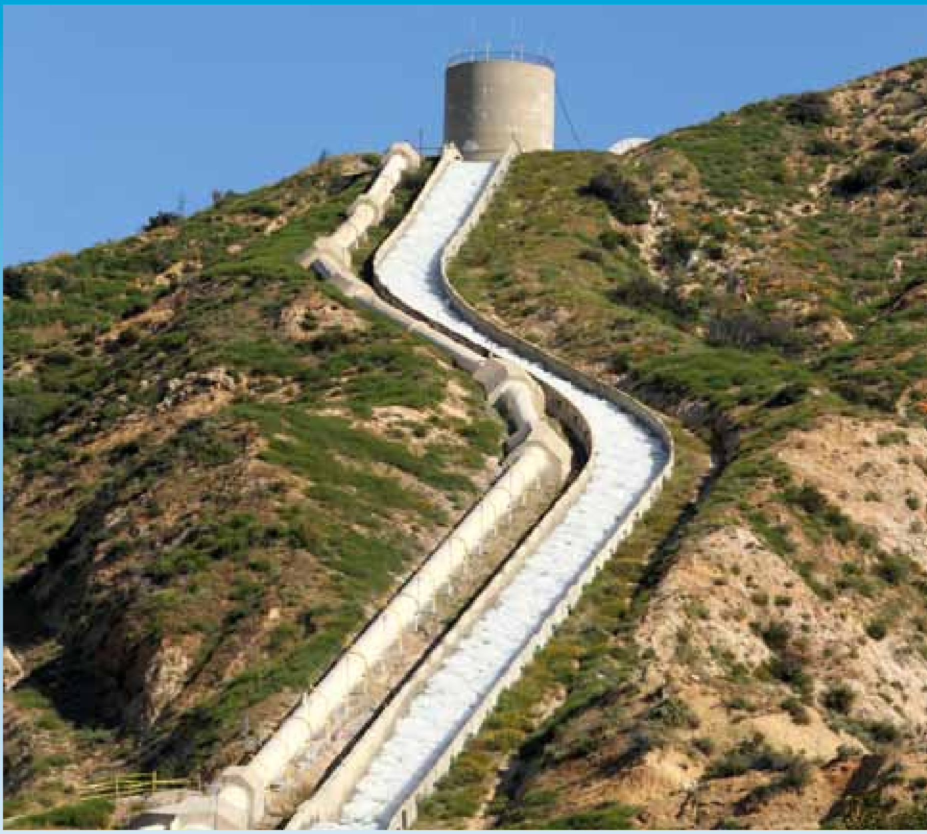
Pipe Dreams: Water Supply Pipeline Projects in the West

June 2012



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Acknowledgments

The Natural Resources Defense Council would like to thank the Pisces Foundation, The William and Flora Hewlett Foundation, the TOSA Foundation, and an anonymous donor for supporting NRDC's work on the intersection of water, climate, and energy issues.

This white paper also received substantial input and review from a number of individuals. Their participation contributed to the quality of the document and its recommendations. We acknowledge that they may not necessarily endorse all of the recommendations, which are solely those of the Natural Resources Defense Council. In particular, we wish to thank our peer reviewers: Robert Adler, University of Utah, S. J. Quinney College of Law; Lawrence J. MacDonnell, University of Wyoming College of Law; Rita Maguire, Attorney and Former Director of Arizona Department of Water Resources; Stacy Tellinghuisen, Western Resource Advocates; an anonymous reviewer; and NRDC staff, including Sheryl Carter, Steve Fleischli, and Ed Osann.

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EXECUTIVE SUMMARY

Large-scale water supply conveyance pipelines have long been an important tool for addressing water needs in the western United States. These pipelines have traditionally been used as a component in complex water projects constructed to capture, store, and move water to serve urban and agricultural users. Traditional water projects have long been designed to tap into major sources of water, frequently through the construction of surface storage projects and associated pipelines, canals, and pumping stations. Indeed, dams have often been the most well known and expensive features of large water projects, which often came at high economic and environmental costs. In the last 20 years, the construction of new dams has slowed to a trickle for a variety of reasons, including the lack of available "new" water, the growing costs of these projects, and a public that is more protective of its rivers.

The western water landscape has changed dramatically in recent years. This is a factor that should be seriously considered by water managers as they design solutions to meet the needs of the coming century. Today, the new conditions facing water managers in the West may guide us to new solutions. Indeed, many managers are shifting focus to groundwater storage, water recycling, and a suite of water efficiency tools. A number of water interests, however, continue to propose a new generation of large scale water conveyance projects around the West—some of which may be significantly less reliable than past projects, raising important questions around their level of cost-effectiveness and sustainability.

Some of the new water conveyance projects described in this report could increase the water supply vulnerability, over the long-term, of communities that rely upon them. For example, for proposed projects for which groundwater is key, it is important to note that in many parts of the West, groundwater is withdrawn more quickly than natural recharge can replenish the supply. Such groundwater mining is inherently unsustainable.

Other proposed pipeline projects would tap into surface water supplies from rivers that are already under stress from existing users. In addition, climate change and other factors suggest that water from some sources will be less reliable during the driest years and in the long-term. With more stress on water sources, the competition from established users, often with older priority dates, suggests more conflict in the future for some proposed projects. When evaluating proposed projects, it is important to remember that water conveyance projects can only generate reliable water supplies if they tap into reliable water sources. In short, water projects that rely on unreliable sources could lead to future shortages for the very communities that pay for these expensive facilities.

In addition, the energy costs of proposed conveyance projects can be enormous, requiring the commitment of massive quantities of power (and, except in rare cases, greenhouse gas emissions) to pump and move water to the

location where it would be used. An acre-foot (af) of water weighs more than 1,360 tons. Therefore, the energy costs associated with moving water are extraordinarily high. For example, pumping water from the San Francisco Bay-Delta to Southern California requires approximately 3,200 kilowatt hours (kwh) per af, the State Water Project the state's single largest user of electricity.[1] Nonetheless, federal, state, and local water agencies continue to propose new pipeline projects, often with little analysis of energy requirements and usually without incorporating the use of renewable energy.

The western United States already has more than its share of water conflicts and unsustainable uses. In designing new projects, NRDC suggests that water managers follow the old adage: When you find yourself in a hole, the first thing to do is to stop digging. Today, water managers have a range of alternatives to new pipeline projects, including urban and agricultural water-use efficiency, voluntary water transfers, water recycling, improved groundwater management, and more. The success of efficiency efforts can be seen today across the West. Many of these less environmentally disruptive alternatives are more reliable, more affordable, less vulnerable to climate change impacts, and less energy intensive than traditional water development projects.

This report provides a brief introduction to some of the pipeline projects proposed recently in the West. Also, it provides a summary of issues that have often been overlooked in proposed pipeline projects, and recommendations for a more effective approach to meeting the water needs of western communities. Our recommendations, which address a broad range of issues, such as sustainability, cost, and energy use include:

- New water supply projects in the West should be designed to reduce, rather than increase, the current imbalances in water use, such as groundwater overdraft and overcommitted surface water sources.
- Federal funds should be focused on projects where there is a strong federal nexus, such as resolving Native American water rights claims and addressing endangered species issues. Also, state and federal water supply funding should be focused on the most affordable and reliable projects—those that increase the efficiency of water use and re-use, as opposed to traditional water development, particularly in regions such projects would be unsustainable.
- A beneficiary-pays approach to financing water projects provides the best way to internalize the costs of water projects and encourage efficient water use.

- Proposed pipeline projects should include an analysis of *all* of the following issues:
  - The capital, financing, planning, mitigation, operating, and maintenance costs of the proposed project, in comparison with the benefits. This should include an analysis of the external costs of proposed projects, such as environmental impacts.
  - All feasible alternatives to the project, particularly urban and agricultural water-use efficiency, water recycling, urban stormwater capture, and voluntary water transfers.
  - Energy use and energy sources.
  - Potential new greenhouse gas emissions.
  - The reliability of proposed water sources, including the potential impacts of climate change on the water sources.
  - Potential impacts to existing water users and communities.
  - Potential impacts of proposed new transbasin diversions on water use in the basin of origination.
- State water agencies, tribal governments, environmentalists, and other stakeholders should work collaboratively to investigate these issues, including possible effects across political or hydrologic boundaries.
- Given the number of proposed projects to divert water from the Colorado River, as well as into the Basin, the Bureau of Reclamation's (BOR) Colorado River Basin Water Supply and Demand Study and subsequent efforts should address the cumulative potential impacts of the potential projects summarized in this report.
- Energy for future pipeline projects should be provided through investments in renewable energy sources. Also, water agencies should invest in renewable sources to provide the energy required for existing pipeline projects, such as California's State Water Project.
- The new Principles and Guidelines for Water and Land Related Resources that are under development by federal agencies should address the issues discussed in this paper, to provide decision-makers a more complete understanding of proposed projects.
- Federal agencies, particularly the BOR, should report the energy usage of existing and new projects, as they comply with President Obama's Executive Order on Greenhouse Gasses.
- Ratepayers should be provided with information regarding these issues before water utilities make decisions on proposed water supply projects.

I. INTRODUCTION

New water management strategies are needed in the western United States. With mounting populations, over-tapped rivers, extended droughts and severely damaged aquatic ecosystems, water managers face increasing challenges in locating reliable water supplies for their communities, to protect their natural systems, and to sustain local and regional economies.

In the last century, reservoirs and associated pipelines and aqueducts were the dominant strategy for providing water in the western United States. The BOR alone lists 339 dams among its project facilities.[2] The Corps of Engineers and state and local water agencies have constructed hundreds of additional facilities. California's State Water Project includes 34 storage facilities and more than 700 miles of pipelines and canals.[3] These projects made possible the development of many large western cities and extensive irrigated agriculture.

This traditional water supply development pattern has slowed dramatically over the past two decades. There are many reasons for this change. First, traditional infrastructure projects are increasingly expensive and many ratepayers are resistant to further increases in water rates that have risen dramatically in recent years. Further, in much of the West, there is little "new" water to be developed by traditional water projects. Indeed, many rivers have already hit clear limits in terms of the water available for diversion. In addition, the public is increasingly supportive of efforts to protect rivers and wildlife. Finally, in much of the West, climate change is anticipated to further reduce available water supplies from traditional water projects.

At the moment, western water managers are pursuing two diametrically opposed strategies. On the one hand, many water agencies are investing in water conservation, water recycling, groundwater clean-up, and other tools designed to increase the efficiency with which we use existing supplies. On the other hand, some water managers and private entrepreneurs have offered a growing number of proposals for public and private long-distance water supply pipelines—usually without the surface storage projects that have been so common over the past century. Some of these projects are extremely large in scale and would stretch for hundreds of miles. This new generation of long-distance pipelines raises a host of questions for water policymakers and the public.

This analysis revealed that a range of key issues have often been overlooked in the analysis of these proposed projects. These issues include:

- Serious questions about the reliability of surface and groundwater sources for proposed pipeline projects, including potential environmental impacts, existing constraints on water sources, and the likely impacts of climate change on these supplies.
- Potential water user impacts, including impacts from proposed projects on other water users in overtapped basins, as well as water rate impacts and potential long-term water shortages for the communities that would rely on proposed new projects.
- The high financial and energy cost of many proposed pipeline projects.
- The growing number of proven, cost-effective, alternative approaches—particularly water use efficiency—that could offer greater potential to meet the needs of western communities more cheaply and reliably.

This report concludes that many of the pipeline projects under consideration today are dramatically different from those constructed in the past, in terms of sustainability of water supplies, available alternatives, costs, environmental impacts and energy use. The communities and agencies that are considering these projects would be well served by a careful analysis of the implications of these important choices.

II. PIPELINE PROJECTS: EXISTING AND IN DEVELOPMENT

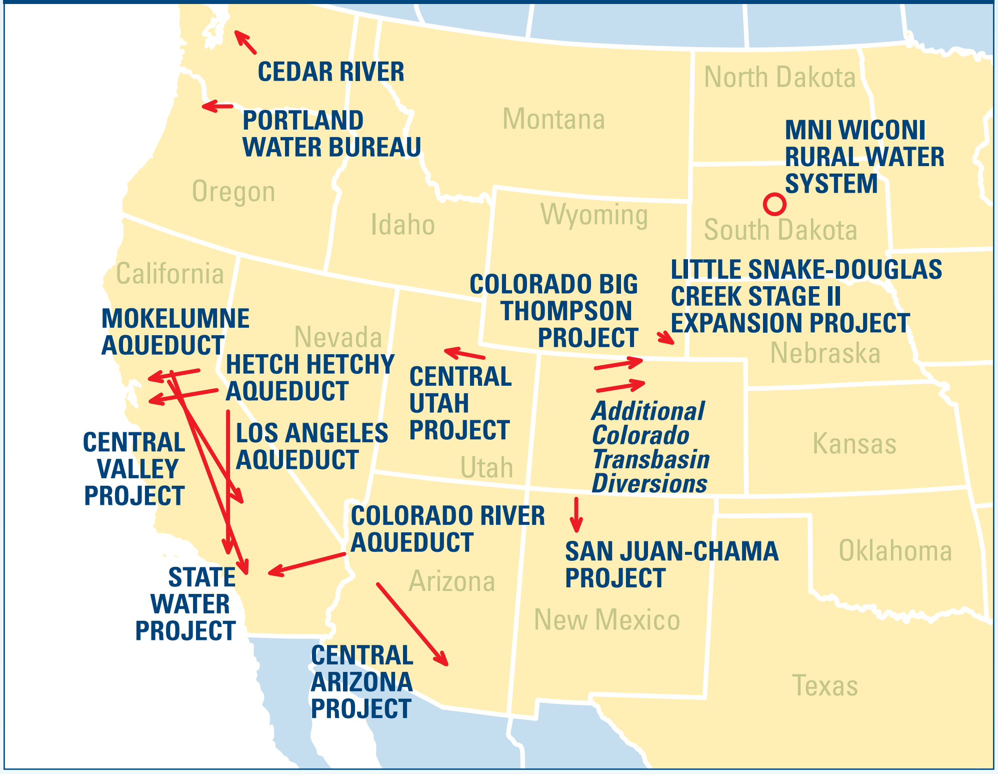
Pipelines and aqueducts have been a familiar part of the landscape in the western United States for more than a century. Many of these projects involve surface reservoirs and transbasin diversions. The American West is noteworthy in the history of water development, because the West was where the world first learned how to build dams on large river systems. In addition, the West still contains some of the most ambitious water engineering projects on the globe (see figure 1 and table A).[1] A summary of the existing projects listed on the next page can be found in Appendix A.

Table A. Existing Major Pipeline Project in the West

Project	Delivery Volume (afy)	Transbasin Diversion	Length (mi)
Little Snake-Douglas Creek Project, WY	21,000	Yes	21 miles diversion pipeline; 113 miles of delivery pipeline
The Colorado-Big Thompson Project, CO	213,000	Yes	35 miles of tunnels; 95 miles of canals
Additional Colorado Transbasin Diversions, CO. Grand River Ditch, Harold D. Roberts Tunnel, Homestake Tunnel, Moffat Water Tunnel and Twin Lakes Tunnel	150,000	Yes	56.6 miles of tunnels
San Juan-Chama Project, NM	86,210	Yes	27 miles of tunnels
Central Utah Project, UT	218,000	Yes	More than 200 miles of aqueducts, tunnels, and canals
Central Arizona Project, AZ	1,500,000	Yes	335 miles of aqueducts, 15 miles of tunnels
Colorado River Aqueduct, CA	1,200,000	Yes	242 miles of aqueduct; 63 miles of canals; 92 miles of tunnels; 84 miles of buried conduit and siphons
Los Angeles Aqueduct, CA	254,000	Yes	223 miles of canal and pipelines—first aqueduct. 137 miles—second aqueduct
California State Water Project, CA	2,400,000	Yes	700 miles of pipelines and canals
Central Valley Project, CA	5,300,000	Yes	500 miles of canals, conduits, tunnels, and related facilities
Hetch Hetchy Aqueduct, CA	165,000	No. Transfer to a different sub-basin	160 miles of pipeline
Mokelumne Aqueduct, CA	364,000	No. Transfer to a different sub-basin	91 miles of pipeline
Portland Water Bureau, OR	132,000	No. Transfer to a different sub-basin	26 miles of pipeline
Cedar River, WA	103,500	No	56 miles of pipelines
Mni Wiconi Rural Water System, SD	Projected 8,591–12,474	No	4,400 miles of pipelines

This paper summarizes 19 of the more prominent existing pipeline projects in the West. These projects were selected to include the largest pipeline projects, as well as broad geographic representation. The projects are summarized in roughly clockwise order as shown on figure 1, beginning in the headwaters of the Colorado River.

Figure 1: Existing Pipeline Projects



Little Snake-Douglas Creek Project, WY
- Communities Served: Cheyenne, Wyoming
- Water Source: Douglas Creek Watershed and Little Snake Watershed

The Colorado-Big Thompson Project, CO
- Communities Served: Colorado Front Range and Plains
- Water Source: West Slope water from Colorado River headwaters

Additional Colorado Transbasin Diversions, CO. Grand River Ditch, Harold D. Roberts Tunnel, Homestake Tunnel, Moffat Water Tunnel and Twin Lakes Tunnel
- Communities Served: Colorado Front Range
- Water Source: Colorado River Basin

San Juan-Chama Project, NM
- Communities Served: Rio Grande Basin
- Water Source: San Juan River Tributaries

Central Utah Project, UT
- Communities Served: Uintah and Bonneville Basins, and the Wasatch Front
- Water Source: Bonneville and Green River Basins

Central Arizona Project, AZ
- Communities Served: Southern Arizona
- Water Source: Colorado River
- Southern California

Colorado River Aqueduct, CA
- Communities Served: Southern California
- Water Source: Colorado River

Los Angeles Aqueduct, CA
- Community Served: Los Angeles
- Water Source: Mono Lake Basin and Owens River

California State Water Project, CA
- Communities Served: California's Central Valley, Alameda and Santa Clara Counties, cities on the northern edge of the San Francisco Bay Area, California's Central Coast, Southern California
- Water Source: Sacramento-San Joaquin Delta

Central Valley Project, CA
- Communities Served: Central Valley, Central Coast, and Santa Clara County
- Water Source: Sacramento-San Joaquin Delta

Hetch Hetchy Aqueduct, CA
- Communities Served: San Francisco, San Mateo, Santa Clara and Alameda Counties
- Water Source: Tuolumne River in Yosemite National Park

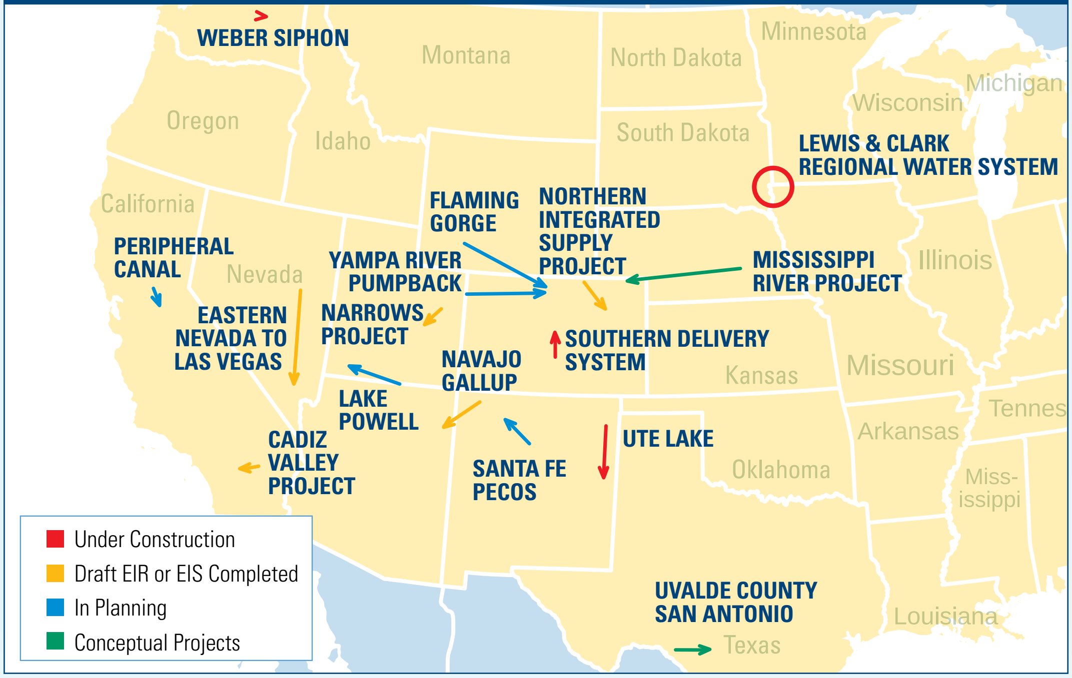
Mokelumne Aqueduct, CA
- Communities Served: East Bay communities, including Oakland, Berkeley and Richmond
- Water Source: Mokelumne River

Portland Water Bureau, OR
- Communities Served: Portland, OR
- Water Source: Bull Run watershed

Cedar River, WA
- Communities Served: Seattle, WA
- Water Source: Cedar River

Mni Wiconi Rural Water System, SD
- Communities Served: South Dakota
- Water Source: Missouri River

Figure 2: Projects in the Pipeline



Flaming Gorge, WY and CO
- Communities Served: The Front Range of Colorado, and Wyoming
- Water Source: Green River
- Federal Funding: Funding not yet identified

Lake Powell Project, AZ and UT
- Communities Served: Utah
- Water Source: Colorado River
- Federal Funding: No

Yampa River Pumpback, CO
- Communities Served: The Front Range of Colorado
- Water Source: Yampa River
- Federal Funding: No

Navajo-Gallup Project, NM
- Communities Served: Eastern section of the Navajo Nation, the southwestern part of the Jicarilla Apache Nation, and the city of Gallup
- Water Source: San Juan River
- Federal Funding: Yes (100%)

Southern Delivery System, CO
- Communities Served: Colorado Springs and surrounding communities
- Water Source: Arkansas River
- Federal Funding: No

Cadiz Valley Water Conservation, Recovery and Storage Project, CA
- Communities Served: Southern California Water Districts
- Water Source: Groundwater from Bristol, Fenner, and Cadiz Watersheds
- Federal Funding: No

Peripheral Canal/Tunnel, CA
- Communities Served: Central California, Southern California, and some Northern California water agencies
- Water Source: Sacramento River
- Federal Funding: No

Weber Siphon, WA
- Communities Served: Agricultural land in the Odessa Subregion in Washington State
- Water Source: Columbia River
- Federal Funding: Yes (100%)

Lewis and Clark Regional Water System, SD, IA, and MN
- Communities Served: South Dakota, Iowa, Minnesota
- Water Source: Aquifer adjacent to the Missouri River near Vermillion, SD
- Federal Funding: Yes (80%)

Mississippi River/Ogallala Aquifer, Various states
- Communities Served: Colorado River Basin communities, including Las Vegas, and western irrigation
- Water Source: Mississippi River
- Federal Funding: No

Narrows Project, UT
- Communities Served: Sanpete County in Utah
- Source: Price River, a tributary of the Green River
- Federal Funding: The applicants propose funding from the Small Reclamation Projects Act

Ute Lake Project, NM
- Communities Served: Eight eastern New Mexico communities
- Water Source: Canadian River
- Federal Funding: Yes (75%)

Santa Fe-Pecos, NM
- Communities Served: Santa Fe and other communities in the Rio Grande Basin
- Water Source: Transfer of Pecos River water rights used for agriculture
- Federal Funding: No

Eastern Nevada to Las Vegas, NV
- Communities Served: Las Vegas and surrounding communities
- Water Source: Groundwater from 5 Basins: Snake Valley, Spring Valley, Cave Valley, Dry Lake Valley, and Delamar Valley
- Federal Funding: No

Northern Integrated Supply Project, CO
- Communities Served: 15 Northern Front Range water providers
- Water Source: Cache la Poudre River
- Federal Funding: No

Uvalde County – San Antonio Pipeline Project, TX
- Communities Served: San Antonio, Texas
- Water Source: Groundwater from Edwards Aquifer
- Federal Funding: No

In recent years, a host of new water conveyance pipeline projects have been proposed by western water managers and entrepreneurs. (Please see figure 2 and table B. Appendix B also includes a summary of the 15 proposed projects presented in table B, which are at various stages of planning and construction.)

PROPOSED MAJOR PIPELINE PROJECT IN THE WEST

In April of 2012, the BOR's Colorado River Basin Water Supply and Demand Study released a summary of more than 140 options that have been submitted by stakeholders to help resolve water supply and demand imbalances in the basin.[2] Thirty-one percent of the options received by BOR included increasing available supply through a range of strategies such as new pipelines, desalination in Southern California and Mexico, water recycling, cloud seeding, and watershed management. The list of pipeline-related options includes proposals to import water from rivers including the Snake, the Columbia, the Clark's Fork of the Yellowstone River, the Missouri, the Mississippi, and the Bear. Many of these proposals appear to be at a conceptual level. (With the exception of the Mississippi River project, which has been proposed elsewhere, these projects are not included in figure 1 and table B. Brief summaries of these proposals are, however, included in Appendix B.)[3]

There is a critical difference between most of the proposed pipeline projects summarized here and many of those built in the past century. Most of the pipeline projects in the past were constructed as part of larger water projects. In particular, most of the existing projects were built in conjunction with surface storage projects on major river systems. These surface storage projects were expensive and often came at significant environmental cost. Nevertheless, they produced relatively reliable sources of water for pipelines and aqueducts to carry to distant users. By comparison, most of the new generation of pipeline projects do not include new surface storage facilities. As the discussion in the next section indicates, this change is, to a large extent, the result of the far less abundant water sources that this new generation of pipeline projects propose to tap into.

Together, these new pipeline proposals represent a significant new phase in western water policy, which present critical issues that must be closely examined before new projects and those under development are pursued further. Key issues include: 1) sustainability of water sources, including environmental impacts, existing uses and climate change; 2) transbasin diversions; 3) potential alternatives, including water use efficiency; 4) renewable and conventional energy use; and 5) the role of federal agencies. All of these issues are examined in depth in the following chapters.

Table B. Projects in the Pipeline

Colorado River Basin Projects	Delivery Volume (afy)	Transbasin Diversion	Project Cost	Length (mi)
Flaming Gorge Pipeline, WY and CO	250,000	Yes	$6 BB	500
Lake Powell Pipeline Project, AZ and UT	100,000	No	$1.064 BB	158
Yampa River Pumpback, CO	300,000	Yes	$3.2 BB to Front Range $3.9 BB to Denver	250
Gallup-Navajo Pipeline Project, NM	35,893	Yes	$864 MM	260
Narrows Project	5,400	Yes	$40.3 MM	16.8
Total Proposed New Colorado River Diversions	**691,293**			
Other Western Projects				
Southern Delivery System, CO	52,900	No	$1.1 BB	62
Ute Lake Pipeline Project, NM	16,450	No	$500 MM	87.5 miles of transmission pipelines, 94.8 miles of lateral pipelines
Santa Fe-Pecos Pipeline, NM	6,600	Yes	Unknown	150
Eastern Nevada to Las Vegas Pipeline, NV	84,000 (SNWA projects a maximum capacity of 217,655)	Yes	$3.5 BB	300
Cadiz Valley Water Conservation, Recovery and Storage Project, CA	50,000	Yes	$536 MM	43
Peripheral Canal/Tunnel, CA	Uncertain	Yes	$12 BB	37
Weber Siphon, WA	30,000	No	$48 MM	< 2
Lewis and Clark Regional Water System, SD, IA, and MN	24,770	No	$433.85 MM	337
Mississippi River/Ogallala Aquifer, various states	Unknown	Yes	Unknown	Unknown
Northern Integrated Supply Project, CO	40,000	No	$490 MM	36 to 62
Uvalde County – San Antonio Pipeline Project, TX	40,000	Yes	$250 MM	67 to 75

III. SUSTAINABILITY OF WATER SOURCES

Most previous pipeline projects have included large facilities—primarily surface storage projects—to capture and store water to be conveyed to end users. By contrast, most of the proposed pipeline projects summarized in this report are associated with far less abundant water sources than were water projects in the past.

Some of the proposed systems would carry water from groundwater basins that provide questionable long-term yield. Others would carry surface water from basins that are already undergoing severe water stress. For example, several of these projects would tap into the Colorado River and existing Colorado River Basin storage projects (e.g. Flaming Gorge and Lake Powell) that are in long-term decline. The proposed Mississippi River project is certainly a fundamentally different proposal from the rest of the projects located in the more arid West. That project, however, faces a wide range of additional challenges.

The fact that only three of the proposed projects presented in this report include new proposed surface storage facilities is primarily because of a realization that there is limited additional surface water yield to capture in the basins into which these projects would tap.

As the West pursues ever more distant sources of water, the issue of sustainability looms over the search for new water supplies. The landscape facing this new generation of water supply pipelines is fundamentally different from that facing water managers in the past. A century and a half ago, most pioneering western water leaders faced a largely undeveloped landscape and few competing uses of water. Today, that landscape has changed dramatically, leading to significant concerns regarding the extent and cost of additional water from western rivers and groundwater basins. Water projects can only generate reliable water supplies if they tap into reliable sources.

The sustainability of water supplies in the West should be confronted by policymakers in a far more focused fashion than it has to date. The *hot spots* for reliable supplies, such as Los Angeles, Las Vegas, and Phoenix, and other major metropolitan areas are well known, but medium, small, and even rural areas are now confronting significant potential shortages of water. For example, Congress has just authorized hundreds of millions of dollars to deliver water to the sparsely populated Navajo reservation and for the small town of Gallup, New Mexico. (This project was authorized to resolve Indian water rights claims, which raises different issues from other federally funded projects.)

Meeting water needs is challenged by population growth, groundwater mining, competing demands for water from different sectors, ecosystem degradation, and increasingly from the effects of climate change. There is increasing evidence that water use across much of the West, particularly the Southwest, is significantly out of balance. Our review found that many factors affecting long-term reliability have been overlooked, or not analyzed in sufficient detail. This chapter summarizes a broad range of issues that affect the sustainability of water from proposed pipeline projects.

A. RELIABILITY OF SURFACE WATER SOURCES

Many surface water sources in the West are under severe stress as a result of existing uses. Because the entire flow of the Colorado and the Rio Grande Rivers are captured upstream, these large rivers often run dry before they reach the sea. As a result, there is no remaining "new" water to be captured in these systems.

Indeed, existing supplies are predicted to decline over time. For example, BOR recently determined that the long-term average supply in the Colorado River Basin is less than recent average water use.[1] As discussed later, this imbalance is projected to increase in the future. As indicated by table B, recently proposed new pipeline projects represent a

total additional potential demand of more than 690,000 af annually on the Colorado River. (These are not the only proposals that would increase diversions from the Colorado River Basin. Two other water development projects in Colorado that do not involve new pipelines, the Windy Gap Firming Project and the Moffatt Collection System Project, would further increase transbasin diversions by 33,000 af and 18,000 af per year, respectively.) [2]

Because there is no "new" water to capture in the Colorado River Basin, surface-storage projects would not increase the net amount of water available for use. As a result, in the short-term, these additional proposed Colorado River Basin diversions would likely result in further reductions of stored water in a basin that has faced a dramatic reduction in storage over the past decade. In the long-term, such projects may increase the pressure on the supplies currently used by others. Simply put, where there is no available new supply, the water diverted by new projects must come from somewhere. This issue is perhaps most clear in the Colorado River Basin, but it could be a challenge facing proposed projects in other basins.

B. GROUNDWATER MINING

Aquifers are used by many cities in the United States and represent the source for about 20 percent of the nation's fresh water withdrawals.[3] Groundwater has allowed the growth of western cities and enabled agriculture in areas far removed from available surface waters. But, in the arid West, many aquifers are being mined, and as they are drawn down, current users will join those looking for alternative water supplies. For example, in the past 50 years, California's Tulare Lake Basin has suffered from more than 60 million af of cumulative overdraft.[4] Additionally, the Ogallala Aquifer, which extends northward from Western Texas to South Dakota, is in a state of overdraft. The aquifer could be depleted in only a few decades if withdrawals continue unabated.[5]

The U.S. Geologic Survey (USGS) has determined that declining groundwater levels is a widespread phenomenon around the nation.[6] As shown in figure 2 and explained in table B, the Cadiz Valley project proposes to extract up to 50,000 afy—ten times one estimate of long-term recharge. The Las Vegas pipeline would also lead to long-term declines in groundwater elevations.

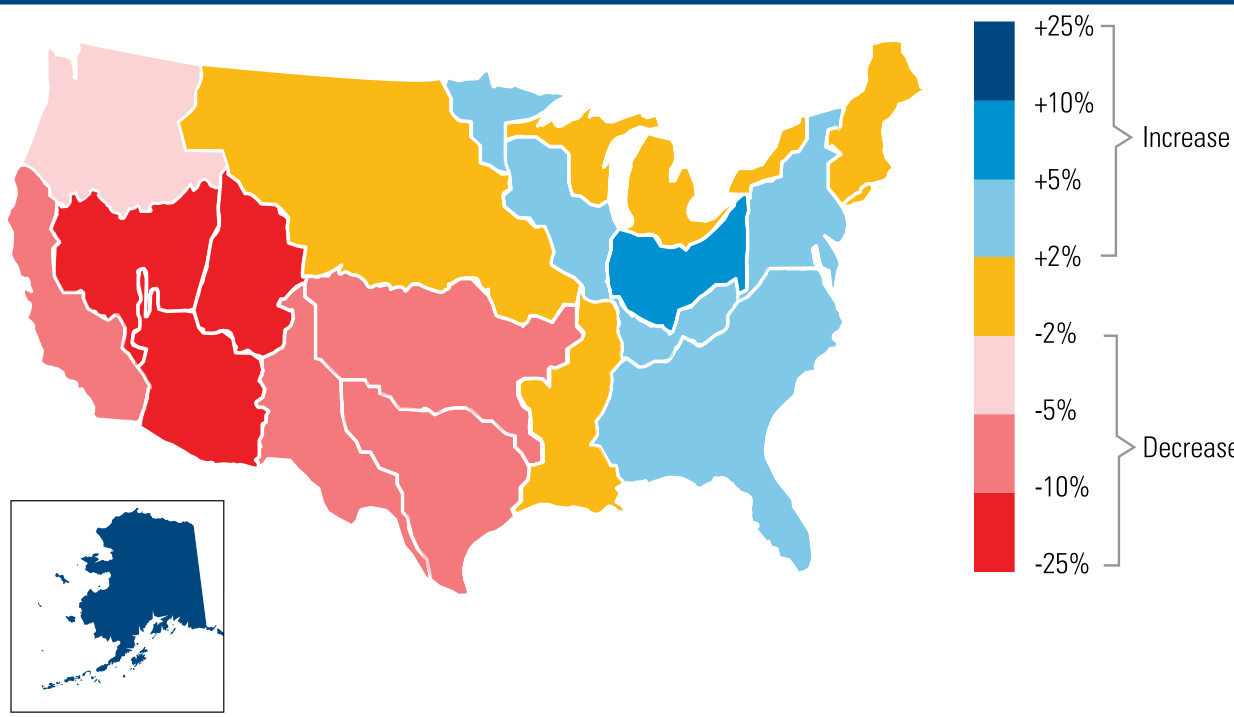
If proposed pipeline projects tap into groundwater in an unsustainable manner, these projects could lead to increased water usage, followed by an inevitable reduction in supply. Thus, these projects could increase future water shortages.

This trend toward transbasin projects that rely on groundwater represents a reversal of an historic pattern of development. Projects like the Central Arizona Project, the Central Valley Project, and California's State Water Project were designed in part to provide surface water to replace unsustainable groundwater pumping. Today, as those surface sources begin to hit limits, some proposed pipeline projects are turning back to groundwater sources.

C. CLIMATE CHANGE

Climate change will have a range of impacts on water supplies in the West. Higher temperatures will increase losses of water through increased evaporation and transpiration, which will affect agricultural irrigation and urban landscapes, particularly where turfgrass is prevalent. In both cases, increased temperatures will increase water demands,

Figure 3: U.S. Climate Change Science Program Projections for Reductions in Flows By Mid Century



unless there are changes in current management practices. Changes in precipitation patterns and, in some locations, total precipitation, are also expected to reduce available water supplies in much of the West.[7] Climate change could also result in more frequent prolonged dry periods and severe droughts. This could lead to increased challenges for agriculture, which is the largest consumer of water, and also for municipal, industrial and other uses.

Additionally, unless current practices change, industrial cooling could require increased water quantities due to increased atmospheric and water temperatures.[8]

The U.S. Climate Change Science Program (USCCSP) has projected that the Colorado River Basin is likely to face a decline in runoff of -10 to -25 percent by mid-century as a result of climate change impacts (see figure 3).[9] The BOR has adopted a relatively conservative approach, projecting a 9 percent decline in water availability by mid-century (see figure 4).[10]

The BOR has concluded recently that, by mid century, the Colorado River may suffer a shortfall of 3.5 million acre feet (maf) or more annually "particularly when considering potential changes in climate."[11] This trend of increasing demand and decreasing supply in the Colorado River Basin is shown in figure 4.

These potential climate change effects extend across much of the West. According to an analysis undertaken for NRDC, more than 1,000 counties—one-third of the counties in the nation—are likely to suffer from high to extreme water stress, when considering the results of climate change. Another 1,100 counties were predicted to suffer from moderate water stress. These counties include much of the West (see figure 5).[12] Finally, climate change may reduce water availability in groundwater basins in parts of the West.[13]

In short, climate change may decrease the potential water available from both surface and groundwater sources in the West. Each of the proposed projects discussed here is at a different stage in development. Nonetheless, the treatment of the challenges posed by climate change for these projects was mixed and, in general, lacked detail and adequate analysis.

Several of these documents simply mention that climate change could have an impact on the project, without further analysis. For example:

- **Lake Powell Project:** The draft climate change study for this project noted future water shortages are expected due to climate change.[14] Specifically, the analysis concluded that "Additional potential future curtailments (due to climate change) could affect deliveries through the Lake Powell Pipeline." The analysis also concluded that the "intake would be designed at an elevation which would be physically capable of receiving water in times of low storage."[15] NGOs have criticized the treatment of climate change in the Draft Environmental Impact Statement (DEIA).[16] The document does not quantify potential reductions in available water supplies.
- **Ute Lake:** The BOR's analysis for the Ute Lake project

Figure 4: Future Potential Colorado River Basin Shortages Projected by the U.S. Bureau of Reclamation Colorado River Basin Study

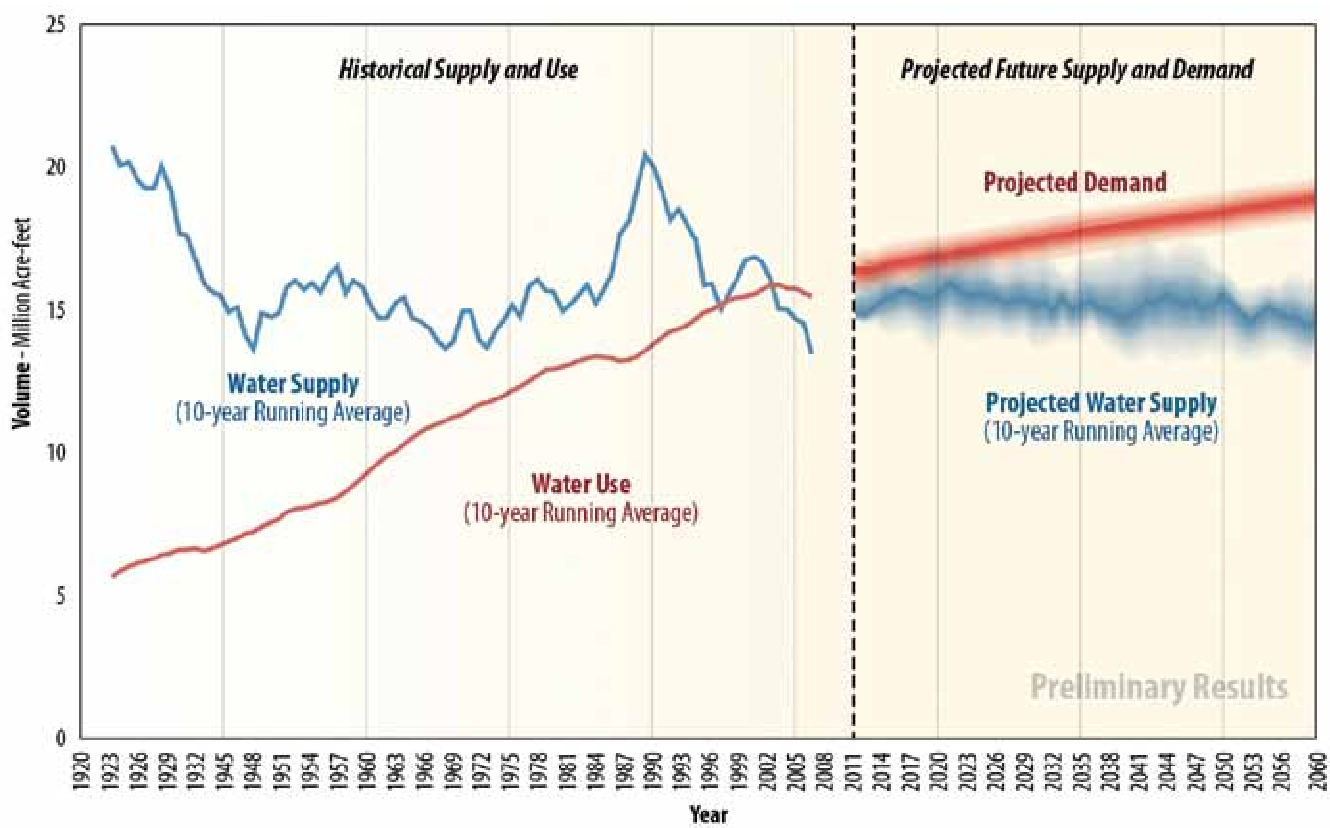
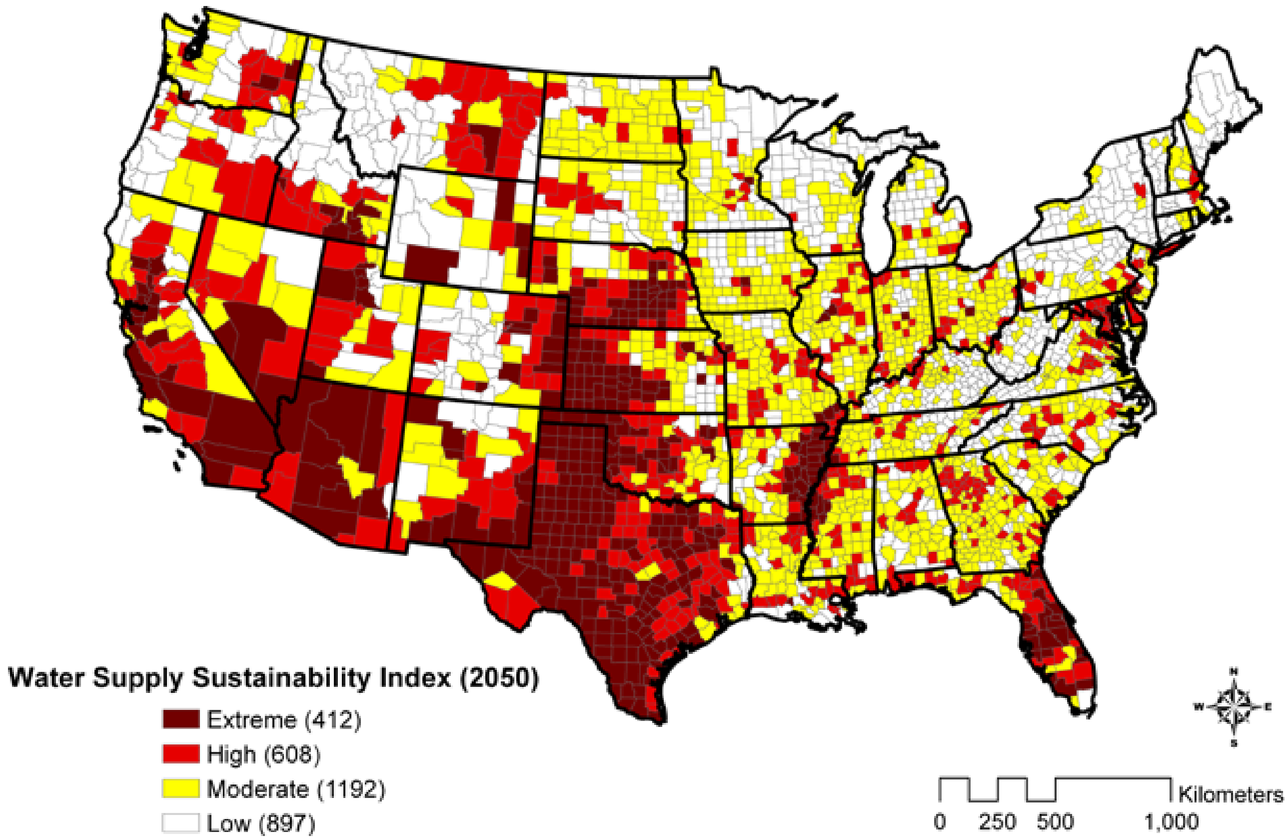


Figure 5: Water Supply Sustainability Index at the County Level (2050), including Climate Change Impacts



inexplicably concluded that climate change would lead to additional precipitation in the region.[17] This conclusion runs contrary to the bulk of scientific studies of the likely effect of climate change on the southwestern United States, such as the USCCSP, which projected a 5 to 10 percent reduction in runoff in this region (see figure 4).

- **Cadiz Valley Project:** This draft Environmental Impact Report mentions climate change, cites the study (discussed earlier) prepared for NRDC by TetraTech, and concludes that local runoff could be reduced.[18] The document does not quantify this potential impact.
- **Narrows Project:** The BOR draft Environmental Impact Statement (EIS) does not discuss the availability of additional water in the Colorado River Basin, nor does it cite any of the many studies that have concluded that climate change is likely to significantly reduce the availability of water in the Colorado River Basin. Instead, following a generic discussion of possible climate-induced impacts, the document states that:

  > "Reclamation has undertaken steps to model the effects of climate change on water delivery systems on a regional basis and for its larger reservoirs, such as Lake Powell and Flaming Gorge Reservoir. To date, however, models have not been developed with sufficient detail or sensitivity to capture small projects such as the proposed Narrows Project."[19]

Several of the projects analyzed include only a brief summary of the range of impacts suggested by different climate models. For example:

- **Navajo-Gallup:** The Final EIS for this project states that, as a result of climate change:

  > "The impact to total runoff to the San Juan River is expected to be from -38 percent to +8 percent. These changes would reduce the available water supply and affect the ability of the system to meet the Flow Requirements promulgated by the SJRBRIP. However the changes are sufficiently complex that an estimation of the impact on Flow Recommendations is not possible for a detailed analysis."[20]

  This discussion includes a broad range of possible climate change impacts on flow. However, as in the case of the Ute Lake project, this discussion does not reflect the scientific consensus regarding the likelihood of a reduction in total instream flows in this region.
- **Las Vegas Pipeline:** The DEIS includes a significant discussion of climate change and potential impacts on regional hydrology and water available for the project. However, the document concludes that:

  > "(T)here is insufficient information available to predict how changes in climate would affect the rate of groundwater recharge in the region. Because of the uncertainties regarding

> potential effects of climate change on the groundwater flow system, it was not possible to provide a reasonable or meaningful simulation of the combined effects of pumping and climate change on water resources."[21]

Thus, the DEIS mentions the potential impact of climate change on existing Southern Nevada Water Authority supplies, but does not quantify the potential impacts of climate change on the water available in the groundwater basins from which the proposed project would pump.

Only the analysis for the Peripheral Canal included quantified estimates of impacts on water availability for the proposed project. The Bay-Delta Conservation Plan (BDCP), which is analyzing a complex project (described in Appendix B), including a large proposed tunnel, recently released an administrative draft Effects Analysis (EA) that includes a significant investigation of the likely impacts of climate change on the Bay-Delta system.[22] These impacts include a general drying trend, changes in the mix of rain and snowpack, sea level rise, and increased temperatures. The administrative draft EA includes significant quantified reductions in future water yields from the preliminary proposed project as the result of climate change impacts, including changes in hydrology and sea level rise. This analysis has been greatly facilitated by California's extensive adaptation planning on climate issues. A more detailed appendix on potential climate change impacts is expected to be released by BDCP in the near future.

Predicting the likely impacts of climate change on water supply availability is more difficult in some parts of the West. Even in these areas, however, projects can address this risk—by analyzing a range of scenarios, presenting the bulk of the conclusions of scientific analyses, and analyzing the relative confidence of estimates from the scientific community regarding impacts on water availability.

Given the cost of these projects and their importance to the future of communities planning them, the stakes are high. Constructing new pipelines that rely on unreliable water sources could have significant long-term risks.

D. STATE LEVEL CLIMATE AND WATER ADAPTATION PLANNING

In April of 2012, NRDC released a report, *Ready or Not: An Evaluation of State Climate and Water Preparedness Planning*, which evaluates the efforts of all 50 states to prepare adaptation strategies to address the likely impacts of climate change on water resources. The report includes four preparedness categories to compare progress made among states. Those categories include states that have undertaken comprehensive adaptation planning, states with fragmented adaptation planning, states with limited adaptation efforts and those with no adaptation planning. Of the 17 western states, the report concludes that only three—California, Oregon, and Washington—are among the nation's most prepared states, and adaptation planning efforts have stalled in some areas in one of those states (Oregon).[23] On the other hand, 13 western states fall into the last two categories—states that have done nothing or very little to prepare for water-related climate impacts. Those states include Arizona, Kansas, Idaho, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming. It is noteworthy that most of the states in the Interior West, where the impacts of climate on water supply may be most profound, have done little to prepare. Indeed, five of the seven Colorado River Basin states are identified among the states in the last two categories.

Comprehensive state adaptation planning addresses a broad range of the potential impacts of a warming climate on aquatic ecosystems, water supply, and other water resources. Many of those issues are central to the evaluation of proposed pipeline projects. Clearly, addressing all of those issues comprehensively at the project level is more difficult without a broad state-wide adaptation framework. Thus, the lack of adaptation planning in most western states makes it more difficult to adequately evaluate the climate issues related to proposed new conveyance projects.

E. WATER USER IMPACTS

There are several ways in which poorly conceived pipeline projects could affect water users. First, in fully-appropriated river systems, additional diversions will increase pressure on existing water users. This risk is very clear today on some river systems, such as the Colorado. Second, using groundwater from mined basins to support new urban growth is a recipe for a future crisis; by definition a mined basin will not provide a secure water supply. In California, which lacks state-wide groundwater management, and in other states with less than fully protective groundwater management, such additional pumping could threaten existing water users. And third, water users who would rely on poorly conceived pipeline projects could face unreliable supplies and future cost increases.

F. BIODIVERSITY

The declining health of aquatic ecosystems highlights the need to protect remaining functioning ecosystems and to restore rivers. Especially in the western United States, wildlife species rely heavily upon aquatic habitats. For example, in New Mexico, waterways comprise less than 2 percent of the landscape, but are critical to a significant number of wildlife species.[24]

- Fifty-five percent of all wildlife species and 75 percent of all vertebrates depend on waterways for survival.
- Eighty percent of all sensitive and specially classified species (State or Federal threatened and endangered listed species) rely on waterways at some point in their life cycle.
- Desert riparian ecosystems have the highest density of breeding birds in North America, with at least 400 different bird species observed.

The decline of aquatic-dependent species is partly or wholly due to low-flow conditions in many river systems. In river systems such as the Rio Grande, Colorado, Klamath, Owens, San Francisco Bay-Delta, and many others, increasing municipal and agricultural diversions have led to significant ecosystem impacts. Proposed projects that would increase diversions from already imperiled ecosystems should carefully examine likely current and future constraints to protect aquatic ecosystems. Poorly planned projects could cause additional impacts on already degraded ecosystems, such as the San Francisco Bay-Delta. Such supplies could also prove to be unreliable in the long-term because of the likelihood of additional future regulatory constraints.

Rio Grande at Big Bend National Park, Texas

G. POPULATION GROWTH IN THE WEST

The western United States has grown at an explosive rate over the last two decades. In the 1990's the population of the western United States grew by 19.7 percent, and an additional 13.7 percent in the 2000.[25] The growth has primarily occurred in what have been dubbed "urban archipelagos," such as Denver, Boise, Albuquerque, Las Vegas, Phoenix, and Tucson. In the past decade, large metropolitan areas have grown at more than twice the rate of "micro" areas (those with an urban area population between 10,000 and 50,000 residents).[26]

- In the 2000s, the Las Vegas metropolitan area accounted for 72 percent of Nevada's 2010 population and 82 percent of the state's growth. Nevada led state population growth in both decades at 66 percent in the 1990s and then 35 percent in the 2000s.
- Arizona was second in state population growth, coming in at 40 percent and 25 percent in the 1990s and 2000s, respectively.
- Colorado ranked third, with 31 percent in the 1990s, and 17 percent in the 2000s; and Utah saw growth of 30 percent and 24 percent during these decades.[27]

Central Arizona Project

This growth is forecasted to continue through the 21st century, with Nevada's population projected to increase 23 percent by 2030, Colorado's population projected to increase by 55 percent by 2040, Arizona's population to increase nearly 100 percent by 2050, and Utah's population to increase by over 110 percent by 2050.[28] California's population is also projected to increase 60 percent by 2050.[29] Pressure will continue to grow for reliable water supplies for municipal and industrial uses as western states become more and more populated.

The long-term consequences of the current economic slow-down may be different across the West. Some regions may experience lower growth than in recent decades. In these areas past estimates of future growth and water demand may be inaccurate and in need of revision. Other regions may recover more rapidly and return to rapid growth rates.

TRANSBASIN DIVERSIONS

Many of the existing and proposed projects described in this report involve or would involve transbasin diversions, which move water across hydrologic basins. Transbasin diversions are an ongoing source of conflict in western water policy. A community that loses significant water supplies can face a constrained future and the bitter political divisions over existing transbasin diversions reflect that understanding.

Before legislatures and courts gave a voice to smaller communities, their opposition may not have been viewed as significant by project proponents, but circumstances have changed. Even the relatively small pipeline from a rural area on the Pecos River to Santa Fe, New Mexico is being opposed by citizens in the area of origin.[30] As water resources become more constrained across the West, conflict around transbasin diversions can be expected to increase, and will likely have important implications for potential investments in this kind of traditional water development.

Some pipeline projects that transport water to distant users rely on rights that are relatively junior in seniority, yet also supply urban water uses that can be less flexible than agricultural uses. Thus, new transbasin diversion projects may present a rising number of significant challenges, as they increase reliance on imported water, increase the challenges involved in bringing river and groundwater basins into balance and increase the vulnerability of western communities and economies.

IV. POTENTIAL ALTERNATIVES, INCLUDING WATER USE EFFICIENCY

The issues summarized in the previous chapter address the sustainability and cost of proposed pipeline projects that would rely on surface and groundwater sources. Increasingly, alternative approaches, particularly water use efficiency, may provide more reliable and cost-effective strategies to meet future water supply needs. In designing water supply solutions, a range of actions should be considered, with a focus on the most affordable, effective solutions.[1] As water managers evaluate ways to meet new needs, they should consider adopting a "least cost first" approach to water supply investments, similar in concept to California's energy loading order.[2] Such a loading order approach focuses agency investments on the most cost-effective and environmentally preferable solutions before turning to investments that are less cost-effective and more environmentally damaging.

Analysis of the projects presented in this paper revealed that most had very limited analysis of efficiency as a project alternative or component. For instance, curiously, water conservation, as an alternative to the Cadiz Valley groundwater pumping project, was rejected because the region to be served by the project is already aggressively pursuing conservation measures.[3] Analysis of the project ignored the fact that some Southern California water agencies are planning major additional investments in conservation and other tools—and that additional cost-effective investments are possible.[4] Other examples of poor or inadequate analysis or consideration of water efficiency alternatives include:

- **Navajo-Gallup:** Analysis for this project concluded that water use levels were already so low (110 gallons per capita per day [gpcd] where piped water is available and 10 to 20 gpcd where water is hauled, among the lowest levels in the southwest), that efforts to further increase conservation and efficiency were simply unachievable.[5] The analysis did not include an evaluation of agricultural water conservation alternatives.
- **The Lake Powell Pipeline:** The alternatives analysis for the Lake Powell Pipeline included a very limited analysis of conservation potential, despite per capita water use as high as 430 gallons per capita per day.[6]
- **Narrows Project:** The DEIS for the project states that 270 gallons per capita per day are "required" for Sanpete County, Utah.[7] This level of per capita usage is assumed to remain unchanged, and that the region will see a 3 percent annual population growth rate until 2050.[8] The discussion of alternatives includes a modest discussion of agricultural water conservation and no discussion of opportunities to reduce per capita water use in the M and I sector, despite very high per capita water use.[9]

Perhaps most striking of all of the project analyses reviewed for this report is that for the Peripheral Canal; the current evaluation of alternatives to canal project does not include an analysis of water use efficiency, water recycling, or other tools as alternatives to be considered.

Only the Southern Delivery System included significant analysis of conservation alternatives. All alternatives evaluated for this project include a conservation component,


Irrigation system in turnip field

perhaps in recognition that water resources in Colorado are already heavily tapped.[10]

The growing importance of efficiency was highlighted by the National Research Council, which determined that the potential for new surface storage in the Colorado River basin is "limited," and that "(d)eclining prospects for traditional water supply projects are perhaps more correctly seen not as an end to "water projects" but as part of a shift toward nontraditional means for enhancing water supplies and better managing water demands."[11] Overall, water management is transitioning from traditional water development to a focus on improving water use efficiency.

A. AGRICULTURAL EFFICIENCY

In the West, agriculture continues to be the dominant consumer of water, continuing patterns that were established many decades ago. Increasing agricultural water efficiency can be achieved by modernizing farming techniques, including:

- Weather-based irrigation scheduling that uses local weather information to determine the amount of water needed
- Regulated deficit irrigation (inducing water stress in crops with drought-tolerant life stages, sometimes increasing crop quality while reducing irrigation amounts)
- Switching from gravity or flood irrigation to sprinkler or drip irrigation systems
- Switching to less water intensive crops

The Pacific Institute has estimated that these strategies can result in annual savings of nearly 700,000 af in California.[12] These and other management tools could reduce agricultural water demands across the West and could improve the sustainability of the agricultural economy. These savings also could provide for dry-year or permanent transfers to urban water users and the environment. In some areas, long-term or dry-year fallowing can also provide water for other uses, through voluntary transfers. Implementing efficiency measures could also result in significant savings by avoiding the cost of additional water development.

B. URBAN WATER USE EFFICIENCY

Many studies have documented the potential water savings from investments in urban efficiency. Improvements can be achieved by:

- Upgrading homes that have old, inefficient devices to higher efficiency fixtures (low-flow toilets and showerheads, aerating faucets, and low-use appliances)
- Alterations in commercial/industrial water use (installation of water efficient devices)
- Conversion of lawns and gardens to xeriscaping
- Residential metering and sub-metering
- Leak detection
- Rate structures that better communicate and capture the value of water (e.g., block rate pricing wherein lower rates are charged for low to moderate use, creating a direct and immediate economic incentive for conservation)

Applying these efficiencies in California alone has been estimated to result in water savings of 320,000 af per year, 2,300 GWh electricity savings per year, and 86.8 million therms of natural gas savings per year.[13]

One obvious efficiency to be gained is in fixing leaks in delivery systems. According to the Congressional Budget Office, many drinking water systems lose as much as 20 percent of treated drinking water each year due to leaks in piping networks.[14] One summary of the failing infrastructure for water delivery and treatment systems reports that an estimated 50 major main breaks and 500 stoppages occur for every 1,000 miles of pipe each year, amounting to an estimated 50,000 breaks and 500,000 stoppages annually in the U.S.[15] In 2009, Southern California Edison submitted a report to the California Public Utility Commission with an estimate of the potential water supply benefits of leak reduction in California.[16] The report estimated that 870,000 af is lost annually to leaks, and that 350,000 af could be cost-effectively recovered through leak reduction efforts.

Urban efficiency can also be increased through Low Impact Development (LID, or green infrastructure) to mimic natural infiltration systems by capturing and reusing stormwater runoff.[17] Runoff diversion and capture prior to discharge to surface waters can be used either to replenish groundwater supplies through infiltration or for gray water uses, like landscape irrigation and toilet flushing. NRDC has estimated that more than 400,000 af of water could be developed through LID investments in California by 2030.[18] In California, most runoff from urban areas is discharged into the ocean. In the Interior West, the capture of rainwater is being recognized as a useful conservation practice, despite some concerns. In Colorado and Utah, legislation was passed in 2009 making it legal for homeowners to capture rainwater.[19]

Wastewater recycling and reuse is another method to reduce the use of imported water. Recycled water is a viable alternative to imported water for uses that range from irrigating golf courses, parks, and crops, to recharging groundwater, mixing concrete, and even to firefighting. The National Research Council recently released a report that carefully endorses recycling of wastewater, noting the many cities where it is now practiced.[20] The California Department of Water Resources has estimated that 0.9 to 1.4 million af of recycled water could be developed in California by 2030.[21] By way of comparison, the annual water use of the City of Los Angeles is less than 0.7 million af per year.


Garden sprinkler system

It is important to note that water recycling and low-impact development can reduce downstream flows. Therefore, their potential to produce "new" water varies across the West, with the greatest potential in areas where urban runoff and treated wastewater are discharged to the ocean.

The promise of traditional development may be more alluring to politicians and engineering firms, but experience over the past two decades has shown that efficiency and reuse is the low hanging fruit.

C. EXAMPLES OF THE BENEFITS OF WATER USE EFFICIENCY AND OTHER TOOLS

Across the West and the nation, there are many examples of successful water use efficiency programs. For example, the Pacific Institute has examined the water use of 100 municipal agencies that rely on Colorado River water and determined that, between 1990 and 2008, per capita water use in these agencies declined, on average, by 1 percent per year during this period. Per capita water use in some cities declined far more, including Albuquerque (38 percent reduction), Southern Nevada (31 percent), Phoenix (30 percent), and San Diego (29 percent). Twenty-eight of these agencies reduced their total water deliveries, despite increases in population.[22] Additional examples across the nation include:[23]

- *Goleta, California*: Future water shortages from population growth and an insufficient water source prompted Goleta to establish a water efficiency program that emphasized plumbing retrofits, including high-efficiency toilets, high-efficiency showerheads, and increased rates. The program resulted in a 30 percent drop in total district water use, a 50 percent drop in per capita water use, and the city was able to delay a wastewater treatment plant expansion.[24]
- *Seattle, Washington*: The 10-year goal of the Seattle Water Partnership, which was launched in 2000, is to reduce per capita consumption 1 percent year and achieve a total savings of 11 million gallons per day (33.75 af) by the end of 2010, at a total cost of $55 million dollars.[25] By the end of 2010, the program had achieved cumulative savings of 9.56 mgd from residential, commercial and institutional customers at a cost of $35 million—results that are more cost-effective than anticipated.
- *Orange County, California*: This community uses advanced treatment technologies to purify wastewater, then allows it to percolate into the groundwater basin for later use as potable water. The Groundwater Replenishment System facility, which cost $481 million to build, is the largest water recycling facility in the world, producing 70 million gallons per day (214 af).[26] Orange County is planning to expand this project to 100 million gallons per day (306 af). This system uses approximately one-third the energy that would be required to desalinate seawater.[27]

These examples demonstrate that investments in efficiency and other water supply tools are proven, cost-effective approaches to meeting water supply needs that should be evaluated as a part of planning for any proposed pipeline project.

D. GAINS IN WATER USE EFFICIENCIES TRANSLATE INTO IMPORTANT ENVIRONMENTAL BENEFITS

Most major rivers in the United States are stressed by the competing demands for hydroelectric and thermoelectric power generation, municipal use, recreation, mineral production, livestock, agriculture, and wildlife. In the western United States in particular, population growth and the dependence on freshwater withdrawals for those populations have resulted in a trend of increasing demands on increasingly stressed supplies.

Water use efficiencies can help ameliorate the stresses of overuse and curb further degradation of rivers in a number of ways.[28] For instance, by reducing runoff from agricultural lands, efficiency improvements can lessen pesticides, fertilizers, salts, and fine sediments from surface erosion that can contaminate surface and groundwater sources, increase treatment costs for downstream users, and degrade fish and wildlife habitat.

Water conservation can, under some circumstances, also increase the amount of water left in the stream—also referred to as instream flows, which are environmentally important for:[29]

- Removing fine sediments that can cement river substrate and smother fish and invertebrate eggs and larvae
- Maintaining suitable levels of water temperature, dissolved oxygen, and water chemistry
- Establishing stream morphology, including the formation and maintenance of river bars and riffle-pool sequences
- Maintaining riparian communities, preventing riparian vegetation from invading the channel and altering stream form and function
- Flushing waste products and pollutants; and allowing and supporting fish passages and migrations

Investments in water use efficiency can also alter the timing of instream flow, contributing important environmental benefits. Although some withdrawn water may eventually flow back to a stream system via surface runoff or groundwater percolation, there is a lag time between when the water is withdrawn and when it flows back into the river. This timing can be important because the natural life cycles of many aquatic and riparian species are adapted to either avoid or exploit annual and seasonal variations in flows.

Finally, diversions from waterways can pose a direct threat to fish and wildlife populations. For example, large pumps for the California State Water Project and Central Valley Project have killed more than 110 million fish over the course of 15 years, included many threatened and endangered species, leading to expensive infrastructure retrofits, legal challenges, and controversial environmental restrictions on withdrawals.[30] Therefore, by compensating for lower diversion levels, water efficiency measures can benefit fish and wildlife.

It is important to note that all efficiency investments may not provide the above benefits. Increasing water use efficiency can reduce water use, leaving more water available to meet instream flow needs. However, wastewater reuse and increases in efficiency that increase consumptive use and reduce return flows can have the effect of reducing downstream flows. An affirmative program to protect instream flows is a necessary component of sustainable water management.

E. INCREASED WATER USE EFFICIENCY CAN RESULT IN ENERGY EFFICIENCY BENEFITS

Efficiencies gained in water use frequently result in efficiencies gained in energy use. This relationship is highlighted in a 2011 report by the U.S. Government Accountability Office (GAO), which evaluated energy efficiency reductions via improvements in the urban water lifecycle, from capture and pre-treatment to delivery, use, post-treatment, and discharge.[31] The GAO report detailed gains to be made in the following areas:

- Process optimization (implementing monitoring and control systems, modifying pumping operations, and reconfiguring aeration systems)
- Infrastructure improvements (equipment upgrades, including right-sizing equipment, and improving maintenance and leak detection)
- Water conservation
- Better energy management, beginning with energy audits of treatment facilities
- Improved advanced treatment options to lessen energy-intensive processes such as ultraviolet disinfection
- Redesigning systems to better integrate drinking water, wastewater, and stormwater management
- Use of renewable energy in operations

California has also investigated the energy benefits of improvements in the water sector. As a result, the state has included energy and greenhouse gas reductions from the water sector in the state's greenhouse gas reduction strategy. In that plan, the California Air Resources Board concluded that the water sector can contribute 4.8 million metric tons of carbon dioxide (CO_2) emissions reduction by 2020, with 1.4 million metric tons of that reduction coming from water use efficiency, and 2.0 million metric tons coming from water system energy efficiency.[32] The latter conclusion also suggests opportunities for water projects and water agencies to install system improvements, such as in-conduit hydropower facilities and efficient pumps to reduce energy consumption.

V. ENERGY USE—CONVENTIONAL AND RENEWABLES

The energy costs of capturing, storing, treating, and delivering water are very large. Pumping and treating water for industrial and urban uses consumes between 2 and 3 percent of the world's energy, and can cost up to half of a municipality's total operating budget in developing countries.[1] In the United States, one estimate is that upwards of 13 percent of the total energy consumption is water related.[2] Energy consumption for water delivery and wastewater treatment is typically 30 to 60 percent of U.S. city energy bills.[3] The California Energy Commission has concluded that in California 19 percent of electricity use, 30 percent of non-power plant related natural gas, and 88 million gallons of diesel fuel are consumed annually for water related uses—including urban and agricultural water use and including the energy costs related to transportation of water, end use (the single largest factor) treatment and discharge.[4]

Long-distance water pipelines can consume large amounts of energy.

Credit: BOR

Pipelines frequently require substantial amounts of energy to pump and transport water to out-of-basin users. For example, in California, the State Water Project's electricity use represents the largest single consumer of electricity, amounting to 2 to 3 percent of the state's entire electricity consumption.

The use of energy to pump water great distances has another significant consequence that exacerbates the environmental consequences of pipelines. The production of conventional energy requires copious amounts of water. Energy and water are thus interrelated. Water use consumes significant amounts of energy. We use energy to access many water sources, and vice versa. For example, water is diverted for electricity production at dams for hydroelectric power generation, and to cool thermoelectric power plants, which represent the single largest source of water withdrawals in the United States.[5] In addition, water is used in accessing some natural gas deposits and would be used in refining oil shale.[6]

Energy is also used to treat water for use to distribute it within a water district, heat it, and treat wastewater for disposal. If new water sources, such as saline waters, are tapped into, energy costs associated with treatment will rise. Advanced treatment, recharge, and reuse also have associated energy costs, although not necessarily higher than imported supplies. Developing technologies to reduce the energy costs of these processes is important, as is conserving water—the surest way to reduce energy use.

Analysis of the proposed pipeline projects covered in this paper reveal that despite the significant energy costs of water projects, many did not include a well-developed analysis of energy consumption. For example, the Ute Lake Pipeline Project effects analysis (EA) does not include a detailed discussion of the project's potential energy use. The document does include a discussion of the potential to include renewable energy facilities in the document. However, to date, the project applicants have chosen not to pursue renewable power facilities related to the project.

The DEIS for the Narrows Project does not include a discussion of the project's energy requirements.

The Cadiz Valley Project appears not to include total energy costs to reach end users. A draft EIR for the project was released in December of 2011.[7] In it, the project is estimated to use 3,112 kWh/MG of water delivery (or 1,014 kWh/af).[8] This number includes groundwater pumping and the energy required to pump water to the Colorado River Aqueduct (CRA). This total, however, does not include the energy cost to pump the water through the Colorado River Aqueduct to users in Southern California. The document acknowledges that the energy used by the CRA is significant—6.138 kWh/MG at full capacity.[9] Water from the Cadiz project would not, however, be conveyed the full length of the CRA. The document does not quantify the amount of energy that would be required to convey water through part of the CRA to end users. The energy discussion in this document focuses primarily on comparing energy use by the proposed project to energy used by the State Water Project, one of the most energy intensive water projects in the nation. The document does not compare the proposed project's energy use to the many local water supply options in Southern California that can consume a fraction of the energy used by the SWP.

A number of project documents, such as those for the Yampa River Pumpback and the Lake Powell Pipeline, include peak energy requirements,[10, 11] rather than total annual energy requirements and per acre-foot energy requirements.[12] Only a few projects analyzed projected factors including total energy use, per acre-foot energy requirements and associated greenhouse gas emissions. And very few projects addressed all of these issues. The per-acre-foot energy requirement is particularly important to understand the potential for long-term fluctuations in water costs as a result of changes in electricity prices.

The Lewis and Clark Regional Water System is projected to use, at completion, 24.2 GWh/y.[13] These energy numbers are derived from the project's Engineering Report analysis of operating costs, which does not summarize these energy demands, nor does it include a separate discussion of energy use. The project's federal Finding of No Significant Impact does not include an analysis of energy use.

Other projects that did not adequately analyze projected energy use include:

- **Northern Integrated Supply Project:** projected to result in an energy demand between 0.85 and 1.45 MWh/af.[14]
- **Southern Delivery System:** would require 4.63 MWh/af upon delivery. The energy required to meet 2046 water demands is projected to average 671 GWh per day, or 245 GWh per year. [15] This per acre-foot energy requirement is approximately equivalent to the energy cost of desalinated seawater and approximately 50 percent more than the energy required to pump water from the Bay-Delta to Southern California. [16] This system would demand the equivalent of the average daily per capita residential electricity use of over 12,500 Coloradans.[17]
- **Las Vegas Pipeline:** The June 2011 BLM DEIS prepared for the project indicates that the proposed pumping facilities will require the continuous use of 97.2 MW of power, including 51.9 MW for groundwater wells and associated facilities.[18] Power for the project would be provided by the Silverhawk Generating Station, a natural gas-powered facility with a capacity of 520 MW, 25 percent of which is owned by SNWA. The DEIS concludes that this electrical generation will result in the release of 327,000 tons of carbon dioxide per year—equal to the emissions from the electricity use of 35,000 homes.[19] The document adds that these energy requirements and greenhouse gas emissions may be reduced through the use of solar power and in-conduit generating turbines. These estimates do not include energy use per acre-foot.
- **Peripheral Canal:** The BDCP concluded recently that the preliminary proposed project (a 15,000 cfs tunnel project) would result in increased energy demands for pumping ranging from 2,027 to 2,319 GWh/y.[20] This compares with current net CVP energy use for water pumping of 814 GWh/y and SWP net energy use for pumping of 6,327 GWh/y. Thus, the project would represent nearly a one third increase in combined energy use.

The BDCP is pursuing a "dual conveyance" approach to pumping, in which some CVP and SWP water would be pumped through a new canal or tunnel, and other water would continue to be pumped from the existing CVP and SWP diversion points in the South Delta. As indicated above, water pumped through a new tunnel would require a significant amount of additional energy. This would add to the SWP's already large energy footprint, particularly for Delta water delivered to Southern California.

Some of these projects have not yet moved to the environmental analysis stage, so the energy costs have not been considered. The Santa Fe-Pecos Pipeline, for example, would climb nearly 4,000 feet in elevation to reach its destination.[21] This would be a lift double that of the California State Water Project's 2,000 foot lift over the Techachapi Mountains—an extraordinarily energy-intensive water project.[22]

The Mississippi River Project also has many options for water diversion, delivery and exchange from the Mississippi River. Nevertheless, pumping water to "mile high" Denver, one possible destination of a pipeline from the Mississippi, would include very high energy requirements. For example, the City of Omaha, which lies at the confluence of the Platte River and the Mississippi, lies 4,000 feet lower than Denver, at an elevation of 1,090 feet.

In short, many of these proposed projects would be very energy intensive. It is important to note that, in contrast, some water use efficiency alternatives can save significant amounts of energy.

A. THE FEDERAL GOVERNMENT'S ROLE IN THE ENERGY/WATER CONNECTION

The federal government currently does not compile information on energy use by water projects, except for the quantity of hydropower from BOR projects that is used to deliver federal water. There is limited information on current and proposed projects concerning the substantial amount of energy consumed by these facilities.

As discussed earlier, some pipeline projects require large amounts of energy. The use of fossil fuels to provide this energy could increase greenhouse gas emissions, contributing to the very warming that threatens western water supplies. President Obama ordered federal agencies to create inventories of their greenhouse gas emissions under Executive Order 13514 (October 5, 2009) and the Guidance on Federal Greenhouse Gases Accounting and Reporting (October 6, 2010). However the Department of Interior has not included in its inventory the greenhouse gas emissions that result from its water facilities or the projects that the BOR funds.[23]

The federal government is also required by the National Environmental Policy Act (NEPA) to provide environmental reviews of major federal actions that significantly affect the quality of the environment. Unfortunately this NEPA review is sometimes not sufficiently probing, with respect to water alternatives or the use of renewable energy to power conventional facilities. For example, the Navajo-Gallup EIS does not include the use of renewable energy in its list of alternatives.

B. RENEWABLES AND WATER PROJECT ENERGY USE

Pumping and moving water is very energy intensive and using renewable sources to provide at least some of the energy would be beneficial. Much of the western United States receives abundant sunshine and wind. As a result, the West has significant potential for the development of renewable energy sources, which significantly reduce greenhouse gas emissions. However, renewable energy projects must be carefully designed and selected. It is important to note that solar technologies have very different water requirements. For example, dry-cooled thermoelectric solar can require some make up water for boiler systems and water to wash heliostats. However, wet-cooled solar has dramatically greater water requirements. As a result, the California Energy Commission has adopted a policy that represents a de facto prohibition on wet cooling for solar facilities in California's desert regions, except in very limited circumstances.[24] In addition, large-scale wind, solar, and transmission facilities must be cited carefully to avoid environmental impacts.[25]

When determining whether wind or solar energy should be used, cost may be a controlling factor. In 2009, renewable energy accounted for 8 percent of total U.S. energy consumption. Of that percentage, only 9 percent was from wind, and 1 percent was from solar energy (the remainder is provided by hydropower, biomass, and geothermal sources).[26] Although wind energy accounts for more energy production than solar in the United States, solar energy technology is improving rapidly. Large scale solar adoption is becoming more feasible all of the time.[27]

Renewable energy sources, such as photovoltaic solar, wind, and in-conduit hydropower to help power water projects are increasingly being pursued across the world. A few examples include:

- California water agencies, currently the largest customer group for solar installations, with 20 MW of generation currently in operation or under construction, and nearly 50 MW in the proposal stage.[28]
- The Palmdale, California Water District, which uses a 950 kW wind turbine at its water treatment facility, providing the majority of the energy required for operation of the facility. The district has installed a solar array system at its shop facilities buildings to offset power costs.[29]
- The Las Vegas Valley Water District, operating solar photovoltaic systems at six reservoirs and pumping station sites since June 2007, with a combined capacity of 3.1 MW. The system cost $23.4 million to build and is being paid back through annual energy savings of approximately $725,000 and through the sale of renewable energy credits to local electric utilities,

The Los Angeles aqueduct, unlike most proposed projects, does not require energy for pumping.

yielding a payback period of 11.6 years for a system with a projected lifetime of 35 years.[30]

- The largest seawater desalination project in the Southern Hemisphere, which opened in 2006 in Perth, Australia, with a daily capacity of 140,000 cubic meters. The facility is powered by energy from a wind farm, making the facility the largest desalination project in the world whose energy needs are provided by renewable energy sources.[31]

C. RENEWABLES, STORAGE, AND GRID INTEGRATION

It is important to note that many renewable energy sources (e.g., wind and solar) are not continuous. Combining these two sources could help some water agencies use renewable power to meet water pumping needs. In either case, it could be useful to have the ability to store renewable power for later use. The primary technology to achieve this end is pumped storage.

Some existing water projects have utilized pumped storage projects, which have traditionally been designed to allow water projects to generate and sell power during peak demand periods and pump water from a lower reservoir to a higher one when power is less expensive. Such projects could be designed to smooth out the peaks in wind and solar power production, for example by pumping water during daylight hours and periods of high winds. When energy is needed during times of high demand, water in the higher elevation reservoir would be released to generate electricity.

California's State Water Project, for example, includes one of the largest pumped storage projects in the nation, combining Pyramid Lake (1,495 MW) and Castaic Lake.[32] Few new pumped storage facilities have been built since the 1990s, but with the recent increased focus on renewable energy sources, pumped storage is again being pursued. For example, permitting for three new systems is underway in Oregon, the largest of which will have a 500 MW capacity and storage potential of 16,000 MWh.[33] Similar projects are being evaluated in California, Wyoming, Hawaii, and elsewhere.[34] Other newer technologies are emerging to store energy from renewables, including the use of compressed air, molten salt, concrete and ice.[35]

The use of renewable power or pumped storage should not be used as justification for unsustainable or un-economic water projects. However, existing water pipelines and future pipeline projects should be designed to include renewable power as a source. For example, California's State Water Project consumes approximately 1.4 billion kWh annually from a coal-fired plant in Nevada that it partially owns. This power can and should be replaced with renewable sources.

VI. THE ROLE OF FEDERAL AGENCIES

Federal agencies, including the BOR and the Corps of Engineers, have long played a central role in the planning and development of water projects. In addition to the role of federal agencies in issuing permits and in energy issues (discussed in Chapter V), several current federal activities have important implications for proposed pipeline projects.

A. FEDERAL PRINCIPLES AND GUIDELINES

In December of 2009, the White House CEQ issued the Proposed National Objectives, Principles and Standards for Water and Related Resources Implementation Studies. These Principles and Guidelines were first adopted in 1973. They serve as the foundation of federal water planning efforts, and have been largely unchanged for more than 25 years.[1] The original Principles and Guidelines guide the work of the BOR, the U.S. Army Corps of Engineers, the Natural Resources Conservation Service, and the Tennessee Valley Authority. However, the revised draft document is expanded in scope and is intended to cover all federal agencies that undertake water resource projects.

The Principles and Guidelines document does not yet address the full range of issues related to potential federal involvement in proposed water pipeline projects. For example, the draft Principles and Guidelines document does not use the word "energy" once. It does, however, list some of its goals as to "protect and restore…the environment while encouraging sustainable economic development" and to avoid "adverse impacts to natural ecosystems wherever possible and fully mitigating any unavoidable impacts."[2] The incorporation of the changing western water landscape and the issues discussed in this report would provide valuable guidance for federal agencies that evaluate and fund water projects, including the BOR. Modernized Principles and Guidelines should guide federal agency involvement in all types of water projects, including proposed pipeline projects.

B. FEDERAL FINANCING

With the high cost and diminished yield of traditional water development, alternative water supply strategies are increasingly cost-effective, including water recycling, improved groundwater management, urban stormwater capture and particularly urban and agricultural water use efficiency.[3] Many of these projects are now more cost effective than some traditional water development projects. There is no single rule governing how much the federal government will contribute to states and local governments to assist in the financing of pipeline projects, or for other means of providing water. There has been an assumption among many state and local leaders that the federal government will be involved in some fashion in large scale water projects, although this funding may be ad hoc. For example, the federal government is committed to funding 75 percent of the Ute Lake Project in eastern New Mexico, while the state government and involved communities are each contributing 15 percent and 10 percent, respectively.[4] The basis for federal involvement is unclear; there are no tribal water interests in the area. In many other areas, federal funding involvement is at substantially lower levels.

In the past, the federal government (through the Bureau of Reclamation and the Corps of Engineers) has devoted tens of billions of dollars to highly-subsidized water storage projects. As a result of declining water availability, environmental degradation and dramatically escalating costs, most people agree that the 20th century dam building era is drawing to a close. For example, in the Colorado River Basin, that era may

have reached an end with the construction of the Animas La Plata project in the Upper Basin and the Drop 2 Reservoir on the Lower Colorado. Through the Bureau of Reclamation's Title XVI program and water conservation programs, the Bureau has begun moving away from its traditional role as a dam-builder. Given the water challenges facing the West, the Bureau's role is likely to increasingly focus on efficiency and reuse strategies.

Alternative water solutions, such as water use efficiency, may prove to be more reliable over the long-run, less likely to contribute to future water conflicts, less environmentally damaging and more cost-effective. However, because the Bureau does not provide such generous financing for water use efficiency and other solutions, the federal government's current financing policies are encouraging more damaging, expensive and unreliable solutions. If continued, this practice is likely to encourage additional proposals for pipeline projects around the West. Over the long-term, by encouraging what may prove to be unsustainable sources, this federal funding could increase future water shortages.

Many proposed projects lack a clear nexus to strong federal interests to justify funding from federal taxpayers. Such connections include resolving Native American water rights claims and addressing endangered species issues where there is no clear responsible party. However, there is no federal interest in projects that place additional stress on over-allocated surface supplies or overtapped groundwater basins.

C. COLORADO RIVER BASIN WATER SUPPLY AND DEMAND STUDY

This analysis has revealed that the Colorado River Basin is the focus of the largest concentration of proposed pipeline projects in the West. Specifically, Appendix B summarizes five proposals for new pipelines to divert water from the Colorado River and another seven proposals to divert water

into the Basin. Many of these proposed projects are large individually. In addition, the cumulative impact of these projects could be significant.

The BOR's Colorado River Basin Water Supply and Demand Study is scheduled for completion in September of 2012. That effort is working to characterize the water management challenges facing the Basin. It is not yet clear if the Basin Study effort will continue or what other planning efforts will continue the effort begun by the Basin Study. Whatever the forum, it is important that the projects and issues identified in this report, including potential cumulative impacts, be addressed carefully.

VII. CONCLUSIONS

- Surface and groundwater sources and aquatic ecosystems in the West are under significant stress.
- Climate change is likely to reduce the available water in much of the West, and present additional challenges to maintaining healthy aquatic ecosystems.
- Rising costs and the declining availability of cost-effective "undeveloped" water has reduced the number of traditional surface storage projects in the West.
- There is a new generation of pipeline projects proposed around the West. Many of these projects rely on water sources that are far less reliable than past water projects.
- Some of these projects have the potential to increase conflict and harm other existing water users.
- By increasing reliance on unsustainable water sources, some of these projects could increase the water supply and economic vulnerability of communities in the long term.
- The analysis of proposed pipeline projects frequently overlooks key issues related to cost, reliability of water sources, energy impacts and alternatives, particularly improvements in water use efficiency.
- The federal government's traditional role in funding water infrastructure in the West, and its emerging role in funding new pipeline projects, encourages infrastructure solutions such as pipeline projects, rather than more cost-effective solutions such as water use efficiency. There is a federal interest in resolving Native American water rights claims and addressing endangered species issues where there is no clear responsible party. However, there is no federal interest in projects that place additional stress on overallocated surface supplies or overtapped groundwater basins.
- Pipeline projects can be very energy intensive. The use of fossil fuel sources to provide this energy would further increase greenhouse gas emissions and further increase the pressure on western water resources by exacerbating climate change.
- The volatility of energy prices suggests that the ultimate volumetric cost of water from new energy-intensive pipeline projects could be highly variable.
- The use of renewable energy could reduce the carbon footprint of water conveyance projects in the West.

VIII. RECOMMENDATIONS

NRDC recommends that local, state, and federal agencies utilize the following approach in investigating and pursuing proposed pipeline projects:

- New water supply projects in the West should be designed to reduce, rather than increase, the current imbalances in water use—such as groundwater overdraft and overcommitted surface water sources.
- A beneficiary pays approach to the financing of water projects is the best way to internalize the costs of water projects and encourage efficient water use.
- Proposed pipeline projects should include an analysis of all of the following issues:
  - The reliability of proposed water sources, including existing demand, current constraints on proposed surface sources, the sustainability of proposed groundwater pumping, dry-year reliability, ecosystem health and likely changes in hydrology and demand caused by climate change.
  - Potential impacts to existing water users and communities.
  - Potential impacts of proposed new transbasin diversions on water use in the basin of origination.
  - The capital and operating cost of the proposed project, in comparison with the benefits. (This should include an analysis of the external costs of proposed projects, such as environmental impacts.)
  - The alternatives to the project, particularly urban and agricultural water use efficiency, water recycling, urban stormwater capture, and voluntary water transfers. Water managers should consider adopting a "least cost first" approach to water supply investments, similar in concept to California's energy loading order.
  - Energy use and energy sources,including per acre-foot and total annual energy use.
  - Potential new greenhouse gas emissions.
- Energy for future pipeline projects should be provided through investments in renewable energy sources. (Such use of renewable power, however, should not justify uneconomic and unsustainable projects.) Water agencies should also invest in renewable sources to provide the energy required for existing pipeline projects, such as California's State Water Project.

A. LOCAL AGENCIES

As a result of constraints on the federal budget, it likely that the vast majority of the funding for most new water supply projects in the West will be borne by local agencies. Local water users, of course, have a great deal at stake if they rely on unsustainable sources. Ultimately, these communities could suffer increased water shortages and higher water rates if they pursue poorly designed projects. Local agencies also have the ability to pursue and invest in a broad range of water solutions. (As explained below, this is not true, at the moment, for federal agencies.) In addition to considering general recommendations above, local agencies should ensure that rate payers are provided with information regarding the above issues and the range of alternatives before water utilities make decisions on proposed new pipeline projects.

B. STATE AGENCIES

State agencies often play critical roles in studying financing and implementing water supply projects. Projects such as California's State Water Project represent the most dramatic examples. However, the growing need for cooperation among Colorado River Basin states to address the current and growing imbalance between supply and demand also demonstrates the clear role for state involvement in thoughtfully addressing imbalances between supplies and demand. In addition to considering the general recommendations above, state agencies should ensure the following:

- Where proposed projects could have impacts to other water users and across state lines, state water agencies should actively investigate the issues summarized above, in collaboration with tribal governments,

environmentalists, and other stakeholders.

- All western states should undertake ambitious and comprehensive efforts to prepare for the potential impacts of climate change on water resources. These adaptation efforts should address a full range of potential impacts on aquatic ecosystems, water supply and other resources. Such adaptation planning efforts, as discussed in NRDC's report *"Ready or Not: An Evaluation of State Climate and Water Preparedness Planning,"* will allow significantly improved evaluations of proposed new conveyance projects and available alternatives.
- Scarce state water supply funding should be focused on the most affordable and reliable projects—those that increase the efficiency of water use and re-use.

C. FEDERAL AGENCIES

The federal government plays a far larger role in water policy than is often realized. The BOR and the Corps of Engineers finance and manage water storage and power on major western rivers. Federal environmental laws affect water policy, as does federal management of tribal water. But one of the most important roles in the next decades will be in helping to determine how the western United States will respond to the pressures bearing on western water resources. Simply put, the federal government can encourage local communities to manage demand and support research into new water technologies, or it can provide federal funding for water pipelines across great distances to water stressed communities. The latter approach may, in many cases, prove more costly, more environmentally damaging and less reliable in the long-term. We suggest a more clearly defined and limited federal role. In addition to considering general recommendations above, federal agencies should ensure the following:

- Federal funds should be focused on projects where there is a strong federal nexus, such as resolving Native American water rights claims and addressing endangered species issues where there is no clear responsible party.
- Scarce federal water supply funding should also be focused on the most affordable and reliable projects — those that increase the efficiency of water use and re-use. Federal agencies should no longer fund traditional water development, particularly in regions where such additional traditional development would be unsustainable.
- Given the large number of proposed projects to divert water from the Colorado River, as well as into the Basin, the BOR's Colorado River Basin Water Supply and Demand Study and subsequent efforts should address the cumulative potential impacts of the potential projects summarized in this report.
- President Obama's Executive Order on Greenhouse Gasses mandates that agencies seek means of reducing their carbon emissions. One of the stated goals of the Order is to "make reduction of greenhouse gas emissions a priority for Federal agencies." Federal agencies, particularly the Bureau of Reclamation and the Corps of Engineers, should implement this Executive Order with respect to their water responsibilities by reporting the energy use and associated greenhouse gas emissions of projects that they fund.
- The new Principles and Guidelines for Water and Land Related Resources (Principles and Guidelines) that are under development by federal agencies should address the issues discussed in this paper, to give decision-makers a more complete understanding of proposed projects. In particular, these principles should address the energy issues raised by water projects, including proposed pipeline projects.

IX. APPENDIX A

PIPELINE PROJECTS IN OPERATION

Throughout the West, there is a vast number of existing water projects that include pipelines and tunnels as significant project facilities. The following list includes 19 of the more prominent existing pipeline projects in the West. This appendix does not include many large projects that do not include significant pipelines. It also excludes many small projects. These projects were selected to include the largest pipeline projects, as well as broad geographic representation. This list provides a valuable baseline against which to compare proposed new pipeline projects.

Little Snake-Douglas Creek Project: This project has been in use by Cheyenne, Wyoming since the 1960s. Water is collected in the Little Snake River Basin, located west of the Continental Divide, transferred across the Divide through a tunnel, and stored in Hog Park Reservoir, on the eastern side of the Divide. This water is provided to the City of Cheyenne through exchanges with other water users on tributaries of the North Platte River.[1] Stage II water diversion construction began in 1982, enlarging reservoirs, laying new pipelines and increasing diversions.[2] Stage I and Stage II were operated together for the first time in 1992.[3] The anticipated average annual water yield from Stage I and Stage II together is 21,000 af.[4]

The Colorado-Big Thompson Project: This diversion project collects Western Slope water from the headwaters of the Colorado River and diverts it to the Front Range and Plains. It was built between 1938 and 1957, and provides 213,000 af of water to 30 cities and towns. The water is used to help irrigate approximately 693,000 acres of northeastern Colorado farmland. It consists of 35 miles of tunnels, 95 miles of canals, and 700 miles of transmission lines. The project spans 150 miles east to west, and 65 miles from north to south.[5]

Additional Colorado Transbasin Diversions: Five additional diversions from the Western Slope to the Front Range collectively divert approximately another 150,000 af per year from the Colorado River Basin.[6] These diversions include Grand River Ditch, Harold D. Roberts Tunnel, Homestake Tunnel, Moffat Water Tunnel, and Twin Lakes Tunnel.

The San Juan-Chama Project: This project moves water from the San Juan River basin to the Rio Grande basin, providing water to Albuquerque and Santa Fe, New Mexico. Overall, the San Juan-Chama project provides 86,210 af per year to water users in New Mexico, one-fourth of which is used for irrigation.[7]

The project utilizes water from the Navajo, Little Navajo, and Blanco Rivers, all upper tributaries of the San Juan River, and transports it to the Rio Grande basin. Water from the rivers is transferred via pipelines of varying lengths, the longest of which is 12.8 miles, from Heron Dam on Willow Creek. The reservoir has a capacity of 401,320 af, or more than four years of full supply of the project.[8]

Central Utah Project (CUP): The CUP was originally authorized as a BOR project in 1956. It is a complex project with several authorized units, utilizing water from the Bonneville and Green River basins. The Bonneville Unit is the largest and most complex of these units, including transbasin water diversions, 10 reservoirs, and more than 200 miles of aqueducts, tunnels, and canals. Major reservoirs include Starvation Reservoir, with a capacity of 167,000 af; Jordanelle Reservoir, with a capacity of 363,000 af; and Strawberry Reservoir, with a capacity of 1.1 maf. Strawberry Aqueduct is 37 miles long and collects water from tributaries of the Dechesne River to deliver to Strawberry Reservoir.[9] The Jordan Aqueduct is 36 miles long and delivers approximately 70,000 af of water annually to the Salt Lake Valley from the Provo River and Jordanelle Reservoir. The CUP is working to complete a system of more than 50 miles of additional pipelines in the Utah Lake Basin.[10] Collectively, the Bonneville unit's facilities are designed to provide municipal residents with a total of 107,000 af of water annually, with another 111,000 af for agricultural water users.[11]

Central Arizona Project (CAP): The CAP was begun in 1973 and is among the largest and most expensive aqueduct systems in the United States. It includes 335 miles of aqueducts, 14 pumping stations, and 15 miles of tunnels that are designed to lift and move 1.5 maf of water annually from Lake Havasu to central and southern Arizona.[12,13] The project

is substantially complete, but there are plans to build several distribution systems for Native American communities which could take another 10 to 20 years.[14]

The Colorado River Aqueduct: Completed in 1939, this 242 mile long aqueduct provides Southern California with approximately 1.2 maf of water annually from the Colorado River. It includes nine reservoirs, five pumping stations, 63 miles of canals, 92 miles of tunnels, and 84 miles of buried conduit and siphons.[15]

Los Angeles Aqueduct: There are two Los Angeles aqueducts. The first was completed in 1913 for less than $23 million, and includes 223 miles of aqueduct. The second was completed in 1970. It cost nearly $89 million and includes 137 miles of aqueduct.[16] Both pipelines are gravity fed. Today, these projects provide Los Angeles with an average of 254,000 af per year, although there is significant variation in deliveries among years. [17]

California's State Water Project: This project includes 34 storage facilities and more than 700 miles of pipelines and canals.[18] In addition to providing water for agriculture in the Central Valley through the California Aqueduct, the project includes a series of pipelines, canals, and tunnels serving urban areas. The project includes the South Bay Aqueduct, which is composed of a series of pipelines that reach from the Sacramento-San Joaquin Delta to Alameda and Santa Clara Counties in the southern part of the San Francisco Bay Area. [19] The North Bay Aqueduct carries water to cities on the northern edge of the San Francisco Bay Area.[20] The Coastal Branch reaches to California's Central Coast, near the City of Santa Barbara.[21] Finally, the project includes the west and east Branches, which pump water 2,000 feet up and over the Techachapi Mountains to Southern California. On average, the SWP delivers 2.4 maf of water. [22]

The Central Valley Project (CVP): The BOR's CVP consists of 20 dams and reservoirs, 11 power plants, and 500 miles of major canals, as well as conduits, tunnels, and related facilities.[23] The vast majority of this water is consumed by agriculture in the Central Valley, however, the San Felipe Division carries water through a 48 mile pipeline to agricultural water users in the Central Coast area and to urban water users in Santa Clara County.[24] Between 2005 and 2010, the CVP delivered an average of 5.3 maf per year.[25]

The Hetch Hetchy Aqueduct: San Francisco's 160-mile long aqueduct diverts water from Hetch Hetchy Reservoir in Yosemite National Park and delivers about 165,000 af of Sierra Nevada water per year to San Francisco, as well as parts of San Mateo, Santa Clara, and Alameda counties. Annually, the system generates more than 2 billion kwh of hydropower. The aqueduct is dependent entirely on gravity to convey water. It was built in the 1920s and 1930s.[26]

The Mokelumne Aqueduct: The 91 mile long Mokelumne Aqueduct supplies water to the East Bay communities in California, including Oakland, Berkeley, Richmond, and parts of Alameda and Contra Costa County. Initial construction began in the 1920s and additional aqueducts and pipelines were built as recently as the 1960s.[27] Pardee Reservoir holds 210,000 af of water, which is used to regulate supply in winter and spring. The district has rights of up to 364,000 af of water on the Mokelumne River. [28]

Portland Water Bureau: Three pipelines take water approximately 26 miles from two reservoirs in the Bull Run watershed to provide domestic supplies for Portland, Oregon.[29] The project diverts approximately 132,000 af annually.[30]

Cedar River: The City of Seattle receives some of its water supply from two 28-mile long pipelines from the Cedar River watershed, diverting approximately 92 million gallons per day, or 103,500 af annually, to serve Seattle and surrounding communities.[31] The city also receives water from the Tolt River watershed.

Mni Wiconi Rural Water System: Providing water for Native American communities in South Dakota, this project has been in development for more than 20 years; construction is scheduled to be completed in 2013 at a cost of more than $400 million. The water system will provide communities with Missouri River water to replace contaminated groundwater. Through a network of 4,400 miles of pipelines, the project will serve more than 51,000 people in 10 counties.[32] When completed, the system will provide between 8,591 and 12,474 af annually.[33] The federal government is financing the construction costs—some $350 million—to provide water to the three reservations served. Local ratepayers are required to pay back a low-interest state loan and cover ongoing maintenance and operations costs.[34]

X. APPENDIX B

PROJECTS "IN THE PIPELINE"

As described in Chapter 2, there is a growing list of proposed water pipeline projects throughout the western United States. The projects summarized in this appendix do not represent a comprehensive list. They are also at various stages of completion, ranging from the early conceptual stage of planning to ongoing construction. The following projects present a cross-section of pipeline projects currently under consideration in the West.

COLORADO RIVER BASIN PROJECTS

Five new water conveyance projects have been proposed in the Colorado River Basin. Together, these projects would increase diversions from an already-overtapped Colorado River Basin by more than 690,000 af per year—more than double Nevada's 300,000 af allocation.

Flaming Gorge Pipeline: A pipeline from Flaming Gorge reservoir has been proposed for several years, also dubbed the Colorado-Wyoming Cooperative Supply Project and the "Million Pipeline," after project supporter and entrepreneur Alex Million. The project will likely mirror a prior proposal for a 500-mile long pipeline to move approximately 250,000 af of water annually from the Green River above Flaming Gorge to the Front Range. The project has been proposed by two entities—Aaron Million and the Colorado-Wyoming Coalition, a group of cities and utilities (primarily in Colorado). In addition, the State of Colorado has sponsored a task force to investigate the potential benefits and drawbacks of the project.[1] In February 2012, the Federal Energy Regulatory Commission (FERC) dismissed the application for this project as premature.[2] On May 17 2012, FERC denied a request to reconsider the project.[3]

Lake Powell Pipeline Project: This project would provide 100,000 af annually of Colorado River water to communities in Utah. It would include 120 miles of 66-inch diameter pipeline from the Lake Powell Glen Canyon dam site in Arizona to Sand Hollow Reservoir near St. George, Utah, and potentially an additional 38 miles of 30-inch diameter pipeline from Sand Hollow to Cedar City.[4] The most current cost estimate is almost $1.1 billion as of June 2008.[5] In March of 2012, the Utah Legislature rejected a proposal to dedicate Utah sales tax revenues to the project.[6] The EIS for the project is scheduled to begin in mid-2012.[7]

Yampa River Pumpback: This proposed project, which was the subject of a feasibility study by the Northern Colorado Water Conservancy District, would consist of a new 500,000 af reservoir and 250 miles of tunnels and pipelines through the Continental Divide to carry up to 300,000 af of water to the Front Range.[8] The project could cost close to $4 billion. It stalled in 2008, after the completion of an initial study.

Navajo-Gallup Project: Congress authorized this project to provide water to the Navajo Nation and nearby communities. The proposed project will provide water for approximately 250,000 people by the year 2040. It will take water via diversions from the San Juan River in northern New Mexico and divert it to the eastern section of the Navajo Nation, the southwestern part of the Jicarilla Apache Nation, and the City of Gallup. The proposed project would provide these locations with a total of 35,893 af of Colorado River Basin water annually.[9]

The preferred alternative for the Navajo-Gallup Project, known as the San Juan River Public Service Company of New Mexico alternative, includes 260 miles of pipeline, 24 pumping plants, and two water treatment plants. Based on a 2007 estimate, the cost of the project is $864 million, a considerable increase from the 2005 estimate of $716 million.[10] In 2009, Congress authorized construction of the project, in part to resolve Indian water rights issues.

The EIS was issued March 2007.[11] The EIS did not include an analysis of the cost of a water conservation-based alternative.[12] The BOR has considered the use of renewable energy in this project, but it would be more expensive than the hydropower that is available to the project.

Narrows Project: This project would divert water from the Price River (a tributary of the Green River in the Colorado River Basin) to Sanpete County, Utah. It was first investigated by the Bureau of Reclamation in the 1930s.[13] The proposal would represent a transbasin diversion from the Colorado River Basin to the Great Basin and would involve three tunnels, totaling 16.8 miles, as well as a new Narrows Dam and 17,000 af reservoir.[14] The project would divert a

maximum of 5,400 af per year and an average of 5,136 af. Of that average amount, 855 af would be for municipal and industrial uses, and 4,281 af for irrigation.[15] Construction costs for the project would total $40.3 million dollars, with a proposed federal loan providing a portion of this cost. The document does not include a discussion of annual operating costs.[16] A draft EIS for the project was issued in March of 2010.

OTHER WESTERN PROJECTS

Although the Colorado River Basin has the most proposed pipeline projects, there are additional projects located in basins across the rest of the West:

Northern Integrated Supply Project: This project, proposed by the Northern Colorado Water Conservancy District, would provide up to 40,000 af of water from the Cache la Poudre River. The project would include a new 170,000 af Glade Reservoir and a system of pipelines ranging from 36 to 62 miles long to serve 15 water providers.[17] The project would cost approximately $490 million.[18] A draft EIS was issued in April of 2008 and a supplemental document is currently in preparation.[19]

Mississippi River/Ogallala Aquifer: Pat Mulroy, general manager of the Southern Nevada Water Authority, recently reintroduced the decades-old idea of capturing floodwater from the Mississippi River and diverting it to the Ogallala Aquifer beneath the Central Plains in order to replenish it. The Ogallala Aquifer, which covers some 174,000 square miles and includes portions of eight states, is suffering from high levels of groundwater overdraft. This project could dwarf both the Hoover and Glen Canyon Dams in terms of cost. This proposal would employ a complex series of multi-state water transfers, designed to reduce the transbasin use of Colorado River water on the Front Range, freeing up water for other communities in the Colorado River Basin, including Las Vegas. Mulroy has said that, "We can't conserve our way out of a massive Colorado River drought" and believes that pipeline projects such as this are necessary to prevent water shortages. Years of study and multi-state negotiations would be needed if this project were to be undertaken. A project of this size and complexity faces an uncertain future.[20]

Southern Delivery System: Designed to serve Colorado Springs and surrounding communities, the Southern Delivery System in Colorado will use a 62 mile pipeline to transport 52,900 af per year from the Arkansas River. Construction began in 2010, and the system is slated to begin delivering water in 2016.[21]

Ute Lake Project: In 2008, the Ute Water Commission granted approval for a facility to take Canadian River water from Ute Lake for use in eight eastern New Mexico communities. The project is now estimated to cost approximately $500 million.[22] A draft environmental assessment concluded that there is no significant environmental impact to the project, despite the energy required to pump and deliver water. The project is designed to include 87.5 miles of transmission pipelines ranging from 30 to 54 inches and 94.8 miles of lateral pipelines, from 4 to 36 inches.[23] The project is designed to deliver 16,450 af of water per year.[24] Proponents intend for the federal government to pay most of the costs of the project. Although the project has been authorized, very little federal funding has been appropriated. Construction has begun in an effort to secure the federal funding. In this analysis, the average elevation gain from the Ute Lake Reservoir to the seven participating community members of the Eastern New Mexico Regional Water System project was estimated to be approximately 535 feet. In May of 2012, local citizens concerned about impacts on lake levels and the local economy filed two requests in state court for injunctions to block construction of the project.[25]

Uvalde to San Antonio Pipeline: Private investors have proposed a pipeline that would transport water from the Edwards Aquifer in Uvalde County Texas to San Antonio. The pipeline would be 67 to 75 miles long and would transport up to 40,000 af of water per year. The project is estimated to cost about a quarter of a billion dollars and the financing would be raised privately. There currently is a ban on pipelines to transport Edwards Aquifer water from Uvalde County to another county, but investors are trying to persuade state lawmakers to make an exception for this project.[26]

Santa Fe-Pecos Pipeline: Another proposed pipeline would provide water to homes and businesses in Santa Fe and other communities in the Rio Grande Basin from Fort Sumner, near the Pecos River. This project, which was proposed by a private developer, would include 150 miles of pipeline. Five farmers in the Fort Sumner area have agreed to transfer rights to 6,600 af of Pecos River water to Santa Fe. Opposition to the project includes local, state, and area water agencies.[27]

Eastern Nevada to Las Vegas Pipeline: Nevada received a 300,000 af entitlement from the Colorado River when it was allocated among seven western states. Rapid growth has led Las Vegas to seek new sources of water. The Southern Nevada Water Authority (SNWA) is pursuing plans for an almost 300-mile long pipeline project to pump water from groundwater basins in eastern and central Nevada (and from groundwater resources shared with Utah) per year. The project would cost $3.5 billion to build.[28] However, a 2011 report that the SNWA described as a "worst case" analysis concluded that the project could cost as much as $7.3 billion to build.[29] The Nevada Supreme Court held up the project in early 2010 when it found violations of the rights of people who had opposed the water rights for the proposed project. (In 1989, SNWA's predecessor filed applications for these water rights.) The Nevada Supreme Court ruled in 2010 that the State Engineer must re-notice SNWA's remaining water rights for public comment.[30] In March of 2012, the State Engineer granted SNWA permission to divert 84,000 af per year from four rural valleys in Eastern Nevada, less than the 126,000 af that SNWA had originally sought.[31] The DEIS for the project includes projections of long-term drawdown of groundwater levels.[32]

Cadiz Valley Project: Cadiz, a publicly-traded firm, is seeking to develop a project that would pump groundwater from a closed Mojave Desert basin in Southern California through a 43-mile pipeline to the Colorado River Aqueduct. The project would deliver up to 50,000 af per year to participating water districts, which, according to Cadiz, include the Santa Margarita Water District, Three Valleys Municipal Water District, Suburban Water Systems, Golden State Water Company, and Jurupa Community Services.[33] The project, which could also include a second phase with a storage component, is a revised version of a project that was rejected by the Metropolitan Water District of Southern California in 2002.[34] A retired United States Geological Services hydrogeologist has concluded that annual groundwater recharge is only approximately 5,000 af per year.[35]

The Peripheral Canal/Tunnel: The Bay-Delta Conservation Plan (BDCP) is preparing a Habitat Conservation Plan for California's Bay-Delta estuary. BDCP is a state-federal partnership, financed by water users. Under state law, the BDCP plan must advance the dual goals of restoring ecosystem health and increasing water supply reliability for the Central Valley farms and Southern California and Bay Area cities that depend on deliveries from the Delta. It must also advance a state policy of reducing reliance on Delta water supplies. BDCP is studying a possible new Delta conveyance facility to carry water from the Sacramento River in the North Delta to the State Water Project and Federal Central Valley Project pumps in the South Delta. (In 1982, California voters defeated a previous proposal to construct a Peripheral Canal in the Delta.) Stakeholders have offered different, and sometimes conflicting, reasons to construct a new Delta facility, including reducing the risk to water supplies from sea level rise, earthquakes and potential Delta levee failures, increasing water exports, and helping to restore the Bay-Delta estuary and its fisheries. Many alternative Delta conveyance approaches have been proposed, including strengthening existing levees and building a pipeline, aqueduct or tunnel with capacities ranging from 3,000 to 15,000 cfs.

At the moment, the BDCP is focused primarily on a 15,000 cfs, 37-mile long facility that would consist of twin tunnels under the Delta, each 33 feet in diameter.[36] The amount of water that such a facility would produce is uncertain. Water users who rely on Delta exports are seeking a significant increase in Delta pumping up to 5.9 million af—a 1.2 maf increase, on average—compared with currently authorized pumping levels.[37] However, the State Water Resources Control Board has determined that restoring the Bay-Delta ecosystem would require a significant reduction in total water diversions in comparison with current levels.[38] To date, the BDCP has been unwilling to investigate water use efficiency, water recycling, and other water strategies in its development of alternatives. The capital cost of the construction of a tunnel could be $12 billion or more. Total annual costs of the BDCP, including capital cost for a new facility, operations, maintenance, habitat restoration, and financing could reach $948 million for 50 years.[39]

Weber Siphon: Currently under construction by the BOR, the Weber Siphon is a $48 million project that would more than double the capacity of this portion of the Columbia Basin Project, adding 1,950 cfs to create a total conveyance capacity of 3,650 cfs where the project crosses Interstate 90.[40] This short project is designed to deliver 30,000 af of water to 10,000 acres of agricultural land in the Odessa Subregion in Washington State.[41] The project was funded by the American Recovery and Reinvestment Act.

Lewis and Clark Regional Water System: When completed, the system will provide drinking water through 337 miles of pipeline to over 300,000 people in South Dakota, Iowa, and Minnesota.[42] Construction is scheduled to be complete in 2019, although progress has been slowed by the recent ban on congressional earmarks.[43] The federal government is providing 80 percent of the funding for the $430 million dollar project.[44] The project relies on water from wells that tap into an aquifer adjacent to the Missouri River near Vermillion, South Dakota. Lewis & Clark's member systems will use this new source of water to either replace or supplement existing sources of supply. The proposed maximum for the completed system is 45 million gallons per day.[45] The project's 2002 Final Engineering Report projected the system's demands to average 22.1 million gallons per day by 2030 (approximately 24,770 af per year).[46]

COLORADO RIVER BASIN STUDY PROPOSALS

As referenced in Chapter 2 of this paper, the following projects were included in the BOR's Colorado Basin Study as stakeholder submissions. These supply augmentation proposals include significant new pipeline conveyance facilities. Additional information about the submissions can be found on the bureau's website.[47]

These projects are summarized below, but were not included in figure 2 or table B in the body of the report.

Snake River Import: This proposal involves diverting water from the Snake River and delivering it to the Green River Basin. Project submitters approximated that this could provide 33,000 afy of water using existing storage, or 155,000 afy if new storage were constructed. This project would require 26 miles of pipe and 6 miles of tunnel. The project's cost is estimated at $250 million, with $13 million per year of operations and maintenance (O&M) costs. The water is estimated to use 15.7 kWh per 1,000 gallons. This would represent an energy footprint of more than 5 mWh per af—greater than the energy required to desalinate seawater.

Missouri River Import: This conceptual proposal advocates that Missouri River and Mississippi River water be diverted to the Colorado River, and that Nevada and Arizona subsidize desalination plants along the California coast in exchange for an equivalent share of Colorado River water currently held by California.

Bear River to Ham's Fork Creek Import: This option involves diverting water from the Bear River, and diverting and pumping it to the Green River Basin. The proposal estimates that the project could provide 50,000 afy of water, that it would require 11.5 miles of pipeline, and that it would cost $314 million to build.

Clark's Fork to Green River Import: This import would divert water from Clark's Fork of the Yellowstone River in Wyoming and deliver it to the Green River Basin. The project submission estimates that this project would provide 75,000 afy. Pipeline and tunnel length estimates range from 140 to 225 miles. Energy requirement estimates range from 83,000 hp to 90,000 hp.

Columbia River via a Submarine Pipeline: This proposal is for an under-sea pipeline from the mouth of the Columbia River to Castaic Lake for MWD usage and to the All-American Canal to offset diversions from the Colorado River. The proposal suggests studying diversions of 1,000,000 afy.

Missouri River Reuse Project: This proposal is to divert up to 600,000 afy of water from the Missouri River for reuse within the Missouri River Basin of Kansas and Colorado. The water would be used to fill surface reservoirs and recharge depleted aquifers. Conveyance of the water across Kansas and eastern Colorado would be through single or parallel large-diameter pipelines.

Mississippi River to Colorado Front Range Pipeline: This proposal would deliver 675,000 afy of water from the Mississippi River near Memphis to the Colorado Front Range using the largest pipeline available—one 144" pipe. The alignment option would require 660 miles of pipe and 150 miles of canal, as well as pumping stations capable of lifting the water from 200 feet above sea level to elevations between 4,000 and 5,800 feet above sea level. The total cost of the project is estimated at $15.8 billion with annual O&M costs at $541 million per year. Energy usage would be between 850 and 1,000 megawatts of generation. Mississippi River water could be "moved" into the Colorado River Basin through a series of exchanges with existing water users east of the Rockies, freeing up Colorado River water that is currently diverted to the Front Range.

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CHAPTER II

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