WATER: THE FUEL FOR COLORADO ENERGY

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I. INTRODUCTION

"We used to think that energy and water would be the critical issues for the next century. Now we think water will be the critical issue."[1] This observation by Dr. Mostafa Tolba of Egypt, former head of the U.N. Environmental Program, may also prove a fitting perspective for Colorado. Since before statehood, water has played a fundamental role in Colorado's economy. It was a critical resource to the miners who flooded into the state in the 1850s and 1860s to search for gold and silver; it was the driving force behind the agricultural settlement of the state, from the peach orchards in Mesa County to the cantaloupe fields in Rocky Ford; and it was brought over and through the Continental Divide to support the a growing population in the state's economic hub—Denver and the Front Range.

Although producing energy in Colorado has historically created a relatively minor water demand compared to agriculture, which still accounts for approximately ninety percent of the water used in Colorado,[2]

1. HERBERT C. YOUNG, UNDERSTANDING WATER RIGHTS AND CONFLICTS 21 (2d. ed. 2006) (quoting Dr. Mostafa Tolba).

2. Douglas Kenney, *Water and Growth in Colorado Frequently Asked Questions,* http://www.colorado.edu/law/centers/nrlc/publications/water_and_growth_faq.pdf (last visited Feb. 17, 2012). *See also* DOUGLAS KENNEY & ROBERT WILKINSON, THE WATER-ENERGY NEXUS IN THE AMERICAN WEST 222 (2011) ("Water demands for thermoelectric generation

acquiring a reliable water supply has long gone hand-in-hand with the development of various energy resources—from coal to hydropower—as well as the hydroelectric generation stations needed to convert the energy resource to electricity and supply it to the power grid. In the 21st century, water's historic role in supporting western agricultural, municipal, and industrial development is being challenged by a growing population, a changing climate, and escalating demands—not only for traditional water uses, but also for relatively new uses such as recreation, environmental preservation, and new methods of energy production.

The U.S. Department of Energy Information Administration ("EIA") projects that electricity demand will grow by thirty-one percent between 2009 and 2035 (an average of one percent per year, from 3,745 billion hours in 2009 to 4,908 billion in 2035).[3] While the U.S. and world demand for energy will only increase, in Colorado our ability to develop our state's own substantial energy resources is hurtling head-on toward water supplies that are more and more limited by other demands, as well as anticipated reductions in certainty of supply due to climate change.[4] Colorado will need an additional 600,000 to one million acre-feet of water per year by 2050 for municipal and industrial needs, including energy industry development.[5] More specifically, a Colorado oil shale industry yielding 1,500,000 barrels of oil per day could require from zero to 120,000 acre-feet of water per year.[6]

Other Colorado-specific cases illustrate some of the challenges of limited water supplies impacting energy development. The San Luis Valley receives the most intense sunshine in Colorado, and as such this region is considered optimal for commercial-level solar development.[7] Despite this abundance of sunshine, the water needed to cool-down a solar powered turbine is a scarce resource in the San Luis Valley.[8] In 2011, com-

are relatively small in relation to water demands for agriculture or municipal use across the Western States.").

3. U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK 2011: WITH PROJECTIONS TO 2034, 73 (2011).

4. *See* URS CORP., DRAFT ENERGY DEVELOPMENT WATER NEEDS ASSESSMENT, PREPARED FOR COLO., YAMPA, AND WHITE RIVER BASIN ROUNDTABLES ENERGY SUBCOMMITTEE at ES1-ES14 (2008) [hereinafter WATER NEEDS ASSESSMENT] (a report prepared for the Colorado, Yampa and White River Basin Roundtables Energy Subcommittee ("RES") summarizing northwest Colorado's water needs in regard to natural gas, coal, uranium, and oil shale development).

5. Statewide Water Supply Initiative, *SWSI 2010 Mission Statement, Key Findings, and Recommendations*, at 3 (Jan. 26, 2011), http://cwcb.state.co.us/water-management/water-supply-planning/Documents/SWSI2010/SWSI2010FactSheet.pdf [hereinafter *Water Supply Fact Sheet*].

6. *Id.*

7. *See* SAN LUIS VALLEY COLO. INFO. CTR. AND REAL ESTATE, *San Luis Valley -- An Alpine Valley with Solar Opportunities* (May 5, 2010, 6:57 AM), http://www.sanluisvalley.us.

8. *See* B.C. Farhar, et. al., *Community Response to Concentrating Solar Power in the San Luis Valley*, 27 (2010), *available at* http://www.nrel.gov/csp/pdfs/48041.pdf ("The most frequently occurring environmental comments concerned water availability by stakeholders within . . . and outside . . . the Valley.").

munity outcry prompted a solar company to withdraw its application for a utility scale solar plant it planned to locate there.[9]

Colorado may contain approximately 500 million to 1.5 billion barrels of recoverable unconventional oil in the rapidly developing Niobrara formation centered in the northeastern portion of the state.[10] In order to recover that oil trapped in the shale, the process of hydraulic fracturing ("fracking") is employed.[11] Fracking shale for unconventional oil uses large amounts of water: the Colorado Oil and Gas Commission recently estimated that developing the Niobrara in Colorado may requireabout 6.5 billion gallons, or 20,000 acre-feet, of water.[12] The demand for fracking water to develop the Niobrara, and other unconventional oil and gas resources, must compete with a plethora of other demands, such as agricultural, municipal, industrial, recreational, and environmental interests. Although small in terms of overall demand, development of the Niobrara is anticipated to occur in an area that has seen significant transfers from agricultural to municipal use, and irrigators who were reliant on wells shut down due to inadequate water supplies.[13] Moreover, state water officials predict that Colorado could fall short of the water needed to sustain population and agriculture by 600,000 to one million acre feet.[14]

This paper focuses on water quantity issues impacting the various energy resources that are developed to generate Colorado's electrical power: the energy that powers Colorado homes, businesses, and industries, as well as energy demands in other states that use Colorado-generated energy. Throughout the paper the authors highlight Colorado's unique water market, and how, in Colorado, private transactions and water courts play a major role in the development of energy. Section II begins by providing a brief introduction to the legal basics governing Colorado's administration of water rights and protection of water quality. Section III addresses the important relationship between water and the generation of electricity, and how new energy technologies affect that relationship. Finally, Section IV addresses the several energy resources found in Colorado—coal, oil & gas, coalbed methane, oil shale, solar,

9. Ceal Smith, *Tessera Solar Withdraws Saguache County Application,* THE SALIDA CITIZEN, July 17, 2011, http://www.salidacitizen.com/2011/07/tessera-solar-withdraws-saguache-county-application/.

10. Mark Jaffe, *Anadarko Estimates Colorado Has up to 1.5 Billion Barrel Oil Reserve*, DENVER POST (last updated11/15/2011, 4:37 PM), http://www.denverpost.com/breakingnews/ci_19333957.

11. U.S. ENERGY INFO. ADMIN., *Shale Gas: Hydraulic Fracturing and Environmental Issues*, INTERNATIONAL ENERGY OUTLOOK 2011 (Sept. 19, 2011), http://www.eia.gov/forecasts/ieo/hei.cfm.

12. *Energy Companies Buying Water for Colorado Fracking*, DENVER POST (last updated Nov. 23, 2011, 1:32 PM) http://www.denverpost.com/popular/ci_19398846?source=pop_neighbors_fortcollins.

13. *See* Bruce Finley, *Fracking of Wells Puts Big Demand on Colorado Water*, DENVER POST (Nov. 23, 2011, 7:41 AM), http://www.denverpost.com/news/ci_19395984.

14. *Water Supply Fact Sheet*, *supra* note 5, at 3, 5.

hydropower, and geothermal—and the water requirements associated with producing those resources.

II. BACKGROUND PRINCIPLES OF COLORADO WATER LAW

Water in Colorado is allocated pursuant to the prior appropriation doctrine.[15] The first person to put water to a beneficial use establishes a priority right to use a certain quantity of water over every other person who subsequently puts water to a beneficial use.[16] This first-in-time, first-in-right system was necessary to ensure that water in the arid West was allocated to economically important activities, rather than only to those few people fortunate enough to own riparian land.[17] In Colorado, the priority system of water allocation is established through the adjudication of water rights in water courts, which confirm when each water right is appropriated for use.[18] Colorado statutes also give water judges the authority to attach conditions and terms to a water right;[19] such terms and conditions typically include a limitation on the quantity of water attributable to the water right, either in terms of a rate of flow limit (cubic feet per second) used to quantify flowing water, or a volumetric limit (acre-feet) used to quantify storage rights. Water court decrees also typically specify what the water can be used for (irrigation, industrial, municipal, and so forth), where the water can be diverted from the river and/or stored,[20] and where the water can be used.

The Colorado Division of Water Resources, Office of the State Engineer, maintains a list of all adjudicated water rights, in order of priority,[21] for each of the seven major river basins.[22] The State and Division Engineers are also responsible for administering water rights in accordance with their relative priority, as well as other terms and conditions contained within the water court's decree.[23]

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15. Sarah A. Klahn, 2A COLORADO PRACTICE SERIES: METHODS OF PRACTICE § 76.1 (West, 5th ed. 2011).
16. *Id.*
17. Gregory J. Hobbs, Jr., *Colorado Water Law: A Historical Overview*, 1 U. DENV. WATER L. REV. 1, 3, 4, 15 (1997).
18. *Id.* at 10.
19. COLO. REV. STAT. 37-92-305(4)(a) (2012); *see also* Melinda Kassen, *Statutory Expansion of State Agencies' Authority to Administer and Develop Water Resources in Response to Colorado's Drought*, 7 U. DENV. WATER L. REV. 47, 53 (2003).
20. Casey S. Funk, *Basic Storage 101*, 9 U. DENV. WATER L. REV. 519, 522–25 (2006).
21. COLO. REV. STAT. § 37-92-401(1)(a) (2012).
22. *Id.* § 37-92-301; *See Division Offices by Major River Basin(s)*, COLO. DIV. OF WATER RES, http://water.state.co.us/DivisionsOffices/Pages/default.aspx. The seven major river basins in Colorado are the South Platte River Basin (Water Division 1); the Arkansas River Basin (Water Division 2); the Rio Grande River Basin (Water Division 3); the Gunnison River Basin (Water Division 4); the Colorado River Basin (Water Division 5); the Yampa River Basin (Water Division 6); and the Animas River Basin (Water Division 7).
23. *Id.*

Virtually all of the major rivers in Colorado, and their smaller tributaries, are over-appropriated.[24] This means that under typical circumstances, there are more water rights decreed on paper, and more demands for water, than there is a physical supply of water to meet those demands. Accordingly, when new or increased demands arise for water, one can rarely depend upon appropriating a new, junior water right to reliably meet that demand.[25] Water will simply not be available under a junior priority often enough to provide a reliable water supply. Instead, people typically obtain water for new uses by purchasing existing, senior, water rights, and then applying to the water court to change the water right to the new use.[26]

The good news for latecomers to the water scene, such as energy producers, is that Colorado has a developed water rights market, which distinguishes it from most other prior appropriation states. Water rights in Colorado are considered to be real property rights, which can be severed from the land, and bought and sold.[27] The bad news is that determining whether or not there are sufficient existing water rights available for transfer to new uses is often a highly localized inquiry. When transferrable water rights are available, the transactions costs of purchasing the rights, changing them through a water court application process, and frequently dealing with local regulatory and political concerns can be quite high.[28] When existing, reliable, and transferrable water rights are not readily available, acquiring sufficient water rights for a new project frequently involves complex, multi-phased transactions, which both increases the costs and the timetable required to secure the necessary water supply.[29]

Water rights transactions are often very slow moving. It takes time to find water—and the more permanent and reliable the needed water supply, the longer it can take to identify water rights that will provide a dependable, long-term source of water. The energy industry may be better equipped than most water users to absorb the potentially high costs of water rights transactions.[30] However, for fast-moving developments in energy production, such as the discovery of a new oil or gas field, the

24. Derek L. Turner, *Pagosa Area Water & Sanitation District v. Trout Unlimited and an Anti-Speculation Doctrine for a New Era of Water Supply Planning*, 82 U. COLO. L. REV. 639, 647 (2011).

25. 94 C.J.S. *Waters* § 376 (2011).

26. *See* Klahn, *supra* note 15, § 76.12.

27. *Id.*

28. According to a 1990 report, obtaining legal approval for a transfer in Colorado cost on average $187 per acre-foot, compared with $54 in New Mexico and $66 in Utah. This figure does not include other types of transactions costs: approval of a transfer application took an average of twenty-nine months in Colorado, compared with five or fewer in New Mexico and Utah. Bonnie G. Colby, *Transactions Costs and Efficiency in Western Water Allocation*, 72 AMER. J. AGR. ECON. NO. 5, at 1184-92 (1990).

29. *Id.*

30. *See* Bruce Finley, *Fracking bidders top farmers at water auction*, THE DENVER POST, Apr. 2, 2012, http://www.denverpost.com/entertainmentcolumnists/ci_20306480.

time it takes to secure a water supply can be a significant limitation. For these reasons, and as the remainder of this article demonstrates, it is critical for those in the energy industry to:

(1) understand their water demands, including:
  - the amount of water needed,
  - the amount of water consumed in the process,
  - whether water can be reused,
  - whether there are process-related spikes in demand for water,
  - whether water storage is needed for a project,
  - whether water treatment is needed to meet the demand, and
  - how long water will be needed for the project; and

(2) integrate water acquisition into project planning at the earliest stage possible, and on an ongoing basis in order to ensure that water is available for project demands when needed.

III. WATER AND ELECTRICITY DO MIX

The generation of electrical power is the end-product of most of the energy development in Colorado. The state has a number of long-established electric generation stations, including the historic Ames Hydropower Station above Telluride, the Shoshone Hydropower Station on the Colorado River above Glenwood Springs, as well as many gas and coal-fired steam turbine generation stations.[31] However, as the demand for power increases in Colorado and the West due to population demands, the use of electrically-powered devices surges, and the need to replace aging power generation infrastructure accelerates, new capacity for generating electricity requires utility companies to plan for and consider the water requirements necessary to continue to meet electric generation demands.

A. DEMAND

One cannot address the generation of electricity without also considering water supply.[32] Most electricity-generation technologies use both steam to power a turbine to create electricity and water to cool-down that generation equipment. Thus, a large and reliable water supply is required to maintain utility-scale generation.[33] Modern electric power plants use about two hundred billion gallons of water per day, five times what

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31. *Hydro*, XCEL ENERGY, http://www.xcelenergy.com/Environment/Renewable_Energy/Hydro (last visited Feb. 7, 2012); *Colorado Overview*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/state/state-energy-profiles.cfm?sid=CO (last visited Feb. 19, 2012).

32. *See* Kate Galbraith, *The Energy-Water Paradox*, N.Y.TIMES BLOG: GREEN (Oct. 24, 2008, 5:45 PM), http://green.blogs.nytimes.com/2008/10/24/the-energy-water-paradox/.

33. *See Water Science for Schools: Thermoelectric Power Water Use*, U.S. GEOLOGICAL SURVEY (Dec. 22, 2011, 9:41 EST), http://ga.water.usgs.gov/edu/wupt.html [hereinafter *Water Science for Schools*].

they used in 1950.[34] In 2009, the average power plant in the United States used approximately twenty-five gallons of water for every kilowatt-hour (kWh) produced.[35] According to the U.S. Department of Energy, cooling water for thermoelectric generation ranks just behind irrigation/agriculture in total freshwater withdrawals.[36] While Colorado withdraws significantly less water for use in thermoelectric power generation than most states, water is also more scarce in Colorado than in many other states—indeed, it is estimated that the Denver metropolitan area will have a summer water deficit by the summer of 2025, and with this shortage, Colorado is the eighth most vulnerable state for water deficits due to thermoelectric power generation.[37]

B. PRODUCING THERMOELECTRIC POWER: THE TECHNOLOGY

Understanding thermoelectric technology is also important for understanding its demand for water. Thermoelectric power production relies on a fuel source (gas, coal, biomass, nuclear, geothermal or solar) to heat a fluid (usually water) to drive a turbine, which converts the thermal energy into electricity.[38] Water is also necessary to cool the steam after it goes through the turbine, and most of the demand for water in thermoelectric plants is cooling water for condensing steam.[39] There are three types of cooling system designs used in thermoelectric power stations: open-loop systems (or "once-through" cooling systems), closed-loop systems (or "recirculating" systems), and dry or air-cooling systems.[40] The water demand for the generating station depends on the type of cooling system.

Open-Cooling System. In once-through systems, the cooling water is withdrawn from a nearby water body, such as lake or reservoir, and subsequently discharged back to the same water body after it passes through

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34. Dr. Benjamin K. Sovacool, *Running on Empty The Electricity-Water Nexus and the U.S. Electric Utility Sector*, 30 ENERGY L. J. 11, 13 (2009) [hereinafter *Running on Empty*].

35. *Id.*

36. BARBARA CARNEY, ET AL., U.S. DEP'T OF ENERGY, WATER REQUIREMENTS FOR THERMOELECTRIC GENERATION 1 (2011), available at http://www.netl.doe.gov/technologies/coalpower/ewr/water/pdfs/NETL%20Paper%20Unesco%20Conference.pdf.

37. Benjamin K. Sovacool & Kelly E. Sovacool, *Preventing National Electricity-Water Crisis Areas in the United States*, 34 COLUM. J. ENVTL. L. 333, 362-63 (2009) [hereinafter *Preventing National Electricity-Water Crisis*]; *See also Running on Empty*, *supra* note 34, at 23, n.64.

38. CARNEY, ET AL., *supra* note 36, at 1.

39. *Id.* at 2.

40. *Id.*

the condenser to cool the steam.[41] The once-through process therefore results in relatively high water withdrawal but low water consumption.[42]

Closed-Loop Systems. Closed loop or recirculating systems use wet cooling towers or ponds to dissipate heat from the cooling water to the atmosphere.[43] Most of the cooled water is then recycled back to the generating plant to be used again.[44] However, because clean water is evaporated leaving behind salts and minerals, a portion of the cooling water needs to be discharged to prevent a buildup of minerals and sediment in the water that could impact cooling ability and electric generating efficiencies.[45] New water is added into the cooling water supply as water is evaporated and discharged.[46] As a result, plants equipped with closed-loop systems have relatively low water demands for water withdrawal, but these plants consume a relatively high portion of what they do withdraw (as compared to open-loop systems).[47]

Dry-Cooling Systems. Dry-cooling systems use air or air combined with cooling water to cool steam in power generation stations.[48] In either case, water withdrawal and consumption in dry cooling systems are minimal.[49] Because they depend on the ambient air for cooling, dry-cooling systems are most often used in wetter, colder climates.[50] Even though the water demands for dry-cooling systems are significantly reduced, less than one percent of the generating capacity in the United States uses a dry-cooling system,[51] because it is significantly less efficient from an energy production standpoint.[52]

C. WATER RIGHTS AND COMPETING RESOURCES

Not only does cooling for thermoelectric generation compete with other energy resources for water, it competes directly with municipal, agricultural, and other industrial water users.[53] When Xcel Energy, Inc.

41. *Preventing National Electricity-Water Energy Crisis*, *supra* note 36, at 338. The open-loop cooling system accounts for 91 percent of United States' water used for thermoelectric power plants. *Id.*
42. CARNEY, ET AL., *supra* note 36, at 2.
43. Amit Kohli & Karen Frenken, FOOD AND AGRIC. ORG. OF THE UNITED NATIONS, *Cooling Water for Energy Generation and its Impact on National-Level Water Statistics* 1 (2011), *available at* http://www.fao.org/nr/water/aquastat/catalogues/Thermoelectric_cooling_water_20110429.pdf.
44. *Id.*
45. *Preventing National Electricity-Water Energy Crisis*, *supra* note 36, at 338-39.
46. *Id.*
47. Kohli & Frenken, *supra* note 43, at 1.
48. *Preventing National Electricity-Water Crisis*, *supra* note 36, at 372.
49. *Id.*
50. *Id.*
51. CARNEY, ET. AL., *supra* note 36, at 3.
52. *Preventing National Electricity-Water Crisis*, *supra* note 37, at 372.
53. *See* U.S. DEP'T OF ENERGY, ENERGY DEMANDS ON WATER RESOURCES: REPORT TO CONGRESS ON THE INTERDEPENDENCY OF ENERGY AND WATER (2006), *available at*

was planning for a new generating unit at its Comanche Station near Pueblo, Colorado, water supply was a major consideration.[54] Water requirements for the new unit using a traditional closed-loop system would have been significant, and likely would have required Xcel to acquire and change existing agricultural rights for industrial purposes. However, Xcel designed the new 750-megawatt unit with a low-water use system (air-cooled condenser).[55] This system reduced the unit's water use by about half.[56] As a result, Xcel was able to contract with the Pueblo Board of Water Works to meet the water demand of the new unit, rather than having to buy and convert agricultural water rights from local farmers.[57]

Utility companies generally must make these types of decisions—weighing capital costs and efficiencies versus water supply costs—each time new generating capacity is brought online in Colorado. As competition for water increases, utility companies will likely have to look toward technological solutions to reduce their water demand in order to produce energy economically and meet the political demands of customers who value water for other uses.

IV. WATER FOR FUEL SOURCES

In order to generate electricity, all generating plants require a fuel source such as coal, gas, geothermal water (in the case of hydroelectric generation), or solar.[58] In addition to the water used for the production of electricity, there are varying demands for water in the development of the fuel sources used in the electric generation plants.[59] Water use varies by fuel source, but includes uses such as fracking unconventional oil and gas wells, cleaning sulfur from coal, and washing dusty solar panels. But, in virtually every case, water is required to develop fuel, further demonstrat-

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http://www.sandia.gov/energy-water/docs/121-RptToCongress-EWwEIAcomments-FINAL.pdf.

54. *Comanche Generating Station: Environmental Highlights*, XCEL ENERGY, http://www.xcelenergy.com/About_Us/Our_Company/Power_Generation/Comanche_Generating_Station (last visited Dec. 22, 2011).

55. *Id.*; *Xcel Energy Selects Preferred Site For New Coal Generation*, XCEL ENERGY (Feb. 17, 2004), http://www.xcelenergy.com/About_Us/Energy_News/News_Archive/Xcel_Energy_selects_preferred_site_for_new_coal_generation.

56. *Comanche Generating Station: Environmental Highlights*, *supra* note 54.

57. *See* Chris Woodka, *Water Board Approves Power Plant Lease*, PUEBLO CHEFTAIN (July 20, 2005, 12:00 AM), *available at* http://www.chieftain.com/metro/article_d8eac477-855b-56b7-8c3f-22dff5972877.html.

58. *Coal,* ENVTL. PROT. AGENCY, http://www.epa.gov/cleanenergy/energy-and-you/affect/coal.html(last visited Feb. 20, 2012); Natural Gas, ENVTL. PROT. AGENCY, http://www.epa.gov/cleanenergy/energy-and-you/affect/non-hydro.html (last visited Feb. 20, 2012); *Non-Hydroelectric Renewable Energy: Electricity from Non-Hydroelectric Energy Sources*, ENVTL. PROT. AGENCY, http://www.epa.gov/cleanenergy/energy-and-you/affect/natural-gas.html (last visited Feb. 20, 2012).

59. *See Water Quality Issues of Electricity Production: Consumption of Water Resources*, PACE UNIVERSITY, http://www.powerscorecard.org/issue_detail.cfm?issue_id=5 (last visited Jan. 29, 2012).

ing the close connection between energy development and water. Below is a discussion of several fuel sources produced in Colorado and the water required for development.

A. COAL

In the United States, coal is still "king"—coal mining operations extract one billion short tons of coal annually, and the energy content of that coal in the United States is comparable to the energy available from worldwide oil reserves.[60] The amount of water used in coal mining varies greatly depending on the method of mining, the equipment used, and the availability of water.[61] In the western United States, most coal is found in seams of sedimentary layers that lie near the surface; as a result, surface mining is the dominant method of coal extraction in Colorado.[62] Coal production in Colorado averaged approximately 32.6 million tons per year between 2001 and 2007.[63] In 2008, approximately thirty-two million tons of Colorado coal was produced for a total value of production at $887.7 million based on production data provided by the Colorado Mining Association.[64] Coal is used to generate sixty-five percent of Colorado's electricity supply.[65]

Coal is a solid, brittle carbonaceous sedimentary rock, made up of carbon, hydrogen, oxygen, nitrogen, and lesser amounts of sulfur and other trace elements.[66] There are several different types of coal:[67] 1) lignite, 2) subbituminous, 3) bituminous, and 4) anthracite.[68] Colorado coal is generally of a higher quality compared to coal in the East, with low ash, sulfur, and mercury levels and high heat value.[69] The sulfur content in Colorado coal is approximately four times lower than the bituminous coal present in the eastern United States.[70]

60. DOUGLAS KENNEY & ROBERT WILKINSON, THE WATER-ENERGY NEXUS IN THE AMERICAN West 33-4 (2011).

61. JIM MAVIS, WATER USE IN INDUSTRIES OF THE FUTURE: MINING INDUSTRY 50 (2003), *available at* http://www1.eere.energy.gov/manufacturing/industries_technologies/mining/pdfs/water_use_mining.pdf.

62. U.S. DEP'T OF ENERGY, EMERGING ISSUES FOR FOSSIL ENERGY AND WATER: INVESTIGATION OF WATER ISSUES RELATED TO COAL MINING, COAL TO LIQUIDS, OIL SHALE, AND CARBON CAPTURE AND SEQUESTRATION 10 (2006), *available at* http://www.netl.doe.gov/technologies/oil-gas/publications/AP/IssuesforFEandWater.pdf.

63. WATER NEEDS ASSESSMENT, *supra* note 4, at 3-13.

64. Colorado Mining Association, *Mining Facts & Resources: Unique Facts About Colorado Mining*, http://www.coloradomining.org/mc_miningfacts.php (last visited Jan. 22, 2012).

65. *Id.*

66. COLO. DEP'T OF NAT. RESOURCES, COLORADO COAL: ENERGY SECURITY FOR THE FUTURE, COLORADO GEOLOGICAL SURVEY, VOL. 8., NO. 2, at 2 (2005), *available at* http://geosurvey.state.co.us/pubs/Documents/rtv8n21.pdf.

67. *Id.* at 4.

68. *Id.* at 2.

69. *See* WATER NEEDS ASSESSMENT, *supra* note 4, at 3-15.

70. *Id.*

1. Water Demands

Surface mining requires significantly less water than underground mining, and U.S. Department of Energy estimates put water quantity needs for coal mining at about ten to 150 gallons per ton of coal produced.[71] In Colorado surface coal mining, water is mostly used for three activities: 1) mining (and air quality) demands associated with dust suppression via spraying along conveyer belts, at railway and truck docks, and along access roads; 2) preparation and washing demands from coal by placing coal in pools of high-density water;[72] 3) reclamation and grading associated with disturbed areas resulting from mining, though this last use is a one-time (or few times) water demand that occurs once the producer closes portions of the mine that are no longer producing coal and reclaims the surface with plantings.[73] But water demands associated with coal mining typically are not significant; many coal mines actually produce more water through dewatering activities than they consume to support mining operations.[74] However, water needs increase dramatically where unconventional coal production activities, like liquefaction or gasification, occur.[75]

2. Regulatory Framework

The federal Surface Mining Control and Reclamation Act of 1977 ("SMCRA") is, as its name implies, focused on surface coal mining.[76] It was enacted by Congress in 1977 to regulate surface mining in a manner to reduce impacts to land, air, and water resources.[77] In Colorado, the use of water for mining coal is regulated both at the federal and state levels.[78] One of the SMCRA's distinguishing features is the underlying premise that coal mining should constitute a temporary land use and that mined lands should be reclaimed and returned to the "approximate original contours" that existed prior to mining operations.[79]

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71. MELISSA CHAN ET AL., U.S. DEP'T OF ENERGY, EMERGING ISSUES FOR FOSSIL ENERGY AND WATER: INVESTIGATION OF WATER ISSUES RELATED TO COAL MINING, COAL TO LIQUIDS, OIL SHALE, AND CARBON CAPTURE AND SEQUESTRATION 11 (2006), *available at* http://www.netl.doe.gov/technologies/oil-gas/publications/AP/IssuesforFEandWater.pdf.

72. WATER NEEDS ASSESSMENT, *supra* note 4, at 3-19.

73. *Id.*

74. *Id.* at 3-13.

75. *Id.*

76. MICHAEL S. MCCARTHY & HUBERT A FARBES, JR., FEDERAL AND STATE PERMIT REQUIREMENTS APPLICABLE TO SURFACE COAL MINING OPERATIONS, 9A ROCKY MTN. MIN. L. FOUND. INST. 6 (1979).

77. *Id.*.

78. *See, e.g.*, COLO. REV. STAT. § 34-33-120(2)(h) (2012); HAROLD P. QUINN, JR. & BLAIR M. GARDNER, THINGS DONE AND LEFT UNDONE: THIRTY YEARS OF EXPERIENCE WITH THE SURFACE MINING CONTROL AND RECLAMATION ACT, 54 ROCKY MTN. MIN. L. FOUND. INST. 19-1 (2008).

79. *See Id.*

The U.S. Department of the Interior, Office of Surface Mining ("OSM") administers the SMCRA programs and delegates regulatory authority to states with properly designed programs for administering the substantive standards and procedural aspects of the Act.[80] Colorado adopted the Colorado Surface Coal Mining Reclamation Act ("CSCMRA") in 1979.[81] The CSCMRA tracks the SMCRA closely, with a few changes unrelated to issues of water quantity or water availability.[82] Under both regulatory regimes, water quantity concerns arise particularly as it pertains to reclamation activities.

Under the CSCMRA, each operator is required to adhere to certain environmental protection performance standards, and must create "permanent impoundments of water on mining sites as part of reclamation activities only when it is adequately demonstrated that ... such water impoundments will not result in the diminution of water or the quantity of water available to water rights holders for agricultural, industrial, recreational, or domestic uses."[83] In addition, the CSCMRA also addresses the surface effects of underground coal mining, requiring coal mining operators to "minimize the disturbances of the prevailing hydrologic balance at the mine site and in associated off-site areas and to the quantity of surface water and groundwater systems both during and after underground coal and during reclamation."[84] Finally, the CSCMRA requires that coal operators give a detailed description of the measures taken during coal mining and reclamation operations to assure the protection of "the quantity of water in surface and groundwater systems. Protection measures may include providing water by exchange, substitution, replacement, or augmentation, as appropriate under state law."[85]

As in SMCRA (§ 510 (b)(5)), one of the most significant water-related provisions in the Colorado coal mining regulations is one designed to protect alluvial valley floors—where most western farms and ranches are located. The Colorado Code of Regulations section requires certain performance standards for surface mining operations around alluvial floors.[86] Section 407-2:4.24 "establishes minimum environmental protection performance, reclamation, and design standards for surface coal mining operations on or which affect alluvial valley floors in arid or semi-arid regions."[87] Surface mining operations must preserve the essential hydrologic functions of alluvial valley floors not within a surface mine operation's permit area, and most relevantly, "shall not cause material damage to the quality or quantity of water in surface or underground water sys-

80. MCCARTHY & FARBES, *supra* note 76.
81. COLO. REV. STAT. § 34-33-101 (2012).
82. *See id.* §§ 34-33-101 to -137.
83. *Id.* at § 34-33-120.
84. *Id.* at § 34-33-121(2)(a)(III)(i).
85. *Id.* at § 34-33-111(1)(m)(III).
86. COLO. CODE REGS. § 407-2:4.24.1 (2007).
87. *Id.* § 407-2:4.24.1.

tems that supply alluvial floors."[88] The surface coal mining operation must also include an environmental monitoring system to ensure that the quantity or quality of water in the surface or groundwater systems that supply alluvial floors is protected.[89]

3. Clean Coal

"Clean coal" does not refer to a special type of coal that burns cleaner than other types. Instead, it refers to advances in technology that have developed cleaner coal-burning systems that can dramatically reduce air pollution including carbon dioxide emissions.[90] Some of those technologies include innovations in scrubbing to remove sulfur compounds from coal before burning,[91] using combustion chambers to remove nitrogen oxide (NOX) from coal before burning to generate electricity,[92] and using fluidized bed boilers that burn cooler than standard coal boilers to remove ninety percent of sulfur and nitrogen oxide components.[93] Addressing carbon emissions requires the development and use of carbon capture and storage for coal-fired power plants—a continuing economic and technologic challenge.[94] Clean coal is promoted as a way to utilize abundant domestic coal resources, while addressing the environmental downsides of burning coal to produce electricity.[95] However, many clean coal technologies require much more water than conventional coal technologies.[96]

Many clean coal technologies contemplate inclusion of some type of carbon sequestration addition to reduce or prevent the release of sulfides and nitrogen oxide into the air.[97] This is often a multi-stage process, and a significant amount of water can be used at the capture stage as the CO_2

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88. *Id.* § 407-2:4.24.3.
89. *Id.* § 407-2:4.24.4(1)(c).
90. C. LOWELL MILLER, U.S. DEP'T OF ENERGY, CLEAN COAL TECHNOLOGIES, CLEAR AIR LEGISLATION, AND NATIONAL ENERGY STRATEGY 1358-59, *available at* http://www.anl.gov/PCS/acsfuel/preprint%20archive/Files/Merge/Vol-35_4-0003.pdf.
91. *Cleaning Up Coal: The Clean Coal Technology*, U.S. DEP'T OF ENERGY (last updated Mar. 29, 2011), http://www.fe.doe.gov/education/energylessons/coal/coal_cct2.html.
92. *Cleaning Up Coal: Knocking the NOx out of Coal*, U.S. DEP'T OF ENERGY (last updated Mar. 29, 2011), http://www.fe.doe.gov/education/energylessons/coal/coal_cct3.html.
93. *Cleaning Up Coal: A "Bed" for Burning Coal?*, U.S. DEP'T OF ENERGY, http://www.fossil.energy.gov/education/energylessons/coal/coal_cct4.html (Mar. 29, 2011).
94. *See Clean Coal Technology & The Clean Coal Power Initiative*, U.S. DEP'T OF ENERGY http://www.fossil.energy.gov/programs/powersystems/cleancoal/ (last updated Oct. 04, 2011).
95. *Id.*, *Cleaning Up Coal: Introduction to Coal Technology*, U.S. DEP'T OF ENERGY, http://www.fossil.energy.gov/education/energylessons/coal/index.html (last updated Oct. 09, 2008).
96. WATER NEEDS ASSESSMENT, *supra* note 4, at 3-13.
97. *See* World Nuclear Association, *"Clean Coal" Technologies, Carbon Capture & Sequestration*, http://world-nuclear.org/info/inf83.html (last updated Dec. 2011).

is separated and stored.[98] In order to sequester the CO_2, the CO_2 has to be impounded by something, and possible mediums include saline water, depleted oil and gas reservoirs, and unmineable coal seams.[99] Groundwater contamination can occur if the sequestered CO_2 migrates or leaks, potentially impacting the availability of safe or clean water.[100]

B. OIL AND GAS

1. Hydraulic Fracturing Technology

Technological advancements in hydraulic fracturing or "fracking" and horizontal drilling are opening up reserves and formations where oil and gas were not previously retrievable.[101] In Colorado, over ninety percent of gas wells are fracked.[102] Fracking is incredibly effective at producing unconventional gas in the Piceance Basin in western Colorado, and energy companies are also ramping up unconventional oil development in the Niobrara formation, mainly in northeastern Colorado.[103] Fracking is controversial in terms of its possible effects on water quality, and there is a growing concern about the amount of water necessary to fully develop the Niobrara play, if it proves to be as extensive as predicted.[104] Essentially, water is a primary component of this technology, which uses up to five

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98. *Preventing National Electricity-Water Crisis*, *supra* note 37, at 376; *see also* Jeffrey Logan et. al., *Opportunities and Challenges for Carbon Capture and Sequestration,* WRI ISSUE BRIEF: CARBON CAPTURE AND SEQUESTRATION, Oct. 2007, at 2, *available at* http:// pdf.wri.org/opportunities-challenges-carbon-capture-sequestration.pdf (describing four different possible approaches to capturing CO_2).

99. National Energy Technology Laboratory, U.S. DEPARTMENT OF ENERGY, *Carbon Sequestration FAQ Information Portal: Carbon Storage*, http://www.netl.doe.gov/technologies/carbon_seq/FAQs/carbonstorage2.html (last visited Feb. 6, 2012).

100. *Preventing National Electricity-Water Crisis*, *supra* note 37, at 377.

101. *See, e.g.,* GROUND WATER PROT. COUNCIL & ALL CONSULTING, U.S. DEP'T OF ENERGY, MODERN SHALE GAS DEVELOPMENT IN THE UNITED STATES: A PRIMER ES-3 (2009), *available at* http://www.netl.doe.gov/technologies/oilgas/publications/epreports/shale_gas_primer_2009.pdf.

102. *Hydraulic Fracturing*, COLO. OIL & GAS ASS'N., http://www.coga.org/index.php/Hydraulic%20Fracturing (last visited Feb. 4, 2012).

103. *Fast Facts: The Niobrara*, COLORADO OIL & GAS ASS'N., http://www.coga.org/index.php/Hydraulic%20Fracturing (follow "Niobrara" hyperlink) (last updated June 14, 2011); *Piceance Basin – Green River Formation – Colorado Oil & Natural Gas Field*, OILSHALEGAS.COM, http://oilshalegas.com/piceancebasin.html (last visited Feb. 7, 2012).

104. In 2011, there were 3,000 oil and gas well completions, accounting for 0.9 percent of the state's water use. Because the COGCC's focus on fracking has primarily dealt with water quality issues, at present, the only reason the Commission knows about water quantity – how much water a company uses is as a result of companies voluntarily sharing the information – the COGCC does not track the amount of water used separately. *See* Chris Woodka, *State Bores Into Water Data for Oil Drilling*, THE PUEBLO CHIEFTAIN (Dec. 13, 2011), http://www.chieftain.com/news/local/state-bores-into-water-data-for-oil-drilling/article_91cd38ea-1274-11e1-9802-001cc4c03286.html.

million gallons of water for each well that is fracked, depending on the type of well.[105]

It is important, here, to highlight the distinctions among unconventional oil and gas resources—*e.g.* shale gas, shale oil, and coalbed methane. Oil shale—an immature kerogen oil that must be heat-treated either before or after extraction—is discussed in Section IV(4).

Shale Gas. Approximately 400 million years ago, thick shale was deposited as fine silt and clay at the bottom of relatively enclosed bodies of water.[106] Methane—formed from organic matter existing at that time—was buried with the sediment and escaped into sandy rock layers adjacent to the shale, thus forming the conventional accumulations of natural gas.[107] Some of that methane remained locked in the low permeability shale layers.[108] At present, "[t]he [Energy Information Administration] projects that there are 827 trillion cubic feet (TcF) of natural gas recoverable from U.S. shales using the currently available technology."[109]

Shale Oil. Similar to shale gas, shale oil is produced directly from shale oil reservoirs.[110] (Oil shale, discussed *infra*, is different and is either mined, or the reservoir is heated in order to remove the oil shale). Oil hydrocarbons are trapped in the shale rock, and recent technology developments, such as fracking and horizontal drilling, now allow developers to recover them.[111] Major shale oil plays include the Bakken, in Montana and North Dakota,[112] and the Niobrara, in Colorado.[113]

Coalbed Methane. Discussed at greater length below, coalbed methane is an unconventional source of natural gas, in that the methane is adsorbed to coal cleats or fractures in coal seams. Coalbed methane is held in place by the pressure of the coal seam aquifer,[114] and the gas is released once the water is pumped out.[115]

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105. Colorado Oil & Gas Association, *Water Use Fast Facts*, http://www.coga.org/index.php/Hydraulic%20Fracturing (follow "Water Use" hyperlink) (last visited Feb. 7, 2012).

106. NAT'L ENERGY TECH. LAB., U.S. DEPT. OF ENERGY, SHALE GAS: APPLYING TECHNOLOGY TO SOLVE AMERICA'S ENERGY CHALLENGES 3 (2011), *available at* http://www.netl.doe.gov/technologies/oilgas/publications/brochures/Shale_Gas_March_2011.pdf.

107. *Id.*

108. *Id.*

109. *Id.* at 4.

110. *Shale Oil*, HALLIBURTON, http://www.halliburton.com/ps/default.aspx?navid=1413&pageid=4787 (last visited Feb. 5, 2012).

111. *Id.*

112. *Id.*

113. *Niobrara Play*, HALLIBURTON, http://www.halliburton.com/ps/default.aspx?navid=2280&pageid=5180 (last visited Feb. 5, 2012).

114. *See Wyoming Geology: Coalbed Methane Information*, WYO. STATE GEOLOGICAL SURVEY, http://www.wsgs.uwyo.edu/GeologyBySubject/coalbed_methane.aspx (last visited Feb. 5, 2012) [hereinafter *Wyoming Geology*].

115. *See id.*

2. Water is Major Component in Hydraulic Fracturing Technology

The process of fracking is a well stimulation process used to maximize the extraction of oil, natural gas, and even geothermal energy.[116] The process involves the pressurized injection of fluids (comprised mostly of water), propping agents (such as sand), and various chemical additives into a geologic formation.[117] The resulting pressure will exceed the strength of the rock, and the fluid opens or enlarges pre-existing fractures in the rock.[118] As the formation is fractured, a propping agent, such as sand or ceramic beads, is pumped into those fractures to keep them from closing as the pumping pressure is released.[119] The fracturing fluids—the water and chemical additives—are returned back to the surface, and the natural gas or oil will flow from pores and fractures in the rock into the well for later extraction. [120]

The amount of water required for fracking varies by site and by type of formation.[121] According to the Colorado Oil & Gas Commission, two to five million gallons of water may be necessary to fracture one horizontal well in a shale formation.[122] In some cases, operators can use the fluids returned from the wellbore to frack more than one well in order to conserve water, money, and perhaps time.[123]

3. Meeting Water Demands for Hydraulic Fracturing

While the overall water demand for fracking in Colorado is small in comparison to other kinds of water demands, such as agricultural irrigation, it can still present a stumbling block for oil and gas companies because the ability to obtain water varies greatly from place to place, and also over hydrologic conditions.[124] For these reasons, it is an element of resource development worthy of advanced planning. For example, recent news articles have focused on water supplies used to develop the Niobrara shale in areas along Colorado's Front Range.[125] Contract water haulers are leasing excess municipal water from various cities and towns and hauling that water to the drill sites.[126] Short-term municipal contracts may not always be an option, though, particularly if municipal customers are subject to water restrictions due to drought or other planning pur-

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116. Environmental Protection Agency, Hydraulic Fracturing Research Study 1, 2 (2010), *available at* http://epa.gov/tp/pdf/hydraulic-fracturing-fact-sheet.pdf [hereinafter *EPA Fracking Study*].
117. *Id.* at 1.
118. *Id.*
119. *Id.*
120. *Id.* at 2.
121. *Id.*
122. *Water Use Fast Facts*, *supra* note 105, at 1.
123. *Id.*, at 3-4*; EPA Fracking Study*, *supra* note 116, at 2.
124. *See* Bruce Finley, *Fracking of wells puts big demand on Colorado water,* Denver Post Nov. 23, 2011, *available at* http://www.denverpost.com/news/ci_19395984.
125. *See, e.g., id.*
126. *Id.*

poses.[127] Therefore, assuming the Niobrara develops into a significant hydrocarbon field, it is likely that oil and gas companies will have to acquire water supplies other than short-term purchases from cities and towns.[128]

Longer-term water supplies can be difficult to obtain along the South Platte River downstream of the Denver metropolitan area.[129] This is a region of the state that has seen substantial water battles in recent years.[130] Farmers who irrigate with wells have had to adjudicate augmentation plans to cover their out-of-priority depletions.[131] The two largest plans, decreed by the Division 1 Water Court in Case Nos. 02CW335 and 03CW99, are managed by subdistricts of the Central Colorado Water Conservancy District, and together augment over 800 wells.[132] The 02CW335 plan has provided its members with a marginally increased ability to pump water.[133] The 03CW99 augmentation plan has not allowed pumping by its member wells since the water court's initial entry of the decree approving the plan for augmentation in 2008 due to a lack of replacement supplies.[134]

In addition to unmet demand for water supplies for agriculture, there have are several large municipal projects that have been, or are in the process of being, completed in the same area. For example, Aurora's Prairie Waters Project captures the city's water using riverside wells, treats the water, and pumps it upstream for use by Aurora customers.[135] East Cherry Creek Valley Water and Sanitation District and Arapahoe County Water and Wastewater Authority, in conjunction with Farmers Reservoir and Irrigation Company and the United Water and Sanitation District, have acquired large amounts of senior South Platte River irrigation rights and changed those rights for municipal use in the south metro area.[136] Between the shortage of water for existing irrigation demands, and

127. *Id.*
128. *Id.*
129. *See* Jeremy P. Meyer, *S. Platte Water Rift Idles Land,* DENVER POST (June 29, 2007), http://www.denverpost.com/headlines/ci_6256517.
130. *See* Jerd Smith, *Platte River Use Studied,* ROCKY MOUNTAIN NEWS (June 30, 2007), http://m.rockymountainnews.com/news/2007/jun/30/platte-river-use-studied.
131. *See, e.g.,* Simpson v. Bijou Irrigation Co., 69 P.3d 50, 65, 72-3 (Colo. 2003).
132. Application for Water Rights of Lower Logan Well Users, Inc., Case No. 03CW99, Water Court Division 1 (Feb. 2003); Application for Water Rights of Ground Water Management Subdistrict of Central Colorado Water Conservancy District, Case No. 02CW335, Water Court Division 1, 02CW335 (Dec. 2002).
133. *See* CENTRAL COLORADO WATER CONSERVANCY DISTRICT, *GMS Quota Raised to 40%* (June 22, 2011), http://www.ccwcd.org/gms-quota-raised-to-40/.
134. Telephone Interview with Randy Ray, Executive Director, Central Colorado Water Conservancy District (April 4, 2012).
135. *Prairie Waters Project, FAQs,* AURORA WATER, http://www.prairiewaters.org/faqs.asp (last visited Feb. 21, 2012).
136. *Northern Project FAQs*, ECCV WATER & SANITATION DISTRICT, http://www.eccv.org/view/66 (last visited Feb. 8, 2012); ACWWA Flow FAQ's, Arapahoe County Water and Wastewater Authority; http://www.arapahoewater.org/faq/ACWWA_Flow_FAQ.html#4 (last visited April 2, 2012).

the increase in demands from municipalities, the Lower South Platte River Basin is the focus of intensified competition for reliable water supplies.

How will water demands for energy development fit into the competitive water market on the Lower South Platte River? One factor that sets the oil and gas industry apart from most other South Platte water users is that their demand for fracking water is relatively temporary.[137] The water needed to frack each well is very short term—it occurs over the course of days or a couple of weeks.[138] The current water demand for development of the Niobrara shale is likely to continue for a decade or two, but does not represent a permanent demand.[139] Accordingly, Colorado's water rights market may provide the oil and gas industry with the opportunity to pursue creative options in order to acquire the water necessary for developing the Niobrara and other hydrocarbon reserves, while at the same time preserving the ability to use water rights for longer-term demands.

One example of such a solution comes out of the Arkansas River basin. The Lower Arkansas Valley Water Conservancy District ("LAVWCD") is working on a plan that uses rotational fallowing to enable irrigators to lease water for temporary use by thirsty cities, water districts, and other water users, while retaining water ownership and irrigation in the Valley.[140] The LAVWCD implemented this plan using the "super ditch company" model that has found success in California's Imperial Valley.[141] Instead of one farmer selling his water and drying up his land permanently, LAVWCD's strategy draws from a relatively large group of irrigators.[142] Individual irrigators can elect to dry up a small portion of their total irrigated acres, but the aggregate of all these smaller contributions creates a substantial amount of fully consumable water available for other uses.[143] This is not to say that such plans come without transactional costs. This plan still requires that water users go to water court in order to quantify their irrigation rights and implement augmenta-

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137. *See, e.g.,* CHESAPEAKE ENERGY CORP., WATER USE IN NIOBRARA DEEP SHALE GAS EXPLORATION 1 (2012) *available at* http://www.chk.com/media/educational-library/fact-sheets/niobrara/niobrara_water_use_fact_sheet.pdf.

138. *Id.*

139. *See* Debra K. Higley & Dave O. Cox, U.S. Geological Survey, *Oil and Gas Exploration and Development Along the Front Range in the Denver Basin of Colorado, Nebraska and Wyoming* 34 (2007) (explaining the scale of potential oil and gas development in the Denver basin).

140. *See Arkansas Valley Irrigators Incorporate "Super Ditch Company"*, LOWER ARK. VALLEY WATER CONSERVANCY DIST., http://www.lavwcd.org/pressreleases/Arkansas-Valley-Irrigators-incorporate-Super-Ditch-Company.html (last visited Feb. 11, 2011) [hereinafter *LAVWCD Plan*].

141. *Id.*

142. *Id.*

143. According to the LAVWCD, it is expected that irrigators will forgo irrigation of approximately twenty five percent of their land and lease the water they do not use for municipal and other use. Feasibility studies show that 60,000 acre-feet or more of water can be available for lease each year. *See LAVWCD Plan*, *supra* note 140.

tion plans and/or exchanges as necessary.[144] However, such solutions can create incentives for senior water rights owners, particularly farmers, to enter into water deals that senior water users may otherwise be unwilling to consider. Such deals can be structured with a lot of flexibility, thereby enabling energy developers to meet short-term demand, while preserving long-term water supplies for agriculture.

Another option for obtaining temporary water supplies for fracking is through a statutorily created Interruptible Water Supply Agreement as provided in Colorado Revised Statute § 37-92-309.[145] This provision allows for administrative approval for the use of interruptible water supply agreements without the need for adjudicating an application in water court.[146] It allows a water rights owner to loan a water right to another user for a specified length of time, provided that it is not exercised more than three years in a ten-year period.[147] The parties to the interruptible water supply agreement submit a written application to the State Engineer, which includes a detailed engineering report containing information such as the historical consumptive use, return flows, terms and conditions to prevent injury to other water rights users, and a plan to prevent erosion, blowing soils and noxious weeds.[148] The application is published in the appropriate water court resume, and interested parties have thirty days to provide comments to the state engineer.[149] The state engineer may deny the application or approve it with any terms and conditions he determines are necessary to prevent injury to other water users.[150]

4. Hydraulic Fracturing, Water Quality, and the Impact on Water Demand

No present-day discussion of hydraulic fracturing is complete without discussing the water quality issues at the forefront of the recent fracking controversy. Such water quality issues can also have an impact on water demand. Although fracking has been used since the 1940's, the recent escalation of its use to develop unconventional oil and gas fields across the country has led to growing concern about the potential threats to water contamination, particularly groundwater contamination, from "produced water."[151] There are two phases of the fracking process where

144. *See* COLO. REV. STAT. § 37-92-301(2) (2012).
145. *See id.* § 37-92-309(1) ("This section is intended to enable water users to transfer the historical consumptive use of an absolute water right for application to another type or place of use on a temporary basis without permanently changing the water right.").
146. *Id.*
147. *Id.* § 37-92-309(2)(a), (3)(c).
148. *Id.* § 37-92-309(3).
149. *Id.* § 37-92-309(3)(a).
150. *Id.* § 37-92-309(3)(b).
151. "Produced water" is naturally occurring water that exists in the formation and is "produced" along with hydrocarbons. It is usually saline or high in total dissolved solids ("TDS"). In a fracked well, produced water mixes with hydraulic fracturing fluid returning to the surface. The mixture of produced water and hydraulic fracturing fluid "flow back" is generally referred to in this article as "produced water." NETL, *Produced Wa-*

groundwater contamination could theoretically occur. First, during the actual fracking process, fracking fluid could escape into groundwater if the integrity of the well casing is insufficient.[152] Second, because some of the fracking fluid returns out of the well (flow back), it must either be reused or disposed of.[153] One technique to manage produced water is to store it in lined pits on the surface, and let the water evaporate.[154] If the pits leak or overflow, contamination of surface or groundwater could result.[155] A second technique for disposing of produced water is to reinject it into very deep formations through an injection well.[156] Again, if the integrity of the injection well casing is insufficient, groundwater contamination could occur through leaking of the produced water. Third, produced water may be treated to meet state water quality standards and discharged to surface water with a permit.[157] Mishandling of the components (salts) that are removed during treatment could result in groundwater contamination.

One way to minimize the risks of produced water is to reuse it to the extent possible in the fracking process. In Colorado, produced water is regulated by the Colorado Oil and Gas Conservation Commission ("COGCC").[158] Produced water may be reused for future operations; where there is a high demand for water in other operations, nearly all produced water is reused for servicing new wells.[159] However, reuse and recycling rates vary due to field conditions, and, regardless of the formation, current hydraulic fracturing technologies require the use of relatively low salinity water.[160] High salt content makes pumping the injection fluid

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ter Management Information System: Introduction to Produced Water (last visited Feb. 11, 2011), http://www.netl.doe.gov/technologies/pwmis/intropw/index.html [hereinafter *NETL Produced Water*].

152. *See* Ken Cohen, *"Fracking" Fluid Disclosure: Why It's Important,* EXXONMOBIL PERSPECTIVES (Aug. 25, 2011), http://www.exxonmobilperspectives.com/2011/08/25/fracking-fluid-disclosure-why-its-important/; cite to DOE SEAB August 2011 report that identified this as key.

153. The COGCC is working to implement reuse plans between operators, and with the STRONGER Report recommendations, will institute guidelines and requirements for flowback pits in order to implement those reuse and recycle plans. STRONGER, COLORADO HYDRAULIC FRACTURING STATE REVIEW 25 (October 2011) [hereinafter STRONGER Report].

154. *See Fast Facts: Produced Water,* at 2 COLORADO OIL & GAS ASSOCIATION (June 14, 2011), http://www.coga.org/pdfs_facts/produced_water_fastfacts.pdf [hereinafter *COGA Produced Water*].

155. *See id.*

156. *Id.*

157. *See* 33 U.S.C. § 1342 (2008).

158. Produced Water Treatment and Beneficial Use Information Center*, State Regulations: Colorado* http://aqwatec.mines.edu/produced_water/regs/state/co/index.htm (last visited Feb. 11, 2012).

159. *COGA Produced Water*, *supra* note 154, at 2.

160. *Natural Gas Water Usage Facts: Water Recycling*, CHESAPEAKE ENERGY http://www.naturalgaswaterusage.com/Water-Recycling/Pages/information.aspx (last visited Feb. 11, 2012).

difficult and can make the fracturing fluid ineffective.[161] In some cases, use of recycled water can increase the power requirements and result in higher volumes of chemicals needed to reduce friction.[162] Colorado's recent STRONGER Report—which evaluated the effectiveness of COGCC regulations governing hydraulic fracturing (prior to the new rules released in December 2011)—recommended that the COGCC work with the Division of Water Resources to evaluate water use in Colorado and also to administer programs that maximize water reuse.[163] Accordingly, there is also an incentive on the water quality side of the hydraulic fracturing process to look for ways to maximize the reuse of produced water and minimize the need for fresh water supplies.

Energy companies are just now starting to explore the water options available for developing the Niobrara formation in Colorado. Not only does it appear that developing the Niobrara shale will likely be more water intensive than developing gas in the Piceance Basin on the West Slope,[164] but the competition for water in the South Platte Basin has escalated in the past several years due to increased municipal demand on the Front Range.[165] These factors may provide additional cost incentive to energy production companies to treat and reuse produced water, rather than simply dispose of it as a waste stream.[166] On the West Slope, treating produced water for reuse in fracking is far more expensive than simply disposing of it through reinjection.[167] However, due to a more competitive water market on the Front Range, treating produced water for reuse in fracking may end up being a more viable alternative when developing the Niobrara shale if the price of fresh water supplies, and the cost of transporting fresh water to the drilling site, become excessive.

161. Gayathri Vaidyanathan, *Alternatives to fresh water eyed for fracturing,* E&E News GREENWIRE, Mar. 6, 2012, http://connect.sierraclub.org/ActivistNetwork/home ["Teams", search "Hydrofracking Team", see March 6, 2012 dispatch].

162. *Id.*

163. STRONGER Report, *supra* note 153, at 17.

164. *Compare Water Use in Niobrara Deep Shale Gas Exploration*, CHESAPEAKE ENERGY FACT SHEET 1, at 1 (September 2011), http://www.chk.com/Media/Educational-Library/Fact-Sheets/Niobrara/Niobrara_Water_Use_Fact_Sheet.pdf. (Fracing a single Niobrara deep shale well requires an average of 4 million gallons of water), *with Well Completion & Hydraulic Fracturing: Piceance Basin, Colorado,* ENCANA NATURAL GAS, (April 2011), http://www.encana.com/pdf/communities/usa/wellcompletionandhydraulicfracturing(Piceance).pdf. (the water requirement for fracing a well in the Piceance Basin is about 1.2 million gallons of water).

165. *Western Water Assessment: The Challenge of Supply and Demand,* UNIVERSITY OF COLORADO AT BOULDER: SPRAT, *available* at http://wwa.colorado.edu/front_range/sprat_dmnd.html (last visited Jan. 30, 2012).

166. U.S. DEP'T OF INTERIOR, BUREAU OF RECLAMATION, *Oil and Gas Produced Water Management and Beneficial Use in the Western United States*, Sept. 2011, *available at* http://www.usbr.gov/research/AWT/reportpdfs/report157.pdf.

167. COLORADO GEOLOGICAL SURVEY, *Coalbed Methane Stream Depletion Assessment Study – Piceance, Basin,* Colorado, April 2008, *available at* http://geosurvey.state.co.us/water/CBM%20Water%20Depletion/Documents/Piceance_Final_Report.pdf.

C. COALBED METHANE

1. The Technology: Producing Coalbed Methane

Coalbed methane ("CBM") is natural gas that is trapped within coal seams.[168] It is created either by thermo-chemical reaction or by microbiological action[169] The methane is absorbed into the coal cleats (surface area of the coal) and held by water pressure.[170] Coalbed methane is produced by reducing the water pressure by pumping it out of the formation so that the gas may flow out.[171] The gas separates from the water and flows up a separate pipe.[172] Once CBM is extracted, the gas and water are divided. The gas is transported via pipeline, while the water is either injected back into the ground, treated, or discharged on the surface.[173]

CBM accounts for seven percent of natural gas production and eight percent in United States reserves, with eighty percent of that production coming from the Rocky Mountain West.[174] Regional sources for CBM include: the Piceance Basin (northwestern Colorado), the San Juan Basin (southwest Colorado/New Mexico), the Powder River Basin (Wyoming), the Uintah Basin (Utah), and the Raton Basin (south-central Colorado).[175] To complete production, companies must pump about 12,000 gallons of water per day, per well, in order to separate the methane.[176] Pumping water during CBM development in basins with deep methane-bearing coals such as the San Juan, Raton, and Piceance basins is unlikely to lower the water table of shallow alluvial aquifers, because of the distance of separation between the two formations. For this reason, Colorado has taken a unique approach with regard to the potential impact of dewatering CBM formations on existing water rights.[177]

2. Regulatory and Common Law Framework

i. Colorado's Legal Perspective on CBM Produced Water

Absent a showing to the contrary, groundwater in Colorado is presumed to be "tributary," or hydraulically connected to surface water so as to require administration within the prior appropriation system.[178] Pursuant to the Water Right Determination and Administration Act of 1969,

168. Gary Bryner, *Coalbed Methane Development in the Intermountain West: Producing Energy and Protecting Water,* 4 WYO. L. REV. 541, 543 (2004).
169. *See Wyoming Geology, supra* note 114 (For more information on the biological processes of bacteria-produced CBM).
170. Bryner, *supra* note 168, at 543.
171. *Wyoming Geology, supra* note 114.
172. *Id.*
173. Bryner, *supra* note 168, at 543.
174. *Id.* at 541-42.
175. *Id.* at 542.
176. *Id.* at 543.
177. *See* Bryner, *supra* note 168, at 549-550.
178. Simpson v. Bijou Irrigation Co., 69 P.3d 50, 59 n.7 (Colo. 2003).

§§ 37-92-101 through -602, Colorado Revised Statute ("C.R.S.") ("1969 Act"), the State Engineer must protect existing rights from injury by curtailing out-of-priority diversions of groundwater that may cause injury to vested water rights.[179] In addition, the Colorado Groundwater Management Act requires that all water users obtain a permit from the State Engineer for any "well," which is defined as "any structure or device used for the purpose or with the effect of obtaining groundwater for beneficial use from an aquifer."[180] However, based on their conclusion that produced water was under the exclusive jurisdiction of the COGCC, the State Engineer's office never regulated groundwater produced in the course of oil and gas operations.[181] This position was challenged by a group of water users, and the case ultimately went to the Colorado Supreme Court.[182]

As it pertained to CBM production, Colorado water law (as of 2009) was similar to Wyoming water law, in that produced water from CBM production constituted a beneficial use of that water, though the water was not the object of production.[183] In 2009, the Colorado Supreme Court, affirming a water court ruling, held in *Vance v. Wolfe* that produced water from CBM development constitutes "beneficial use" and further, operators of CBM wells must obtain well permits pursuant to the Ground Water Management Act.[184] In addition, the *Vance* decision held that produced water is not only subject to regulation by COGCC, but is also subject to the 1969 Act and the Ground Water Management Act.[185] Accordingly, the *Vance* decision necessitated that the State Engineer permit all of the five thousand or so existing CBM wells in Colorado.[186]

ii. Changing the State Regulatory Framework: Produced Nontributary Groundwater Rules (2 CCR 402-17)

In light of the *Vance v. Wolfe* decision, the Colorado General Assembly passed HB 09-1303,[187] codified in title 37, article 90, sections 137,

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179. COLO. REV. STAT. § 37-92-502 (2011).

180. COLO. REV. STAT. § 37-90-137(1); *Id.* § 37-90-103(21)(a).

181. DEP'T OF NATURAL RES., OFFICE OF THE STATE ENGINEER, STATEMENT OF BASIS, PURPOSE, AND SPECIFIC STATUTORY AUTHORITY: PRODUCED NONTRIBUTARY GROUNDWATER RULES, 2 CCR 402-17, at 2 (last visited Jan. 23, 2011), *available at* http://water.state.co.us/DWRIPub/Produced%20Nontributary%20Ground%20Water/FinalProducedNontributaryGroundWater_SOBP.pdf. [hereinafter STATEMENT OF BASIS].

182. Dave Colvin et al., *Origins of Produced Water Regulations in Colorado – A Brief History*, AWRA – Colorado, http://awracolorado.havoclite.com/newsletter/brief-history-of-produced-water-in-colorado/.

183. Holly Franz & Rebecca W. Watson, *Produced Water: Water Rights and Water Quality: "A 'Meeting' of the Waters"?* ROCKY MTN. MIN. L. FOUND. INST., Chapter 12, at 12-8 (2006) *available at* http://wsmtlaw.com/publications/.

184. Vance v. Wolfe, 205 P.3d 1165, 1173 (Colo. 2009).

185. *Id.*

186. Mark Jaffe, *Drilling Requires Water Permits*, DENVER POST (Apr. 21, 2009), http://www.denverpost.com/headlines/ci_12187563.

187. STATEMENT OF BASIS, *supra* note 181, at 2.

138(2), and 308(11) of the C.R.S.,[188] the intent of which was to assist the State Engineer to "efficiently and expeditiously identify those oil and gas wells that withdraw nontributary groundwater" and administer CBM well permits accordingly.[189] The State Engineer's office promulgated new rules that: (1) delineated certain areas or geologic formations as nontributary for the purposes of the State Engineer's administration of produced water; and (2) established an adjudicatory procedure for the State Engineer to make individual nontributary determinations for the administration of produced water.[190]

The first purpose of the rules—to establish certain areas or formations as "nontributary"—was of critical importance to both the State of Colorado and energy companies conducting CBM operations within Colorado borders.[191] Nontributary groundwater is statutorily defined as "that groundwater, located outside the boundaries of any designated groundwater basins in existence on January 1, 1985, the withdrawal of which will not, within one hundred years, deplete the flow of a natural stream."[192] Unlike tributary water, nontributary groundwater is *not* administered within the priority system.[193] Therefore, CBM wells extracting nontributary groundwater do not have to meet the regular requirements of 1) proving no injury to vested rights and 2) submitting augmentation plans to replace any out-of-priority diversions.[194]

Without a categorical determination that certain areas are nontributary, the energy companies would have to quantify the impacts of the produced water on surface flows, and even more importantly, find existing water rights that could be used to augment the depletions caused by pumping produced water from the coal bed methane formations.[195] Because the formations tapped for CBM production are often thousands of feet deep,[196] it is technically very difficult to quantify the amount, timing

188. COLO. REV. STAT. §§ 37-90-137 (2011); § 37-90-138(2) (establishing a reasonable period of delay—until April 30, 2010—before oil and gas wells must obtain Ground Water Act permits); § 37-92-308(11) (providing an additional transition period—until December 31, 2012—wherein operators of CBM wells that withdraw tributary groundwater could obtain approval for substitute water plans without having to file applications for plans to augmentation in water court).

189. STATEMENT OF BASIS, *supra* note 181, at 2.

190. *Id.* at 2-3.

191. *See* Jaffe, *supra* note 186 (noting that energy companies are disappointed with the ruling, but that it only affects wells using nontributary groundwater).

192. COLO. REV. STAT. § 37-90-103(10.5) (2011).

193. COLO. REV. STAT. § 37-92-305(11) (2011).

194. STATEMENT OF BASIS, *supra* note 181, at 1-3.

195. *See id.*

196. For example, the San Juan Basin ranges from 550 to 4,000 feet in depth, and parts of the Piceance Basin are up to 6,000 feet deep. ENVTL. PROT. AGENCY, EVALUATION OF IMPACTS TO UNDERGROUND SOURCES OF DRINKING WATER BY HYDRAULIC FRACTURING OF COALBED METHANE RESERVOIRS STUDY 5-2 to 5-3 (2004), *available at* http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_coalbedmethanestudy.cfm.

and location of depletions attributable to the produced water. Moreover, because of the deep formations, the lagging impact of developing produced water extends out over many, many years.[197] This means that any requirement to augment such depletions would also extend out decades or even hundreds of years into the future. In other words, for CBM production to continue to be economically viable in Colorado, it is important that most of the CBM wells are considered nontributary.

Prior to these rules, there was no procedure in place for the State Engineer to determine whether waters produced during CBM extraction were or were not nontributary.[198] The purpose of the new rules is to create an efficient means for the State Engineer to determine which of the current wells that withdraw produced groundwater are nontributary, thereby requiring permitting under C.R.S. § 37-90-137(7), and which are tributary—thereby requiring water court adjudication, and that any out-of-priority depletions caused by the production of water during coalbed methane development be augmented.[199]

The State Engineer made the following determinations about which areas of Colorado are considered nontributary for the purposes of the well permitting scheme required under C.R.S. § 37-90-137(7).[200]

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197. For instance, after 30 years of mining the West Decker Mine in Montana, 10 feet of drawdown were recorded at a distance of about 5 miles from the mine. JOHN WHEATON & JOHN METESH, POTENTIAL GROUND-WATER DRAWDOWN AND RECOVERY FROM COALBED METHANE DEVELOPMENT IN THE POWDER RIVER BASIN, MONTANA 13 (2002), *available at* http://www.blm.gov/pgdata/etc/medialib/blm/mt/field_offices/miles_city/og_eis/techdocs.Par.26011.File.tmp/CBM3DGWReport.pdf.

198. STATEMENT OF BASIS, *supra* note 181, at 3.

199. *Id.* at 3-4.

200. *Id.* at 11-34.

Basin/Field (Name)	Formation (Name)	Rule Dictating Nontributary Designation	Area Designated As Nontributary
Piceance Basin	Mesaverde Formation	Rule 17.7.D.1	Cameo and South Canyon Coal Groups (in the Muddy Creek Drainage North of Paonia Reservoir in Delta and Gunnison Counties)
	Neslen Formation		All Neslen Formation within Piceance Basin in Garfield and Rio Blanco Counties
	Shallow Formations		Undifferentiated Wasatch Formation, middle and lower Wasatch Formation, Iles Formation of the Mesaverde Group, Williams Fork Formation of the Mesaverde Group, and undifferentiated Mesaverde Group, within certain delineated areas in Rio Blanco, Garfield, Mesa, Delta, and Pitkin Counties.
	Weber Formation		Rangely Oil Field in Rio Blanco County
	Morrison and Entrada Sundance Formations		Wilson Creek Oil Field in Rio Blanco County
Northern San Juan Basin	Fruitland Formation	Rule 17.7.D.2	All Fruitland Formation
	A Pictured Cliff, Cliff House, Menefee, Point Lookout, and Dakota Formations		Within delineated areas in Southwestern Colorado
Paradox Basin	Paradox Formation		Hovenweep Shale, Gothic Shale, and Desert Creek Members within Mesa, Montrose, San Miguel, Dolores, and Montezuma Counties

Basin/Field (Name)	Formation (Name)	Rule Dictating Nontributary Designation	Area Designated As Nontributary
Sand Wash Basin	From Fort Union Formation, Lance Formation, Lewis Shale, Meseverde Group, Baxter Shale, Frontier Formation		Mowry Shale, Dakota Sandstone, Nugget Sandstone, and Hiawatha Member of the main body of the Wasatch Formation in Moffat County.
	Wasatch Formation		Hiawatha and West Hiawatha Gas Fields
Denver—Julesburg Basin	Pierre Shale Formation, Lower Pierre Shall Formation, the Niobrara Formation, the Carlile Formation, the Greenhorn Formation, the Graneros Formation, the Dakota Group, and the Lyons Formation		Parkman, Sussex, and Shannon Members of Pierre Shale Formation; within certain delineated areas in northeastern Colorado.

As a result of these findings, the producers of wells within these areas, although required to obtain a well permit from the State Engineer's office, do not have to attempt to quantify the out-of-priority depletions associated with produced water, nor find alternative water supplies to replace those depletions on a virtually permanent basis.[201] Under the new State Engineer rules, wells outside of these formations may also seek a nontributary designation pursuant to the adjudicatory process established therein.[202] The new State Engineer rules appear to have balanced the concerns of water rights users, who have been provided with a forum to demonstrate injury to their rights by the production water in the CBM process, and energy producers, who can continue to produce CBM efficiently at least in nontributary-designated formations.

D. OIL SHALE

Commentators have again suggested that an oil shale boom is coming to Colorado in the next decade.[203] Oil shale is attractive due to its abun-

201. *See id.* at 1-3.
202. *Id.* at 2-3.
203. Carrie Covington Doyle, *The Modern Oil Shale Boom: An Opportunity for Thoughtful Mineral Development*, 20 COLO. J. INT'L ENVTL. L. & POL'Y 253, 254 (2009).

dance and potential as a domestic source of oil—it is a sedimentary rock that contains solid bituminous materials (known as kerogen) that are released as petroleum-like liquids when the rock is heated.[204] The biggest known resource for oil shale lies in the Green River Formation, located at the intersection of Utah, Wyoming, and Colorado (known as the Piceance Basin), which may contain as much as 800 billion to 1.8 trillion barrels of oil resources.[205] Over seventy percent of those oil shale deposits are lie within federal lands and fall under the regulatory authority of the U.S. Department of the Interior, Bureau of Land Management ("BLM").[206] Reserve estimates in the area of Colorado surrounding Grand Junction indicate there are 1.5 to 1.8 billion barrels (bbl) of retrievable oil.[207]

1. History of Oil Shale Development in Colorado

Coloradans have known about significant oil shale reserves since the late 19th century,[208] and have attempted to take advantage of this resource since that time. For as long as the energy industry can remember, oil shale development has been "around the corner." However, until recent technological developments, oil shale was difficult to develop.[209] Energy companies have attempted to harness the oil shale resources in Colorado for over a century; many of those companies hold at least somewhat senior water rights, and this fact may have major implications for the West Slope in particular.[210]

Shell, a subsidiary of Royal Dutch Shell, has slowly acquired water rights and cropland in the Piceance Basin[211] for the purposes of oil shale research and development—indeed, Shell states that it believes oil shale development will become commercially viable "in the next decade."[212]

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204. *About Oil Shale*, OIL SHALE AND TAR SANDS PROGRAMMATIC EIS INFO. CTR., http://ostseis.anl.gov/guide/oilshale/index.cfm (last visited Feb. 9, 2011).

205. Covington Doyle, *supra* note 203, at 261-62.

206. *Id.* at 262. *See also* BUREAU OF LAND MANAGEMENT, U.S. DEP'T OF THE INTERIOR, FES 08-32, PROPOSED OIL SHALE AND TAR SANDS RESOURCE MANAGEMENT PLAN AMENDMENTS TO ADDRESS LAND USE ALLOCATIONS IN COLORADO, UTAH, AND WYOMING AND FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (2008), *available at* http://ostseis.anl.gov/.

207. *See* WATER NEEDS ASSESSMENT, *supra* note 4 at 3-26.

208. *See* Center for the American West, *What Every Westerner Should Know About Oil Shale*, http://www.centerwest.org/publications/oilshale/2history/1boom.php (last visited Feb. 8, 2012) [hereinafter *Every Westerner*].

209. *Id.*

210. Most hold senior rights from the 1950s, but some hold water rights from as far back as the 1890s. *See* LAWRENCE J. MACDONNELL, WESTERN RES. ADVOCATES, WATER ON THE ROCKS: EXECUTIVE SUMMARY, *available at* http://www.westernresourceadvocates.org/land/wotrreport/index.php.

211. *See* Steve Lipsher, *Colorado's oil shale draws Shell's interest*, THE HOUSTON CHRONICLE (May 11, 2008), http://www.chron.com/business/energy/article/Colorado-s-oil-shale-draws-Shell-s-interest-1785278.php.

212. *See* SHELL, *Operations Overview*,

Oil shale development has been susceptible to crude oil boom-and-bust cycles and development of oil shale has begun only to be halted a number of times.[213] One of the more recent cycles began in 2005 when Congress declared, in the Energy Policy Act of 2005 ("EPACT"), that oil shale development should take priority as a "strategically important resource."[214] This statutory provision tasked BLM with oil shale leasing to promote rapid commercial development.[215] Early in 2006, BLM, by rulemaking, granted research and development leases in Colorado.[216] But EPACT directed an accelerated move to commercial oil shale development, and to facilitate oil shale leasing BLM began an environmental analysis of a leasing program.[217] In 2007 a Draft Programmatic Environmental Impact Statement ("PEIS") was issued for public comment and completed in 2008.[218] The Record of Decision identified areas open for leasing and amended eight Resource Management Plans to allow for leasing of oil shale.[219] In addition, commercial oil shale rules were promulgated.[220] However, when Secretary of the Interior Ken Salazar arrived in 2009, he pulled back on the reins of commercial oil shale. Instead of expediting the development process of oil shale, as the EPACT 2005 directed, Secretary Salazar slowed the process,[221] explaining that he would take a "judicious approach to oil shale development [that] will help Western Slope communities avoid any unfortunate bust that comes from an unchecked boom on commercial leasing."[222]

In February 2011, Secretary Salazar directed that the Department of Interior take a "fresh look" at oil shale and review the commercial rules

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http://www.shell.us/home/content/usa/aboutshell/shell_businesses/upstream/ (last visited Feb. 6, 2012).

213. The Colony Oil Project in Parachute Creek was spearheaded by Exxon in the early 1980s after the oil embargo in the 1970s fanned the flames of fear over reliance on foreign oil. After the oil bust in 1982, Exxon shut down the Colony Oil Project – a $5 billion project. *See* ANTHONY ANDREWS, CONGRESSIONAL RESEARCH SERVICE, DEVELOPMENTS IN OIL SHALE, at CRS-29 (2008), *available at* http://www.fas.org/sgp/crs/misc/RL34748.pdf.

214. *Id.* at Summary; Energy Policy Act of 2005 § 369, Pub. L. No. 109-58 (2005).

215. ANDREWS, *supra* note 213.

216. *See* CTR. FOR THE AM. W., *We'll Get it Right Next Time: Commercial Leasing* (last visited Jan. 23, 2011), *available at* http://www.centerwest.org/publications/oilshale/4getitright/2commercial.php#30 [hereinafter *Get It Right*]

217. Energy Policy Act § 369(d).

218. *Get It Right, supra* note 217.

219. *See* BUREAU OF LAND MGMT., *Details on the Oil Shale & Tar Sands PEIS*, http://www.blm.gov/wo/st/en/prog/energy/oilshale_2/PEIS_details.html (last visited Feb 9, 2012).

220. *Id.*

221. *See* Stephen Power, *Interior Secretary Scraps Oil-Shale Leasing*, THE WALL STREET JOURNAL (Feb. 25, 2009), *available at* http://online.wsj.com/article/SB123560039534376131.html.

222. *Get It Right*, *supra* note 216.

for oil shale development[223] and BLM began a new planning process for oil shale.[224] One of Secretary Salazar's noted concerns was the "protect[ion] of water supplies in the arid West" and the Rule's low royalty rate.[225] On February 3, 2012, the BLM issued a new Draft Programmatic Environmental Impact Statement for oil shale and Tar Sands with a comment period closing on May 4, 2012.[226] How this story will unfold is anybody's guess, but so long as oil and gas companies remain interested in developing technologies making oil shale commercially viable,[227] oil shale development will remain a potentially significant future water demand in Colorado.

2. Oil Shale Production Techniques

The two methods generally under discussion for extracting oil from shale rock are surface retort and *in situ* underground retort.[228] Surface retort—the older of the two technologies—involves mining the shale out of the earth first and then extracting or retorting the oil from the shale above ground.[229] Above ground oil shale retort is plagued by environmental concerns. In particular, it requires access to significant amounts of water.[230] *In situ* underground retort uses heat to extract oil from the shale while the rock is in place underground.[231] Currently, oil companies are using BLM research and development leases to test *in situ* technology to extract oil from the shale. In some cases, the heating process, which itself can require significant power, can take years before the oil is adequately heated and extracted from the shale so that it can be pumped to the surface.[232] However, until the regulatory environment is more settled and the long-term economics are viable - the cost of producing oil from

223. Press Release, BUREAU OF LAND MGMT., *Salazar: Technology, Water Supplies, and Fair Return Must Guide Nation's Oil Shale Program* (Feb. 5, 2011), *available at* http://www.blm.gov/wo/st/en/info/newsroom/2011/february/NR_02_15_2011.html.

224. Notice of Intent to Prepare a Programmatic Environmental Impact Statement (EIS) and Possible Land Use Plan Amendments for Allocation of Oil Shale and Tar Sands Resources on Lands Administered by the Bureau of Land Management in Colorado, Utah, and Wyoming, 76 Fed. Reg. 21003 (proposed April 14, 2011), *available at* http://www.blm.gov/wo/st/en/prog/energy/oilshale_2.html.

225. *Id. See also* U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-11-35, ENERGY-WATER NEXUS: A BETTER COORDINATED UNDERSTANDING OF WATER RESOURCES COULD HELP MITIGATE THE IMPACTS OF POTENTIAL OIL SHALE DEVELOPMENT (2010), *available at* http://www.gao.gov/products/GAO-11-35.

226. Fed. Reg. (Feb 3, 2012) available at http:// http://ostseis.anl.gov/documents/index.cfm (Colorado lands open to federal oil shale leasing were reduced by approximately ninety percent - 350,000 acres to 35,308). Bruce Finley, "Federal officials scale back plan to open Rocky Mountain land to shale development," Denver Post (Feb. 3, 2012).

227. SHELL, *supra* note 212, at Colorado.

228. Covington Doyle, *supra* note 203, at 263.

229. *Id.*

230. ANDREWS, *supra* note 213, at CRS-7.

231. Covington Doyle, *supra* note 203, at 264.

232. *Get It Right*, *supra* note 216.

oil shale is currently greater than sixty dollars per barrel[233] and oil shale becomes economically viable when oil prices are higher and stay high, it is likely that oil shale remains in the more distant future.

3. Water Demand for Oil Shale Production

Even if the lower water use estimates of three to four barrels of water per barrel of oil shale[234] are correct,[235] oil shale development requires large quantities of water. To develop Colorado's estimated oil shale reserve, the direct demand (1.55 million bbl) will require approximately 100,000 acre-feet per year, according to a February 2011 Colorado River Water Conservation District ("CRWCD") Study.[236] This number was cut drastically from an earlier study (the CRWCD's Phase I Study), where the estimate suggested approximately 400,000 acre feet per year to produce Colorado's recoverable oil shale.[237] The CRWCD notes, however, that the study is not predictive, and that the water needs for oil shale development will vary depending on technological improvements, economic viability, future demand, and other limitations such as environmental permitting requirements.[238]

In anticipation of oil shale development, oil companies have established conditional water rights associated with more than 200 separate proposed structures, including reservoirs and pipelines in the Colorado River and White River Basins.[239] Collectively, these rights would enable the direct diversion of more than 10,000 cubic feet per second and the storage of more than 1.7 million acre-feet.[240] If energy companies were to exercise their decreed water rights, Western Resource Advocates ("WRA"), a Colorado conservation organization, argues there would be four major impacts on traditional water use in Colorado: 1) impacts on agriculture;[241] 2) impacts on junior users;[242] 3) restrictions on the 1922 Colorado River Compact;[243] and 4) impacts on endangered fish.[244]

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233. *About Oil Shale*, *supra* note 204.

234. WATER ON THE ROCKS: EXECUTIVE SUMMARY, *supra* note 210, at xiii.

235. Initial process water requirement estimates of 2.1 to 5 barrels of water per barrel of oil developed in the 1970s has declined to the present estimated 1 to 3 barrels of water per produced barrel of oil shale. *See* DOE OFFICE OF PETROLEUM RESERVES, Fact Sheet: Oil Shale Water Resources, fossil.energy.gov/.../reserves/npr/Oil_Shale_Water_Requirements.pdf (last visited Jan. 23, 2011).

236. COLORADO RIVER WATER CONSERVANCY DIST., ENERGY DEVELOPMENT WATER NEEDS ASSESSMENT: PHASE II FINAL REPORT, at iii (Feb. 2011), http://www.crwcd.org/media/uploads/Energy_Development_Water_Needs_Assessment_Phase_II_Final_Report.pdf. [hereinafter CRWCD REPORT].

237. *Id.* at iii.

238. *Id.* at iv.

239. WATER ON THE ROCKS: EXECUTIVE SUMMARY, *supra* note 210, at v.

240. Energy companies have also acquired full or partial ownership of over 100 existing irrigation ditches, with rights to divert more than 650 cfs for oil shale deposits. *See id.*

241. *Id.* at xiv ("Energy companies own large portions of the water rights historically used to irrigate lands in the region...Should oil shale move beyond the research phase,

The water rights associated with oil shale development have, from time to time, come under legal challenges from other water rights users. In 1999 and 2000, there were a series of cases challenging oil companies' conditional water rights appropriated for oil shale development on the basis that (1) the companies had failed to diligently develop the water rights; (2) the companies could not meet the statutory requirement (C.R.S. § 37-92-305(9)(b)) that they "can and will" develop the water rights and put them to beneficial use within a reasonable time, and; (3) that the water rights were speculative because it was unlikely that commercial scale oil shale development would occur.[245]

The Colorado Supreme Court determined that, in addition to the reasonable diligence requirement,[246] the "can and will" standard and the anti-speculation doctrine would be applied in the context of an application for diligence for conditional water rights.[247] However, the Colorado Supreme Court also held that the current economic infeasibility of oil shale extraction due to low oil prices could be taken into account, and thus determined that OXY USA, Inc. had met its burden of proof demonstrating that it had diligently developed its conditional water rights.[248]

More recently, in July of 2011 the water court in Water Division No. 6 nullified 140,000 acre-feet of White River Basin conditional water rights, some of which were intended for use in potential oil shale development, on the basis that the Yellow Jacket Water Conservancy District did not have the requisite quorum of directors necessary to authorize the filing of diligence applications when the same were filed by the District's secretary and general counsel in 2009.[249] The District has appealed the water court ruling to the Colorado Supreme Court.[250] If unsuccessful on

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many...of these rights would be changed in use, and the lands historically irrigated would be taken out of agriculture.").

242. An outcome of oil shale development would be the displacement of existing uses to new oil-shale-related uses with senior priorities – as some of these rights date back to the 1950's, more junior uses would be affected in western Colorado and the Colorado Front Range. *See id.*

243. As increased consumption would increase the risk of a "call" by the Lower Colorado Basin states against the Upper Basin, decreasing the legal availability of water under the 1922 Colorado River Compact's associated laws and requirements. *See id.*

244. According to the U.S. Fish and Wildlife Service, additional depletions from the Colorado River Basin would jeopardize the continued existence of four species of fish – any new water development program would be required to follow regulations associated with protection of the endangered fish. *See id.*

245. Mun. Subdistrict, N. Colo. Water Conservancy Dist. v. Getty Oil Exploration Co., 997 P.2d 557 (Colo. 2000); Mun. Subdistrict, N. Colo. Water Conservancy Dist. v. OXY USA, Inc., 990 P.2d 701 (Colo. 1999); Mun. Subdistrict, N. Colo. Water Conservancy Dist. v. Chevron Shale Oil Co., 986 P.2d 918 (Colo. 1999).

246. *OXY*, 990 P.2d at 705-06.

247. *Id.* at 707-08.

248. *Id.* at 711-12.

249. *In re* Yellow Jack Water Conservancy Dist., No. 09CW48, 09CW50 (Colo. Dist. Ct., Water Div. No. 6, July 1, 2011)

250. Colorado Supreme Court Case No. 2011SA306 and 2011SA307, Consolidated into Case No. 2011SA306.

appeal, the District could apply for new conditional water rights, though, if granted, it would have lost its priority date of the voided rights.[251] Some observers believe that the water court decision is one which shows disfavor for oil shale development.[252] Whether that is true or not, if upheld, this decision, and other inevitable future challenges to the water rights appropriated for oil shale development, could have significant impact on energy development because of the potential impact on actual water availability.

4. Protecting Water Quality

In addition to refining the extraction process, companies with oil shale interests are attempting to reduce water demands associated with oil shale production and develop techniques to protect water quality in the nearby alluvial aquifers. Shell engaged in testing the viability of an underground freeze wall—one that is designed to create an impermeable frozen barrier that will surround the heat zone—in order to protect nearby groundwater from contamination.[253] American Shale Oil is working on a similar project to protect groundwater, but intends to drill into deeper layers of the oil shale below the Piceance Basin's aquifers.[254] Chevron plans to target shale beds capped by impermeable geological formations, in an effort to prevent groundwater from seeping into the contaminated rubble left behind from the extraction process.[255] A successful technology to prevent groundwater contamination will be a key factor for commercial scale oil shale production to become a reality in Colorado.

E. SOLAR

1. The Technology: Producing Solar

Production of photovoltaic solar energy ("PV") is the world's fastest growing technology, and because demand is increasing and technology improvements for producing solar panels are improving, costs for installing direct-use PV systems have dropped.[256] Considering the rapidly de-

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251. Dennis Webb, *Oil Shale Water Rights Nullified*, GRAND JUNCTION SENTINEL, July 1, 2011, *available at* http://www.gjsentinel.com/special_sections/articles/oil_shale_water_rights__nullif.

252. *See* Press Release, WESTERN RES. ADVOCATES, *Coalition Praises Decision to Terminate Oil Shale Water Rights: Decision Upholds Agric. Traditions and Healthy Rivers* (July 5, 2011), *available at* http://www.westernresourceadvocates.org/media/archive11/YellowJacketwaterrights7-5-11.pdf.

253. *Get It Right*, *supra* note 216, at 19.

254. *Id.* at 19-20.

255. *Id.*

256. Joseph Glennon & Andrew Reeves, *Solar Energy's Cloudy Future*, 1 ARIZ. J. ENVTL. L. & POL'Y 91, 105 (2010); In 2012, U.S. Department of Energy, Secretary Chu noted the cost of solar panels have dropped four-fold over the past three years and he

creasing cost of PV, implementation of renewable energy portfolio standards (mandated by state governments such as California, Colorado, and Washington), state and federal subsidies,[257] a less arduous permitting process, and the heightened water concerns surrounding other forms of utility grade solar power, PV, which does not require cooling water, is playing a growing role in the solar technology development game.[258]

Another type of utility-grade solar —Concentrating Solar Power ("CSP")—has raised concerns regarding water availability. CSP is a utility-scale technology, and because it can include storage capabilities, CSP with storage can avoid the intermittency problems found in typical solar energy sources. [259] CSP technologies come in four different forms: solar trough, linear Fresnel, power tower, and dish/engine.[260] The first three utilize a steam cycle similar to that used in coal and gas-fired electric power plants: the energy harnessed from the sun boils water, creating exhaust steam, and spins a turbine that generates electricity.[261] Though the boiled water is usually recycled, it is the cooling process that uses large volumes of water. Closed-loop CSP withdraws approximately 750 - 920 gal/mWh, depending on whether the system utilizes trough or tower technology.[262] Some CSP projects, like Ivanpah Solar Electric Generating System in California (power tower), have elected to air-cool the turbine – there is a significant loss of efficiency, but the issue of using scarce Mohave Desert water is addressed.[263] Others, like Crescent Dunes (power

predicted those prices would likely fall by another 50% in the next eight years. Platts, *Inside Energy* at 11 (April 16, 2012).

257. *Id.* at 106.

258. *See generally* Energy.gov, *Department of Energy Awards More Than $145 Million for Advanced Solar Technologies* (Sept. 1, 2011), *available at* http://energy.gov/articles/department-energy-awards-more-145-million-advanced-solar-technologies. Despite its intense focus on developing renewable energy standards for electric utilities, California is also very strict about the use of water in clean energy projects. In addition to the requirement that solar developers not use any drinking-quality groundwater, they are encouraged to embrace dry-cooling technologies and to sign a power purchase agreement with a utility before applying for a license application with the California Energy Commission. *See* Todd Woody, *Rules for Clean Energy Projects in California*, green.blogs.nytimes.com (October 2, 2009), *available at* http://green.blogs.nytimes.com/2009/10/02/clean-energy-project-rules-for-california/#more-26091.

259. Glennon & Reeves, *supra* note 256, at 97; U.S. Department of Energy, Energy Basics, "Thermal Storage Systems for Concentrating Solar Power" explaining the use of molten salt for solar storage, *available at* http://www.eere.energy.gov/basics/renewable_energy/thermal_storage.html.

260. *Id.* at 97.

261. *Id.*

262. *Id.* at 99-100 (Various closed-loop CSP technologies consume between 750-920 gal/mWh. This is compared to approximately 300-480 gal/mWh for fossil fuels, 100-180 gal/mWh for natural gas, and 400-720 for nuclear. Solar does beat out geothermal, which consumes 1400 gal/mWh.).

263. BUREAU OF LAND MGMT., CALIFORNIA DESERT CONSERVATION AREA PLAN AMENDMENT, FINAL ENVIRONMENTAL IMPACT STATEMENT: IVANPAH SOLAR ELECTRIC GENERATING SYSTEM, FEIS-10-31 (2010), *available at*

tower) in Tonopah, Nevada have elected to use a hybrid system – part air, part water—to reduce the impact on efficiency and water consumption.[264]

2. Concentrating Solar Power (CSP) v. Photovoltaic Solar (PV)

Some commentators believe that CSP, particularly with storage, is more competitive dollar for dollar than PV; however, when one considers the long-term costs of CSP's potential heavy water consumption, along with the greater construction and permitting costs of CSP, and the rapidly decreasing cost of PV panels, PV might actually be more economically competitive.[265] Indeed, three major solar companies have switched from CSP to PV.[266] Switching from CSP to PV projects can make it easier and less expensive to obtain permits and construct and, thus, easier to obtain financing particularly when water consumption and the effects on water resources in arid climates is a concern.[267] Still, PV is at a disadvantage without storage capability, and until that issue can be addressed, interest in CSP technologies will continue.[268]

3. Reconciling Federal and State Objectives: Solar Development in the San Luis Valley

In the Draft Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States, the BLM identifies the proposed Antonito Southeast solar energy zone ("SEZ") in Conejos County, Colorado as one of the major SEZ opportunities in the United States.[269] Conejos County is located in the San Luis Valley, a high eleva-

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http://www.blm.gov/pgdata/etc/medialib/blm/ca/pdf/needles/lands_solar.Par.79875.File.tmp/Ivanpah%20FEIS%20exec%20sum.pdf.

264. *See* BUREAU OF LAND MGMT, CRESCENT DUNES SOLAR PROJECT ENVIRONMENTAL IMPACT STATEMENT, Jan. 7, 2011), *available at* http://www.blm.gov/nv/st/en/fo/battle_mountain_field/blm_information/national_environmental/crescent_dunes_solar.html. *See also* Paul Denholm and Mark Mehos, ENABLING GREATER PENETRATION OF SOLAR POWER VIA THE USE OF CSP ENERGY STORAGE, NATIONAL RENEWABLE ENERGY LABORATORY, Nov. 2011, *available at* http://www.nrel.gov/csp/pdfs/52978.pdf.

265. John Farrell, *When Picking Solar Options, It's the Water, Stupid,* CleanTechnica (Aug. 5, 2011), available at http://cleantechnica.com/2011/08/05/when-picking-solar-power-options-its-the-water-stupid/.

266. Reuters, *Solar Thermal Plants Scrap Steam for Photovoltaic*, cnet.com (July 1, 2011), available at http://news.cnet.com/8301-11128_3-20076065-54/solar-thermal-plants-scrap-steam-for-photovoltaic/.

267. *Id.*

268. *But compare* SEIA, *New Report Finds U.S. Solar Energy Installations Soared by 109% in 2011 to 1,855 Megawatts (March 14, 2012), http://www.seia.org/cs/news_detail?pressrelease.id=2000.* 2011 was a record year for PV installation. While the US saw no new CSP projects last year, 10 new PV projects came online. At the end of 2011, cumulative PV capacity reached nearly 4,000 MW in 2011.

269. *See* BUREAU OF LAND MGMT., SOLAR DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT, 10.1-1 (December 2010), *available at*

tion (approximately 8,000 feet) basin between two mountain ranges,[270] and is in the Rio Grande Headwaters sub-basin of the Rio Grande hydrologic region.[271] The climate is arid and evaporation rates generally exceed precipitation rates, with average annual precipitation and snowfall amounts in the southern San Luis Valley measuring seven and twenty-five inches respectively.[272] According to the BLM, "[a]quifers in the San Luis Valley are predominantly recharged by snowmelt runoff from higher elevations of the surrounding mountain ranges along the valley rim . . . as well as by irrigation return flows, subsurface inflow, and seepage from streams."[273] The surface and groundwater rights in the Rio Grande Headwaters sub-basin, where the Antonito Southeast SEZ is located, are already over appropriated, meaning that solar companies would have to purchase an augmentation certificate or existing water rights in order to use water.[274]

As the BLM notes in the solar environmental analysis, it would be very difficult for any project seeking an amount of water more than approximately 1,000 acre-feet per year (1.2 million m3/yr) to be successful in obtaining needed water rights, because any use of water in the SLV area must be augmented (or taken from other areas) and this directly affects other water rights and rights of other states under inter-state treaties.[275] In addition, there would be a significant amount of produced wastewater—normal operations would produce up to 22 acre-feet per year (27,100 m3/yr) of sanitary wastewater requiring treatment on-site or sent to an off-site facility[276]—and the quantity of water discharged would range from 246 to 422 acre feet per year (303,000 to 521,000 m3/yr).[277]

SLV residents, who host three PV solar facilities have also fought the plans for construction of some utility-scale solar projects in the SLV.[278] Residents have noted the wastewater problem, but on March 26, 2012 the Saguache County Commissioners decided (2-1) to issue a permit for a 6,200 acre CSP solar with storage project capable of producing up to 200 mw.[279] Although it would appear that the citizens of the SLV do not oppose utility-scale solar projects wholesale, in addition to aesthetic and

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http://solareis.anl.gov/documents/dpeis/Solar_DPEIS_Colorado_SEZs.pdf [hereinafter SOLAR DPEIS]; Solar Supplemental Programmatic Environmental Impact Statement C-79 (October 2011), *available at* http://solareis.anl.gov/documents/supp/index.cfm.

270. *Id.*

271. *Id.* at 10.1-57.

272. *Id.* at 10.1-57.

273. *Id.* at 10.1-59.

274. The Bureau of Land Management notes that the "viability of a solar project will depend on its ability to obtain water rights" in the SLV. *Id.* at 10.1-61.

275. *Id.* at 10.1-61 to -62.

276. *Id.* at 10.1-66. In compliance with COLO. REV. STAT. ANN. § 25-8-204 (1981).

277. SOLAR DPEIS, *supra* note 270, at 10.1-66.

278. Smith, *supra* note 9.

279. Sara Burnett and Mark Jaffe, *Sprawling solar plant on tap for San Luis Valley*, THE DENVER POST, March 27, 2012, http://www.denverpost.com/breakingnews/ci_20262088/sprawling-solar-plant-tap-san-luis-valley.

land use objections, local groups express concern over the availability of water and of pitting solar in competition with traditional water uses, such as irrigating crops.[280] In addition to these citizen objections, recent changes to local water district regulations in response to Rio Grande River compact issues will likely make finding adequate, reliable water supplies more challenging.[281]

4. Water Availability Issues: Meeting the Rio Grande Compact

The BLM's Solar DPEIS identifies the Rio Grande Compact of 1938, an interstate treaty that obligates Colorado to deliver a certain amount of water to the Colorado-New Mexico border, as a potential restriction on water availability for solar projects in the San Luis Valley.[282] This is a result of irrigators in the San Luis Valley using more than Colorado's share of Rio Grande water for a number of years.[283] In an effort to reduce overall water use in the Valley, while still maintaining the viability of the agricultural community, local organizations have implemented new management plans.[284] These plans will ultimately result in the retirement of tens of thousands of acres of irrigated agricultural land in the San Luis Valley in order to reduce overall water depletions and enable the State of Colorado to meet its Rio Grande River compact obligations.[285]

C.R.S. § 37-48-126 authorizes the Rio Grande Water Conservation District ("RGWCD") to create sub-districts for the administration of a water management plan in each sub-district.[286] In June 2009, the RGWCD's Board of Directors adopted the Water Management Plan for Special District #1 (Sub-district #1).[287] As such, the sub-district is respon-

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280. *Position Paper*, SAN LUIS VALLEY ECOSYTEM COUNCIL, http://www.slvec.org/images/stories/docs/Final.Position_paper4F1.pdf (last visited Feb. 9, 2012).

281. SOLAR DPEIS, *supra* 270, at 10.1-61. This federal-state policy tug of war over energy and water is not unique to Colorado. In 2010, Arizona Senator Jon Kyle issued a policy report on the state of solar energy development on federal lands in his state, stating: "Placing additional demands on Arizona's water supply in order to export 'renewable energy' to other states that have greater energy demands is unsustainable. Arizona should not become a solar energy farm for the rest of the country, especially when its water supply is limited and it is currently in the midst of a long-term drought." OFFICE OF SENATOR JON KYL, DEPLOYING SOLAR POWER IN THE STATE OF ARIZONA: A BRIEF OVERVIEW OF THE SOLAR-WATER NEXUS 18 (2010), *available at* http://www.circleofblue.org/waternews/wp-content/uploads/2010/08/solar-water1.pdf .

282. SOLAR DPEIS, *supra* note 270, at 10.1-61.

283. RIO GRANDE WATER CONSERVANCY DIST., PROPOSED PLAN OF WATER MGMT. 5 (2009), *available at* http://www.rgwcd.org/attachments/File/Plan_of_Water_Management_51109.pdf [hereinafter RGWCD PROPOSED PLAN].

284. *See id.* at 7-8.

285. *Id.* at 6, 10.

286. COLO. REV. STAT. ANN. § 37-48-126(1) (1975).

287. *Plan of Water Mgmt.,* RIO GRANDE WATER CONSERVATION DIST., *available at* http://www.rgwcd.org/page6.html (last visited Jan. 23, 2012).

sible for imposing "limits on groundwater withdrawals in order to reduce groundwater extractions to a sustainable level and help sustain [Rio Grande River Compact] obligations."[288] The sub-district plan involves using fees imposed upon well users within the sub-district to purchase and retire groundwater rights from irrigators.[289] The operation of the Plan complies with the applicable Colorado statutory requirements.[290] Sub-district #1, alone, anticipates retiring 40,000 acres of irrigated land.[291]

Because water demands are already so oversubscribed in the Rio Grande basin that the local water users must implement such drastic reduction of existing water use, finding sufficient water supplies for solar companies to develop utility-scale solar projects that use CSP wet-cooling will likely prove exceedingly difficult.[292] Therefore, unless CSP developers adequately address water consumption, uncertainty of water availability in the San Luis Valley draws into question whether there is a realistic chance that the Antonito Southeast Solar Energy Zone will develop into one of the country's main solar resources.

F. HYDROPOWER

The connection between energy and water demand associated with hydropower is fairly obvious—power is generated from the flow of water.[293] "Hydropower was one of the oldest forms of energy harnessed before the industrial revolution" and is by far the most significant renewable energy resource in the country.[294] Hydropower accounts for seventy percent of renewable energy, half of which is produced in Washington, California, and Oregon,[295] and provides for approximately seven percent of United States electricity needs.[296] However, Colorado is not a very big hydropower state—hydropower only accounts for 3.7 percent[297] of the total electricity produced in Colorado as of 2009.[298]

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288. SOLAR DPEIS, *supra* note 270, at 10.1-61; *see also* RGWCD PROPOSED PLAN, *supra* 284, at 10.
289. RGWCD PROPOSED PLAN, *supra* 284, at 10-11.
290. *Id.* at 8.
291. *Id.* at 6.
292. SOLAR DPEIS, *supra* note 269, at 10.1-61 to -62
293. K. K. DUVIVIER, THE RENEWABLE ENERGY READER 125-27 (2011).
294. *Id.* at 125.
295. *Id.* at 125-26.
296. *Id.* at 126. However, some estimates show from five percent up to ten percent of United States electricity generated from hydropower. *See*, CARPE DIEM – WESTERN WATER & CLIMATE PROJECT, *Herding Cats: Dealing with Uncertainty and Many, Many Shareholders—Panel III*, Summary of Proceedings 11 (2010).
297. Hydro makes up 3.7 percent of the ten percent of electricity generated from renewables in Colorado. Wind – at 6.3 percent – generated the most of other renewables. U.S. ENERGY INFO. ADMIN., SUMMARY RENEWABLE ELECTRIC POWER INDUSTRY STATISTICS (July 2011), *available at* http://www.eia.gov/cneaf/solar.renewables/page/state_profiles/pdfstate/colorado.pdf.
298. Totals are from 2005 to 2009 data, reported in July 2011. *Id.*

Hydropower is a very efficient renewable resource and can operate on utility scale at an average of ninety percent efficiency.[299] That being said, hydropower can have significant environmental consequences,[300] though in most cases—such as in Colorado—large hydropower projects are entirely nonconsumptive, and one hundred percent of the water is released back into the river.[301]

1. The Technology: Producing Hydropower

To generate hydroelectric power, the water must be in motion – the flowing water turns blades in a turbine, and the form of energy is changed from kinetic to mechanical energy.[302] The turbine then turns the generator rotor, which converts the mechanical energy into electrical energy.[303] Most hydroelectric power plants are located on rivers and streams in order to guarantee a stable water supply, and dams are utilized to guarantee that supply.[304] The dam creates a height from which water flows (called "head"), while a pipe called a penstock carries the water from the reservoir to the turbines.[305] Then, the water's force on the turbine blades turns the rotor (the moving part of the electric generator), so that electricity is produced when coils of wire on the rotor move past the generator's stationary coil (or stator).[306] The output of energy from a dam is determined by the volume of water released (discharge) and the vertical distance the water falls (head)—the discharge and head determine what type of turbine must be used (the stronger the head, the more pressure available to drive those turbines).[307] The water flows unchanged back into the river or stream.[308] From there, the electricity generated is transmitted through transmission lines and facilities.[309]

299. DUVIVIER, *supra* note 294, at 126.
300. Volumes are written on the issues associated with hydropower and its effects on fish, particularly salmon. *See generally* Michael C. Blumm, Erica J. Thorson, & Joshua D. Smith, *Practiced at the Art of Deception: The Failure of Columbia Basin Salmon Recovery Under the Endangered Species Act*, 36 ENVTL. L. 709 (2006).
301. *See, infra* page 52, the Shoshone Hydro Plant; CHRISSY SLOAN, THE EFFECT OF THE SHOSHONE AND CAMEO CALLS ON THE ROARING FORK WATERSHED, Roaring Fork Conservancy 1 (2004), *available at* www.roaringfork.org/images/other/shoshone.pdf.
302. U.S. DEP'T OF INTERIOR, BUREAU OF RECLAMATION, POWER RES.OFFICE, RECLAMATION: MANAGING WATER IN THE WEST – HYDROELECTRIC POWER 3 (2005) [hereinafter POWER RESOURCES OFFICE].
303. *Id.*
304. The DOI's analogy is helpful for understanding the role of dams: "The reservoir acts much like a battery, storing water to be released as needed to generate power." *Id.*
305. *Id.* at 4.
306. *Id.*
307. *Id.* at 7.
308. *Id.* at 4.
309. *Id.* at 5.

2. Federal Permitting Regulation v. State Determined Water Rights

The Federal Energy Regulatory Commission ("FERC"), an independent federal agency, is responsible for the hydropower licensing process under the Federal Power Act ("Power Act").[310] Fifty-percent of the nation's installed hydroelectric capacity was due for licensing renewals in 2010.[311] Section 4(e) of the Power Act authorizes FERC to "issue licenses . . . for the purpose of constructing, operating and maintaining dams, water conduits, reservoirs, power houses, transmission lines, or other project works necessary or convenient for the . . . development, transmission, and utilization of power" on bodies of water within Congress's Commerce Clause jurisdiction or

> upon any part of the public lands and reservations of the United States . . . : *Provided,* That licenses shall be issued within any reservation only after a finding by the Commission that the license will not interfere or be inconsistent with the purpose for which such reservation was created or acquired, and shall be subject to and contain such conditions as the Secretary of the department under whose supervision such reservation falls shall deem necessary for the adequate protection and utilization of such reservations.[312]

Thus, pursuant to Section 4(e), FERC must consult with the department that manages the subject federal land regarding conditions to include in the license.[313] Under section 15 of the Power Act, the Commission may "issue a new license to the existing licensee upon such terms and conditions as may be authorized or required under the then existing laws and regulations, or . . . issue a new license under said terms and conditions to a new licensee."[314]

In some cases, FERC-conditioned approval of a renewed license for a hydropower project can come into conflict with state-issued water rights.[315] One of the common conditions placed upon a hydropower license, especially in water-short stream systems, is a bypass flow requirement to protect fish and wildlife.[316] This means that the hydropower project is required to forego diverting a portion of its decreed water right in order to maintain certain flows for the benefit of fish and wildlife.[317] In a similar

310. 16 U.S.C. § 79*2* (2006).
311. *See* Sarah C. Richardson, *The Changing Political Landscape of Hydropower Project Relicensing*, 25 WM. & MARY ENVTL. L & POL'Y REV. 499, 511 (2000).
312. 16 U.S.C. § 797(e).
313. *See id.*
314. 16 U.S.C. § 808(a)(1).
315. *See, e.g.*, North Carolina v. Fed. Energy Regulatory Comm'n, 112 F.3d 1175, 1189 (D.C. Cir. 1997) (finding that the withdrawal from Virginia Beach waters did not constitute a "discharge" under the CWA, and so FERC was not required to obtain a § 401 certificate in its relicensing process).
316. US FISH & WILDLIFE SERVICE, *Hydropower: Examples of Accomplishments*, http://www.fws.gov/habitatconservation/hydropower.html (last accessed Feb. 26, 2012).
317. *Id.*

context, the Forest Service imposed a bypass flow on a reservoir located on federal land above Ft. Collins pursuant to the Federal Land Policy Management Act ("FLPMA") 43 U.S.C. §§ 1701-1782.[318] Water user interveners in the case challenged the authority of the Forest Service to impose the bypass flow requirement on the basis that "Congress has *not* granted to the Forest Service the authority to impose bypass flow conditions in order to reallocate water from existing uses to unmet National Forest needs."[319]

The water user interveners asserted: (1) that the exercise of this authority by the Forest Service would contradict the repeated and explicit decisions by Congress to defer to and respect state authority over water allocation and use; (2) that the imposition of bypass flow requirements on existing water uses would be contrary to Congressional intent to authorize the National Forest system principally to enhance the quantity of water that would be available for nonfederal water users; (3) that the applicable statutes explicitly and broadly disclaim any agency authority to affect existing nonfederal uses of water or to interfere with state control over the allocation and use of water; (4) that the applicable statutes also limit the exercise of Forest Service authority by making it subject to valid existing rights such as existing water rights and facilities; and (5) that the use of bypass flow requirements by federal agencies to obtain water for federal purposes is inconsistent with the McCarran Amendment, 43 U.S.C. § 666, by which Congress established a unified and all-inclusive method to allocate the use of water between federal and non-federal water uses, including the riparian uses which Plaintiffs seek to protect in this case.[320] The court rejected all of these arguments and held that the Forest Service's exercise of its regulatory authority to impose bypass flows as a condition on the use of National Forest land does not constitute the assertion of a water right.[321]

There have been recent instances where FERC relicensing has imposed bypass flows on Colorado hydropower projects. Public Service Company of Colorado's ("PSCo") Salida Hydropower Station on the South Fork of the Arkansas River was relicensed in the late 1990s.[322] The license was issued May 7, 1997 and required PSCo to implement a staged bypass flow regime at two locations, with bypass flow amounts increasing at ten, fifteen, and twenty years after issuance of the license in order to support fishery values on the river.[323] This was a negotiated condition, which attempted to balance the demands of state and federal wildlife

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318. Trout Unlimited v. U.S. Dep't of Agric., 320 F. Supp. 2d 1090, 1109 (D. Colo. 2004).

319. *Id.* at 1102.

320. *Id.*

321. *Id.* at 1106.

322. FEDERAL ENERGY REGULATORY COMM'N., Order Issuing Subsequent License, Project No. 2275-002 (Issued May, 1997), *available at* http://www.ferc.gov/industries/hydropower.asp [hereinafter Salida Hydro License].

323. *Id.* at 12, 22.

agencies with the economics of the project.[324] More recently, FERC issued the Tacoma Hydropower Station a license on January 29, 2010.[325] The license requires PSCo to bypass water it would otherwise be entitled to divert under its water rights to provide continuous flows in Cascade and Elbert Creeks to enhance habitat for trout and other aquatic resources.[326] PSCo had opposed the imposition of bypass conditions for a number of reasons, including the concern that these conditions would make winter operations difficult under certain conditions, and would make the project non-economical.[327]

These two examples demonstrate that even though hydropower is a critical piece of the renewable energy portfolio in Colorado—in that it provides clean, reliable, low-cost energy—even the most established hydropower projects can be threatened at each new FERC license renewal because of stringent bypass flow conditions which not only diminish state-granted water rights, but also make continued economic operation of the projects more difficult.

3. The Shoshone Hydro Plant: A Critical Link in West Slope Water Administration

The Shoshone Hydropower Plant, which has been in operation for over a century, provides a unique example of the links that bind water and energy in Colorado. Unlike most hydropower stations, which rely upon releases of stored water to produce energy, the Shoshone project diverts water directly from the Colorado River.[328] A diversion dam across the river backs up water and diverts it at a rate of 1,250 cubic feet per second ("cfs") into a tunnel constructed at the top Shoshone Falls.[329] The water falls down 287 feet to the generation station housing the turbines and provides the mechanical energy required by the generators to create electrical energy.[330] The water right powering the entire project is a 1902 direct flow right for 1,250 cfs.[331] This senior water right has become the most powerful water right on the Colorado River, preserving flows in the river for the benefit of other West Slope water users.[332] During times of

324. *Id.* at 12-13.
325. FEDERAL ENERGY REGULATORY COMM'N., Order Issuing New License, Project No. 12589-001 (Issued Jan, 2010), *available at* http://www.ferc.gov/industries/hydropower/gen-info/licensing/issued-licenses.asp [hereinafter Tacoma Hydro License].
326. *Id.* at 8.
327. *Id.* at 5, 14-15, 42.
328. Chrissy Sloan, *The Effect of the Shoshone and Cameo Calls on the Roaring Fork Watershed*, ROARING FORK CONSERVANCY 1 (Nov. 1, 2004), www.roaringfork.org/images/other/shoshone.pdf.
329. *Id.* at 1; Donna Gray, *Generating Electricity since 1909*, GLENWOOD SPRINGS POST INDEPENDENT (Oct. 1, 2006), http://www.postindependent.com/article/20061001/VALLEYNEWS/110010029
330. Sloan, *supra* note 329, at 1; Gray, *supra* note 330.
331. Sloan, *supra* note 329, at 1.
332. *Id.*

low flow, the Shoshone Hydro Plant may divert the entire flow of the river into its turbines, which dries up several miles of the Colorado River between the Shoshone diversion dam and the tailrace, where virtually all of the water diverted returns to the river.[333] Because the Shoshone senior water right calls water downstream to its diversion dam in Glenwood Canyon year round, Eric Kuhn, general manager of the Colorado River Water Conservation District, credits the Shoshone call as the key factor that "makes the river run."[334] By calling the water downstream, Shoshone Hydro's water rights prevent upstream, transbasin diversions, such as Denver's Roberts Tunnel system, from taking water out of the Colorado River.[335] Other water users all along the Colorado River, including municipalities, irrigators, and rafters, rely on the Shoshone water right to keep water in the river.[336]

It should come as no surprise then that the Shoshone water right has been in the cross-hairs between Front Range and West Slope water interests for years. In response to severe drought in 2003, Denver Water, Xcel Energy, and several West Slope water users reached a cooperative agreement that provided for the partial shutdown of the Shoshone Hydro plant during times of low flow.[337] Denver Water compensated Xcel for lost revenue due to inefficient power generation and earmarked ten percent of the water gained from the call to be returned to the West Slope.[338]

Denver Water and Xcel, with input from Western Slope water interests, renewed the agreement in 2006.[339] Because Xcel must maintain a franchise agreement with Denver Water in order to use the city's rights of ways for its distribution facilities, Denver Water has significant leverage over Xcel at the negotiating table.[340] West Slope interests are wary that Denver Water will demand more concessions from Xcel on the Shoshone call in future franchise agreement negotiations.[341] Accordingly, the Shoshone call was important to recent negotiations for a comprehensive East Slope–West Slope water agreement.[342]

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333. *Id.*
334. *Id.*
335. *Id.* at 1-2.
336. *Id.*
337. AGREEMENT CONCERNING REDUCTION OF SHOSHONE CALL (Mar. 13, 2006), *available at* http://www.crwcd.org (follow "Public Information" hyperlink; then select "Shoshone Agreement"; then select "Agreement" hyperlink in the text) [hereinafter Shoshone Call Agreement].
338. *Id.* at 2-3.
339. *See id.* at 4-5.
340. *Shoshone Power Plant and Xcel-Denver Franchise Agreement*, COLO. RIVER WATER CONSERVATION DIST., *available at* http://www.crwcd.org/media/uploads/Shoshone_agreement_06_facts.pdf (last visited Feb. 12, 2012) [hereinafter *Xcel-Denver Franchise Agreement*].
341. *See Colorado River Cooperative Agreement*, COLO. RIVER WATER CONSERVATORY DIST. (April 28, 2011 proposed agreement), http://www.crwcd.org/media/uploads/20110428_CRAC_mediation_agreement.pdf, 1, 36, 37-38, 40 [hereinafter *Colorado River Cooperative Agreement*].
342. *See id.* at 33-41.

Denver Water, the Colorado Water River Conservation District, and many West Slope counties, towns, water providers, recreational interests, and other water users are parties to this draft Colorado River Cooperative Agreement (Xcel is not among them).[343] This agreement has the potential to create a new era of cooperation between Denver Water and water users in the Colorado River Basin by creating significant benefits for both Denver Water and West Slope water interests. According to Denver Water, the Colorado Cooperative Agreement will provide:

For Cities, Counties and Other Entities in the Colorado River basin[344]

- Additional water for towns, districts, and ski areas in Grand and Summit counties to serve the needs of their residents and to improve the health of our rivers and streams;
- An agreement to operate key Denver Water facilities, such as Dillon Reservoir in Summit County, and Williams Fork Reservoir, and the Moffat Collection System in Grand County, in a way that better addresses the needs and concerns of neighboring communities and enhances the river environment;
- Enhanced recreational opportunities by providing additional water to certain ski areas;
- Greater certainty in the continued availability of water in the middle and lower Colorado River by ensuring that when the Shoshone Power Plant in Glenwood Canyon is not operating, the parties will operate their facilities as if the plant was operational to help maintain the historic flows in the Colorado River;

For Denver Water[345]

- Greater certainty in developing a secure water future for its customers by resolving long-standing disputes over its service territory, its ability to use West Slope water, its ability to develop future water supplies in the Colorado River Basin, and other legal issues;
- Additional water and enhanced system reliability for customers of Denver Water, representing nearly twenty-five percent of the state's population, by moving forward the Moffat Collection System Project;
- Agreement by all partners to not oppose Denver's storage of its Blue River and Moffat Project water on the Front Range;

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343. *Proposed Colorado River Cooperative Agreement: Path to a Secure Water Future*, DENVER WATER (last visited Feb. 3, 2012), http://www.denverwater.org/SupplyPlanning/Planning/ColoradoRiverCooperativeAgreement.

344. *Id.*

345. *Id.*

- Clarification of the conditions under which Denver Water will be able to provide water outside its service territory — thus paving the way for the cooperative WISE Project;

The Colorado Cooperative Agreement is not yet final as it is currently pending final approval by the thirty-five participating entities.[346]

4. Small Hydropower

While Colorado is not a big hydropower state compared to its other Western counterparts, there is a small but growing movement for the implementation of small hydro.[347] Small hydro is not utility-scale, and exists to serve and generate electricity for specific project areas.[348] Some cities in Colorado—such as Boulder and Aspen—have either built, or intend to build, small hydropower facilities for municipal-scale use. In the City of Boulder, eight small hydroelectric generators are enough to support eleven percent of the city's electricity needs for 96,000 residents.[349] Aspen recently applied for preliminary licensing to build hydropower plants that would produce approximately eight percent of the town's needed energy. The project, however, is not without controversy. Critics claim the power generated by the facility is not worth the potential harm caused by reduced stream flows.[350]

The future of hydropower in Colorado is somewhat uncertain. Because many older hydropower projects were the first large scale electrical generating plants to supply significant power to the state, they benefit from relatively senior water rights—unlike many more current energy development projects in Colorado. A project owner's ability to generate power economically through state-derived water rights, however, is in question because federally imposed bypass conditions are now standard practice for FERC relicensing.

346. Bob Berwyn, *Colorado: Transmountain Water Deal Still on Hold,* SUMMIT COUNTY CITIZEN'S VOICE (Dec. 30, 2011), http://summitcountyvoice.com/2011/12/30/colorado-transmountain-water-deal-still-on-hold.

347. There are a number of associations and groups working in Colorado on small hydropower systems that will not produce hydropower on a commercial scale. *See generally* COLO. SMALL HYDRO ASS'N, http://www.smallhydro.co (last visited Feb. 11, 2012); COLO. SMALL HYDRO WORKING GROUP, http://coloradohydro.groupsite.com/main/summary (last visited Feb. 11, 2012); *Small Hydropower Loan Program*, COLO. WATER RESOURCES AND POWER DEV. AUTH., http://www.cwrpda.com/SHLPsubmenu.htm (last visited Feb. 3, 2012).

348. *See* DUVIVIER, *supra* note 294, at 165-66.

349. *Case Study: The Benefits of Small Hydro in Boulder,* CHELSEA GREEN PUB. (April 12, 2009), http://www.chelseagreen.com/content/case-study-the-benefits-of-small-hydro-in-boulder-colorado.

350. Bob Berwyn, *Aspen Hydropower Plan Triggers Green v. Green Tussel,* SUMMIT COUNTY CITIZEN'S VOICE (Dec. 22, 2011), http://summitcountyvoice.com/2011/12/22/aspen-hydropower-plan-triggers-green-v-green-tussle.

G. GEOTHERMAL

For hundreds of years, people have enjoyed geothermal energy mostly through hot springs.[351] In the twentieth century, however, technologies to exploit the earth's natural heat to generate electricity became more available.[352] While geothermal energy might be "effectively unlimited,"[353] its "most significant environmental and economic impact . . . [is] the effect on water, the material transfer medium for *all* geothermal systems."[354] Those seeking to develop geothermal resource must seek standard water rights to take advantage of the earth's heat. A myriad of water issues affect the development of geothermal energy, in both a technological and legal sense.

1. The Technology: Producing Geothermal

There are a number of geothermal technologies and a number of applications. Four generate electricity—1) dry steam systems; 2) hot water systems; 3) hybrid geothermal brine systems; and 4) hot dry rock systems—and the fifth application uses low temperature geothermal waters to heat buildings (also known as "direct use").[355] In addition, there is Geothermal Heat Pump (GHP) technology, which takes advantage of the difference in temperature between above and below ground, and thus differs from other types of geothermal resources.[356]

Dry Steam Systems. Where a well is drilled to access the geothermal dry steam in a reservoir, the steam rises through the drilled well to the surface and then expands to drive a steam turbine.[357] Steam then discharges through a condenser and mixes with cool water, and this heated water is pumped to a cooling tower where most of the condensation evaporates.[358] Any unevaporated water is then eventually re-injected into the reservoir.[359]

351. WENDELL A. DUFFIELD & JOHN H. SASS, U.S. DEP'T OF INTERIOR, U.S. GEOLOGICAL SURVEY, GEOTHERMAL ENERGY: CLEAN POWER FROM THE EARTH'S HEAT 2 (2003).

352. *Id.*

353. DUVIVIER, *supra* note 294, at 219 (quoting U.S. Secretary of Energy Steven Chu).

354. George Vranesh & John D. Musick Jr., *Geothermal Resources: Water and Other Conflicts Encountered by the Developer – An Alternative Energy Source Which Is "Gathering Steam"*, 13 LAND & WATER L. REV. 109, 121-22 (1977).

355. BUREAU OF LAND MGMT. & U.S. FOREST SERV., GEOTHERMAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT: GEOTHERMAL LEASING IN THE UNITED STATES, 1-3 to 1-4, 1-6 (2008).

356. DUFFIELD SASS, *supra* note 352, at 21.

357. Donald J. Kochan & Tiffany Grant, *In the Heat of the Law, It's Not Just Steam: Geothermal Resources and the Impacts on Thermophile Biodiversity*, 13 HASTINGS W.-NW. J. ENVTL. L. & POL'Y 35, 42 (2007) (explaining that dry steam resources are the most readily usable form of geothermal energy).

358. *Id.*

359. *Id.*

Hot Water Systems. Where the underground water's temperature is higher than its boiling point, and remains in liquid form because of extreme underground pressure, electricity can be generated through either flash steam or binary processes.[360] A binary power plant uses cooler geothermal reservoirs than a power dry steam or flash steam power plant[361] Binary plants pump hot water through a heat exchanger, and the cooled water is then returned to the geothermal reservoirs.[362] In the heat exchanger, the hot water heats and vaporizes the lower boiling "binary" fluid, whose vapors then power the steam turbine.[363]

Hot Dry Rock Systems. To exploit hot rock, typically located at depths of eight thousand to twenty thousand feet, high pressure pumps inject water into the formation, fracturing the rock and thereby creating a reservoir.[364] Water, when heated in this hot rock reservoir and extracted from secondary wells, can then generate electricity.[365]

Warm-Water Systems: Direct Use. Before high-temperature drilling and well-completion technology, geothermal energy was utilized to heat homes through direct use applications.[366] While thermal water can cool or heat homes and businesses, it cannot be transported without thermal loss and this limits its application.[367]

Geothermal Heat Pumps. GHPs cause thermal energy to flow up temperature, opposite the direction that it would naturally flow.[368] A heat pump works best when the outdoor air is too hot or cold, and this technology substantially increases the efficiency of traditional heating and cooling systems by significantly decreasing the lift – the extra work necessary to get heat or cool air to flow upstream.[369]

While numerous geothermal energy technologies exist, they all have one component in common—they all need a lot of water (with the exception of GHP technology). A utility-scale geothermal power plant consumes 1400 gal/mWh of water to cool equipment and generate electricity.[370] Even an area rich in geothermal resources, such as The Geysers in California, requires large volumes of cooling water.[371]

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360. *Id.* at 43.
361. *See* ALYSSA KAGEL, DIANA BATES & KARL GAWELL, GEOTHERMAL ENERGY ASS'N, A GUIDE TO GEOTHERMAL ENERGY AND THE ENVIRONMENT 5 (2007).
362. *Id.* at 5-6.
363. *Geothermal Basics,* GEOTHERMAL ENERGY ASS'N, http://geo-energy.org/Basics.aspx#how_plant_work (last visited Jan. 29, 2012).
364. DUFFIELD & SASS, *supra* note 352, at 10, 22.
365. *Id.* at 22.
366. *Id.* at 17.
367. *Id.*
368. *Id.* at 21.
369. GHPs offer opportunity for significant energy savings (up to seventy five percent), and can help reduce peak demand for power. Worldwide, there are more than five hundred thousand GHPs, for an output of seven thousand megawatts (U.S. output is five thousand megawatts). *See* DUFFIELD & SASS, *supra* note 352, at 21.
370. Glennon & Reeves, *supra* note 256*,* at 99-100.
371. According to the USGS, The Geysers can generate one thousand megawatts of electricity. *See* DUFFIELD & SASS, *supra* note 352, at 7. However, the authors do not

2. Demand for Geothermal (and GHP technology in particular) in Colorado

GHP technology is among the most efficient cooling and heating technologies available, transferring heat between buildings and the earth three to five times more efficiently than other HVAC systems.[372] Currently, buildings contribute 48 percent of U.S. energy consumption and greenhouse gas emissions:[373] "GHPs could avoid the need to build 91 to 105 [gigawatts] of electricity generation capacity, or 42 to 48 percent of the . . . net new capacity additions projected to be needed nationwide by 2030."[374] However, only about 1.54 percent of heating, ventilating, and cooling in North America comes from GHP technology.[375]

Colorado is not among the top states taking advantage of geothermal resources, either on a utility-scale or for direct use, despite its fifty-nine hot springs.[376] In fact, in the Mount Princeton and Waunita Hot Springs areas, five hot springs produce temperatures at or above 165 degrees Fahrenheit, an optimum temperature for binary power plant development.[377] Colorado also holds a number of low to moderate temperature sites that make direct use with GHP technology possible;[378] and Colorado ranks fifth among states in total geothermal resource potential.[379] According to the Colorado Geothermal Strategic Plan, the following characteristics make Colorado an optimum place for geothermal development: (1)

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address the commercially limiting issues associated with voluminous water consumption. *Id. Cf.* Glennon & Reeves, *supra* note 256, at 99-100; the Geysers has acquired and uses heated waste water to fuel the facility. "Santa Rosa (treated) Waste Water Facility Geothermal Reservoirs at the Geysers" (September 14, 2010). *See* LXRICHTER, *Santa Rosa Treated Waste Water Fueling Geothermal Reservoirs at the Geysers,* THINK GEOENERGY, Sept. 24, 2010, http://thinkgeoenergy.com/archives/5783.

372. Elizabeth C. Battocletti & William E. Glassley, *Measuring the Costs and Benefits of Nationwide Geothermal Heat Pump Deployment*, GHC BULLETIN, Nov. 2010, at 4, *available at* http://geoheat.oit.edu/bulletin/bull29-3/art2.pdf.

373. *Id.*

374. *Id.* at 5.

375. *Id.* at 4.

376. GEOPOWERING THE WEST COLO. STATE WORKING GROUP, COLORADO GEOTHERMAL DEVELOPMENT: STRATEGIC PLAN, at 7 (August 2007) [hereinafter COLO. GEOTHERMAL DEV. STRATEGIC PLAN], *available at* http://geosurvey.state.co.us/SiteCollectionDocuments/EnergyResources/Geothermal/ColoradoGeothermalDevelopmentStratPlan.pdf.

377. *Id.* at 10. The committee bases this observation on Alaska's production of economically competitive geothermal electricity via binary power plants where well temperatures are 165 degrees Fahrenheit. *Id.* However, the competitive electric utility market in Colorado makes this less economically viable. *Id.*

378. THE CITY OF ASPEN & PITKIN CNT'Y, http://aspenpitkin.com/Living-in-the-Valley/Green-Initiatives/Renewable-Energy/Geothermal/ (last visited Jan. 29, 2012). The City of Aspen is conducting a geothermal test project to determine whether geothermal direct use is a viable option for its portfolio. *Id.* The project will resume in 2012. *Id.*

379. COLO. GEOTHERMAL DEV. STRATEGIC PLAN, *supra* note 377, at 11.

high heat flow;[380] (2) volcanism; (3) recent faulting, and (4) continental rifting.[381]

Presently, geoexchange resources, including GHPs, heat and cool a number of Colorado State government buildings.[382] Colorado offers financial incentives promoting demand side management technologies, including GHPs.[383]

3. Federal Geothermal Law and the Geothermal Steam Act

In 1970, Congress passed the Geothermal Steam Act, authorizing the Secretary of the Interior to issue leases and establish royalties for geothermal resources.[384] In 1977, the Ninth Circuit Court resolved a fundamental resource ownership issue.[385] The Ninth Circuit determined that although the federal government did not reserve geo-resources expressly, the United States had reserved the minerals when it conveyed the surface under the Stock-Homestead Raising Act of 1916, and determined that reservation would include subsurface fuel resources like geothermal.[386]

In 2005, the Energy Policy Act ("EPACT") amended the Geothermal Steam Act to streamline the process of leasing and development of federal geothermal resources by eliminating the previous two-tiered leasing system and implementing a competitive leasing system, including leasing for "direct use" systems for purposes other than commercial electricity generation.[387] EPACT also sought to address a twenty year backlog in U.S. Forest Service geothermal leasing.[388]

In 2008, in response to the direction of EPACT, the BLM and the U.S. Forest Service issued a Programmatic Environmental Impact Statement regarding geothermal leasing on federal public lands.[389] In addition to the monitoring activities that the BLM and the U.S. Forest Service must engage in while permitting geothermal development, the BLM and

380. "Colorado has the second largest areal heat flow anomaly in North America . . . [which] predominantly coincides with the mountainous central and western portions of Colorado." COLO. GEOTHERMAL DEV. STRATEGIC PLAN, *supra* note 377, at 9.
381. *Id.* at 11.
382. *Id.* at 7.
383. *Id.* at 29. Colorado enacted geothermal financial incentives under House Bill 07-1037. *Id.*
384. Geothermal Steam Act of 1970, 30 U.S.C. §§ 1001-04 (2011).
385. United States v. Union Oil Co. of Cal., 549 F.2d 1271, 1272 (9th Cir. 1977).
386. *Id.* at 1277.
387. Energy Policy Act of 2005, Pub. L. No. 109-58, §§ 221-37, 119 Stat. 594, 660-74 (2205); *see also*, *Geothermal Leasing Under the Energy Policy Act of 2005*, U.S. DEP'T OF INTERIOR, BUREAU OF LAND MGMT. (Oct. 9, 2008), *available at* http://www.blm.gov/wo/st/en/info/regulations/Instruction_Memos_and_Bulletins/national_instruction/2009/IM_2009-022.html.
388. Energy Policy Act of 2005 § 225(b)(3).
389. U.S. DEP'T OF INTERIOR, BUREAU OF LAND MGMT., Geothermal Programmatic Environmental Impact Statement 1 (2008), *available at* http://www.blm.gov/pgdata/etc/medialib/blm/wo/MINERALS__REALTY__AND_RESOURCE_PROTECTION_/energy/geothermal_eis/final_programmatic.Par.41814.File.dat/Volume_I_FINAL.pdf.

U.S. Forest Service must apply stipulations to the leases in order to protect the integrity of the leased lands, particularly where geothermal operations are likely to cause significant adverse environmental effects pertaining to water quality and quantity.[390] While federal protections for geothermal development operations and water quantity affect federal lands, the state also plays a major role in geothermal regulation.[391]

4. State Water Law and Geothermal Development

As discussed above (*supra* at Section IV(3)), in 2009, the Colorado Supreme Court declared that CBM produced water constituted a "beneficial use" under Colorado water law.[392] Decades before the *Vance v. Wolfe* decision, the use of water as a material medium for geothermal production was codified as a beneficial use of water in Colorado.[393] Accordingly, geothermal resources, like CBM produced water, are subject to water court jurisdiction and are under the jurisdiction of the State Engineer.[394] In order to develop geothermal resources from a well, at a minimum, a permit must be obtained from the State Engineer;[395] and if the geothermal resource is determined to be tributary water, a water right must be obtained through the water court.[396]

5. Conflicts over BLM Leasing of Geothermal in Colorado

The BLM offered geothermal leases in Colorado in 2009,[397] but there was significant pushback in Salida and Mt. Princeton, Colorado.[398] In December of 2010, 3E Geothermal LLC of Colorado Springs successfully bid for a 30-year lease on a parcel of federal land near the Mt. Princeton Hot Springs.[399] 3E Geothermal has 10 years to develop the

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390. *Id.* at 2-19.

391. *See* ELIZABETH DORIS, CLAIRE KREYCIK, KATHERINE YOUNG, NAT'L RENEWABLE ENERGY LAB. POLICY OVERVIEW AND OPTIONS FOR MAXIMIZING THE ROLE OF POLICY IN GEOTHERMAL ELECTRICITY DEVELOPMENT, 16,18 (2009), *available at* http://www.nrel.gov/docs/fy10osti/46653.pdf.

392. Vance v. Wolfe, 205 P.3d 1165, 1169 (Colo. 2009); *see also* C.R.S.A. § 37-92-103(4) (West 2012).

393. COLO. REV. STAT. ANN. § 37-90.5-107(1).

394. *See generally id.* § 37-90.5-107.

395. *Id.* § 37-90.5-107(2)(a).

396. *Id.* § 37-90.5-104(1), -107(1).

397. The BLM notes on its leasing websites that BLM leases do not authorize ground-disturbing activities to explore for or develop geothermal resources without further application, environmental review, and approval by the BLM. *See Gunnison Field Office Geothermal Lease Nomination*, BUREAU OF LAND MGMT. (Aug. 11, 2011), *available at* http://www.blm.gov/co/st/en/fo/gfo/geothermal_lease_nomination.html.

398. *See* Trey, *BLM Defers Mt. Princeton Geothermal Lease Sale*, THE SALIDA CITIZEN (Nov. 12, 2009), http://salidacitizen.com/2009/11/blm-defers-mt-princeton-geothermal-lease-sale/.

399. Tracy Harmon, *Geothermal Lease Controversy Cools: Christian Ministry Vows to Preserve Mount Princeton Resort's Beauty Near Salida*, THE PUEBLO CHIEFTAIN (Dec. 22, 2010), *available at* http://www.chieftain.com/business/local/article_e3080354-0d7d-11e0-bb93-001cc4c03286.html.

geothermal resource, and the lease will continue beyond its primary term as long as3E Geothermal makes a beneficial use of that resource under Colorado water laws.[400] Because 3E Geothermal, LLC is a subsidiary of the Christian ministry group Young Life, one of 60 private landowners in the Mt. Princeton area, there is speculation that 3E Geothermal purchased the geothermal lease in order to protect the area from geothermal development.[401] Although BLM addressed and put stipulations in place to protect water resources in the area in the 2010 leases, the community opposed the lease based largely on concerns over the aesthetic effects of geothermal development and the placement of a geothermal power plant in the Chalk Creek Valley.[402] On February 9, 2012 the BLM offered and sold two geothermal lease parcels, totaling 8,353.26 acres in Gunnison County.[403] As before, the geothermal leases were purchased by a resort company, Double Heart Lodge, LLC whose owner is opposed to geothermal development adjacent to his property.[404]

Despite its environmental benefits relative to fossil-fuel power plants, and its constant energy availability in contrast to intermittent wind and solar resources, large-scale geothermal development is likely to continue to hit significant bumps and obstacles in Colorado. This is due in part to the aesthetic effects on the resort communities in Colorado where the geothermal resource is most available, and in part to over-appropriated water resources.

V. CONCLUSION

From fossil fuels to renewable resources, all forms of energy development (with a few exceptions, such as wind energy) require water resources. As Colorado's population continues to increase, constraints on water resources will become more pronounced. As concerns over gaining control of domestic energy supplies and creating national energy security continue to increase, energy developers will continue to flock to

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400. *Id.*

401. *Id.*; Mark Jaffe, *Geothermal Lease Set to Go in Colorado: Hurdles Cleared, the BLM Will Offer 799 Acres in Chaffee County,* THE DENVER POST (Sept. 6, 2010), *available at* http://www.denverpost.com/business/ci_16086540.Jaffe.

402. Mark Jaffe, *Geothermal lease set to go in Colorado: Hurdles cleared, the BLM will offer 799 acres in Chaffee County,* The Denver Post (Sept. 6, 2010), available at http://www.denverpost.com/business/ci_16086540.

403. Mark Jaffe, *BLM to Offer New Oil and Gas and Geothermal Leases in Colorado*, THE DENVER POST (Nov. 9, 2011), *available at* http://blogs.denverpost.com/thebalancesheet/2011/11/09/blm-to-offer-new-oil-and-gas-and-geothermal-leases-in-colorado/1658/.

404. BUREAU OF LAND MANAGEMENT, *Competitive Geothermal Lease Sale,* Feb. 9, 2012, http://www.blm.gov/pgdata/etc/medialib/blm/co/programs/oil_and_gas/Lease_Sale/2012/february.Par.89301.File.dat/February%20_9_%202012%20Final%20Sale%20Results%20Summary.pdf. *See also* Joe Stone, *Geothermal development expansion setback*, THE MOUNTAIN MAIL NEWS, Feb. 14, 2012, http://www.themountainmail.com/news/article_4e0edc8e-5730-11e1-97c9-0019bb30f31a.html.

Colorado where a variety of energy resources are abundant. But where will the water come from? Some commentators have discussed the option of re-drafting some of the more constraining Compacts with other states, since Colorado's population growth is the highest in the Rocky Mountain West. Others simply suggest that Coloradans avoid jumping into development before a particular energy source is economically viable. However, such arguments fail to address development of resources that are currently economically viable, such as solar, geothermal, hydropower, coal, shale oil, and shale gas, and those arguments do not acknowledge the long-term and critical need of energy developers to plan for water supplies.

As the authors have illustrated, Colorado is fortunate in that it has a well-established mechanism for moving scarce water resources to new demands through market transactions. As water supplies have become more limited, water users have developed more innovative and cooperative ways to meet multiple water demands. The Colorado legislature has also assisted by creating statutory mechanisms, such as temporary water leasing, that enable water users to structure creative deals. The keys to integrating energy development into Colorado water demands include market-based solutions, as well as ongoing efforts to protect existing water rights decreed for energy development from loss or attrition due to federal or state regulatory action.