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WATER, OIL, AND GAS: A LEGAL AND TECHNICAL FRAMEWORK

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I. INTRODUCTION

The economic impact of oil and gas operations is tremendous. In 2011, oil and gas generated nearly 10% of all new jobs in the United States.[1] The University of Colorado Leeds School of Business reported $3.1 billion in direct labor income–supporting over 107,000 jobs and $32 billion of economic activity–from oil and gas in Colorado.[2] Remarkable technologies are breathing new life into old oil and gas fields. With hydraulic fracturing and directional drilling, the Rocky Mountain West could produce as much oil and natural gas as the United States currently imports from countries like Saudi Arabia and Venezuela.[3] But hydraulic fracturing requires water. Both the source water used for the process and the water produced subsequent to drilling are heavily regulated under various state and federal laws.

Water demands for hydraulic fracturing are less than a proverbial drop in the bucket. According to the Colorado Department of Natural Resources, water required for hydraulic fracturing will be less than 20,000 acre-feet annually for the next several years.[4] This amounts to less than one tenth of one percent of Colorado's annual water use.[5] By comparison, releases for environmental purposes at a single Colorado reservoir (the Aspinall Unit) exceeded 35,000 acre-feet last year in 2011.[6] And the Platte River Recovery Implementation Program requires Colorado, Wyoming, and Nebraska to provide 130,000 to 150,000 acre-feet per year for the federally listed least turn, pallid sturgeon, and piping plover.[7]

Many water professionals may not realize severance taxes from oil and gas help fund water projects throughout Colorado. Industry contributes over $600 million of severance taxes and annual *ad valorem* taxes to state and local governments.[8] These taxes help finance water projects through the Colorado Water Conservation Board's ("CWCB") construction loan program.[9] By statute,

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1. Nick Snow, *Oil, gas created 9% of new US jobs in 2011, WEF report notes*, OIL & GAS J., http://www.ogj.com/articles/2012/03/oil-gas-created-9-of-new-us-jobs-in-2011-wef-report-notes.html (last visited Dec. 14, 2012).
2. RICHARD WOBBEKIND ET AL., ASSESSMENT OF OIL AND GAS INDUSTRY ECONOMIC AND FISCAL IMPACTS IN COLORADO IN 2010 21 (Dec. 2011) *available at* http://www.coga.org/pdf_studies/cu_econbenefits.pdf.
3. W. ENERGY ALLIANCE, THE BLUEPRINT FOR WESTERN ENERGY PROSPERITY 6 (July 8, 2011) *available at* http://westernenergyalliance.org/wp-content/uploads/2011/07/Blueprint-for-Western-Energy-Prosperity.pdf.
4. COLO. DIV. OF WATER RES., COLO. WATER CONSERVATION BD. & COLO. OIL & GAS CONSERVATION COMM'N, PROJECTED WATER DEMANDS FOR HYDRAULIC FRACTURING IN COLORADO DURING THE PERIOD FROM 2010 THROUGH 2012 at 4, http://cogcc.state.co.us/Library/Oil_and_Gas_Water_Sources_Fact_Sheet.pdf.
5. *Id.*
6. U.S. BUREAU OF RECLAMATION, ASPINALL OPERATIONS MEETING MATERIALS (Aug. 18, 2011) http://www.usbr.gov/uc/wcao/water/rsvrs/mtgs/pdfs/archives/ho2011_08.pdf.
7. *Water Plan*, THE PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM, https://platteriverprogram.org/AboutPRRIP/Pages/WaterPlan.aspx (last visited Dec. 14, 2012).
8. Wobbekind *supra* note 2.
9. COLO. REV. STAT. § 37-60-121 *et seq.* (2012).

the first priority for those funds is putting Colorado's compact waters to beneficial use.[10] Other priorities include repair and rehabilitation of existing water storage and delivery systems, maintenance, satellite monitoring, management, and studies.[11] Severance taxes also support Colorado's Species Conservation Trust Fund, which helps provide Endangered Species Act compliance for water right owners around the state.[12]

This Article discusses the integration of oil and gas into the western water law system as well as the legal and technical framework related to water produced from oil and gas operations in Colorado.

II. TECHNICAL ASPECTS OF PRODUCED WATER MANAGEMENT AND TREATMENT

Exploration and production of energy resources like oil and gas are inextricably linked with technical challenges relating to water. Freshwater sources required to start a well and begin production ("source water") may be in short supply or may require treatment prior to use.[13] On the other end of development, the flow of produced water from production wells may require treatment prior to reuse, discharge, or disposal.[14] This section first provides an overview of production methods. Second, it explains the water issues related to various production methods. Third, it explains how the Clean Water Act and Safe Drinking Water Act govern these water issues. Last, it describes water management and treatment alternatives required by law in the state of Colorado, and includes cost estimates for their implementation.

A. OVERVIEW OF PRODUCTION METHODS

Oil and gas production is a multi-step process and involves the use of water at every step. The first step is exploration. During the exploration phase, geologists perform extensive surveys of a potential formation, including drilling test wells.[15] Second, producers drill a vertical well into the target formation. Water is required to facilitate the drilling process.[16] For conventional production, after the initial well is drilled and cased, oil or gas can flow up the well

10. COLO. REV. STAT. § 37-60-121(1)(b)(I) (2012).

11. *Id.* at (b)(II).

12. COLO. REV. STAT. § 37-60-122.2 *et seq.* (2012).

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

14. *Conversion of Oil Field Produced Brine to Fresh Water*, GLOBAL PETROLEUM RESEARCH INST., http://www.pe.tamu.edu/gpri-new/home/BrineDesal/BasicProdWaterMgmnt.htm (last visited Oct. 6, 2012).

15. *Natural Gas—From Wellhead to Burner Tip: Exploration*, NATURALGAS.ORG, http://www.naturalgas.org/naturalgas/exploration.asp (last visited Oct. 6, 2012).

16. *Drilling: Drilling Ahead*, OCCUPATIONAL HEALTH AND SAFETY ADMIN., http://www.osha.gov/SLTC/etools/oilandgas/drilling/drilling_ahead.html (last visited Oct. 6, 2012).

shaft and little else is required.[17] Unconventional production requires more complicated techniques. For example, in coalbed methane ("CBM") extraction, a coal seam must be completely dewatered before production can occur, which results in the extraction of large quantities of "produced water."[18] With other forms of production like hydraulic fracturing ("fraccing"), producers may need to drill horizontal wells and inject fluid (mostly water) at high pressure to create micro-fractures, allowing oil or gas to flow freely to the production well.[19] As conventional and non-CBM unconventional wells approach the end of their life spans, the wells start to produce significantly less quantities of oil and gas and increasing amounts of water.[20] This produced water is highly regulated and must be dealt with in very specific ways.

On a macro scale, economics and an emphasis on energy independence have led to an increase in production activity from unconventional resources in the United States.[21] Geographically, unconventional resources are widespread, from the Rocky Mountain West to North Dakota, Texas, and the northeast United States.[22] The abundance or scarcity of surface water and groundwater, competing demand for that water, and a variety of state and local regulations across diverse regions all play into the technical challenges associated with the management and treatment of produced water.

It is important to note that water issues in oil and gas exploration and production are highly site-specific. There is no typical characterization for produced water. The water quality characteristics can vary greatly within a production basin or even within a production-well field.[23] Nor is there a single most economically or technically effective process for treating produced water.[24] Produced water characterization before treatment (influent) and quality requirements for water in its post-treatment disposition (effluent) are the key drivers in the water management/treatment decision-making process.[25]

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17. U.S. DEPT. OF ENERGY, OFFICE OF FOSSIL ENERGY & NAT'L ENERGY TECH. LAB., MODERN SHALE GAS DEVELOPMENT IN THE UNITED STATES: A PRIMER 15 (2009), *available at* http://www.netl.doe.gov/technologies/oil-gas/publications/epreports/shale_gas_primer_2009.pdf.

18. *Id.*

19. THOMAS H. ZIMMERMAN ET AL., NAT'L PETROLEUM COUNCIL, TOPIC PAPER #19: CONVENTIONAL OIL AND GAS (INCLUDING ARCTIC AND ENHANCED OIL RECOVERY) 9-10 (2007), *available at* http://www.npc.org/study_topic_papers/19-ttg-conventional-og.pdf; *Water Use*, ENERGY FROM SHALE.ORG, http://www.energyfromshale.org/-fracturing-water-supply (last visited Oct. 6, 2012).

20. *Oil and Gas Production Wastes*, U.S. ENVTL. PROT. AGENCY, http://www.epa.gov/rpdweb00/tenorm/oilandgas.html (last updated Aug. 30, 2012).

21. David Ropeik, *Cultural Problems which Prevent Progress in the Fracking Debate*, OIL PRICE.COM, (Aug. 7, 2012, 9:59 PM), http://oilprice.com/Energy/Energy-General/Cultural-Problems-which-Prevent-Progress-in-the-Debate.html.

22. *Coalbed Methane Fields, Lower 48 States Map*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/oil_gas/rpd/coalbed_gas.pdf (last updated April 8, 2009).

23. David Alleman, Treatment of Shale Gas Produced Water for Discharge at Technical Workshops for the Hydraulic Fracturing Study: Water Resources Management 3, 7 (March 29-30, 2011) *available at* http://www.epa.gov/hfstudy/17_Alleman_-_Produced_Water_508.pdf.

24. *Id.* at 3-6.

25. *Id.* at 23.

On the broadest level, oil and gas production methods are either conventional or unconventional. Conventional production refers to resources that are relatively easy to develop. This type of production often occurs in highly permeable formations like limestone or dolomite formations with interconnected pore spaces.[26] Drilling into a conventional oil or gas reservoir will result in the relatively free flow of product to the surface.[27] In contrast, resources that are more tightly bound in the formation, requiring additional steps beyond simply drilling vertical wells, define unconventional production.[28] Examples of unconventional resources include low permeability formations that have to be fractured to allow production flow, or CMB, which is typically bound in coal seams near the presence of groundwater.[29]

1. Conventional Production

Early in conventional production, the resource-bearing formations allow for the relatively free flow of the resource to the production well.[30] As the readily recoverable resource becomes increasingly difficult to access, enhanced oil recovery ("EOR") techniques may be required for continued production.[31] EOR methods include chemical flooding, miscible displacement, and thermal recovery, pressurization, steam flooding or hot water flooding.[32]

2. Unconventional Production

Resource-bearing formations that cannot be economically exploited through conventional methods require the use of unconventional production techniques.[33] Tight shale formations and coal beds are examples of unconventional resources.[34] The label "unconventional production" applies to the resource formation rather than just the individual well.[35] Unconventional production techniques are not necessarily innovative or new. For example, unconventional production in tight shales may utilize hydraulic fracturing, a technique that dates back to the 1960s.[36]

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26. U.S. DEPT. OF ENERGY, OFFICE OF FOSSIL ENERGY & NAT'L ENERGY TECH. LAB., *supra* note 17, at 15.
27. *Id.*
28. *Id.*
29. *Id.*
30. *Id.*
31. ZIMMERMAN, *supra* note 19, at 2-3.
32. *Id.* at 3.
33. U.S. DEPT. OF ENERGY, OFFICE OF FOSSIL ENERGY & NAT'L ENERGY TECH. LAB., *supra* note 17, at 15.
34. *Id.* at ES-1, 15.
35. *Id.* at 15.
36. Scott Suttell, *Fracking Has Been Around Longer Than You Might Think*, CRAIN'S CLEVELAND BUS. ENERGY BLOG, February 14, 2012, http://www.crainscleveland.com/article/20120214/BLOGS03/120219920/0/SEARCH.

Fraccing can involve both vertical and horizontal drilling into formations situated thousands of feet below surface.[37] The primary advantage of horizontal drilling is the ability to reach a greater area of the formation from a single surface well location, in comparison to the multiple vertical wells required to achieve the same areal coverage.[38] This means that with horizontal drilling, there is minimal surface impact *and* maximum production from a single well. The vertical portion of the horizontal well is cased and cemented in order to isolate the producing formation from contact with other formations.[39] Therefore, horizontal drilling and effective well casings cause more gas and/or oil to reach the surface while protecting groundwater resources from contamination by fraccing fluid, gas, or produced water.[40]

In areas where groundwater is relied upon for potable or other beneficial uses, the groundwater formation is typically found at a depth of no more than several hundred feet, while the gas-bearing shale formation may be at a depth of over seven thousand feet.[41] This means a properly executed well casing and cementing will provide minimal probability for contamination of the groundwater resource by fraccing fluid or produced gas.[42] See Figure 1 below for a visual representation of the casing and depth of a horizontal well, and isolation of the gas bearing formation from drinking water aquifer resources.

37. *What is Fracking?*, RIGANO LLC, http://riganollc.com/what-is-hydraulic-fracturing/ (last visited Oct. 6, 2012).

38. ZIMMERMAN, *supra* note 19, at 22.

39. U.S. DEPT. OF ENERGY, OFFICE OF FOSSIL ENERGY & NAT'L ENERGY TECH. LAB., *supra* note 17 at ES-3.

40. *Id.* at 52.

41. *Id.* at 52, 54.

42. *Id.* at 53.

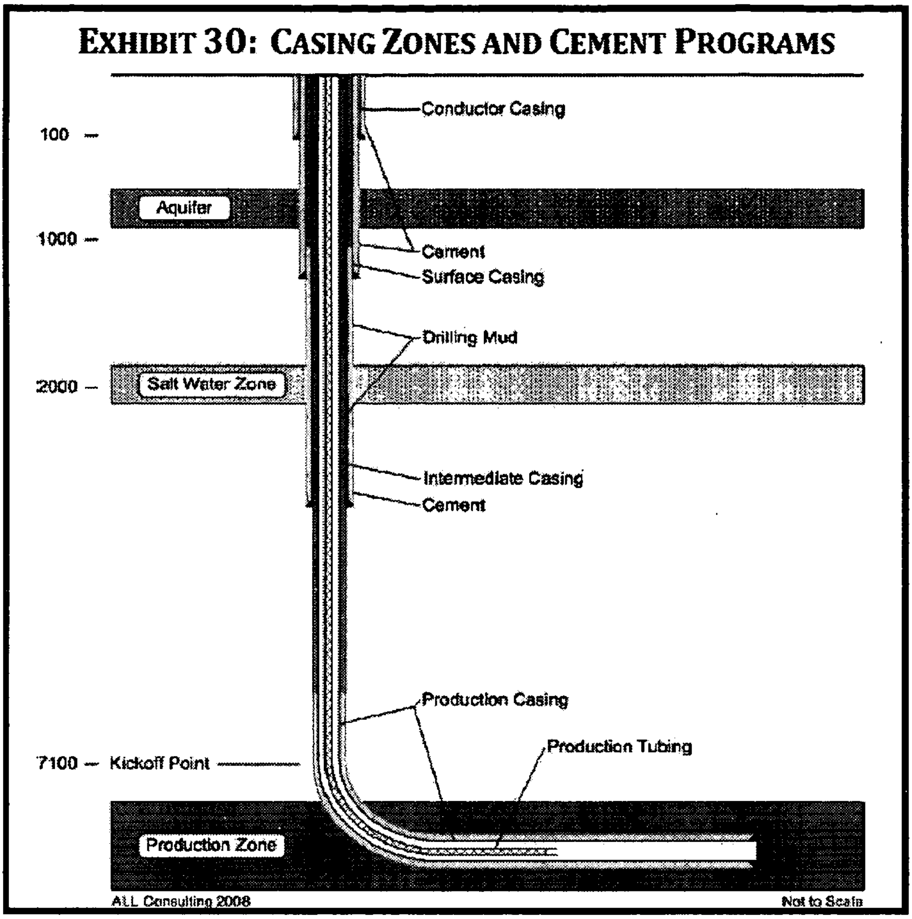

Figure 1[43]*: Casing Zones and Cement Programs*

Notice the multiple casings required through the drinking water aquifer.

The fraccing process follows horizontal drilling.[44] Fraccing creates micro-fissures in the producing formation.[45] Fraccing fluid is over ninety-eight percent water,[46] and includes sand, which acts as a "proppant" to hold the micro-fissures open after the fraccing process is complete, and allows for maximum gas flow.[47] In addition to sand, a completed frac requires multiple injections with a variety of chemistries (for example, high viscosity to carry the sand, low viscosity to release the sand, friction reducers, corrosion preventers, and biocides).[48] Completion of a single frac can require between five hundred thou-

43. *Id.* at 52.
44. *Id.* at 58.
45. *Id.* at 56.
46. *Id.* at 61.
47. *Frac Sand in Wisconsin (Factsheet 05),* WIS. GEOLOGICAL AND NATURAL HISTORY STUDY, 1, 2 (2012) *available at* http://wisconsingeologicalsurvey.org/pdfs/frac-sand-factsheet.pdf.
48. *Water-Related Issues Associated with Gas Production in the Marcellus Shale,* URS CORP., 2-2 to 2-5 (March 25, 2011) *available at* http://www.nyserda.ny.gov/

sand and five million gallons of water.[49] This is largely a one-time use, with fifty to ninety percent of the injected fluid remaining below ground. Between ten and forty percent of the flowback that returns up the wellbore after fraccing is frac fluid.[50] The majority of this flowback occurs in the first several weeks after production begins.[51] However, produced water may continue to flow throughout the productive life of the well.[52] In total, fraccing water constitutes a miniscule percentage of the Colorado's total water use; and oil and gas development accounts for just one tenth of one percent of the total water use in the state.[53]

3. Coalbed Methane

CBM resources typically do not require the use of hydraulic fracturing or horizontal drilling to optimize gas production.[54] Coal beds are shallower formations, relative to tight shales, so they are closer to groundwater formations and water wells and are relatively porous and naturally fractured.[55] CBM is considered an unconventional resource because the coal is both the source and storage reservoir for the gas.[56] Because the gas is often held in coal seams by the presence of water,[57] dewatering of a CBM formation is necessary to allow for gas flow.[58] And because of its relatively shallow depths, the produced water from CBM development can be of good quality, even very near potable standards.[59] The primary issue related to CBM production may be finding a

Publications/NYSERDA-General-Reports/~/media/Files/Publications/NYSERDA/ng/urs-report-11-3-25.ashx.

49. *Id.* at 3-1.

50. Radisav D. Vidic, Sustainable Water Management for Marcellus Shale Development, University of Pittsburgh: Civil and Environmental Engineering, 9 (*available at* http://www.temple.edu/environment/NRDP_pics/shale/presentations_TUsummit/Vidic-Temple-2010.pdf.

51. *Id.*

52. *Id.*

53. Mark Harden, *Fracking in Colorado uses a city's worth of water, enviro report says*, DENVER BUS. J., June 20, 2012, http://www.bizjournals.com/denver/news/2012/06/20/-in-colorado-uses-a-citys.html?page=all.

54. *About "Coal Bed Methane,"* WEST VIRGINIA SURFACE OWNERS' RIGHTS ORG., http://www.wvsoro.org/resources/coal_bed_methane.html (last visited Oct. 6, 2012).

55. *Id.*

56. *Natural Gas and Coalbed Methane*, ALBERTA CANADA (July 25, 2012, 1:41 AM), http://www.albertacanada.com/business/industries/og-natural-gas-and-coal-bed-methane.aspx; Joseph Michael Evers, *Coalbed Methane*, INTERMOUNTAIN OIL AND GAS BMP PROJECT, http://www.oilandgasbmps.org/resources/cbm.php.

57. *Id.*

58. Don Warlick, *Gas Shale and CBM Development in North America*, OIL AND GAS FIN. J., Nov. 1, 2006, http://www.ogfj.com/articles/print/volume-3/issue-11/features/gas-shale-and-cbm-development-in-north-america.html.

59. *Water Produced with Coal-Bed Methane*, USGS, *available at* http://pubs.usgs.gov/fs/fs-0156-00/fs-0156-00.pdf (last visited Oct. 6, 2012).

use or disposal method for the water produced during dewatering of the formation and dealing with affected landowners.[60]

B. WATER QUALITY ISSUES AND RELATED PRECAUTIONS

1. Water Quality Risks

There are a variety of pathways that could potentially result in adverse impacts to surface or groundwater quality as a result of oil and gas production. Wells that are improperly cased or cemented in shallow aquifer zones could provide a contamination route for oil, gas, or production fluids to reach drinking water wells.[61] Surface impoundments that are frequently used to temporarily store produced water near drilling pads prior to reuse or disposal could allow for contamination of shallow aquifers if leaks develop in liner materials.[62] Moreover, breaching or overtopping of surface impoundments may result in the release of produced water or drilling fluids into the surrounding environment.[63] Fencing and bird repellant devices are frequently used, but even when properly maintained and contained, surface impoundments can present environmental risks to wildlife.[64]

In a produced water treatment scenario, unexpected changes in the treatment process may result in the release of inadequately treated effluent.[65] Spikes in contaminant loads or surges in flow are potential causes of process excursions. Failures of treatment process equipment or controls could also result in release of inadequately treated effluent.[66]

In an evaporation pond disposal scenario, the risks to groundwater, environmental release, and wildlife exposure are similar to those described for well pad surface impoundments.[67] Deep injection well disposal also presents risks

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60. *See generally* Vance v. Wolfe, 205 P.3d 1165 (Colo. 2009) (holding that produced water from CBM extraction is subject to the Water Right Determination and Administration Act of 1969 and the Colorado Ground Water Management Act).

61. TEX. CTR. FOR POLICY STUDIES, TEX. ENVTL. ALMANAC, GROUNDWATER AQUIFERS ch. 2 at 7 (1st ed. 1995), *available at* http://texascenter.org/almanac/txenvalmanac.html.

62. RESPONSIBLE DRILLING ALLIANCE, *Freshwater Impoundment Leaked Flowback: Excerpts from File Review of 7/2/12 of Phoenix Pad S Permit #117-21148*, http://responsibledrillingalliance.org/index.php/education/water-quality.

63. Rebecca Hammer and Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater*, NDRC DOCUMENT 1, 57 (May 2012), http://www.nrdc.org/energy/files/-Wastewater-FullReport.pdf.

64. *See, e.g., Bird Control Radar Systems*, DETECT, http://www.detect-inc.com/other.html (last visited Oct. 2, 2012).

65. Dave Alleman, ALL Consulting, LLC, Treatment of Shale Gas Produced Water for Discharge 18 (Mar. 29-30, 2011), http://www.epa.gov/hfstudy/17_Alleman_-_Produced_Water_508.pdf.

66. *Id.* at 12.

67. *Produced Water Management Technology Descriptions Fact Sheet - Evaporation*, THE ENERGY LAB: WHERE ENERGY CHALLENGES CONVERGE AND ENERGY SOLUTIONS EMERGE, http://www.netl.doe.gov/technologies/pwmis/techdesc/evap/index.html (last visited Oct. 4, 2012).

of contamination due to well failure or surface spill.[68] When produced water is hauled by tanker truck from a production site to a distant disposal site, as is common in the Marcellus shale formation, transportation hazards may also pose environmental risks.[69] These risks include traffic accidents, leaks, spills associated with loading and unloading the tankers, and the resulting impacts on human health or the environment.[70] Along with environmental risks are the "nuisances" of truck traffic such as noise, traffic congestion, and dust kicked up on unpaved roads.[71] A 5,000,000-gallon frac could require transport of 500 to 1,000 truckloads of water.[72]

All of the environmental release scenarios just described would only occur due to a failure of industry standards and regulations. As noted above, the production and disposal wells are cased and cemented to provide an isolation barrier between the well and any aquifers that the well passes through.[73] For pond leakage to reach groundwater would usually require the simultaneous failures of a double liner system and leak detection instrumentation.[74] Pond overflow would only occur where a storm overfilled the pond in excess of its capacity.[75] Produced water treatment systems normally include an influent equalization basin to buffer the treatment process from influent "spikes," and real-time monitoring of critical-process control parameters, allowing system operators to take corrective actions.[76]

2. Federal and State Laws Regulating Water Quality

Both federal and state laws govern water quality issues associated with produced water. The federal regulatory scheme includes the Clean Water Act ("CWA") and Safe Drinking Water Act ("SDWA").

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68. U.S. DEPT. OF ENERGY, OFFICE OF FOSSIL ENERGY & NAT'L ENERGY TECH. LAB., *supra* note 17 at 53-54.

69. *Id.* at 49.

70. *Id.*

71. *Id.*

72. Kristian Boose, *Effect of Marcellus drilling on West Virginia fisheries could be profound*, PROTECTING OUR WATERS (Feb. 23, 2011), http://protectingourwaters.wordpress.com/2011/02/23/effect-of-marcellus-drilling-on-west-virginia-fisheries-could-be-profound/.

73. *Coal bed methane extraction*, DART ENERGY IN SCOTLAND, http://www.dartenergyscotland.com/coal-bed-methane-process.html (last visited Oct. 4 2012).

74. COLO. OIL AND GAS CONSERVATION COMM'N, RULE 904 PIT LINING REQUIREMENTS AND SPECIFICATIONS, *available at* http://cogcc.state.co.us/Announcements/Rule904.pdf (requiring that evaporation impoundments be lined where there is a potential to impact an area determined to be environmentally sensitive for water quality).

75. *See* Thomas Swartz, *Hydraulic Fracturing: Risks and Risk Management*, 26 NATURAL RES. & ENV'T, no. 2, Fall 2011 at 31, 30, *available at* http://usa.marsh.com/NewsInsights/ThoughtLeadership/Articles/ID/12717/Hydraulic-Fracturing-Risks-and-Risk-Management.aspx.

76. *See* Ramesh K. Goel et al., *Flow Equalization and Neutralization*, *in* PHYSIOCHEMICAL TREATMENT PROCESSES, 21-22, 31 (Lawrence K. Wang, Yung-Tse Hung & Nazih K. Shammas eds., 2005), *available at* http://www.google.com/search?client=safari&rls=en&q=Produced+water+treatment+systems+normally+include+an+influent+equalization+basin&ie=UTF-8&oe=UTF-8.

i. The Clean Water Act

In 1972, Congress enacted the Federal Water Pollution Control Act, also known as the Clean Water Act.[77] The CWA imposes national, technology-based standards on individual sources to make the nation's water fishable, swimmable, and to eliminate pollutant discharge into navigable waters.[78] The two main programs under the CWA are its point source and nonpoint source programs.[79] The point source program monitors the discharge of pollutants from a specific conveyance.[80] Direct discharges into water systems are permit-controlled through the National Pollutant Discharge Elimination System ("NPDES").[81] The nonpoint source program governs pollution from nonspecific areas, but regulation of these areas has produced little actual control and is not discussed in this Article.[82]

Either the Environmental Protection Agency ("EPA") or states with EPA-approved programs (called "primacy states") can issue NPDES permits to dischargers meeting "Effluent Limitation Guidelines" in order to regulate "point sources."[83] EPA works with other federal agencies, state and local governments, and Indian Country governments to develop and enforce regulations under existing environmental laws.[84] A point source is "any discernible, confined and discrete conveyance . . . from which pollutants are or may be discharged."[85] NPDES grants permits that control the amount and concentration of pollutants discharged directly into streams, lakes, or the ocean by industrial and municipal facilities.[86] All private industrial facilities discharging pollutants into waters of the United States may only discharge subject to stringent technology-based standards. In Colorado, these permits are required for discharges into tributary groundwater.[87]

Section 302 of the CWA authorizes EPA to monitor the overall water quality of a body of water.[88] EPA and states do this by issuing Total Maximum Daily Loads ("TMDLs") that establish the minimum requirements of the CWA for each body of water.[89] All NPDES permits issued by the state or EPA must be in keeping with the TMDLs for the relevant body of water.[90] If existing water quality is better than the minimum requirement, the CWA imposes an

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77. Exec. Order No. 11742, 38 FR 29,457 (Oct. 23, 1973), *reprinted in* 33 U.S.C. §§1251-1387 (2012).
78. 33 U.S.C. § 1311(2012).
79. *See id.* § 1342(f); David Zaring, *Agriculture, Nonpoint Source Pollution, and Regulatory Control: The Clean Water Act's Bleak Present and Future*, 20 HARV. ENVTL. L. REV. 515, 517 (1996).
80. *Id.* §§ 1342(b)(1)(D), 1342(f), 1362(14).
81. *Id.* § 1342(a)(1).
82. *Id.* § 1319(a)(5)(B).
83. *Id.* § 1342 (b)(1)(A).
84. *Id.* §§ 1251(g), 1377(a).
85. *Id.* § 1362 (14).
86. *Id.* §§ 1311(a), 1312(a).
87. Sierra Club v. Colo. Ref. Co., 838 F. Supp. 1428, 1431 (D. Colo. 1993).
88. 33 U.S.C. §§ 1312, 1313(a)(1) (2012).
89. *Id.* §§ 1313(d)(1)(C)-(D).
90. *Id.* § 1313(d)(3).

"antidegradation" requirement to enforce the status quo.[91] EPA rules clarify sediment from oil and gas construction activities will not trigger NPDES requirements unless the sediment carries oil, pollutants or other hazardous substances.[92]

ii. The Safe Drinking Water Act

The SDWA, also enacted in 1972, is the major federal law that ensures the quality of America's drinking water both above and below ground.[93] Under the SDWA, EPA sets health-based standards for drinking water quality and oversees the states, localities, and water suppliers who implement those standards.[94] EPA regulates these water systems by specifying contaminants and setting limits for them called maximum contaminant levels.[95] EPA also specifies treatment techniques on a "best available technology" standard.[96]

EPA sets two types of standards for roughly ninety total contaminants.[97] The first type of standard is the primary standard, which applies to biological contamination, disinfectants, organic and inorganic chemicals, and radionuclides.[98] The primary standard sets the limit of these contaminants at a point to which their presence in drinking water will result in no known or expected risk to health.[99] The second type of standard is the secondary standard, which creates non-enforceable guidelines regulating contaminants that may cause cosmetic effects or aesthetic effects.[100]

The SDWA also legally defines underground sources of drinking water.[101] Groundwater is considered clean enough for use as drinking water if it has less than 10,000 mg/l of total dissolved solids ("TDS") and currently supplies or contains a sufficient quantity of groundwater to supply a public water system.[102]

Finally, the SDWA has an underground injection control ("UIC") program.[103] This program regulates deep well injection of waste into "dry" wells, thereby assuring underground injection will not endanger drinking water sources.[104] The extent of the regulation depends upon which of five regulatory categories the well encompasses. See Table 1 below for a breakdown of the five regulatory categories:

91. 40 C.F.R. § 131.12 (2012).
92. 40 C.F.R § 122.26(a)(2)(ii).
93. 42 U.S.C. § 300g-1 (1996).
94. *Id.* §§ 300g-1(b)(1)(A), 300g-2.
95. *Id.* at § 300g-1 (b)(4).
96. *Id.* at § 300g-1 (b)(5)-(6).
97. *See* 40 C.F.R. § 141.2 (1998); 40 C.F.R. § 143.1 (1988).
98. 40 C.F.R. § 141.50-.55 (2006).
99. *Id.* § 141.2.
100. 40 C.F.R. § 143.1 (1988).
101. *See* 40 C.F.R. § 144.3 (2011).
102. *Id.*
103. *See* 42 U.S.C. § 300h(d) (2005).
104. *Id.*

Table 1: Types of Wells Under the UIC Program

Class	Basic Description	Level of Monitoring Required	# of wells Nation-wide
Class I	Class I wells inject hazardous and nonhazardous wastes into deep, isolated rock formations that are thousands of feet below the lowermost USDW	The construction, permitting, operating, and monitoring requirements are more stringent for Class I hazardous wells than for the other types of injection wells.	Approximately 550
Class II	Class II wells inject fluids associated with oil and natural gas production. Most of the injected fluid is salt water (brine), which is brought to the surface in the process of producing oil and gas. In addition, brine and other fluids are injected to enhance (improve) oil and gas production.	A state has the option of requesting primacy for Class II wells under either § 1422 or 1425 of the SDWA: § 1422 requires states to meet EPA's minimum requirements for UIC programs. Programs authorized under § 1422 must include construction, operating, monitoring and testing, reporting, and closure requirements for well owners or operators. Enhanced oil and gas recovery wells may either be issued permits or be authorized by rule. Disposal wells are issued permits. The owners or operators of the wells must meet all applicable requirements, including strict construction and conversion standards and regular testing and inspection. § 1425 allows states to demonstrate that their existing standards are effective in preventing endangerment of USDWs. These programs must include permitting, inspection, monitoring, and record-keeping and reporting that demonstrates the effectiveness of their requirements.	Approximately 1440,000

Table 1: Types of Wells Under the UIC Program

Class III	Class III wells inject fluids to dissolve and extract minerals such as uranium, salt, copper, and sulfur. More than 50 percent of the salt and 80 percent of the uranium extraction in the United States involves the use of Class III injection wells.	All Class III wells are operated under individual or area permits. Contamination from mining wells is prevented by implementing requirements for mining well operators: Before commencing injection: operators must obtain an aquifer exemption if they are injecting into a USDW (which is common in ISL uranium mining), or if the overlying aquifer may subside (which may happen in salt mining operations). The wells must be constructed with tubing made of materials that are appropriate for the injected fluids, which are cased and cemented to prevent the migration of fluids into a USDW. They must also provide financial assurance that resources exist to properly plug the wells when injection operations are complete. Operators must pressure test their wells prior to injection. During Operation: the operator must monitor injection pressure and flow rate, and they may not inject fluid between the outer-most casing and the well bore. Operators must also monitor USDWs below and above the mining interval if the well is injecting into a USDW of 3,000 ppm TDS or less. Operators of salt solution mining wells must test the well casing for leaks at least once every 5 years. When injection is complete: Class III operators must properly close (plug and abandon) the wells.	Approximately 18,500
Class IV	Class IV wells are shallow wells used to inject hazardous or radioactive wastes into or above a geologic formation that contains a USDW.	In 1984, EPA banned the use of Class IV injection wells for disposal of hazardous or radioactive waste. Now, these wells may only be operated as part of an EPA- or state-authorized ground water clean-up action.	There are about 32 waste clean-up sites with Class IV wells
Class V	Most Class V wells are shallow disposal systems that depend on gravity to drain fluids directly in the ground. There are over 20 well subtypes that fall into the Class V category and these wells are used by individuals and businesses to inject a variety of non-hazardous fluids underground. Most of these Class V wells are unsophisticated shallow disposal systems that include storm water drainage wells, cesspools, and septic system leach fields. However, the Class V well category also includes more complex wells that are typically deeper and often used at commercial or industrial facilities.	EPA established minimum requirements to prevent injection wells from contaminating underground sources of drinking water (USDWs). Operators must: - Submit inventory information to their permitting authority and verify that they are authorized to inject. The permitting authority will review the information to be sure that the well will not endanger a USDW. - Operate the wells in a way that does not endanger USDWs. - Properly close their Class V well when it is no longer being used. The well should be closed in a way that prevents movement of any contaminated fluids into USDWs.	More than 650,000 Class V wells

As evidenced by the chart above, the majority of wells used by the oil and gas industry are either Class II or Class V. As also noted in the chart, Class II wells are deep injection wells. These wells are used in areas where surface impoundments and discharge are technically and economically unfeasible.[105] Class II wells are also used to safely store hydrocarbons once they are produced.[106] These wells must inject into a geologically isolated formation in order to protect USDWs.[107] In order to ensure the integrity of these wells, injection pressure and the geology of the injection zone are carefully examined to ensure beneficial groundwater sources are not contaminated.[108]

The type of Class V wells used by the oil and gas industry are shallow aquifer storage and recovery wells.[109] These wells are most commonly used in CMB production because they inject produced water of sufficient quality, with or without treatment, into relatively shallow wells or back into the coalbed aquifer itself.[110]

Permits for Class II or V wells can be written for a single well or for an area served by multiple wells.[111] Typically, the state oil and gas agency has primacy for issuing permits for Class II wells, as is the case in Colorado where the Colorado Oil and Gas Conservation Commission ("COGCC") issues permits.[112] Conversely, a water quality agency, public health agency, or EPA primarily issues permits for Class V wells.[113]

Certain aquifers are exempted from the SDWA. Exempt aquifers include aquifers that are not and will not be suitable for water supply purposes, aquifers that are "mineral, hydrocarbon or geothermal energy producing," aquifers that are capable of becoming commercially mineral or hydrocarbon energy producing, aquifers that are already contaminated, or aquifers that are located over a Class III mining area subject to collapse.[114]

As a result, water that meets federal drinking water standards is generally considered to be high quality. It is therefore common for permits under a variety of environmental regulatory programs to reference federal drinking water standards.

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105. *See Water: Class II*, ENVTL. PROT. AGENCY, http://water.epa.gov/type/groundwater/uic/class2/index.cfm (last updated May 9, 2012).

106. *Id.*

107. *See* Ming Lu, *Rock engineering problems related to underground hydrocarbon storage*, J. OF ROCK MECHANICS AND GEOTECHNICAL ENGINEERING 289, 289 (2010), *available at* http://202.127.156.15/qikan/manage/wenzhang/2010-04-01.pdf.

108. See *id.* at 297.

109. *Water: Class V Wells*, ENVTL. PROT. AGENCY, http://water.epa.gov/type/groundwater/uic/class5/index.cfm (last updated May 4, 2012).

110. *Id.*

111. *Glossary*, ENVTL. PROT. AGENCY, http://water.epa.gov/type/groundwater/uic/glossary.cfm (last updated Mar. 6, 2012).

112. *COGCC Underground Injection Control and Seismicity in Colorado*, STATE OF COLO. OIL AND GAS CONSERVATION COMM'N, at 2 (Jan. 19, 2011), *available at* http://cogcc.state.co.us/Library/InducedSeismicityReview.pdf.

113. *See Class V Wells*, ENVTL. PROT. AGENCY, http://www.epa.gov/region9/water/groundwater/uic-classv.html (last updated June 9, 2011).

114. 40 C.F.R. § 146.4 (2011).

C. CHEMISTRY OF PRODUCED WATER

Oil and gas-bearing formations are often encased in briny, non-potable groundwater.[115] When drilling a well, this water will often flow up the well bore to the surface and is subsequently called "produced water."[116] Produced water may be present throughout the life of a well.[117] In addition to groundwater, produced water can include "frac flowback."[118] Frac flowback is an initially high flow of produced water from a fraced well.[119] Enhanced oil recovery methods, including the use of steam or hot water flooding, also contribute to the flow of produced water in long-term production.[120]

The chemistry of produced water is extremely variable from site to site.[121] Produced water contaminants may include free oils; gritty solids; finely emulsified oil and other suspended solids; water-soluble organic compounds; and dissolved inorganics including: salts, metals, and naturally occurring radioactive materials.[122] Microbiological components (bacteria) may also be present.[123] Combinations, proportions, and concentrations of contaminants present site-specific challenges in water management.[124]

Further complicating the characterization of produced water is the potential for changes in water quality and quantity over time.[125] Changes in water quality or quantity may occur naturally or may result from enhanced recovery techniques, such as hot water flooding.[126] Understanding the complexities of water chemistry is vital to the decision-making process over the disposition of produced water.[127] The variability in chemical characterization of produced waters is illustrated below in Table 2. The complexity and costs of treatment increase when there is a greater variety of contaminants, and/or contaminants at higher concentrations.

115. *Produced Water Management Information System Introduction to Produced Water*, THE ENERGY LAB: WHERE ENERGY CHALLENGES CONVERGE AND ENERGY SOLUTIONS EMERGE, http://www.netl.doe.gov/technologies/pwmis/intropw/index.html (last visited Oct. 7, 2012).

116. *Id.*

117. Mark Kidder et al., *Treatment Options for Reuse of Frac Flowback and Produced Water from Shale*, 232 PRODUCED WATER SOC'Y 7 (July 2011), http://www.worldoil.com/July-2011-Treatment-options-for-reuse-of-frac-flowback-and-produced-water-from-shale.html.

118. *Id.*

119. *See id.*

120. *See* Zimmerman et al., *supra* note 19, at 39.

121. *See Modern Shale Gas Development in the United States: A Primer*, U.S. DEP'T. OF ENERGY: OFFICE OF FOSSIL ENERGY NATIONAL ENERGY TECHNOLOGY LABORATORY, 67-68 (2009), *available at* http://www.netl.doe.gov/technologies/oil-gas/publications /epreports/shale_gas_primer_2009.pdf.

122. *See Modern Shale Gas Development in the United States: A Primer*, *supra* note 19, at ES5, 66-67, 70.

123. Alfred Tischler, *Controlling Bacteria in Recycled Production Water for Completion and Workover Operations*, 25 SPE PRODUCTIONS & OPERATIONS 2, 232 (May 2010).

124. *Challenges in Reusing Produced Water*, SOC'Y OF PETROLEUM ENGINEERS 2 (2011), *available at* http://www.spe.org/industry/docs/reusingwater.pdf.

125. *Id.*

126. *See* Zimmerman et al., *supra* note 19, at 3.

127. *See Challenges in Reusing Produced Water*, *supra* note 124, at 2-3.

Parameter (mg/L)	Wind River, WY	Rifle, CO	Vernal, UT	Trinidad, WI
Total dissolved solids	6,500	14,000	29,000	9,900
Chloride	2,000	8,500	28,500	3,200
Total suspended solids	150	330	150	189
Oil & grease	120	30		200 to 1,900
Gasoline range organics	78	350	55	
Diesel range organics	14	150	100	240
Chemical oxygen demand				4,700

Table 2: Chemical Characterization of Produced Waters [128]

Along with the variability in chemical characterization of produced water, there are also a variety of potential end uses. Producers may consider economics, legal requirements, and sustainability when deciding what to do with produced water. Regional environmental conditions, including climate and the abundance or scarcity of surface water and groundwater, also factor into the final disposition of produced water.

1. Economics of Water Management and Treatment

The handling, management, and treatment of produced water fall into operating expenses for oil and gas production ("OPEX").[129] For Industry, minimizing OPEX results in higher profitability.[130] If ongoing production activities require water resources, such as fraccing or steam flooding, on-site treatment of produced water allows for immediate reuse.[131] The economic advantages associated with this type of treatment are twofold: there is reduced demand for fresh water supply and there is reduced volume of wastewater to dispose.[132]

When produced water is not needed on-site for continuing production activities, disposal by deep well injection is typically the most economical

128. Water quality data for WY, CO, UT, is attributed to MWH Americas, Inc. Water quality for Trinidad, WI is attributed to Golder Associates, Inc. Certain fields are intentionally blank due to lack of data.

129. Zara Khatib & Paul Verbeek, *Water to Value–Produced Water Management for Sustainable Field Development of Mature and Green Fields*, HSE HORIZONS 26 (2003), http://www.spe.org/jpt/print/archives/2003/01/JPT2003_01_hse_horizons.pdf.

130. *See id.*

131. *Id.* at 27.

132. *Id.* at 28.

choice.[133] Alternatively, hauling water to offsite commercial deep well injection facilities remains an option.[134] In arid and semi-arid regions, disposal by solar evaporation is also an option.[135] However, some states regulate solar evaporation ponds for air emissions.[136] The presence of volatile organic compounds in produced water that may potentially be released into the air may preclude evaporation as a disposal option.[137]

There is a preference for on-site treatment for immediate reuse in fraccing operations.[138] Removal of suspended solids may be the only treatment step required prior to reusing produced water as frac fluid.[139] If the produced water requires more intensive treatment, hauling water offsite to a commercial treatment or disposal facility will likely prove more economical.[140]

Oil and gas prices further complicate the economics of produced water treatment. When the natural gas commodity price is low, gas fields may temporarily shut down only to be put back into production when the price allows for profitable operation.[141] Fields from which it is easier to produce natural gas with less water, or simpler water chemistry, will receive preference.[142]

2. Legal Requirements

Legal drivers for produced water treatment come into play when the best option for final disposition is discharge to the environment, or to a regulated form of reuse. Discharges may be to surface water, groundwater, or land application.[143] Crop irrigation and livestock watering are examples of typical state-

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133. Tom Hayes & Dan Arthur, *Overview of Emerging Produced Water Treatment Technologies*, The 11th Annual International Petroleum Environmental Conference (2004), http://ipec.utulsa.edu/Conf2004/Papers/hayes_arthur.pdf.

134. *Modern Shale Gas Development in the United States: A Primer*, U.S. DEP'T OF ENERGY: OFFICE OF FOSSIL ENERGY NAT'L ENERGY TECH. LAB. 68 (2009), http://www.netl.doe.gov/technologies/oil-gas/publications/epreports/shale_gas_primer_2009.pdf.

135. *SMI Produced Water Treatment for Oil & Gas Wastewater*, SMI EVAPORATIVE SOLUTIONS, http://www.evapor.com/wastewater_applications/evaporation_oilgas.html (last visited Nov. 25, 2012).

136. Jennifer Mattox, *Oil & Gas Air Quality Regulation Update*, COLO. OIL & GAS CONSERVATION COMM'N 10 (2007), http://cogcc.state.co.us/Library/Presentations/NW%20Colorado%20Oil%20and%20Gas%20Forum%2012-7-06/CDPHE_UPDATE_031507.pdf.

137. *Id.*

138. Matthew E. Mantell, *Produced Water Reuse and Recycling Challenges and Opportunities Across Major Shale Plays*, EPA HYDRAULIC FRACTURING STUDY TECHNICAL WORKSHOP #4: WATER RES. MGMT. 16 (March 29-30, 2011), http://www.epa.gov/hfstudy/09_Mantell_-_Reuse_508.pdf.

139. *Id.* at 15.

140. *Fact Sheet - Commercial Disposal Facilities*, DRILLING WASTE MGMT. INFORMATION SYS., http://web.ead.anl.gov/dwm/techdesc/commercial/index.cfm (last visited Oct. 1, 2012).

141. Andrew Maykuth, *Natural-Gas Prices Force Down Number of Marcellus Drilling Rigs*, THE INQUIRER (July 8, 2012), http://articles.philly.com/2012-07-08/business/32589447_1_natural-gas-prices-drilling-natural-gas.

142. *Difference Engine: Awash in the Stuff*, THE ECONOMIST BABBAGE BLOG (May 4, 2012, 2:29), http://www.economist.com/blogs/babbage/2012/05/natural-gas?test=babbage.

143. *State Regulations: Colorado*, DRILLING WASTE MGMT. INFO. SYS., http://web.ead.anl.gov/dwm/regs/state/colorado/index.cfm (last visited Nov. 30, 2012).

regulated reuses.[144] Each of these discharge and reuse options have their own sets of water quality standards, permitting, and long-term monitoring requirements. The range of standards is illustrated in Table 3. The viability of any particular discharge or reuse option is dependent on the complexity and cost of treatment required to produce effluent that is compliant with discharge standards. Where multiple discharge options are available, cost usually determines the preferred option.

Constituent	NPDES (permitted surface water outfall)	Land application (surface disposal or irrigation use)	Industrial re-use
Total suspended solids	20 - 30		<50
pH (standard units)	6.5 - 9	4.5 - 9	9.8 - 10.2
Oil and grease	10		1.4
Biological oxygen demand	30 - 45		30
Chemical oxygen demand			250
Coliform (count/100 mL)	6,000		0
Residual chlorine	2.2 - 3.6		0.25
Total dissolved solids		480	
Sulfate		192	
Chloride	230	250	45 - 55
Trace metals	<1	<1	<1

Table 3: Regulatory and industry standards for discharge and reuse options for produced water, post-treatment.[145] *All constituent target values are reported as mg/L, except as noted.*

Municipal wastewater treatment plants may also treat produced water in accordance with a pretreatment permit.[146] Pretreatment permits typically require that produced water will not result in toxicity to microbiological processes in the wastewater treatment plant, and will not pass through the plant untreated.[147] However, this discharge option is used infrequently; municipal treatment facilities may not be in close proximity to production sites, and gen-

144. C.E. Clark & J.A. Veil, *Produced Water Volumes and Management Practices in the United States*, U.S. DEP'T. OF ENERGY, OFFICE OF FOSSIL ENERGY, NAT'L ENERGY TECH. LABORATORY, 17 (2009), http://www.netl.doe.gov/technologies/coalpower/ewr/water/pdfs/anl%20produced%20water%20volumes%20sep09.pdf.

145. NPDES data attributed to U.S. Environmental Protection Agency. Other data attributed to Golder Associates, Inc. Certain fields are left blank due to lack of data.

146. *Hydraulic Fracturing 101*, EARTHWORKS, http://www.earthworksaction.org/issues/detail/hydraulic_fracturing_101 (last visited Nov. 30, 2012).

147. *Id.*

erally are not designed to remove the contaminants potentially present in produced water.[148]

In Colorado, produced water also affects water rights (as discussed in more detail below).[149] The determination of whether produced water is tributary or nontributary, or whether a vested water right is potentially injured by the flow of produced water from aquifer to the surface, may figure into the level of treatment and how the treated water is reintroduced to the stream.[150]

III. WHAT DO WE DO WITH PRODUCED WATER?

Variability in the chemistry of produced water, variety of potential dispositions, and economic factors provide for an abundance of treatment and management alternatives.[151] Direct disposal, including deep well or evaporation ponds, may be the most expeditious of alternatives.[152] If economic disposal options are not available, treatment to an appropriate quality level for onsite reuse is the next logical step.[153] And, while every instance of produced water is different, there are some common characteristics that allow for a "roadmapped" approach to treatment and management planning.

Treatment stages include removal of free oils, fine suspended solids, emulsified oils, dissolved organic compounds, and dissolved inorganic compounds (salts, metals and in some cases naturally occurring radioactive materials).[154] Each stage produces secondary waste by-products, which need to be managed or disposed of.[155] Thus, the general producer's preference is for the simplest treatment process that results in reusable water.[156]

Web-based software programs are used to assist in the decision-making process for treatment of produced water, or to answer the question "how clean is clean?" The U.S. Department of Energy's National Energy Technology Laboratory developed a "Produced Water Management Information Sys-

148. *Id.*

149. Dave Colvin, *Origins of Produced Water Regulations in Colorado - A Brief History*, AMERICAN WATER RES. ASS'N—COLORADO SECTION, http://awracolorado.havoclite.com /newsletter/brief-history-of-produced-water-in-colorado/ (last visited Oct. 2, 2012).

150. *See Using Produced Water as a New Resource*, COLO. WATER CONGRESS WATER QUALITY WORKSHOP (2008), *available at* http://www.cowatercongress.org/ AnnualConvention/Archived/2009/Presentations/David%20Stewart%20- %20Colorado%20Water%20Congress%20WQ%20Workshop%20Jan%202009.pdf.

151. *See Modern Shale Gas Development in the United States: A Primer*, U.S. DEP'T OF ENERGY: OFFICE OF FOSSIL ENERGY NAT'L ENERGY TECH. LAB., 67-68 (2009), *available at* http://www.netl.doe.gov/technologies/oil-gas/publications/epreports/shale_gas_primer_2009.pdf.

152. *See id.*

153. *See id.* at 68.

154. *Produced Water Management Technology Descriptions: Introduction to Produced Water*, U.S. DEP'T OF ENERGY: OFFICE OF FOSSIL ENERGY NAT'L ENERGY TECH. LAB., http://www.netl.doe.gov/technologies/PWMIS/intropw/index.html (last visited Nov. 30, 2012).

155. *Produced Water Management Technology Descriptions: Fact Sheet—First Step: Basic Separation*, U.S. DEP'T OF ENERGY: OFFICE OF FOSSIL ENERGY NAT'L ENERGY TECH. LAB., http://www.netl.doe.gov/technologies/pwmis/techdesc/sep/ (last visited Nov. 30, 2012).

156. *See id.*

tem."[157] This tool provides information for treatment and disposal of produced water subject to EPA regulations for both onshore and offshore production.[158] Figure 2 is an illustration of the framework.

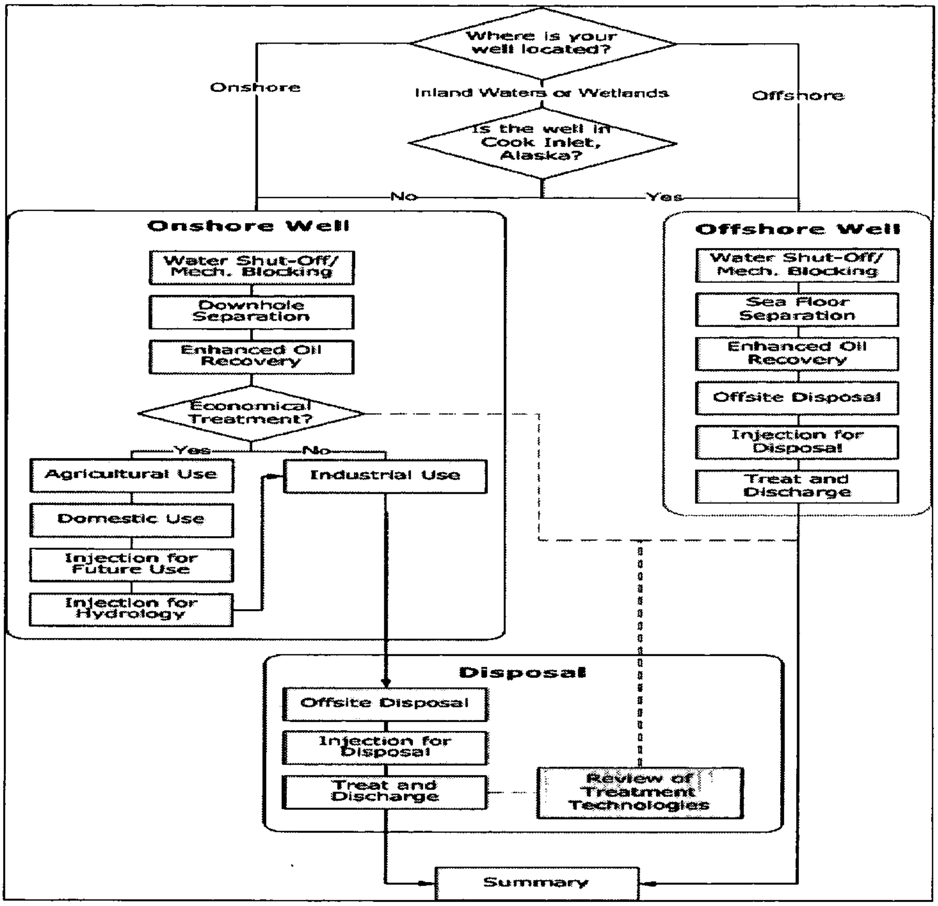

Figure 2: NETL Produced Water Decision Tree

Another useful tool, targeting CBM development in the Mountain West, is the "CBM Produced Water Management Tool."[159] This tool steps through four modules, allowing user input to water quality, treatment selection, benefi-

157. *Produced Water Management Information System*, U.S. DEP'T OF ENERGY: OFFICE OF FOSSIL ENERGY NAT'L ENERGY TECH. LAB., http://www.netl.doe.gov/technologies/PWMIS (last visited Nov. 30, 2012).

158. The tool is hyperlinked to more in-depth information at each stage. *Produced Water Management Technology Descriptions*, U.S. DEP'T. OF ENERGY: OFFICE OF FOSSIL ENERGY NAT'L ENERGY TECH. LAB., http://www.netl.doe.gov/technologies/PWMIS/techdesc/index.html (last visited Nov. 30, 2012).

159. *CBM Produced Water Management Tool*, PRODUCED WATER TREATMENT AND BENEFICIAL USE INFO. CTR., http://aqwatec.mines.edu/produced_water/tools/index.html (last visited Nov. 30, 2012).

cial use screening, and economics.[160] The resulting output can be a guide to balanced optimization of treatment efficiency, cost and sustainability—a triple bottom line evaluation.

Because the OPEX costs associated with produced water management can vary drastically, these logic flow diagrams are useful to sort through issues such as regional variability, production methods, reuse, treatment, and disposal options.[161] Regional availability of commercial treatment facilities, mobile treatment equipment available for leased use, or the production company's willingness to make a capital investment in water treatment all figure into the cost of produced water management and treatment.[162]

As a result, it is difficult to quantify the cost to treat produced water.[163] As illustrated above, the relevant considerations include the chemical characterization of produced water; discharge or reuse water quality standards; hauling distance to treatment or disposal; availability of mobile equipment; generation and disposal or secondary waste products; and the potential to offset treatment cost through reducing demand for source water.[164] Reported costs for treatment of produced water range from $0.08 to $12.00 per barrel.[165] NETL reports a more moderate range of treatment costs from $3.00 to $5.00 per barrel.[166] More accurate costs associated with management and treatment of produced water can only be developed on a site-specific basis.

IV. AN OVERVIEW OF WATER LAW

Water laws and water rights are increasingly relevant to oil and gas. Operators must ensure that water used for drilling, and produced subsequent to drilling, complies with applicable laws and regulations. With an understanding the basic framework and history of western water law, operators can make more informed decisions about water used and produced in their operations.

In the Raton Basin, the COGCC estimates that a shallow coalbed methane well requires between 1/8th and one acre-foot of water.[167] In the Piceance

160. *Id.*

161. *See id; see also Produced Water Management Information System*, U.S. DEP'T. OF ENERGY: OFFICE OF FOSSIL ENERGY NAT'L ENERGY TECH. LAB., http://www.netl.doe.gov/technologies/PWMIS (last visited Nov. 30, 2012).

162. *See Produced Water Management Technology Descriptions: Fact Sheet - Offsite Commercial Disposal*, U.S. DEP'T. OF ENERGY: OFFICE OF FOSSIL ENERGY NATIONAL ENERGY TECHNOLOGY LABORATORY, http://www.netl.doe.gov/technologies/pwmis/techdesc/offsite/index.html (last visited Nov. 30, 2012).

163. *See id.*

164. *See* Figure 2 above.

165. *Oil and Gas Industry, Produced Water*, ALTELA, http://www.altelainc.com/applications/detail/oil-and-gas-industry-produced-water/ (last visited Nov. 30, 2012).

166. *Produced Water Management Technology Descriptions*, U.S. DEP'T. OF ENERGY: OFFICE OF FOSSIL ENERGY NAT'L ENERGY TECH. LAB., http://www.netl.doe.gov/technologies/pwmis/techdesc/offsite/ (last visited Oct. 21, 2012).

167. *Frequently Asked Questions About Hydraulic Fracturing*, COLO. OIL & GAS CONSERVATION COMM'N, http://cogcc.state.co.us/Announcements/Hot_Topics/Hydraulic_Fracturing/Frequent_Questions_about_Hydraulic%20Fracturing.pdf (last visited Nov. 30, 2012).

Basin, wells require approximately two to six acre-feet.[168] In the Denver-Julesburg Basin, approximately 7/10th of an acre-feet may be used to frac a vertical well, while fraccing a horizontal well may require up to fifteen acre-feet of water.[169] While these amounts are minute compared to other uses, dependable supplies of water are critical to oil and gas production.[170]

Compliance with applicable water laws is just as essential. For example, water used for hydraulic fracturing must be used in priority and for purposes consistent with those permitted by the Colorado State Engineer or decreed in water court.[171] Water produced from operations must not injure vested water rights and may require separate water right permitting and adjudication.[172] A general understanding of how water laws developed and the principles upon which they are based may help guide operators in permitting and compliance decisions.

Western water law was developed to govern the allocation of scarce resources in a structured and consistent manner.[173] The two basic water law systems in the United States, riparian rights and the doctrine of prior appropriation (and the hybrid systems that combine the two), have a long, complicated, and contentious history.[174]

A. RIPARIAN LAW GENERALLY

Like many aspects of its laws, the United States inherited its water law from England.[175] Riparian water law is well suited to the water-abundant eastern United States, and is still used in most eastern states, including Alabama, New York, and West Virginia.[176] The early rationale for riparian law was that it protected the rights of landowners while simultaneously providing for the continuing navigability of streams, which was crucial to commercial operations in the days before the advent of large highways.[177]

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168. *Id.*

169. *Id.*

170. *Hydraulic Fracturing Facts: Water Usage*, CHESAPEAKE ENERGY, http://www.hydraulicfracturing.com/Water-Usage/Pages/Information.aspx (last visited Nov. 30, 2012).

171. *Water Rights*, COLO. DIV. OF WATER RES., http://water.state.co.us/SurfaceWater/SWRights/Pages/default.aspx (last visited Nov. 30, 2012).

172. *Guide to Colorado Well Permits, Water Rights, and Water Administration*, COLO. DIV. OF WATER RES., 6-7 (2012), *available at* http://water.state.co.us/DWRIPub/Documents/wellpermitguide.pdf.

173. D. Craig Bell & Norman K. Johnson, *State Water Laws and Federal Water Uses: The History of Conflict, the Prospects for Accommodation*, 21 ENVTL. L. 1, 4 (1991).

174. *See, e.g.*, A. DAN TARLOCK, LAW OF WATER RIGHTS AND RESOURCES § 1:1 (2012).

175. Fred W. Welden, *History of Water Law in Nevada and the Western States* 1 (2003), *available at* http://www.leg.state.nv.us/Division/Research/Publications/Bkground/BP03-02.pdf.

176. *See* GEORGE VRANESH, VRANESH'S COLORADO WATER LAW 2 (James N. Corbridge, Jr. & Teresa A. Rice eds., Univ. Press of Colo. rev. ed. 1999).

177. *See Public Lands Surveying Casebook Chapter D: Basic Law of Water Boundaries*, BUREAU OF LAND MGMT. (1975), *available at* http://www.blm.gov/cadastral/casebook/casebook.htm.

Under riparian law, water use is tied to land ownership.[178] In other words, if one owns land next to a stream, he is entitled to reasonable use of an amount of water roughly proportionate to the amount of land he owns along the stream, and his use must be reasonable with respect to other downstream users of the water.[179] A riparian owner may not sever the use of his water from his property, nor can he transfer water out of the basin from which it was diverted.[180] Further, in times of shortage, riparian owners must cut back their water use proportional to their respective rights.[181] Therefore, there is no priority in riparian law.[182] An older right is on equal footing with rights acquired more recently.[183]

B. PRIOR APPROPRIATION: HISTORY

Riparian law proved problematic, however, for settlers seeking to establish themselves in the arid West.[184] The West had far less water, and what little water existed was unpredictable and difficult to harness.[185] Water supplies tend to swing wildly from rampant floods to prolonged droughts.[186] Up to seventy-five percent the West's water supplies comes from snowmelt;[187] therefore, water storage is required to capture spring floods and distribute water throughout the rest of the year.[188] Development of the West required diversion, storage, and irrigation techniques rarely required in the East.[189]

Conflicts over water developed early on. For example, in 1874, the Cities of Fort Collins and Greeley (Union Colony) had a major water conflict over the Poudre River.[190] Even though Greeley had the older appropriation date,

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178. Parker v. Griswold, 17 Conn. 288, 299-300 (1846).
179. *Id.*
180. Williams v. Wadsworth, 51 Conn. 277, 304 (1883).
181. Westland Water Dist. v. U.S. Dep't of Interior, 153 F. Supp. 2d 1133, 1173 (2001).
182. *Water Rights Definitions*, U.S. FISH & WILDLIFE SERV., http://www.fws.gov/mountain-prairie/wtr/water_rights_def.htm#PRIORITY (last visited Nov. 30, 2012).
183. *Id.*
184. DONALD WORSTER, RIVERS OF EMPIRE: WATER, ARIDITY, AND THE GROWTH OF THE AMERICAN WEST, 88-89 (1985).
185. *The Arid West—Where Water Is Scarce - Water In The West—liquid Gold*, http://www.libraryindex.com/pages/2635/Arid-West-Where-Water-Scarce-WATER-IN-WEST-LIQUID-GOLD.html (last visited Oct. 28, 2012).
186. J. W. POWELL, LANDS OF THE ARID REGION OF THE UNITED STATES 92 (2d ed. 1879), *available at* http://0-www.heinonline.org.bianca.penlib.du.edu/HOL/Contents?handle=hein.beal/rlndus0001&id=1&size=2&index=&collection=beal.
187. *The Water Cycle: Snowmelt Runoff*, U.S. GEOLOGICAL SURVEY, http://ga.water.usgs.gov/edu/watercyclesnowmelt.html (last visited Nov. 10, 2012).
188. *See, e.g.*, Brian Werner, *Irrigation Development in Northern Colorado: A Brief History of How Water Influenced the Development of the Fort Collins Region*, COLO. WATER INST., http://www.cwi.colostate.edu/ThePoudreRunsThroughIt/files/Irrigation_Development_in_Northern_Colorado.pdf.
189. *Id.*; *see* WORSTER, *supra* note 184, at 89.
190. ROSE LAFLIN & BRIAN WERNER, *Cache la Pourdre River*, *in* CITIZEN'S GUIDE TO COLORADO'S ENVIRONMENTAL ERA 20, 20 (2005), *available at* http://cospl.coalliance.org/fedora/repository/co:3453.

Fort Collins placed its headgates further upstream and was thereby able to reduce flows in the Poudre River and deprive Greeley of its water.[191]

Colorado broke from the mold in 1876 when it became the first state to officially adopt the prior appropriation doctrine in Article XVI of its Constitution.[192] Unlike California, which was trying to strike a precarious balance between prior appropriation and riparian law, Colorado fully embraced the prior appropriation doctrine.[193] This became even more apparent in 1882, after the Colorado Supreme Court decided *Coffin v. Left Hand Ditch Co.*[194] In *Coffin*, the Court enthusiastically applied prior appropriation law and categorically rejected riparian law.[195] After that case, prior appropriation became known as the "Colorado Doctrine" and many western states followed Colorado's example by incorporating prior appropriation into their constitutions and legal systems.[196]

Today, the western states, including Colorado, New Mexico, and Wyoming, apply prior appropriation law.[197] Under the prior appropriation doctrine, a landowner's water right is severable from the land.[198] A water right owner with an older priority date is considered the "senior" water user.[199] A water right owner with a newer priority date is considered a "junior" user.[200] A senior user, regardless of placement on the stream, is entitled to fulfill their water right even at the expense of a junior user.[201] In dry years, senior users are entitled to the full amount of their water right while junior users may experience a shortage.[202] This is in contrast to riparian law, which requires all riparian owners to share the burden of shortage.[203]

191. *See id.*
192. COLO CONST. art. XVI, § 5; *Irrigation Water Conservation: Opportunities and Limitations in Colorado*, COLORADO WATER RESOURCES RESEARCH INSTITUTE, http://www.cwi.colostate.edu/old/pubs/newsletter/specinterest/irrigcons.htm (last visited Oct. 20, 2012).
193. Irwin v. Phillips, 5 Cal. 140, 145-47 (1885); VRANESH'S COLORADO WATER LAW 7 (James N. Corbridge, Jr. et al. eds., Rev. ed. 2000).
194. Coffin v. Left Hand Ditch Co., 6 Colo. 443 (1882).
195. *Id.* at 446-47.
196. Vranesh, *supra* note 193, at 8-9.
197. *Id.* at 9; John Bredehoeft, *Physical Limitations of Water Resources*, *in* WATER SCARCITY IMPACTS ON WESTERN AGRICULTURE 55-56 (Ernest A. Engelbert & Ann Foley Scheuring eds., 1984), *available at* http://publishing.cdlib.org/ucpressebooks/view?docId=ft0f59n72f&chunk.id=d0e404&toc.id=d0e111&brand=ucpress.
198. *See Irwin*, 5 Cal. at 147.
199. *See Coffin*, 6 Colo. at 447; Stephen Bretsen, *Rainwater Harvesting Under Colorado's Prior Appropriation Doctrine: Property Rights and Takings*, 22 FORDHAM ENVTL. L. REV. 159, 169 (2011).
200. *Coffin*, 6 Colo. at 447.
201. *Id.*
202. *Id.*
203. Westland Water Dist. v. U.S., 153 F.Supp.2d 1133, 1173 (E.D. Cal. 2001).

C. DUE DILIGENCE AND WATER RIGHTS

In the West, a water right is a property right freely grantable and severable from the land.[204] Water rights are conveyed by deed and should be specifically enumerated.[205] Due diligence is critical on water sources used for hydraulic fracturing. Some, but far from all, the questions to consider include:

- Is title to the water vested in the person selling or leasing?
- Is the water decreed or permitted for industrial purposes?
- Is the basin from which the water originates over-appropriated? If so, is the water in priority? If not, does it have an approved source of replacement water?
- How will the water be delivered to its point of use?
- Can it legally be used where the drilling is to occur?

There is a minor language barrier between water professionals and oil and gas professionals. In the oil and gas world, resources are measured in barrels. One barrel holds forty-two gallons.[206] Water rights are quantified in cubic feet per second ("cfs") or acre-feet ("af").[207] Direct flow rights, measured in cfs, quantify water flowing in a stream.[208] One cfs equals 7.48 gallons of water per second.[209] A flow of one cfs for a full day will produce 1.98 af.[210] An af is the amount of water required to cover one acre of land, one foot deep.[211] This equates to 325,851 gallons, or roughly the amount needed to supply the domestic needs of five people for one year.[212]

D. THE ROLE OF THE STATE ENGINEER IN ADMINISTERING WATER RIGHTS

Colorado's 1969 Water Rights Determination and Administration Act ("1969 Act") provides that surface water rights and tributary groundwater rights[213] are administered in priority by the State Engineer's Office ("SEO"), also known as the Division of Water Resources, within the Colorado Department of Natural Resources.[214] There are seven Division Engineer's Offices, one in each of Colorado's seven major river basins.[215] Each Division Engineer's

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204. Christopher Brooks, *Separating Groundwater Rights from Land in Arizona*, SOUTHWEST HYDROLOGY 8 (July/August 2009), *available at* http://www.swhydro.arizona.edu/archive/V8_N4/dept-ontheground.pdf.
205. *See* Bessemer Irrigation Ditch Co. v. Woolley, 76 P. 1053, 1054 (Colo. 1904).
206. *Crude Oil*, ORG. OF THE PETROLEUM EXPORTING COUNTRIES, http://www.opec.org/opec_web/en/press_room/180.htm (last visited Nov. 30, 2012).
207. A. DAN TARKLOCK, JAMES N. CORBRIDGE, JR. & DAVID H. GETCHES, WATER RESOURCE MANAGEMENT: A CASEBOOK IN LAW AND PUBLIC POLICY 6 (5th ed. 2002).
208. *Id.*
209. *Id.*
210. *Id.*
211. *Id.*
212. *Id.*
213. Safranek v. Limon, 228 P.2d 975, 977 (Colo. 1951) (en banc) (under Colorado law, all groundwater is presumed tributary until proven otherwise).
214. COLO. REV. STAT. § 37-92-301(1), (3) (2012).
215. *Id.* § 37-92-201.

Office employs a number of water commissioners who handle the day-to-day administration of water rights.[216]

Tasked with the duty to "administer, distribute, and regulate the waters of the state," the SEO primarily maintains a list of water rights on each stream in order of priority and administers those rights in priority.[217] The SEO also has the authority to issue permits for groundwater use.[218] Similar to other agencies, the SEO also has the authority to promulgate rules and regulations to aid in the administration of water rights as well as to impose fines and damages for violations.[219]

One of the most common ways the SEO administers existing water rights is through a "call." A call occurs when a holder of a senior water right is not receiving his or her full water right.[220] When this happens, the senior user generally places a call to the local water commissioner.[221] The water commissioner then must determine if there is actual injury to the senior user and, if necessary, curtail the diversions of the junior user.[222] Calls are a matter of public record and the water commissioners must maintain a complex list of calls that they update daily.[223] Other duties of the SEO include, but are not limited to, regulating headgates, distributing transmountain water, administering and monitoring dam safety, conducting inspections, and enforcing compliance with statutes.[224]

Of the prior appropriation states, only Colorado created a separate system of water courts.[225] Under the 1969 Act, Colorado is divided into seven water divisions.[226] Each division has both a division engineer and a water court.[227] One district court in each division sits as the water court and these courts have jurisdiction over all water matters.[228]

Today, seventeen western states have permit systems including, among others, Utah, New Mexico, Wyoming, and Montana.[229] These systems are very

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216. *Id.* § 37-92-202(3); COLO. DIV. OF WATER RES., *supra* note 171, at 1.
217. COLO. REV. STAT. §§ 37-92-401(1)(a), 37-92-501.
218. *Id.* § 37-92-301; COLO. DIV. OF WATER RES., *supra* note 171, at 1-2.
219. COLO. REV. STAT. §§ 37-92-501 to -503.
220. COLO. DIV. OF WATER RES., WATER DICTIONARY, water.state.co.us/Home/Help/Pages/WaterTerminology.aspx (last visited Nov. 30, 2012).
221. J. GREGORY J. HOBBS, JR., COLO. FOUND. FOR WATER EDUC., CITIZEN'S GUIDE TO COLORADO WATER LAW 18 (Karla A. Brown ed., 2d ed. 2004).
222. *Id.*; COLO. REV. STAT. § 37-92-502(2)(a).
223. *See, e.g.*, COLO. DIV. OF WATER RES., CALL CHRONOLOGY, http://cdss.state.co.us/onlineTools/Pages/CallChronology.aspx (last visited Nov. 30, 2012).
224. DICK WOLFE, COLO. DIV. OF WATER RES., SURFACE WATER AND GROUND WATER ADMINISTRATION IN COLORADO 5-6 (2005), *available at* http://water.state.co.us/DWRIPub/DWR%20Presentations/dwolfe_060305_a.pdf.
225. Roger Adams, *Water Issues Bound to See More Courtroom Time*, ASPEN PUBLIC RADIO (May 16, 2012), http://www.aspenpublicradio.org/local-news/story/2012/05/16/water-issues-bound-to-see-more-courtroom-time.
226. J. Gregory J. Hobbs, Jr., *Colorado Water Law: An Historical Overview*, 1 U. DENV. WATER L. REV. 1, 10 (1997).
227. COLO. REV. STAT. §§ 37-92-202 to -203 (2012).
228. *See id.* § 37-92-203.
229. VRANESH, *supra* note 193, at 18.

similar to Colorado's water court system.[230] Both systems require that an applicant file an application for a water right and both systems undertake fact-finding and adjudication.[231] However, under a permit system, a state agency, usually the SEO, conducts the fact-finding and adjudication.[232]

E. OVER-APPROPRIATED STREAMS

As populations in the West grew, more and more streams became over-appropriated.[233] In other words, there are more water rights to the stream than wet water during times of high demand, such as the irrigation season.[234] As a result, by the 1890s, it became almost impossible for new users to obtain meaningful water rights on the streams and rivers along the Denver Front Range including the South Platte and Arkansas Rivers.[235]

Because Colorado water law is based on the concept of "no injury," in which a junior user can appropriate water out of priority as long as they do not injure a senior user, the Colorado General Assembly codified the ability of junior users to develop augmentation plans.[236] Augmentation plans are court-approved plans that protect senior water right owners while allowing junior users to divert out of priority so long as they replace their depletions to keep senior diverters whole.[237] The augmentation plan must meet the needs of the senior user at the time, place, quantity, and approximate quality they would have enjoyed before the out-of-priority diversion.[238] Augmentation water, also known as replacement water, is water that is added, left, or replaced in a stream system to offset out-of-priority diversions.[239]

Temporary approvals of replacement water can also be received administratively from the SEO through substitute water supply plans ("SWSPs").[240] Augmentation plans, or SWSPs, must be supported by an engineering analysis, usually prepared by a water resources engineer,[241] and all out-of-priority depletions, regardless of whether the they occur prior to or subsequent to an application, must be fully replaced.[242]

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230. *Id.*

231. COLO. REV. STAT. § 37-92-302; CROOK CNTY. NATURAL RES. DIST., WYOMING WATER RIGHTS FACT SHEET 1-2 (2001), *available at* http://www.ccnrd.org/Documents/Wyoming.pdf.

232. CROOK CNTY. NATURAL RES. DIST., *supra* note 231, at 1.

233. COLO. DIV. OF WATER RES., PRIOR APPROPRIATION LAW, http://water.state.co.us/surfacewater/swrights/pages/priorapprop.aspx (last visited Nov. 30 2012).

234. Bretsen, *supra* note 199, at 169.

235. GREGORY M. SILKENSEN, WINDY GAP: TRANSMOUNTAIN WATER DIVERSION AND THE ENVIRONMENTAL MOVEMENT 6-7 (1994), http://www.cwi.colostate.edu/old/pubs/series/technicalreport/TR%2061.pdf.

236. Lawrence J. MacDonnell, *Out-of-Priority Water Use: Adding Flexibility to the Water Appropriation System*, 83 NEB. L. REV. 485, 507-08 (2004-2005).

237. *Id.*

238. Simpson v. Bijou Irrigation Co., 69 P.3d 50, 60-61 (Colo. 2003).

239. *Id.* at 55.

240. COLO. REV. STAT. § 37-92-308(1)(e) (2012).

241. COLO. REV. STAT. §§ 37-92-302(1)(a), (b), - 308(e).

242. Well Augmentation Subdistrict of the Cent. Colo. Water Conservancy Dist. v. Aurora, 221 P.3d 399, 411 (Colo. 2009).

F. GROUNDWATER

In Colorado, there are two different types of groundwater: tributary and deep groundwater. Tributary groundwater is hydrologically connected to the stream.[243] In Colorado there is a rebuttable "presumption that all ground water . . . is tributary."[244] Tributary groundwater is administered through the priority system.[245]

Deep groundwater is not easy to replenish and is divided into three different types. The first type is designated groundwater. As defined in the Groundwater Management Act ("GWMA"), designated groundwater is "ground water which, in its natural course would not be available to and required for the fulfillment of decreed surface rights, or groundwater in areas not adjacent to a continuously flowing natural stream wherein ground water withdrawals have constituted the principal water usage for at least fifteen years preceding the date of the first hearing on the proposed designation of the basin. . . ."[246] Designated groundwater is administered by the Colorado Groundwater Commission.[247] Currently, the Colorado Groundwater Commission administers eight different designated basins in Colorado.[248]

243. J. Gregory J. Hobbs, Jr., *Protecting Prior Appropriation Water Rights Through Integrating Tributary Groundwater: Colorado's Experience*, 47 IDAHO L. REV. 5, 13 (2010).
244. Safranek v. Limon, 228 P.2d 975, 977 (Colo. 1951).
245. *Id.*
246. COLO. REV. STAT. § 37-90-103(6)(a) (2012).
247. *Id.* § 37-90-103(8).
248. COLO. DIV. OF WATER RES., COLORADO GROUND WATER COMMISSION HOME, http://water.state.co.us/groundwater/CGWC/Pages/default.aspx (last visited Nov. 30, 2012).

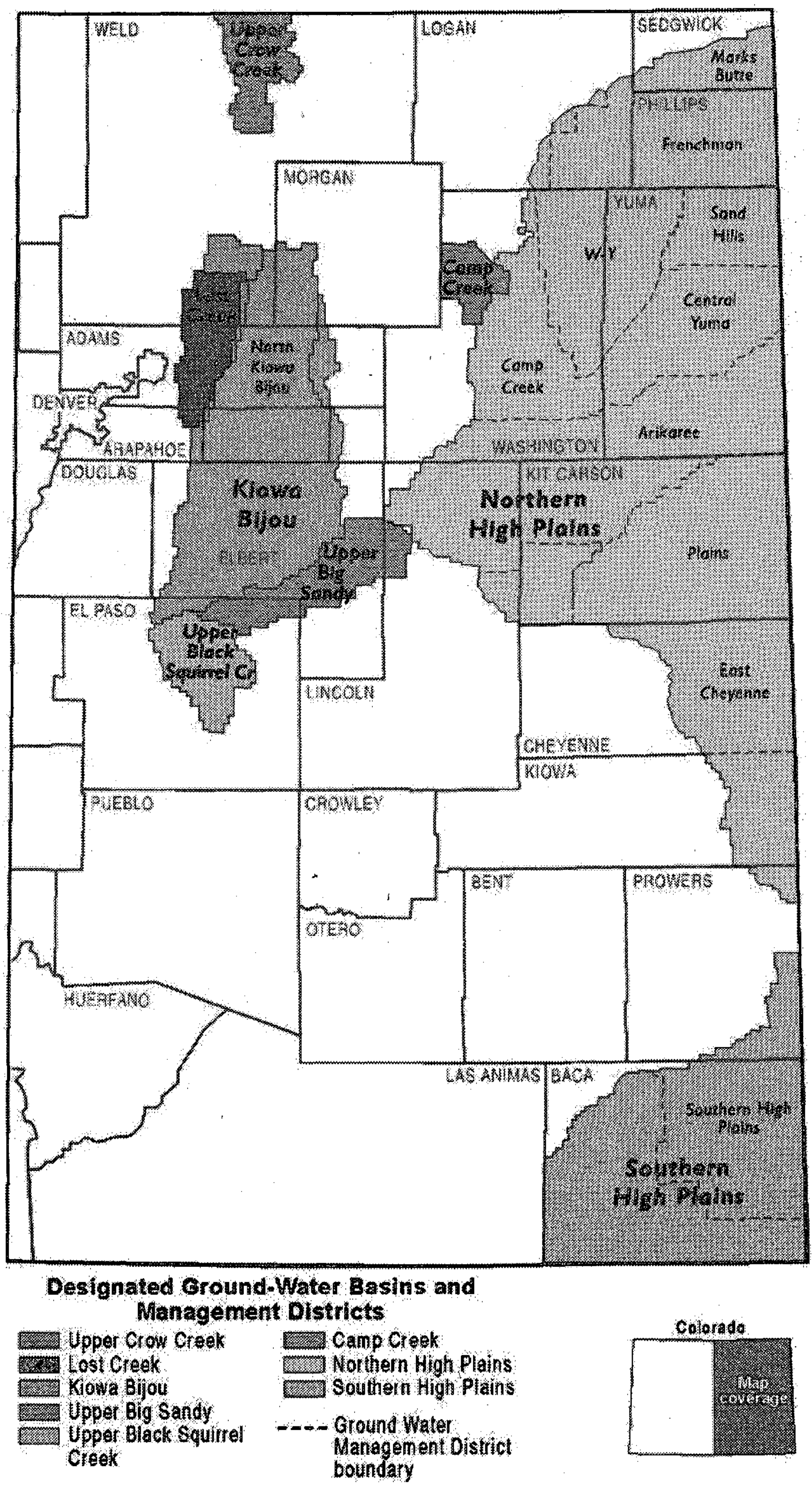

Figure 3: Designated Groundwater Basins and Management Districts
Source: http://geosurvey.state.co.us/apps/wateratlas/chapter3page3.asp

The second type of deep groundwater is called nontributary groundwater. Pursuant to the GWMA, nontributary groundwater is groundwater "located outside the boundaries of any designated groundwater basin in existence on January 1, 1985, the withdrawal of which will not, within one hundred years of continuous withdrawal, deplete the flow of a natural stream . . . at an annual rate greater than one-tenth of one percent of the annual rate of withdrawal."[249] With some exceptions discussed below, the GWMA further specifies that nontributary groundwater is available to the overlying landowner in the amount of one percent per year of the 100-year life of the underlying aquifer.[250]

The third and final type of deep groundwater in Colorado is not-nontributary groundwater. Not-nontributary groundwater only exists in Colorado's Denver Basin, which consists of the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers.[251] Not-nontributary groundwater is defined as groundwaters within the Denver Basin

> [T]hat are outside the boundaries of any designated ground water basin in existence on January 1, 1985, the withdrawal of which will, within one hundred years, deplete the flow of a natural stream, including a natural stream at an annual rate of greater than one-tenth of one percent of the annual rate of withdrawal.[252]

According to the GWMA, all groundwater wells require a permit.[253] In order to drill a groundwater well, one must first file an application with the state engineer.[254] Generally, nontributary wells simply need this initial permit.[255] Furthermore, because tributary groundwater is hydrologically connected to surface water, tributary groundwater users must replace their out-of-priority depletions with an augmentation plan or SWSP.[256]

V. INTEGRATING OIL AND GAS WITH WATER LAWS

A. PRODUCED WATER

Historically, oil and gas wells were regulated at the state level exclusively by the Colorado Oil and Gas Conservation Commission ("COGCC").[257] In 2009, the Colorado Supreme Court held that water produced during the CMB extraction process constituted a "beneficial use" of the water, subject to administration by the Colorado SEO.[258] Following the *Vance* decision, the SEO faced the staggering reality that thousands of oil and gas wells in the state

249. COLO. REV. STAT. § 37-90-103(10.5).
250. *Id.*
251. *Id.* § 37-90-103(10.7).
252. *Id.*
253. *Id.* § 37-90-137(1).
254. *Id.*
255. COLO. REV. STAT. § 37-90-137(4)(a).
256. COLO. REV. STAT. § 37-90-137(9)(C).
257. *State Regulations: Colorado,* DRILLING WASTE MGMT. INFO. SYS., http://web.ead.anl.gov/dwm/regs/state/colorado/index.cfm (last visited Nov. 30, 2012).
258. Vance v. Wolfe, 205 P.3d 1165, 1168-69 (Colo. 2009).

could require individual permitting determinations.[259] There was also significant concern on the part of the industry that the SEO could curtail the production of oil and gas in order to protect vested water rights.[260]

To address these issues, the Colorado General Assembly authorized the SEO to undertake an orderly process integrating CBM wells and, where necessary, conventional oil and gas wells into the priority system.[261] These bills amended the GWMA, and specifically section 37-90-137(7), to help provide certainty to water users, oil and gas, and the SEO without jeopardizing vested water rights.[262] Under that authority, the SEO then promulgated "Rules and Regulations for the Determination of the Nontributary Nature of Ground Water Produced Through Wells in Conjunction with the Mining of Minerals" ("Rules").[263]

Over a three-year period, the Colorado General Assembly passed three amendments to section 37-90-137(7) of the GWMA. Colorado House Bill 09-1303 ("HB 09-1303") created specific timelines for compliance and granted the SEO authority to promulgate rules to administer the withdrawal of nontributary groundwater for oil and gas development.[264] Furthermore, HB 09-1303 clarified that (i) nontributary water was not subject to the priority system; (ii) interested parties would have the right to conduct cross-examinations during the rule making; and (iii) judicial review of the rules would be in water court under an Administrative Procedure Act standard of review.[265]

Senate Bill 10-165 extended certain deadlines and provided further permitting guidelines for the SEO.[266] For example, nontributary groundwater produced in oil and gas development does not require a permit, with the exception of CBM development, if the water is not beneficially used.[267] Generally, under these circumstances, water is not deemed beneficially used if it is extracted for the purpose of facilitating oil and gas production and it is disposed of in the same geologic basin from which it was removed.[268] The legislation also exempted nontributary wells from the landowner consent and the six hundred foot spacing requirement.[269]

These bills created a framework for the SEO to administer groundwater produced during oil and gas development that recognizes the differences between CBM extraction and other forms of oil and gas development and allows

259. Kristin H. Mosely, Produced Water Associated with Shale Gas Development 4 (Feb. 24, 2012) (on file with the University of Denver WATER LAW REVIEW).
260. *See* Kenneth A. Wonstolen & Karen L. Spaulding, *Water Issues Flow in Mountain West*, THE AM. OIL & GAS REP., Mar. 2011, *available at* http://www.bwenergylaw.com/News/documents/WaterIssuesFlowin MountainWest.pdf.
261. S.B. 10-165, 67th Leg., 2nd Reg. Sess. (Colo. 2010); H.B. 09-1303, 67th Leg., 1st Reg. Sess. (Colo. 2009).
262. H.B. 09-1303, 67th Leg., 1st Reg. Sess. (Colo. 2009).
263. 2 COLO. CODE REGS. § 402-17 (2012).
264. COLO. REV. STAT. § 37-90-137.
265. *Id.*
266. S.B. 10-165, 67th Leg., 2nd Reg. Sess. (Colo. 2010); H.B. 09-1303, *supra* note 262.
267. COLO. REV. STAT. § 37-90-137(7).
268. *See id.*
269. *See id.*

for the integration of oil and gas into the priority system (refer to Table 4 for a chart that explains this framework).[270]

Type of Well	Well Permit Required?	Required to Replace Depletions via SEO Substitute Water Supply Plan?	Required to Replace Depletions via Water Court Augmentation Plan?
Conventional **Nontributary**	NO (unless water put to beneficial use)	NO	NO
Conventional Tributary	YES	YES	YES
CBM **Nontributary**	YES	NO	NO
CBM **Tributary**	YES	YES	YES

Table 4: Permit Requirements

Much of the groundwater associated with oil and gas development is generally very deep and trapped in isolated geologic formations.[271] The Rules include basin-specific rules that define boundaries delineating large areas of land where wells are deemed to be nontributary to any surface stream.[272] The Rules also provided a process for subsequent identification of other such areas.[273]

For those oil and gas wells that the SEO deemed to be tributary, operators in over-appropriated basins must replace their depletions to prevent material injury to vested water rights.[274] Because nontributary groundwater is not administered within Colorado's water rights priority system, a party need not replace depletions for nontributary wells to prevent injury to vested water rights.[275] The rulemaking was an extensive effort that took nearly a year of the SEO's staff's time and a three million-dollar industry investment.[276]

In 2010, many of the same plaintiffs from the *Vance* case challenged the SEO's authority to promulgate the Rules in lawsuits filed throughout the ma-

270. *See id.*
271. COLO. OIL & GAS ASS'N, HYDRAULIC FRACTURING WHITE PAPER 2 (Nov. 26, 2012) http://www.coga.org/pdfs_facts/hfwhitepaper.pdf
272. COLO. REV. STAT. § 37-90-103.
273. *Id.*
274. COLO. REV. STAT. § 37-90-137.
275. *Id.*
276. Ken Wonstolen, *Energy News Alert: Produced Water Rulemaking Concludes; General Assembly Acts; Litigation Commences*, BEATTY & WOZNIAK, PC. (2010), http://www.bwenergylaw.com/News/documents/ProducedWaterRulemakingConcludes-GeneralAssemblyActs-LitigationCommences.pdf.

jority of Colorado's water divisions.[277] Those cases were consolidated case in Division 1 Water Court in Greeley, Colorado.[278] In 2011, the Colorado General Assembly passed legislation to clarify and confirm the SEO's authority for the rulemaking and subsequent adjudications; that appeals and facial challenges to the Rules and nontributary determinations thereunder be held to an APA standard; and the creation of a rebuttable presumption in favor of the SEO's determinations where allege injury in water court as a result of oil and gas development.[279]

Challenges to the SEO Rules. The SEO adopted the Final Rules in December 2009 and the Basin-Specific Rules were incorporated in early 2010.[280] On March 1, 2010, a group of water users and water right holders, including the plaintiffs in *Vance,* filed complaints in Water Divisions 1, 2, 4, 6, and 7, which were consolidated into one proceeding in Division One Water Court in Greeley, captioned *Pawnee Well Users v. Wolfe.*[281] In their complaint, the plaintiffs challenged the Final Rules and the Basin-Specific Rules, claiming that the SEO exceeded its statutory authority and that there was insufficient public notice of the rulemaking and related procedures.[282] The water court ruled in favor of the SEO and industry intervenor defendants on nearly every claim.[283] Among other things, the court ruled that the SEO had the authority to make nontributary determinations in section 37-90-137(7) of the Colorado Revised Statutes through rulemakings or adjudicatory proceedings.[284]

However, the water court did set aside the SEO's rule for the Fruitland Formation within and outside of the Southern Ute Reservation on grounds that the SEO lacks jurisdiction on tribal lands.[285] Both the SEO and the Southern Ute Tribe filed motions for reconsideration on this issue, and the Colorado Supreme Court heard the issue on November 7, 2012.[286]

Currently, the SEO has issued CBM permits for over 5,000 wells in Colorado.[287] Thousands of wells can now operate without the need for permits or administration where they are within nontributary geologic basins.[288] Where the wells are tributary, producers need to file SWSPs with the SEO and/or augmentation plans in water court.[289] The Rules strike a reasonable balance. They

277. Pawnee Well Users v. Wolfe, No. 2010CW89 at *3 (Colo. Water Div. I 2011).
278. *Id.*
279. H.B. 11-1286, 68th Gen. Assemb., 1st Reg. Sess. (Colo. 2011).
280. Pawnee Well Users, No. 2010CW89 at *3.
281. *Id.*
282. *Id.* at *4.
283. *Id.* at *25.
284. *Id.* at *12.
285. *Id.* at *22.
286. Ken Wonstolen, *Energy News Alert: Produced Water Decision Issued,* BEATTY & WOZNIAK, PC. (2011); *Pawnee Well Users v. Wolfe,* No. 2010CW89 (Colo. Water Div. I 2011), *appeal docketed,* No. 2012SA13 (Colo. Nov. 7, 2012).
287. Kevin Rein, Colo. Div. of Water Res., Presentation: Water Rights and Administration of Produced Water in Colorado 51 (Oct. 1, 2010), *available at* http://water.state.co.us/DWRIPub/DWR%20Presentations/SEOForum10_ProducedWater_Rein.pdf.
288. *Id.*
289. *Id.*

recognize the importance of oil and gas to Colorado while protecting vested water rights.

B. LOCAL REGULATION OF WATER SOURCES

Local regulation may also impact water used for oil and gas operations. For example, on June 1, 2012, the Northern Colorado Water Conservancy District ("Northern") adopted Rules Governing the Use of Colorado-Big Thompson Project Water and Windy Gap Project Water for the Development of Oil, and Gas Wells ("Northern Rules").[290] The Northern Rules require that all Colorado-Big Thompson Project water and the first use of all Windy Gap water used for oil and gas must be within the boundaries of the Northern District and its municipal sub-district.[291] This significantly restricts water used for oil and gas in the northern Front Range.

Congress approved the Colorado-Big Thompson Project ("C-BT") in 1937[292] to bring water from the western slop, across the continental divide, and to the eastern slope of Colorado via a thirteen-mile tunnel under Rock Mountain National Park.[293] Northern and its municipal sub-district administer the projects[294] that irrigate some 640,000 acres and serve roughly 850,000 people.[295] Northern enacted these rules because its key governing documents require that C-BT Project water, and the first use of Windy Gap Project water, be within the boundaries of Northern or its municipal subdistrict.[296] Northern cited the terms of its 1938 Contract with the United States, the Conservancy Act, and its allotment contracts as authority.[297]

The Northern Rules impact many municipalities that earn significant revenues selling water for oil and gas purposes. Service providers and companies were particularly affected in Weld County. Local regulation of facets of oil and gas development has become a significant issue in Colorado. For example, residents of the City of Longmont voted to ban fraccing in the November 2012 election.[298] While such actions are likely preempted by state law, additional local regulations related to water and oil and gas may be forthcoming.

290. N. COLO. WATER CONSERVANCY DIST., RULES GOVERNING THE USE OF COLORADO-BIG THOMPSON PROJECT WATER AND WINDY GAP PROJECT WATER FOR THE DEVELOPMENT OF OIL AND GAS WELLS 1 (2012).

291. *Id.*

292. ROBERT AUTOBEE, COLORADO-BIG THOMPSON PROJECT 10 (1996) *available at* http://www.morganangel.com/uploads/Big%20Thompson.pdf.

293. NORTHERN WATER, COLORADO-BIG THOMPSON PROJECT http://www.northernwater.org/WaterProjects/C-BTProject.aspx (last visited Oct. 27, 2012).

294. NORTHERN WATER, 75TH ANNIVERSARY http://www.northernwater.org/AboutUs/75thAnniversary.aspx (last visited Oct. 27, 2012).

295. *Id.*

296. N. COLO. WATER CONSERVANCY DIST., *supra* note 290, at 1.

297. *Id.*

298. Scott Rochat, *Ballot Question 300: Longmont Fracking Ban Storms to Victory*, DENVER POST, Nov. 6, 2012, http://www.denverpost.com/recommended/ci_21943036.

VI. CONCLUSION

Oil and gas has a tremendous economic impact on Colorado and the West. While the industry's demands on water are comparatively small, the need for dependable water supplies in hydraulic fracturing is great. Accordingly, water rights and water quality are increasingly important for source water as well as produced water. We hope this article provides a general understanding of applicable state and federal laws that may help operators make key compliance decisions.