FOREWORD

WHY THIS WATER AND OIL SHALE ANALYSIS MATTERS

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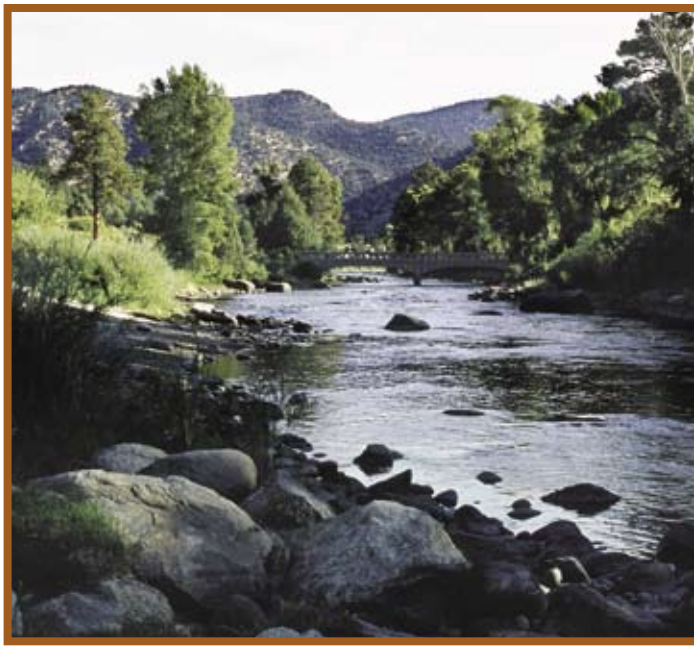
Since the early 1900s, the dream of tapping vast oil shale reserves has drawn energy companies to western Colorado. That dream has proven elusive, for while small quantities of oil have been released after heating shale, commercial production technology remains undeveloped. Past development attempts have failed because of a number of technical, economic, and environmental challenges that have yet to be overcome, despite the billions of dollars invested by both government and industry.

Some members of Congress and a few oil companies suggest the oil shale puzzle may soon be solved. Should this prove to be the case, western Colorado will witness, as Colorado Governor Bill Ritter cautions, "the largest industrial development in the State's history — with enormous implications for all of Northwest Colorado and for the State itself."[1] Oil shale development would bring significant change in western economies, communities, and ways of life. One of the most significant aspects of such change would be in the use of water.



Oil shale development would have tremendous impacts on current and future uses of water — Colorado's most precious natural resource. Water is the lifeblood of the West. It's the foundation of western economies and communities, the basis of political divisions, and often the cause of conflict. Battles over water often pit Front Range cities, such as Denver and Colorado Springs, against West Slope communities, such as Rifle and Grand Junction. Renewed efforts to develop a commercial oil shale industry could once again fan the flames that fuel such battles.

Initial analyses by the RAND Corporation and the U.S. Departments of Energy and the Interior conclude that significant amounts of water will be required to both extract oil from shale and power the extraction processes. Large quantities of water will also be needed to support major infrastructure development and the influx of new workers. It would be folly to discount the crucial link between oil shale development and water resources, ignoring the fact that the arid Rocky Mountain Region is defined by the scarcity of water. Westerners understand this link — and our leaders understand the vital importance of examining potential oil shale development within the context of increasing competition for dwindling water supplies.

It is undisputed that oil shale development will stress limited water resources. The question for elected officials and other community leaders are how, when, where, and to what extent. In a May 2008 letter to Congress, Hamlet J. "Chips" Barry III, manager of the Denver Water Board, stated that "development of oil shale in Colorado could significantly affect the [Front Range Water Users] Council's ability to serve existing customers and the future growth projected for the Front Range of Colorado."[2] That conclusion is significant. What is unclear, however, are the specific impacts on Colorado water and the timing of such impacts.

In order to more fully understand the conflict Barry identifies, Western Resources Advocates (WRA) engaged Larry MacDonnell to investigate the extent of water rights in Colorado held by oil companies, individuals, and water providers that could be used for oil shale development. Entitled "Water on the Rocks: Oil Shale Water Rights in Colorado," this report frames critically important issues vital to the future of Colorado and the West.

BACKGROUND AND KEY FINDINGS

In a 2008 environmental analysis covering oil shale development, the Department of the Interior's Bureau of Land Management (BLM) concluded that oil shale development would likely transform communities in western Colorado from agricultural-based to industrial economies. While noting the likelihood of this fundamental shift, the BLM largely ignored the potentially staggering ramifications.

For northwest Colorado, the fundamental change the BLM forecasts is troubling. Several analyses have already kicked off the public debate. Recently, the Associated Governments of Northwest Colorado teamed with the Colorado Department of Local Affairs to evaluate the socioeconomic impacts of energy development in a four-county region. Their report, which was issued in February 2008, projects a $1.3 billion shortfall in the monies local governments will need to support critical infrastructure upgrades required by oil and natural gas development and oil shale development.

Another study, commissioned by water providers in northwestern Colorado, estimates the growth in water demand needed to support increased extraction and production of energy in four sectors in northwest Colorado, including natural gas, coal, uranium, and oil shale.[3] That report concludes water demands for oil shale could be as much as 378,000 acre-feet per year, an amount that is approximately 25% more than the city of Denver uses annually.[4]

This report fills in another critical piece of the puzzle. It identifies water rights held by energy companies and water providers that could support oil shale development. The report:

- Projects water requirements associated with oil shale development.
- Identifies all major water rights currently owned by energy companies that could be used for oil shale development in Colorado, as well as conditional rights that could be exercised in the future.
- Analyzes legal and hydrological issues of the Colorado River Basin affecting future development of Colorado's allocation under the 1922 Colorado River Compact and subsequent 1948 Upper Basin Compact.
- Explains how the Upper Colorado River Endangered Fish Recovery Program affects and limits additional consumptive uses of water in the mainstem Colorado River.

To illustrate the scope and potential impacts of building new water reservoirs and pipelines, plus shifting existing agricultural rights to oil shale, Geneva Mixon, a Colorado-based cartographer, mapped these rights.

The report's key findings include the following:

1. Energy companies and water supply districts have established conditional water rights associated with more than 200 separate structures (e.g., reservoirs and pipelines) in the Colorado River and White River Basins that potentially could be developed to support oil shale production. Most of these conditional rights were established in the 1950s and 1960s.
2. Collectively, with these rights, energy companies have the right to divert annually more than 10,000 cubic feet per second (cfs) — or 7.24 million acre-feet (af) — of water and store more than 1.7 million af, enough storage to meet the annual needs of 8-10 million Colorado residents.
3. Energy companies have acquired rights in more than 100 existing irrigation ditches in the Colorado River and White River Basins. The flow associated with these rights total 650 cfs. Diverting scarce water for oil shale and other energy development would likely eliminate much of the existing irrigated agriculture in northwest Colorado.
4. The Upper Colorado River Endangered Fish Recovery Program and 1922 Colorado River Compact limit the amount of water Colorado has available for development. As the state edges closer to these limitations, large-scale oil shale and other development projects become mutually exclusive.
5. Large-scale oil shale development would affect existing uses established under more junior water rights, either by curtailment and/or through decreased water availability. Because of potential limits imposed by the 1922 Colorado River Compact, rights junior to 1922 but senior to the oil shale rights could become subject to a call if oil shale resulted in an over-development of Colorado's compact entitlement. A call would potentially limit other planned water development projects, which propose to rely on water from Colorado's West Slope. Those development projects include plans to transfer additional water to Colorado's Front Range cities.

WRA'S CONCLUSIONS FROM THIS REPORT AND OTHER ANALYSES

This report frames a vitally important issue — the nature and extent of water rights that could support oil shale development. By design, however, the report generally does not examine broader issues of the nexus of oil shale and water, and the potential impacts on local economies, the environment, and other water users. Nor does it address the critical issue of climate change and the potential impacts on water availability.

The report's findings are all the more significant when viewed in the larger socioeconomic context of oil shale development. By synthesizing this report and other analyses of potential energy development in Colorado, Utah, and Wyoming, WRA has reached the five conclusions described below on important questions facing the region.

Conclusion #1: ***Commercial oil shale development would transform western Colorado communities.***

> "Water is likely to be transferred from traditional agricultural uses to industrial uses, resulting in the loss of traditional irrigated agriculture. Changes may also result in an increase in dryland agriculture, and depending on scale it may also result in a transition from traditional agriculture based community to a more urbanized lifestyle."[5]
>
> *— Bureau of Land Management, 2008*

> "If commercialization progresses, the oil shale industry has the potential to expand very rapidly – very likely overwhelming the capacity of local governments to deal with growth requirements."[6]
>
> *– Associated Governments of Northwest Colorado, 2008*

First, as this "Water on the Rocks" report makes clear, water for oil shale will partially come at the expense of agricultural use. The vast majority of the agricultural water rights held by oil companies are in Rio Blanco County, an area of the state where the local economy depends heavily on existing agriculture. Many of these water rights, which date back to the late 1800s and early 1900s, are owned by oil companies and are now being leased back to ranches. So, for now, most of the water still remains in irrigation.

However, as this report cautions — and as the BLM notes through its environmental analyses — should commercial oil shale development take off, oil companies would transfer water currently used for agriculture to oil shale production. Thousands of acres historically irrigated would be taken out of agriculture, resulting in a dramatic transformation of land use and associated water uses in the region from an agricultural to an industrial landscape. As witnessed in the Arkansas Basin in Colorado, once a critical mass of farmers (or, in the case of the Piceance Basin, ranchers) sell their lands and associated water rights, it is hard for the agriculture community to sustain itself. The infrastructure that supported the local economy — suppliers, producers, and landowners — shifts to a new economy, and with it the impetus and ability to sustain an agriculture economy. Such changes signal a marked difference in the socioeconomic fabric of agricultural-based communities — the transformation the BLM forecasts.

Anticipated changes in populations necessary to support large-scale industrial development add to the changing uses of water. With rapid industrialization comes the ripple effect of increased populations and related infrastructure needs. The amount of water associated with changing demographics is significant. According to a recent report prepared for the Colorado, Yampa, and White River Basin Roundtables Energy Subcommittee, full-scale oil shale production (which the BLM estimates could occur from 2036-2050) will require an additional 21,100 af of water to accommodate municipal use resulting from the additional 100,000 workers and their families who will move to the area.[7]

Estimated Oil Shale Water Demands

Source of Water Demand	Annual Quantity (af)
Direct demand (1.55 million barrels per day)	112,675
Electric power	244,535
Increased population	21,100
Total	**378,310**

A second impact resulting from oil shale development that requires careful examination is the development of senior conditional water rights. While these rights have not yet been exercised, they have priority dates that are senior to many developed water rights on which Colorado's economy depends today. As MacDonnell discovered through his extensive research of the hundreds of conditional water rights held by energy companies, many of these rights date back to the 1950s. Once oil companies begin using these rights for oil shale development, other users whose rights are junior to oil shale rights could see use of their rights curtailed. This report provides some key examples of development scenarios that show the extent of such displacements.

One example is ski towns in western Colorado. Many of Colorado's premier destination resorts were developed in the 1950s and 1960s, the same period that oil companies were establishing initial water rights for oil shale. Once sleepy towns in the Colorado River Basin, these commu-

nities now sustain substantial year-round populations, recreation, and numerous second homes. As this report notes, much of the water used to serve these communities depends on rights that are junior to oil shale rights. These towns are a core component of a diversified economy that could, along with agriculture, be undermined by oil shale development. Impacts would not be limited to existing uses, as oil shale development would likewise threaten future municipal, recreational, and other development projects on Colorado's West Slope.

Conclusion #2: ***Oil shale development in western Colorado would affect Colorado's Front Range communities and must be thoroughly evaluated and understood.***

> "The prospects of oil shale proceeding to high-level development and the prospects of developing water for Front Range growth are mutually exclusive so there has to be a balancing act."[8]
>
> *— Colorado River Water Conservation District, 2008*

Front Range water providers, such as the Denver Water Board and the Northern Colorado Water Conservancy District, agree with the Colorado River Water Conservation District on one key conclusion — oil shale development will stress and/or compromise future water projects as well as existing projects that are subject to calls from senior in-basin rights and compact curtailment throughout Colorado.

Denver Water and other Front Range water providers divert several hundred thousand acre-feet of water annually out of the Colorado River Basin. Much of this water is senior to conditional water rights established for oil shale development and thus is less likely affected by such development. However, oil shale could trigger a compact call that could lead to curtailment of any post-1922 water uses. Because of increasing needs on Colorado's Front Range, plans are in place to boost water deliveries to Denver and other cities by enlarging existing transbasin diversions and developing new projects. For some of these new projects, water utilities would rely on a combination of both older, pre-oil shale rights and newer junior rights.

For instance, Denver Water's Williams Fork project holds a conditional water right for the Darling Creek Enlargement that is junior to a collection of conditional rights for oil shale. Similarly, the refill right for Williams Fork Reservoir is junior to oil shale conditional rights held by oil companies, as is the proposed Straight Creek Collection System for Roberts Tunnel. Under Colorado water law, senior rights must be fulfilled prior to junior rights. During dry years, junior rights may only be partially met, if at all.

Similarly, the Northern Colorado Water Conservancy District's Windy Gap Reservoir has a 1967 priority date. While this project currently only diverts small amounts of water from the Colorado River Basin, water providers have encountered difficulties in diverting water because their rights are relatively junior. Efforts are underway to "firm" the yield from this project by improving the delivery and reliability of the existing supply with an additional Front Range reservoir. However, substantial development of senior rights for oil shale development would make this task much harder to achieve.

To some outside of the West, these conflicts may appear minor in relation to the need to increase domestic oil production. To those of us in this arid region, how such conflicts are resolved bears directly on Colorado's economic prosperity, future growth, and environmental protection.

Conclusion #3: ***Oil shale will accelerate climate change and will further stress water availability.***

> "Production of unconventional fuels (oil shale, coal to liquids, heavy oil) produces more CO_2 than is produced when using conventional petroleum."[9]
>
> *— U. S. Department of Energy, 2007*

Photo courtesy of The Story Group

Climate change exacerbates and potentially eclipses all other foreseeable stresses on the environment in the region. In February 2007, the Intergovernmental Panel on Climate Change (IPCC) declared: "Warming of the climate system is unequivocal…" and "Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic GHG [greenhouse gas] concentrations."[10]

Oil shale development poses serious climate threats. Producing oil from shale will likely result in the generation of huge quantities of greenhouse gas emissions. Transportation fuels derived from oil shale will be highly energy-intensive and have a carbon footprint greater than both conventional fuels and cleaner fuel alternatives.

Throughout the western United States, climate change is projected to further reduce water availability. In general, these transformations will result from changes in temperature, precipitation, and evapotranspiration. The challenge facing allocation and use of western water is determining the impacts in future years on water availability as temperatures rise and supplies decrease. While the specific impacts are hard to predict, scientists of all disciplines are sounding the alarm. Here is what we do know:

1. <u>The West is getting hotter.</u>
   In a recent, comprehensive assessment, researchers found that 46 out of 49 global circulation model simulations project a more arid southwestern U.S. in future years, with droughts becoming the norm.[11] Climate models project Colorado's average temperature will warm 1.5 to 3.5°F by 2025, relative to the 1950-1999 baseline, and 2.5 to 5.5°F by 2050.[12]

2. <u>The West is getting drier.</u>
   In the arid and semi-arid West, global warming is already having serious consequences for the region's scarce water supplies. As with much of the West, Colorado has a snowfall-dependent water system, deriving 70% of its water supply from snowmelt. Recent hydrologic studies of the Upper Colorado River Basin project multi-model average decreases in runoff ranging from 6% to 20% by 2050 compared to the 20th century average.[13] Relative to the 1950-2000 baseline, evaporation is projected to exceed precipitation by 1.24 inches in the period 2021-2040.[14] This difference compares to that of the Dust Bowl years.[15]

3. Droughts will increase.
   As global warming continues, the IPCC predicts more intense and longer droughts, as characterized by the severe drought that began in the western United States in 1999 and continues today. Moreover, whereas past droughts have been caused by natural variability in ocean and atmospheric circulation (e.g., La Niña events), climatologists predict future drying will be caused by an overall warming. Normal climatic variability will further stimulate additional, increasingly severe, droughts.

4. Streamflows will change.
   Throughout the 20th century, much of the United States has experienced higher streamflow and precipitation, with a corresponding decrease in the duration and severity of drought. The notable exception is the West and Southwest. With drought comes a trend toward reduced mountain snowpack and earlier spring snowmelt runoff, both of which affect water availability and quantity.[16]

5. Ecosystems will be disrupted and wildlife will be affected.
   The IPCC also concluded that recent warming is already strongly affecting ecosystems and wildlife. Glaciers are melting and forests across the West have suffered as warming has extended the range of some damaging insects, such as the mountain pine beetle. Warming is also disrupting the natural timing of seasons and leading to loss of wildlife, including diminished fishing and hunting opportunities in the West.[17]

Importantly, federal officials project oil shale production would not reach full capacity before 2050, the same time that climatologists believe runoff in the Colorado River Basin will have dropped by 6-20% over 20th century levels. The convergence of events would further stress water availability, compounding the challenges and conflicts MacDonnell identifies, including constraints associated with the Upper Colorado River Endangered Fish Recovery Program and allocations under the 1922 Colorado River Compact.

Conclusion #4: ***Water needs must be quantified and supply sources identified before committing to commercial oil shale leasing.***

> "We need to be thoughtful about our approach, especially in light of the magnitude of such development. In fact, if the Department of the Interior were to authorize a commercial oil shale industry in Colorado, the development would constitute the largest industrial development in the State's history — with enormous implications for all of Northwest Colorado and for the State itself."[18]
>
> *— Colorado Governor Bill Ritter, Jr., 2008*

Future municipal development, power production, instream flows for federally endangered fish, and other types of energy development are expected to rely on water from the Colorado River. However, as a result of anticipated changes in climate, population, and changing land uses both within and outside the Colorado River Basin, the margin of uncertainty regarding water availability is troubling.

Estimates of water needed to directly support oil shale development also vary by 400%. According to the RAND Corporation, 1 to 3 barrels of water would be needed for construction, operation, and production for every barrel of oil produced via in-situ methods;[19] 2.6 to 4 barrels of water would be needed for every barrel of oil produced via retort.[20] When electricity demand is added, these estimates jump to 5 barrels of water for every barrel of oil produced. Water used for refining (called "upgrading") further increases the water demands. These margins are significant, especially when the BLM estimates peg potential oil shale development at 2 million barrels per day.

Bruce Lytle, a hydrologist who has evaluated water needs associated with oil shale development, underscores the significance of this margin of uncertainty. He points out that the BLM's analysis of water needed is deficient, noting the BLM's analysis:

- Does not adequately evaluate site-specific water supplies in river basins where oil development may occur.
- Fails to assess impacts from oil shale development in forcing the retirement of agricultural water rights and the dry-up of agricultural lands.
- Does not sufficiently address water rights issues related to hydraulic interconnection of aquifers, permanent changes to surface and groundwater systems, water quality, and mitigation of impacts related to either surface or groundwater supply development.

These conclusions present important warnings to policy makers, especially when coupled with the "Water on the Rocks" report's findings regarding (a) likely elimination of most of the existing irrigated agriculture in northwestern Colorado, (b) constraints associated with the Upper Colorado River Endangered Fish Recovery Program and obligations under the 1922 Colorado River Compact, and (c) impacts on junior water rights throughout Colorado.

These facts are the reason, we believe, why Denver Water and other water providers warned Congress that oil shale development could significantly affect their "ability to serve existing customers and the future growth projected for the Front Range of Colorado."[21]

As long as there is ample water to appropriate, there is little need or incentive for parties to collaborate. That was the case during the failed oil shale development program of the early 1980s, when water was a secondary concern. Since that time, Colorado has experienced a population explosion, which has increased competition for water and decreased water availability.

As Colorado begins to push up against Colorado River Compact allocations and endangered fish recovery goals and agreements, it is vital that stakeholders collaborate to address competing needs. Planning must be integrated to ensure development is consistent with other projects. As a first step in this process, companies seeking to develop oil shale must quantify their water needs and identify supply sources. Without such information, regional planning cannot be accomplished — and regional planning is increasingly necessary as supplies become further stressed.

Conclusion #5: ***Energy demands must be quantified and sources identified before committing to commercial oil shale leasing.***

> "In addition to the emissions associated with the operations themselves, extraction of oil from shale could consume immense quantities of electricity. This would necessitate the building of new power plants, which could further contribute air emissions."[22]
>
> *— Bureau of Land Management, 2008*

> "We do not know the amount of energy that will be needed to process shale oil, the sources or locations of necessary power plants, the impacts such energy production would have on regional air quality and visibility, or the greenhouse gas implications."[23]
>
> *— Colorado Governor Bill Ritter, Jr., 2008*

The BLM estimates that a 100,000-barrel-per-day (bpd) oil shale operation using in-situ conversion technology would likely require 1,200 megawatts (MW) of electricity. That amount of energy roughly equates to the amount needed to serve a city of 500,000. To produce one million barrels of shale oil per day would require 10 new power plants and 5 new coal mines.

In addition to the water required to extract the resource, water would also be needed to power the extraction process. Because oil shale technologies remain in their infancy, it is difficult to ascertain how much energy development would be required or the source of such energy.[24] Nevertheless, the Colorado River Water Conservation District estimates that the BLM's goal of full-scale oil shale development (2 million barrels per day) could require as much as 244,532,000 af of water to power oil shale development.[25] One of the critical policy issues Congress and federal officials must ask is whether the huge volumes of energy required to produce shale is an appropriate use of such power. A closely linked question is whether the associated water needs are an appropriate use of increasingly limited water supplies.

Water need projections for power generation are based on the BLM's assumptions that oil companies will use coal-fired power plants to power oil shale operations. In addition to the vast water requirements, these plants will be a major source of air pollution, which damages human health and the environment. They likewise will use dwindling water supplies and impact (and, in some cases, curtail) junior water users throughout the state.

Before diverting limited water supplies to support 20th century technologies, federal, state, and local leaders must engage in a robust public dialogue on broader energy policy — and must determine whether to promote old technologies or pursue new ones. WRA supports the latter and thus questions using limited water supplies to generate huge amounts of power for oil shale development.

WRA's final conclusion: Develop the information necessary to make informed decisions.

> "Currently, there is no oil shale industry and the oil shale extractive technology is still in its rudimentary stages; as such, commercial oil shale production does not exist anywhere in the world."[26]
>
> *— Bureau of Land Management, 2008*

> "The lack of a domestic oil shale industry makes it speculative to project the demand for oil shale leases, the technical capability to develop the resource, and the economics of producing shale oil."[27]
>
> *— Bureau of Land Management, 2008*

Oil shale development is fraught with uncertainty. While this report sheds light on the nexus between oil shale development and water, the unknowns are still paramount. The BLM acknowledges a 400% range of uncertainty for the amount of water needed to support oil shale development. Uncertainties regarding water availability and water requirements also include:

- Sequencing of development projects
- Rate of consumption
- Power generation needs
- Competition for shared resources
- Impacts of perfecting conditional water rights on junior users
- Impacts of climate change

Photo courtesy of The Story Group

This report makes clear that the link between oil shale and water is complex. Whether changes faced by communities will be incremental or seismic is difficult to predict. Nevertheless, while the specific impacts are difficult to quantify, the BLM's prediction that western Colorado will transition from an agricultural society to an industrial society is well-grounded.

Before we rush headlong into a commercial leasing program, it is wise to remember Spanish philosopher George Santayana's counsel: "Those who cannot remember the past are condemned to repeat it." In May 1982, as world oil prices plummeted, Exxon Oil pulled out of its oil shale Colony Project in Parachute, Colorado, leaving 2,000 people without work. The promise of energy independence turned bust overnight. Government subsidies were not enough to save this faltering industry as the technological obstacles and many costs proved too powerful a force.

Governmental officials at the local, state, and federal level continue to warn policy makers in Washington, D.C. that the knowledge base is simply not there to make informed decisions. Colorado cannot afford to again compromise its strong and diversified economy, but that's what certain lawmakers are asking us to do. By gambling on oil shale and failing, the state could once again be driven into an economic and social recession.

WRA opposes development of oil shale resources in the West unless and until industry and government demonstrate that proven technologies can develop oil shale without unacceptable environmental, climate, economic, or social costs. The industry has barely begun to address that challenge.

One of the significant differences in Colorado today, when compared to 1982, is water availability. In 1982, water was a secondary concern. Now, because of a number of factors — including significant increases in population, an energy boom, and development of the state's recreational economy — water resources and related environmental values are increasingly stressed. Water is central to oil shale development — but it is also critical to Colorado's economic, social, and environmental foundation.

As the Obama Administration takes its seat in Washington, D.C., it is time for elected officials and administration officials at the federal, state, and local level to comprehensively review the federal government's oil shale policy. Front and center must be a hard look at the water requirements and the opportunities and constraints posed by large-scale commercial leasing.

This is a time of great challenge and opportunity in the West. The Colorado Plateau and neighboring Rocky Mountain states are changing dramatically. The Interior West is still a place of spectacular landscapes that support vital ecosystems, important wildlife habitat, and large areas of undeveloped land. But it is also a region characterized by accelerating growth. While the environmental challenges facing the region are huge, the opportunities to address and resolve them are huge as well. The public is increasingly aware of the need for new energy policies and practices, for careful management and conservation of water, and for stewardship of irreplaceable public land resources. Oil shale development runs counter to these needs.