and gas resources.

Many Federal agencies use the information in the USGS National Oil and Gas Assessment for land-use planning, energy policy formulation, and economic forecasting. Customers include the Department of the Interior, Bureau of Land Management, National Park Service, U.S. Forest Service, Bureau of Indian Affairs, Energy Information Administration, and the Department of Energy, among others. In addition, most State Geological Surveys and/or State Divisions of Oil and Gas use the USGS assessment for regional and local resource evaluation and lease planning purposes. Many private sector organizations also use the digital oil and gas assessment results, including environmental protection advocacy groups, petroleum exploration companies, and utility companies (including natural gas and electricity utilities).

## **USGS Resource Assessment of the 1002 Area of the Arctic National Wildlife Refuge**

The Alaska National Interest Lands Conservation Act established the Arctic National Wildlife Refuge (ANWR) as a wildlife refuge in 1980. In section 1002 of that Act, Congress deferred a decision regarding future management of the 1.5-million-acre coastal plain ("1002 Area") in recognition of the area's potential for oil and gas resources and its importance as wildlife habitat. A report on the resources (including petroleum) of the 1002 Area was submitted in 1987 to Congress by the Department of the Interior (DOI). Since completion of that report, numerous wells have been drilled and oil fields discovered near ANWR on State lands, new geologic and geophysical data have become available, seismic processing and interpretation capabilities have improved, and the economics of North Slope oil development have evolved.

Anticipating the need for scientific information and considering the decade-old perspective of the petroleum resource estimates included in the 1987 Report to Congress, the USGS reexamined the geology of the ANWR 1002 Area and prepared a new petroleum resource assessment that was released in 1998.

Based on this 1998 USGS assessment, the total quantity of technically recoverable oil within the entire assessment area is estimated to be between 5.7 and 16.0 billion barrels (95-percent and 5-percent probability range), with a mean value of 10.4 billion barrels. The entire assessment area includes Federal, State, and Native areas. Technically recoverable oil within the ANWR 1002 Area (excluding State and Native areas) is estimated to be between 4.3 and 11.8 billion barrels (95- and 5-percent probability range), with a mean value of 7.7 billion barrels. These estimates reflect new data and techniques and thus should not be directly compared to results of the 1995 National Oil and Gas Resource Assessment.

According to the 1998 USGS assessment, volumes of oil are expected to occur in a number of accumulations rather than a single large accumulation, such as the giant Prudhoe Bay field. However, most of that oil is estimated to occur in accumulations that are sufficiently large to be of potential economic interest. At the mean, nearly 80 percent of the oil is thought to occur in the western part of the 1002 Area, which is closest to existing infrastructure developed on State lands. We estimate that the western portion of the 1002 Area contains between 3.4 and 10.2 billion barrels of oil (BBO) (95- and 5-percent probability), with a mean of 6.4 BBO. We estimate that the eastern area contains between 0 and 3.2 BBO (95- and 5-percent probability), with a mean of 1.2 BBO.

As part of our 1998 assessment, the USGS conducted an economic analysis that considers the cost of producing estimated technically recoverable volumes of oil from the 1002 Area. Our study estimates the market price that would have to be paid to find, develop, produce, and transport a specific volume of oil to the West Coast of the United States. Figure 2 summarizes estimated volumes of economically recoverable oil as a function of the market price of that oil. This graph assumes constant 1996 dollars and the expectation that production will repay all operating costs, including taxes and transport to market, all

investment expenditures, and provide an after-tax rate of return of at least 12 percent on the investment.

## **Comparison with Previous Assessments**

Among previous assessments of ANWR 1002 Area petroleum resources, only the 1987 USGS assessment of in-place resources is directly comparable to our 1998 assessment. The technically and economically recoverable petroleum resource estimates cannot be compared directly because different methods were used in preparing those parts of the 1987 Report to Congress. The current assessment shows an overall increase in estimated in-place oil resource when compared to the 1987 assessment. Ranges are 11.6 to 31.5 BBO versus 4.8 to 29.4 BBO, (95- and 5-percent probabilities) and mean values are 20.7 BBO versus 13.8 BBO (current assessment compared to 1987 assessment). The increase is a consequence of improved resolution of reprocessed seismic data, which allowed the identification of many more potential petroleum accumulations in parts of the area, as well as information available regarding recent nearby oil discoveries.

Another significant change is in the geographic distribution of resources. In the 1987 assessment, about 75 percent of the mean estimated in-place oil was thought to occur in the southeastern section of the 1002 Area and only 25 percent was thought to occur in the northwestern area. In the current assessment, nearly 85 percent of the in-place oil is thought to occur in the northwestern area and only about 15 percent is within the deformed area. The reason for this change in interpretation is largely related to improved resolution of the seismic data, especially in the northwestern area where, in various plays, it allowed the identification of many more potential petroleum accumulations than were previously thought to exist. The southeastern area--with only a single well offshore and complex geology onshore--carries great uncertainty. Further, part of that area considered oil prospective in 1987 is now considered prospective only for gas because of new understanding of the thermal history of the rocks.

## **Sec. 604 Energy Act of 2000**

The Secretary of the Interior is charged with conducting an inventory of energy resources and the restrictions and impediments to their development on Federal Lands in Section 604 of the Energy Act of 2000, signed into law on November 9, 2000. The exact text is given below:

### **SEC. 604. SCIENTIFIC INVENTORY OF OIL AND GAS RESERVES.**

**IN GENERAL.**--The Secretary of the Interior, in consultation with the Secretaries of Agriculture and Energy, shall conduct an inventory of all onshore Federal lands. The inventory shall identify--

(1) the United States Geological Survey reserve estimates of the oil and gas resources underlying these lands; and

(2) the extent and nature of any restrictions or impediments to the development of such resources.

(b) REGULAR UPDATE.--Once completed the USGS reserve estimates and the surface availability data as provided in subsection (a)(2) shall be regularly updated and made publicly available.

(c) INVENTORY.--The inventory shall be provided to the Committee on Resources of the House of Representatives and to the Committee on Energy and Natural Resources of the Senate within 2 years after the date of the enactment of this section.

(d) AUTHORIZATION OF APPROPRIATIONS.--There are authorized to be appropriated such sums as may be necessary to implement this section.

It is our understanding that the role of the USGS will be to assess the oil and gas resources of oil and gas-bearing basins with Federal land ownership, consistent with the USGS assessment and allocation methodology. Then, USGS geologists will allocate resource estimates to those specific land parcels owned by the Federal government. The USGS resource estimates will be combined with reserve volumes from the DOE/EIA, and will be incorporated into a geographic information system (GIS) that shows the spatial distribution of those potential resources and known reserves. The resource and reserve GIS will be integrated with a GIS of restrictions and impediments constructed by BLM and USFS. The USGS has met several times with representatives of the Bureau of Land Management (BLM), the US Forest Service, the US Department of Energy and their Energy Information Administration and the staff of this committee to discuss plans to produce this inventory.

The USGS intends to use some of the resource estimates from the 1995 National Oil and Gas Assessment, for which there are not significant new data, and will update resource estimates for the gas-prone areas of the country for which we have new data and are developing improved assessment methods.

Madame Chairman, this concludes my remarks. I would be happy to respond to any questions.

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## Congressional Testimony

### **Statement of John R. Filson Before the Subcommittee on Research, House Committee on Science, March 21, 2001**

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Submitted by [Congressional Liason Office](#)

### **Statement of John R. Filson, Coordinator, Earthquake Hazards Program, U.S. Geological Survey, Department of the Interior Before the Subcommittee on Research, House Committee on Science, United States House of Representatives, March 21, 2001**

#### **1. Introduction**

Mr. Chairman and distinguished members of the Subcommittee, thank you for this opportunity to present testimony on behalf of the U.S. Geological Survey (USGS) regarding the recent earthquake near Olympia, Washington.

The USGS Earthquake Hazards Program is the applied Earth sciences element of the National Earthquake Hazards Reduction Program (NEHRP), led by the Federal Emergency Management Agency (FEMA). We carry out three roles: (1) earthquake monitoring and notification through the support national and regional networks of seismic instruments, (2) earthquake hazards assessments at the national and regional scales, and (3) research on earthquake processes, theory, and effects.

We have been working in the Pacific Northwest for over 20 years. With our partners at the University of Washington and elsewhere, we have made significant strides in our understanding of earthquake causes and earthquake hazards in the region. We have promoted, supported, and implemented improvements in earthquake monitoring and notification. And most important of all, we have worked tirelessly with government agencies at all levels and with private and industrial interests to educate anyone who would listen on the nature of the earthquake threat and to advise them on how to prepare to meet that threat.

The recent earthquake is referred to as the Nisqually earthquake, due to the location of the epicenter near the mouth of the Nisqually River. My testimony will focus on the geological cause of this earthquake, its seismological and geological effects, the lessons the USGS has learned and expects to learn from it, and our continuing work on addressing earthquake hazards in the Pacific Northwest. Every earthquake that causes damage in an urban area provides the USGS and others with opportunities to evaluate our past assessments of the earthquake hazard, to test the effectiveness of earthquake preparedness measures, and to strengthen and adapt these measures to lessen the impact of future events.

We welcome advice and direction from this Subcommittee as we address these opportunities.

#### **2. What Causes Earthquakes in the Pacific Northwest?**

**Tectonic Setting.** The term "tectonics" describes the broad, active geology of a region. Most of the tectonic activity of the Earth is related to the movement of large sections of the Earth's crust, called plates. There are a dozen or so plates that drift slowly with respect to each other and to the deeper mantle of the Earth. The rate of drift varies but can be a few inches per year. Most of the Earth's volcano and earthquake activity can be tied to sub-ocean ridges where plates form, or to continental masses and margins where plates collide or grind past each other. The size of these tectonic plates can vary widely. The North American plate stretches some 5,000 miles from the mid-Atlantic ridge to the San Andreas fault in California, whereas the Juan de Fuca plate is bounded by our Pacific Northwest coastline and an ocean ridge less than 500 miles offshore. The Juan de Fuca plate is being pushed away from the sub-ocean ridge of the same name toward the coast at a rate of about 1.5 inches per year.

The tectonic setting of the Pacific Northwest is complex due to the convergence of the Juan de Fuca plate and the North American plate, as shown in Figure 1. In this plate convergence, the Juan de Fuca plate, as it drifts to the northeast, is being overridden by the North American plate. This plate convergence is commonly called the Cascadia subduction zone. The boundary or contact between the two plates is the Cascadia subduction zone fault. As the Juan de Fuca plate is overridden, it slowly sinks into the Earth's mantle.



Figure 1 - Tectonic setting of the Pacific Northwest.

Figure 1  
Tectonic setting of the Pacific Northwest

Although the buildup of strain along the Cascadia subduction zone fault and internally within the two plates is a continuous process, the release of this strain is not. The rock near the plate boundary and within the plates is slowly bent over years and centuries, until the accumulated strain is suddenly released in earthquakes as the rock breaks or fails.

**Types of Earthquakes.** This process of strain buildup and release gives rise to three types of earthquakes in the region:

- Type 1. Very large earthquakes that occur on the Cascadia subduction zone fault, the contact between the two plates,
- Type 2. Deep earthquakes, such as the Nisqually earthquake, occur internally within the Juan de Fuca plate as it bends and deforms while sinking into the mantle, and

- Type 3. Shallow earthquakes that occur in the North American plate, as it is internally deformed due to strain caused by overriding the Juan de Fuca plate in the convergence process.

Very large Type 1 earthquakes are the most infrequent and largest that can affect the region. This is the same kind of earthquake that struck Alaska in 1964, when the shallow fault boundary between the Pacific and North American plates "broke" for some 500 miles, releasing a tremendous buildup of strain energy and causing an earthquake of magnitude 9.2. Seismologists estimate that the Cascadia subduction zone could rupture over a distance of 360 miles, causing an earthquake of magnitude 9.0. Although, in such an event, the rupture at the Earth's surface would be offshore; it would have widespread impact throughout western Oregon and Washington. Such a large-scale earthquake could also generate a devastating tsunami. The last earthquake of Type 1 occurred in 1700, based on evidence of shoreline deformation in western Washington and historical records from Japan of a large tsunami hitting Hokkaido.

Type 2 earthquakes occur 30-40 miles deep and are caused by deformation and rock changes within the Juan de Fuca plate as it sinks, or subsides, under the continent. The recent Nisqually earthquake was of this type. These earthquakes are more frequent than Type 1 events. A previous earthquake of the same type occurred in 1949 with a magnitude of 7.1. Because these earthquakes occur at depth, the strong shaking at the source of the earthquake is weakened somewhat before it reaches the surface, which results in diminished impact compared to an earthquake of similar size at shallow depth.

Type 3 earthquakes occur along shallow faults distributed in the crust throughout the Pacific Northwest region west of the Cascade Mountains. These earthquakes can reach the magnitude 7.5 range; however, earthquakes of this type at that size are infrequent. Nevertheless, these can be the most dangerous earthquakes in the region because they can occur at shallow depths near urban centers where the strong shaking can have an immediate impact on concentrations of population and development.

**Pacific Northwest Earthquake Hazard Assessment.** As part of a nationwide earthquake hazard assessment, the USGS has produced an analytical model (or map), that shows the expected levels of ground shaking for all geographic regions for various time (or exposure) periods. Figure 2 shows a portion of this map for the Puget Sound region. The contour lines represent horizontal ground shaking, as a percentage of gravitational acceleration, which we expect, with a 98% confidence level, will not be exceeded over a 50-year period. (A building subject to a horizontal acceleration equal to 50% of gravity ("0.5g") will be subject to a horizontal shaking force equal to 50% of its weight). Other versions of this map with different confidence limits and exposure periods are available.

The warmer colors on this map indicate stronger expected shaking. The higher shaking levels near the coast reflect a model scenario in which there is a large earthquake of Type 1. The oblong, east west contours near Seattle are due to the Seattle fault, a potential source of shallow earthquakes of Type 3. The broad areas with smooth contours showing moderate expected shaking from Olympia to the Canadian border are due mainly to deep earthquakes of Type 2.



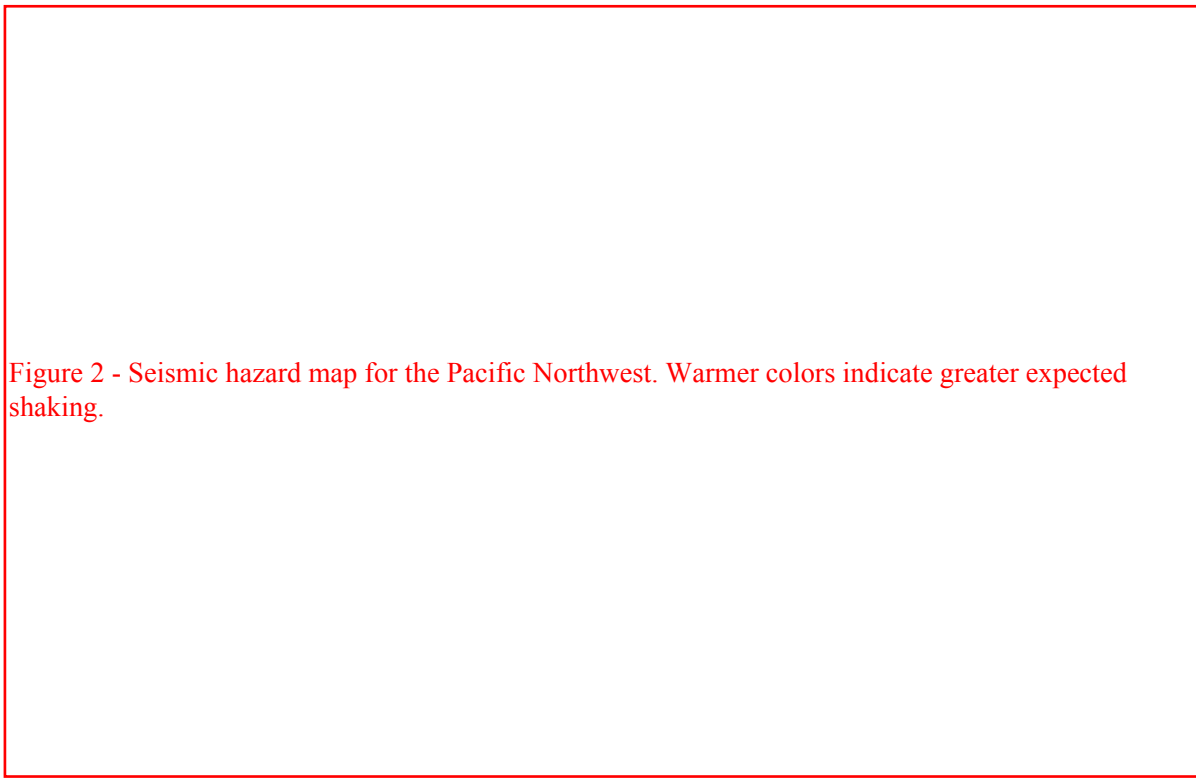


Figure 2

Seismic hazard map for the Pacific Northwest. Warmer colors indicate greater expected shaking.

These maps are the most important product of our USGS Earthquake Hazards Program. Practically everything we do -- earthquake and geodetic monitoring, geologic mapping, and detailed studies of earthquake fault history and behavior -- goes into these maps. Engineers and architects use this information to take into account expected earthquake shaking in the design of buildings and structures. Most importantly, FEMA has adopted these maps in their seismic design guidelines, through which they have also become the exclusive earthquake hazard basis of building codes published by the International Code Council. These codes are used to design structures throughout the United States.

### **3. The February 28, 2001, Nisqually Earthquake - Geological and Seismological Effects**

**Earthquake source.** The Nisqually earthquake was a Type 2 event, 33 miles deep in the top portion of the sinking Juan de Fuca plate. The earthquake occurred at 10:54 am local time (PST) and had a magnitude of 6.8. The epicenter, or point on the surface of the Earth directly above the earthquake source, is near the "Nisqually delta," a prominent feature in South Puget Sound at the mouth of the Nisqually River. Analysis of seismic data from the earthquake indicates that it was caused by slippage on a normal fault striking in a north-south direction. Normal, or gravity, faults are caused by tension, or "pull apart," forces. In this case, the tension may have been caused by the bending of the upper portion of the Juan de Fuca plate as it sinks into the mantle. Figure 3 shows a cross section of the seismicity beneath Puget Sound and the location of the Nisqually earthquake. The location and faulting pattern of the recent earthquake are almost identical to an earthquake of magnitude 7.1 that occurred in 1949.

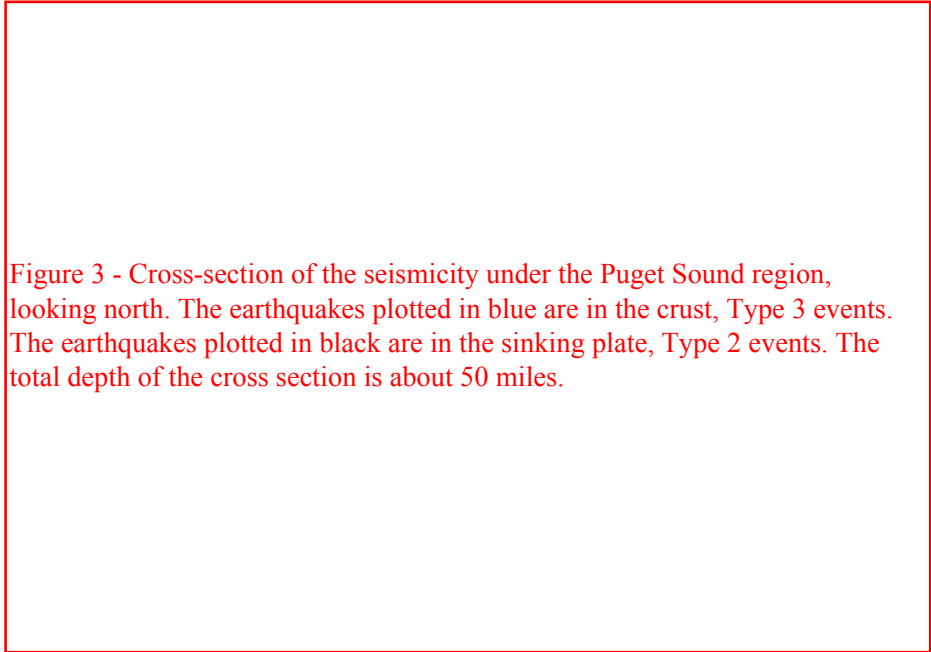


Figure 3 - Cross-section of the seismicity under the Puget Sound region, looking north. The earthquakes plotted in blue are in the crust, Type 3 events. The earthquakes plotted in black are in the sinking plate, Type 2 events. The total depth of the cross section is about 50 miles.

Figure 3

Cross-section of the seismicity under the Puget Sound region, looking north. The earthquakes plotted in blue are in the crust, Type 3 events. The earthquakes plotted in black are in the sinking plate, Type 2 events. The total depth of the cross section is about 50 miles.

**Ground shaking.** The Nisqually earthquake was widely felt, as far south as Salem, Oregon, and as far east as Spokane. Figure 4 is a map of ground shaking caused by the earthquake, with the warmer colors showing a higher level of shaking. In this map the yellow colors represent shaking capable of causing light to moderate damage, with peak accelerations within the 0.1g to 0.3g range.




Figure 4 - Ground shaking pattern from the Nisqually earthquake. Yellow color indicates that the earthquake was strongly felt but with light damage potential. Green indicates that it was felt lightly throughout the region.

Figure 4

Ground shaking pattern from the Nisqually earthquake. Yellow color indicates that the earthquake was strongly felt but with light damage potential. Green indicates that it was felt lightly throughout the region.

It is interesting to compare the shaking pattern of the Nisqually earthquake with that of the Northridge earthquake, which occurred in the Los Angeles area in 1994. The Northridge earthquake had a magnitude of 6.7, killed 60 people, and resulted in approximately \$40 billion in losses. Figure 5 shows the shaking patterns for the two events on maps of the same scale.

Figure 5 - Ground shaking patterns for the Northridge and Nisqually earthquakes.

Figure 5

Ground shaking patterns for the Northridge and Nisqually earthquakes.

It is clear that the intensity of shaking for the Northridge event was much more severe than that experienced recently near Seattle. The reason for this is that the Northridge event was relatively shallow -- the buried fault that broke came within 2 miles of the Earth's surface. Strong seismic shaking decreases rapidly with distance from the fault that is the source of the shaking. This effect is shown in the sketch in Figure 6. Because the Nisqually earthquake was 33 miles deep, every location on the surface was at least 33 miles from the source and outside of the range of severe shaking. In the Northridge case much of the eastern portion of the densely populated San Fernando Valley was within 30 miles of the earthquake source.

Figure 6 - Schematic diagram showing the effect of depth on surface shaking for the Nisqually and Northridge earthquakes.

Figure 6

Schematic diagram showing the effect of depth on surface shaking for the Nisqually and Northridge earthquakes.

The shaking map for the Nisqually earthquake shown in Figures 4 and 5 was prepared several days after the earthquake. The capability to produce such maps within ten minutes of an earthquake has been developed by the USGS for southern and northern California and was in the process of being implemented in the Puget Sound region when the Nisqually earthquake occurred. The capability to produce such maps within 10 minutes in all seismic regions is a goal of the Advanced National Seismic System (ANSS).

The development of these "shakemaps" is a major advance of the USGS Earthquake Hazards Program. The availability of these maps within 10 minutes of an earthquake is very valuable to emergency response officials and others for whom a quick determination of the scale of the problem and of the severity and distribution of ground shaking is important. This information can be used in the life-saving dispatch of emergency equipment to where it is needed most, in the assessment of damage to infrastructure elements, and in the restoration of infrastructure services.

Last year, 20 new ANSS seismometers were installed in the Seattle area--too few to produce a rapid, accurate shakemap for the Nisqually earthquake. However, the data from these modern seismometers enabled scientists to quickly determine that the ground shaking was not likely to cause heavy damage. These 20 new instruments nearly doubled the number of permanent seismic stations in the area capable of recording strong ground shaking in a digital format and sending the data in real-time to regional and national data centers. All of these instruments functioned well during the earthquake and provided valuable, quantitative data on the amplitude, frequency content (shaking cycles per second), and duration for shaking at given sites, and the variation of these parameters from site to site.

All measured levels of shaking were lower than those shown in the USGS hazard assessment for the Pacific Northwest (Figure 2), which we estimate with 98% confidence will not be exceeded in any 50-year period. It is important to note that the estimated levels on Figure 2 are for one uniform geologic layer throughout the entire region. Local geologic structures and soil conditions can amplify and extend the duration of seismic shaking. The data collected in the recent earthquake can now be used to estimate and map the expected ground shaking in the region in much finer detail than shown in Figure 2. The results of this "microzonation" can be used in the future design and construction of buildings and structures at specific sites in the region. Figure 7 shows the relative amplitudes of shaking recorded on sites of various soil conditions within the City of Seattle. In general, soft alluvium soils and areas of artificial fill were subject to greater shaking.

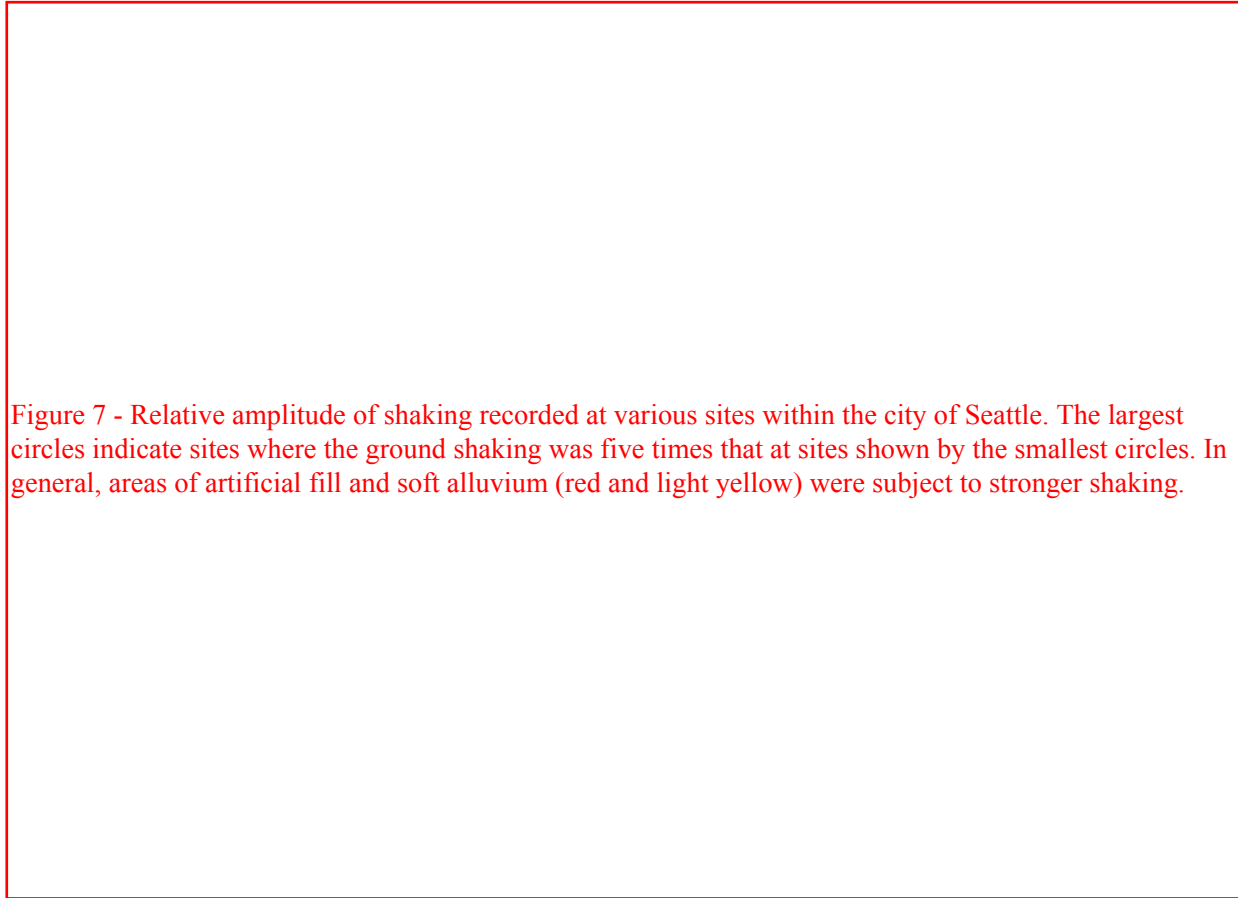


Figure 7 - Relative amplitude of shaking recorded at various sites within the city of Seattle. The largest circles indicate sites where the ground shaking was five times that at sites shown by the smallest circles. In general, areas of artificial fill and soft alluvium (red and light yellow) were subject to stronger shaking.

Figure 7

Relative amplitude of shaking recorded at various sites within the city of Seattle. The largest circles indicate sites where the ground shaking was five times that at sites shown by the smallest circles. In general, areas of artificial fill and soft alluvium (red and light yellow) were subject to stronger shaking.

**Ground failures.** In addition to direct damage to structures caused by seismic shaking, earthquake shaking can also trigger landslides, lateral spreading of weak soils, and liquefaction, a process in which soils lose bearing strength and begin to flow like liquids. The hillsides of the Puget Sound region are susceptible to landslides during or following intense rainfall, even without an earthquake acting as a triggering mechanism. Although ground failures were observed at sites over a wide area, the number and impact of the failures was not severe. The distribution of these sites is shown in Figure 8. Coastal Washington is experiencing a serious drought, with below-normal rainfall since November 2000. If the earthquake had occurred after a series of intense storms, or even after a normally wet winter, the damage from landsliding and other ground failures may have been much greater.

Figure 8 - Summary map showing areas of greatest ground failure and damage.

Figure 8  
Summary map showing areas of greatest ground failure and damage.

**Aftershocks.** There have been only four recorded aftershocks from the Nisqually earthquake, all were below magnitude 3.4. Earthquakes of this size near the surface are usually followed by aftershock sequences that may cause additional damage and most certainly cause general unrest in the population. These aftershocks decrease in frequency and magnitude with time. Generally speaking, deeper earthquakes have fewer aftershocks than earthquakes of the same magnitude near the surface. The 1949 earthquake in this region generated only a few aftershocks.

#### 4. USGS Earthquake Hazards Program in the Pacific Northwest

Under the aegis of the National Earthquake Hazards Reduction Program (NEHRP), the USGS has been supporting earthquake monitoring and hazards assessment work in the Pacific Northwest for over 20 years. We have eight personnel at a field office at the University of Washington in Seattle; other personnel from Menlo Park, California, and Golden, Colorado, are fully committed to working in the Seattle area. In addition, we work closely with local governments and private interests in translating the results of our scientific studies into terms that can be understood and acted upon by those responsible for public safety, industrial and economic development, and maintaining the critical infrastructure in the wake of an earthquake.

Important examples of our work in the region are:

- **Earthquake monitoring.** The USGS provides annual support for the operation and maintenance of the Pacific Northwest Seismic Network by the University of Washington. We have provided additional recent support for the expansion and modernization of this network through the Advanced National Seismic Network (ANSS). Twenty new stations were installed last year in or near urban areas, and an additional 20 stations are being installed this year. All 20 instruments installed last year provided

data from the recent earthquake. Shakemaps, such as those described earlier in this testimony, will be available quickly after the next earthquake through ANSS implementation in this region.

- **Evidence for a large subduction zone earthquake (Type 1).** A USGS scientist working out of the University of Washington for the past 15 years has uncovered evidence for large earthquakes (magnitude 9) occurring on an offshore fault that will impact the entire Pacific Northwest region. This evidence is in the form of buried marsh and forest soils and tsunami deposits in southern coastal Washington, which provide a geologic history of past large earthquakes and foretell the future possibility of future events of this size.
- **Evidence for shallow faults near urban areas (Type 3).** For over 5 years the USGS, along with researchers from the University of Washington and elsewhere, has conducted extensive geological and geophysical studies of the structure of the shallow crust on the Puget Sound region. These studies have identified several shallow faults that appear capable of producing earthquakes that could cause considerable damage. For example, the Seattle fault, which runs (from west to east) under Bainbridge Island and Mercer Island and just south of downtown Seattle, was discovered by advanced geophysical techniques and recently confirmed through LIDAR observations.
- **Ground-Motion Studies.** The USGS and other collaborators are conducting extensive studies of the geologic and soil conditions in the Puget Sound area that may amplify and extend the duration of seismic shaking. These studies include detailed geologic mapping and use of portable arrays of seismic instruments to record natural and manmade seismic events.
- **CREW.** Along with the Federal Emergency Management Agency (FEMA), the USGS helped form the Cascadia Regional Earthquake Work Group (CREW), a coalition of private and public representatives working to reduce the impact of earthquakes in the Pacific Northwest. Private interests represented include Hewlett-Packard, Boeing Corporation, Bank of America, and Intel.
- **City of Seattle.** During the past 5 years, the USGS has been working with the City of Seattle in providing information on earthquake and landslide hazards. As recently as November 2000, the USGS sponsored a workshop in Seattle that brought together the "user community" so that we could convey the results of our efforts and receive guidance on future work. Approximately 250 representatives of local government and private industry, including Mayor Schell of Seattle, attended this workshop.

## 5. LESSONS LEARNED.

Although it is still too early to know all that we may learn from the data collected in the earthquake, we shall permit ourselves a few general observations:

- Although the earthquake event itself was startling and frightening to those who experienced it, it was not unexpected. Information had been made available to government officials and the general population on the earthquake hazard in the region. There was no widespread panic.
- Seismic retrofitting of older buildings was a significant factor in reducing structural damage; however, it is too early to quantify this impression.
- Seismic instrumentation in urban areas provided valuable data on the amplification, the shaking cycles per second, and the duration of ground shaking at specific sites throughout the region. However, the 40 modern, digital seismic instruments capable of recording strong shaking and sending data continuously to the regional data center are completely inadequate. Additional stations of this type will be needed to adequately cover the region. Instruments are also needed in buildings and structures to record their response to strong shaking.
- Much more work is needed to locate and understand the characteristics of shallow, crustal faults capable of producing damaging earthquakes (Type 3). Seismic and geomagnetic surveys are needed to locate these faults underground; high-resolution topographic surveys (LIDAR) are needed to locate the surface expressions of these faults.

- More work is needed in the major urban areas in estimating the response of surface rock, soils, and artificial fill to earthquake shaking. Work in Seattle is ongoing. Work has not begun in Tacoma, Olympia, and other cities of the region.
- From the USGS perspective, the fact that we had a small staff of qualified and dedicated personnel stationed in the area has greatly increased the effectiveness with which we can deliver our messages and products related to earthquake hazards and provide the support and information that the community needs.
  
- World Wide Web sites at the USGS National Earthquake Information Center and the University of Washington Pacific Northwest Seismic Network (supported by the USGS) were overwhelmed in the hours after the earthquake. Up to 1,000 hits per second were experienced. The USGS needs to increase the capacity of the electronic "pipelines" to these sites and of the web servers at these sites.
  
- The use of partnerships, such as CREW, between FEMA, the USGS, State and local governments, and the private sector are very effective, in fact essential, in earthquake preparedness.
  
- The partnerships and cooperative research efforts we have formed with the scientists at the University of Washington and with other Federal, State, and local agencies in the region served us all well in response to this earthquake. We look forward to continuing our work with these institutions and agencies.
  
- The national earthquake monitoring and assessment program of the USGS, which -- working in cooperation with others -- maintains long-term data on earthquake occurrence, develops hazards assessments, produces maps of shaking intensity, and is continually investigating and implementing new knowledge and technology, is a tremendous asset to the Nation in ensuring that society has the information that science can provide and is needed to address the earthquake threat.

Mr. Chairman, this concludes my remarks. I shall be happy to respond to any questions.

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