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Communication

Securing Fluid Resources for Geothermal Projects in a World of Water Scarcity

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Abstract: Water in some form plays a critical role in geothermal projects, given current technology. This paper explores inconsistencies in treatment of water and geothermal resources at the federal and state levels, and discusses legal and practical issues the developer should consider, relating to use of water, geothermal resources, and alternative sources of water supply. The developer is urged to incorporate water resource planning into project planning beginning at the project feasibility stage, and to seek creative solutions, possibly in cooperation with key stakeholders in the project area, to secure needed fluid resources.

Keywords: geothermal; water; geothermal fluids; geothermal law; water law; oil and gas; reclaimed water; recycled water; power production; electric power; alternative energy

1. Overview

This paper provides an overview of practical and regulatory challenges associated with securing water for geothermal projects. With increasing demands on water supplies worldwide, the geothermal developer faces competition for limited resources and inconsistent and sometimes conflicting laws and regulations relating to their use. Focusing on laws and regulations in the Western United States, this paper highlights the emergence of water planning and water management at the watershed level as critical factors in modern regulatory schemes. The developer is urged to incorporate planning for water resources into initial project feasibility evaluations and throughout project planning and development. In most cases, identifying opportunities to develop collaborative water resource solutions in the project area will offer the most efficient means to secure water supply. Alternative sources of fluid resources

are discussed, including reclaimed (or "recycled") water, water from oil and gas fields, and potential future use of CO_2 as a geothermal fluid.

2. Water Requirements of Geothermal Projects

Water in some form is currently used to transfer heat and generate power in geothermal projects. Approximately 1,000 gallons per minute of fluid resources at 120 ℃ (240 ℉) are required to produce one megawatt of electric power [1].

The fluid used may take the form of low temperature in-situ water resources, often in highly mineralized form, or it may be in the form of water diverted or withdrawn from a groundwater or surface water source, either onsite or from another location.

A study on Enhanced Geothermal Systems (EGS) published by the Massachusetts Institute of Technology stated, "It is expected that in most advanced Enhanced Geothermal System (EGS) applications, surface water will be needed to both stimulate and operate the reservoir and produce the circulation patterns needed. In the Western part of the United States, where water resources are in high demand, water use for geothermal applications will require careful management and conservation programs [2]. The report identifies CO_2 as a possible substitute for water. Calculations presented by John Pritchett of Science Applications International Corporation (SAIC) at a recent conference indicated that CO_2 may not be an effective substitute for water in EGS power applications [3]; however, developers are currently testing proprietary technology utilizing CO_2-based geothermal fluids, in cooperation with federal labs [4].

Specific water requirements will depend on project type and design, and project phase. For EGS projects, for example, several million gallons may be needed in a short period for reservoir development and startup. Ongoing operations may require additional water supply at a continuous rate, depending on leakage from the reservoir and other design issues. Planning for water supply should be built into project planning and design for these different project stages.

3. The Competitive World of Water

Critical water shortages are increasingly impacting human activities and related planning worldwide. In its May 22nd, 2010 issue, *The Economist* magazine included a special report on water, entitled, "For want of a drink." The magazine reported that 8% of the world's population (500 million people) currently lives in countries "chronically short of water." That number will rise to 4 billion (45% of the population) by 2050. The publication points to a dramatic increase in population as the primary cause of water shortages, explaining that the world's population was 2.5 billion 60 years ago, "when worries about water supply affected relatively few people." The population was 6 billion in 2000; ten years later, in 2010, it is nearly 7 billion. The world's population is projected to be 9 billion in 2050 [5].

In the Western United States, in addition to population growth, two important causes of critical water shortages are decreased water storage in mountain snowpack and increased incidence and severity of droughts. The U.S. Bureau of Reclamation has assessed future water supply scenarios for the Western U.S. and predicts potential water supply crises by 2025 in regions roughly described as follows: Sacramento and areas to the southeast; Reno-Carson City; Las Vegas and the area south to the

Mexican border; two areas in central Arizona; Santa Fe-Albuquerque; Salt Lake City; Denver and areas along the Front Range of the Rockies; and along the southern boundary of Texas [6]. The largest impacts are expected in southern mountain ranges and close to warming ocean water [6].

Despite the increasing competition for water and the challenges associated with securing water supplies for energy development, the critical nexus of water and energy development has not been adequately considered to date in renewable energy planning. A 2009 report published by the Western Governors' Association, *Western Renewable Energy Zones, Phase I Report*, focuses mainly on transmission as the critical factor in siting renewable energy projects. While some known hydrothermal (low- to moderate temperature geothermal) resources are discussed, the report does not consider the location and availability of water resources for geothermal projects that require potable water or alternate supplies for reservoir development, reservoir pressure maintenance or cooling [7]. In December 2009, the U.S. Department of Energy announced the award of federal stimulus funding to the Western Governors' Association to continue an evaluation of transmission requirements. This study will include an analysis of the regional impacts of new energy generation on water use, and the potential impacts of long-term drought on energy production [8].

4. Federal Geothermal Regulatory Framework and Its Ambiguous Relationship to Water

The primary federal law applicable to geothermal resource development is the Geothermal Steam Act of 1970 [9]. "Geopressured geothermal resources" fall within the category of "Leasing Act minerals" for the purpose of federal leasing programs established for natural resource development [10]. With certain limitations, the use of water resources appropriated in the Western states is subject to state water laws. The U.S. Supreme Court has stated "the effect of [passage by Congress of the Act of July 26, 1866] was to recognize, so far as the United States is concerned, the validity of the local customs, laws, and decisions of courts in respect to the appropriation of water" [11].

The relevance of state water laws was cited in the recent Programmatic Environmental Impact Statement for the federal geothermal leasing program (PEIS) [12]. In response to comments on its draft PEIS from persons representing water right holders, the Bureau of Land Management (BLM) and U.S. Forest Service stated, "The geothermal lease is for the heat in the federal mineral estate. Unless specifically owned in fee, the fluid part of the resource falls under state water laws. Therefore, the amounts of fluid that can be extracted or injected are subject to the individual state's allocation programs, as is the use of other groundwater or surface water sources" [13].

Despite its assertions that state water laws apply, this statement appears to be contradicted by the plain language in the definition of "geothermal resources" in the Geothermal Steam Act, which provides,

> geothermal resources means (i) all products of geothermal processes, embracing indigenous steam, hot water and hot brines; (ii) steam and other gases, hot water and hot brines resulting from water, gas, or other fluids artificially introduced into geothermal formations; (iii) heat or other associated energy found in geothermal formations; and (iv) any byproduct derived from them [14].

Given this statutory definition, the question remains, *which* fluid resources are subject to state water laws? A line of federal judicial decisions including the 2002 *Rosette* case, offers limited guidance. In

that case, the 10th Circuit Court of Appeals held that, on land patented under the Stock Raising Homestead Act of 1916, the use of warm water to heat greenhouses constituted use of federally reserved geothermal resources and was subject to federal leasing requirements. The court held that in passing the Act, Congress intended to support stock raising on the land. Absent specific conveyance, conveyance of geothermal resources by patent would not be implied, since use of geothermal resources was not necessary to fulfill Congress's intent [15].

5. State Geothermal Laws and Water Laws: Unclear Boundaries

The developer should be aware that the definition of geothermal resources differs from state to state in the Western U.S.—and the "boundary" between state water laws and geothermal laws may be unclear. This lack of clarity may mean that the state water code may apply to some or all aspects of the project, and that objections to use of the resource may be asserted based on impacts to groundwater, surface waters, or senior water right holders under state water laws.

Idaho's definition of "geothermal resource" includes an explicit reference to water, defining "geothermal resource" as "the natural heat energy of the earth, the energy, in whatever form, which may be found in any position and at any depth below the surface of the earth present in, resulting from, or created by, or which may be extracted from such natural heat, and all minerals in solution or other products obtained from the material medium of any geothermal resource. Ground water having a temperature of two hundred twelve (212) degrees Fahrenheit or more in the bottom of a well shall be classified as a geothermal resource [16].

Nevada's geothermal statute, in contrast, does not reference water or other fluids in its statute, which defines "geothermal resource" as "the natural heat of the earth and the energy associated with that natural heat, pressure and all dissolved or entrained minerals that may be obtained from the medium used to transfer that heat, but excluding hydrocarbons and helium." [17]

Because of the potential for interaction between geothermal resources and groundwater aquifers or surface water bodies, the interface of geothermal and water resources receives special attention in some state statutes. Nevada law provides, for example, that "use of water brought to the surface outside of a geothermal well is subject to the appropriation procedures of [the state water code]," except for water that is removed from or reinjected to the "same aquifer or reservoir." [18] Obviously, under Nevada law, the delineation of the source aquifer or reservoir will be critical to avoid the complex requirements of the water code. The developer should keep in mind, however, that a water right may be required in any event, to make up for evaporation or other system losses.

Arizona law exempts geothermal resources and their development from state water laws unless "(1) such resources are commingled with surface waters or groundwaters of this state, (2) such development causes impairment of or damage to the groundwater supply; and (3) well drilling to obtain and use groundwater shall be subject to the water laws of this state." [19] Regardless of the statutory definitions of water and geothermal resources, the developer should expect that the interaction between geothermal resources and other water bodies may be of special concern to state regulators. Special studies, including hydrogeologic modeling and reports, may be required to ensure that the project will not have an impermissible impact on drinking water aquifers, streams and other surface waters, and senior water rights.

6. Potential Federal and State Law Conflicts

Potential conflicts between federal and state laws relating to water and geothermal resources are highlighted in the recent Geothermal PEIS issued by the Bureau of Land Management and U.S. Forest Service. In it, the agencies addressed comments from water right holders concerning impacts on senior rights, stating,

> Site-specific impacts on water resources, including water importation, would be addressed as part of the environmental analysis for the permitting process. All development, utilization, and reclamation activities, including the use of reclaimed water, would be subject to future site-specific permitting and environmental analysis, including public involvement, as appropriate.
>
> [W]ater rights are administered and adjudicated at the state level. Each prospective lessee-developer will be required to apply for and obtain an adjudicated state water right before actually attempting to recover geothermal resources [20].

Three issues raised by these statements merit comment here. First, the assertion that impacts of the use of water will be subject to federal environmental review raises the possibility that federal review may usurp one of the essential functions of state water laws, which is to evaluate potential impacts on senior rights and to protect those rights. In theory, federal review can be harmonized with state laws through cooperation at the state and federal level. However, there is a danger that the developer's impact analysis may be "federalized" in the sense that senior water right holders may seek review under the federal process, rather than state water laws; or that the approval process will become more complex because of "parallel" state and federal processes.

The second issue raised by the agencies' comment is their assertion that use of reclaimed water is subject to environmental review. Again, this presents the possibly of impacts on, or inconsistencies with, potentially state-based regulatory schemes.

Third, the agencies' statement that the lessee-developer will be required to apply for and obtain an "adjudicated state water right" is misleading. In most cases, under Western water laws a water right need not be adjudicated in order to constitute a valid property interest. While a statement in an EIS is obviously not dispositive of the treatment of fluid resources relating to an actual project, a requirement in a federal permit that a lessee must secure an adjudicated water right could conflict with state water laws, and in many areas, such a water right would not even exist. These examples of the potential overlap of federal and state roles show that federal and state roles must be exercised cooperatively and with caution and that the developer should understand and seek to move through these processes as efficiently as possible.

7. Water from a Utility

What are the alternatives to securing water supply in this confusing and sometimes conflicting regulatory environment? Probably the most convenient source of water supply is a local utility. Unfortunately, utility service may not be available at remote locations where most geothermal projects are located. A rare example of utility service at a remote location is at Pike's Peak in Colorado, where the Cripple Creek mine receives approximately 500 gallons per minute (gpm) on a continuous basis

from a local utility [21]. This utility exists at an elevation of 10,000 feet above sea level because mining towns in that area once had a population of 100,000 people. The developer should anticipate, however, that water service from a utility likely will not be available at remote sites.

Where utility service is available, it is important for the developer to understand the utility perspective. Assuming for the sake of discussion that the project requires 500 gpm on a continuous basis, the developer should understand that this is the output of a good municipal well for a town or small city, and that, because of limited capacity, small utilities may be unable or unwilling to supply the needed quantity. If water is made available, the utility will likely require the developer to construct or pay for at least a portion of the utility's required added capacity in the form of wells or other infrastructure, in addition to the developer's share of transmission extensions and project-specific improvements such as storage.

Unless the utility has a large rate base of industrial customers, the utility will likely treat the developer's project as a special ratepayer class. This situation presents the possibility of an arbitrary or overreaching rate structure. The project team should carefully review and comment on rate proposals and capital expenditures being considered by the utility or its decision-making body in connection with the geothermal project.

8. Developing Your Own Supply

In previous papers, the author has discussed at some length the application of Western water law principles in the context of geothermal project planning and development. These issues will not be discussed in detail here. The following brief overview of water law and water planning will provide a context for discussion of water supply planning and development.

8.1. Western Water Law

Although remnants of the older riparian system of water laws remain in many Western states, Western water laws are generally based on the "prior appropriation" system of laws that originated in the mining camps of the mid-19th century. Scarce water resources were needed to extract gold and other metals, and an informal system was established to provide certainty in meeting those needs. Rules of use were established, requiring posting one's intention to use water, taking diligent actions to fulfill that intent, and continuous use of water without waste. In this system, senior appropriators established property interests in the use of water ("usufruct rights"), and had superior rights to the use of available water than later (junior) appropriators.

State water codes and modern permitting systems in the Western U.S. have adopted variations of these prior appropriation principles. Western water laws, with some exceptions, retain ownership and control of water resources in the people of the state, while vesting the right to use water in persons who put water to beneficial use. The water right holder has a usufruct right to the resource and, with some exceptions, is required to maintain continuous beneficial use in order to keep the water right in good standing. Generally, the initial grant of a water right is based on findings that (1) water is available; (2) water will be put to beneficial use; (3) the use of water is in the public interest (or not detrimental to the public interest); and (4) the use of water will not be detrimental to senior water right holders [22].

8.2. Planning

Rapid population growth in the Western U.S. over the past several decades has resulted in state legislatures, courts and administrative agencies taking significant proactive steps to clarify water laws and establish new programs for water management. Courts, legislatures and state agencies continue to clarify the parameters of "beneficial use" of water; define and regulate interactions between groundwater aquifers and surface waters; update public interest criteria to meet modern needs; and establish and support conservation and watershed-based management solutions. Adjudications have clarified rights to use water within specific water bodies, both in and among states.

Current trends in legislation, administrative rulemaking and planning for water focus on conservation, reclaimed (or "recycled") water and other alternative sources of water supply, impacts of climate change, water storage, watershed management, and transfers of existing rights to meet new demands. An example of a report focusing on efficient water resource administration and management at the state level is Colorado's Water Future, published by University of Denver in 2007 [23].

At the regional level, the Western Governors' Association (WGA) has also focused on watershed-based water planning. In its policy entitled "Watershed Restoration Through Partnerships," the WGA states, "Increasingly, governors are looking to watershed councils and broad stakeholder, community-based groups within basins to reach consensus on solutions to complex water problems. In this manner, solutions are tailored to the site-specific situation and localities take ownership of those solutions. Water storage is a critical, expensive and long-term problem. To solve water storage issues it is imperative to have a strong working relationship and commitment from all stakeholders to a mutually productive process with the goal of streamlining (not shortcutting) planning, implementation, and regulation" [24].

These local and regional planning efforts reflect a pragmatic direction at a time when state budgets are constrained, competition for water resources is increasing, and more efficient mechanisms are needed to address increasing demands for water—for all purposes—in the Western U.S.

Water management at the watershed or basin level may have different regulatory or practical effects, depending on the state and the planning context. For example, the voluntary planning approach in Washington State has limited binding effect, but establishes a framework and guidance for decisions by state water managers [25]. Oregon has quantified available supplies in certain watersheds and makes allocation decisions in priority order on that basis [26]. In Colorado, water courts authorize water rights based on a watershed-based allocation scheme [27]. Special management schemes may also be established for specific regions. In the Columbia River basin in Washington, for example, a regional management structure has been established by the state legislature that provides opportunities for regional transfers of conserved water [28]. In the Klamath River basin, the courts have established special requirements [29].

Drinking water aquifers also play an important role in water resource planning. The federal Safe Drinking Water Act requires that such aquifers be protected [30]. As discussed above, the developer should be aware of concerns about drinking water aquifers and other water bodies of concern in the project area, and should seek to avoid or mitigate any such impacts.

9. Consider Alternatives: Recycled or Reclaimed Water

Given the limited availability of water, the developer should consider alternatives to potable water supply. One option is recycled water, also called reclaimed water or highly treated wastewater. California defines "recycled water" as "water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and is therefore considered a valuable resource." [31] The California Water Code provides that use of potable water for non-potable purposes constitutes waste [32]. A significant example of the use of recycled water in a geothermal project is the Santa Rosa Geysers Recharge Project in Northern California, which provides up to 17 million gallons per day of recycled water, through two 41-mile pipelines, to maintain reservoir pressure at Calpine Geyser's geothermal operation [33].

9.1. Hybrid of Water and Wastewater Regulations

State laws and regulations for reclaimed water are evolving in the United States. Because reclaimed water may include a component of sanitary wastewater, reclaimed water regulations may include requirements relating to the protection of human health as well as protection of the environment. Health agencies as well as environmental agencies may have regulatory authority over aspects of production and use of the resource, presenting the possibility of inconsistent requirements and project oversight by the regulatory agencies. A geothermal project using reclaimed water may also be subject to special operations and management requirements, and enhanced reporting requirements.

9.2. Disinfection Requirements

State regulations may require that residual levels of disinfectant chemicals be maintained in the system. The presence of these chemicals may affect the operation of the geothermal project and should be considered early in the design process. In addition to potential impacts of disinfectant chemicals on the plant itself, the chemical and physical characteristics of geothermal fluids may make it difficult to meet residual disinfectant requirements in the system.

9.3. Permits and Contracts

Most utility or wastewater treatment operators that produce reclaimed water treat and discharge wastewater under a federal National Pollutant Discharge Elimination System (NPDES) permit [34]. Under the "umbrella" of that permit, additional terms and conditions will be established for the production and distribution of reclaimed water. In most cases, a separate "user agreement" or "end user agreement," approved by regulatory agencies, will be required for the use of reclaimed water. California's regulatory scheme is an example of the potential complexity of these contractual relationships, which may include the producer, wholesaler, retail provider, and customer [35]. Permits and agreements may be subject to periodic renewal processes, presenting the risk that conditions of use will change. In the worst case, the source of reclaimed water may not be available in the future.

9.4. Impairment and Water Rights

The production and use of recycled water may result in elimination of a portion of the wastewater stream that was previously discharged to a surface water body. Senior water right holders may assert that the change in volume, or a change in the location of the discharge, impairs their rights. Several states have recently attempted to address this issue. Oregon authorizes the "registration" of a right to reclaimed water; however, the statute does not provide a clear process for challenging or defending one's right except in very narrow circumstances [36]. The Washington legislature has directed state agencies to undertake a study, currently in progress, to address impairment and other issues. Current draft recommendations require consideration of impairment on a watershed-wide basis (both upstream and downstream) [37]. California requires consideration of potential downstream impacts only [38]. The issue of impairment—what it means and how rights are protected—will no doubt be the subject of future litigation, presenting some level of risk to the developer.

9.5. Feasibility

In making a threshold determination regarding the feasibility of using reclaimed water as a geothermal fluid, the developer should consider two critical factors. First, is there a motivated utility? For example, is the utility faced with a court order or increasingly stringent wastewater discharge limits that motivate the utility to expand ratepayer funds to produce highly treated wastewater? Second, does the wastewater plant have adequate flow? Assuming that no other industries in the area are discharging substantial quantities of wastewater into the wastewater treatment system and wastewater flow is primarily from residential sources, a population of approximately 10,000 would be required to generate the hypothetical 500 gpm needed on a continuous basis for a geothermal project [39].

10. Consider the Alternatives: Waste Streams from Oil and Gas Projects and Other Innovative Approaches

Another alternative source of water resources receiving recent attention is co-location of geothermal development with oil and gas projects. Hot water in the oilfield is generally considered a waste stream. The "Low-Temperature" program of the U.S. Department of Energy (DOE) Geothermal Technological Program (GTP) is looking at energy production from co-produced water from oil developments, focusing in particular on potential use of the approximately 10 barrels of hot water produced for every barrel of oil in some of the declining and marginal oilfields along the Gulf Coast and southeastern U.S.

The Department of Energy is interested in energy production from geopressured resources and is restarting an earlier program to harness kinetic, thermal, and potential (hydrocarbon) energy from this resource. The agency is also looking at opportunities for energy production through bottom cycling on higher temperature thermal cycles, seeking to capture additional energy from those systems [40]. On May 19, 2010, DOE announced a Funding Opportunity Announcement (FOA) seeking proposals for development of these technologies [41].

10.1. Testing

The Department of Energy is currently conducting tests at the Rocky Mountain Oilfield Testing Center (RMOTC) in Wyoming, where several geologic formations produce sufficient hot water to generate low-temperature geothermal energy. The target formations produce 45,000 barrels of water per day (BWPD), at temperatures in the range of 195 ℉ to 210 ℉. Prior to this test, hot water in the oilfield had been treated through a series of treatment ponds and discharged to an adjacent stream. In 2007 Ormat Nevada, Inc. and DOE entered into an agreement to demonstrate that a binary geothermal power generation system using hot water produced at an oilfield can reliably generate electricity on a commercial scale. Since being put into full-time service in September 2008, the net power output has ranged from 80 kW to 280 kW [42]. Changes are being made to the system to reduce power fluctuations and to increase power output. DOE's Geothermal Technologies Program and Ormat will continue operating the existing 250 kW unit for three more years, with a second 250 kW unit to be added and operated for three years. A geothermal testing facility will also be established for testing small-scale prototype power production systems [43].

10.2. Leasing and Regulatory Issues

The Department of Energy is also working with BLM on issues relating to dual leasing and permitting for geothermal development under existing oil and gas leases and permits [40]. The American Clean Energy Leadership Act of 2009 had sought to amend the Geothermal Steam Act of 1970 [43] to provide that land that is under an oil and gas lease (issued pursuant to the Mineral Leasing Act [44] or the Mineral Leasing Act for Acquired Lands) [45], and that is subject to an approved application for permit to drill, and from which oil and gas production is occurring, would be available for geothermal leasing by the holder of the oil and gas lease upon findings that geothermal energy would be produced from a well currently producing or capable of producing oil and gas, and the public interest would be served by the issuance of such a lease[44]. While the work of the Department of Energy continues, the energy bill did not pass, making it unclear whether and how federal oil and gas leasing laws will change to incorporate geothermal development in the future.

10.3. Considerations for Statutory and Regulatory Changes

The current statutory language treats geothermal use as an add-on to an existing oil and gas project. In the author's opinion, it would be helpful to authorize coordinated review and approval of new leases for co-located oil and gas and geothermal facilities. Combining and harmonizing what are now two separate leasing processes would promote geothermal investment in the context of oil and gas development, and would establish a more efficient and cost-effective review process for new co-located facilities.

The author has recommended that the following issues be considered by DOE and other federal agencies in evaluating and modifying current laws, in order to minimize conflicts and inconsistencies in permits and leases for co-located projects:

1. What is the effect of co-located facilities on calculation of royalties? For example, what costs are deductible for tax and royalty purposes?

2. What is the effect of co-located geothermal facilities on oil and gas plans of operation, pooling agreements, unit plans and agreements? For example, how will preexisting federal or state unitization requirements or agreements be harmonized with new leasing requirements for co-located facilities?
3. What is the effect of depletion of oil and gas resources on geothermal operations? What are the tax implications? May an oil and gas lease be converted to a geothermal lease when the oil and gas resource is substantially depleted?
4. Regulations for oil and gas and geothermal projects may include different technical requirements, such as drilling and casing requirements. How will these issues be harmonized and/or variances authorized?
5. What is the effect of co-location of projects on surface access and use?
6. Is a delay in securing adequate water or geothermal resources for geothermal energy development sufficient justification for delay in developing wells under an oil and gas lease?

11. Consider Alternatives: Co-location with Other Projects

Other alternatives to potable water supply include co-location with desalination facilities or large industrial users, combined heat and power systems, and district heating projects. The developer should look for potential partners and opportunities, for joint development of capital projects or cooperative management of water resources. For example, in the Western states, persistent drought conditions and limited snowpack have revived planning for upstream water storage. Storage and transmission projects at higher altitudes are a natural "fit" for cooperative development by geothermal developers and downstream water users such as municipalities, farmers, or industrial users.

Financial opportunities may present themselves in these cooperative arrangements. Municipal partners, for example, may be able to take advantage of bonding authority, low interest loans, and grants. A recent example of a cooperative approach to water management is an agreement among municipalities and utilities for management of water resources at a former hydropower facility and reservoir, Lake Tapps in Washington State [46].

12. Toward More Certainty

In prior papers and presentations, the author has advocated for development and adoption of a Model Geothermal Code that would clarify and streamline geothermal permitting and ensure consistent regulatory treatment of geothermal resources and their development. The Model Geothermal Code would (1) support and encourage development and extraction of heat and mineral resources, consistent with mining law or oil and gas law principles; (2) regulate fluid resources in a way that protects surface waters, drinking water aquifers and senior water right holders; (3) provide certainty and flexibility with respect to use of water that is subject to state water codes, as well as nonpotable geothermal fluids; and (4) provide consistent guidance in specific areas such as drilling and injection.

A draft Canadian Geothermal Code for Public Reporting has been published by the Canadian Geothermal Energy Association (CanGEA). According to the CanGEA website, the code is intended to provide "a basis for transparency, consistency and confidence in the public reporting of geothermal

information."[47] The CanGEA draft code does not address regulatory inconsistencies and conflicts as proposed by the author; however, it represents a step toward greater certainty and reduced risk in geothermal development.

13. Conclusions

Demand for water is increasing worldwide. Available supplies are limited, especially in remote locations where geothermal projects are likely to be sited. Careful planning, creativity and cooperation will be essential elements in securing and developing fluid resources for geothermal projects in the 21st century. The project developer should develop a preliminary strategy for acquisition, management and discharge of fluids early in project planning, taking into account design parameters and phasing of the project. Strategic adjustments should be made, as more information is available regarding site-specific requirements and the laws, regulations and planning processes applicable in the project area. Successful geothermal developers in the 21st century will clearly understand their project's water resource requirements, carefully evaluate applicable laws, regulations and plans, consider alternate sources of supply, and capitalize on opportunities to implement water resource solutions in collaboration with other stakeholders in the watershed.

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22. For more information, the reader is referred to one of the several excellent treatises on Western water law, such as *Water Rights Laws in the Nineteen Western States* by Wells A. Hutchins (1971).
23. University of Denver Water Futures Panel. *Colorado's Water Future*; University of Denver: Washington, DC, USA, 2007. Available online: http://www.du.edu/issues/reports/documents/ColoradosWaterFutureFinalReport.pdf (accessed on 2 August 2010).
24. Policy Resolution. Available online: http://www.westgov.org/index.php?option=com_wga&view=resolutions&Itemid=53 (accessed on 2 August 2010).
25. WASH. REV. CODE § 90.82.
26. Rules for allocation under watershed-based water management programs have been adopted pursuant to OR. REV. CODE 536.220 536.350, and are found, for example, at OR. ADM. R. § 690-500 to 690-521.
27. COLO. REV. STAT. § 148-21-18 to 148-21-23, 148-21-27, 148-21-28, 148-221-34.
28. WASH. REV. CODE § 90.90.
29. Questions certified by the 9th Circuit Court of Appeals are the subject of ongoing litigation in Oregon, pursuant to decision in Klamath Irrigation District v. United States (Klamath I), 67 Fed Cl 504 (2005).
30. EPA. *Safe Drinking Water Act Amendments of 1996 (PL 104-182), § 1453*. EPA: Washington, DC, USA.
31. CAL. WATER CODE § 13050(n).
32. CAL. WATER CODE § 13550.
33. Renewable Energy. Available online: http://www.geysers.com/renewable.htm (accessed on 28 July 2010).
34. EPA. *1972 Amendments to the Federal Water Pollution Control Act (Clean Water Act) § 402*. EPA: Washington, DC, USA.
35. CAL. WATER CODE § 13580.
36. OR. REV. STATE § 537.132.

37. Coleman, Lynn. *Water Rights Impairment Standards for Reclaimed Water: Stakeholder Views and Ecology Recommendations*; Washington Department of Ecology: Washington, DC, USA, 2009.
38. CAL. WATER CODE § 13550(4).
39. Assumes an average 70 gallons per day of use per person, discharged to wastewater treatment plant, of a total of 100 gallons used.
40. Stillman, G. U.S. Department of Energy, Washington, DC, USA. Personal communication, 5 April 2010.
41. *Energy Efficiency and Renewable Energy Geothermal Technologies Program, Funding Opportunities Announcement DE-FOA-0000318*; U.S. Department of Energy: Washington, DC, USA, 2010.
42. RMOTC. Available online: http://www.rmotc.doe.gov/ (accessed on 28 July 2010).
43. 30 U.S.C. § 1003 (b).
44. 30 U.S.C. § 181, et seq.
45. 30 U.S.C. § 351, et seq.
46. *2010 Lake Tapps Area Water Resource Agreement Among the Cities of Auburn, Bonney Lake, Buckley and Sumner, and Cascade Water Alliance*; Lake Tapps, Washington, DC, USA, 5 February, 2010. Copies of the agreement are available from the author at Callison@callisonlaw.com.
47. The Geothermal Code. Available online: http://www.cangea.ca/ccpr/ (accessed on 11 June 2010).