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Testimony

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UNCONVENTIONAL OIL AND GAS PRODUCTION

Opportunities and Challenges of Oil Shale Development

Statement of Anu K. Mittal, Director
Natural Resources and Environment



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UNCONVENTIONAL OIL AND GAS PRODUCTION

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Highlights of [GAO-12-740T](#), a testimony before the Subcommittee on Energy and Environment, Committee on Science, Space, and Technology, House of Representatives

Why GAO Did This Study

Fossil fuels are important to both the global and U.S. economies, and “unconventional” oil and gas resources—resources that cannot be produced, transported, or refined using traditional techniques—are expected to play a larger role in helping the United States meet future energy needs. With rising energy prices one such resource that has received renewed domestic attention in recent years is oil shale. Oil shale is a sedimentary rock that contains solid organic material that can be converted into an oil-like product when heated. About 72 percent of this oil shale is located within the Green River Formation in Colorado, Utah, and Wyoming and lies beneath federal lands managed by the Department of the Interior’s Bureau of Land Management, making the federal government a key player in its potential development. In addition, the Department of Energy (DOE), advances energy technology, including for oil shale, through its various offices, national laboratories, and arrangements with universities.

GAO’s testimony is based on its October 2010 report on the impacts of oil shale development ([GAO-11-35](#)). This testimony summarizes the opportunities and challenges of oil shale development identified in that report and the status of prior GAO recommendations that Interior take actions to better prepare for the possible future impacts of oil shale development.

What GAO Found

In its October 2010 report, GAO noted that oil shale development presents the following opportunities for the United States:

- *Increasing domestic oil production.* Tapping the vast amounts of oil locked within U.S. oil shale formations could go a long way toward satisfying the nation’s future oil demands. Oil shale deposits in the Green River Formation are estimated to contain up to 3 trillion barrels of oil, half of which may be recoverable, which is about equal to the entire world’s proven oil reserves.
- *Socioeconomic benefits.* Development of oil shale resources could lead to the creation of jobs, increases in wealth, and increases in tax and royalty payments to federal and state governments for oil produced on their lands. The extent of these benefits, however, is unknown at this time because the ultimate size of the industry is uncertain.

In addition to these opportunities and the uncertainty of not yet having an economical and environmentally viable commercial scale technology, the following challenges should also be considered:

- *Impacts on water, air, and wildlife.* Developing oil shale and providing power for oil shale operations and other activities will require large amounts of water and could have significant impacts on the quality and quantity of surface and groundwater resources. In addition, construction and mining activities during development can temporarily degrade air quality in local areas. There can also be long-term regional increases in air pollutants from oil shale processing and the generation of additional electricity to power oil shale development operations. Oil shale operations will also require the clearing of large surface areas of topsoil and vegetation which can affect wildlife habitat, and the withdrawal of large quantities of surface water which could also negatively impact aquatic life.
- *Socioeconomic impacts.* Oil shale development can bring an influx of workers, who along with their families can put additional stress on local infrastructure such as roads, housing, municipal water systems, and schools. Development from expansion of extractive industries, such as oil shale or oil and gas, has typically followed a “boom and bust” cycle, making planning for growth difficult for local governments. Moreover, traditional rural uses would be displaced by industrial uses and areas that rely on tourism and natural resources would be negatively impacted.

GAO’s 2010 report found that federal research efforts on the impacts of oil shale development did not provide sufficient data for future monitoring and that there was a greater need for collaboration among key federal stakeholders to address water resources and research issues. Specifically, Interior and DOE officials generally have not shared information on their oil shale research efforts, and there was a need for the federal agencies to improve their collaboration and develop more comprehensive baseline information related to water resources in the region. GAO made three recommendations to Interior, which the department generally concurred with and has already begun to take actions to address.

Chairman Harris, Ranking Member Miller, and Members of the Subcommittee:

I am pleased to be here today to participate in your hearing on the challenges and opportunities related to the potential development of unconventional oil and natural gas resources. As you know, fossil fuels are important to both the global and U.S. economies, and among other things, we rely on oil to fuel our transportation vehicles and on natural gas to a significant extent to heat and power our homes, businesses, and industries. For many years, the United States has relied heavily on imported oil and, to a lesser extent, imported natural gas, with domestic production largely limited to conventional oil and gas resources. However, in recent years, improvements in technology have allowed oil and gas operators to extract oil and natural gas from unconventional resources—resources that cannot be produced, transported, or refined using traditional techniques. Examples of unconventional resources include oil shale (a sedimentary rock containing solid organic material that can be converted into a petroleum-like oil when heated), shale oil and gas, natural gas hydrates (crystalline solids consisting of water, methane, and usually a small amount of other gases that form beneath permafrost and on the ocean floor), and tar sands (a combination of clay, sand, water, and bitumen, a heavy black viscous oil).

These unconventional oil and gas resources are expected to play a larger role in helping the United States meet its future energy needs. In recognition of this fact, the Departments of Energy and the Interior and the Environmental Protection Agency released a memorandum on April 13, 2012, announcing a collaborative interagency effort on unconventional oil and gas research. The memorandum states that the agencies will develop a multi-agency program focused on the highest priority challenges associated with safely and prudently developing unconventional resources.

My statement today is focused on oil shale development and will highlight several issues related to the opportunities and challenges related to oil shale development that we identified in an October 2010 report undertaken at the request of this committee.¹ In addition, I will highlight

¹GAO currently has work ongoing on several topics related to other unconventional energy resources, namely shale oil and gas and issues related to federal and state agency regulation of unconventional resources.

the key actions that federal agencies can take to proactively prepare for the potential development of a future oil shale industry. Our October 2010 report was one of a series of reports that we have completed that examine the nexus between energy and water resources.² This 2010 report contains a detailed explanation of the methods used to conduct our work, which we performed in accordance with generally accepted government auditing standards.

Background

One unconventional energy resource that has received renewed attention in recent years in the United States is oil shale. Historically, interest in oil shale development as a domestic energy source has waxed and waned since the early 1900s, as average crude oil prices have generally been lower than the threshold necessary to make oil shale development profitable over time. More recently, however, higher oil prices have renewed interest in developing oil shale. The federal government is in a unique position to influence the development of oil shale because nearly three-quarters of the oil shale within the Green River Formation lies beneath federal lands managed by the Department of the Interior's (Interior) Bureau of Land Management (BLM). The Energy Policy Act of 2005 directed Interior to lease its lands for oil shale research and development. In June 2005, BLM initiated a leasing program for research, development, and demonstration (RD&D) of oil shale recovery technologies. By early 2007, it had granted six small RD&D leases: five in the Piceance Basin of northwest Colorado and one in the Uintah Basin of northeast Utah. The leases are for a 10-year period, and if the technologies are proven commercially viable, the lessees can significantly expand the size of the leases for commercial production into adjacent areas known as preference right lease areas. The Energy Policy Act of 2005 also directed Interior to develop a programmatic environmental impact statement (PEIS) for a commercial oil shale leasing program. During the drafting of the PEIS, however, BLM determined that, without proven commercial technologies, it could not adequately assess the environmental impacts of oil shale development and dropped from consideration the decision to offer additional specific parcels for lease. Instead, the PEIS analyzed making lands available for potential leasing

² GAO, *Energy-Water Nexus: A Better and Coordinated Understanding of Water Resources Could Help Mitigate the Impacts of Potential Oil Shale Development*, [GAO-11-35](#) (Washington, D.C.: Oct. 29, 2010). Also see related GAO products at the end of this statement.

and allowing industry to express interest in lands to be leased. Environmental groups then filed lawsuits, challenging various aspects of the PEIS and the RD&D program. Since then, BLM has initiated another round of oil shale RD&D leasing and the lawsuits were settled.

Stakeholders in the future development of oil shale are numerous and include the federal government, state government agencies, the oil shale industry, academic institutions, environmental groups, and private citizens. Among federal agencies, BLM manages federal land and the oil shale beneath it and develops regulations for its development. The United States Geological Survey (USGS) describes the nature and extent of oil shale deposits and collects and disseminates information on the nation's water resources, which are a significant consideration for oil shale development in the West. The Department of Energy (DOE), advances energy technologies, including oil shale technology, through its various offices, national laboratories, and arrangements with universities. The Environmental Protection Agency (EPA) sets standards for pollutants that could be released by oil shale development and reviews environmental impact statements, such as the PEIS. Also, Interior's Bureau of Reclamation (BOR) manages federally built water projects that store and distribute water in 17 western states and provides this water to users, including states where oil shale research, development, and demonstration, is underway.

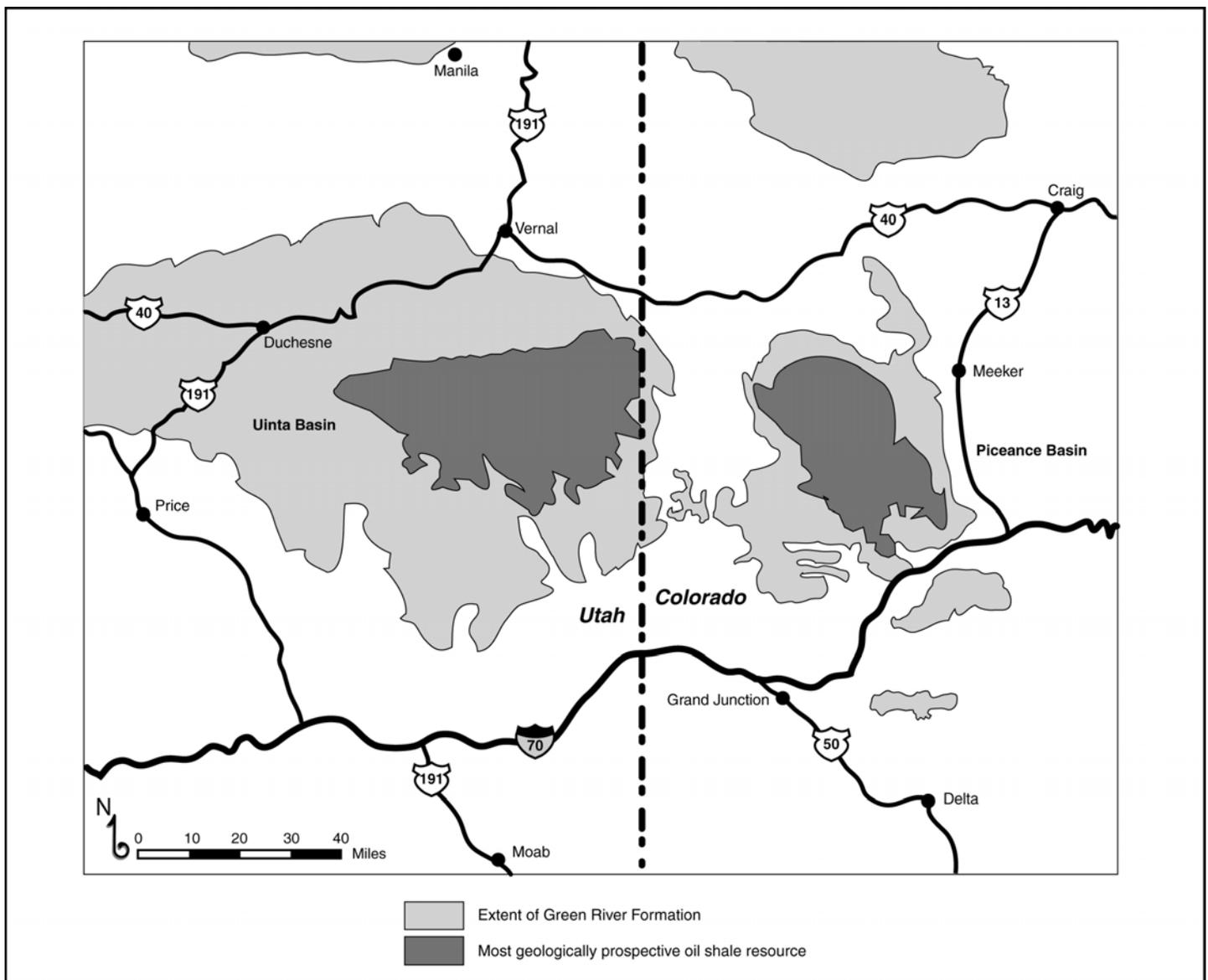
Opportunities Presented by Future Oil Shale Development

Our October 2010 report found that oil shale development presents significant opportunities for the United States. Potential opportunities associated with oil shale development include increasing domestic oil production and socioeconomic benefits.

- *Increasing domestic oil production.* Being able to tap the vast amounts of oil locked within U.S. oil shale formations could go a long way toward satisfying the nation's future oil demands. The Green River Formation—an assemblage of over 1,000 feet of sedimentary rocks that lie beneath parts of Colorado, Utah, and Wyoming—contains the world's largest deposits of oil shale. USGS estimates that the Green River Formation contains about 3 trillion barrels of oil, and about half of this may be recoverable, depending on available technology and economic conditions. The Rand Corporation, a nonprofit research organization, estimates that 30 to 60 percent of the oil shale in the Green River Formation can be recovered. At the midpoint of this estimate, almost half of the 3 trillion barrels of oil would be recoverable. This is an amount about equal to the entire world's

proven oil reserves. The thickest and richest oil shale within the Green River Formation exists in the Piceance Basin of northwest Colorado and the Uintah Basin of northeast Utah. Figure 1 shows where these prospective oil shale resources are located in Colorado and Utah.

Figure 1. Location of Oil Shale Resources in Colorado and Utah



Source: Adopted from BLM.

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- Socioeconomic benefits. Development of oil shale resources could also yield important socioeconomic benefits, including the creation of jobs, increases in wealth, and increases in tax and royalty payments to federal and state governments for oil produced on their lands. Our October 2010 report did not attempt to quantify these potential socioeconomic benefits because of current uncertainty surrounding the technologies that might be used to develop oil shale resources, which would influence the ultimate size of a future oil shale industry.

Challenges Presented by Future Oil Shale Development

Our October 2010 report also found, however, that there are a number of key challenges associated with potential oil shale development in the United States, including: (1) uncertainty about viable technologies, (2) environmental impacts that affect water quantity and quality, air, and land, and (3) socioeconomic impacts.

- *Uncertainty about viable technologies.* A significant challenge to the development of oil shale lies in the uncertainty surrounding the viability of current technologies to economically extract oil from oil shale. To extract the oil, the rock needs to be heated to very high temperatures—ranging from about 650 to 1,000 degrees Fahrenheit—in a process known as retorting. Retorting can be accomplished primarily by two methods. One method involves mining the oil shale, bringing it to the surface, and heating it in a vessel known as a retort. Mining oil shale and retorting it has been demonstrated in the United States and is currently done to a limited extent in Estonia, China, and Brazil. However, a commercial mining operation with surface retorts has never been developed in the United States because the oil it produces competes directly with conventional crude oil, which historically has been less expensive to produce. The other method, known as an in-situ process, involves drilling holes into the oil shale, inserting heaters to heat the rock, and then collecting the oil as it is freed from the rock. Some in-situ technologies have been demonstrated on very small scales, but other technologies have yet to be proven, and none has been shown to be economically or environmentally viable at a commercial scale. According to some energy experts, the key to developing our country's oil shale is the development of an in-situ process because most of the richest oil shale is buried beneath hundreds to thousands of feet of rock, making mining difficult or impossible. In addition to these uncertainties, transporting the oil produced from oil shale to refineries may pose challenges because pipelines and major highways are not prolific in the remote areas where the oil shale is located, and the large-scale

infrastructure that would be needed to supply power to heat the oil shale is lacking.

- *Environmental impacts on water, air, and wildlife.* Developing oil shale resources poses significant environmental challenges, particularly for water quantity and quality but also for air and wildlife.
- *Water quantity.* Oil shale development could have significant impacts on the quantity of surface and groundwater resources, but the magnitude of these impacts is unknown because of the technological uncertainties, and also because the size of a future oil shale industry is unknown, and knowledge of current water conditions and groundwater flow is limited. Developing oil shale and providing power for oil shale operations and other associated activities will require significant amounts of water, which could pose problems, particularly in the arid West where an expanding population is already placing additional demands on available water resources. For example, some analysts project that large scale oil shale development within Colorado could require more water than is currently supplied to over 1 million residents of the Denver metro area and that water diverted for oil shale operations would restrict agricultural and urban development. The potential demand for water is further complicated by the past decade of drought in the West and projections of a warming climate in the future. Current estimates of the quantities of water needed to support a future oil shale industry vary significantly depending upon the assumptions that are made. However, as our 2010 report noted, while water is likely to be available for the initial development of an oil shale industry, the eventual size of the industry may be limited by the availability of water and demands for water to meet other needs of the region. Oil shale companies operating in Colorado and Utah will need to have water rights to develop oil shale, and representatives from all of the companies with whom we spoke for our 2010 report were confident that they held at least enough water rights for their initial projects and will likely be able to purchase more rights in the future. Sources of water for oil shale will likely be surface water in the immediate area, such as the White River, but groundwater could also be used. However, as we reported in 2010, the possibility of competing municipal and industrial demands for future water, a warming climate, future needs under existing compacts, and additional water needs for the protection of threatened and endangered fishes, may eventually limit the size of a future oil shale industry.

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- *Water quality.* While the water quantity impacts from oil shale development are difficult to precisely quantify at this time, hydrologists and engineers have been able to more definitively determine the water quality impacts that are likely because other types of mining, construction, and oil and gas development cause disturbances similar to impacts expected from oil shale development. According to these experts, in the absence of effective mitigation measures, impacts from oil shale development to water resources could result from (1) disturbances to the ground surface during the construction of roads and production facilities, which could result in the degradation of surface water quality from the related runoff of sediment, salts, and possible chemicals to nearby rivers and streams, (2) the withdrawal of water from streams and aquifers for oil shale operations, which could decrease flows downstream and temporarily degrade downstream water quality by depositing sediment during decreased flows, (3) underground mining and extraction, which would permanently impact aquifers by affecting groundwater flows through these zones, and (4) the discharge of waste waters from oil shale operations, which could temporarily increase water flows into receiving streams, thereby altering water quality and water temperature.
 - *Air.* Construction and mining activities during the development of oil shale resources can temporarily degrade air quality in local areas. There can also be long-term regional increases in air pollutants from oil shale processing and the generation of additional electricity to power oil shale development operations. Pollutants, such as dust, nitrogen oxides, and sulfur dioxide, can contribute to the formation of regional haze that can affect adjacent wilderness areas, national parks, and national monuments, which can have very strict air quality standards. Environmental impacts could also be compounded by the impacts of coal mining, construction, and extensive oil and gas development in the area, and air quality appears to be particularly susceptible to the cumulative effect of these development impacts. According to some environmental experts that we spoke to for our 2010 report, air quality impacts may be the limiting factor for the development of a large oil shale industry in the future.
 - *Wildlife.* Oil shale operations are likely to clear large surface areas of topsoil and vegetation, and as a result, some wildlife habitat will be lost. Important species likely to be negatively impacted from loss of wildlife habitat include mule deer, elk, sage grouse, and

raptors. Noise from oil shale operations, access roads, transmission lines, and pipelines can further disturb wildlife and fragment their habitat. Wildlife is also particularly susceptible to the cumulative effects of nearby industry development. In addition, the withdrawal of large quantities of surface water for oil shale operations could negatively impact aquatic life downstream of the oil shale development.

- *Socioeconomic impacts.* Large-scale oil shale development offers certain socioeconomic benefits outlined earlier, but it also poses some socioeconomic challenges. Oil shale development can bring a sizeable influx of workers, who along with their families, put additional stress on local infrastructure such as roads, housing, municipal water systems, and schools. As noted in our 2010 report, development from expansion of extractive industries, such as oil shale or oil and gas, has typically followed a “boom and bust” cycle, making planning for growth difficult for local governments. Furthermore, development of a future oil shale industry would have the potential to replace traditional rural uses by the industrial development of the landscape, and tourism that relies on natural resources, such as hunting, fishing, and wildlife viewing, could be negatively impacted.

Federal Agencies Can Proactively Take Actions to Prepare For Oil Shale Development

Our 2010 report noted that current federal research efforts on the impacts of oil shale development do not provide sufficient data for future monitoring and that there is a greater need for collaboration among key stakeholders to address water resources and research issues related to oil shale development. As noted earlier, the federal government is in a unique position to influence the development of oil shale because 72 percent of the oil shale within the Green River Formation lies beneath federal lands managed by BLM. In addition to its leasing of these lands, Interior has sponsored oil shale projects related to water resources—to develop a common repository of water data collected from the Piceance Basin and to begin monitoring groundwater quality and quantity within this basin using existing and future wells. The common repository project was funded jointly with Colorado cities and counties as well as with oil shale companies. DOE also plays an important role in developing these resources and has sponsored most of the oil shale research that involves water-related issues. DOE also provides technological and financial support for oil shale development, through its research and development efforts. However, our October 2010 report noted that Interior and DOE officials generally have not shared information on oil shale research and that there is a need for federal agencies to improve their efforts to

collaborate and develop more comprehensive baseline information on the current condition of groundwater and surface water in these areas. Such information will be important for understanding the potential impacts of oil shale development on water resources in the region.

To prepare for possible impacts from the potential future development of oil shale, which industry experts believe is at least 15-20 years away, we made three recommendations in our October 2010 report to the Secretary of the Interior. We recommended that the Secretary direct BLM and USGS to

- establish comprehensive baseline conditions for groundwater and surface water quality, including their chemistry, and quantity in the Piceance and Uintah Basins to aid in the future monitoring of impacts from oil shale development in the Green River Formation;
- model regional groundwater movement and the interaction between groundwater and surface water, in light of aquifer properties and the age of groundwater, so as to help in understanding the transport of possible contaminants derived from the development of oil shale; and
- coordinate with DOE and state agencies with regulatory authority over water resources in implementing these recommendations, and to provide a mechanism for water-related research collaboration and sharing of results.

Interior fully supported the concepts in the report and agreed with the need to answer the science questions associated with commercial oil shale production prior to its development. In addition, Interior indicated that it already had begun to take some actions in response to our recommendations. For example, Interior told us that USGS is undertaking an analysis of baseline water resources conditions to improve the understanding of groundwater and surface water systems that could be affected by commercial-scale oil shale development. In addition, Interior stated that BLM and USGS are working to improve coordination with DOE and state agencies with regulatory authority over water resources and noted current ongoing efforts with state authorities.

In conclusion, Mr. Chairman, while there are potential opportunities for commercial development of large unconventional oil and gas resources, such as oil shale, in the United States, these opportunities must be balanced with other potential technological, environmental and socioeconomic challenges. The recommendations in our October 2010 report on oil shale provide what we believe to be important next steps for federal agencies involved in the development of oil shale, particularly as it relates to water resources. By proactively improving collaboration between departments and state agencies and developing key baseline information the federal government can position itself to better monitor water resources and other environmental impacts should a viable oil shale industry develop in the future.

Chairman Harris, Ranking Member Miller, and Members of the Subcommittee, this completes my prepared statement. I would be pleased to respond to any questions that you may have at this time.

Contact and Staff Acknowledgments

Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this testimony. For further information about this testimony, please contact Anu K. Mittal, Director, Natural Resources and Environment team, (202) 512-3841 or mittala@gao.gov. In addition to the individual named above, key contributors to this testimony were Dan Haas (Assistant Director), Alison O'Neill, Barbara Timmerman, and Lisa Vojta.

Recent Related GAO Products

Department of Energy: Advanced Research Projects Agency-Energy Could Benefit from Information on Applicants' Prior Funding ([GAO-12-112](#), January 13, 2012).

Energy Development and Water Use: Impacts of Potential Oil Shale Development on Water Resources ([GAO-11-929T](#), August 24, 2011).

Federal Oil and Gas: Interagency Committee Needs to Better Coordinate Research on Oil Pollution Prevention and Response ([GAO-11-319](#), March 25, 2011).

Oil and Gas Leasing: Past Work Identifies Numerous Challenges with Interior's Oversight ([GAO-11-487T](#), March 17, 2011).

Oil and Gas Management: Key Elements to Consider for Providing Assurance of Effective Independent Oversight ([GAO-10-852T](#), June 17, 2010).

Federal Oil and Gas Management: Opportunities Exist to Improve Oversight ([GAO-09-1014T](#), September 16, 2009).

Oil and Gas Management: Federal Oil and Gas Resource Management and Revenue Collection In Need of Stronger Oversight and Comprehensive Reassessment ([GAO-09-556T](#), April 2, 2009).

Department of the Interior, Bureau of Land Management: Oil Shale Management—General ([GAO-09-214R](#), December 2, 2008).

Advanced Energy Technologies: Budget Trends and Challenges for DOE's Energy R&D Program ([GAO-08-556T](#), March 5, 2008).

Department of Energy: Oil and Natural Gas Research and Development Activities ([GAO-08-190R](#), November 6, 2007).

Department of Energy: Key Challenges Remain for Developing and Deploying Advanced Energy Technologies to Meet Future Needs ([GAO-07-106](#), December 20, 2006).

Energy-Water Nexus report series

Energy-Water Nexus: Information on the Quantity, Quality, and Management of Water Produced during Oil and Gas Production ([GAO-12-156](#), January 9, 2012).

Energy-Water Nexus: Amount of Energy Needed to Supply, Use, and Treat Water Is Location-Specific and Can Be Reduced by Certain Technologies and Approaches ([GAO-11-225](#), March 23, 2011).

Energy-Water Nexus: A Better and Coordinated Understanding of Water Resources Could Help Mitigate the Impacts of Potential Oil Shale Development ([GAO-11-35](#), October 29, 2010).

Energy-Water Nexus: Many Uncertainties Remain about National and Regional Effects of Increased Biofuel Production on Water Resources ([GAO-10-116](#), November 30, 2009).

Energy-Water Nexus: Improvements to Federal Water Use Data Would Increase Understanding of Trends in Power Plant Water Use ([GAO-10-23](#), October 16, 2009).

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