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Topical Report

CONJUNCTIVE SURFACE AND GROUNDWATER MANAGEMENT IN UTAH: IMPLICATIONS FOR OIL SHALE AND OIL SANDS DEVELOPMENT

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TOPICAL REPORT:

CONJUNCTIVE SURFACE AND GROUNDWATER MANAGEMENT IN UTAH: IMPLICATIONS FOR OIL SHALE AND OIL SANDS DEVELOPMENT

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Abstract

Unconventional fuel development will require scarce water resources. In an environment characterized by scarcity, and where most water resources are fully allocated, prospective development will require minimizing water use and seeking to use water resources in the most efficient manner. Conjunctive use of surface and groundwater provides just such an opportunity.

Conjunctive use includes two main practices: First, integrating surface water diversions and groundwater withdrawals to maximize efficiency and minimize impacts on other resource users and ecological processes. Second, conjunctive use includes capturing surplus or unused surface water and injecting or infiltrating that water into groundwater aquifers in order to increase recharge rates.

Conjunctive management holds promise as a means of addressing some of the West's most intractable problems. Conjunctive management can firm up water supplies by more effectively capturing spring runoff and surplus water, and by integrating its use with groundwater withdrawals; surface and groundwater use can be further integrated with managed aquifer recharge projects. Such integration can maximize water storage and availability, while simultaneously minimizing evaporative loss, reservoir sedimentation, and surface use impacts. Any of these impacts, if left unresolved, could derail commercial-scale unconventional fuel development. Unconventional fuel developers could therefore benefit from incorporating conjunctive use into their development plans.

Despite its advantages, conjunctive use is not a panacea. Conjunctive use means using resources in harmony to maximize and stabilize long-term supplies — it does not mean maximizing the use of two separate but interrelated resources for unsustainable short-term gains — and it cannot resolve all problems or provide water where no unappropriated water exists. Moreover, conjunctive use may pose risks to ecological values forgone when water that would otherwise remain in a stream is diverted for aquifer recharge or other uses.

To better understand the rapidly evolving field of conjunctive use, this Topical Report begins with a discussion of Utah water law, with an emphasis on conjunctive use issues. We contrast Utah’s approach with efforts undertaken in neighboring states and by the federal government. We then relate conjunctive use to the unconventional fuel industry and discuss how conjunctive use can help address pressing challenges.

While conjunctive management cannot create water where none exists, it does hold promise to manage existing resources in a more efficient manner. Moreover, conjunctive management reflects an important trend in western water law that could provide benefit to those contemplating activities that require large-scale water development.

Executive Summary

The intermountain west is home to massive oil shale and oil sands resources. These resources, if they can be developed without compromising the region's other important values, have the potential to dramatically reduce dependence on foreign liquid transportation fuel sources and to reinvigorate stagnant economies. Unconventional fuel development is, however, replete with challenges, not the least of which is the demand for water.

Water is in short supply throughout much of the intermountain west and significant water-dependent development stands to displace other valuable water uses. Water must be used judiciously to minimize the risk of potential disruptions. Conjunctive use of surface and groundwater resources involves integrating management to optimize efficiencies without compromising ecological integrity — and conjunctive use holds promise as a means of enhancing water availability within this arid region.

Conjunctive use addresses both the physical interactions between surface water and groundwater resources and the multiple uses both are put to, as well as the legal structures that have developed to address these uses. Our understanding of hydrologic processes and western water law both continue to evolve, even if their evolution is not fully integrated. Advances in our understanding of physical processes have paved the way for important developments in water law, but while the water law of most western states has evolved to reflect scientific realities, some states have done so more effectively than others.

If balance can be struck, conjunctive management holds promise as a means of addressing some of the west's most intractable problems. Conjunctive management can firm up water supplies by more effectively capturing spring runoff and surplus water, and by integrating their use with groundwater withdrawals; surface and groundwater use can also be integrated with managed aquifer recharge projects. Such integration can maximize water storage and availability, while simultaneously minimizing evaporative loss, reservoir sedimentation, and surface use impacts. All of these impacts, if left unresolved, could derail commercial scale unconventional fuel development. Unconventional fuel developers would therefore do well to incorporate conjunctive use into their development plans.

Despite its advantages, conjunctive use is not a panacea. Conjunctive use means using resources in harmony to maximize and stabilize long-term supplies — it does not mean maximizing the use of two separate but interrelated resources for unsustainable short-term gains — and it cannot provide water where unappropriated water does not exists. Moreover, the search for more efficient water development cannot allow us to lose sight of the ecological values forgone when water that would otherwise remain in a stream is diverted for aquifer recharge or other uses.

Western water law recognizes the dueling imperatives of maximizing development and fostering resource stewardship. Water law in most western states also recognizes at least some level of connection between surface and groundwater resources. States like Utah and Colorado have been leaders in recognizing these interactions while statutory water law in states like California and Texas has lagged. But from a policy perspective, recognition of interconnections alone is insufficient. Recognition must be coupled with management. Utah, for example, presumes interconnection between surface and groundwater resources, requires consideration of impacts to existing water users when new water rights are granted, and at least theoretically applies the prior appropriation doctrine across both resources.

But integrated management and the prior appropriation doctrine's promise that the first in time shall be the first in right to the use of water do not always reflect practical realities. Impacts to surface water resources may be the result of multiple separate groundwater withdrawals, the interaction between these wells and surface resources may be poorly understood, withdrawals may precede impacts by long periods of time, and cessation of withdrawals may not provide immediate redress. Thus, Utah, like many western states, focuses on conflict avoidance and impact minimization rather than strict priority enforcement. The promise of priority enforcement, however, remains an important hammer in the bundle of tools available to water managers and the threat of enforcement can be an effective means of spurring action.

This Topical Report addresses conjunctive surface and groundwater management in the context of unconventional energy development. While our discussion focuses on unconventional fuels, the issues discussed in this Report have broader application.

Section 1 provides background and context, with a brief review of the unconventional fuel resource located within Utah, as well as the interaction between surface and groundwater resources.

Section 2 provides an overview of Utah water law, with an emphasis on the issues most relevant to unconventional fuel development. After discussing the legal framework for water management we turn to groundwater management efforts within Utah. Because Utah does not distinguish between surface and groundwater resources for purposes of acquiring water rights, determining impairment, or enforcing priority, Utah's efforts necessarily consider integration of surface and groundwater resources. Section 2 concludes with examples of how conjunctive surface and groundwater resources are currently managed.

Section 3 recognizes that water resource management is largely a matter of state law and that states throughout the intermountain west have adopted different approaches to integration. We review conjunctive management law in neighboring states and conjunctive management under federal law, highlighting the most profound differences because other states' efforts may serve as models for addressing challenges that could arise in Utah.

Section 4 discusses conjunctive surface and groundwater management's implications for oil shale and oil sands producers, with emphasis on resources within Utah's Uinta Basin. Areas of interest include supply maximization, storage, evaporative loss, sediment management, and endangered species.

We close with concluding remarks and brief recommendations.

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List of Acronyms

ABCWUA	Albuquerque Bernillo County Water Utility Association
AC	Acres
AF	Acre-Foot
AF/Y	Acre-Foot per Year
BBL	Barrel
BLM	Bureau or Land Management
BPD	Barrel per Day
CFS	Cubic Foot Per Second
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
GPD	Gallons per Day
ICSE	University of Utah's Institute for Clean and Secure Energy
PEIS	Programmatic Environmental Impact Statement

1. Introduction

The relationship between surface and groundwater is a central aspect of the hydrologic cycle,[1] and the interactions between surface and groundwater resources play an important role in that system. "[S]treams gain water from inflow of ground water into the surface stream, streams lose water to the aquifer from outflow from the stream, or do both by gaining water from aquifers in some reaches and losing it to aquifers in other reaches."[2] See Figure 1. The extent of this relationship is often overlooked, as "approximately 40 percent of streamflow is ultimately derived from ground-water sources."[3] Working within the physical and legal requirements of interrelated surface and groundwater resources represent both opportunities and challenges for prospective unconventional fuel developers.

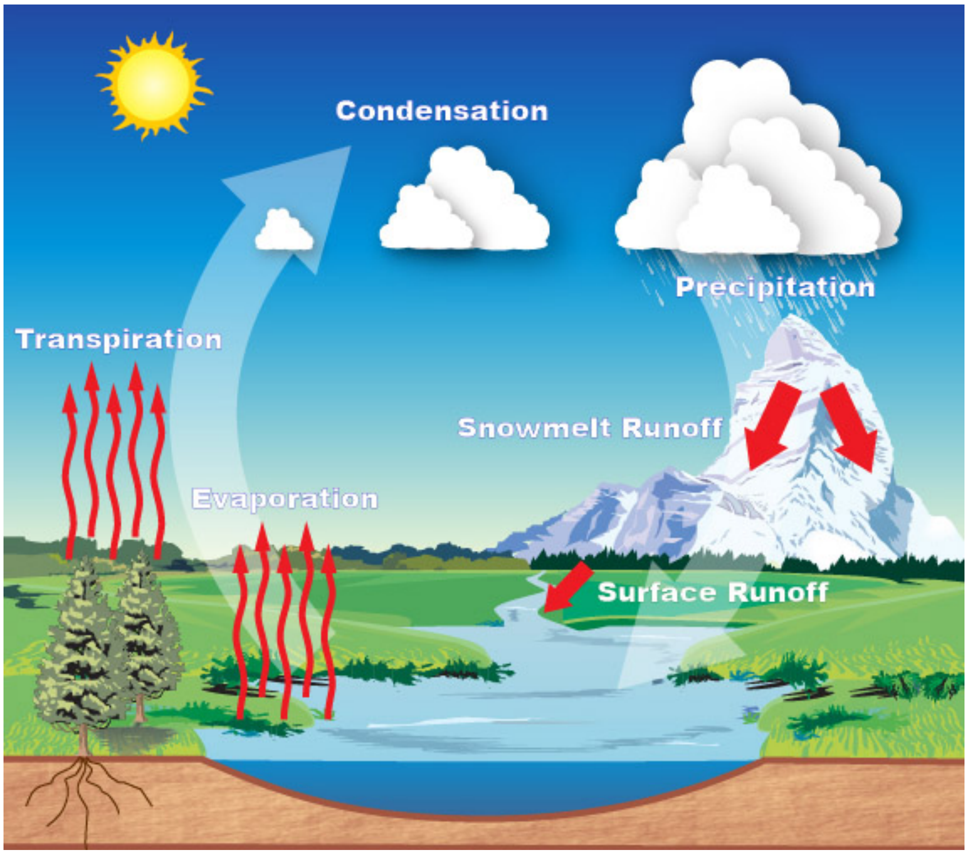

Figure 1 - Hydrologic Cycle
Source: NOAA

"Without human intervention, the surface/ground water interconnected system exists in a state of approximate equilibrium which implies a long-term balance between natural recharge and discharge processes in a groundwater basin."[4] But we do not live in a world free of human intervention. Groundwater pumping that lowers the water table can deplete surface streams; conversely, groundwater augmentation and changes in surface storage can affect the flow of surface streams. Generally, increasing surface flows or storage increases groundwater recharge, while reducing surface flows and storage reduces groundwater recharge.

Conjunctive management reflects these realities and "takes into account the interconnections of surface and subsurface waters within the drainage basin, and the term 'integrated management' means arrangements that integrate the management of water resources with other sorts of resources."[5] This report addresses both concepts under the common heading of conjunctive management. We discuss integrating surface and groundwater appropriations, managed aquifer recharge and recovery, and their applicability to unconventional fuel development.

The extent to which groundwater can be withdrawn from or recharged into an aquifer without impairing natural processes or injuring others is the key issue in conjunctive management. Generally, western states follow the prior appropriation doctrine and have been willing to adopt conjunctive management programs, though they have done so in different ways and to different degrees.[6]

The common thread binding disparate conjunctive use projects is the goal of maximizing economic benefit while minimizing ecological impacts. Most western states advocate water resource development;[7] and groundwater, in many locations, represents an attractive alternative to surface water since groundwater availability is less influenced by the seasonal fluctuations in flow that commonly affect surface waters. When electric pumps first became affordable, groundwater was readily available while surface water was often overprescribed and unavailable for new appropriations. Conjunctive surface and groundwater management became increasingly important as improvements in drilling technology, vertical turbine and submersible pumps, and rural electrification allowed groundwater pumping to grow rapidly.[8]

By the early 1980s (and earlier in many places), irrigation withdrawals were overwhelming natural groundwater recharge.[9] Excessive groundwater withdrawals present particular problems by lowering water levels or creating a cone of depression that can impact nearby water users. See Figure 2. "[P]umping can [also] reduce the artesian pressure of the water in the aquifer (the lifting power naturally present), creating the need to invest in energy for artificial pumping. As a result, both traditionally and today, economic interest, political controversy, and legal action have centered on the use and replenishment of aquifers."[10] The rapid increase in groundwater withdrawals, along with the growing recognition of the interaction between surface and groundwater resources, gave rise to an increase in conjunctive management. In many instances, surface and groundwater resources are connected such that a change in one ultimately produces a change in the other.

The advantages of conjunctive management are clear:

> Nature often supplies abundant rainfall when humans do not need it. That water could be stored. In the past, storage was in surface reservoirs that were vulnerable to loss from evaporation, seepage, siltation, and flooding. Furthermore, resistance to taking any additional land for surface impoundments has increased greatly. Compared then to using surface storage, the use of empty or drawndown aquifers for seasonal supply has the advantage in that it not only does not impair an existing ecosystem, it might actually serve to restore one. While more is involved than simply putting water into an empty aquifer, the water basically is injected into the space created in an aquifer by earlier withdrawal of water for consumption on the surface. With conjunctive storage, what has been a regional problem can become a regional opportunity. Upon injection into an aquifer, the stored water is protected from sedimentation, erosion, surface run-off, and acid rain. With subsurface water storage, water is warehoused; aquifers are protected from impaction and from brackish water invasion; the surface is supported against subsidence; and some of the surface does not have to serve as the site of a water impoundment. Industry's intermittent demands for water,

especially water used in cooling processes, make storage in an aquifer for later use helpful, perhaps with less concern about the temperature at which the water is returned to storage.[11]

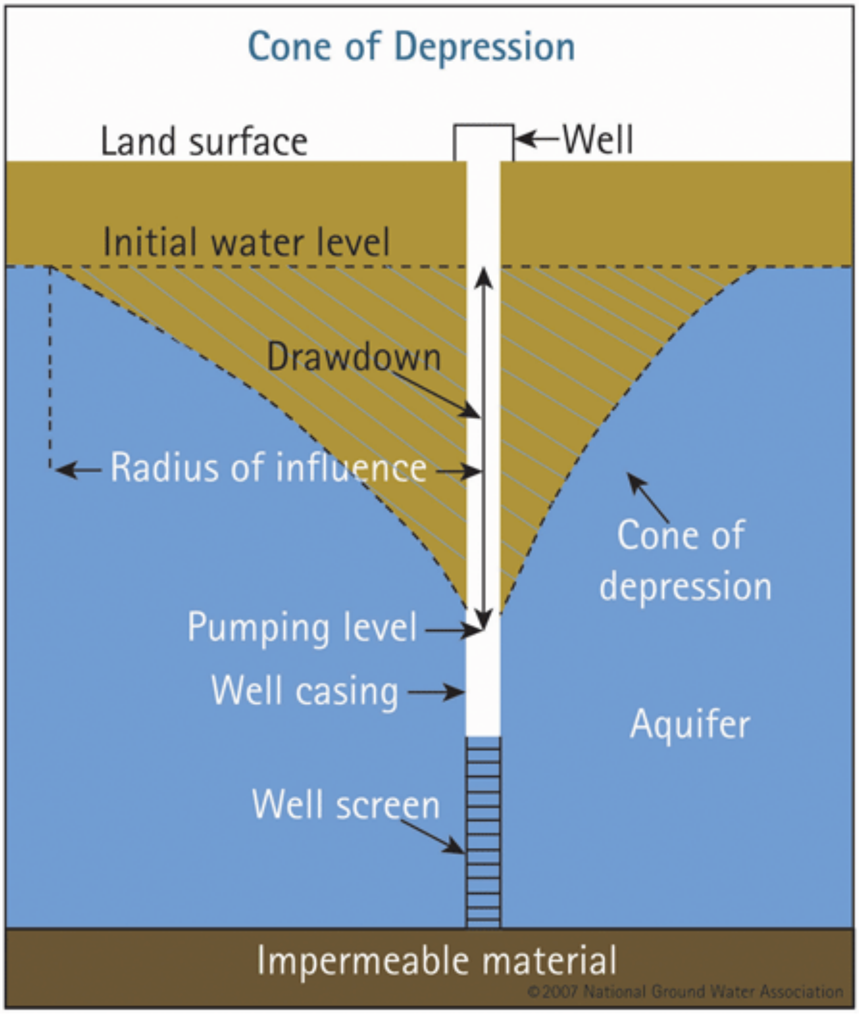

Figure 2 - Effect of Groundwater Pumping
Source: National Ground Water Association

While there is little dispute that better water resource integration would yield wide-ranging benefits, the challenges to applying abstract concepts across a vast and varied landscape are formidable. Hydrologists rely on complicated models to understand and predict hydrologic interactions. As modeling capabilities grow to address physical interactions in a more comprehensive way, the cost of modeling and acquisition of the needed input data grow as well. The unintended consequence of better decision-making tools is that application of these same tools may be prohibitively expensive for many decisions. What is needed is not a model that is 95% accurate but so expensive that it can be used only 5% of the time, but a model that is capable of answering 95% of our questions with sufficient precision to inform good decisions.

While water law is evolving to better reflect scientific understandings, state water laws have not always kept pace with the advances in our understanding of the hydrologic cycle.

"Many states have developed entirely separate systems for regulating ground and surface water, even though there are often physical connections between the two and capture processes are occurring. The consequence is a set of legal rules that fails to conform to physical reality."[12] Reconciling science and law is foundational to effective management, and the interplay between law and science is an important consideration for any entity contemplating large-scale water use, including unconventional fuel producers.

While much progress has been made over the last few decades, many challenges remain. Professor Tarlock succinctly identified the major challenges to integrated and conjunctive management:

> In theory, a groundwater permit should not be issued if it interferes with existing rights. However, it is not as easy to enforce a call by a senior pumper compared to a call made by a senior surface user. There are two reasons. First, there is seldom an absolute shortage. There is almost always water available for extraction at some level. The issue is the cost of lifting it. Second, it is much more difficult for a senior pumper to determine which junior must be shut down to satisfy a call. The problem is compounded by the fact that all pumpers mutually contribute to the drawdown of an aquifer. For these reasons, there is little traditional enforcement of priorities in the prior appropriation states, but it does occur.[13]

The unfortunate reality is that "[i]n the twenty-first century, hydrogeology and law still are not wholly integrated. Given the different purposes each discipline pursues, they may never be wholly integrated."[14] For decades, institutions have relied on what are now factually suspect assumptions. Consequently, change may not be possible without severely impacting long-established water uses.[15] Furthermore, as Professor Thompson points out, "no western state has adopted a state-wide program to protect groundwater basins from land uses and development that reduce the quantity or quality of recharge."[16] While regulation remains imperfect, the State of Utah is a leader in groundwater management, having developed a state water plan and basin-specific plans for much of the state.[17]

Resolution of pressing conjunctive surface and groundwater management issues also requires a better understanding of water resources and their interconnections. For example, heavy winter snowfall in Utah during the 2010-11 winter, coupled with an abnormally wet and mild spring, resulted in significant groundwater recharge. Preliminary accounts indicate that this single year of exceptional recharge may offset several previous years of groundwater mining. The extent to which exceptional water years can accelerate aquifer recharge is not well quantified and the subject of ongoing research.[18]

Improving conjunctive management, while working within an imperfectly integrated legal system, is both a challenge and an opportunity for prospective alternative fuel producers. The remaining sections of this report address these challenges. Section 2 discusses conjunctive management in Utah: how the current water resource management framework developed, ongoing groundwater management efforts that integrate conjunctive management concepts, and examples of conjunctive management. Section 3 summarizes how neighboring states and the federal government address conjunctive management. Section 4 discusses how, in light of the need for water and limits on its availability within Utah's Uinta Basin, conjunctive management could benefit the nascent oil shale and oil sands industries. Our conclusions and recommendations are contained in Section 5.

While our focus is on unconventional fuels within eastern Utah, the concepts discussed and lessons learned have broader applicability. Conjunctive surface and groundwater management has the potential to benefit water users in general, not just those contemplating unconventional fuel development. Likewise, these benefits are available throughout much of the western United States.

2. Conjunctive Management in Utah

"It is a matter of common knowledge that in this mountainous region the water which percolates into and through the porous soil of the mountains, especially in the higher altitudes, at some time and in some manner finds its way into the mountain streams."[19] In the words of Justice Frick: "It must be remembered that in this mountainous country all streams are necessarily, to some extent at least, fed from underground sources as well as from surface sources."[20]

While the law of appropriation in Utah draws no distinction between surface and groundwater, managing interactions between these two resources raises complicated factual questions. Surface streams are easily mapped and measured; whereas the size, extent, and character of groundwater resources is less well known. Additionally, surface water diversions have an immediate and measureable downstream impact; while weeks, months, or even years may pass before the effects of groundwater withdrawals are felt. Further complicating matters, it is often difficult to determine how multiple wells interact and how responsibility for impairment should be apportioned. Practical administration therefore has not always matched simple pronouncements.

This section discusses efforts to conjunctively manage surface and groundwater resources within Utah. We begin with the legal aspect — a brief overview of Utah's water resource management framework, looking to the historic roots of today's laws and the current Utah Water Code. We turn next to the practical application — ongoing groundwater management planning efforts within Utah and the means by which they address conjunctive management. We conclude with a discussion of two ongoing conjunctive management projects and how they address both legal and factual issues. While neither project involves energy development, both highlight the benefits as well as the challenges involved in conjunctive management.

2.1. Management Framework

The discussion that follows briefly summarizes Utah water law in order to provide context for subsequent discussion of conjunctive water management issues. Readers are referred to prior ICSE reports and other documents for a more thorough discussion of Utah water law.[21]

In Utah, "[a]ll waters in this state, whether above or under the ground, are hereby declared to be the property of the public, subject to all existing rights to the use thereof."[22] New rights to appropriate public waters are obtained exclusively through applications that are subject to approval by the State Engineer.[23] Surface and groundwater permit applications are subject to the same requirements, and surface and groundwater rights are administered under the same priority system.

The path to a general legal recognition of surface and groundwater interactions was not always clear, as groundwater law sometimes struggled to keep pace with scientific understanding. Even when recognized, protection of interests developed around surface and groundwater use has often been challenging. As the past is prelude, we begin with a summary of early appropriative law and how it put Utah on a track for conjunctive management. We then turn to modern water law and its relationship to conjunctive management.

2.1.1. Early Appropriative Law

In 1903, the Utah legislature enacted the state's first comprehensive water rights legislation, declaring all surface waters to be the property of the state and that the right to use these waters could be obtained only through permits issued by the State Engineer.[24] In 1935, the Utah Supreme Court held that all groundwater within the state was subject to appropriation.[25] That same year, the legislature amended Utah's water code to require a state-issued permit to appropriate groundwater.[26] For the last seventy-six years, new surface and groundwater rights have been obtained exclusively by filing an application to appropriate with the State Engineer. Many water rights predate the 1903 water code, and the Utah Supreme Court has unwaveringly recognized pre-1903 diversions of water to a beneficial use as valid water rights, even if earlier requirements were not adhered to strictly.[27] While the road is now clear, the path to these recognitions deserves brief discussion, both as background and because several other states continue to wrestle with these same issues.

Figure 3 - Highland Improvement Company Well (1914)
Source: Utah State Historical Society

Prior to amendment in 1935, the Utah Water Code stated that "[t]he water of all streams and other sources in this State, whether *flowing* above or under the ground, *in known or defined channels*, is hereby declared to be the property of the public . . . ."[28] Utah courts struggled to distinguish flowing from non-flowing groundwater, and groundwater in defined channels from diffuse groundwater flowing or percolating to the surface[29] — a problem that continues to plague states that separately administer surface and groundwater resources.[30]

Up until 1935, Utah case law recognized three classes of groundwater: underflow of surface streams, water flowing in a definite underground stream, and percolating waters.[31] Underflow of a surface stream was treated as part of the surface stream and subject to appropriation as a surface water source.[32] Water flowing in a definite underground stream was subject to appropriation and required only diversion to a beneficial use.[33] Percolating groundwater included all groundwater not covered by the two other categories,[34] and was initially treated as part of the soil and owned by the landowner.[35] Therefore, percolating waters were not subject to appropriation and overlying landowners possessed a correlative right to use groundwater in proportion to surface ownership.[36] Overlying landowners could develop groundwater and even lower the water table, but they could do so only if they did not inflict unreasonable hardship on their neighbors and common users of the same groundwater resource.[37]

In 1935, the Utah Supreme Court issued two transformative opinions, criticizing both the legal distinction between surface and groundwater as well as the three classes of groundwater.[38] In *Wrathall v. Johnson*, the court went through an exhaustive review of its prior decisions before concluding that the correlative rights doctrine, as applied to percolating waters, had become unworkable.[39] Eight days later, the court resolved any question about its holding in *Wrathall* when it said that "fundamental principles of law are at war with each other, and with rules of nature that are constantly asserting themselves in opposition to these conflicting legal principles."[40] The court went on to explain that:

> [A]n artesian basin is nothing more than a body of water more or less compact, moving through the soils with more or less resistance . . . . [I]t may be fairly inferred that the resistance which causes the water to rise in the wells is merely the action of the water in percolating or oozing through the soil . . . .
>
> It necessarily follows that it is impossible to apply the doctrine of reasonable use or correlative rights so as to give any assurance of permanency to men who may spend their money in developing sources of water supply, improving the country, and building their homes.[41]

Following *Wrathall* and *Justesen*, the legislature promptly amended the water code, defining public water so broadly that the distinction between different classifications of water became meaningless.[42]

2.1.2. <u>Modern Appropriative Law</u>

Today, "[a]ll waters in this state, whether above or under the ground, are hereby declared to be the property of the public, subject to all existing rights to the use thereof."[43] Both surface and groundwater are public resources and new rights to the use of unappropriated public waters are obtained only through permits issued by the State Engineer.[44] Both types of water are subject to the prior appropriation doctrine under which the first in time is the first in right,[45] and at least theoretically, subject to curtailment in reverse order of priority when water is limited.[46]

<u>The Application Process</u>. Persons seeking new water rights must file an application to appropriate with the State Engineer.[47] The State Engineer evaluates the application and approves it if: (1) there is unappropriated water available, (2) the proposed appropriation will not "impair existing rights or interfere with the more beneficial use of the water," (3) the proposed appropriations are both "physically and economically feasible" (except for Bureau of Reclamation appropriations), (4) the proposed appropriations would not be detrimental to the public interest, and (5) the application was not filed for the purpose of speculation or to obtain a monopoly over water resources.[48] The existence of unappropriated water and impairment to existing uses are the most contentious criteria.

The State Engineer must reject the application if he or she "has reason to believe that an application to appropriate water will interfere with its more beneficial use for irrigation, domestic or culinary, stock watering, power or mining development, or manufacturing, or will unreasonably affect public recreation or the natural stream environment, or will prove detrimental to the public welfare."[49] Because precipitation and stream flows are variable, not all the water approved in the application may be available, especially during drought periods, and a court of competent jurisdiction resolves disputed questions of impairment, after water rights have been perfected and awarded.[50] Appropriators may therefore perfect a water right only to find that utilization is possible only during high-flow periods.[51] Many portions of Utah are currently closed to new appropriations because unappropriated water is unavailable. See Figure 4.

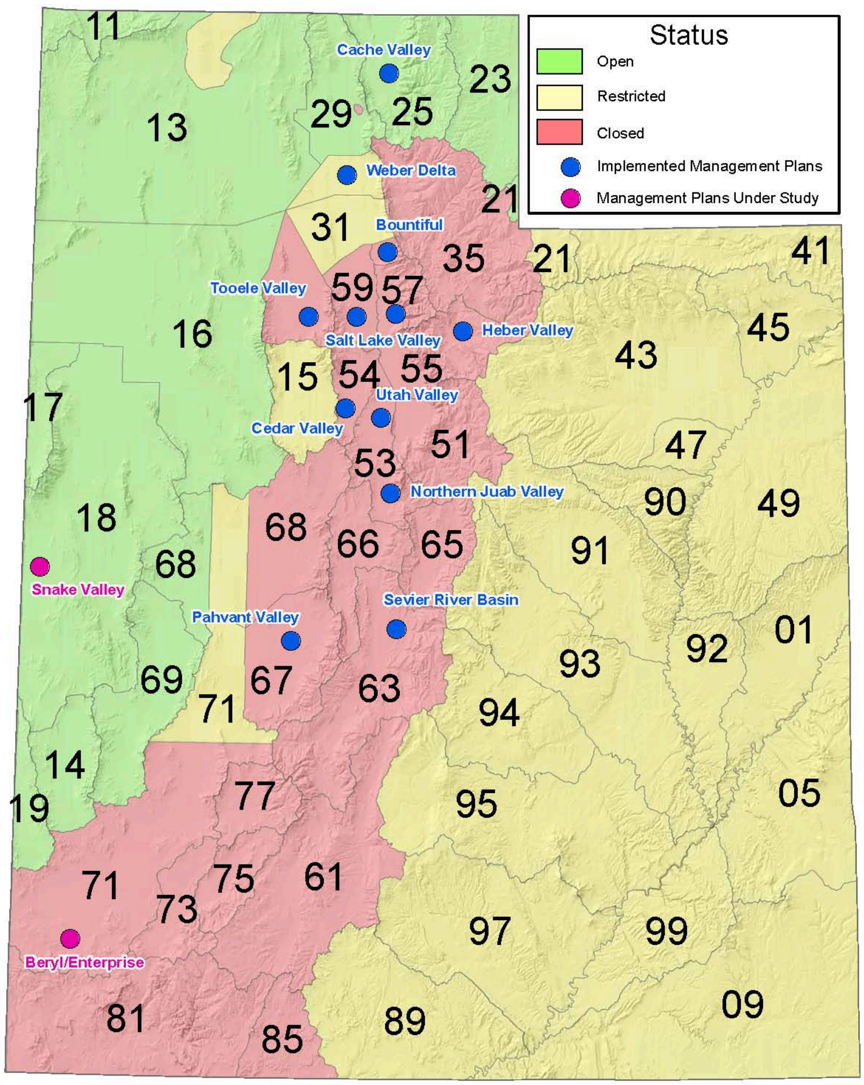

Figure 4 - Utah Groundwater Management Areas
Source: Utah Division of Water Rights

An application to appropriate water that has been approved by the State Engineer "does not give the applicant a vested right to the use of the water sought to be appropriated, it merely gives a right to complete the appropriation and put the water to a beneficial use in compliance with the act."[52] Holders of approved applications must proceed with reasonable diligence to apply water to the approved beneficial use.[53] Following perfection by diversion and application to a beneficial use, the State Engineer issues a certificate of beneficial use.[54] The certificate indicates the source of water, the quantity of water appropriated, the point of diversion, the nature and place of use, the seasonal limits on use, and any other limitations or conditions imposed by the State Engineer.[55] The certificate is prima facie evidence of the holder's right to use water as set forth in the certificate.[56] Once perfected, the water right becomes a vested interest in real property that can be leased or sold.[57] As a practical matter, most surface water sources were fully appropriated years ago and groundwater resources in most parts of the state are either heavily restricted or closed to new appropriations. See Figure 4. Much of the practice of modern water law thus involves negotiating water right conveyances and change applications.

Priority of Rights and Reasonable Use. "Between appropriators, the one first in time is first in rights."[58] Priority, however, protects only reasonable means of surface water diversion or groundwater withdrawal, and courts will not protect unreasonable means of withdrawal to the detriment of efficient water development.[59] In light of reasonableness requirements:

> Priority of appropriation does not give a right to an inefficient means of diversion, such as a well which reaches to such a shallow depth into the available water supply that a shortage would occur to such senior even though diversion by others did not deplete the stream below where there would be an adequate supply for the senior's lawful demand.[60]

Whether the means of groundwater withdrawal are reasonable depends on, at a minimum, "the quantity of water available, the average annual recharge in the basin, [and] the existing rights and their priorities."[61] For groundwater users, this means that appropriators may need to replace pumps, or even deepen wells that are unreasonably shallow or have been allowed to fill with sediment.

In all cases of groundwater appropriation, junior appropriators have the right to replace, at their sole cost and expense, impaired senior groundwater rights, subject to State Engineer approval.[62] Thus, a junior appropriator that is installing a large well can elect to provide water to a senior appropriator that relies on the same source of supply rather than risk a claim of impairment to the senior's older, and likely shallower, well.

Beneficial Use. "Beneficial use shall be the basis, the measure and the limit of all rights to the use of water in this state."[63] No right can exist for the wasteful use of water. More importantly for those seeking to acquire water rights, when an amount put to beneficial use is less than the amount of water shown on the application or certificate, only the beneficially used portion is perfected.[64]

When an appropriator, without excuse, fails to use all or a portion of a water right for a period of seven years, the water right or the unused portion of that water right is subject to forfeiture and reverts to the state.[65] Additionally, where an appropriator evidences "a definite intent to relinquish the right to use and ownership of such water right," the right can be deemed abandoned.[66] Whether abandonment has occurred depends on intent and does not require any particular period of time.[67]

Water Right Changes. The Utah Water Code authorizes holders of certificated water rights to change the point of diversion, place of use, and purpose of use.[68] Change applications are reviewed by the State Engineer and approved if they satisfy the requirements applied in the review of new applications to appropriate[69] and will not impair vested rights without just compensation.[70] The State Engineer may not reject change applications for the sole reason that the change would impair vested rights.[71] If otherwise proper, change applications will be approved but limited or conditioned to avoid impairment. Alternatively, approval of the new use may be conditioned upon acquisition of the conflicting right.[72]

A water right change, subject to permitting requirements, can convert a right to divert from a surface water source into a right to withdraw groundwater. Changes from surface diversions to groundwater withdrawals are common, as they can facilitate access to more reliable or higher quality water supplies.[73] Surface to groundwater changes can also reduce impacts by leaving more water in the stream, thereby protecting water quality related values.

Runoff and Shallow Groundwater. Some of the most complicated issues in Utah water law involve shallow groundwater flow. Surface water and shallow groundwater resources generally have a high degree of continuity, and while the connection is recognized, management implications are often quite complex. Rights to the use of these waters depend on the water's classification.

Return flow is water that returns to the source from which it was diverted after its use, and is therefore a part of the stream available to downstream appropriators.[74] Once the appropriator ceases to use the water and allows it to leave his/her land, the appropriator loses rights to the water's continued use.

Saved or salvaged water is water previously lost to seepage or to phreatophytic vegetation.[75] Since beneficial use is the measure and limit of a water right,[76] water users who cease wasteful or inefficient practices have no right to the water that is saved or salvaged, and an appropriator who saves water previously lost to the system through piping or lining ditches must (after 1903) file a new application to appropriate the water saved.[77] For the application to be approved, the appropriator must show that others have not already appropriated the water that will be salvaged and satisfy all other statutory criteria for a new appropriation.[78] If the application is approved and perfected, it will have a junior priority and be among the first rights curtailed during shortage.[79] Such disincentives to conservation are widely criticized by water rights scholars.[80]

Waste water is water in excess of irrigation demands that collects in low spots below irrigation ditches and irrigated fields.[81] Waste water also includes water that flows or seeps from the original appropriator's land, is captured by the adjacent land owner, and is put to beneficial use.[82] Waste water differs from return flow in that return flow "is irrigation water seeping back to a stream after it has gone underground to perform its nutritional function;" waste water does not return to the source from which the appropriation occurred.[83] Water users may appropriate waste water and obtain protection against junior appropriators, but Utah water law encourages improvements in irrigation efficiency,[84] and the appropriator of waste water cannot compel the continued wasteful use of water.[85] The original appropriator can recapture and reuse waste water, provided it does not expand the amount of water consumed, on the original land and for the original beneficial use.[86]

The distinction between waste water and return flow is important, but not always clear. Where inefficient irrigation or conveyance practices have been in place for decades, stable economies may have developed based on seepage from what were once state-of-the-art facilities, but which are inefficient by today's standards. Sources of supply may also have been developed without a clear understanding that they depend on the inefficient practices of others. In such cases, strict application of these principles can lead to harsh results.

Developed water is water that is external to the system and brought into the system by the actions of a water developer — a classic example is water imported from another basin or encountered and drained during mining operations.[87] In Utah, all appropriators have a protected interest in the source of supply feeding the well or stream from which they appropriate their water, including the right to follow their water supply to its source in order to protect their water rights from interference.[88] The interest in protecting one's source of supply results in a presumption that groundwater is tributary to surface streams and that the right to use the water is vested in the prior appropriators of the stream.[89] If the presumption is overcome and the water is determined not to be tributary to the system, developed water may be captured, used, and fully consumed by the party who developed it.[90] Downstream appropriators may use the water while it is available to them, but as with waste water, they cannot compel the developer of the water to continue to make the water available to them.

Groundwater Recharge and Recovery. The Utah Legislature enacted the Groundwater Recharge and Recovery Act in 1991, defining the State Engineer's authority to permit and regulate aquifer recharge and recovery projects.[91] Under the Act, no entity may "artificially recharge an aquifer without first obtaining a recharge permit."[92] The permit applicant must possess a valid water right to the water proposed for recharge or an agreement to use such water.[93] The applicant must also provide a plan of operation that includes: (1) a description of the project, (2) project design capacity, (3) a detailed monitoring program, (4) evidence of financial and technical capability to complete the project, and (5) a hydrologic study demonstrating (a) the area of hydrologic impact, (b) hydrologic feasibility of the project, (c) assurance that the project will not cause unreasonable harm, and (d) assurance that existing water rights will not be impaired.[94] The applicant must also submit information regarding the quality of the recharge water and the quality of the water in the receiving aquifer[95] as well as evidence that all applicable water quality permits have been obtained.[96]

Under the Act, no entity may recover artificially recharged groundwater unless the party making the withdrawal first obtains a recovery permit.[97] The permit applicant may recover only that portion of the recharge water that has reached the aquifer and remains within the hydrologic area of influence.[98] If the recharge and recovery permit applicants are not the same, the permit applicants or holders must have a written agreement regarding the recharge, recovery, and use of the water.[99]

In addition, the project proponent may need a well permit for any wells needed to monitor the project and for any new well used to inject water into the aquifer or to recover water from the aquifer.[100] Recharge projects involving new surface water diversions will also require a stream alteration permit,[101] as well as water quality approvals to ensure that recharge does not degrade water quality.[102]

2.2. Groundwater Management Planning

While Utah appropriative law does not distinguish between surface and groundwater, factual differences exist and our imperfect knowledge of the two resources, their interrelationship, and the reasonable use doctrine dictate different management.

Changes in water levels due to groundwater withdrawals may take months or even years to occur.[103] Attributing causation for injuries resulting from groundwater withdrawals between competing appropriators can be difficult, and groundwater may take years to recover after withdrawals have been slowed or stopped.[104] Furthermore, groundwater may be fed in whole or in part by seepage or return flow and, as already noted, the distinction between the two can be problematic. All of these factors frustrate attempts to blend administration of groundwater withdrawals into the traditional prior appropriation system. Therefore, as a practical matter, groundwater management tends to emphasize source protection over priority enforcement. But foregoing priority enforcement is problematic. "Lack of priority enforcement makes a junior as good as a senior, diluting the value of senior priorities and impeding the important prior appropriation market functions of reallocation to changing needs of the community."[105]

Under Utah law, the State Engineer may prepare groundwater management plans to promote wise use of groundwater, protect existing water rights, and address water quality issues and over appropriation.[106] "In developing a groundwater management plan, the [S]tate [E]ngineer may consider . . . the relationship between surface water and groundwater, including whether the groundwater should be managed in conjunction with hydrologically connected surface waters . . . ."[107] Where a groundwater management plan has been enacted, the State Engineer must limit withdrawals to the basin's safe yield,[108] which is defined as "the amount of groundwater that can be withdrawn from a groundwater basin over a period of time without exceeding the long-term recharge of the basin or unreasonably affecting the basin's physical and chemical integrity."[109]

The Salt Lake Valley Ground-Water Management Plan is an example of a plan that appears to be working. Under the plan, the Salt Lake Valley is closed to all new groundwater appropriations.[110] Where new wells are constructed, "[e]ach new well should be designed, constructed, and operated so that, when pumped at its maximum flow rate, it will not cause more than 12 feet of draw down on an existing well unless the owner of the new well provides just compensation to the affected well owner(s)."[111]

The plan divides the Salt Lake Valley into four regions: western, eastern, central, and northern; and the State Engineer limits the quantity of water withdrawn so that average long-term water withdrawals do not exceed safe yield.[112] See Figure 5. The plan also identifies two "restricted areas" that are subject to special regulation because of groundwater contamination.[113] Change applications are reviewed critically to avoid injury, and applications to "transfer water rights historically supplied from the shallow aquifer to the [deeper,] principal aquifer" will be denied.[114] Applications proposing to transfer water rights across regional boundaries or in a direction contrary to groundwater flow patterns will also be denied, as will applications proposing to transfer water rights into a restricted area.[115] Additional requirements are imposed if the transfers involve areas that are already experiencing heavy diversions or withdrawals.[116]

Other efforts to develop groundwater management plans have been less effective. The Beryl-Enterprise area and Escalante Valley area are located in the far southwest corner of Utah, west of Cedar City.[117] The Beryl-Enterprise area is a closed basin with limited surface water resources. Groundwater development within the area began in 1860,[118] and accelerated rapidly in the 1940s. Within the basin, the State Engineer has issued 1,623 groundwater rights,[119] and approximately 28,000 acres of land are currently irrigated to produce alfalfa.[120] Total groundwater depletions are estimated at 65,000 AF/Y,[121] but the safe yield of the aquifer averages only 34,000 AF/Y.[122] Groundwater levels at one well within the Beryl-Enterprise area have declined by more than 120 feet.[123] Groundwater mining has also caused the ground surface across the valley to subside by as much as four feet and develop severe surface cracking.[124] See Figure 6.

If water right priorities were enforced strictly to require consumption of no more than safe yield, 658 (forty percent)[125] of the existing water rights would be required to curtail withdrawals.[126] Curtailment would impact all water right holders with priority dates later than January 25, 1945.[127] Forcing junior appropriators to cease withdrawals is not an attractive option because many junior water users have been using water for decades or even generations; many have invested significant resources in developing irrigation systems, and many more are residential users.[128] Curtailment would take approximately 11,000 acres out of agricultural production[129] and devastate the local community; therefore, efforts to address groundwater mining focus on avoiding this harsh result.

In 2003, the State Engineer took concerns over groundwater mining to the legislature, seeking clarification of both state law and policy.[130] Three years later, the Utah Water Code was amended to include a section on groundwater management planning.[131] Under that section, the State Engineer may develop groundwater management plans and is required to develop a plan prior to limiting withdrawals to safe yield.[132] Once the plan is developed, the State Engineer must limit withdrawals to the aquifer's safe yield, but the State Engineer can allow for "gradual implementation" of reductions to minimize harsh social and economic impacts.[133] In reducing withdrawals to the safe yield, the State Engineer must enforce priorities unless area water users have adopted a voluntary agreement to reduce withdrawals.[134]

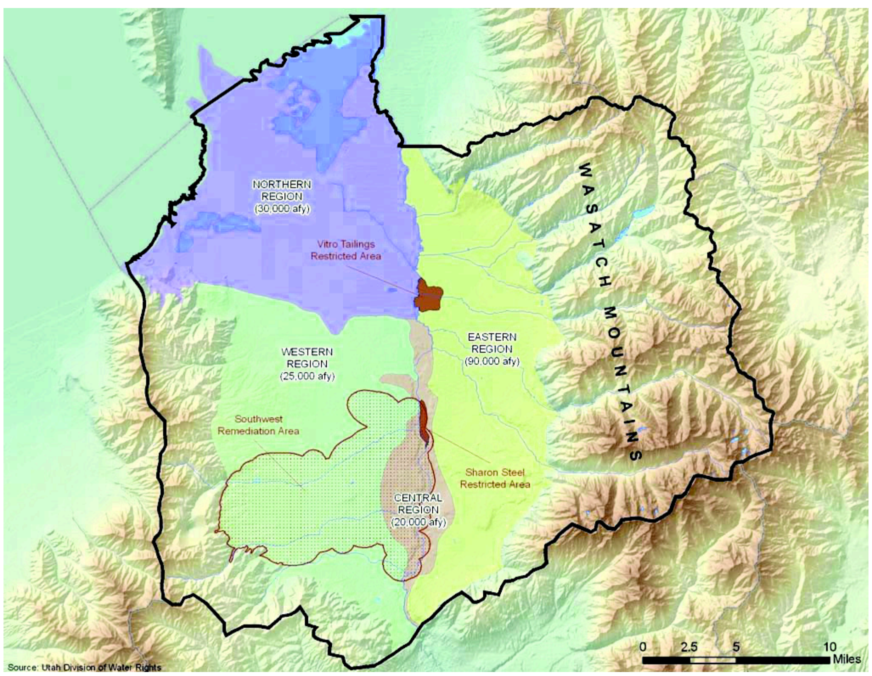

Figure 5 - Salt Lake Valley Groundwater Management Zones
Source: Utah Division of Water Resources

Figure 6 - Bossardt Earth Fissure Near Beryl, Utah
Source: Utah Geological Survey

The Escalante Valley Water Users Association, which represents groundwater users in the Beryl-Enterprise area, began work on a voluntary agreement that attempted to minimize the social and economic impacts of curtailed withdrawals. The voluntary agreement proposed to protect existing domestic and municipal uses by redistributing reductions across irrigation uses and phasing implementation to minimize local impacts.[135] As summarized by the State Engineer, the Association proposed to adopt a formal resolution within one year. That resolution would set forth measures to reduce the irrigation duty from 4.0 to 3.2 AF/AC, begin "metering" withdrawals based on power records,[136] and reduce water use ten percent over the following forty-years. Withdrawals would be further reduced at a rate of five percent every twenty years, finally reaching safe yield in 2190. To accomplish these goals, the Association proposed a ten million dollar compensation program funded equally by local and state governments.[137]

Outside of the Beryl-Enterprise area, many were unimpressed by an agreement that depended on government subsidies and almost two centuries to achieve its intended result. Setting these concerns aside, it appears that even if the agreement were somehow seen as responsive to the issue, the agreement would likely fail to affect the intended result.

It is unclear whether senior water right holders could forego water withdrawals without risking permanent abandonment or forfeiture.[138] Arguing that the water source fails to satisfy senior water rights, thereby protecting senior appropriators from abandonment and forfeiture, may be problematic because senior appropriators are entitled to their full right and junior right holders' withdrawals have not been curtailed.[139] Each water user could be deemed to have intentionally abandoned a portion of his/her right. Water right abandonment is, of course, the point of the agreement; but voluntary abandonment is desirable only if other water users are likewise committed to abandoning a portion of their water rights.

A larger problem is the Utah Water Code's provision that voluntary agreements have no force or effect against third parties.[140] The inability to force participants to forego withdrawals during times of shortage calls the value of the agreement into question. Furthermore, the code is silent with regard to the ability to withdraw from a voluntary agreement. If parties can pull out from the agreement and per-capita groundwater withdrawal reductions requirements remain constant, the agreement declines in value with each departing water user as fewer groundwater withdrawals are foregone. If net reductions are held constant, withdrawal from the agreement effectively increases the burden imposed on the remaining parties to the agreement, giving each party a strong incentive to ensure that he or she is not the last person bound by the agreement.

Likewise, water users have an incentive to encourage others to enter into a voluntary agreement but not to enter the agreement themselves. Such strategic bargaining puts the burden of groundwater withdrawal reductions on a willing few while benefits accrue to all without regard to their cooperation. Junior water right holders have the most to gain by entering into the voluntary agreement, as they would be the first to have their appropriative rights curtailed if the State Engineer chose to aggressively enforce the prior appropriation doctrine.[141] Yet in agreeing to reduce their diversions, they bring little to the table because the rights they propose to forego are the least secure.[142] Conversely, senior right holders accrue little benefit from the agreement; their source of supply remains legally secure,[143] yet they face the highest cost of participation by retiring the most valuable and secure water rights.

In short, a voluntary agreement, if formalized, appears unlikely to survive for long, and time lost to negotiating an ineffective agreement allows conditions to worsen. It is possible that local residents will see the threat of an externally imposed solution as sufficient to drive agreement, but whether the perceived risk of outside regulation is sufficient remains uncertain.

Two recent water code revisions increase the ability of local communities to craft solutions to severe groundwater mining. The first amendment allows local districts[144] to acquire and hold groundwater rights within a critical groundwater management area,[145] and retire those rights in order to reduce groundwater mining.[146] This amendment also vests in the district the power to levy assessments to facilitate groundwater management planning and water right acquisition.[147]

The second amendment allows local districts to "hold or acquire a right to surface waters that are naturally tributary to the groundwater basin subject to the groundwater management plan" in accordance with the Water Code and Groundwater Recharge and Recovery Act.[148] The amendment clarifies that within a critical management area, the artificial recharge of a groundwater basin by a local district, utilizing surface water naturally tributary to the groundwater basin, "constitutes a beneficial use of water."[149] The beneficial use determination requires that that the recharge occurs while the area is designated a critical management area. The recharge must be authorized by a valid recharge permit, and cannot be withdrawn under a recovery permit. Finally, the recharge must be needed to replenish groundwater.[150] This amendment resolves a key concern by clarifying that groundwater recharge without subsequent withdrawal constitutes a beneficial use. Without a beneficial use, the State Engineer would have been unable to issue a water right.[151] Furthermore, by declaring that aquifer recharge is a beneficial use, the amendment precludes challenges that the district had abandoned or forfeited any water right dedicated to recharge.[152] With these amendments in place, local water users have begun directing runoff into an infiltration gallery and recharging local aquifers.

Recent revisions to Utah law recognize that groundwater mining can be addressed by reducing withdrawals and by increasing the rate of recharge. Recent amendments attempt to avoid the harsh result of priority enforcement and curtailment of withdrawals by empowering local communities to acquire and retire water rights, and by allowing local communities to pursue efforts to increase aquifer recharge.[153] While the practice of empowering local communities to manage their water resources is desirable, the promise of an unenforceable consensus should not preclude efforts to curtail uses that exceed the appropriators' right or that are conducted without valid water rights. Additional steps that facilitate increased aquifer recharge also are promising and essential elements of a comprehensive water management strategy.

With the Escalante Valley Water Users Association unable to formalize a workable agreement, the State Engineer recently issued a Draft Groundwater Management Plan for the Beryl-Enterprise Area.[154] The Draft Plan, which is an apparent compromise between the timeline advocated by the Association and earlier timelines proposed by the State Engineer calls for two phases of stepped reductions. Phase I would require consumptive reductions of five percent over each of two twenty-year periods; Phase II would require similar five percent reductions but over seven ten-year periods, concluding with a three percent reduction over the final decade. Under the Draft Plan, safe yield will not be achieved for 120 years.[155] Reductions would be implemented based on water right priority,[156] effectively requiring junior water users to either forego withdrawals or acquire water rights from senior water users.

2.3. Conjunctive Water Resource Management in Practice

Western water law is a delicate, even precarious, balance of competing interests. The basic tenets of priority, beneficial use, and aversion to waste and speculation provide a stable foundation; but, ever increasing demand for water and expanding scientific knowledge of hydrologic systems make change inevitable. Over time, statutory and decisional law developed in ways that recognize subtle distinctions and historic practices. Changes to statutory law that appear minor can have wide-ranging impacts, and court decisions addressing unique facts can set more expansive precedents, upsetting this delicate balance. Consequently, great effort often goes into avoiding both litigation and ensuring that water code revisions are narrowly tailored. For conjunctive surface and groundwater management, this means that "[i]f it makes sense economically, in general, it is already being done."[157]

Within Utah, conjunctive management strategies are two-fold: "the deliberate, planned and coordinated use of surface and ground water resources with the intent of balancing those resources;" and the prior conjunctive use strategy "coupled with aquifer storage and recovery."[158]

Within the Salt Lake Valley, surface streams are fed by runoff from melting winter snows.[159] Flows vary throughout the year, peaking in the spring when irrigation demands are still low, and falling steeply later in the year. For example, fifty-four percent of the Weber River's annual flow occurs during April, May, and June; flows drop to roughly one-third of their peak during July and August, and flows during November, December, and January are roughly one-eighth of spring peak flows.[160] In the Salt Lake Valley, which receives a portion of its culinary water from the Central Utah Project, including water from the Weber River, demand peaks in July and August.[161] Therefore, streams often go underutilized during the spring while failing to meet demand during peak summer periods. Where individual water suppliers hold both surface and groundwater rights, they commonly utilize surface water to meet base demands and groundwater wells to meet peak demands. Incorporating aquifer storage and recovery allows such water suppliers to capture peak surface runoff and store it for use during low-flow periods, thereby maximizing the amount of water that can be put to a beneficial use.

The best examples of conjunctive water management occur in the Salt Lake Valley, which is bounded to the east by the Wasatch Mountains, to the west by the Oquirrh Mountains, to the north by the Great Salt Lake, and to the south by the Traverse Mountains. Rivers originating in the Wasatch Mountains historically flowed into ancient Lake Bonneville, depositing sand and gravel at the rivers' deltas.[162] As Lake Bonneville rose and fell, sandy benches were formed along the lake's edge, and clays carried by the rivers were deposited to form confining layers.[163] Today, Lake Bonneville is gone and snowmelt-fed streams flowing out of the mountains percolate through the highly permeable sand and gravel layers, flowing beneath the confining clay layer to recharge the confined aquifer below the valley floor.[164] The pervious benches created by Lake Bonneville form natural aquifer recharge zones and sites for aquifer storage and recovery projects.[165] See Figure 7.

The Jordan Valley Water Conservancy District directly serves approximately 600,000 valley residents and is involved in water distribution to the remaining 400,000 residents through system interties.[166] The District holds a combination of surface and groundwater rights, including rights to waters imported from outside the basin, and coordinates diversions and withdrawals from these various sources to maximize system efficiency.[167] Surface water diversions are maximized during spring runoff and for base flow, with supply shifting to or being augmented by groundwater withdrawals as demand increases and runoff tapers.[168]

The District considers this type of conjunctive management to be a "means to an end," identifying eight areas of benefit directly attributable to conjunctive surface and groundwater management: (1) using the most cost-effective water resource available at the time, (2) optimizing electric power costs by running groundwater pumps in the most efficient manner possible, (3) optimizing aquifer safe yield in accordance with the Salt Lake Valley Ground Water Management Plan and minimizing the likelihood that the State Engineer will need to curtail withdrawals, (4) optimizing pipeline and facility operation efficiency, (5) optimizing aquifer recharge and maintaining more consistent water table levels throughout the supply area, (6) optimizing yields from distant basins by drawing from the area with the greatest snowpack and minimizing stresses on water-constrained basins, (7) optimizing surface reservoir operation to maintain reserve supplies, and (8) fostering interconnectedness with sister agencies that create redundant supplies that can be utilized in the event of contamination or drought.[169]

The District was the first water provider within the Valley to invest heavily in aquifer storage and recovery, spending roughly $20 million to implement an aquifer storage and recovery project, and upgrade its water distribution system.[170] The District's four primary objectives in pursuing aquifer recharge and recovery are to: (1) stabilize declining groundwater levels, (2) use off-peak aqueduct import capacity more efficiently, (3) capture and store snowmelt runoff during April through June, and (4) extract stored water to meet July through September peak demand.[171] The project, which was completed in 2002, consists of nineteen wells across a roughly fifteen-square-mile portion of the Lake Bonneville Bench, southeast of Salt Lake City.[172] Surface water injected into the aquifer is obtained from rivers and streams flowing out of the Wasatch Mountains, treated to drinking water standards, and injected into geological strata draining to the Valley's aquifers.[173] Project capacity is approximately 5,800 AF/Y.[174]

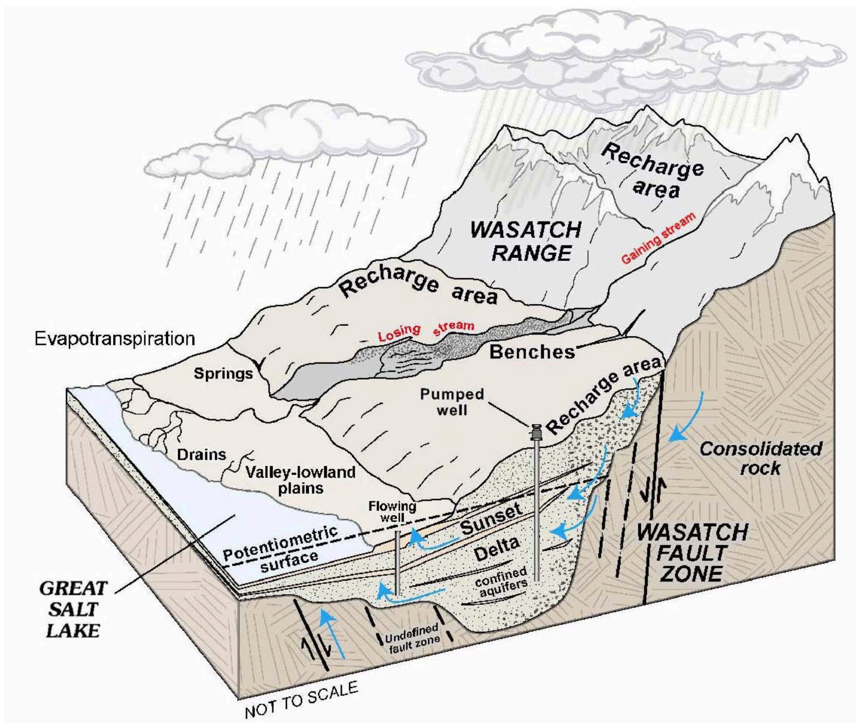

Figure 7 - The Bonneville Bench
Source: Utah Division of Water Resources

The project is permitted to recharge or withdraw water from any of the wells and to recover 100 percent of recharged water, provided recovery takes place during the first twelve months following injection.[175] A ten percent per-year reduction in the recoverable amount is imposed on withdrawals occurring more than twelve months after the date of injection,[176] accounting for recharge that travels down gradient, past the District's lowermost recovery well.[177]

The District estimates project capital costs at approximately $500,000 per cubic foot per second (CFS), compared to $1.8 million per CFS for an aqueduct and water treatment plant. Unit supply costs are approximately $550 per AF and include water supply, treatment, transmission, wells, and capital amortization.[178] While the District is pleased with the project, further work is needed to identify better methods to control injection well plugging, study bacteria that can plug well screens, and optimize injection well design.[179]

As the first large aquifer storage and recovery project in the state, changes in the points of diversion and places of use to facilitate the District's project were approved without firm assurances that aquifer recharge was a beneficial use or that other appropriators could not file to appropriate the water injected into the recovery wells.[180] To resolve these concerns, the state legislature adopted the Groundwater Recharge and Recovery Act, discussed above, during the legislative session following implementation of the project.[181] The District now holds recharge and recovery permits and is therefore able to protect its project waters.

A common theme among these examples is the need for better information regarding the connections between surface and groundwater resources, and the consequences of different management actions. Administrative agencies, courts, and communities cannot craft workable solutions absent good information; but the absence of complete information provides poor policy justification for inaction. Conjunctive water resource management will improve only if interested parties seek solutions based on sound science that incorporate flexibility to respond to new information and changed conditions. As Utah's chief water planner pointed out, our efforts must begin with a clearer vision of what we are managing for because conjunctive management really means adaptive management.[182]

The managed aquifer recharge efforts discussed in this report both involve spring runoff. While spring runoff represents an attractive source of water for these types of projects, runoff is but one potential water source. Agricultural irrigators may be able to forego some diversions during years with above average precipitation or below average temperatures. Diversions foregone could potentially be directed towards managed aquifer recharge efforts. Where water managers are forced to release water from reservoir storage in order to create capacity to capture spring runoff, unused releases could potentially be utilized for managed aquifer recharge. Likewise, stormwater management can incorporate biofiltration and infiltration galleries, providing benefits both in terms of stormwater management and aquifer recharge. In short, the sources of water for managed aquifer recharge projects depend on water manager ingenuity. New sources of water for such projects are likely to emerge as interest in managed aquifer recharge projects increases.

3. Conjunctive Management in the Intermountain West

Hydrologic conditions vary throughout the west, and conjunctive management must account for variations in climate, precipitation, geology, and water resources — as well as legal and political obstacles and opportunities. Complicating matters, conjunctive water resource management laws remain underdeveloped and less homogenous than in most other areas of water law.

> Although the number of disputes between surface-water users and groundwater users has been growing, most states have not had to resolve more than a handful of cases to date, and states often have resolved these through informal administrative processes. As a result, there are few cases, regulations, or administrative rulings from which the details of integration — or the lessons to be learned from such integration — can be gleaned.[183]

While changes in water law are trending towards greater recognition of the connections between surface and groundwater resources, factual realities are not always enough to drive change. The argument has been made — and at least one state's highest court has held — that where agricultural, industrial, mining, and urban interests have long "accommodated" themselves to "an understanding of hydrology less precise than current theories, it would be inappropriate to undo that which has been done in the past."[184] The Arizona Supreme Court's conclusion is premised on concerns that where "vast investments, the founding and growth of towns and cities, and the lives of our people" have developed based on a flawed factual foundation, "the prospective effect of change threatens important vested rights and may affect every [resident's] well-being."[185] Stability, in such cases, can outweigh other considerations.

In light of the immature and evolving nature of conjunctive management law, management regimes that are appropriate for one state or region may not be appropriate or politically palatable elsewhere. While lessons can be learned from neighboring states, one size fits all management systems should be avoided.

The subsections that follow summarize conjunctive surface and groundwater management laws that have developed in states throughout the intermountain west. We focus primarily on states possessing unconventional fuel resources, contrasting these systems against those adopted by Utah's northern neighbors and federal law. We also include a brief discussion of the divergent approaches adopted in California, Arizona, and Texas. While some of the states discussed lack oil shale or oil sands resources, states seeking to enhance conjunctive management will undoubtedly look beyond Colorado, Utah, and Wyoming to assess efforts adopted elsewhere. Accordingly, a broader perspective is appropriate when considering how this evolving area of law may affect prospective unconventional fuel developers.

3.1. Wyoming

The Wyoming Constitution declares that "the water of all natural streams, springs, lakes or other collections of still water, within the boundaries of the state, are hereby declared to be the property of the state."[186] Wyoming's Constitution is silent with respect to groundwater, probably because little groundwater development had occurred as of 1890, when Wyoming adopted its state Constitution.

With respect to groundwater, the Wyoming Supreme Court initially recognized multiple types of groundwater and held that "percolating waters developed artificially by excavation and other artificial means . . . belong to the owner of the land upon which they are developed."[187] Rural electrification and high-capacity pumps lead to rapid groundwater development and a call for state control of groundwater withdrawals. Initial regulatory efforts attempted to distinguish between percolating groundwater and underground streams, but by 1947, Wyoming had abandoned the distinction and applied the prior appropriation doctrine to all underground waters.[188] Today, surface and groundwater are held to belong to the state, and Wyoming applies the doctrine of prior appropriation to both surface and groundwater.[189]

Water rights are now required for both surface diversions[190] and groundwater withdrawals.[191] Beneficial use is the basis, measure, and limit of the right to use water.[192] For new applications, the date an application is filed establishes the priority date, provided the right is diligently developed and eventually approved.

All applications for new surface and groundwater appropriations are submitted to the State Engineer, who reviews whether the proposed use would interfere with already existing rights or be contrary to the public welfare.[193] Outside of critical areas,[194] groundwater withdrawal applications are granted "as a matter of course, if the proposed use is beneficial and, if the state engineer finds that the proposed means of diversion and construction are adequate."[195] Once a permit is approved, the permittee must diligently develop the right or it will lapse and revert to the state. After beneficial use is verified and public disputes are settled, a final certificate of appropriation is issued. Although exemptions initially existed for domestic and stock water use, the statutes now expressly require that anyone proposing to drill a well for groundwater must first obtain a permit.[196]

Water rights are subject to the prior appropriation doctrine whereby the first in time is the first in right.[197] Strict priority enforcement is modified by a prioritization of drinking water and municipal uses over industrial or irrigation uses.[198]

For water planning purposes, Wyoming is divided into seven different water basins: Snake/Salt, Wind/Bighorn, Powder/Tongue, Northeast, Platte, Green, and Bear.[199] Each basin has its own water plan, which contains detailed information on water availability.[200] Surface and groundwater rights are generally physically available in all basins except for the Platte River Basin, which is considered fully appropriated. Less water may be legally availability because of administrative and environmental requirements.[201]

Groundwater declines and conflicts are concentrated in the Platte and Powder River Basins. The Platte River Basin is home to all three of Wyoming's Groundwater Control Areas: Prairie Center, Platte County, and Laramie County. Control Areas are designated in response to: the waste of water, conflicts between water users, groundwater use that is approaching the rate of groundwater recharge, groundwater decline, or other conditions requiring protection of the public interest.[202] All of Wyoming's control areas were designated because of declining groundwater levels.[203] While there are no designated control areas in the Powder River Basin, there are concerns over groundwater level declines attributed to coalbed methane extraction.[204] Additionally, in the Wind/Big Horn Basin, groundwater levels have dropped somewhat due to municipal and irrigation withdrawals.[205] These areas may therefore face increased management attention in the future.

No statewide criteria have been promulgated to assess whether surface and groundwater are interconnected.[206] The general rule in Wyoming is that surface and groundwater are presumed to be hydrologically separate.[207] The assumption is overcome when "water is pumped from an obvious alluvial well or the interconnection has been previously discovered."[208] According to the state water plan, "[i]n general, the deeper and more distant from surface water features the groundwater is, the less is the likelihood of significant surface water connection."[209]

In areas where it is determined that "underground waters and the waters of surface streams are so interconnected as to constitute in fact one source of supply, priorities of rights to the use of all such interconnected waters shall be correlated and such single schedule of priorities shall relate to the whole common supply."[210] Unfortunately, there is presently little formal guidance regarding what must be found to satisfy the "so interconnected" standard.[211] Where surface and groundwater resources are interconnected, the State Engineer is authorized to adopt "such actions as refusing to grant any permits in the area, apportioning permissible total withdrawal among the appropriators with valid rights, ordering junior appropriators to cease or reduce withdrawals . . . ."[212] Furthermore, every groundwater permit includes an express condition that if it is later determined that surface water and groundwater are interconnected, the permit may be subject to regulation and correlation with surface waters.[213] Notably, the corrective controls grant the State Engineer a degree of flexibility to regulate in a manner other than strict priority enforcement that does not exist with pure priority enforcement. While the added flexibility is helpful in addressing surface and groundwater interactions, the flexibility creates less certainty in terms of how interference will be addressed.

The major issues of concern in Wyoming are the lack of clear criteria to prove connectivity between surface and groundwater, and its effect on the enforcement of priority rights.[214] The primary geographic areas of conflict appear to be in the fully appropriated Platte River Basin, particularly in the groundwater control areas. Most of the hydrologic connectivity issues that have arisen deal with interstate compacts. For example, under the Modified North Platte Decree, a joint settlement between Wyoming, Nebraska, and Colorado, a hydrologically connected groundwater well is defined as one "that is so located and constructed that if water were intentionally withdrawn by the well continuously for 40 years, the cumulative stream depletion would be greater than or equal to 28% of the total groundwater withdrawn by that well."[215]

Wyoming courts have had limited opportunities to clarify state law regarding conjunctive surface and groundwater management. Existing opinions give deference to State Engineer's determinations of interference. In *Wyoming State Engineer v. Willadsen*,[216] the Willadsens petitioned the State Engineer to curtail pumping from a junior groundwater well in order to prevent interference with their senior surface water rights. After conducting pumping tests and investigating the alleged interference, the State Engineer concluded that there was no measurable interference. The court deferred to the State Engineer's expertise, finding substantial evidence to support the finding.

Eighteen years later, a similar claim arose after the State Engineer decided to curtail groundwater pumping in the Bates Creek drainage because of impacts on surface waters.[217] In contrast to *Willadsen*, this time the State Engineer's investigation identified wells that were interconnected with surface waters. The plaintiffs failed to provide evidence rebutting the State Engineer's findings and the court again deferred to the State Engineer's findings.

These cases are important for two primary reasons. First, they demonstrate that the Wyoming State Engineer can and will manage surface and groundwater conjunctively, enforcing priority against junior groundwater developers when necessary to protect senior surface water right holders. Second, these cases highlight the important role science plays in resolving these disputes and the difficulty of challenging scientific findings. As the saying goes, "the party in groundwater litigation who has the burden of proof will lose. This is because of the presumed cost of trying to demonstrate physical reality."[218]

Managed aquifer recharge and recovery projects are currently uncommon in Wyoming. However, the concept has been studied in the Cheyenne area, and Laramie is currently investigating managed aquifer recharge and recovery as a technique for banking groundwater for later use.[219] Interest in managed aquifer recharge and recovery is also growing in relation to

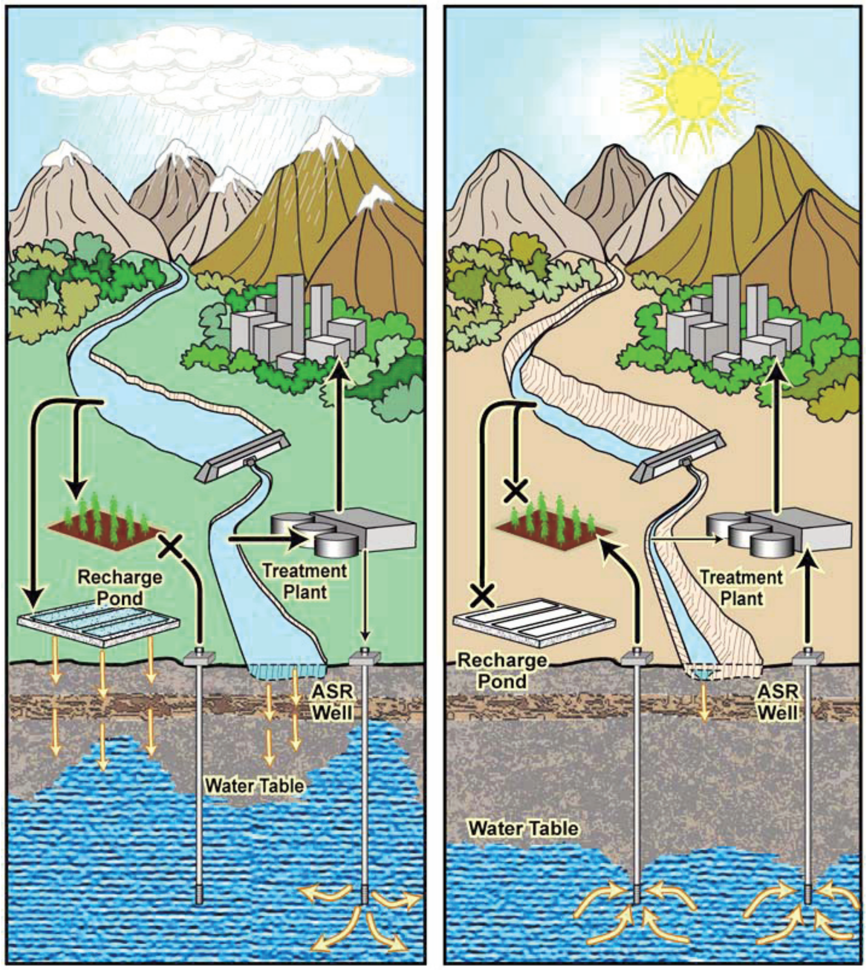

Figure 8 - Conjunctive Use
Source: Utah Division of Water Resources

energy production and produced water management.[220]

3.2. Colorado[221]

In Colorado, both surface and groundwater belong to the public.[222] Article XVI, sec. 6 of the Colorado Constitution declares that prior appropriation governs administration of natural streams; therefore the first in time shall be the first in right.[223] When the waters of a natural stream are unable to service all that claim a right, domestic users have preference over those claiming water for any other purpose, and agricultural users have preference over manufacturers.[224] The term "natural stream" includes the perennial and intermittent sources that supply the stream, including springs and percolating groundwater,[225] as well as underflow and tributary waters.[226]

The Colorado State Engineer is responsible for administration and distribution of waters of the state.[227] The state is divided into seven geographic regions or "divisions," and the State Engineer, with approval of the Director of the Department of Natural Resources, appoints one Division Engineer for each water division. The Division Engineer and his or her staff are responsible for day-to-day water administration. Field offices are staffed by Water Commissioners who are responsible for the hands-on administration of water rights. Each water division also has a water judge, appointed by the Colorado Supreme Court; a water referee, appointed by the water judge; and a water clerk, assigned by the district court. Water court judges are district judges and have jurisdiction in the determination of water rights, the use and administration of water, and ancillary matters necessary to the resolution of water right disputes.[228]

Applications for a surface water appropriation, groundwater appropriation, change of water right, approval of plan for augmentation or exchange, and findings of due diligence are filed with the water court clerk in the division in which the diversion or appropriation occurs. Permits for new or replacement wells, or for the increase or change in use of existing non-exempt[229] wells are approved if: (1) the withdrawal and use will not materially injure vested water rights, (2) unappropriated groundwater are available for withdrawal, and (3) the proposed well conforms to well spacing requirements.[230] Before a ruling is entered regarding an application, the referee consults with the appropriate division engineer, and that engineer files a written report regarding the consultation. Once an application is granted, the right holder must diligently develop the right or else it will lapse and revert to the state.

Under Colorado law, groundwater is "any water not visible on the surface of the ground under natural conditions."[231] Groundwater is also defined, for the purposes of the Water Rights Administration and Determination Act, as "water in the unconsolidated alluvial aquifer of sand, gravel, and other sedimentary materials, and all other waters hydraulically connected thereto which can influence the rate or direction of movement of the water in that alluvial aquifer or natural stream."[232]

Tributary groundwater is any underground water that is hydraulically connected to a stream system that influences the rate and/or direction of flow on that stream system.[233] Groundwater is presumed to be tributary to a surface stream and subject to prior appropriation, adjudication, and administration unless clear and convincing evidence shows that the groundwater is not tributary.[234] In accordance with this recognition, the "policy of the state is to integrate the appropriation, use, and administration of underground water tributary to a stream with the use of surface water in such a manner as to maximize the beneficial use of all waters of the state."[235] Accordingly, groundwater withdrawals that interfere with senior rights to the utilization of surface water may be enjoined, when necessary, to ensure the proper administration of the prior appropriation doctrine.[236]

In 1969, Colorado adopted the Water Right Determination and Administration Act, which, among other things, states that tributary groundwater and surface water are administered in accordance with the doctrine of prior appropriation, in accordance with their priority.[237] Withdrawal of tributary groundwater requires a state-issued permit. Any new groundwater diversions that are tributary to an over-appropriated stream system require a water court-approved augmentation plan to offset out-of-priority depletions.[238]

Complicating matters, there are three other types of groundwater in Colorado. And while the prior appropriation doctrine generally applies except as set forth below, the "doctrine should be modified to permit the full economic development of designated ground water resources."[239] Historic water levels are therefore not maintained and a reasonable level of groundwater mining is acceptable.

"Designated" groundwater basins are areas in the eastern plains with very little surface water where users rely primarily on groundwater. There are eight designated groundwater basins within Colorado and groundwater in these basins is subject to a modified system of prior appropriation, governed by a twelve-member Ground Water Commission.[240] "The general rule is that the rate of withdrawal from a proposed well cannot exceed 40% depletion within 100 years. If the rate of depletion exceeds 40% calculated for a three-mile circle, then the area within the circle is considered overappropriated and the well permit application will be denied."[241] Special rules also apply within the Denver Basin.[242]

"Nontributary" groundwater is groundwater "located outside the boundaries of any designated ground water basin in existence on January 1, 1985, the withdrawal of which will not, within 100 years, deplete the flow of a natural stream . . . at a rate greater than one tenth of one percent of the annual rate of withdrawal."[243] A system of modified appropriation applies, and the right to divert nontributary groundwater is based on land ownership or the owners' consent to withdraw.

"Not nontributary" groundwater is groundwater "located within those portions of the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers that 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 . . . at an annual rate of greater than one-tenth of one percent of the annual rate of withdrawal."[244] Not nontributary groundwater is subject to special rules specific to these designated aquifers. "[T]he 0.1% test is so comprehensive, and the burden of proof so difficult to sustain, that the Colorado system substantially protects surface flows," at least with respect to non nontributary groundwater[245]

Whether nontributary or "not nontributary" groundwater is available for withdrawal outside designated groundwater basins generally depends on the "amount of unappropriated water, exclusive of artificial recharge, underlying the land owned by the applicant or underlying land owned by another who has consented to the applicant's withdrawal."[246]

Prospective unconventional fuel developers should be aware that well permits are required for gravel pits that intercept groundwater and have the potential to affect water rights.[247] Presumably, this requirement would apply equally to other large excavations such as surface mines. A well permit is also required for water extraction occurring as part of the coalbed methane extraction process.[248] In late 2009 and early 2010, the State Engineer's Office promulgated Rules and Regulations for the Determination of the Nontributary Nature of Ground Water Produced Through Wells in Conjunction with the Mining of Minerals.[249] These rules identified nontributary oil and gas producing areas throughout Colorado and created a process for the identification of other such areas. These areas can be quite large, reducing significantly the number of oil and gas wells requiring water right permits. For wells outside of nontributary areas and within an over-appropriated water basin, well operators must replace depletions to prevent material injury to vested water right holders.

Colorado authorizes the holders of valid water rights, under conditions set forth in statute and administrative rules, to artificially recharge an aquifer and enjoy the benefit of the augmentation if the aquifer can accommodate the recharged water without injury to decreed senior water rights.[250] "[T]he Water Court may issue a conditional decree for storage of water in underground aquifers if the applicant can and will lawfully capture, possess, and control water for beneficial use which it then artificially recharges into the aquifer."[251]

A party proposing an aquifer storage project must, at a minimum:

(1) capture, possess, and control the water it intends to put into the aquifer;

(2) not injure surface or groundwater users by appropriating recharge water;

(3) not injure water use rights, either surface or underground, as a result of recharging the aquifer and storing water in it;

(4) show that the aquifer is capable of accommodating the stored water without injuring other water users;

(5) show that the storage will not interfere with overlying landowners' use and enjoyment of their property;

(6) not physically invade the property of another by activities such as directional drilling, or occupancy by recharge structures or extraction wells, without proceeding under eminent domain procedures;

(7) have the intent and ability to recapture and use the stored water; and

(8) have an accurate means for measuring and accounting for the water stored and extracted.[252]

Figure 9 - White River Valley West of Meeker, Colorado
Source: John Ruple

As of 2004, there were nineteen managed aquifer recharge projects underway in Colorado. Notable projects include groundwater augmentation in the lower South Platte River Basin, seasonal storage as part of conjunctive use of ground water and surface water in the San Luis Valley, direct injection by two water districts in the Denver Basin, and regulation of water supply and water quality at several smaller municipal water systems.[253] Interest in expanding these efforts appears high.

3.3. New Mexico

In New Mexico, unappropriated water belongs to the public and is subject to appropriation for beneficial use in accordance with state law.[254] Water rights are regulated, both as to volume and periods of use, by either permits issued by the State Engineer or court decrees.[255] Priority of appropriation gives the better right, and the doctrine applies to both surface and groundwater rights.[256] As in other western states, beneficial use is the basis, measure, and limit of the right to use water.[257] Surface water supplies are fully appropriated statewide, and groundwater supplies are fully appropriated in many areas of the state.[258] Most water right acquisition activity therefore involves purchase and transfer of existing water rights.

Permits are required for the withdrawal of surface and groundwater, through separate but substantially similar procedures.[259] A permit application must be filed with the State Engineer's office.[260] In determining whether to grant a permit application, the State Engineer considers potential impairment to existing water rights, conservation of water resources, and the public welfare.[261] The State Engineer may issue permits to appropriate water subject to conditions.[262] Therefore, in fully appropriated groundwater basins, the State Engineer may require as a condition of approval to issued permits, the acquisition and retirement of surface water rights offsetting the impacts proposed groundwater pumping will have on surface supplies.[263] Once granted, permits must be diligently developed or they will lapse and the water right will revert to the state.

Despite the New Mexico Constitution's adherence to the prior appropriation doctrine, New Mexico, like Utah, has been reluctant to enforce priorities. Priority enforcement has generally been left to private parties and instead of priority enforcement, New Mexico began a lease-purchase program to acquire and retire senior water rights in order to meet interstate compact delivery requirements.[264] This preference notwithstanding, the New Mexico Legislature, in 2003, passed a bill recognizing the State Engineer's authority "to administer water allocations in accordance with the water right priorities," and directing the State Engineer to promulgate regulations for priority-based administration.[265] These regulations require the State Engineer to: (1) determine the elements of water rights, including priority, (2) set an administration date delineating which water rights are out-of-priority and must cease diversion; and (3) define enforcement mechanisms that enable curtailment of out-of-priority water rights.[266]

The initial regulations promulgated by the State Engineer were challenged, in part, as violating the principles of separation of powers by authorizing the State Engineer to exert an exclusively judicial function in determining the elements of water rights. In contrast to a recent Utah Supreme Court opinion,[267] the New Mexico court held that "[t]he New Mexico Constitution contains nothing to indicate that determination of the elements of water rights is consigned exclusively to the judicial branch . . . . Nor do basic principles of separation of powers prohibit administrative agencies from engaging in the processes of making factual and legal determinations respecting the rights of individuals."[268] However, the court also held that the legislature had failed to grant the State Engineer authority to determine priorities, concluding that, "the Legislature did not intend . . . to provide the State Engineer with the additional power of determining water right priorities as among water rights owners and to curtail water usage based upon such administrative determinations."[269] Thus, the State Engineer is empowered to consider adjudication decrees and licenses, but not file records or other evidence that was neither expressly identified by the legislature nor the subject of prior judicial proceedings.[270]

In terms of day-to-day administration, conjunctive management in New Mexico began in 1956, when the State Engineer ruled on a water right application from the City of Albuquerque, requiring the city to retire surface water rights to offset the effects of groundwater pumping.[271] The State Engineer's 1956 ruling was appealed to the State Supreme Court, which concluded that the State Engineer had properly conditioned the permit on retirement of surface water rights equivalent to the depletions resulting from the new wells.[272] The court recognized both the need for conjunctive management, and that the State Engineer's power to deny an application also included the inherent power to fashion mitigation to avoid the harsh result of denial.[273] "Since that ruling, water rights and stream-related groundwater basins in the state have been administered based on the effects on surface water."[274]

New Mexico allows managed storage of water in groundwater aquifers for later use.[275] Construction or operation of a storage and recovery project in a declared groundwater basin requires a State Engineer issued permit. A project is defined by the Act as a facility designed to "add measured volumes of water by injection or infiltration to an aquifer or system of aquifers, to store water underground and to recover it for beneficial use."[276] The State Engineer may permit such projects provided that the project will not impair existing water rights or the state's interstate obligations, and that it will not be contrary to the conservation of water or detrimental to the public welfare.[277]

In New Mexico, the Middle Rio Grande Basin, which includes Albuquerque, has experienced severe groundwater overdrafts and localized water level declines of more than 120 feet.[278] In response to these declines and water availability concerns, the Albuquerque Bernalillo County Water Utility Authority (ABCWUA) and City of Rio Rancho have both initiated managed aquifer recharge projects. ABCWUA operates a 3,000 AF/Y project infiltrating treated stormwater, and a 30,000 AF/Y project to inject treated stormwater is in the planning phase.[279] Rio Rancho has an injection and infiltration project underway, recharging a total of 1,700 AF/Y of reclaimed wastewater.[280]

3.4. Nevada

In Nevada, "[t]he water of all sources of water supply within the boundaries of the State whether above or beneath the surface of the ground, belongs to the public."[281] As a prior appropriation state, the first in time is the first in right,[282] and "[b]eneficial use shall be the basis, the measure and the limit of the right to the use of water."[283]

All uses of water, whether from surface or underground sources, other than single-family residential uses of less than two AF/Y, requires a permit from the State Engineer.[284] The State Engineer must deny applications "where there is no unappropriated water in the proposed source of supply, or where its proposed use or change conflicts with existing rights or with protectable interests in existing domestic wells, . . . or threatens to prove detrimental to the public interest."[285] Additionally, applicants must show good faith to construct the works necessary to put the water to the intended beneficial use with reasonable diligence, and must have the financial ability to construct the project and apply the water to beneficial use with reasonable diligence.[286] The State Engineer also "has the inherent authority to condition his approval of an application to appropriate based on his statutory authority to deny applications if they impair existing water rights."[287] Water rights not diligently developed revert to the state.

Most surface waters within Nevada were appropriated before enactment of the Nevada Water Code in 1905, and pre-code uses are recognized as valid rights pursuant to detailed adjudication procedures.[288] Most groundwater development in Nevada began after 1960.[289] Groundwater withdrawals are limited to the natural recharge of the groundwater basin.[290]

Application for a water right permit are limited to only one source of water, even if the intended use requires water from more than one source, or a supplemental source.[291] The Nevada Division of Water Planning identified separate management of surface and groundwater resources and the inability to combine water right permitting across connected sources as impediments to effective integrated water management.[292] Other issues include limited knowledge of water resources as a whole – "[e]ffective management of the surface and groundwater supplies depends on a clear understanding of the nature and interaction of the water resources."[293]

According to the Nevada State Water Plan,

> The State of Nevada encourages conjunctive management of groundwater and surface water resources, to improve the reliability, economics and yield of available water supplies. The goal of conjunctive use of water systems in Nevada is to maximize the total yield of water. One approach is to maximize the use of surface water supplies when they are available and only rely on groundwater when surface water is not available . . . . Another goal of integrated water management is to encourage the use of higher quality water sources for uses such as public drinking water supply. Lower quality sources can then be used for agricultural and landscape irrigation, mining, and other commercial and industrial uses which do not require potable water.[294]

Managed groundwater recharge is an attractive option in Nevada because of lower cost when compared to surface reservoir construction, and because evaporative loss in southern Nevada can be eight feet or more per year. Evaporation losses from managed aquifer recharge projects are "non-existent."[295]

Managed aquifer recharge projects require a permit from the State Engineer; permits are granted if: (1) the applicant has the technical and financial capability to construct and operate a project, (2) the applicant has a right to use the proposed source of water for recharge, (3) the project is hydrologically feasible, (4) the project is in an active management area and consistent with the program of augmentation for that area, and (5) the project will not cause harm to users of land or other water within the area of hydrologic effect of the project.[296] Once approved, projects are subject to ongoing monitoring and annual reporting requirements.[297]

Currently there are at least six ongoing aquifer recharge projects within Nevada.[298] Most conjunctive use projects involve injection of excess surface water into underground aquifers for use during times of limited surface water.[299] The most notable managed aquifer recharge program is in the Las Vegas Valley, where managed recharge has been occurring since 1987. These efforts were a response to a drop in the water table of approximately 150 feet and have lead to a stabilization and slight raising of the water table. As of December 2003, there were as many as fifty-three artificial recharge wells in the Las Vegas Valley, injecting at rates of up to 315.6 AF/day. Currently, the Las Vegas Valley Water District has seventy-eight permitted aquifer recharge wells. As of December 31, 2010, the Las Vegas project had banked roughly 360,000 AF of water, providing important insurance against drought or disruption of Colorado River supplies.[300]

3.5. Idaho

In Idaho, "[a]ll the waters of the state, when flowing in their natural channels, including the waters of all natural springs and lakes within the boundaries of the state are declared to be the property of the state."[301] Between appropriators, the first in time is the first in right.[302] All appropriations must be for a beneficial purpose, and when that purpose ceases, the right ceases.[303] The prior appropriation doctrine governs the use of both surface water and groundwater in Idaho.[304] Water rights are obtained only through state-issued permits, which are required for all appropriators, other than for the diversion of groundwater for domestic purposes.[305]

Applications to appropriate both surface and groundwater are filed with the Director of the Department of Water Resources, who evaluates the application for impacts on existing water rights, the adequacy of the water supply for the proposed use, whether the application is filed for speculative purposes, the financial ability of the applicant to complete the project, and the effect of the proposed use on the local public interest.[306] The Director may reject, condition, or grant a permit for a reduced amount if the new water right fails to fully satisfy these requirements.[307] A portion of the Snake River Basin is held in trust by the State for the Idaho Power Company. Applications in this area are subject to additional criteria.

In Idaho, the party claiming that a common groundwater supply exists bears the burden of demonstrating continuity.[308] A common groundwater supply will be found where (1) the groundwater source receives water from or supplies water to a surface water source, (2) groundwater withdrawals cause surface waters to recede, or (3) groundwater diversions impact other groundwater users.[309] Where a common groundwater supply has been established, new groundwater withdrawals are, two narrow exceptions aside,[310] not allowed where withdrawals would affect "the present or future use of any prior surface or ground water right or result in the withdrawing of the ground water supply at a rate beyond the reasonably anticipated average rate of future natural recharge."[311]

With respect to conflicts between existing rights, administrative rules promulgated by the Department of Water Resources and applicable to the Eastern Snake River Plain Aquifer address enforcement of priority against junior groundwater appropriators.[312] The rules temper strict priority enforcement with "reasonable use" requirements, authorizing administrative enforcement of priorities only if the senior appropriator "is suffering material injury," and authorizing the Director to consider whether both the senior and junior appropriators are diverting and using water efficiently and without waste.[313] Notably, the Director can consider whether the senior water right could be filled without curtailing junior wells if the senior appropriator would use "alternative reasonable means of diversion or alternative points of diversion, including the construction of wells or the use of existing wells . . . ."[314]

The Idaho Legislature also gives "maximum support" to groundwater recharge programs, declaring that appropriations for groundwater recharge are consistent with beneficial use requirements.[315] The Department of Water Resources approves, disapproves, or modifies groundwater recharge projects based on adverse impacts to existing water rights.[316]

The State of Idaho is in the process of revising its statewide water plan. With respect to conjunctive management, the Draft Plan identifies six goals: (1) quantify the hydraulic relationship between groundwater supplies, surface water supplies, and spring flows in designated river basins, (2) prioritize basins where additional technical information is needed to assess ground and surface water interaction, (3) develop enhanced technical tools for evaluating the interaction between surface and groundwater resources for use in planning and administration, (4) increase measurement and monitoring of spring flow, (5) continually assess conditions and trends of groundwater levels in primary aquifers to estimate the rate of future aquifer recharge and withdrawal under various climatic conditions, and (6) procure funding to implement these goals.[317]

The Draft Plan also recognizes managed aquifer recharge projects as "an important element in meeting future water use needs."[318] The Draft Plan identifies five goals specific to managed aquifer recharge projects: (1) cooperate on implementing, evaluating, and managing recharge projects, (2) update statutes and rules to better facilitate these projects, (3) identify river basins where managed recharge projects have the greatest potential to address increased demand on water supplies, (4) monitor and evaluate recharge projects to document effects on water supply and water quality, and (5) create and appoint an Aquifer Storage and Recovery Task Force.[319]

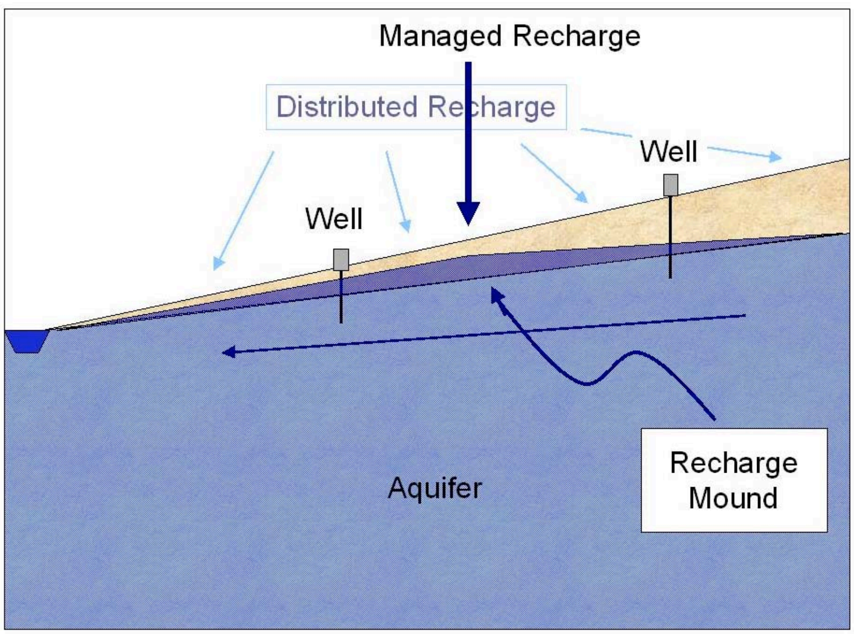

Figure 10 - Managed Aquifer Recharge and Mounded Groundwater
Source: Idaho Department of Water Resources

There are currently no managed aquifer recharge projects in Idaho.[320] Interest in managed recharge within the Eastern Snake River Plain, however, has existed since at least 1962 and responds to concerns over groundwater mining. Ongoing planning efforts anticipate phased recharge, eventually involving up to 600,000 AF of storage. Costs for Phase I, which calls for roughly 186,000 AF, are anticipated at approximately $3 per AF.[321]

The best example of conjunctive management occurs in the Eastern Snake River Plain, where trout farms holding senior water rights rely on high quality spring water for their operations. Groundwater pumping by agricultural users holding junior water rights has resulted in diminished spring flows and injury to the trout farmers. In the face of potentially curtailment, a coalition of groundwater districts agreed to pay $30 million for roughly 400 CFS of senior spring water flows. These spring flows will be leased back to the trout farmers subject to curtailment during periods of impairment. Essentially, the transaction shifts the burden of curtailment from agricultural users to the trout farmers in return for financial payments offsetting that risk. The transaction succeeds because the cost of the water is lower than the value of the agricultural production foregone.[322]

While most attention to managed aquifer recharge within Idaho has involved the Eastern Snake River Plain, the Idaho Department of Water Resources recently investigated managed aquifer recharge in the Treasure Valley, southwest of Boise. Investigations respond to concerns that climate change will make snowmelt fed runoff less reliable and complicate surface reservoir operations. By distributing recharge, the Department of Water Resources believes that an additional 200,000 to 400,000 AF of storage can be readily attained. Water conveyance infrastructure, however, is a limiting factor.[323]

3.6. Divergent State Approaches

State-specific discussions of conjunctive management have thus far focused on states that have unconventional fuel resources and Utah's northern neighbors. Arizona, California, and Texas have adopted different approaches to surface and groundwater management that deserve mention. Key aspects of these three states' approaches to conjunctive management are discussed in turn.

In California, the prior appropriation doctrine applies to surface water and to "subterranean streams flowing through known and definite channels."[324] All other groundwater, referred to as "percolating water," is administered subject to the correlative rights doctrine.[325] "This doctrine allows the use of percolating water on overlying land subject to the rights of other overlying owners to use a fair and just proportion of the supply without regard to when their uses commenced."[326] The correlative rights doctrine also allows the use of percolating water on nonoverlying lands if the supply exceeds the needs of overlying owners.[327] A permit is required to appropriate from a surface or subterranean stream; no permit is needed to take percolating water. Where conflicts between surface and groundwater appropriators arise, "the burden of proof is on the party seeking the protection of the surface water rules to demonstrate the existence of 'underflow' or a 'subterranean stream.'"[328]

The California Court of Appeals strictly interprets claims of appropriation from subterranean streams, requiring proof of: (1) a subsurface channel, (2) a bed and banks that are relatively impermeable, (3) a course that is known or knowable by reasonable inference, and (4) a flow of groundwater in the channel.[329] The fourth requirement does not require water to flow precisely in the subsurface channel at all times, but subterranean streams must flow in the same general direction as the channel.[330] "Despite the court's inclusive approach to the fourth requirement, the four-element test of a subterranean stream probably leaves much ground water that is hydrologically connected to a surface stream outside of the appropriation system."[331]

Similar to California, Arizona applies the prior appropriation doctrine to surface streams and their subflow, but leaves percolating water to the common law of reasonable use.[332] The line between appropriable groundwater and percolating groundwater is often unclear. Subflow, in Arizona, is defined narrowly as "those waters which slowly find their way through the sand

and gravel constituting the bed of a stream, or the lands under or immediately adjacent to the stream, and are themselves part of the surface stream."[333]

> [I]f a well is drawing water from the bed of a stream, or from the area immediately adjacent to a stream, and that water is more closely related to the stream than to the surrounding alluvium, . . . the well is directly depleting the stream. If the extent of depletion is measurable, it is appreciable. This is not an all-or-nothing proposition. For example, if the cone of depression of a well has expanded to the point that it intercepts a stream bed, it almost certainly will be pumping subflow. At the same time, however, it may be drawing water from the surrounding alluvium. Thus, part of its production may be appropriable subflow and part of it may not.[334]

Including in subflow any measurable surface water depletion associated with groundwater withdrawals effectively increases the reach of Arizona's prior appropriation doctrine to include many, if not most, groundwater wells.[335] Thus, Arizona, while often seen as a holdout in its treatment of surface and groundwater, is trending towards increased recognition of hydraulic continuity.

In Texas, apart from the Edwards Aquifer, surface water appropriations are subject to the prior appropriation doctrine and percolating groundwater is subject to the absolute ownership of the overlying landowner. The absolute ownership doctrine effectively allows the overlying landowner to pump groundwater from beneath their land without regard to the effect withdrawals may have on others.[336] Local groundwater districts have some authority to regulate percolating groundwater, but this authority has been exercised ineffectively.[337]

Within Texas, the Edwards Aquifer is subject to a conjunctive management program that requires groundwater withdrawal permits and caps annual withdrawals. The program is an outgrowth of litigation challenging Texas' failure to regulate groundwater withdrawals, and unmitigated impacts to habitat for federally protected species.[338] Thus, federal law is in many ways driving Texas' approach to conjunctive management.

Even though Arizona is trending towards greater recognition of hydrologic realities, California, Arizona, and Texas remind us that water law may not reflect scientific reality. Conjunctive management is a rapidly evolving area of law, and prospective unconventional fuel developers should be aware of counterintuitive laws, regulatory gaps, and ongoing evolution of this area of water law.

3.7. Conjunctive Management Under Federal Law

The federal government has historically deferred to the states for water resource allocation and water rights administration is, apart from certain narrow but important exceptions, a matter of state law.[339] Despite expansive federal deference to the states, federal law still generally prevails and state water resource allocation remains subject to the federal constitutional limitations.[340] If states fail to develop adequate rules to address conjunctive surface and groundwater issues, federal interests may demand federally imposed solutions.

Reserved water rights provide the best example of the federal government's role in water resource allocation.[341] When the federal government reserves land for a specific purpose, it impliedly reserves the right to sufficient water to serve the primary purpose of the reservation.[342] These "reserved rights" carry a priority date reflecting the date upon which the reservation was created or the associated use began. Where reservations were created long ago, the associated reserved rights can be some of the most senior water rights within a basin.

Federal reserved rights law recognizes the frequent connection between surface and groundwater resources, and that both are "integral parts of the hydrological cycle."[343] Where junior groundwater withdrawals impair senior federal surface water rights, the junior groundwater right must yield. For example, in *Cappaert v. U.S.*,[344] the federal government brought suit to enjoin groundwater pumping that caused the drawdown of an underground pool within the Devil's Hole unit of the Death Valley National Monument. The U.S. Supreme Court first concluded that the underground pool was surface water,[345] and then went on to hold that "groundwater and surface water are physically interrelated as integral parts of the hydrologic cycle . . . . [S]ince the implied-reservation-of-water-rights doctrine is based on the necessity of water for the purpose of the federal reservation . . . the United States can protect its water from subsequent diversion, whether the diversion is of surface or groundwater."[346] Thus, federal law can, under certain circumstances, require subordination of certain state issued water rights to senior federal water rights.

As ICSE noted with respect to reserved water rights within the Uinta Basin, the full extent of such rights is not always settled.[347] If claims of impairment were to arise in the context of reserved rights that remain subject to dispute over the timing, location, allowed use, or amount of withdrawal, the number of interrelated issues will complicate and delay settlement. Resolution of reserved rights claims therefore remains an important issue.

The 1996 settlement agreement resolving federal-reserved rights for Zion National Park goes beyond *Cappaert* by not only quantifying federally reserved groundwater rights, but providing for a groundwater protection zone. Within the two-mile wide groundwater protection zone surrounding the Park, the rate and amount of withdrawals is limited to protect flows in the Virgin River.[348] See Figure 11. Thus, settlement agreements may encompass more than just the nature and extent of the rights involved.

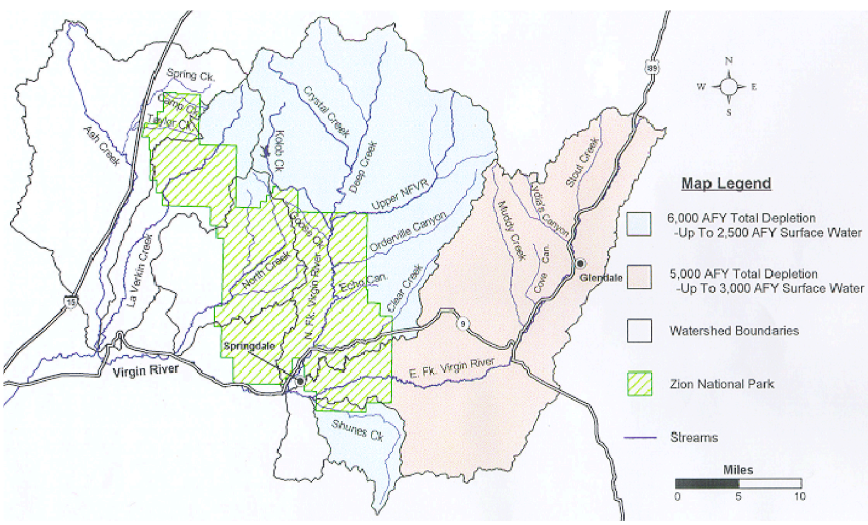

Figure 11 - Allowable Groundwater Depletions Near Zion National Park
Source: Zion National Park Water Rights Settlement Agreement

The connection between surface and groundwater flows is also recognized in apportioning water between states. In 1907, the U.S. Supreme Court held, as part of an interstate equitable apportionment case, that groundwater flowing alongside the Arkansas River should be treated as part of the flow of the river.[349] In more recent disputes involving interstate water compacts, the U.S. Supreme Court found the compacts covered not only surface water but also hydrologically connected groundwater, even where the compacts did not explicitly discuss groundwater.[350]

Federal reserved rights associated with Naval Oil Shale Reserves have some limited potential to provide water for commercial oil shale development.[351] The larger issue will be whether water used for energy development adversely impacts federal resources and the reserved water rights they encompass. The extent to which water resources are required to fulfill the primary purpose of the National Parks, Indian Reservations, and federal facilities within eastern Utah and northwestern Colorado will need further exploration.

Connection between surface and groundwater resources also raises qualitative concerns that are beyond the scope of this report. While not discussed specifically, unconventional fuel developers should be aware that changes in surface conditions that result from withdrawal of connected groundwater resources can impact water temperature, riparian vegetation, contaminant dilution, or other factors regulated under the Clean Water Act. Changes in surface water quantity or quality may likewise impact water dependant species or the habitat they depend upon. In some cases, this could raise issues under the Endangered Species Act (ESA).[352]

Overall, emerging approaches to conjunctive surface and groundwater management are more similar than different, with a strong push towards integrating complex scientific principles into an historic body of law. The thirst for a solid foundation of information upon which to make decisions comports with a growing emphasis on “reasonableness” in groundwater management. Despite these similarities, the differences between states remain significant and telling, with some states presuming continuity while others presume discontinuity. Likewise, states recognize that changes to conform to modern understanding can have far-reaching impacts on institutions that grew up during simpler times. The appropriate balance between the need for certainty, the need for accuracy, and the practical constraints involved in modeling efforts requires policy judgments that defy hard and fast rules. One size will not fit all due to divergent physical conditions and political realities. The unconventional fuels industry will therefore need to employ flexible and creative approaches to water management in order to capitalize on Utah’s rich oil shale and oil sands resources.

4. Implications for Oil Shale and Oil Sands

Oil shale and oil sands production will require water, and potentially lots of it.[353] A 100,000 barrel-per-day (BPD) oil shale industry would require approximately 7,000 to 14,000 AF/Y of water; a comparably sized oil sands industry would require 11,000 to 33,000 AF/Y.[354] To put this in perspective, average annual household usage in Utah is 0.6 AF/Y;[355] so based on a mid-range estimate, a 100,000 BPD oil shale industry would require slightly more water than the city of Ephraim, Utah.[356]

Figure 12 - White River Near Bonanza, Utah
Source: John Ruple

While water use associated with a developing unconventional fuels industry is small in comparison to Utah's entitlement to Colorado River water, approximately 1.37 million AF/Y,[357] Utah's water resources are already fully allocated. New water uses must therefore displace either existing uses or future uses such as municipal growth that have yet to occur but for which water supplies have been dedicated. Major new water uses are therefore certain to receive critical attention and public scrutiny.

New water developments will need careful planning to maximize efficiencies and minimize impacts to other water users and water-dependent natural processes. These planning efforts must continue to expand our understanding of the water resources involved. Simultaneously, the regulatory framework encompassing conjunctive management must continue to evolve as our scientific understanding improves.

As a practical reality, demand for water continues to grow while water supplies remain constant, and in many cases we are learning that past groundwater withdrawals are unsustainable, often necessitating reductions in pumping. The tension created by increasing demand for a finite resource drives interest in more efficient, integrated management. Interest in managed aquifer recharge projects also reflects a growing need for storage that is sensitive to siting limitations, opposition to new dams, and permitting challenges.

As an emerging field, conjunctive water resource management creates opportunities for creative entrepreneurs, allowing for more efficient water use and impact minimization. But decisions are only as good as the information upon which they are based, and the need for better understanding of interactions between surface and groundwater resources is a recurring theme in the published literature. Groundwater resources are often poorly understood, and their interactions with other resources are even less certain. Interactions between multiple groundwater wells remain difficult to predict, can take years to develop, and are difficult to quantify. Responses to cessation of groundwater withdrawals may also take time to occur, further complicating priority enforcement efforts. Better understanding of key water resources, the geologic formations in which they are contained, and the interactions between resources will be key to future development efforts.

Two of the most formidable challenges to western water users during the twenty-first century will be flow variability as exacerbated by a changing climate, and the need for water storage. These challenges are especially relevant to prospective unconventional fuel developers, and conjunctive management is well suited to addressing these issues. We first discuss major challenges and then turn to potential responses.

4.1. Dwindling Supplies

Mountains are natural reservoirs. Snow falls during the winter, accumulates, and melts gradually over the spring and summer, releasing as streamflow snow that fell months earlier. While these natural reservoirs are reasonably well suited for agriculture and seasonal irrigation, seasonal flows pose significant problems for year-round water use like energy production.

By way of example, average annual undepleted flows of the White River near the Colorado-Utah border are estimated at 590,100 AF,[358] with a mean flow of 604 CFS.[359] Flows vary year-to-year and season-to-season, with spring runoff swelling the river to an average discharge of 1,765 CFS during June — almost five times the average discharge experienced in December and January.[360] Such seasonal fluctuations are common for snowmelt-fed rivers and the seasonal nature of surface flows means that while excess water may exists during spring runoff, inadequate water may be found during winter months.

Climate change increases existing challenges by causing higher temperatures throughout the southwest, leading to higher evaporation rates, reductions in streamflow, and increased frequency of droughts — even in the absence of changes in precipitation.[361] Higher temperatures and a growing population translate into higher water demand; and greater stress on available water resources. Climate change could also affect overall precipitation levels, increase the proportion of moisture that falls as rain rather than snow, and change both the frequency and intensity of precipitation events.

4.2. The Need for Storage

In order to provide stable, year-around water supplies, many water users already turn to storage. Impoundments provide more stable supplies throughout the year and offer insurance against droughts. The combination of less reliable surface water flows and increased demand for water will necessitate more water storage. Development of new large-scale surface reservoirs, however, is both expensive and complicated.[362]

It is no surprise that past efforts to develop oil shale involved significant new surface water reservoir proposals. For example, anticipating an oil shale boom, the State of Utah, in

1965, filed to appropriate 250,000 AF from the White River and its tributaries, identifying the intended uses as mining, drilling, and retorting oil shale.[363] The Utah Division of Water Resources filed connected applications with the BLM, seeking authorization to construct an 11.7-mile-long reservoir, just west of the Colorado border. Interest in the project waned and the dam was not built. Questions exist regarding the continued validity of the water rights for this project, whether a reservoir could be built without imperiling fishes protected under the ESA, and evaporative loss associated with this reservoir.[364] In light of these concerns, the White River Reservoir may no longer be a viable option.

Figure 13 - Red Fleet Reservoir
Source: U.S. Bureau of Reclamation

During the last oil shale boom, the State of Colorado also considered constructing major impoundments along the White River.[365] As with Utah's White River Dam, interest withered with falling oil prices. Dams and other infrastructure, however, remain an important consideration. As of 2009, there were thirty-four conditionally decreed rights for reservoirs within Colorado's portion of the White River Basin.[366] A recent Colorado Water Court Order notes the Yellow Jacket Water Conservancy District's decision to abandon an approximately 130,000 AF water right associated with the proposed Warner Point Reservoir.[367] While the reason for abandonment is not stated, the Warner Point Reservoir site may have been abandoned because it would have inundated several miles of the White River and several very expensive ranches.[368]

4.3. Evaporation, Sedimentation, and Endangered Species

Three sub-issues associated with surface impoundments merit special attention: evaporation, sedimentation, and impacts on protected species. Much of the Uinta Basin is hot and dry. July high temperatures in Vernal, Utah average ninety degrees.[369] Warm temperatures and low humidity cause high evaporative loss from surface reservoirs. Evaporation rates are highly variable and dependent on both climatic and reservoir conditions; however, 40-45 inches per year is a rough estimate of annual free water surface evaporation for southern Uintah County, Utah.[370]

Vegetation is sparse throughout much of the Uinta Basin and soils can be easily eroded. Sediment washed into reservoirs can be a major issue as sediment reduces storage capacity. For example, the White River Reservoir would have impounded 109,250 AF of water and had an active storage capacity of 70,700 AF.[371] The difference between capacity and active storage — 38,550 AF or 35 percent of the reservoir's total capacity — was set aside for sediment storage. Complicating matters, as reservoirs fill with sediment, surface area remains constant while capacity decreases; as reservoirs become shallower over time, water temperature and evaporative loss increases. Surface impoundments therefore can become less useful over time.

Impacts to protected species, discussed at length in prior ICSE publications,[372] have the potential to halt water development projects and deserve brief reiteration here. The White, Yampa, and Green rivers are likely to experience pressure from unconventional fuel development, and all three rivers contain critical habitat for ESA-protected fishes.[373] The ESA requires protection of these species, imposing obligations on federal agencies, their agency licensees and permittees, state and local governments, and private individuals.[374] The ESA prohibits the "take" of listed animals, except under federal permit.[375] "Take" means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct."[376] "Harm" is defined as "an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering."[377] The ESA's prohibition on "take" may therefore preclude conventional reservoir construction.

Aquifer recharge and recovery projects provide an attractive alternative to conventional reservoirs. Evaporative losses are greatly reduced if not eliminated entirely, surface disturbances are reduced dramatically, and project costs are significantly lower. Minimizing evaporative loss and surface disturbance also reduces permitting challenges.

However, conjunctive use in general, and managed aquifer recharge and recovery projects in particular, is not a panacea. Managed recharge and recovery projects are premised on an implicit assumption that the water used for these projects has greater value as recharge than if it were left in the stream. The surface use foregone cannot be ignored as that water may have supported riparian habitat, sediment transport, or filled downstream reservoirs. Displacing these uses and biological functions may not be acceptable. Indeed, changes in river conditions, reduced sediment transport capacity and associated changes in river habitat and productivity, and reduced future flexibility in stream flow management resulting from increased consumptive use are identified as major threats to ESA listed fish native to the Colorado River system.[378]

4.4. Responding to the Challenges Ahead

Conjunctive management provides important benefits in allowing appropriators to use water more efficiently, utilizing surface flows when available, augmenting recharge with surface water flows when excess surface flows exist, and relying on groundwater when surface water resources are fully allocated or in need of protection. The ability to integrate multiple sources provides insurance against constraints on water availability associated with a single source of supply. Likewise, aquifer storage and recovery provides some protection against seasonal droughts and avoids many of the problems associated with conventional reservoir construction. Droughts and storage are likely to grow in importance over coming decades, demanding more integrated water management.

Conjunctive surface and groundwater management projects that capture peak spring flows and inject or infiltrate them to recharge potable water aquifers represent an attractive option, as they are much less expensive to construct than conventional reservoirs. Artificial recharge injection wells have a smaller surface footprint than reservoirs, which could translate into reduced project opposition. Infiltration galleries and spreading basins, while creating a larger surface imprint, can be incorporated into public amenities as nature areas or golf course water hazards.

While surface water diversions associated with aquifer storage projects will need to be timed to avoid injuring ESA protected fishes, timing withdrawals to avoid injury may be possible where on-channel reservoir construction is not. And, in the dry environs of eastern Utah, managed aquifer recharge projects also hold the promise of significantly reduced evaporative loss.

Water quality protections associated with conjunctive management projects represent important concerns. Injection into recharge wells requires permitting under the Safe Drinking Water Act. Spreading basins are generally not regulated under the Safe Drinking Water Act but may trigger state groundwater protection requirements. Managed groundwater recharge projects will be more difficult to monitor for water quality impairment than their aboveground counterparts, and any contamination that does occur could be very difficult to remediate. Water quality protections are therefore likely to emerge as larger issues as managed aquifer recharge projects become more common. The quality of groundwater into which recharge occurs as well as proposed and alternate uses of that water will be important concerns.

In light of water supply constraints, the almost certain need for storage, and the challenges to surface reservoir construction, managed recharge and storage represent an attractive option. Integrated surface and groundwater management and aquifer recharge and recovery projects create opportunities for prospective oil shale and oil sands developers — opportunities that may prove necessary if an unconventional fuel industry is to develop in the dry Uinta Basin. While spring runoff represents the obvious source of water for such projects, surplus irrigation water or reservoir storage spilled to increase reservoir flood control capacity could also represent promising sources of water. Creativity will be key in developing projects that respond to site-specific issues.

Earlier efforts to improve integration between surface and groundwater management contain important lessons for the unconventional fuel industry. First and foremost, good science is needed for good project design and to navigate the permitting process. Good modeling and the inputs required to obtain reliable results, however, do not come cheap. Others have noted the proliferation of million dollar models and the irony that hydrology's increased sophistication risks pricing it out of the legal universe.[379]

Voltaire famously said that perfect is the enemy of good enough. Nowhere is this truer than as applied to modeling surface and groundwater interactions. In light of the costs and challenges involved in modeling imperfectly understood systems, it may be preferable to endure a lack of precision in determining the interactions between the surface and groundwater than to impose standards so rigorous that they doom the party saddled with the burden of proof. "Simple analytical solutions or bright-line rules might come close to approximating physical reality and at a fraction of the transaction costs. For example, a bright-line rule such as 'no wells may be placed in the younger alluvium,' would encompass the most pronounced areas of hydraulic continuity, but could be implemented with relatively low transaction costs."[380]

While groundwater aquifers near Utah's richest unconventional fuel resources have not been as heavily studied as those along the Wasatch Front,[381] they have also not been subject to the extensive water development found along the Wasatch Front. While more information will be needed regarding geology and groundwater hydrology, the comparative lack of development may simplify modeling.

Extrapolating from existing projects may be difficult as managed aquifer recharge projects are almost universally associated with domestic and municipal uses. Whether industrial uses can utilize lower quality groundwater, and whether injection or infiltration can occur cost-effectively within the constraints imposed by the Safe Drinking Water Act remains to be seen.[382]

5. Conclusion

Our knowledge of groundwater systems is incomplete; and we know even less about the interaction between surface and groundwater resources. The uncertainties in natural systems are compounded when dealing with human interventions and the multiple points of diversion and withdrawal found in most basins. While uncertainty has allowed strict enforcement of priorities against groundwater appropriators to take a backseat to more holistic management of groundwater resources, the threat of priority enforcement remains a key driver in efforts to integrate and reform water resource management.

There is a clear shift towards recognition of connections between most surface and groundwater resources. States like Utah and Colorado embrace a presumption of continuity and even states like California and Arizona, that have traditionally treated surface and groundwater as separate resources, are progressing towards a more integrated approach to resource management. This trend is likely to continue as laws evolve to account for hydrologic realities.

The emphasis on "reasonableness" rather than strict priority enforcement is also a common theme in western efforts to advance more efficient and integrated groundwater management. This trend is also likely to continue as states seek to do more with less and encourage efficient groundwater withdrawals.

The challenges ahead remain numerous; our population continues to grow, and with it our thirst for water becomes increasingly hard to slake. Climate change will compound demand-side concerns by making supplies at best less reliable, and at worst appreciably smaller. Storage will become more important as a hedge against uncertain water supplies, but traditional surface storage is replete with problems: cost, evaporative loss, siltation, and impacts to other resources being only the most obvious.

Our growing population will continue to demand energy and liquid transportation fuels. Oil shale and oil sands hold promise to meet these needs. Great effort has gone into reducing the amount of water required for unconventional fuel development and demands have been reduced significantly. Despite these best efforts, a developed unconventional fuel industry will still need water; water that is in short supply throughout much of the west. Moving forward, we must do more with less.

Conjunctive surface and groundwater management — both the practice of integrating surface and groundwater into a single supply network, and the utilization of managed aquifer recharge and recovery projects — hold promise as a way of doing more with less. Integrating supplies creates redundancy and insulation against supply interruptions. Managed recharge and storage allows for optimum utilization of available resources while creating additional assurances against supply interruptions. Both will be critical to a budding unconventional fuel industry.

Emergent industries benefit from integrated surface and groundwater supplies that recognize natural system fluctuations and harness that variability. Flood water is available sporadically, but if captured when available, can provide significant benefits. When use is harmonized with carefully planned groundwater withdrawals, supplies can be firmed up and costs minimized. Opportunities similar to those presented by flood flows may be available with stormwater runoff and surplus water.

While managed aquifer recharge projects are most commonly associated with efforts to firm domestic and municipal supplies, the concepts apply more broadly. In arid regions like the Uinta Basin where energy development could introduce significant new stresses on limited water supplies, managed aquifer recharge may represent both a cost-effective and environmentally preferable path forward. Fortunately, the nascent oil shale and oil sands industries are not tied to the technologies of yesterday and may be uniquely positioned to take the lessons learned from what have been largely potable water projects and apply them in an industrial context.

Our knowledge of surface and groundwater interactions is incomplete and answering the pressing questions of tomorrow will require improved understanding of natural processes. Large-scale unconventional fuel development will likely need state-of-the-art models to address the high level of scrutiny first of kind projects will face. But there is an at least equal need for less complex models that can be widely deployed to address the types of challenges that arise frequently.

Conjunctive management is not a ticket to unlimited water supplies, but a path to better integration and more efficient management of the resource that are available. Unconventional fuel developers will need vision to realize the benefits offered by conjunctive management. They will also need patience, as regulations are often underdeveloped. Operators should engage water resource managers and regulators early, seeking creative answers to hard questions. Flexibility will be required and permits should, to the extent possible, be drafted to adapt to dynamic hydrologic conditions. With effort and planning, conjunctive surface and groundwater management can prove invaluable to the emerging unconventional fuels industry.

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Sierra Club v. Lujan, 1993 WL 151353 (W.D. Texas 1993).

Wyoming

CONSTITUTION OF THE STATE OF WYOMING.

WYOMING STATUTES ANNOTATED (multiple titles, chapters, and sections).

1947 WYO. SESS. LAWS ch. 107.

Hunt v. City of Laramie, 181 P. 137 (Wyo. 1919).

Willey v. Decker, 73 P. 210 (Wyo. 1903).

Wyoming State Eng'r v. Willadsen, 792 P.2d 1376 (Wyo. 1990).

Yentzer v. Hemenway, 441 P.2d 320 (Wyo. 1968).

Endnotes

[1] The hydrologic cycle is "a natural system embracing the endless circulation of water between the ocean, atmosphere and land." IAN WEBSTER & ALISTER D. BURNETT, HYDROLOGY, AN ENVIRONMENTAL APPROACH 23 (1995 ed.). "Water is drawn up from the seas into the atmosphere and moves over the land masses in the form of clouds that deposit moisture. This deposited moisture then flows toward the oceans or is lost through evaporation, transpiration, or seepage into the soil." 1 WATER AND WATER RIGHTS § 1.03 (Robert E. Beck & Amy L. Kelley, eds., 3rd ed.).

[2] Bd. of County Com'rs of County of the Park v. Park County Sportsmen's Ranch, 45 P.3d 693, 702 (Colo. 2002), *citing* U.S. Geological Survey Circular 1139, *Ground Water and Surface Water, A Single Resource* 9 (1999).

[3] WEBSTER & BURNETT, HYDROLOGY, *supra* note 1 at 9.

[4] Park County Sportsmen's Ranch, 45 P.3d at 702 (internal quotations and citations omitted).

[5] 3 WATER AND WATER RIGHTS *supra* note 1 at § 18.02.

[6] *Id*.

[7] *See e.g*. Current Creek Irr. Co. v. Andrews, 344 P.2d 528, 534 (Utah1959) ("Because our state is comparatively dry and arid, from the earliest times it has been the policy of our law to encourage in every possible way the discovery and development of water and the broadest and most continuous application to useful purposes.").

[8] *See generally*, Steven L. Rhodes & Samuel E. Wheeler, *Rural Electrification and Irrigation in the U.S. High Plains*, 12 J. RURAL STUDIES 311-17 (1996).

[9] *See id.*

[10] 3 WATER AND WATER RIGHTS § *supra* note 1 at 18.02 (internal citations omitted).

[11] *Id*.

[12] Robert Jerome Glennon & Thomas Maddock, *The Concept of Capture: The Hydrology and Law of Stream/Aquifer Interactions*, FORTY-THIRD ANNUAL ROCKY MOUNTAIN MINERAL LAW INSTITUTE § 22.03[1] (1997), cited with approval in Bd. of County Com'rs of County of the Park v. Park County Sportsmen's Ranch, 45 P.3d 693, 702 (Colo. 2002).

[13] A. DAN TARLOCK, LAW OF WATER RIGHTS AND RESOURCES § 6.9 (internal citations omitted) (2009 ed.).

[14] 3 WATER AND WATER RIGHTS *supra* note 1 at § 18.02.

[15] *See In re* Gen. Adjudication of All Rights to Use Water in Gila River Sys. & Source, 857 P.2d 1236, 1243 (Ariz. 1993) (*Gila River II*) (discussing reluctance to embrace conjunctive management for fear of impacting vested rights).

[16] Barton H. Thompson, Jr., *Beyond Connections: Pursuing Multidimensional Conjunctive Management*, 47 IDAHO L. REV. 265 , 267 (2011).

[17] The state water plan is available at http://www.water.utah.gov/waterplan/default.htm; basin specific plans are available at http://www.water.utah.gov/planning/waterplans.asp.

[18] *See* Amy Joi O'Donoghue, *Officials Want to Study Utah Snowpack Impact on Groundwater Supplies, Aquifers*, DESERET NEWS (July 20, 2011).

[19] Mountain Lake Mining Co. v. Midway Irrigation Co., 149 P. 929, 936–37 (Utah 1915) (Frick, J., concurring).

[20] Rasmussen v. Moroni Irrigation Co., 189 P. 572, 576 (Utah 1920).

[21] *See* JOHN RUPLE & ROBERT KEITER, TOPICAL REPORT: POLICY ANALYSIS OF WATER AVAILABILITY AND USE ISSUES FOR DOMESTIC OIL SHALE AND OIL SANDS DEVELOPMENT (2010) (hereinafter WATER AVAILABILITY TOPICAL REPORT); *see also* ROBERT KEITER, JOHN RUPLE & HEATHER TANANA, TOPICAL REPORT: POLICY ANALYSIS OF PRODUCED WATER ISSUES ASSOCIATED WITH IN-SITU THERMAL TECHNOLOGIES (2011) (hereinafter PRODUCED WATER TOPICAL REPORT). ICSE Topical Reports are available at http://www.ices.utah.edu/index.jsp?leftnavid=5;&subleftnavid=24;.

[22] UTAH CODE ANN. § 73-1-1(1).

[23] § 73-3-1; Bullock v. Tracy, 294 P.2d 707, 709 (Utah 1956) and cases cited therein. The right must be perfected by diversion to a beneficial use. Duchesne County v. Humphreys, 148 P.2d 338, 339 (Utah 1944).

[24] 1903 Utah Laws, ch. 100, § 34. *See also Bullock*, 294 P.2d at 709.

[25] Wrathall v. Johnson, 40 P.2d 755 (Utah 1935).

[26] 1935 Utah Laws 195 (amending 1933 Utah Laws § 100-3-1).

[27] Robert W. Swenson, *A Primer of Utah Water Law: Part I*, 5 J. ENERGY L. & POLICY 165, 169 (1983-84). at 174 (*citing* Bishop v. Duck Creek Irrigation Co., 241 P.2d 162 (Utah 1952); Robinson v. Schoenfeld, 218 P. 1041 (Utah 1923); Patterson v. Ryan, 108 P. 1118 (Utah 1910)).

[28] 1919 Utah Laws 177 (emphasis added).

[29] *See, e.g*., Riordan v. Westwood, 203 P.2d 922 (Utah 1949); Horne v. Utah Oil Refining Co., 202 P. 815 (Utah 1921); Rasmussen v. Moroni Irrigation Co., 189 P. 572 (Utah 1920); Howcroft v. Union & Jordan Irrigation Co., 71 P. 487 (Utah 1903).

[30] *See* Section 3.6.

[31] NAT'L WATER COMM'N, A SUMMARY-DIGEST OF STATE WATER LAWS 731 (Richard L. Dewsnup et al. eds., 1973).

[32] *Howcroft*, 71 P. at 488 (holding "subsurface flow in a known and well-defined channel constitutes a part of the stream, and is subject to the rights of appropriation the same as the surface flow.").

[33] Chandler v. Utah Copper Co., 135 P. 106, 109 (Utah 1913).

[34] *See Riordan*, 203 P.2d at 925 (stating that percolating waters were waters not "naturally flowing in a stream with a well-defined channel, banks, and course.").

[35] Willow Creek Irrigation Co. v. Michaelson, 60 P. 943, 944 (Utah 1900).

[36] *See* Horne v. Utah Oil Refining Co., 202 P. 815, 819 (Utah 1921), *see also Riordan*, 203 P.2d at 924.

[37] *See Horne*, 202 P. at 824.

[38] Wrathall v. Johnson, 40 P.2d 755 (Utah 1935); Justesen v. Olsen, 40 P.2d 802 (Utah 1935).

[39] 40 P.2d at 776.

[40] *Justesen*, 40 P.2d at 804.

[41] *Id.* at 806.

[42] *See* 1935 Utah Laws 195 (declaring "[a]ll waters in this state, whether above or under the ground are hereby declared to be the property of the public, subject to all existing rights to the use thereof.").

[43] UTAH CODE ANN. § 73-1-1(1).

[44] § 73-3-1, -2.

[45] § 73-3-1(5)(a); *see also* Sanpete Water Conservancy Dist. v. Carbon Water Conservancy Dist., 226 F.3d 1170, 1172 (10th Cir. 2000) (holding that senior appropriators are guaranteed the full measure of their rights before any junior right may be satisfied).

[46] Practical realities make it difficult to determine whether one or more groundwater withdrawals is responsible for impairment, and cessation of withdrawals may not immediately improve water availability for injured appropriators. Responses to these complications are discussed *infra*.

[47] UTAH CODE ANN. § 73-3-1. Separate procedures apply for confirming pre-code surface and groundwater rights. Prospective operators that either hold are pursue acquisition of pre-code rights should, as part of their due diligence, investigate these procedural requirements as appropriate and pre-code rights will not be discussed further.

[48] § 73-3-8.

[49] § 73-3-8(1)(b).

[50] *See* Little Cottonwood Water Co. v. Kimball, 289 P. 116, 118 (Utah 1930); *see also* Whitmore v. Welch, 201 P.2d 954, 959 (Utah 1949).

[51] *See generally* Salt Lake City v. Silver Fork Pipeline Corp., 5 P.3d 1206, 1214 n.9 (Utah 2000) (recognizing "the need for insuring the highest possible development and most continuous beneficial use of all available water with as little waste as possible.").

[52] Duchesne County. v. Humpherys, 148 P.2d 338, 339 (Utah 1944) (*citing* Deseret Live Stock Co. v. Hooppiania, 239 P. 479 (Utah 1925)).

[53] UTAH CODE ANN. § 73-3-12(2)(a).

[54] § 73-3-17(1).

[55] § 73-3-17(1).

[56] § 73-3-17(6).

[57] *See, e.g.*, McNaughton v. Eaton, 242 P.2d 570, 574 (Utah 1952) ("The original appropriator as long as he has possession and control . . . may sell or transfer the right to the use of such waters . . . as long as he does so in good faith and they are beneficially used . . . .").

[58] UTAH CODE ANN. § 73-3-1(5)(a).

[59] Wayman v. Murray City Corp., 458 P.2d 861, 865–66 (Utah 1969).

[60] *Id.* at 865-66 *quoting* Colorado Springs v. Bender, 366 P.2d 552, 555 (Colo. 1961).

[61] *Wayman*, 458 P.2d at 865–66 ("On the whole, it seems obvious that to accord the first appropriator under a ground-water administrative statute the right to have the water level maintained at the point at which he first pumps it, or damages in lieu thereof, so long as there is an adequate water supply of equivalent quality available at lower depths from which it is feasible to pump, would unduly complicate the administration of water rights in the area and might seriously curtail the fullest utilization of the ground-water supply, for later uses under such a handicap may prove to be economically impracticable." *quoting* WELLS A. HUTCHINS, SELECTED PROBLEMS IN THE LAW OF WATER RIGHTS IN THE WEST 179 (1942)).

[62] UTAH CODE ANN. § 73-3-23.

[63] § 73-1-3.

[64] Until recently, the State Engineer would review past water use when reviewing change applications. Where he determined that less than the full right had been beneficially used, the State Engineer would allow the change for only that portion of the right that had been subject to beneficial use because beneficial use is the measure and limit of the right, UTAH CODE ANN. § 73-1-3, and to do otherwise would unlawfully enlarge the right. A 2011 Utah Supreme Court opinion disallowed that practice, concluding

that the State Engineer cannot consider unadjudicated issues of water right forfeiture in ruling on a water right change application. Where such questions arise, the State Engineer must initiate legal action to adjudicate the extent and validity of the right before ruling on the change application. *See* Jensen v. Jones, 2011 UT 31, ___ P.3d ___, 2011 WL 5111056 (Utah 2011). This ruling has the potential to significantly delay water right transactions where prior use is in question. Legislation to broaden the State Engineer's authority is anticipated during the 2012 legislative session.

[65] UTAH CODE ANN. § 73-1-4(2)(a).

[66] *In re* the Drainage Area of the Bear River, 361 P.2d 407, 409 (Utah 1961).

[67] *Id*. at 409.

[68] UTAH CODE ANN. § 73-3-3(2)(a).

[69] § 73-3-3(5)(a).

[70] § 73-3-3(2)(b).

[71] § 73-3-3(7)(a).

[72] § 73-3-3(7)(b).

[73] A list of proposed changes is available at http://www.waterrights.utah.gov/wrinfo/lists.asp. Examples of pending surface to groundwater change applications includes a37539, a37541, a37544, a37546, and a37549. *Utah Div. of Water Rights, WRPRINT Water Right Info Viewer*, http://www.waterrights.utah.gov/cgi-bin/wrprint.exe?Startup (enter application number then click "Submit Query").

[74] TARLOCK, *supra* note 13 at § 5:17.

[75] *See generally* Howcroft v. Union & Jordan Irrigation Co., 71 P. 487 (Utah 1903).

[76] UTAH CODE ANN. § 73-1-3.

[77] *See* Little Cottonwood Water Co. v. Kimball, 280 P. 116, 119 (Utah 1930) (upholding applicant's right to apply for rights to water saved by improving water delivery system).

[78] UTAH CODE ANN. § 73-3-8.

[79] § 73-3-1(5).

[80] *See e.g*., Charles F. Wilkinson, *In Memoriam: Prior Appropriation 1848-1991*, 21 ENVTL. L. v (1991).

[81] TARLOCK, *supra* note 13 at § 5:17.

[82] *See id*.

[83] *Id.* (quoting City of Boulder v. Boulder & Left Hand Ditch Co., 557 P.2d 1182, 1185 (Colo. 1977)).

[84] Estate of Steed v. New Escalante Irrigation Co., 846 P.2d 1223, 1229 (Utah 1992).

[85] Lasson v. Seely, 238 P.2d 418, 422–23 (Utah 1951).

[86] *Estate of Steed*, 846 P.2d at 1225.

[87] *See generally* Silver King Consol. Mining Co. v. Sutton, 39 P.2d 682 (Utah 1934).

[88] Chandler v. Utah Copper Co., 135 P. 106, 109 (Utah 1913) ("[W]hen the waters of a natural stream have been appropriated according to law and the waters put to a beneficial use, the appropriator acquires a vested right in the stream to the extent of his appropriation, and such right carries with it an interest in the stream to the source from which the supply is obtained.").

[89] Mountain Lake Mining Co. v. Midway Irrigation Co., 149 P. 929, 934 (Utah 1915).

[90] *See* Mountain Lake Mining Co., 149 P. at 934.

[91] UTAH CODE ANN. §§ 73-3b-101, -104.

[92] § 73-3b-103(1).

[93] § 73-3b-106(1).

[94] § 73-3b-201(1).

[95] § 73-3b-201(1)(g).

[96] § 73-3b-201(1)(h).

[97] § 73-3b-103(2).

[98] § 73-3b-107.

[99] § 73-3b-205(1)(b).

[100] Utah Division of Water Resources, CONJUNCTIVE MANAGEMENT OF SURFACE AND GROUND WATER IN UTAH 81 (2005) (hereinafter CONJUNCTIVE MANAGEMENT IN UTAH).

[101] *Id.* at 81.

[102] *Id.* at 81.

[103] *See* Luna B. Leopold, *Ecological Systems and the Water Resource,* in U.S. GEOLOGICAL SURVEY CIRCULAR 414, 1960, at 21, 23, *available at* http://eps.berkeley.edu/people/lunaleopold/(060)%20Ecologic%20Systems%20and%20the%20Water%20Resource.pdf.

[104] *Id*.

[105] Gregory J. Hobbs, Jr., *Protecting Prior Appropriation Water Rights Through Integrating Tributary Groundwater: Colorado's Experience*, 47 IDAHO L. REV. 5, 18 (2011).

[106] *See generally* UTAH CODE ANN. §§ 73-5-15(2)–(4).

[107] *Id*. § 73-5-15(3)(a)(iii).

[108] *Id*. § 73-5-15(4).

[109] *Id*. § 73-5-15(1)(b).

[110] Utah Dep't of Natural Res. Div. of Water Rights, SALT LAKE VALLEY GROUND-WATER MANAGEMENT PLAN 1 (2002), *available at* http://www.waterrights. utah.gov/wrinfo/mmplan/ugw/slv/slvmgpln.pdf.

[111] *Id*. at 6.

[112] *Id*. at 1.

[113] *Id*. at 7.

[114] *Id*. at 4.

[115] *Id*. at 4.

[116] *Id*. at 3.

[117] *See* CONJUNCTIVE MANAGEMENT IN UTAH, *supra* note 100 at 15–16, 22; *see also* Jamie Hansen, *It Takes a District: Utah Landowners Control Groundwater Use*, HIGH COUNTRY NEWS, MAY 10, 2010 (quoting Utah Deputy State Engineer Boyd Clayton), *available at* http://www.hcn.org/issues/42.8/it-takes-a-district.

[118] *See* Division of Water Rights, Utah Department of Natural Resources, Water Right Diversion / Depletion Priorities, Beryl / Enterprise Underground Water Rights (2007), (hereinafter Beryl-Enterprise Priority List) *available at* http://waterrights.utah.gov/researchDB/WRPriorityDDview2.asp.

[119] *See id.* (counting only filings with depletions greater than zero).

[120] Division of Water Rights, Utah Department of Natural Resources, Draft Beryl Enterprise Groundwater Management Plan (Oct. 7, 2011) (on file with authors).

[121] *Id*.

[122] *Id*.

[123] Office of the State Engineer, Utah Department of Natural Resources, Briefing Paper of the Utah Legislature Executive Appropriations Committee Regarding Ground Water Management Planning in Beryl-Enterprise, Utah 1 (2008) (hereinafter Briefing Paper) *available at* http://www.waterrights.utah.gov/groundwater/ManagementReports/BerylEnt/BerylEnt%20Legislature%20Summary.pdf.

[124] *See generally*, WILLIAM R. LUND ET AL., UTAH GEOLOGICAL SURVEY, UTAH DEPARTMENT OF NATURAL RESOURCES, THE ORIGIN AND EXTENT OF EARTH FISSURES IN ESCALANTE VALLEY, SOUTHERN ESCALANTE DESERT, IRON COUNTY, UTAH (2005).

[125] *See* Beryl-Enterprise Priority List, *supra* note 118 (counting water right filings with depletions greater than zero).

[126] Over the years, farm and water right ownership has been consolidated. Therefore, while hundreds of water rights would be effected, the impact would be felt by a much smaller number of water users. Because most farmers hold multiple water rights with varying priority dates, almost all water right holders would face some level of reduction.

[127] *See* Beryl-Enterprise Priority List, *supra* note 118.

[128] Interview with Kent Jones, Utah State Engineer, and Boyd Clayton, Utah Deputy State Engineer (Oct. 3, 2010).

[129] DEE C. HANSEN, P.E., HISTORY OF UNDERGROUND WATER USE, BERYL-ENTERPRISE AREA 1920-2008, 4 (HDC Engineering 2008) *available at* http://evwua.org/pdf/Dee%20Hansen.pdf.

[130] Briefing Paper, *supra* note 123 at 3.

[131] UTAH CODE ANN. § 73-5-15.

[132] § 73-5-15(4)(a).

[133] § 73-5-15(4)(b).

[134] § 73-5-25(4)(a)(iii).

[135] Briefing Paper, *supra* note 123 at 4.

[136] Where wells are not fitted with water meters, the approximate amount of water withdrawn can still be calculated based on pump electrical requirements and the amount of power consumed.

[137] Division of Water Rights, Utah Department of Natural Resources, PowerPoint Presentation: Ground-Water Management Plan Beryl Enterprise Area 14 (2007) *available at* http://www.waterrights.utah.gov/meetinfo/m20070806/default.htm.

[138] *See* § 73-1-4 (discussing reversion to the public by abandonment or forfeiture for nonuse).

[139] See § 73-3-1(5)(a).

[140] § 73-5-15(4)(c)(iii).

[141] § 73-3-1(5)(a).

[142] *See* § 73-3-1(5)(a).

[143] *See* § 73-3-1(5)(a).

[144] Local districts are limited purpose local government entities, including but not limited to metropolitan water districts and irrigation districts. §§ 17B-1-102(11), 103(1)(a).

[145] "'Critical Management Area' means a groundwater basin in which the groundwater withdrawals consistently exceed the safe yield.'" § 73-5-15(1)(a).

[146] 2010 UTAH LAWS ch. 150 (amending UTAH CODE ANN. § 17B-1-103(2)(a)—(b)).

[147] 2010 UTAH LAWS ch. 150 (amending UTAH CODE ANN. § 17B-1-103(r)(i)—(ii)). During 2011, the legislature again amended the Utah Code to clarify the process for levying such assessments. *See* S.B. 10, 59th Leg. (Utah 2011).

[148] S.B. 20, 59th Leg. (Utah 2011) (enacting UTAH CODE ANN. § 17B-1-202(1)(c)(v)).

[149] *Id*. (enacting UTAH CODE ANN. § 73-5-15(12)(b)).

[150] *Id*. (enacting UTAH CODE ANN. § 73-5-15(12)(b)).

[151] Memorandum from Richard Bay, General Manager/CEO, Jordan Valley Water Conservancy Dist. to Senator Dennis Stowell (Oct. 1, 2010) (on file with authors).

[152] *Id*.

[153] *Id*.

[154] Draft Beryl Enterprise Groundwater Management Plan, *supra* note 120.

[155] *Id*. at 2.

[156] *Id*.

[157] CONJUNCTIVE MANAGEMENT IN UTAH, *supra* note 100 at 30.

[158] *Id*. at 29.

[159] *Id*. at 8.

[160] *Id*. at 40 fig.24.

[161] Interview with Richard Bay, General Manager/CEO, Jordan Valley Water Conservancy Dist. (Oct. 29, 2010).

[162] *Id*. at 34–35.

[163] *Id*.

[164] *Id*. at 35.

[165] *Id*. at 36.

[166] Jordan Valley Water Conservancy Dist., 2009 Annual Report 6 (2009), *available at* http://www.jvwcd.org/news/default.aspx (follow "Publications" hyperlink; then follow "2009 Annual Report" hyperlink).

[167] *Id*.

[168] *Source Protection*, Jordan Valley Water Conservancy Dist., http://jvwcd.org/water/source.aspx.

[169] Interview with Richard Bay, General Manager/CEO, Jordan Valley Water Conservancy Dist. (Oct. 29, 2010).

[170] CONJUNCTIVE MANAGEMENT IN UTAH, *supra* note 100 at 62.

[171] Interview with Richard Bay, General Manager/CEO, Jordan Valley Water Conservancy Dist. (Oct. 29, 2010).

[172] CONJUNCTIVE MANAGEMENT IN UTAH, *supra* note 100 at 62.

[173] *Id*.

[174] UTAH DIVISION OF WATER RESOURCES, JORDAN RIVER BASIN PLANNING FOR THE FUTURE 48 (2010) *available at* http://www.water.utah.gov/Planning/SWP/Jord_riv/Jordan%20River%20Basin%20Final0610t.pdf.

[175] *Id*. at 63.

[176] *Id*.

[177] Interview with Richard Bay, General Manager/CEO, Jordan Valley Water Conservancy Dist. (Oct. 29, 2010).

[178] *Id*.

[179] *Id*.

[180] *See* ADAM EASTMAN, FIVE DECADES: A HISTORY OF JORDAN VALLEY CONSERVANCY DISTRICT 103 (Chad Nielsen 2006).

[181] *Id*.

[182] Interview with Dennis Strong, Director, Utah Div. of Water Res. (Oct. 2, 2010).

[183] Thompson, *supra* note 16 at 273.

[184] *In re* Gen. Adjudication of All Rights to Use Water in Gila River Sys. & Source, 857 P.2d 1236, 1243 (Ariz. 1993) (*Gila River II*).

[185] *Gila River* II at 1243. Notably, the Arizona Supreme Court later tempered *Gila River II* by holding that its ruling "should not serve as a straitjacket that restricts us from reaching in the direction of the facts and, so far as possible under those decisions, conforming to hydrological reality." *In re* Gen. Adjudication of All Rights to Use Water in Gila River Sys. & Source, 9 P.3d 1069, 1079 (Ariz. 2000) (*Gila River III*).

[186] WYO. CONST. art. 8, § 1.

[187] Hunt v. City of Laramie, 181 P. 137, 140 (Wyo. 1919).

[188] Lawrence J. Wolfe & Jennifer G. Haber, *Wyoming's Groundwater Laws: Quantity and Quality Regulation*, 24 LAND & WATER L. REV 39, 43-44 (1989). *See also*, 1947 WYO. SESS. LAWS ch. 107.

[189] Wolfe & Haber, *supra* note 188 at 42-43.

[190] WYO. STAT ANN. § 41-4-501(a).

[191] § 41-3-930.

[192] § 41-3-101.

[193] §§ 41-4-503 (surface water) and 41-3-931 (groundwater). Separate procedures apply for confirming pre-code surface and groundwater rights. Prospective operators that either hold are pursue acquisition of pre-code rights should, as part of their due diligence, investigate these procedural requirements as appropriate and pre-code rights will not be discussed further.

[194] "Critical areas" are not defined in either statute or regulation.

[195] WYO. STAT. ANN. § 41-3-931.

[196] § 41-3-930; Wolfe & Haber, *supra* note 188 at 47. Certain small-scale domestic and stock watering wells, while subject to the permitting requirement, remain exempt from priority enforcement. WYO. STAT. ANN. § 41-3-907.

[197] Yentzer v. Hemenway, 441 P.2d 320, 321 (Wyo. 1968), Willey v. Decker, 73 P. 210, 214 (Wyo. 1903).

[198] WYO. STAT. ANN. §§ 41-3-102 (generally) and -906 (groundwater).

[199] Map of Basins can be found at WYOMING WATER DEVELOPMENT COMMISSION, THE WYOMING FRAMEWORK WATER PLAN: A SUMMARY, 5 (2007), *available at* http://waterplan.state.wy.us/plan/statewide/execsummary.pdf.

[200] Individual basin water plans and State Water Plan links can be found at http://waterplan.state.wy.us/.

[201] Wyoming Water Development Commission, Platte River Basin Plan Executive Summary 8 (May 2006) *available at* http://waterplan.state.wy.us/plan/platte/Executive_Summary_lowres.pdf. Data on estimated physical and legal surface water availability outside of the Platte River Basin is available at: http://waterplan.wrds.uwyo.edu/fwp/tables/table_now.jsp?table=tb72&title=Table%207-2%20%20Available%20Flows.

[202] WYO. STAT. ANN. § 41-3-912(a).

[203] Wyoming Water Development Commission, Wyoming Water Plan § 7.23 - Groundwater (2007), http://waterplan.wrds.uwyo.edu/fwp/ch72.jsp#fr73 (hereinafter Wyoming Water Plan-Groundwater).

[204] *Id*.

[205] *Id*.

[206] *Id*.

[207] Wolfe & Haber, *supra* note 188 at 62.

[208] *Id*.

[209] Wyoming Water Plan - Groundwater, *supra* note 203.

[210] WYO. STAT. ANN. § 41-3-916.

[211] Lawrence MacDonnell, *Integrating Use of Ground and Surface Water in Wyoming*, 47 IDAHO L. REV. 51, 63 (2011).

[212] WYO. STAT. ANN. § 41-3-915; MacDonnell, *supra* note 211 at 63; Wolfe & Haber, *supra* note 188 at 61.

[213] GARY BRYNER & ELIZABETH PURCELL, GROUNDWATER LAW SOURCEBOOK OF THE WESTERN UNITED STATES, 63 (2003), *available at* http://www.colorado.edu/law/centers/nrlc/publications/Groundwater%20Law%20Sourcebook.pdf.

[214] MELINDA HARM BENSON ET AL., LEGAL ANALYSIS OF GROUND WATER AND SURFACE WATER CONJUNCTIVE MANAGEMENT WITHIN THE CONTECT OF WYOMING WATER LAW IN INTEGRATED MANAGEMENT OF GROUNDWATER AND SURFACE WATER RESOURCES: INVESTIGATION OF DIFFERENT MANAGEMENT STRATEGIES AND TESTING IN A MODELING FRAMEWORK 8 (2010), *available at* http://water.usgs.gov/wrri/AnnualReports/2009/FY2009_WY_Annual_Report.pdf.

[215] WYOMING WATER DEVELOPMENT COMMISSION, PLATTE RIVER BASIN FINAL REPORT, at section 3-4 (2007), *available at* http://waterplan.state.wy.us/plan/platte/finalrept/Chapter03.pdf.

[216] 792 P.2d 1376 (Wyo. 1990).

[217] In the Matter of the Decision of the State Engineer Denying Appeal of Decisions of Superintendant of Water Division I Issued on June 12, 2007, July 30, 2008, and July 30, 2008, Civil Action No. 87611-C (D. Wyo. Apr. 22, 2009).

[218] Glennon & Maddock, *supra* note 12 at § 22.03[7].

[219] Wyoming Water Development Commission, WYOMING FRAMEWORK WATER PLAN 7-11 (2007), *available at* http://waterplan.state.wy.us/plan/statewide/Volume_I.pdf.

[220] *See* Cat Shier, *ASR and the "Big Picture,"* SOUTHWEST HYDROLOGY 21 (May/June 2008).

[221] For a concise summary of Colorado Water Law, *see* JUSTICE GREGORY J. HOBBS, JR., CITIZEN'S GUIDE TO COLORADO WATER LAW (3d ed. 2009), *available at* http://www.cfwe.org/flip/catalog.php?catalog=waterlaw and JOSEPH (JODY) GRANTHAM, SYNOPSIS OF COLORADO WATER LAW (2011 ed.), *available at* http://water.state.co.us/DWRIPub/DWR%20General%20Documents/SynopsisOfCOWaterLaw.pdf.

[222] COLO. CONST. art. XVI, § 5. *See also* State v. Southwestern Colo. Water Conservation Dist., 671 P.2d 1294, 1307 (Colo.1983).

[223] COLO. CONST. art. XVI, § 6.

[224] *Id*.

[225] *In re* German Ditch & Reservoir Co., 139 P. 2, 9 (Colo. 1914).

[226] COLO. REV. STAT. § 37-92-102(1). *See also*, Bd. of Cnty. Comm'rs of Park v. Park Cnty. Sportsmen's Ranch, 45 P.3d 693, 704-05 (Colo. 2002).

[227] COLO. REV. STAT. §§ 37-80-101 to 37-80-111, and 37-92-301.

[228] *See* Crystal Lakes Water & Sewer Ass'n v. Backlund, 908 P.2d 534, 543 (Colo.1996) ("water court may resolve ancillary issues . . . that are not water matters because resolution of those ancillary issues would directly affect the outcome of water matters within the exclusive jurisdiction of the water court.).

[229] Exempt wells are small wells, generally producing less than fifteen gallons per minute, that are available for household purposes, lawn and garden watering, fire protection, livestock watering, or groundwater monitoring. Exempt wells require a permit from the State Engineer and operate within statutory limits but are exempt from administration and enforcement within the priority system. *See* COLO. REV. STAT. § 37-92-602.

[230] § 37-90-137(2).

[231] §§ 37-90-103(19), and 37-91-102(7).

[232] § 37-92-103(11).

[233] § 37-92-103(11).

[234] Safranek v. Town of Limon, 228 P.2d 975, 977 (Colo. 1951), *accord* Well Augmentation Subdivision of Cent. Colorado Water Conservation Dist. v. City of Aurora, 221 P.3d 399, 414 (Colo. 2009), Ready Mix Concrete Co. v. Farmers Reservoir & Irrigation Co, 115 P.3d 638, 642 (Colo. 2005).

[235] COLO. REV. STAT. § 37-92-102(2). *See also*, Bd. of Cnty. Comm'rs of Park v. Park Cnty. Sportsmen's Ranch, 45 P.3d 693, 704-05 (Colo. 2002).

[236] *See e.g.*, Simpson v. Cotton Creek Circles, 181 P.3d 252 (Colo. 2008) (upholding administrative rules that require curtailment of out of priority groundwater withdrawals that impair senior surface water rights or the Rio Grand River Compact (apportioning flows of the Rio Grand River between Colorado, New Mexico, and Texas) unless injury is avoided through augmentation).

[237] 1969 COLO. SESS. LAWS. 1200, 1205-06.

[238] *See* Bohn v. Kuiper, 575 P.2d 402 (Colo. 1978) and Fox v. Division Engineer, 810 P.2d 644 (Colo. 1991).

[239] COLO. REV. STAT. § 37-90-1-2(1).

[240] § 37-90-104.

[241] Ramsey L. Kropf, *Colorado Groundwater Law: Colorado's System — Integration (or Not?) of Groundwater and Surface Water*, 49 ROCKY MTN. MIN. L. INST. 7B (2003).

[242] *See id*.

[243] COLO. REV. STAT. § 37-90-103(10.5).

[244] § 37-90-103(10.7).

[245] Glennon & Maddock, *supra* note 12 at § 22.0[3].

[246] GRANTHAM, *supra* note 221 at 11. *See also* COLO. REV. STAT. § 37-90-137(4).

[247] *See* COLO. REV. STAT. §§ 37-90-137(11)(a), 37-90-107, 37-80-120(5) and 37-92-305(12)(a). *See also* Three Bells Ranch Associates v. Cache La Poudre Water Users Association, 758 P.2d 164, (Colo. 1988) and Zigan Sand and Gravel v. Cache La Poudre Water Users Association, 758 P.2d 175 (Colo. 1988).

[248] Vance v. Wolfe, 205 P.3d 1165 (Colo. 2009).

[249] 2 COLO. CODE REGS. § 402-17.

[250] Board of County Comm'rs of County of Park v. Park County Sportsmen's Ranch, 45 P.3d 693, 703-04 (Colo. 2002).

[251] *Id*. at 704. *See also*, Colo. Rev. Stat. §§ 37-92-305(9)(b) and (c).

[252] Park County Sportsmen's Ranch, 45 P.3d at 705 n. 19.

[253] RALF TOPPER ET AL., COLORADO GEOLOGICAL SURVEY, ARTIFICIAL RECHARGE OF GROUNDWATER IN COLORADO—A STATEWIDE ASSESSMENT ii (2004) *available at* http://geosurvey.state.co.us/water/Artificial%20Recharge/Pages/ArtificialRecharge.aspx.

[254] N.M. CONST. art. XVI, § 2.

[255] Harkey v. Smith, 247 P. 550 (N.M. 1926).

[256] N.M. CONST. art. XVI, § 2.

[257] *Id*. at § 3.

[258] Timothy J. De Young, *New Mexico*, in WATERS AND WATER RIGHTS Subpart B: State Surveys § II (Robert E. Beck & Amy K. Kelly, eds., 2009).

[259] *See* N.M. STAT. ANN. §§ 72-5-1 and 72-12-3; *see also*, City of Albuquerque v. Reynolds, 379 P.2d 73, 79 (N.M. 1962) ("The legislature has provided somewhat different administrative procedure whereby appropriators' rights may be secured from the two sources but the substantive rights, when obtained, are identical."). An exception to groundwater permitting requirements exists because the State Engineer's jurisdiction over groundwater extends only to groundwater in declared basins. § 72-12-20. Therefore, the State Engineer has no authority to require a permit outside of declared basins. A declared basin is a basin that the State Engineer, through an administrative fact-finding process, finds as having reasonably ascertainable boundaries. *See* McBee v. Reynolds, 399 P.2d 110, 114 (N.M. 1965). As a practical matter, there are few undeclared basins in New Mexico because the State Engineer has both extended the boundaries of existing basins and declared new basins to cover most of the state. WATERS AND WATER RIGHTS Subpart B: State Surveys New Mexico § II.

[260] N.M. STAT. ANN. §§ 72-5-1 and 72-12-3. Separate procedures apply for confirming pre-code surface and groundwater rights. Prospective operators that either hold are pursue acquisition of pre-code rights should, as part of their due diligence, investigate these procedural requirements as appropriate and pre-code rights will not be discussed further.

[261] §§ 72-5-6 and -7, and 72-12-3(E).

[262] *See* City of Albuquerque v. Reynolds, 379 P.2d 73, 80-81 (N.M. 1962).

[263] *See generally*, *Id*.

[264] WATERS AND WATER RIGHTS Subpart B: State Surveys New Mexico § II; *see also* N.M. STAT. ANN. § 72-1-2.2.

[265] § 72-2-9.1.

[266] *See* N.M. CODE R. §§ 19.25.13.7(C)(3)(c), 19.25.13.16, 19.25.13.17, 19.25.13.27, and 19.25.13.29.

[267] *See* Jensen v. Jones, 2011 UT 31, ___ P.3d ___, 2011 WL 5111056 (Utah 2011) (holding that in reviewing an application to change a water right, the State Engineer's authority to consider whether the applicant is entitled to the use of water does not include the authority to determine whether the right to use water was previously reduced or eliminated through non-use because the latter determination is an exclusively judicial function).

[268] Tri-State Generation and Transmission Ass'n. v. D'Antonio, 249 P.3d 932, 937 (N.M. Ct. App 2010) *certiorari granted* N.M. S. Ct. No. 32,704 (Feb. 9, 2011) (internal citations omitted).

[269] *Id*. at 941.

[270] *Id*. at 942.

[271] *See* discussion of procedural history in, City of Albuquerque v. Reynolds, 379 P.2d 73, 80-81 (N.M. 1962).

[272] *Id*. *See also* State ex rel. Martinez v. City of Roswell, 844 P.2d 831 (N.M. Ct. App. 1992); Martinez v. Lewis, 882 P.2d 37 (N.M. Ct. App. 1994).

[273] City of Albuquerque v. Reynolds, 379 P.2d at 80-81.

[274] Proceedings of the Montana Conjunctive Water Management Conference 19 (2009), *available at* http://dnrc.mt.gov/wrd/water_mgmt/clarkforkbasin_taskforce/pdfs/conjunctive_mgmt_proceedings.pdf.

[275] *See* N.M. STAT. ANN. §§ 72-5A-1 through 72-5A-17.

[276] § 72-5A-3(D).

[277] § 72-5A-6.

[278] Laura M. Bexfield and Scott K. Anderholm, Estimated Water-Level Declines in the Santa Fe Group Aquifer System in the Albuquerque Area, Central New Mexico, Predevelopment to 2002 (2002), http://nm.water.usgs.gov/publications/abstracts/mapreport02-4233.pdf.

[279] Stephanie J. Moore & Robert Marley, Presentation to the Western Governor's Ass'n, Managed Aquifer Recharge in the Middle Rio Grande Basin, Central New Mexico (2011) *available at* http://www.westgov.org/wswc/moore.pdf.

[280] *Id*.

[281] NEV. REV. STAT. § 522.025. *See also* § 534.020 ("All underground waters within the boundaries of the State belong to the public, and, subject to all existing rights to the use thereof, are subject to appropriation for beneficial use only under the laws of this State relating to the appropriation and use of water and not otherwise.").

[282] Lobdell v. Simpson, 2 Nev. 274 (1866).

[283] NEV. REV. STAT. § 533.035.

[284] *See* §§ 533.325, 534.013, and 534.180.

[285] § 533.370(5).

[286] *Id*. Separate procedures apply for confirming pre-code surface and groundwater rights. Prospective operators that either hold are pursue acquisition of pre-code rights should, as part of their due diligence, investigate these procedural requirements as appropriate and pre-code rights will not be discussed further.

[287] United States v. Alpine Land & Reservoir Co., 919 F. Supp. 1470 (D. Nev. 1996).

[288] *See generally* NEV. REV. STAT. ch. 533.

[289] *See* Tracy Taylor & Jason King, Deputy State Engineers, *Water Law, An Overview and Related Issues, Interim Study Committee on the Use, Management and Allocation of Water Resources* (2005), *available at* http://www.water.nv.gov/documents/presentations/interim_study.pdf.

[290] *Id*.

[291] NEV. REV. STAT. § 533.330

[292] Nevada Division of Water Resources, Nevada State Water Plan, 1B-5, *available at* http://water.nv.gov/programs/planning/stateplan/.

[293] *Id*.

[294] *Id*. at 1B-2.

[295] *Id*. at 1B-2—3.

[296] NEV. REV. STAT. § 534.250(2).

[297] §§ 534.250(25) and 534.280.

[298] Taylor & King, *supra* note 289.

[299] Red Lodge Clearinghouse, *Nevada Water Law*, *available at* http://www.rlch.org/content/nevada-water-law.

[300] *See* James Prieur, Senior Hydrologist, Southern Nevada Water Authority, *Las Vegas Valley Artificial Recharge and Hydrologic Monitoring Program Update* (2011), *available at* http://nvawma.org/pdfs/ARandLVValleyUpdateJan2011.pdf.

[301] IDAHO CODE Ann. § 42-101.

[302] IDAHO CONST. art. 15, § 3, IDAHO CODE Ann. § 42-106.

[303] § 42-104.

[304] §§ 42-103 and 42-229.

[305] *See* Phillip J. Rassier, Idaho, in WATERS AND WATER RIGHTS Subpart B: State Surveys § I(A)(2) (Robert E. Beck & Amy K. Kelly, eds., 2009);

[306] IDAHO CODE ANN. § 42-203A, *see also* IDAHO ADMIN. CODE r. 37.03.08.025.01. Separate procedures apply for confirming pre-code surface and groundwater rights. Prospective operators that either hold are pursue acquisition of pre-code rights should, as part of their due diligence, investigate these procedural requirements as appropriate and pre-code rights will not be discussed further.

[307] § 42-203A.

[308] IDAHO ADMIN. CODE r. 37.03.11.031.03, and Clear Springs Foods v. Spackman, 252 P.3d 71 (Idaho 2011).

[309] IDAHO ADMIN. CODE r. 37.03.11.031.03.

[310] Withdrawals in excess of the reasonably anticipated rate of future natural recharge may be allowed if "[a] program exists or likely will exist which will increase recharge or decrease withdrawals within a time

period acceptable to the director to bring withdrawals into balance with recharge," or "[h]olders of senior rights to use ground water will not be caused thereby to pump water from below the established reasonable pumping level or levels." IDAHO CODE ANN. § 42-237A(g).

[311] *Id.*

[312] IDAHO ADMIN CODE r. 37.03.11.20.03.

[313] IDAHO ADMIN CODE r. 37.03.11.40.03. Eight non-exclusive factors are considered in determining whether a senior appropriator is suffering material injury and is using water efficiently without waste. These factors are found at IDAHO ADMIN. CODE r. 37.03.11.42.

[314] IDAHO ADMIN CODE r. 37.03.11.42(h).

[315] IDAHO CODE ANN. § 42-234(1) and (2).

[316] § 42-234(4).

[317] Idaho State Water Plan – 2010 Draft Policies §1E, *available at* http://www.idwr.idaho.gov/waterboard/WaterPlanning/StateWaterPlanning/PDFs/2010/SWP.pdf.

[318] *Id*. at §1I.

[319] *Id*.

[320] Brian Patton, Idaho Department of Water Resources, *Eastern Snake Plain Managed Aquifer Recharge Program* (2011) http://www.usbr.gov/pn/programs/studies/idaho/henrysfork/meetings/2011-02-15/hf-espa-recharge-feb2011.pdf.

[321] *Id*.

[322] For a more detailed discussion of the agreement and the dispute which lead up to it, *see* Andrew J. Waldera, *Junior Groundwater Pumpers in Idaho Move Forward With Buyout of Senior Spring Water Aquaculture Sites*, 16 WESTERN WATER LAW & POLICY REPORTER 1, 8-9 (2011).

[323] IDAHO WATER RES. RESEARCH INST. & IDAHO DEPT. OF WATER RES., MANAGED AQUIFER RECHARGE IN THE TREASURE VALLEY: A COMPONENT OF A COMPREHENSIVE AQUIFER MANAGEMENT PLAN AND A RESPONSE TO CLIMATE CHANGE 22 (2011) *available at* http://www.iwrri.uidaho.edu/documents/201102%20publication.pdf?pid=120275&doc=1.

[324] CAL. WATER CODE § 1200. California also recognizes riparian rights in surface and subterranean streams. *See* Lux v. Haggin, 10 P. 674 (Cal. 1886).

[325] Katz v. Walkinshaw, 74 P. 766, 772 (Cal. 1903).

[326] *Id*.

[327] Douglas L. Grant, *Conjunctive Management of Hydrologically Connected Surface Water and Groundwater: The Problem of Sustainable Use*, PROCEEDINGS OF THE ROCKY MOUNTAIN MINERAL LAW FIFTY-FOURTH ANNUAL INSTITUTE § 14.04(1)(a) (2008).

[328] Glennon & Maddock, *supra* note 12 at § 22.0[2][C] *citing* ARTHUR L. LITTLEWORTH & ERIK L. GARNER, CALIFORNIA WATER 49 (1995).

[329] N. Gualala Water Co. v. State Water Resources Control Bd., 43 Cal. Rptr. 3d 821, 844 (Cal. Ct. App. 2006).

[330] *Id*. at 840.

[331] Grant, *supra* note 327 at § 14.04(1)(a).

[332] John B. Weldon, Jr., Maxine M. Becker & Rebecca C. Goldberg, *Arizona*, in WATERS AND WATER RIGHTS Subpart B: State Surveys (Robert E. Beck & Amy K. Kelly, eds., 2009). The terms correlative

rights and reasonable use are often used interchangeably. Under a strict application of these two doctrines the former implies a coequal share in the water resource between overlying landowners whil the latter doctrine allows reasonable but unequal use.

[333] *In re* Gen. Adjudication of All Rights to Use Water in Gila River Sys. & Source, 857 P.2d 1236, 1241 (Ariz. 1993) (*Gila River II*).

[334] *Id*. at 1245 (internal citations omitted).

[335] Grant, *supra* note 327 at § 14.04(1)(b).

[336] *Id*. at § 14.04(2)(a).

[337] *Id*.

[338] *See* Sierra Club v. Lujan, 1993 WL 151353 (W.D. Texas 1993).

[339] *See* 43 U.S.C. § 661 ("Whenever, by priority of possession, rights to the use of water [on public lands] for mining, agricultural, manufacturing, or other purposes, have vested and accrued, and the same are recognized and acknowledged by the local customs, laws, and decisions of courts, the possessors and owners of such vested rights shall be maintained and protected in the same; and the right of way for the construction of ditches and canals for the purposes herein specified is acknowledged and confirmed."); *see also* 43 U.S.C. § 666 (submitting the federal government to state jurisdiction for water right adjudications) and *California v. United States*, 438 U.S. 645, 653 (1978) (describing "the consistent thread of purposeful and continued deference to state water law by Congress.").

[340] U.S. CONST. art VI, § 2 (supremacy clause); art I, § 8, cl. 3 (commerce clause); and art. IV, § 3, cl. 2 (property clause).

[341] The reserved rights doctrine also supersedes state water laws. United States v. New Mexico, 438 U.S. 696, 714 (1978).

[342] *Id*.

[343] Cappaert v. United States, 426 U.S. 128, 142 (1976).

[344] *Id*.

[345] *Id*. at 142.

[346] *Id*. at 142-43.

[347] *See* WATER AVAILABILITY TOPICAL REPORT, *supra* note 21 at 61-68.

[348] The Zion National Parks Water Rights Settlement Agreement is available at http://wcwcd.state.ut.us/Agreements/Zion%20National%20Park.pdf.

[349] Kansas v. Colorado, 206 U.S. 46, 114–15 (1907).

[350] *See* Kansas v. Colorado, 543 U.S. 86, 90–91 (2004) (interpreting the 1949 Arkansas River Compact); First Interim Report of the Special Master at 43–54, Montana v. Wyoming, 552 U.S. 1175 (2010) (No. 137, Original), 2010 WL 4111634 at *43–54 (interpreting the 1950 Yellowstone River Compact); First Report of the Special Master at 44–45, Kansas v. Nebraska, 530 U.S. 1272 (2000) (No. 126), 2000 WL 35789995 at *44–45 (interpreting the 1942 Republican River Compact).

[351] For more information on federally reserved water rights in general, and the case for reserved rights associated with Naval Oil Shale Reserves, *see* WATER AVAILABILITY TOPICAL REPORT*, supra* note 21 at 61-69.

[352] *See id*. at 61-68.

[353] ICSE previously estimated water demand for oil shale production at 1.5 to 3.0 units of water per unit of oil produced, and water demand for oil sands production at 2.4 to 7.0 barrels of oil produced. *See* PRODUCED WATER TOPICAL REPORT*, supra* note 21 at 8-9.

[354] *Id.* at 9.

[355] Values are for 2005. Average annual household water use is the product of per capita water use and average household size. Per capita water use is from KENNEY, J.F., ET AL., ESTIMATED USE OF WATER IN THE UNITED STATES IN 2005, U.S. GEOLOGICAL SURVEY CIRCULAR 1334, 20 (2009). Average household size was calculated based on annual population and housing estimates available from the U.S. Census Bureau.

[356] Ephraim, Utah has a reported population, as of 2010, of 6,135. *See* GOVERNOR'S OFFICE OF PLANNING AND BUDGET, CENSUS BRIEF: CITIES AND COUNTIES OF UTAH 25 (2011) *available at* http://www.governor.utah.gov/dea/Census/2010/Cities%20and%20Counties.pdf.

[357] *See* WATER AVAILABILITY TOPICAL REPORT*, supra* note 21 at 51-55 (explaining assumptions regarding Utah's share of the Colorado River).

[358] BUREAU OF LAND MANAGEMENT, U.S. DEPARTMENT OF INTERIOR, PROPOSED OIL SHALE AND TAR SANDS RESOURCE MANAGEMENT PLAN AMENDMENTS TO ADDRESS LAND USE ALLOCATIONS IN COLORADO, UTAH, AND WYOMING AND FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT, 3-81 (Sept. 2008).

[359] U.S. DEPARTMENT OF INTERIOR, BUREAU OF LAND MANAGEMENT, FINAL WHITE RIVER DAM PROJECT ENVIRONMENTAL IMPACT STATEMENT 59 (May 1982).

[360] *Id*. Between 1923 and 1978, average monthly flows just west of the state line peaked at 2,934 CFS; monthly low flows over the same period were just 140 CFS. *Id*.

[361] National Research Council, COLORADO RIVER BASIN WATER MANAGEMENT: EVALUATING AND ADJUSTING TO HYDROCLIMATIC VARIABILITY 85-92 (2007).

[362] *See* PRODUCED WATER TOPICAL REPORT*, supra* note 21 at 43-47.

[363] UTAH STATE DIVISION OF WATER RESOURCES, WHITE RIVER DAM PROJECT: PROPOSED ACTION PLAN (REVISED) 3 (1980).

[364] *See* WATER AVAILABILITY TOPICAL REPORT*, supra* note 21 at 33-34, 45-46.

[365] *See* INTERNATIONAL ENGINEERING CO., WHITE RIVER STUDY (Dec. 1983) (on file with author) (addressing consolidated water development and infrastructure construction).

[366] WESTERN RESOURCE ADVOCATES, WATER ON THE ROCKS: OIL SHALE WATER RIGHTS IN COLORADO 8 (2009).

[367] *In re* Yellow Jacket Water Conservancy Dist., Nos. 09CW48 & 09CW50 (D. Ct. Colo. Water Div. 6 2011).

[368] The Order also concluded that the Yellow Jacket Water Conservancy District failed to satisfy procedural requirements in submitting proof of diligent development of certain water rights, causing applications for more than 140,000 AF/Y of consumption to lapse. The lost water rights were associated with the proposed Sawmill Mountain, Ripple Creek, and Lost Park reservoirs. *In re* Yellow Jacket Water Conservancy Dist., Nos. 09CW48 & 09CW50 (D. Ct. Colo. Water Div. 6 2011). *See also* WESTERN RESOURCE ADVOCATES, *supra* note 367 at 32 for explanation of each conditional water right's contents.

[369] Natural Resource Conservation Service, *Climate Narrative for Uintah Area Soil Survey*, Utah, *available at* www.wcc.nrcs.usda.gov/ftpref/support/climate/soil-nar/ut/uintahssa.doc.

[370] NOAA Technical Report NWS 33, *Evaporation Atlas for the Contiguous 48 States* (1982). For purposes of Total Maximum Daily Load calculations for Brough, Steinaker, and Red Fleet reservoirs near Vernal, Utah, the State of Utah assumed evaporation rates of 35 inches per year. Millennium Science &

Engineering, *Total Maximum Daily Load Water Quality Study: Brough, Red Fleet, and Steinaker Reservoirs* (2008), *available at* http://www.waterquality.utah.gov/TMDL/Brough_Steinaker_Red_Fleet_TMDLs.pdf.

[371] U.S. DEPARTMENT OF INTERIOR, BUREAU OF LAND MANAGEMENT, FINAL WHITE RIVER DAM PROJECT ENVIRONMENTAL IMPACT STATEMENT 1 (May 1982).

[372] WATER AVAILABILITY TOPICAL REPORT*, supra* note 21 at 83-90.

[373] *See id*. at 86-88 (discussing specific river reaches and associated ESA issues).

[374] *Id.* at §1538(a)(1), *see also,* Babbitt v. Sweet Home Chapter of Communities for a Great Oregon, 515 U.S. 687, 703 (1995).

[375] 16 U.S.C. § 1538(a)(1)(B).

[376] § 1532(19).

[377] 50 C.F.R. § 222.102.

[378] 6 WATER AND WATER RIGHTS 43-44 (Robert E. Beck & Amy L. Kelley, eds., 2004 ed.) (citations omitted).

[379] Glennon & Maddock, *supra* note 12 at § 22.03[7].

[380] *Id*.

[381] *See generally*, U.S. GEOLOGICAL SURVEY ET AL., GROUNDWATER CONDITIONS IN UTAH, COOPERATIVE INVESTIGATION REP. NO. 51 (2010).

[382] Under the Safe Drinking Water Act (SDWA), an injection well is a device that places fluid deep underground into porous rock formations, or into or below the shallow soil layer. 42 U.S.C. § 300h(b)(1)(A). Injected fluids may include water, wastewater, brine, or water mixed with chemicals. 40 C.F.R. § 144.3. Injection well owners and operators may not site, construct, operate, maintain, convert, plug, abandon, or conduct any other injection activity that endangers underground sources of drinking water (USDWs), and all injections must be authorized by rule or permit. 42 U.S.C. § 300h(b)(1). An underground source of drinking water (USDW) is an aquifer or a part of an aquifer that is currently used as a drinking water source or may be needed as a drinking water source in the future. Specifically, a USDW supplies any public water system, or contains a sufficient quantity of ground water to supply a public water system, and currently supplies drinking water for human consumption, or contains fewer than 10,000 mg/l total dissolved solids, and is not an exempted aquifer. 40 C.F.R. § 144.3. Exempted aquifers satisfy the requirement for USDWs, but do not currently serve as a source of drinking water and will not serve as future sources of drinking water. 40 C.F.R. § 146.4. Under the SDWA, states and tribes may apply for primacy to implement the Underground Injection Control (UIC) Program within their borders. 42 U.S.C. § 300h-1. In Utah, the state has primacy in regulating injection wells; in Colorado, UIC wells are administered under a joint state and the EPA program.