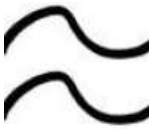

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The Next Nexus: Environmental Ethics, Water Management, and Climate Change[1]

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I. Introduction

Climate change is expected to have profound effects on precipitation and river systems and consequently, on water management. Models predict higher overall temperatures and increased variability of rainfall in most regions. Both droughts and floods will become more frequent and more severe, adding to the already daunting challenge of meeting projected increases in human demand for clean freshwater.

In this paper, I suggest that an ecological approach to water management is needed to avoid catastrophic shortfalls of water for people and irreparable damage to water ecosystems as climate change occurs. The conventional water paradigm of command-and-control is fundamentally unsustainable, even though it is gradually and reluctantly incorporating more environmental features. A competing paradigm of "ecological water management" builds on natural riparian principles and ecological relationships that are becoming increasingly well understood (Richter et al 2003; Postel and Richter 2003; Brierley and Fryirs 2008, Arthington et al 2010). But in spite of strong scientific credentials, ecological water management remains an alternative approach far outside the "mainstream".

This paper proposes how an emphasis on water ethics might inspire more sustainable management practices. The challenges of applying ecological management principles are illustrated by recent efforts to restore environmental flow to the Santa Fe River in New Mexico, USA. The river provides a fairly secure supply of water for the City of Santa Fe, which owns the bulk of the river's water rights. Since the rights holder is receiving the appropriate supply of actual water, and the water is being put to "beneficial" use, the water management system is doing a good job. The fact that the river, which is the source for that

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water, was declared the Nation's Most Endangered River in 2007 because the entire flow is impounded by the City's reservoirs, is not considered a water management problem. In fact, it is a central objective of the water managers to capture the full flow of the river for municipal use. Given these management objectives, the dry river is viewed as an indicator of successful water management.

The problem which this paper tries to address is how good water management can be equated with an outcome of a dewatered river. The problem is not lack of information, or even a lack of ethical values. The real problem stems from conceptualizing the water management task as limited to providing water to the legal owners. If this is the task, the managers of the Santa Fe River are doing a good job. But if the "real" challenge is to sustain the viability of natural systems and manage human water demands within those natural parameters, then the river managers are failing miserably.

What determines the level of our management objectives? Who decides whether environmental flow in the river should be included as a water management consideration? In some countries – Australia, South Africa and the entire European Union – environmental flow and the "good condition" of rivers is written into laws, but how did that happen? Following the causal arrows of legal protection for rivers leads eventually to shared cultural values and ethical principles about the importance of functioning ecosystems. Whether this is based on spiritual beliefs or enlightened self-interest is a question that does not need to be answered for purposes of the present discussion. The starting point for our exploration here is the empirical fact that there are shared ethical principles (values) underlying the policies encoded in the EU's Water Framework Directive, and in South Africa's National Water Law, and in Australia's 1994 Water Reform Framework. But it's not only environmentally progressive policies that are based on ethical foundations. American water policies also reflect an ethical base, albeit with different values attached. Ethics, in other words, are universal in the sense that every water policy reflects ethical principles of some kind. We can and do argue about whether the ethics are the right one, but the fact that there are ethics there, is indisputable.

This assertion, that ethics are everywhere and that our behaviors are guided by them, is the first of two points I want to make in this paper. In other words, ethical principles about water and water ecosystems define water management objectives. While the proximate principle a water manager has in mind may be legal (the requirement to deliver x amount of water to legal owner y) underlying that legal requirement is an ethic about the nature of water (a material commodity) and the rightful use of water (for economic productivity). The second point I want to make has to do with how we can apply ethics to reforming water policies and shifting water management to support the goals of sustainable water ecosystems.

II. Evolving Paradigms of Water Management

Open any history of water development and the notions of conquest and control jump out from the chapters set in the 19th and early 20th centuries, whereas the chapters dealing with the 1980s and 1990s become more complicated and nuanced. Turn to the section on the past decade and the threat of climate change and the role of nature takes on an entirely different

tone. Nature is either a formidable adversary or a powerful friend. The comforting message from history is that our values and paradigms do change over time. The challenge is to avoid causing irreparable damage in the meantime.

The Conventional Water Management Paradigm

The conventional paradigm for managing water during the 19th and most of the 20th centuries was based on the principle of "command-and-control." Dams were built to impound rivers, and release the water on command, for power generation, or into canals for irrigation, industry, or urban water supply. River channels were straightened and deepened; levees kept rivers contained and away from their natural floodplains. Urban runoff from rain and snow which fell on roofs, streets, and parking lots, was channeled and funneled through drains and sewers to get back to the nearest river as quickly as possible.

The principle of "command and control" was, and still is, intricately inter-twined with the principle of "beneficial use" and most particularly, *economically* beneficial use. Under the conventional paradigm, water needs to be tightly controlled in order to direct its service to a "stream" of economic benefits. If water is not providing economic benefits for somebody, it is not being put to beneficial use. In the Western part of the United States, a third principle also comes into play, that of "prior appropriation." Based on the idea of mineral prospecting, this principle grants permanent water rights to the first person to extract water for an economic use. The practical implication of this principle is that any water flowing in a stream that is not already claimed by someone else (for a particular economic use) can be claimed by a newcomer, so long as that newcomer can demonstrate that the water will be put to an economic application (e.g., used in a factory, or for irrigation, or for municipal drinking water, etc).

The idea of putting water to beneficial use is a very old concept. The Sri Lankan King Parakramabahu the Great (1153-1186 CE) famously said "No drop of water that falls from the sky should be allowed to flow to the sea unused." He implemented his own advice by building reservoirs and canals to command and control the water. From a physical, engineering perspective, there are remarkable similarities between ancient Sri Lankan water management practices and the practices of today. During the construction of a sluice gate for a new reservoir in the Mahaweli development project, an ancient sluice gate was discovered on the same location, from an earlier reservoir. What was different, aside from the contrast of stone vs. concrete and steel, was that the ancient stone sluice gate was constructed in the form of a seven headed cobra deity. By honoring the water god, the ancient engineers were acknowledging the "prior appropriation" right of the river spirit, and seeking both permission and protection.

Conventional water management shares the "command-and-control" approach of medieval Sri Lanka, but without the spiritual underpinnings. This view of water and rivers as inert material resources possessing neither consciousness, nor spirit, nor any inherent rights that need to be respected comprises a key principle of the conventional paradigm: Water management is a secular undertaking; rivers and lakes are regarded simply as accumulations of inert matter.

Historians have traced the development of the conventional water management paradigm to European and American political and cultural dynamics. Donald Worster (1985) provides an analysis of water development as an expression of frontier expansion into the American West during the 19th and early 20th centuries. David Blackbourn (2006) takes a similar approach in showing surprising parallels in the evolution of water engineering and the development of modern Germany over the past two centuries.

Environmentalists have waged a long, and generally losing war against the conventional water management paradigm and the destruction of unique natural landscapes. One of the first major battles was John Muir's effort to protect his beloved Hetch Hetchy Valley in the early 1900s. Originally included as part of Yosemite National Park in California, the US government withdrew its protected status to allow construction of a reservoir for the growing city of San Francisco. Muir, founder of the Sierra Club, argued that there were many other potential sources of water for San Francisco, but only one Hetch Hetchy Valley. His impassioned pleas fell on deaf ears: "Dam Hetch Hetchy! As well dam for water-tanks the people's cathedrals and churches, for no holier temple has ever been consecrated by the heart of man" (Muir 1912:262).

The Greening of Conventional Water Management

The sad history of environmental failures to preserve river ecosystems in the United States is documented in Marc Reisner's *Cadillac Desert* (Reisner 1986). Invariably, pleas to leave rivers intact for posterity were no match for money and politics. While countless individual battles were lost, however, the overall campaign to protect rivers from unchecked dam development did have some success. In a later book, *Overtapped Oasis*, Reisner (1990) reviews the history of Western water development up to that time, and notes that the bleak picture he had painted only a few years ago in *Cadillac Desert* was already looking better. The era of new dam construction in the US had come to a close, partly because the best locations for dams already had them, but also because the environmental costs were being more carefully assessed through economic cost-benefit analyses.

Today, it is clear that Reisner's hope for more environmental awareness about water management is being at least partly realized. Restoration projects aimed at mitigating the ecological damage from unfortunate construction projects of the past have become routine. [3] The conventions of water management are shifting towards more emphasis on sustainability and ecosystem services, but there is far more rhetoric than action in adopting ecological principles. Water management continues to be defined as a series of physical challenges to be solved through engineering rather than adaptive management. A fundamentally new approach is needed, and fortunately, has already been developed by ecologists, biologists, and resource economists. This model exists in a parallel scientific universe of conferences, societies, books, and professional papers which describe an ecosystem perspective of man's

[3] For example, the US Army Corps of Engineers is partnering with The Nature Conservancy to write new guidelines for managing dams in support of environmental flows as well as power generation and flood control. See http://www.nature.org/initiatives/freshwater/partnership for details.

relationship to water.[4] This approach, which I call "ecological water management" offers a way of working with, rather than against, nature's water cycles of precipitation, flow, and infiltration.

Ecological Water Management

Articulated at the World Water Forum in 2000 as *A Vision for Water and Nature*,[5] the ecological water management model is predicated on sustainable ecosystems. A fundamental feature of ecological water management, in contrast to "command-and-control" approaches, is a commitment to environmental flow (Postel and Richter 2003). An environmental flow is the natural water regime of a river, wetland or coastal zone which maintains the ecosystem. A minimum environmental flow is the smallest amount of water required at any given time to allow the ecosystem to function. Environmental flows provide critical contributions to both river health and ultimately to economic development, ensuring the continued availability of the many benefits that healthy river and groundwater systems ring to society.[6]

Since the 1990s, the concept of environmental flows has been gradually incorporated into water laws from Europe to South Africa to Australia. The South African *National Water Act* adopted in 1998 granted water resources the status of public goods, under state control; the national government is the custodian of the water resources and its powers are exercised as a public trust. It has the responsibility for the equitable allocation and usage of water and the transfer of water between catchments. The Act establishes a 'reserve 'consisting of an unallocated portion of water that is not subject to competition with other water uses. It refers to both quality and quantity of water and has two segments: the basic human need reserve and the ecological reserve. The first one refers to the amount of water for drinking, food and personal hygiene and the second one to the amount of water required to protect the aquatic ecosystems.

In Europe, the Water Framework Directive, enacted in 2001, requires sustainable water levels and flows to maintain or restore riparian habitats. Three groups of quality standards (biological, hydromorphological and physico-chemical) are identified as necessary to a healthy ecological status. Member States are required to achieve good surface water and groundwater status by 2015, which refers to ecological and chemical status of surface waters, and chemical quality and quantitative status for groundwater, with rates of abstraction sustainable over the long term.

Other dimensions of ecological water management include the morphology of river channels (which should be meandering with functioning floodplains and natural vegetation) storm water management (capturing, slowing, and spreading water so it can infiltrates into the soil, and water use whether for domestic, industrial, or agricultural purposes. In each domain of

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[4] See, for example, the websites of the Instream Flow Council (www.instreamflowcouncil.org), the Environmental Flow Network (www.eflownet.org) and the Society for Ecological Restoration (www.ser.org).

[5] A dedicated website (www.waterandnature.org) is under construction, but the full text of the Vision for Water and Nature can be downloaded at: http://www.rivernet.org/general/docs/VisionWaterNature.pdf

[6] Source: Dyson, M., Bergkamp ,G., Scanlon, J.(eds). *Flow: The Essentials of Environmental Flows*. IUCN, Gland,Switzerland (2003); Available on-line at http://www.waterandnature.org.

water management there are opportunities to utilize ecological principles to capture, store, purify, and reuse water. These complex spheres provide literally endless ways of impacting water ecosystems, which can be helpful, benign, or harmful.

The Water Response to Climate Change

> *As people accept that climate change is real and here to stay, they are likely to realize that while reducing greenhouse gas emissions is all about energy, adapting to climate change will be all about water.*
>
> - Frank Rijsberman, former Director General, International Water Management Institute.

Climate change is adding a new dimension to water management. Within the conventional water management paradigm, climate change adds urgency to more and bigger technical fixes. The inclination is to go "back to the future" of command-and-control approaches and re-engineer a solution to climate change: Build more dams to store more water, more pipelines to cross basin boundaries and more pumping to tap ever deeper sources of groundwater.

Environmental voices within the conventional paradigm call for greater water conservation efforts and smarter "conjunctive use" strategies to rely on surface water during wet years and let the groundwater build up for the dry years (Nelson et al 2007). Along with the calls for new and greener technologies, there is also an emerging consensus among environmental groups that restoring ecological health to rivers, lakes, and groundwater is essential to provide the resilience that will be needed to weather the anticipated greater swings of longer droughts and bigger floods (Seavy et. al 2009). Our best hope as humans, according to this approach, is to rely on "Nature's own infrastructure" (Smith and Barchiesi 2009). If we can keep Nature functioning, we can survive the tribulations of climate change and prevent any further damage to the rivers, lakes and aquifers which our still growing population will depend on.

The dilemma of finding consensus around the best response to climate change stems from the fundamental incompatibility between the conventional and ecological water management paradigms. Building more dams on already dewatered rivers (as often proposed in the conventional paradigm) will further damage the very ecosystems that the ecological paradigm is trying to restore. Proponents of an ecological approach have science on their side. There is a clear trend within the scientific community in favor of ecological solutions which lend themselves to unanticipated synergies, rather than conventional responses which often result in unexpected collateral damage. But proponents of the conventional paradigm still have politics on their side, as we will see in the cast of the Santa Fe River in New Mexico.

III. Competing Paradigms: The Case of the Santa Fe River (New Mexico, USA)

The Santa Fe River emerges from high (3,500m) mountains to the East of Santa Fe City and flows 75kms in a Westerly direction to join the Rio Grande. Two reservoirs in the mountains impound the entire flow of the river for City reservoirs, providing about half the water the city uses each year. The other half of the water comes from deep wells in and near the city,

including from the Santa Fe River aquifer. Santa Fe's water policies are based on 19th Century Western US water law and can be summarized in the phrase, "First in time, first in right." Earlier claims to water trump later claims, other things being equal. The most important of these other things is putting the water to "beneficial use," which means an economically productive purpose. Omitted from the law is any consideration of the water resource itself. Neither the rights of nature in general or the rights of a river in particular, are accorded a seat at the legal table.

History of Water Use along the Santa Fe River

Indigenous Pueblo Indian tribes were already using the Santa Fe River for irrigation when the Spanish arrived in the late 1500s. With the establishment of Santa Fe as a provincial capitol in 1610, agricultural use of water intensified. The Santa Fe River provided water to a growing network of Spanish canals (*acequias*) which provided the food for the growing settlement. More that 30 acequias were established, irrigating roughly 800 hectares of farmland, and diverting so much water that stretches of the river were dry during the summer months.

Based on the cultural values underlying contemporary acequia agriculture (Rodriguez 2007), it seems safe to suggest that the colonial Spanish viewed the river primarily as a means of cultivating a secure food supply in this semi-arid environment. The rights of nature were implicitly assumed: "The tacit, underlying premise [of acequia irrigators] is that all living creatures have a right to water" (Rodriguez, p. 115). Another core belief related to water was that it should be shared: "The principle of water sharing belongs to a larger moral economy that promotes cooperative economic behavior through inculcating the core value of respecto and gendered norms of personal comportment" (Ibid, p. 116).

The 19th Century saw major changes in the cultural orientation towards the river. The United States annexed the territory of New Mexico in 1848. Thirty years later, the first dam was built on the river, to provide municipal water for the newly established Santa Fe Water Company. Initially, the Water Company stored less than 10% of the river's flow for its customers, but by the mid 1900s, that proportion increased to nearly 50%. From now on, the river's water would be the basis for continued urban expansion, rather than agricultural production.

Today the river is operated with the objective of storing as much water as possible in the reservoirs. The rights to the river's water were extracted from the acequia farmers through legal maneuvers by the private water company, which later sold the rights to the City of Santa Fe. The city's rights comprise about 85% of the river's average flow (which is highly variable). An additional 5% is owned by the heirs of the early farmers (now used for urban gardens) and the remaining 10% is unallocated, usually spilling from the reservoirs when the mountain snowpack melts in late Spring. The reservoir dams are operated by City engineers. Water is normally released from the dams in anticipation of Spring floods, and (in a recent policy evolution) for aesthetic purposes during the summer months. During the rest of the year, the river is a dry, heavily eroded ditch. The policy of keeping the river intentionally dry

earned it the designation as "America's Most Endangered River" in 2007.[7] Partly in response to this negative publicity, the City government, which controls the reservoirs, shifted its policy to allow for summer water releases into the river provided the reservoirs are ¾ full rather than completely full. A year-round minimum environmental flow, however, as required in other countries, is not under serious consideration. The City's policy remains one of prioritizing storage at the expense of flow.

What's a River For?

In the prevailing view of the Santa Fe's municipal government (whose view matters most, since the municipality owns the river's water rights), the primary and almost exclusive purpose of the river is to provide water for the city's municipal water supply, thereby supporting existing homes and businesses plus future expansion. The idea that the river itself has a rightful claim to some of its water lies outside the prevailing paradigm, which is based on a legal perspective. If you have a right to the water, and if you are complying with the legal requirement that the water be put to "beneficial use", there is no legal restriction on water withdrawals.

Pealing back the legal and economic veneers we can expose a layer of ethics that is otherwise obscured. The willingness to accept the City's legal entitlement as an adequate justification for dewatering the river implies consent with the principle of water as a commodity that can be freely owned and traded. The environmental ethic being expressed is that water is a natural resource that can (and should) be utilized for economically productive purposes. A corollary to the "water-as-resource" principle is that the ecological context of the water (river, lake, aquifer) lies outside the concern of resource management. In terms of environmental ethics, the municipal government of Santa Fe is not being un-ethical (violating the ethical code) but merely a-ethical (lacking an ethical code). These two principles together explain how the city water managers, who are well educated professionals and generally aware of ecological science, can take the position that the health of the dewatered Santa Fe River is not a problem. By not subscribing to the principle that the river's health has an ethical importance, the test for determining whether river health deserves to be considered as a management will be based solely on economic considerations of managing the water for greatest economic benefit. This management objective is implied in the legal terms defining the conditions for meeting the legal requirements of water-as-property, namely that the water be applied to some "beneficial" activity. This is commonly interpreted to mean domestic water, landscape or crop irrigation, or any industrial purpose. Local water attorneys are divided in their opinion as to whether leaving water in the river for environmental benefit can qualify as a "beneficial" use under the law.

Water managers in New Mexico routinely express their professional mandate as making water available to the water rights holders, and specifically to "senior" rights holders, since under the law, junior water rights can be claimed only after the senior rights holders have received their water allocation. During a water shortage, for example, the owners of the oldest

[7] The designation was made by American Rivers, a national environmental groups based in Washington, DC. For details, see: http://www.americanrivers.org/assets/pdfs/mer-past-reports/mer-3_28_07c76c.pdf.

recorded water rights (based on the date that a claim was filed in the state courts)[8] have a legal right to their full amount of water, as if it were a normal or wet year, before the more junior right holder's rights get activated. In practice, there is usually a sharing of the shortages but there is no legal requirement to share. If a state water manager were to express the objective of making water available for the health of the riparian ecosystems, he would almost certainly be removed from office for advocating a violation of state water law.

Applying "Ecological Water Management" to the Santa Fe River

The blatant disregard for the ecological health of the Santa Fe River, which flows through the middle of a state capitol which is also one of the most popular tourist destinations in the country, has stimulated local efforts to restore a "living river". An initiative from within the city's governing council led to a comprehensive Santa Fe River Corridor Master Plan in 1995 which endorsed the objective of a permanently flowing Santa Fe River, but without any stipulations for how this might be accomplished. The Santa Fe Watershed Association (www.santafewatershed.org) was established in 1999 by a coalition of environmentalists, community activists, and business owners with the aim of "Bringing the Santa Fe River back to life; restoring the heart to our community." The reasons given for why this objective was important were couched in broadly utilitarian values:

> We advocate surface and groundwater management that balances human use with natural resource protection. We encourage government and civic leaders to place high priority on sustaining seasonal stream flow in the river, yielding hydrologic, recreational, aesthetic, and environmental value to the community. We are committed to safeguarding the long-term integrity of the river and the entire watershed.[9]

Pieces of this agenda have been incorporated into City policies. The municipal government has officially endorsed the goal of a living river, including a 20% allocation for river flow, but subject to completion of a new pipeline to secure an additional source of water, and even then only in normal or wet years. Under dry conditions (less than 80% of normal precipitation) the river flow would be shut off in favor of reservoir storage. The precise amount of water necessary for an effective environmental flow is a matter of debate even among environmentalists, but the City's planning provision for shutting off the river completely during moderately dry years clearly lies outside the concept of "environmental flow".

Without the support of legal requirements establishing minimum flows or other ecological standards,[10] river advocates such as the Santa Fe Watershed Association rely on persuasion and community interest. The water management approach advocated by the Santa Fe Watershed Association include the following features:

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[8] Water claims dating to the Spanish era (1610 to 1848) or Indian claims dating to the pre-Conquest era, are also recognized by the courts and constitute an important category of water claims, but the vast majority of water claims date from the American settlement after 1848.

[9] Santa Fe Watershed Association brochure, 2005.

[10] Even water quality standards, which are normally enforced by the federal Environmental Protection Agency, are absent from the Santa Fe River due to a legal loophole. Since the river's water is impounded in the city reservoirs and the river itself no longer flows, there is no longer (legally speaking) a river, and therefore water quality standards do not apply!

- Commit a permanent minimum environmental flow to the river, which would vary according to reservoir levels but always be greater than zero (even during droughts when the reservoirs may be empty).
- Manage the reservoirs to release the Spring runoff over a period of months rather than uncontrolled spills;
- Provide financial incentives for rooftop rain catchment systems;
- Initiate water conservation campaign and incentives, and allocate a portion of conserved water to be returned to the river;
- Enlist the help of private well owners (who account for ca. 10% of total urban water use) through buy-back arrangements to free up water for the river
- Capture storm flows from streets and parking lots and infiltrate into the shallow groundwater and the river.
- Increase groundwater pumping capacity for contingency during droughts

City officials accept the general concept that a flowing water is a good thing, but they stop short of endorsing the principle of environmental flow. They argue that there is not currently "enough" water available for the river. Only after the total supply is increased can the "new" demand of water for the river be accommodated, and then only under normal or above-normal precipitation years. As a City official explained to me, "The river has to live within its means." In the eyes of the City water managers, the river is a water "consumer" which competes with other consumptive demands: drinking water, irrigated gardens and lawns, golf courses, and new housing and office buildings. Each of these existing demands needs to be "balanced" and this balancing is the art of water management. The environmentalist demand for enough water for the river to support its ecological function is viewed as an unfair concession to the environmentalists. Instead, a balanced and "prudent" approach is required.

The Problem: Cultural Values. Why is the Santa Fe River considered a competing "consumer" with no claim to its own water, when in South Africa, a minimum water flow is legally protected as an "ecological reserve"? The problem is not lack of scientific knowledge or expertise. The problem lies in the realm of cultural values, and specifically values related to the role of nature, i.e., environmental ethics. In Santa Fe, the river is considered an inanimate thing, a physical channel through which water sometimes flows. It is not the subject of ethical concern, much less religious veneration. The river is not even seen as a provider of water, which now comes from dams, wells, and pipes. Nature has ceased to have direct relevance to the issues of water management. The river has become a "community amenity" like a park or a garden. Nature has been tamed and can now be managed through technologies, and allocated according to a prudent and balanced assessment of society's competing water demands.

IV. Reforming Water Management through Environmental Ethics

The reform of water policies is normally claimed to be the domain of lawyers, who write the laws, and economists, who apply economic logic to demonstrate the need for new laws and policies. Recent efforts to promote environmental flow as a core feature of sustainable water

management (Dyson et al 2003; Hirji and Davis 2009) utilize economic principles to provide the justification for environmental action, and bring in legal reforms as part of the solution. The case of the Santa Fe River, however, suggests that environmental economics (based on hydrology and ecological science) is limited in its influence.

The municipal water managers who control reservoir releases into the Santa Fe River are not interested in conducting a research study into the environmental economics of their management strategy. Local environmental NGOs such as the Santa Fe Watershed Association have a strong interest in environmental economics but lack the means to undertake the research. Water management institutes[11] have shown little interest in becoming involved in the local concerns of the relatively small Santa Fe River, and would likely face criticisms from local and state authorities for interfering with local water decisions. In the absence of environmental economic analysis, the status quo management of the Santa Fe River can only be challenged conceptually, where, by definition, the status quo dominates. With no compelling case for applying environmental flow to the Santa Fe River, there is also no interest in developing a supportive legal framework. The existing laws already serve the dominant economic interests. In the eyes of Santa Fe's political establishment, there is no environmental problem; the only water problem is one of supply, and the concept of environmental flow would only exasperate the supply problem by catering to yet another consumer, the river.

Climate Change as a Driver of Policy Change?

Concerns about climate change and the security of Santa Fe's water supply offer a possible stimulus for new thinking about the management of river flows. The city's water supply derives from two sources; (1) the Santa Fe River (by impounding the flow) and its associated aquifer and (2) the Rio Grande River (by river diversion and pipe) and its associated aquifer. The anticipated effects of climate change include (a) relatively less snow and more rain, resulting in less effective water storage in the form of snowpack in the upper watershed, and (b) more severe and more frequent droughts and floods. The availability of surface water will almost certainly be more variable and risky, even as there will be a need for greater storage capacity to withstand the anticipated multi-year droughts. Aquifer storage will become a more valuable part of the water supply strategy and there will be a simultaneously greater need for empty reservoir capacity as flood buffer. For the Santa Fe River, the importance of river flows for recharge might prompt some rethinking of reservoir releases.[12]

A scenario of environmental flows that recharge the aquifer, while helping fortify the riparian ecology (vegetation and river channel morphology) could result in a healthier, more resilient, "living river". Is such an outcome possible within the "water-as-resource" utilitarian ethos of Santa Fe's water managers? There will certainly be pressure to respond to climate change by increasing surface storage capacity rather than allowing any river water to infiltrate into the

[11] There are a number of water research centers within the state's university system, and also within the two national laboratories located in New Mexico, Sandia and Los Alamos.

[12] The connection between surface flows and aquifer recharge is discussed in a Watershed Association White Paper (Grant 2009) available at http://www.santafewatershed.org/index2.php?option=com_docman&task=doc_view&gid=18&Itemid=134. .

aquifer. The priority of surface storage over aquifer storage has been the convention for the past half-century. With no value accorded to riparian health, the additional environmental benefits from flows that infiltrate water into the aquifer would not be counted, and the comparison would be made on storage and recovery criteria alone: How much water can be recovered and at what cost, if the water is allowed to infiltrate into the aquifer rather than be stored in the reservoirs? With the higher temperatures and greater evaporation under climate change scenarios, coupled with the increased probabilities for extended droughts that would in any case render surface reservoirs useless, maintaining instream "environmental" flows might be seen as economically preferable even without any environmental considerations. Perhaps Santa Fe's water managers will be induced to take the environmentally enlightened option in spite of themselves.

Climate change will put new stress on water management policies everywhere, and the same types of choices confronting Santa Fe's water managers will become the norm. Faced with greater uncertainty and more extreme floods and droughts, will we try to exert even greater control over unruly rivers, or will we be induced to look for more ecological approaches? Continuing with the conventional command-and-control paradigm would inflict even more damage on already degraded water ecosystems. The urgency of responding to climate change offers an opportunity to take corrective action, to re-orient water policies to operate with the natural ecology and to take advantage of "nature's infrastructure" (Smith and Barchiesi 2009).

Does It Take a Crisis?

Can water management embrace ecology without a crisis? Can we make preemptive reforms to water policies that embrace Nature as having a right to exist and a value above and beyond the ecosystem services that benefit humans? Based on my experience in trying to effect policy reforms in Santa Fe, my sense is that environmental ethics is not going to become a compelling rallying cry for reforming water management. Cultural values and ethics are inherently resistant to change; that is how cultures are maintained over time. Rather than attempting low probability heroics with a frontal attack on well entrenched values, a more effective strategy might be to look for ways that the existing value system might be used to justify environmentally important measures that could lead to larger reforms. An approach of seeking to change behaviors within the umbrella of existing values can start a multiplier effect that can influence values gradually and indirectly. The role of the crisis (e.g., climate change) can be to stimulate the initial behavioral change.

In the Santa Fe case, the need for multi-year carryover storage that is resistant to evaporation could serve as a stimulus for experimenting with "aquifer storage and recovery" (ASR), using instream flow in the Santa Fe River. By appealing to the intuitive logic of storing water underground for long periods of time, a living Santa Fe River becomes not an extremist environmental idea, but a delivery mechanism for storing large amounts of water as drought insurance. As the flowing river and growing aquifer become accepted as a normal aspect of safeguarding long-term (sustainable) water supply, the value placed on a flowing river could become an internalized aspect of the local culture.

Healthy Rivers as a Management Goal

When a healthy river is seen as a management objective for its own sake, utilitarian objectives are forced into an accommodation with sustainability. Under such an approach, the City of Santa Fe would no longer be able to impound the entire flow of the Santa Fe River merely because this is an easy way to obtain water for the city supply. With the health of the Santa Fe River as a central management objective, the needs of urban water supply would have to be met in ways that did not endanger basic ecological functions. The dams would be operated as part of a conjunctive strategy with groundwater management, demand management (conservation), rainwater harvesting, and water reuse.

Setting the health of the river as a priority is a precondition for garnering the political support for reforming the legal framework that would support the implementation of ecological water management. But who can set new priorities without having that political support to begin with? This is the role of the "invisible hand" of cultural values. Like Adam Smith's unseen hand that allows economic markets to function efficiently, the unseen hand of culture can also appear *sui generis* under the right conditions, to protect the interests of Nature through the interplay of individual interests. The evidence that environmental protections are natural outcomes of culture is found in the sacred respect by which rivers, lakes, streams, and springs are held in every indigenous culture, present and past.

Of course, we don't have time to deprogram our current culture and to uncover the forgotten indigenous heritage of spiritual water values.[13] But perhaps science can once again serve as a substitute for religion and help extricate our society from the unsustainable mess we've created. Applying principles from ecology (including hydrology) and social science (including economics and anthropology), we have the tools to recover our lost innocence and to learn to live in compliance with the natural laws governing water ecosystems. Climate change is prompting a search for new approaches; perhaps we should try an approach endorsed by Nature herself.

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[13] See the website of the Water and Culture Institute (www.waterculture.org) for discussion of how indigenous perspectives and cultural values around water can serve as models for re-valuing Western cultural assumptions about water and Nature.

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