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WATER REUSE AS PART OF SAN DIEGO'S WATER PORTFOLIO

by

HILLARY SHIPPS

SUBMITTED TO SCRIPPS COLLEGE IN PARTIAL FULFILLMENT OF THE DEGREE OF BACHELOR OF ARTS

PROFESSOR CUTTER
PROFESSOR ABDULLATIF

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"In the late '90s, the city's purified wastewater program, the first of its kind west of Virginia, was slurred as "toilet to tap" and politically slaughtered by terrified villagers with pitchforks."

-- Logan Jenkins, July 2005

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Thank you!

Introduction

The City of San Diego imports 80 to 90 percent of its water supply from the Colorado River and the State Water Project, which takes water from the Sacramento-San Joaquin River Delta and distributes it to the southern part of the state. San Diego is in something of a perpetual water shortage, as it could not actually exist as it does without water imports, and climate change only risks making the situation more precarious. Acquiring water from so few sources that are outside of San Diego's control is a threat to the City's water supply; proposed solutions include conservation and diversification and localization of source water.

Water reuse is one of San Diego's options to reduce its dependence on imported water. Briefly, water reuse is treating wastewater to a safe level and then recycling/reusing it rather than discharging it to the sea. A demonstration project is in the final stages to determine if augmenting a local reservoir with recycled water would be safe and functional for the City. A 2015 deadline to deal with the Point Loma wastewater treatment plant's chronic failure to meet Clean Water Act standards is pushing the process forward; an upgrade to the plant is required to meet standards, but the upgrade can allow legal discharge into the sea or with a little further upgrading the plant can begin recycling water. The issue is complicated by a previous attempt to introduce water reuse which failed disastrously in the early 1990s.

After an explanation of San Diego's water supply and the related topic of why conservation and water reuse are necessary to the City's ability to reliably supply water, this paper describes the history of water reuse in the City which will complicate the latest attempt to include it. Following is a detailed definition of the different types of water reuse, the history of water reuse in San Diego, and why San Diego's earlier attempt at water reuse crashed and burned so spectacularly. Health concerns, bad public relations, and the psychological factors which combine to create the yuck factor all played a large role in that failure. The paper then describes the economics of water reuse, followed by a section on recommendations for San Diego; I suggest that the new proposal for San Diego should succeed so long as a major effort is made to improve public relations and public education, which will limit the debilitating effects of the yuck factor.

Definitions

These terms will recur throughout the document, and some will be defined in further detail later but may be referred to incidentally before that definition, hence this table.

Term	**Definition**
Acre-foot (AF; acre-feet per year = AFY)	Common measurement of water equal to 43,560 cubic feet; 325,900 gallons; flooding one football field one foot deep. Would serve two average American households for a year.
Advanced tertiary treatment (see Levels of Treatment section)	Wastewater is treated to remove all contaminants to acceptable levels. This form of treatment results in very clean, potable water. Tertiary treatment is not directly drinkable and requires another step to make it so, whether advanced tertiary treatment or biological processes.
Climate Change	Also referred to, less accurately, as global warming. I use "climate change" as shorthand to refer to its effects, particularly those for San Diego and Southern California, which are expected to include higher temperatures and less rainfall.
Conservation (of water)	The elimination of waste in order to use water more efficiently. I include active conservation (legally mandated conservation efforts) and passive conservation (actions of individuals not pushed by regulations) when I refer to conservation.
Direct potable reuse (see water reuse)	A form of water reuse. Wastewater is treated to an advanced tertiary level and sent directly into the drinking water system. Currently not practiced anywhere in the United States and is not legal in San Diego.
Emerging contaminants	Includes contaminants in water "related to residential, industrial, and agricultural wastewaters that previously were not thought to be a problem in drinking water" but have since been recognized as potentially threatening (Green 190).
Indirect potable reuse (see water reuse)	Wastewater is treated to a tertiary level or higher (see advanced tertiary treatment) and released into an aquifer or a reservoir to blend with that water before being sent to consumers.
Potable water	Drinkable; uncontaminated; meets drinking water standards.
Non-potable water	Non-drinkable; does not meet drinking water standards; may include raw (untreated) wastewater or wastewater that has been treated but not to a potable level.
Non-potable water reuse	Wastewater is treated to a tertiary level (see advanced tertiary water treatment) and is sent to a separate water distribution system to be used

	only for non-potable uses including irrigation and industrial uses.
Yuck factor	(Yes, this is a real term.) The instinctive disgust humans feel when confronted with something unpleasant, usually human waste, insects, etc. It seems to come from an evolutionary avoidance of things which might be or signal disease vectors. It is also one of the most important barriers to implementing water reuse.

San Diego's Water Supply

Water in the American West has been problematic since the earliest settlements here. The founding of Los Angeles and to a less famous extent San Diego can be recounted as a never-ending quest for more fresh water, and indeed it has been, in Marc Reisner's *Cadillac Desert* and in Norris Hundley, Jr.'s *The Great Thirst: Californians and Water: A History*. While the quest has returned several grails in the sense of new water supplies, increases in population and in standards of living have ensured that the quest is never entirely completed, and that the search for more water must go on. After all, San Diego County's (not city's, *county's*) local water supply can only support 50,000 people, a vastly smaller population than the 3.14 million that the county supports today (Union Tribune Aug. 2004). Depending on the year, San Diego receives between 80 and 90 percent of its supply from water imports, an extremely variable supply (SDCWA). A combination of factors is producing concern over future water supply, including population growth, an increasingly acknowledged need for environmental water to preserve habitats, and the maintained importance of the products of farms and ranches in the West, in addition to the looming specter of climate change, has reopened the issue of water shortage.

San Diego City's population as of 2011 was over 1.3 million people (US Census Bureau), and is projected to increase to over 1.9 million by 2030 (City of SD Water Dept. ES-1). This growth will put more pressure on an already strained water system. The City of San Diego projected in 2000, when 244,000 acre-feet (AF) were used, that water demand without drought would reach 252,000 acre-feet per year (AFY) in 2010 and 297,000 AFY in 2030; drought would increase these demand projections to 287,000 AFY in 2010 and 350,000 AFY in 2030 (*Ibid.*). In general, depending on the weather patterns of the year and subsequent demand for water, up to 90 percent of San Diego's water is imported (*Ibid.*). That means that San Diego is more vulnerable than other cities to damages from earthquakes, fires, other natural disasters, or manmade damages, because if certain water infrastructure were damaged, San Diego might be cut off from the vast majority of its water for some time.

To reach San Diego, imported water passes under the purview of a number of different agencies, including the Department of Water Resources (DWR), the Metropolitan Water District of Southern California (MWD), and the San Diego County Water Authority (SDCWA). The two primary sources of imported water are the State Water Project, which directs water sourced from various points in Northern California through the Sacramento-San Joaquin Delta, and the Colorado River. Water from the Delta is under the control of the federal Department of the Interior via the Department of Water Resources, from whom the MWD purchases the water to wholesale it to its members. The San Diego County Water Authority (SDCWA) is one of its customers. The MWD is also the go-between for San Diego's portion of Colorado River water (Green 60). The MWD is responsible for providing about half of the water demand in its service area, which includes San Diego (SDCWA). The SDCWA became a member of the MWD "in late 1946 to gain a connection from the Colorado River. Water from the river reached San Vicente Reservoir near Lakeside a year later, via San Diego Pipeline 1 and the Colorado River Aqueduct" (*Ibid.*).

The Colorado River provides approximately 50 percent of San Diego's water, a transfer which is managed by the U.S. Bureau of Reclamation, which functions under the Secretary of the Interior's instruction (SDCWA, Green 56). The Secretary of the Interior ensures that treaties on water distribution are enforced and whether the Colorado River has surplus in a given year, and who receives it if so (Green 57). The Metropolitan Water District of Southern California (MWD) is the wholesaler in charge of directing this water to San Diego, whose county water authority is one of its members. It is also the largest water wholesaler in California and serves most of the Los Angeles area in addition to San Diego, a service area amounting to 5,200 square miles (59).

State Water Project water, which comes through the Sacramento-San Joaquin Delta, provides 30 percent of San Diego's water, depending on the year (SDCWA). It has to travel 444 miles to get from source to customer (WEF). San Diego receives its SWP water through the MWD as it does with its Colorado Water. MWD has contracted for 48 percent of the SWP water and is the single largest buyer for that source (*Ibid.*). The State Water Project has had a long and torturous history and in fact continues to be the subject of litigation over Endangered Species Act (ESA) issues with the Delta smelt, in the larger lens of how much water must stay in the Delta for environmental purposes. A Peripheral Canal has been under consideration on and off for some forty years to manage both ESA issues and to mitigate earthquake threats to the water supply.

The fact that 90 percent of San Diego's water portfolio is made up of imported water poses a serious risk to the future of San Diego's water supply. This supply is subject to forces outside the City's control and therefore not reliable enough to be comfortable sustaining this level of imported water. Importing new water has always been the go-to answer in the past in order to sustain San Diego's rapid growth, but that has put the city at risk of too great a dependence on these sources and is no longer a viable solution.

> "New sources of water are increasingly difficult to find and a wide range of other problems affect the supply/ demand [sic] balance. Existing supplies can decrease

> as environmental water needs, competing water rights, climate change, or other events cause allocations to change. Water quality degradation can also effectively reduce historic supplies, creating a supply/demand imbalance (Wolff and Kasower 1).

Environmental water needs are increasingly being recognized as valid uses of water, whereas in the past any water which flowed to the ocean was considered wasted (Green 114). As one example of environmental water restrictions, the Endangered Species Act has limited the amount of water which can be legally taken because of the threat to endangered species posed by removing too much. Competing water rights have also been an issue, with the complex and sometimes conflicting water rights that exist between states and even between individuals. Southern California has for this reason lately been able to receive less water from the Colorado River; an agreement with Arizona to use their surplus has ended because Arizona no longer has a surplus. Climate change has the potential to vastly shift how San Diego receives water both as rainfall and snowmelt and as imports, which will be discussed in further detail below, with the added irritation of combining with the above issues in unexpected ways. Water quality problems are another potentially problematic aspect of San Diego's water future: they can render a water source entirely unusable, require that it receive increased treatment before it can be used, affect what other water sources can be chosen due to maximum contaminant levels (MCLs), or combine problematically in some combination of the above.

Probable Effects of Climate Change

The effects of climate change are of course unknown at the moment beyond general trends for large regions; however, projections for the region at large can be used to suggest a probable future for San Diego. The region is expected to get warmer, and "in a warmer world, Mother Nature will give up her role as banker of our summertime water supply via the Sierra Nevada snowpack" (Barnett). That is, snow that usually remains frozen in the Sierras will melt faster or even fall as rain instead of snow. Because San Diego has limited reservoir space, it may not be able to store that water if it falls as rain during the winter period of water surplus or melts sooner. Higher temperatures – the number of very hot days in San Diego is expected to double in the next 20 to 30 years – will encourage the use of air conditioning, putting a strain on power as well and potentially returning San Diego to the era of rolling blackouts (*Ibid.*). The City must also concern itself not only with its own weather changes but also those which occur in the areas where San Diego gets its water, including Northern California and the Colorado River basin. The latter is particularly worrisome, as that region is expected to experience more droughts with climate change; a Bureau of Reclamation study projects a "nine percent decrease in the River's water flow over the next 50 years, and anticipates that 40 percent of the time, the region will be subject to droughts spanning five or more years" (Gmitro). This is concerning first because the Colorado River is the source of approximately half of San Diego's water supply and because the amount San Diego can expect to receive is projected to drop even further than the decrease in flow suggests. Modeling suggests an average drop of 20 percent, though it could range anywhere from 6 to 45 percent (*Ibid.*). Returning to the increased risk of drought, droughts tend to make water suppliers more conservative because one has to plan for the worst. Thus suppliers tend to be unwilling to part with their own supplies and desperate to lay their hands on more.

Droughts, which are historically common to Southern California but which are projected to increase in frequency due to climate change, are one of the major causes of water insecurity. During a drought, water availability is limited under Water Code section 350 which allows local water suppliers to declare a water shortage emergency; except in case of a breakage in the water transportation infrastructure, this requires immediate action subject to a public hearing. Water in case of drought is to be conserved "for the greatest public benefit with particular regard to domestic use, sanitation, and fire protection," according to section 353 (Littleworth and Garner 271). The regulatory restrictions put into place during a drought are removed not when the drought is declared over, but when water supplies have been replenished, which partially explains why droughts seem to last so long to the public, and continue after it rains (272). Section 71640 allows the same rights to municipal and county water districts. It is also necessary to note that both sections 350 *et seq*. and 71640 do not require the declaration of an emergency to make nonessential cuts mandatory or prohibit new water connections, if an emergency appears to be on the horizon (*Ibid.*).

Complicating the problem of responding to the effects of climate change on the water supply is that fact that in California, water and energy are inextricably linked. "According to the California Energy Commission, 19% of all the electricity consumed in California is used to pump and treat water" (Green 59). In the reverse, many power plants require water for cooling or to heat into steam to turn generators. In short, whatever affects water in California also affects power. There are good points to this, however; if more water is conserved, or if more water is sourced locally, less power will be required to transport the water, reducing costs. As a mark of how intertwined the issues of water and power are in California, the Department of Water Resources (DWR), which manages the State Water Project and the health of the Sacramento-San Joaquin Delta, was the lead agency for the purchase of energy during the 2001 brown-outs (58). The agency was chosen for its experience managing the power issues for the State Water Project, and because it is "the largest user/purchaser of electricity in the state" (*Ibid.*). One would think that a power company or agency would be chosen to manage the state's power (give a *water* agency control over the state's *power* when it's being managed badly sounds like a bad idea on the face of it), but apparently the DWR was more qualified for the task.

Current Conservation Efforts

While water conservation might seem optional, given how the term is generally only thrown about during droughts, it is in fact a legal requirement under the California State constitution. "The California Constitution, Article X, Section 2, requires that all uses of the state's water be both reasonable and beneficial. It prohibits the waste and unreasonable use, method of use, or method of diversion of water" (113). This prohibition on waste suggests that most people are in violation of the state constitution most of the time, since many people have little trouble cutting back the usual 10 or 20 percent of water use when mandatory conservation is required during a drought. If they were doing their part the rest of the time, it would be a little more difficult.

Water conservation as we understand it today is a product of the last major drought, which from 1987 to 1992 caused the first water shortages in both agricultural and urban sectors. Before, there had always been a surplus, though at that time "surplus" included any water left in the system, as "water was thought wasted if it flowed to the sea" (114). This sparked the formation of the California Urban Water Conservation Council (CUWCC) to eliminate wasteful practices; the group consists of urban water agencies throughout California, environmental groups, and other water professionals. The CUWCC is unfortunately a nonprofit and has no way to produce binding requirements, though those cities that have signed on to the agreement generally hold themselves to their conservation plans, or at least honestly report their progress online. The CUWCC's main achievement is a list of fourteen best management practices (BMPs) for water conservation, including the following:

1. Water survey programs for single-family and multifamily residential customers.
2. Residential and commercial plumbing retrofit.
3. System water audits, leak detection, and leak repair.
4. Metering of all old and new connections and the institution of commodity rates.
5. Large landscape conservation programs and incentives.

6. High-efficiency washing machine rebate programs.
7. Public information programs.
8. School education programs.
9. Commercial and industrial conservation programs.
10. Wholesale agency assistance programs.
11. Conservation pricing.
12. Conservation coordinator.
13. Wastewater prohibition [prohibits certain particularly wasteful practices].
14. Residential ULFT [ultra low-flow toilet] replacement programs (116-8).

Despite the fact that only two of these BMPs are legally required in California (no new wasteful toilets may be installed, and local jurisdictions must implement the state's landscape ordinance or their own, stricter version) (118), from 1991 to 2007 San Diego has saved over 102 billion gallons, or approximately 313,000 acre-feet, of water through conservation (SDCWA). However, the elements which most affect San Diegans are probably rebates and possibly education programs in terms of memorable effect and financial impact. San Diego's water conservation goal is an annual 100,000 acre-feet by 2030; the city is expected to have saved 70,000 acre-feet of water in 2012, which puts the city on track for its goals (SDCWA). Conservation is expected to be a source of 13 percent of the water supply for San Diego by 2020 (SDCWA). The more water provided by conservation, water reuse, and to a lesser extent desalination, the less likely it is that new water supplies will be required, and the water will likely cost less. Conservation shows strong promise for limiting the amount of water which must be found to serve San Diego's still-growing population.

San Diego's implementation of these two mandatory best management practices has been quite successful, and the landscape ordinance has been quite friendly to water reuse. San Diego has replaced more than 518,600 water-guzzling toilets with low-flow toilets via the voucher program, which reimburses the household replacing the toilet with $75 to $165 depending on the type of toilet (*Ibid.*). The low-flow toilets use 1.6 gallons per flush where old conventional toilets use 3.5 to 5 gallons per flush or even more; each toilet replaced at least halves water use per flush, which adds up to significant savings. Indeed, the City of San Diego suggests that the majority of its conservation savings have been made through this program (*Ibid.*).

The landscape ordinance requirements have also played a part. San Diego's landscape ordinance was updated in 2010 to accommodate the Water Conservation Act of 2006, and is now quite strict for new development. The ordinance is primarily intended to discourage wasting water while acknowledging the benefits of landscaping, and also explicitly promotes water reuse (SD County 3). The ordinance applies to most new development in San Diego, including single-family developments with a landscaped area of 1,000 square feet or more, and excluding homes being rebuilt due to natural disaster. It states that anyone landscaping such a new development must absolutely acquire a water use authorization as part of the building permit as well as submit a landscape documentation package which includes: a soil management report, a landscaping and irrigation plan, a water efficient landscape worksheet, and a grading design plan (18). It also requires the calculation of a maximum applied water allowance; exceeding this value earns a fine. The ordinance also states that someone subject to this law "shall use recycled water for irrigation when tertiary treated recycled water is available from the water purveyor who supplies water to the property" (19). This ordinance goes beyond the promotion of water reuse to in fact the requirement of it, when it is available to the consumer.

Even the Metropolitan Water District (MWD), the wholesaler in charge of managing the water for much of Southern California, including San Diego, has joined the conservation bandwagon; with its 5,200 miles of service area, the effects could be quite impressive. The mission statement it adopted in 1992 mentions sustainability as one of its major concerns: "The mission of the Metropolitan Water District of southern California is to provide its service area with adequate and reliable supplies of high-quality water to meet the present and future needs in an environmentally and economically sensitive way" (Green 61). The MWD's relatively new focus on sustainability is a major pull for other water providers to perform more sustainably, and hopefully the MWD will continue to exercise their leadership in a positive way.

Defining Water Reuse

The MWD's favoring of water reuse stands it in better stead with environmentalists, who traditionally hold a less than approving view of the organization which relocates a lot of water and creates a number of environmental issues. Water reuse is the "process of treating wastewater to acceptable health levels for reuse," as opposed to treating it to the point where it may be safely released into the environment and be allowed to pass through the water cycle (132). The former is cleaner not only in treating the wastewater to a higher level but also in not releasing it "into the wild," as it were, but in reusing it. To a certain extent, water reuse is a human-assisted, faster version of the water cycle, through which all water is eventually reused. To be considered recycled water, it must be "suitable for a direct beneficial use or a controlled use that would not otherwise occur" (Asano 6). Water reuse has been practiced in various forms, mostly for irrigation and agriculture, since the 1890s, and California has used recycled water for aquifer recharging since the 1960s (Littleworth and Garner 275-6). Because water "produced" during water reuse would otherwise have been discharged into a water source and sent back through the water cycle, it may be considered a new supply of water that is more reliable than most if not all streamflows simply because wastewater is produced in the normal functioning of a city. Non-potable water reuse may likewise be considered a form of water conservation because potable (that is, safely drinkable) water is not needed for all uses, toilet flushing and landscaping irrigation being two major examples. Using non-potable water would conserve the potable water supply.

Speaking of toilets, we must consider what constitutes wastewater, and where it comes from. Water may be used either consumptively or nonconsumptively (Grant et al. 681); in the former case, the water use results in an irrecoverable fraction which cannot be recycled (Canessa, Green, and Zoldoske 3). The latter case leaves some water after the original use, which is a recoverable fraction (*Ibid.*). When this leftover water is degraded in quality, it is considered wastewater. A single use can have both irrecoverable and recoverable fractions: for instance, the part of irrigation water which is absorbed by the plants and soil is used consumptively and therefore irrecoverable, and the rest of the water which runs off is used nonconsumptively and is therefore available for recovery. This leftover water or wastewater can either be treated and discharged into a body of water to pass through the water cycle, or the wastewater can receive high level treatment and be reused.

A Rose by Any Other Name: Why Names Matter and What They Mean

This treatment and reuse of wastewater is known by a number of names depending on the source, and it is necessary to recognize these names when looking at different sources. There is a great variety of names, including water recycling; water reclamation; water purification; regeneration, used only when the water source is replaced with one of equal or better quality; and less politely, “toilet to tap” and even “toilet water.” Note that for each of the above names “water” can be replaced by “wastewater” with no effect on the meaning but definite effects on how the term is received by the public. Saying “wastewater” as opposed to “water” immediately attaches the product more closely to the “waste;” by doing so, as discussed later, the affect heuristic and the law of similarity in sympathetic magic come into play. The affect heuristic and sympathetic magic are two psychological aspects of the yuck factor which makes water reuse seem unpleasant to the public; their effects will be described in detail in the section below on Cognitive Sewage and the Yuck Factor. The terms "reclaimed water" and "reclamation" have over the years become problematized by argumentative interactions with the public, leading the State of California to amend its Water Code in 1995 to use "recycled water" in place of "reclaimed water" and "recycling" for "reclamation" (Asano 6).

I have chosen to refer to the process in this paper as water reuse, because it is a concise term that describes simply what the process does (in short, water that has been used already is used again after treatment, or reused). The term "water reuse" is relatively free of stigma as compared with the other terms listed above, though water recycling would have approximately the same positive intuitive effect. I will use this term for both the process of treatment and the use of the treated water. Additionally, I refer to the treated water that has been reused as "recycled water" for aesthetic reasons, as "reused water" sounds rather unpleasant. Note that technically, water reclamation refers to the treatment whereas water reuse refers to the use of treated water (8). Some of these terms may have different connotations in different areas or for different water reuse projects depending on the terms used for a particular project and what the history of water reuse has been in the region. While it may seem counterintuitive to bring psychology into a discussion of whether a particular technology should be used, it is actually quite important, as public acceptance and support of water reuse projects has been critical in their approval and construction. The impact of psychology on water reuse will be discussed later in detail.

Different types of water reuse are called potable reuse (synonymous with direct potable reuse), non-potable reuse, and indirect potable reuse, depending on the level to which the water is treated and how it is returned to consumers. *Potable reuse*, sometimes referred to as direct potable reuse to differentiate it from the indirect potable reuse described below, is the process of recycling water for uses which require treatment so that the end product is drinkable. The highly treated water is discharged "either directly into the potable supply distribution system downstream of [a water] treatment plant, or into the raw water supply immediately upstream of a water treatment plant" (5). That is, the water produced through this process is generally reused immediately, and released through the tap with more conventionally produced water. Direct potable reuse is currently not permitted under San Diego law. The process requires advanced tertiary treatment, described above. Few regions do use direct potable reuse, though some have outright favored the technology: Singapore began treating its wastewater for direct potable reuse and bottling it under the brand name NEWater back in 2004 (Walton). However, Singapore is the exception rather than the norm in how well potable water reuse is accepted.

Non-potable recycled water "is *not* used directly for potable purposes, such as drinking and cooking" (Green 134, emphasis added). Alternatively, it includes "all water reuse applications that do not involve either indirect or direct potable reuse" (Asano 4). It is treated to a tertiary standard, which is below the treatment level required for human consumption. Uses of non-potable water include industrial processes such as cooling of machinery, landscape irrigation, recreation purposes such as filling water features, environmental purposes such as maintaining levels of water in rivers or lakes so that the flora and fauna dependent on those water bodies are not threatened, and toilet flushing. Non-potable reuse can include gray water, which is water from "bathtubs, showers, washbasins, washing machines and laundry tubs, but does not include water from kitchen sinks or dishwashers" which produce "untreated wastewater that has not been contaminated by toilet discharge, or by any infections or contaminated bodily wastes"

(Water Code section 14876, qtd. in Littleworth and Garner 280). Gray water can be used directly for irrigation (of non-vegetable plants) at home if a gray water system is set up with the appropriate permit. The term "purple pipes" is shorthand used to describe non-potable water used for landscape irrigation, as all irrigation equipment which uses recycled water must be marked with the color purple, as illustrated below. Industrial uses also mark recycled water in this way.

Purple pipes destined for non-potable water transport.
Photo courtesy of HDR, Inc.

Purple coloration required for marking sprinkler heads using non-potable water.

The color is used to prevent mistaken cross-connections with potable water and to alert the public that recycled water is being used where the purple pipes are visible. A sign warning that irrigation water has been recycled and is not appropriate for drinking must also be installed. The pictured examples are from the area surrounding the Water Purification Demonstration Project plant in North County, San Diego. Currently non-potable reuse is the only form of water reuse permitted in San Diego, though that may change soon depending on the outcome of the demonstration project.

Required signage to mark non-potable reuse

Indirect potable reuse (IPR) is also called conjunctive use, groundwater recharge[1], or reservoir augmentation. "Conjunctive use is the use of surface water [or in the case of IPR, potable recycled water] in conjunction with groundwater. […] It involves putting surface water underground […] so that it can be pumped up or withdrawn later, when it is needed" (Green 151). An alternative to using groundwater is adding recycled water to a reservoir for storage. IPR is generally used to allow potable water to "blend" with groundwater or reservoir water, a process which has several advantages over direct potable reuse. Blending allows a failsafe in case of problems at the treatment plant (which are unlikely), uses natural processes to treat the water further, and most importantly, diminishes the "yuck factor," which increases public acceptance. The blending is a more than adequate failsafe so long as the added water is reasonably clean, as for groundwater augmentation "the bioreactions underground remove much more of any remaining contaminants, providing a natural form of water quality treatment in

[1] Groundwater recharge can be used to protect freshwater supplies from saltwater intrusion by creating a "saltwater-intrusion barrier" that prevents the saltwater from being sucked into depleted freshwater aquifers and contaminating the fresh water. This was done in Orange County.

addition to the tertiary treatment" (136). Making use of these bioreactions in groundwater augmentation is called soil aquifer treatment. A similar bioreaction takes place in a reservoir during blending. From a treatment point of view, the difference between indirect potable reuse and potable reuse is nonexistent; both require advanced tertiary treatment. Psychologically, the two are very different, because indirect potable reuse allows treated water to blend with "natural" sources that feed the reservoir or groundwater aquifer and reduces the mental connection with untreated wastewater.

Levels of Treatment

There are a number of levels of treatment required to clean wastewater for discharge into its traditional destination of a body of water and still more to create potable water. The main steps are referred to as Primary, Secondary, and Tertiary, with Advanced Tertiary being frequently mentioned for water reuse. There are some steps beyond these, however, which must be followed. Metcalf and Eddy's *Water Reuse: Issues, Technologies, and Applications* provides detailed information on each of these steps and should be consulted for further details. The images and details below are from the Water Purification Demonstration Plant in San Diego and are specific to that water recycling plant.

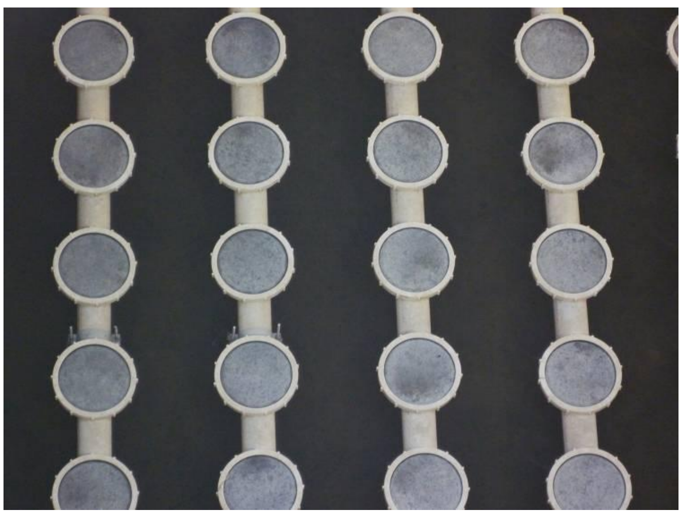
Preliminary treatment is the most basic kind of treatment, which must occur before the wastewater can be treated in other ways. This step is simply the removal of items, grit, and grease that would cause problems in the treatment machinery. This is a basic filtration step.

Initial filtration designed to remove rags, sticks, rocks, and any relatively large items.

A second filtration step removes grit. Above is an image of the empty grit-removal machinery. The pictured bar rotates, which agitates the water and forces the grit to settle as the lighter water remains above.

Primary treatment involves the removal of the majority of suspended solids, which typically includes silt, clay, microorganisms, and particulate organic matter, which consists of biological components including decomposing matter as well as organic (carbon-based) chemicals that may include surfactants, phenols, and agricultural pesticides (Asano 261). This is done through gravity sedimentation, and tends to remove approximately half the suspended solids in the water, and about a third of the biochemical oxygen demand (BOD) from decomposing matter (NRC 21). This level of treatment has no acceptable end uses.

Secondary treatment continues the removal of organic matter and suspended solids. This stage usually involves disinfection, generally by chlorine, which reduces but does not eliminate pathogens (Asano 99). Biological processes such as activated sludge (infused with microorganisms suspended in the sludge) or a trickling filter removes up to 95 percent of BOD (NRC 21). Various inorganic materials tend to settle with the suspended solids, so this step tends to remove at least some of these pollutants, including heavy metals and other substances (Green 134). This is the minimum treatment level required for discharge into the ocean, and indeed the lowest acceptable treatment level for any discharge or use (*Ibid.*).



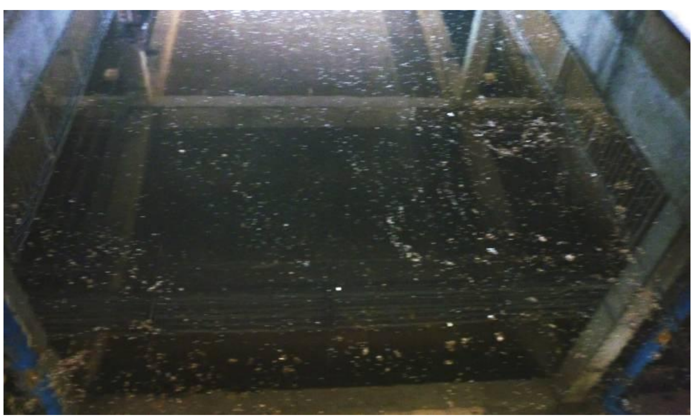
Aerators in the bacteria tanks. Water is pumped across a series of tanks with decreasing amounts of active bacteria to remove BOD.

An optional second step of *nutrient removal* can be added to the secondary treatment level, which removes nutrients such as nitrogen and phosphorus, which are found in fertilizers and can create dead zones if they are released into a body of water in a high enough concentration. However, for agricultural and landscaping uses the presence of nitrates and nitrites is an advantage over more purified water, as it lowers the cost of fertilizer. The San Diego Water

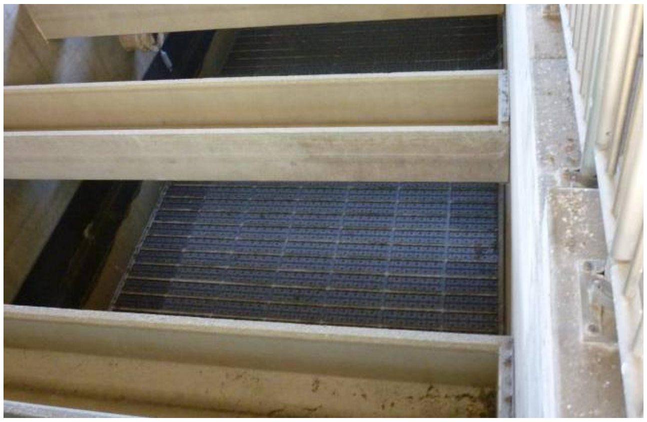
Purification Demonstration Plant serves five golf courses which favor this nitrate/nitrite-laden water, but has been removing these elements to demonstrate that it can do so to produce potable water.

Nitrate and nitrite removal stage. Anaerobic bacteria feed on these chemicals.

Tertiary treatment removes the vast majority of suspended solids, generally involving filtration, membranes, disinfection, and nutrient removal. Many non-potable uses require this level of treatment. The San Diego Water Purification Demonstration Plant uses a combination of carbon filtration, microfiltration, and reverse osmosis, in addition to chlorine.



Carbon filtration stage



Empty carbon filtration tank showing carbon filters at the bottom.

Microfiltration and reverse osmosis treatment area.

Microfiltration tube cutaway.

Advanced tertiary treatment is often specialized depending on the end use for the recycled water. It completely removes dissolved solids and any trace constituents required for the particular use. Advanced tertiary treatment can produce water that is functionally distilled water in terms of cleanliness; it can far exceed the level of cleanliness typically found in tap water (Littleworth and Garner 279).

Regulation of Recycled Water

While only non-potable reuse is currently permitted in San Diego, the results of the Water Purification Demonstration Project could change that very soon. A number of laws deal with the topic of water reuse very favorably, and even encourage it, which is a far call from the public's opposition over the years in San Diego. An early example is the Water Reuse Law of 1974, which says that "the primary interest of the people of the State in the conservation of all available water resources requires the maximum reuse of reclaimed water in the satisfaction of requirements for the beneficial use of water" (Water Code section 460 *et seq.*, qtd. in Littleworth and Garner 276). Since then, among other laws, the Water Recycling Act of 1991, which names a goal for California of 700,000 acre-feet of water recycled annually by 2000, and one million by 2010, expressly favor water reuse (276).

Moving beyond goal-based legislation, the state has also required that some uses for water utilize recycled water if at all feasible. "The legislature has prohibited the use of potable domestic supplies to irrigate cemeteries, golf courses, parks, highway landscaping, or for industrial use *if* suitable recycled water is available as determined by the state board" (Water Code sections 13551, 13552.6, qtd. in Littleworth and Garner 279, emphasis in original). Direct potable reuse is not currently considered one of the acceptable uses of recycled water, at least in San Diego, though indirect potable reuse is actively being considered, so the requirement currently is for non-potable reuse. According to the "Rules and Regulations for Recycled Water Use and Distribution within the City of San Diego" written up in 2008, "uses of recycled water may include, but are not limited to, landscape irrigation, agricultural irrigation, construction water, industrial process water, toilet and urinal flushing, commercial use, groundwater recharge, enhancement of wildlife habitat, and recreational impoundment" (City of SD 21). One of the stated goals of these rules and regulations is that non-potable recycled water never be consumed by people and that cross-connections are to be avoided at all costs (2). This legal position is somewhat contradictory, as state legislation suggests that recycled water should be used whenever possible, though the City of San Diego's position on the matter is rather less enthusiastic. However, state recommendations for the use of recycled water do not really specify the treatment level of recycled water to be used, and San Diego's position is understandable when one considers the public's bad reaction to the original proposal from the early 1990s, to be discussed later.

Jurisdiction of water reuse is a little easier to parse. In 1977, the California Superior Court determined in *Environmental Defense Fund v. East Bay Municipal Utility District* that the State Water Resources Control Board ("State Board") had exclusive jurisdiction over wastewater issues (Littleworth and Garner 192). While the court withheld the authority to adjudicate decisions based on other water issues, it was not convinced that it could safely make decisions on water reuse. The court determined that experts in the State Board would be responsible for water reuse decisions due to the complicated public health and safety issues. The Board is staffed by five experts in specified fields, representing most interests in water issues in California, who are appointed by the governor. The fact that opposition to continued or expanded water reuse is not legal will make implementation easier.

Water Reuse as Conservation

As I begin the arguments in favor of water reuse, it is necessary to redefine water reuse as a type of water conservation, that is, as a way to improve the water supply situation of San Diego without hunting for new sources. Water conservation is the improvement of water use efficiency or water productivity, "the value of goods and services provided per unit of water used. By improving water productivity, communities can enjoy the same goods and services, generate less wastewater, and leave more freshwater in streams, rivers, lakes, and coastal estuaries to support biodiversity" (Grant et al. 681). The word "conservation" is still bound to Jimmy Carter wearing a sweater to encourage the public to lower their thermostats to conserve energy, and to the notion of personal sacrifice for the greater good, which in our profoundly self-interested society is not a very powerful pull to conserve. That conservation is a backup plan of sorts has also historically been the opinion of the water industry due to California's history of searching far and wide for new source water rather than reducing consumption. That mindset has been changing: conservation is now seen as a "viable long-term supply option" (Asano 8). New calls for conservation require a rebranding of "conservation" in order to be effective, pulling it away from its old associations with austerity.

A focus on improved efficiency is the way to go, offering the same increase in supply as cutting back consumption or finding an alternate source, without directly impacting the consumer. In fact, the authors of "Waste Not, Want Not: The Potential for Urban Water Conservation in California," a report on conservation options in California generated by the think tank the Pacific Institute, explicitly "exclude from [their] analysis any options that limit the production of goods and services through deprivation or cutbacks in production" (Gleick et al. 24). Such consideration is thought necessary for the support of the public, who dislike being forced to deprive themselves of any opportunity to consume; such is generally acceptable only at the consumer's own decision to consume less. However, Gleick's limits what conservation behaviors are acceptable, depending on who defines "deprivation." It is also probable that changing consumer habits will be necessary to make significant water use reductions, rendering Gleick's objections moot.

In the perspective of water reuse as conservation, current waste provides an opportunity, and in fact a new source of water. Increases in water use efficiency can preclude the need for a new freshwater source. In addition, they can limit budget constraints in a tight economy: "the largest and least expensive source of water to meet California's future needs is the water currently being wasted in every sector of the economy" (17). That water is already bought and paid for, after all, and is simply being used in inappropriate ways that do not acknowledge its true value. Conservation is after all expected to provide 103,000 acre-feet, or 13 percent, of San Diego's 2020 water portfolio (SDCWA). These savings must come at least partially from consumers. Gleick suggests that a large amount of water could be saved by improving inefficient irrigation practices, but recent scholars disagree. Current science suggests that "evaporation in reasonably well managed systems is generally rather low [so that] real water savings are possible, but generally limited" (Perry et al. 1524). One potential measure for agricultural water savings is regulated deficit irrigation (RDI), which reduces watering when stress has less effect on crop yield. This measure saves water for when yield is more strongly affected by stress; however, this method requires a great deal of management for limited gain, and more worryingly has high risk of losing an inadequately managed crop (1523). While the percentage of water used that can be conserved may not seem like much, it is water that is currently being wasted which could be put to good use. Conserved water can go to new uses, prevent the search for new sources of fresh water, or go to streams to make sure biodiversity is not harmed by water withdrawals. While consumers must play their part, water recycling can also help conserve water.

This wasted resource includes, if you'll pardon the pun, wastewater, and reclaiming that water can reveal a large number of options that were not previously available. Specifically in terms of non-potable water reuse, conservation is predicated on the idea that "many municipal, industrial, and agricultural uses can be satisfied by lower-quality [that is, non-potable] water" (Grant et al. 681). There are also options outside water reuse for the source of such non-potable water, including seawater, rainwater, gray water (water from the laundry, the dishwasher, and bathwater), and stormwater (*Ibid*.). While these ideas are all very interesting and could do San Diego a lot of good, the scope of this paper is water reuse, and I will not be examining these other non-potable sources further. I will only consider wastewater here.

History of "Toilet to Tap" in San Diego

San Diego's foray into water reuse began in the early 1980s, emerging from concerns about how much water is imported and the lack of potential new sources of imported water. San Diego's first water reuse pilot plant was the Aqua I facility in Mission Valley, which operated from 1981 to 1985; the second was the Aqua II Total Resource Recovery facility, which operated in the same place from 1984 to 1992 (NRC 29). The third and final of this set of pilot demonstration projects was the Aqua III facility, which produced water treated to both secondary and advanced tertiary levels and which operated in Pasqual Valley beginning in 1994 and ending in 2001 (*Ibid.*).

The early 1990s marked the first attempt to produce an indirect potable reuse project for San Diego. The initial push was a drought and the EPA's declaration that the Point Loma wastewater treatment plant's exemption from Clean Water Act discharge standards could not continue, and that standards must be met by 2015 to avoid consequences (Davis). San Diego followed the general trend at that time which suggested that since discharge requirements were increasingly stringent and could often no longer be met with current technology, water reuse technology might be an option (*Ibid.*). After all, the plant would be required to upgrade in any case, and doing so to a slightly higher level would allow water reuse at not much more cost (Balint). The 1994 court settlement required a 45 million gallon-per-day water reuse plant to be built, but because the plant produced only non-potable water, the number of customers was quite limited and non-potable reuse is not as extensive as it could be (Hartley 120).

The problem was recognized and the solution of blending recycled and conventional water was suggested, but the public did not take well to the proposal, leading to its cancellation in 1999 (*Ibid.*). As one sarcastic *San Diego Union Tribune* writer put it, "in the late '90s, the city's purified wastewater program, the first of its kind west of Virginia, was slurred as "toilet to tap" and politically slaughtered by terrified villagers with pitchforks" (Jenkins). That project would have taken water treated at the North City Water Reclamation Plant in University City, moved it to another treatment plant and treated it further to the advanced tertiary level. New infrastructure would have consisted of a 23-mile pipeline that would carry potable-level recycled water to San Vicente Reservoir and blended with the water there, after which it would be treated again before emerging from customers' taps (Balint, Jiménez). The public relations debacle had largely to do with the fact that information addressing health concerns was not adequately disseminated, though the literature existed, and that conflicting expert panels both spoke out. Both expert panels took a generally positive view of water reuse, but the difference between "It is the unanimous conclusion of the Blue Ribbon Panel of Experts that water repurification as proposed by the City will provide a safe and appropriate supplemental drinking water supply" and "reclaimed wastewater can be used to supplement drinking water sources, but only as a last resort and after a thorough health and safety evaluation" (Hartley 122). The Blue Ribbon Panel on Water Repurification was arranged by the SDCWA and thoroughly endorsed water reuse, while the National Research Council's report urged caution for a city down to its last resort of water reuse. This public relations error combined badly with an environmental justice scare to kill the project.

Water from San Vicente was thought to flow only to some areas in southern San Diego, leading to "the perception that lower-income neighborhoods in the southern part of the city would become guinea pigs for untested technology" (Lee "Perceptions"). This perceived environmental justice issue is assumed to have combined with bad public relations work on behalf of the city, the lingering health concerns, and safety and operational concerns to produce the perfect storm of public opposition (*Ibid.*). The safety and operational concerns were primarily an issue of trust in the City, which was exceptionally lacking. A worst case scenario, to illustrate why operations are important, would discharge raw sewage directly into San Vicente Reservoir, a source of fresh water. This is exceptionally unlikely due to a large number of safeguards to prevent just that, but fear is a powerful motivator. In 1999 the City Council finally killed the project.

The latest water reuse project under consideration began in 2004, and "would be almost identical to the city of San Diego's 'toilet-to-tap' project that was in the planning stages for six years before being abandoned in 1999" (Balint). It is now (as of December 2012) in the very last stages of a demonstration project. The immediate cause of the project's revival was most likely the drought which in 2004 was in its fifth year, which was thought to "be the region's worst in 500 years. Water levels at the giant reservoirs that hold Colorado River water designed for

California and other states [were] at historic lows" (Union Tribune Aug. 2004). More generally, the City had recognized that it needed to diversify its water supply or risk threats to imports, which would create major problems for San Diego.

The "City of San Diego Long-Range Water Resources Plan (2002-2030)" examined eight options for the City's water future, the eighth being the status quo. Each portfolio option had a primary objective, such as maximizing flexibility or minimizing salinity, and each involved some amount of water reuse, even if only the current level of non-potable reuse. Only the status quo failed to meet projected demand for 2030 under a critically dry scenario, indicating a need for action. However, the three portfolio options with the largest increase in water reuse – Minimum Catastrophe, Minimum Risk, and Minimum Environmental Impact– also provided the greatest amount of local water (City of SD Water Dept. ES-5). This decreases the required imports to meet demand, and puts San Diego more in control of its own vital resources. "Securing a local water supply was a top priority […] because San Diego is almost entirely dependent on imports from the Colorado River and Northern California" (Lee "Repurified"). Decision-makers decided to try water reuse again.

The mayor, however, was harder to convince. In 2006 Mayor Jerry Sanders announced his opposition to potable reuse, ostensibly not due to the yuck factor but because he believed the project untenable for the public. He suggested that he "doesn't dispute the science behind water repurification but that he rejects such projects as expensive, divisive and unnecessary, given the city's other options for increasing its water supply," for which he named desalination and increasing imports (Lee "Sanders"). Later I discuss the problems with the existing level of water importation and why it is important to decrease it. I avoid discussing other options of producing more local water due to word count issues and due to the City's growing acceptance that "it's pretty much unquestioned that this has to happen," in the words of the environmental attorney who forced the City to perform a water reuse study in exchange for not suing them over the Point Loma wastewater treatment facility's continued failure to treat wastewater adequately (Davis).

The City is aware that it made a mistake with handling public relations in the first iteration of the water reuse project, and intends to do better this time. "Unlike the toilet-to-tap plan that was sprung on the public, city water officials plan extensive community outreach to try to convince people of the benefits of recycled water" (Jiménez). It is at least a first step, and in combination with addressing the public's concerns honestly and transparently, this project may succeed where the other failed. So far, public education and public relations efforts have had the desired effect, and a pilot project called the Water Purification Demonstration Project is currently (December 2012) in the final phases of testing to determine if IPR could safely be done in San Diego. The treatment plant has been modeled for easy access to tours, with one of the treatment areas entirely without walls and scattered with cutaway models to show the insides of the equipment (see photos above).

Public relations have come a long way since the project was "sprung" on the public in the early 1990s.

Preliminary results suggest that indirect potable reuse is quite possible in San Diego and that the treatment system works.

Health Concerns

Public relations have been difficult, partially because in the early 1990s attempt to establish water reuse did not deal well with the public's concerns over the health and safety of water reuse. Several of the most universal concerns over water reuse have to deal with health issues, including how well or even if recycled water can meet drinking water standards, whether drinking water standards can even be applied to recycled water, and the potential dangers of emerging contaminants. Concern over whether recycled water could meet the drinking water standards was more prominent in the last iteration of the water reuse project due to bad public relations, but we know from Orange County's extremely successful Groundwater Replenishment System that recycled water can be treated nearly to the level of distilled water and easily meets the health standards set for drinking water (Littleworth and Garner 279). In some cases, the recycled water has a higher quality than other surface waters used for drinking water (NRC 22-4). The San Diego Water Purification Demonstration Project (also known as the pilot project for water reuse) has also been extremely successful in terms of creating incredibly clean water. Water from the San Diego pilot project met drinking water standards for 300 chemicals (Witkowski). This sort of information was available during the initial attempt at water reuse, but it was not disseminated well and the lack of good public relations effectively hid the data.

Meeting drinking water standards is a more than excellent start for proving a safe source of drinking water, as they have a high degree of certainty by their rigorous testing. To qualify as acceptable for drinking water, recycled water must first at least equal the quality of conventional water sources in terms of individual compounds and microbes, which is the test referred to above for the San Diego pilot project. If that criterion is met, the water must pass a three-phase toxicological test (NRC 16). It is worth noting that California has upheld its traditional role of outdoing the federal government in environmental matters in drinking water standards. California's MCLs (maximum contaminant levels) under the California Safe Drinking Water Act[2] are more stringent for some contaminants than federal standards, and California includes secondary MCLs for nuisance conditions (taste, color, etc.) of drinking water that the federal Act does not (Green 180). Meeting California drinking water standards is if nothing else an excellent start to achieving scientific support for water reuse.

Related to whether recycled water can be cleaned to drinking standards is if these standards are even applicable to recycled water. Drinking water standards are by necessity limited, because it would be functionally impossible to list every possible contaminant and then test for each of them with the maximum possible certainty. In fact, the main function of drinking water standards, rather than to precisely delineate what may be present in the water, is to "provide a benchmark for unacceptable risk from selected contaminants for which adequate health information exists" (NRC 20). Further, they are designed to apply to the purest source, which is the traditional source chosen for drinking water, and theoretically the least likely to be affected by emerging contaminants.

Emerging contaminants include those "related to residential, industrial, and agricultural wastewaters that previously were not thought to be a problem in drinking water but have been identified in a United States Geological Survey published in March 2002" in streams the researchers thought likely to be contaminated (80 percent of those streams were contaminated) (Green 190). The term has since come to apply to more chemicals than those originally listed.

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[2] California MCLs are required to meet standards on an annual basis, which means that small, temporary exceedences are allowable provided that the average is acceptably under the MCL (Green 180).

Emerging contaminants which have seen some press time have been birth control hormones and other endocrine disruptors, which have been blamed for frogs changing sex and for reduced sperm counts in men, and triclosan, a major component in most anti-bacterial soaps and hand sanitizers blamed for creating superbugs. Other emerging contaminants of concern include some naturally occurring plant and animal steroids, insect repellent, caffeine, fire retardant, and detergent; most of these chemicals and the others which were found by the Geological Survey were at acceptable levels for drinking water (190-1).

In 2004, when Councilwoman Donna Frye of the San Diego City Council announced that she favored a study of water reuse, she specifically asked the study to examine the issue of endocrine disruptors, which she called "gender benders" (Balint). A particular concern with emerging contaminants is that because they are new to us as contaminants, we do not have enough information on their effects in long-term small dosages and that in some cases our technology is inadequate to remove them with current wastewater treatment practices. However, this issue is to some extent applicable to all waters, as the Geological Survey found these contaminants in streams. Unless the level of contamination present in treated wastewater exceeds allowable standards, emerging contaminants should not be used as a reason to avoid conserving water through water reuse. That said, more research is necessary to evaluate and contain the potential threat posed by emerging contaminants.

Cognitive Sewage and the Yuck Factor

San Diego's complex past with water reuse, branded "toilet to tap" by the unsupportive media, has been dominated by the instinctive disgust people feel when confronted with anything "contaminated" with human waste. This instinctive disgust has actually been and continues to be a valuable resource to humans, though it is not so useful for water reuse promotion. Valerie

Curtis, an evolutionary psychologist of the London School of Hygiene and Tropical Medicine, says that our "strong, intuitive sense of disgust" comes from the fact that "'pretty much all the things we find disgusting have some kind of connection to infectious disease'" (Miller 679). Feces, blood, vomit, and open wounds all fall under this umbrella as directly being able to transmit pathogens. Disgust at the presence of insects also falls under this list, because infestations of insects generally mark the presence of something dirty or decaying they would like to feed on, and which might also transmit disease. In terms of water reuse, this aversion to disgusting things comes from their connection (however faint and however clean the water has since become) to sewage and human excrement, and is called the yuck factor. "The [public's] resistance to recycled water is considered to be a psychological rather than technological barrier as treatment standards dictate the quality of recycled water in line with its intended use" (Callaghan, Moloney, and Blair, references omitted). Even though the technology is sound and accepted by scientists and in some cases by citizens, an innate disgust remains when confronted with recycled water.

Sources for this disgust include the law of contagion in the realm of sympathetic magic and the affect heuristic, and remain in force in the face of technological acceptance due to its social representation. Sympathetic magic, while normally linked to primitive religion and ritual, also has a place in explaining the inherent disgust people feel when confronted with certain stimuli. The law of contagion, or "once in contact, always in contact," functionally produces "a permanent transfer of properties from one object (usually animate) to another by brief contact" (Rozin, Millman, and Nemeroff 703). The law of similarity holds that "things that resemble one another share fundamental properties" (*Ibid.*). These two laws combine in water reuse to cause disgust when one encounters recycled water. By the law of contagion, because the water has once been in contact with human feces (before the cleaning and filtering process), it becomes eternally contaminated by association. The law of similarity suggests that because recycled water is similar to sewage because of its provenance, it is fundamentally contaminated. This combined negative contagion makes recycled water very unappealing for the average person.

Rozin, Millman, and Nemeroff produced a study examining the effects of disgust on people's actions and their preferences in consuming or contacting a "contaminated" object or substance. Most interesting is the experiment in which the researchers offered the subject clean glasses full of two types of juice, which the subject sampled and rated with their level of desire for more, on a 200-point scale. The subject then watched the researcher stir a dead, sterilized cockroach (incapable of physically contaminating the juice) in the juice for five seconds, and a clean plastic candleholder into another, then remove both objects. The subject then rated their willingness to drink each juice, and sipped from the cup of their choice. These cups were removed and fresh juice was poured into new cups, and the subjects were asked to rate how willing they were to drink this juice (704-5). Contact with the cockroach dropped the acceptability of that glass of juice by an average of 102 points, while contact with the candleholder only produced an average drop of 3 points. Less obviously and therefore more interestingly, a new glass of the juice which originally had the cockroach stirred in dropped 10 points in acceptability, where the other juice added 2 points. While not all subjects had this reaction, a few of those that did had a very strong reaction of a 50-point drop in acceptability for the type of juice that had been in contact with the cockroach (706). What is particularly important to note here is that the subjects *recognized* that they were acting irrationally, and yet they still continued to do so: "in general, subjects are somewhat embarrassed about the way they behave or the questionnaire responses they provide" (710).

From a water reuse standpoint, even if an individual recognizes intellectually that the recycled wastewater is clean and without physical contamination, he may still react as though a physical contamination is present, though it is entirely psychological. In other words, because recycled water was once wastewater or sewage, no amount of physical treatment can remove the knowledge that the water was at one point contaminated. Although a certain amount of yuck factor may always remain, education in the water cycle will help here. When people understand that the water they drink, no matter its provenance, has already passed through many sets of bowels by the time it reaches them, the yuck factor has a less insidious hold on the mind. A person is freer to react in a logical rather than instinctive manner if he is given a reason to do so.

Another psychological basis for the irrational negative reaction to recycled water bases this disgust on the affect heuristic, or reliance on an instinctive reaction to a stimulus based on prior experiences to similar or related things. To clarify, “affect” is the positive or negative feeling associated with a stimulus, where the “affect heuristic” is the reliance on that feeling to make decisions. The affect heuristic has also been evolutionarily useful: it assists in making snap judgments in situations that require an immediate response without making a cost-benefit analysis of various reactions. The affect heuristic leads to people measuring risk as feelings, as opposed to risk as analysis where logic and reason are the source of a decision. For water reuse, the topic is charged and has been associated frequently in the past with such phrases as “toilet to tap,” making it difficult for people to set aside the urges of an affect which is primarily negative and make decisions based on the hard facts of the cleanliness of recycled water. An Australian study by Callaghan, Moloney, and Blair on contagion in terms of word associations found that “water recycling” generated a host of words with both very positive and very negative affects, including “sewerage, dirty, clean, brown, environmentally friendly, environment, gardens, good, reusable, reuse, chemicals, disease, tanks, toilets and sustainability" (Callaghan, Moloney, and Blair 28, italics removed), with "sewerage" and "good" major focal points (30). Testing was done both with and without a definition of the term, and it is interesting to note that the "position of the words *drought, sustainability* and *grey water* […] appears more salient for the *definition* condition. Similarly, the position of the words *disease, yuck, drinking* and *health* […] is more salient for the *no-definition* condition" (*Ibid.*). This indicates both that a more rational set of words is generated when a definition is provided, and thus that providing more information may help the public give a more informed opinion on the subject.

The affect heuristic is particularly pertinent in San Diego where in the 1990s the media renamed the water reuse process as toilet to tap and accompanied the slur with cartoons of a dog offering his human a glass of water from the toilet; of a bartending dog offering bottled, tap, or toilet water; and on and on. The environmental justice associations, even though unfounded, also must have struck a nerve so soon after President Clinton's Executive Order requiring action to reduce environmental justice incidents made it a hot-button issue. The affect heuristic is an example of the social representation of an issue being quite different from the scientific understanding of an issue.

This is reflected in social representation theory, which states that "social representations may be qualitatively different from their scientific counterparts in a sense that will not necessarily be linear or predictable. In short, scientific knowledge should not be the barometer against which common sense understanding [is] measured" (22). Thus the public relies on the social representation of a thing rather than on the scientific knowledge base which applies to it. For water recycling, scientists know that the water cleaned to the level required for potable reuse is perfectly safe to drink, and in many cases is cleaner than the water already in our taps. The public understands that water reuse may be necessary in terms of conservation, but have less trust in the science and are subject to less logical impulses which encourage them to shun water reuse as unclean. Further, when the public lacks information about a particular issue, they have less to base an analytic judgment on and therefore rely more on the affect of the situation when considering the risks and benefits of using a particular resource or technology. With a charged issue such as water reuse, this can negatively affect how the public evaluates the risk.

If the public feels "favorable, they are moved toward judging the risks as low and the benefits as high; if their feelings toward it are unfavorable, they tend to judge the opposite – high risk and low benefit" (Slovic et al. 315). The findings of numerous studies suggest that people do not consider risk and benefit separately, but instead as part of the same axis. This is a manifestation of the halo effect, which is what happens when people judge something based on their overall impression of it. The halo effect can be reduced when there is "greater familiarity with what is being rated and greater specificity" (Alhakami and Slovic 1087-8). The Alhakami and Slovic study found that "perceived risk and benefit were almost unrelated when the risk level was perceived to be low or moderate. When the risk level increased, perceived benefit dropped sharply" (1091). Since water reuse is viewed as being risky due to the 1990s debacle with the media and the more valid concerns about emerging contaminants, the public may view it as being of lower benefit, regardless of its actual benefit to the community.

A number of psychological factors are relevant in determining the origins of the yuck factor and public malcontent with water reuse. What might be most accurately called the actual "yuck factor" most likely stems from disgust generated by the laws of sympathetic magic due to relating water reuse with sewage. The affect heuristic is also fairly negative toward water reuse, as it tends to be associated with such words as "sewerage," which as a negative effect has a stronger pull on the public than the words with positive effect such as “good” (Rozin, Millman, and Nemeroff 709). Both of these aspects contribute to a social representation of water reuse that is quite different from how scientists understand the issue, and which is significantly less positive. The affect heuristic associated with the social representation of water reuse is incredibly important for how likely it is that the technology will be used. All of these elements combined in San Diego to create a perfect storm of opposition to water reuse in the early 1990s, but all of them can be reduced by increased efforts toward educating the public.

In summary, an educated public can evaluate risk based on reason rather than on feelings, simply because they have information to base a decision on. The other major water reuse project in Southern California – the largest wastewater recycling plant in the world, in fact – had no such yuck factor issues (Schmidt). Supporters suggest that this is due to the extensive education effort made early in the game in Orange County for their Groundwater Replenishment System (GWRS): “There has been no significant opposition, thanks in part, backers say, to an exhaustive outreach program. The district's staff made 120 presentations a year for seven years, to a wide range of groups in Orange County, including the Daffodil Society, Kiwanis clubs and PTAs” (Boxall). Orange County also framed their project as saving their groundwater source from salinization which would have ruined that source of freshwater. Creating new drinking water was emphasized less. Education and public outreach is therefore the key to success for water reuse in San Diego. Water reuse has a number of aspects that San Diego would benefit from.

Benefits of Water Reuse

The use of recycled water as part of the water portfolio has a number of benefits, particularly to do with conserving water and the favorable economic situation as compared with finding a new source of water.

Conservation

Conservation has been discussed more generally at previous points, so I leave this section to specific elements that are particularly positive for water reuse. Using wastewater from domestic uses for water reuse is particularly advantageous for a number of reasons. First, the recoverable fraction of water in the domestic sphere is exceptionally high; in regions with high total water use, up to 90 percent is nonconsumptive and returned as wastewater (Asano 19). Second, domestic uses are less subject to variation with drought as agricultural uses are, and so the amount of wastewater produced by domestic consumers remains relatively constant regardless of weather. Toilets must be flushed, after all, and farms have a tendency to sell their water to cities during droughts. Water reused from domestic users would therefore be highly reliable, which is a plus in any water system (see Economic and Legal Incentives below).

Two primary benefits come from conservation via water reuse, one in terms of a smaller water and energy requirement for imports which would lessen impacts on the environment and on the pocketbook (see other economic incentives for water reuse below) and a second in terms of reducing if not eliminating the need for new water sources. Both would provide benefits for environmental water at all points of California's water system, which is typically rather strained under conflicting needs from consumers and the species which depend on those bodies of water. The benefit of less water and energy use is best illustrated through example – what was saved in fiscal year 2003-2004 as a result of using recycled water.

Savings from Usage of Recycled Water in Fiscal Year 2003-2004

Category	**Savings**
Water	72,972 AF, which supplies 364,860 people
Energy	218,916,000 kWh; 25 MW; 118,632 barrels of oil
Electricity	$28.5 million
Petroleum	$5 million
Carbon Dioxide	164,187 tons

Data from County Sanitation Districts via Green 144.

Economic and Legal Incentives

The primary economic incentive for the development of water reuse is the fact that using a local and reliable sources of water is much less expensive than finding a new source of freshwater when most sources are spoken for and when San Diego already reaches as far as Colorado for water. Nevertheless, water reuse does not seem economically appealing when, as is usual, the cost of building a new treatment facility is compared with using water already in the system with existing facilities. For this to be a true or valid comparison, one needs by economic laws to consider marginal cost, the cost of the *next* unit of water; "only when the marginal cost of new supplies is considered (what the next increment of fresh water will cost, such as the next dam and reservoir) does reclaimed water make economic sense" (Green 150). Economics tells us that we must consider marginal and not average costs, and further provides a few ways of looking at the big picture (the water portfolio in this case) that help make a more accurate comparison between different water supply options.

Least-cost planning is the method traditionally used to determine the cost of water sources, and is based upon the calculation of average cost per acre-foot. "This approach is incomplete in that it implicitly assumes that waters from two sources have the same environmental profile, for example, or the same level of reliability" (Wolff and Kasower 4). As an extreme historical example, Los Angeles found that taking Owens Valley water essentially by force cost less than any other source, despite the enormous social and later environmental costs. Los Angeles bought out all the farmers who owned the water rights in the Owens Valley then used the water rights to move the water which was then serving Owens Valley and the surrounding area to serve Los Angeles instead. This permanently retarded the growth of the Owens Valley area and created environmental concerns. By a social metric, or even a reliability metric since the aqueduct used to transport the water suffered bombing by opposing groups which interrupted service, many if not most other sources would have been more cost-effective.

According to "Portfolio Approach to Water Supply: Some Examples and Guidance for Planners," a modified form of the least-cost approach would serve more effectively and easily to determine what collection of water sources would produce the most cost-efficient outcome. It differs from the usual approach in that it compares the portfolio options rather than the individual water sources and in that it considers the portfolio's reliability (Wolff and Kasower 5). Increased reliability means hunting less water for each year to ensure a steady supply over the year. When the supply of a necessary good may drop suddenly, the consumer needs to stock extra in case of shortage to guarantee a safe minimum of the good – in this case water. One can see an example of this trend in emergency preparedness: in areas prone to natural disasters, residents tend to be more prepared and have more emergency storage of necessary goods such as bottled water and canned food, necessary and common things which in crisis are nearly impossible to acquire. "When the chosen option is a surface water source, the amount available in an average year must be greater than [the amount needed to meet needs] to ensure that [that amount] is available in a dry year" (10). The greater reliability of water reuse as a water source is one of the major economic reasons to favor water reuse, and is visible so long as the reliability is considered as part of the economic evaluation of the water source. Reliability of a city's water supply must be determined at the portfolio level to be a useful measurement.

I have settled for briefly describing the theory and now direct readers to Wolff and Kasower's "The Portfolio Approach to Water Supply: Some Examples and Guidance for Planners" for specific information for several reasons. It is quite complicated and not entirely within the scope of this paper, because with San Diego's water reuse pilot project in the last stages of determining progress, it suggests that San Diego is at least somewhat committed to water reuse. For the environmental lawyer who allowed the City to create a report on water reuse in lieu of being sued under the Clean Water Act due to the Point Loma wastewater treatment plant's continued flouting of discharge standards, "the only questions are how it will happen, when it will happen and who will pay for it" (Davis). I will therefore be focusing on how rather than if, and limit my comparison of water reuse with other options to the basic if somewhat inaccurate average cost per acre-foot, shown in the table below.

Cost per Acre-Foot for Water Sources

Water source	**Cost/AF**
Conjunctive use/ Groundwater storage	$550-$700
Conservation	$50
Desalination (ocean)	$1,400
Water reuse	$350 with existing operations, $650 for new operations*
Water transfer	$50-$300, depending on source

Data is from City of San Diego Long-Range Water Resources Plan of 2002 unless otherwise noted.

* See the following table to see a more detailed set of options for water reuse.

The appeal of water reuse grows when the availability of funding assistance from various state and federal agencies including the CWA, the MWD, CALFED, and the EPA is taken into account. In fact, the EPA gave a grant to pay for 55 percent of the costs for building San Diego's North City Water Reclamation Plant (NCWRP), with the understanding that San Diego would strive for the goal of reusing 25 percent by 2003 of the 26,900 AFY the plant is expected to treat by 2010, and 50 percent of that amount by 2010 (City of SD Water Dept. 3-6).

Possibly the most compelling argument for adding water reuse to San Diego's water portfolio comes from the study of economics: "like a family planning its financial future, the region needs a diversified water portfolio to protect against drought and earthquakes" (Jenkins). Investing solely in one source, whether financial or water, no matter how invariable that source is, is never a good idea. Diversification is far safer. San Diego was originally dependent on MWD for all of its imported water needs, which it recognized as a risk; the City subsequently diversified its imports with large independent contracts from the Colorado River (SDCWA). While this water comes from the same source as before, different wholesalers may have contracted for different amounts of water and be differently affected by drought, so diversification still helps. The risks of incurring damage to infrastructure and having shortages related to that damage are still the same, but such damage would likely only occur in a natural disaster or terrorist event rather than the more common drought. Water reuse is a way to diversify the water supply while greatly increasing the reliability of the supply, a great benefit. Diversification can also be used to match water sources of different qualities so that the blended result meets water quality standards even if one of the sources does not. For example, Colorado River water has a high level of total dissolved solids, and recycled water can have nearly none if it is processed sufficiently; a blend of the two easily meets TDS standards and does not require that Colorado River water be treated further for TDS (Davis).

Having established water reuse as an option, economics also plays a significant role in determining which method of water reuse is best for a particular region, more so than technology and likely about as much as psychology.

Cost of Various Water Reuse Options

Options for Implementing Water Reuse	**Cost (as of 2012)**
No further water reuse; update Point Loma sewage treatment plant to properly treat wastewater for discharge into the sea	$1.2 billion
Upgrade Point Loma sewage treatment plant and fully implement water reuse	$710 million
Major expansion of purple pipe (non-potable reuse) system; has limited usefulness	$430-$550 million

Data from Davis.

In terms of basic project cost, seen in the table above, a major expansion of the existing purple pipe system is the cheapest option, but it also has extremely limited effect and can only economically produce a small amount of recycled water due to lack of demand. Since the Point Loma sewage treatment plant must be updated to comply with the Clean Water Act (CWA) by 2015, one of the two options in which that occurs above *must* be implemented, and of those fully implementing water reuse is the cheaper (*Ibid.*). The question follows whether direct or indirect potable reuse would be a better fit for San Diego, which is discussed below; non-potable is discussed as comparison.

The main cost for any reuse project, which varies by the type of reuse, is transporting the recycled water to customers (Green 135). Direct potable reuse requires fewer additions to existing infrastructure than the other water reuse options, as due to using existing potable infrastructure, no new infrastructure would be required to transport the product water to consumers aside from the treatment facility. However, wastewater must be treated to an advanced tertiary standard, which can be expensive due to the power required to accomplish the feat. The same treatment level is required for indirect potable reuse for reservoir augmentation, though a little new infrastructure would be needed above that needed for direct potable reuse. "Reservoir augmentation [the form of IPR to be used in San Diego] would require expansion of a treatment plant and laying a pipeline to [San Vicente] reservoir. Because the rest of the delivery system is in place, it is viewed as a much less cumbersome approach than laying purple pipes all over the city," which would be required if we were to expand our current non-potable reuse system (Lee "Perceptions"). As the citizens panel of 2005 on whether San Diego should pursue water reuse or not put it, "indirect potable use broadens the possible uses of this resource and is the most flexible approach to maximize… the city's water resources" (Lee "Repurified").

The economic costs of non-potable reuse vary depending on how widely the resource is intended to be used; current programs allow use of recycled water only for non-potable uses such as irrigation, industrial uses, and indoor residential uses such as toilet flushing. Double piping is required for any location with potable supplies to ensure that they are not contaminated, which can be a considerable expense. This expense could be minimized to the extra materials and time required for installation for new construction, but it is almost entirely economically infeasible for existing buildings or neighborhoods. On the other hand, non-potable reuse requires less extensive treatment, so treatment itself would cost less than it would for IPR and direct potable reuse.

Another problem for non-potable reuse is lack of demand. According to John Cozad, one of the facility's wastewater operations supervisors, San Diego's current water reuse plant is in operation solely for non-potable reuse at this time, and operates far under capacity due to lack of demand (Cozad). Further, non-potable reuse requires a level of management that potable reuse and indirect potable reuse do not: residents, if the non-potable reuse system is implemented in the domestic sphere, need to receive materials on how to use the non-potable water connection, what it can be used for, and who to contact in case of a problem with the supply. Warnings must also be given not to cross-connect pipes. Though expanding the current non-potable reuse system is the cheapest option available above, its use is fundamentally limited; the infrastructure requirements for separate source of water that can only ever be limited in use render increased non-potable reuse problematic at best and completely untenable at worst.

Other economic incentives aside, and whatever means of recycling water San Diego decides upon, there is a distinct advantage to acting now. Between the looming specters of population growth and climate change, demand is projected to increase greatly, and with a business as usual mode, San Diego will not be able to sustain this growth. "The bottom line is that we have viable, though expensive, options. The longer we wait, the more expensive they will be" (Barnett).

The Future of Water Reuse: Recommendations

Potable, IPR, or Non-Potable?

Water reuse in some degree will be necessary to a sustainable water portfolio in San Diego. Logically, we already treat our wastewater to a secondary level, suitable for some non-potable uses at that point, before discharging it into the ocean; why not treat it one step further and use it again? In fact, "about two million acre-feet of wastewater is discharged annually into the ocean from California's coastal cities," most of which has been treated to a secondary level (if it was discharged properly and legally) (Littleworth and Garner 277). Implementing a system now will conserve water, reduce or remove the need for more freshwater sources, and improve the reliability of our water portfolio, before the need becomes urgent.

In carefully considering the data from various sources on water reuse, I came to the conclusion that indirect potable reuse would be the best possible option for San Diego. While I personally am all in favor of direct potable reuse, I do not feel that implementing a direct potable reuse system is a viable option, particularly in San Diego which has a rather unpleasant history with "toilet to tap." Direct potable reuse is the most strongly affected by the yuck factor, the most risky in case of a system failure, and otherwise more objectionable than non-potable reuse. Even though indirect potable reuse has built in safety measures through reducing the possibility of contact with humans and an environmental barrier respectively, I feel that championing the opinion of the National Resource Council's 1998 report on water reuse is appropriate: "Our general conclusion is that planned, indirect potable reuse is a viable application of reclaimed water – but only when there is a careful, thorough, project-specific assessment that includes contaminant monitoring, health and safety testing, and system reliability evaluation" (NRC 3). There are health risks associated with treating any wastewater improperly, and research and good planning is necessary to ensure that water reuse is carried out correctly and with sufficient safety mechanisms. Actual health issues associated with the improper use of recycled water aside, one major contamination problem could damage the already-tarnished reputation of water reuse irreparably, and San Diego may not be able to afford scorning this source of water. That said, the Water Purification Demonstration Project has been extremely thorough in testing for contaminants, and blending the wastewater that has already been treated to the advanced tertiary level protects consumers even further from potential problems.

The yuck factor may have played a role in the City's opinions of water reuse early on, as the City of San Diego Long-Range Water Resources Plan from 2002 insisted that conjunctive use of groundwater storage would only occur for non-potable uses. "The City *would not* store reclaimed water in groundwater basins used for potable demand," says the report (City of SD Water Dept. 3-18, emphasis added). The phrasing seems almost to suggest that the writers had some sort of moral aversion to the thought of doing so, though this may also have had to do with the strong negative public reaction to the suggestion of using potable reuse in the early 1990s. However, opinion has clearly been changing; the same early 1990s project which failed so spectacularly was revived in 2004 – with a great deal more care – and has been well received by scientists if with limited joy by the public. A large amount of care has been put on the public relations end of things which was severely neglected in the last attempt to push indirect potable reuse, when one city council member declared she felt "brought in at the ninth inning" (Hartley 121). Public relations this time around have been much improved, as has communication.

Indirect potable reuse is essentially potable reuse, with an added step which blends the water produced into a groundwater source or a reservoir. This allows the water to blend with the rest of the source water and also provides a backup cleaning system, particularly for groundwater injections, whereby the natural processes continue to clean the water after it is released into the other water source. The delay before the water gets to consumers also provides a check in case something goes wrong at the treatment plant, giving workers more time to track the problem before potentially contaminated water reaches consumers. A benefit of indirect potable reuse over non-potable reuse is that double piping, a potentially large expense, is not necessary for indirect potable reuse. Treated water uses the same distribution system as traditional tap water.

Both non-potable reuse and indirect potable reuse are an improvement on direct potable reuse for two main reasons. The first is that some of the health concerns listed by opponents are viable: while we are technologically capable of producing treated wastewater cleaner than our traditional drinking water is currently, emerging contaminants [definition] do pose a risk. We are uncertain of the long-term effects of certain emerging contaminants, particularly hormones, and having an extra level of protection is all to the good. More to the point, consumers must accept the reuse system for it to be installed, and consumers have noted that direct potable reuse is not something they are prepared to follow. Due to the yuck factor – in reality a series of ingrained psychological reactions having to do with human waste – many people are unwilling to support direct potable reuse due to the required contact with the body. For no-contact uses or in situations where the water has "blended" with the traditional source water, however, people are considerably more accepting, lending support to non-potable and indirect potable reuse plans. To add to this, San Diegans have had bad experiences with direct potable reuse being pushed on them without their consent and without good communication with the public, and even without options other than *potable* reuse.

Either non-potable or indirect potable reuse must be brought into consideration for San Diego, and the consent of the public must be acquired. The public *must* have ownership of this project, or it will fail like previous attempts. They must be involved from the very beginning in the development and location of the project. The leaders for the project must coordination with local non-governmental organizations and community groups to explain the project to the public and make sure they understand and accept what will be proposed. A public relations campaign should be created to spread the word and advertise the project, taking care to explain all parts of the project and particularly note any problems that may emerge, and how the project managers intend to deal with them. Hiding things from an already wary public is the way to make water reuse fail again in San Diego. Not only can San Diego not afford this, but "in the face of population growth and a depleted Colorado River, science and economics, not superstition and fear, should be driving the region's water strategy" (Jenkins).

Public Relations and Water Reuse

Whatever means of recycling water is settled upon, public support will absolutely be necessary. Strong literature on how to manage public relations when attempting to commence a water reuse project exists, mostly drawn from drought-ravaged Australia, which has proved more amenable to water reuse as a whole than the blissfully ignorant American Southwest. California has, no doubt as a result of its history, a semi-chronic inability to take drought seriously, perhaps believing that more imports can solve the problem as they have done in the past. Australia has not had that luxury, and has therefore been forced to take a more local, conservation-based point of view. Data also comes from Florida and Canada. Analysis divides itself along two lines:

what affects public acceptance of water reuse in the beginning stages of a project and what elements are most important to the customers' satisfaction after the fact.

For gaining support for the project to begin, Hartley's "Public perception and participation in water reuse" identified the following five themes as being the most important: "managing information for all stakeholders; maintaining individual motivation and demonstrating organizational commitment; promoting communication and public dialog; ensuring a fair and sound decision-making process and outcome; and building and maintaining trust" (Hartley 115). After a project is complete, perceived quality, perceived value, perceived fairness, communication, trust in the water authority, and perceived risk affect customer satisfaction (Hurlimann et al. 1225). While the public is usually not directly involved in the choice of water source or whether a particular form of treatment would be acceptable, public acceptance can make or break a water reuse project. Without dealing appropriately with the public, attempting to get a water reuse project developed would be futile.

One of the reasons San Diego's early 1990s water reuse project failed was because the City did not adequately share information and attempted to push the project through without the consent of the citizens who would be affected. Naturally, this failed due to opposition from the public, who dubbed the project "toilet to tap." Not only must actual information be shared, and shared freely, but all parties must be aware of any uncertainties inherent in the information given. "When information is managed in a manner that limits data sharing with the public, creates expert panels for review and recommendation that are perceived as black boxes, or targets subsets of the community with specific, narrow messages, problems can arise" (Hartley 121). While the City of San Diego thought itself prepared to deal with the public over the issue, they badly mishandled the issue. Targeted community outreach and education was adopted as a tactic, primarily developing the messages that current imported supplies have been reused already and that San Diego is dependent on imported water, but expert panels released conflicting reports which made the targeted outreach ineffective (*Ibid.*).

Environmental justice, an extremely touchy subject at the best of times, also came to be an issue, as the San Vicente Reservoir was perceived to serve primarily the lower-income southern part of the City. The environmental justice issue was more about the concern that citizens in the south would become "guinea pigs for untested technology," which understandably alarmed the public (Lee "Perceptions"). The City of San Diego dealt badly with these concerns. Rather than dealing with the health and safety concerns implicit in the "guinea pigs" comment, the City assured the public that there was no unequal exposure to recycled water across the city, unconsciously implying that *everyone* in the city would be guinea pigs. The combination of the environmental justice concerns with bad public relations to do with conflicting reports from expert panels alarmed the public. While the City of San Diego thought it had its public relations for the water reuse issue under control, it botched the handling of the public in its attempt to use targeted advertising and its failure to address potential risks truthfully.

Within the topic of education, it is particularly important to note that unplanned indirect potable reuse occurs quite frequently. As the National Research Council wrote in its *Issues in Potable Reuse*, "indirect reuse may be viewed as similar to the unplanned reuse that occurs when one city discharges its waste into a river or stream used by a downstream community for its water supply" (NRC 31). Most cities dependent on rivers are subject to unplanned indirect potable reuse. On a larger level, all water is reused through the water cycle. The water cycle tends to be understood in a rather abstract form by most, and connecting this natural cycle to the human activity of recycling water helps potential consumers deal with concerns about the yuck factor. San Diego's dependence on imported water is less of a critical issue to share, because it requires less explanation for the public to comprehend the importance of diversifying water sources. Health and environmental justice issues were left largely unaddressed by San Diego's 1990s public relations efforts.

Another important factor in achieving support for water reuse is to motivate followers in the public to champion the project and to organize in its favor. Acquiring supporters and those who will organize on behalf of a project is quite a different matter; supporters will note their preferences on surveys, sign petitions, and make small commitments, but organizers invest their own time on behalf of the project and tend to require stronger reasons to spend that time. For water reuse in San Diego, this distinction is particularly important, as the City Council rather than the public votes whether the water reuse project will go through. Where a supporter will vote in favor, an organizer will lobby to convince council members: supporters had no functional place in the decision over water reuse in San Diego.

Communication and public dialog are another necessity for achieving water reuse, which I will combine with trust issues. This area marks another failure for the early 1990s San Diego water reuse project, related to the city's inadequate information-sharing habits and its inability to generate support. Much of the communication and public dialog that generates support for a project is dependent upon trust in the city pushing the project and its information. It may seem like whether the citizenry trusts its government institutions is irrelevant, but when the public does not trust its institutions to do their jobs, a democratic government quickly finds its actions are limited due to that distrust. Specifically for water reuse, if the public does not trust the Water Authority's ability to treat wastewater to an adequate level consistently or report if it fails, they will be considerably less enthusiastic about supporting such a plan. The City of San Diego had an inadequate publicity campaign, and its attempts to communicate with the public were too constricted to give any sense of public trust in the City and therefore in the information released.

A county official for a water reuse project in Georgia deemed it important to "not put hired help between us and the citizens… If we wanted to build trust, [obtain] a higher degree of credibility, then we could not hide [behind] a professional facilitator" (qtd. in Hartley 123, brackets in Hartley). The managers behind the project attempted to remain distant even from the City Council which has to agree to the project for it to go through, and "a city council staff person stated they were not kept informed and were 'brought in at the ninth inning'" (Hartley 121). Bringing in the decision-makers so late was an incredibly bad idea, and their initial reactions were made more negative by this fact.

The City must also be willing to accept feedback and modify the proposed project on the basis of that feedback, or it will lose the trust of the public; in the 1990s iteration of the San Diego indirect potable reuse project, this did not happen, and the plan was "sprung on the public" without such an opportunity for meaningful comment (Jiménez). The project leaders' inability to adequately share information with the people making the decisions for whether the project would go into effect was a definite failing. This relates to the topic of fair and sound decision-making practices, which is partially a trust issue and partially an environmental justice issue. Garnering support for a water reuse project requires managing information, motivating supporters and organizers, promoting communication and public dialog, ensuring fair and sound decision-making, and building and maintaining trust.

After a water reuse project has come into effect, the project must have several qualities to keep the public satisfied with the results, including perceived quality, perceived value, perceived fairness, communication, trust in the water authority, and perceived risk affect customer satisfaction (Hurlimann et al. 1221). The effects of many of these qualities are interconnected and cannot be approached individually. The perceived quality of the system, that is, how well the system seems to function in the eyes of the public, adds value to the project, which increases customer satisfaction. It also adds to the perceived fairness of the project. "Trust [in the water authority] is built through the nature of communication and dialogue," which leads both directly to increased satisfaction and to increased perception of fairness, which leads in turn to perceived value and thus to increased satisfaction (1224). Perceived risk has a negative effect on the satisfaction customers have with a project; when the public feels they may be endangered through a project, they tend to react badly, as did San Diegans in the early 1990s.

Following the suggestions above to improve public education and public relations will help drive water reuse into a positive situation for San Diego, which considering its turbulent history with water reuse, could use the help. In addition to benefits listed at length above, implementing water reuse in San Diego could make the City a leader in water use for reservoir augmentation as Orange County is for groundwater replenishment. That could be a major public relations opportunity for the City, and all it needs to do is manage its internal public relations issues first.

Glossary of Abbreviations

AF – acre-foot. An acre-foot measures 43,560 cubic feet or 325,900 gallons. It is the equivalent of flooding one football field one foot deep and is the amount which would serve two average American households for a year (Jiménez).

AFY – acre-feet per year

BMPs – best management practices

BOD – biochemical oxygen demand, a reduction in available oxygen in the water caused by high levels of decomposing waste which bacteria consume to get rid of the waste.

CALFED – An amalgamation of water management agencies and interest groups representing agriculture, the urban sector, and environmentalists in order to manage the Sacramento-San Joaquin Delta publicly and transparently. The name is an amalgamation of agency names and stands for something approximating California Federal Environmental Directorate (Green 109-10).

CUWCC – California Urban Water Conservation Council, a nonprofit made up of urban water agencies, environmental groups, and other water professionals whose goal is to encourage water conservation and provide BMPs to assist its members.

CWA – Clean Water Act

DBPs – disinfection byproducts, potentially dangerous chemicals that form as a result of using chemical disinfection such as chlorination

DHS – Department of Health Services. Here, I refer to that of California only.

DWR – Department of Water Resources of California, managed by the Secretary of the Interior of the United States Department of the Interior. Evolved in 1956 from a previous agency into the present form to plan the development of the state's water resources (Green 58).

EPA – Environmental Protection Agency

ESA – Endangered Species Act

GWRS – Groundwater Replenishment System, Orange County's highly successful IPR project

IPR – indirect potable reuse

kWh – kilowatt-hour

MAF – million acre-feet

MCL – maximum contaminant level, the upper limit of a contaminant allowed under the Safe Drinking Water Act in drinking water

MW - megawatt

MWD – Metropolitan Water District of Southern California, the largest water wholesaler in California and the largest contractor for SWP water. Serves 18 million residents in six counties in 5,200 miles of service area. Formed in 1928 to acquire additional water to Southern California and educate residents on water issues (Green 59).

RDI – regulated deficit irrigation, the process of reducing watering when stress has a limited effect on crop yield in order to conserve water for the times when the crop yield is highly affected by stress. High management levels are required for effective use of this technique, or one risks losing the crop; limited potential savings make this a risky option.

SDCWA – San Diego County Water Authority (also seen abbreviated as CWA on occasion)

SWP – State Water Project, water system which transports water from north of the Sacramento-San Joaquin Delta to Southern California, including San Diego.

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