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Remaking Waste as Water: The Governance of Recycled Effluent for Potable Water Supply

Katharine Meehan

Department of Geography, University of Oregon, Eugene, OR, USA; meehan@uoregon.edu

Kerri Jean Ormerod

School of Geography and Development, University of Arizona, Tucson, AZ, USA; ormerod@email.arizona.edu

Sarah A. Moore

Department of Geography, University of Wisconsin-Madison, Madison, WI, USA; smoore7@wisc.edu

ABSTRACT: Water managers increasingly rely on the indirect potable reuse (IPR) of recycled effluent to augment potable water supplies in rapidly growing cities. At the same time, the presence of waste – as abject material – clearly remains an object of concern in IPR projects, spawning debate and opposition among the public. In this article, we identify the key governance factors of IPR schemes to examine how waste disrupts and stabilises existing practices and ideologies of water resources management. Specifically, we analyse and compare four prominent IPR projects from the United States and Australia, and identify the techno-scientific, legal, and socio-economic components necessary for successful implementation of IPR projects. This analysis demonstrates that successful IPR projects are characterised by large-scale, centralised infrastructure, state and techno-scientific control, and a political economy of water marked by supply augmentation and unchecked expansion. We argue that – despite advanced treatment – recycled effluent is a parallax object: a material force that disrupts the power geometries embedded in municipal water management. Consequently, successful IPR schemes must stabilise a particular mode of water governance, one in which recycled effluent is highly regulated and heavily policed. We conclude with insights about the future role of public participation in IPR projects.

KEYWORDS: Water reuse, indirect potable reuse, waste, power, governance

INTRODUCTION

From Singapore to San Diego, cities are increasingly utilising wastewater as a 'new' source of potable supply. Sewage is now a sought-after resource in metropolitan areas, particularly given social and environmental pressures such as climate change, rapid urbanisation, and rising infrastructure costs (Scott and Raschid-Sally, 2012). One of the most promising methods to repurpose wastewater is the technique known as indirect potable reuse (IPR): a process in which tertiary or advanced treated effluent is deliberately and indirectly blended with conventional drinking water supplies via an environmental buffer (i.e. attenuation and/or retention in a reservoir, river, or aquifer) and then re-treated to meet drinking water standards before delivery (NRC, 1998). Over the past few decades, IPR has enabled cities to incorporate effluent in their water supply portfolio. For example, Singapore mixes its potable supply with 1% recycled effluent (Royte, 2008); drinking water in California's Orange County Water District contains 10% recycled effluent (Rodriguez et al., 2009); and the drinking water supply of Atlantis, South Africa, consists of 25-40% recycled effluent (Quayle, 2012). During dry periods, the

Langford Recycling Scheme in Essex, England, is capable of contributing 8% recycled effluent to the overall supply (Essex & Suffolk Water, 2008).

But the metamorphosis of sewage has not gone unchallenged. In San Diego, opponents to so-called 'toilet to tap' schemes successfully crushed IPR proposals in 1999 and 2004, meeting organised resistance from groups such as the Revolting Grandmas (Cavanaugh, 2008; Davis, 2009, 2010). In Australia, Toowoomba residents defeated a 2006 proposal to add recycled effluent to the drinking supply despite the region's frequent and severe water shortages (Chu, 2011). With vivid descriptors such as 'sewage to spigot', 'faeces to faucet', and 'backside to frontside' so prominent in media and public discourse about IPR (Davis, 2010), the presence of waste – as abject material – clearly remains an object of concern. Despite numerous studies that have demonstrated the relative safety of recycled effluent (Saywell, 2002; Athavaley, 2008; Grenoble, 2009; Rodríguez et al., 2009; Crook, 2010), the visceral matter of waste remains at political stake, lingering long after the removal of pathogens and pollutants.

In this article, we identify the key governance factors of IPR schemes to examine how waste influences practices and ideologies of water resources management. Specifically, we analyse and compare four IPR schemes from the United States (US) and Australia, and identify the techno-scientific, legal, and socio-economic components necessary for successful implementation of IPR projects. While most reuse research spotlights the technical aspects of treatment (e.g. Asano, 1998; Crook, 2010), the psychological aversion to drinking recycled effluent (e.g. Parkinson, 2008; Schmidt, 2008; Spiegel, 2011), or the social, spatial, and cultural constructs of risk (e.g. Hurlimann and McKay, 2004; Marks and Zadoroznyj, 2005; Hurlimann, 2007, 2008; Nancarrow et al., 2008; Russell and Lux, 2009; Ormerod and Scott, 2012), we draw on critical waste studies to frame recycled effluent as a parallax object. Following Moore (2012), we suggest that recycled effluent itself might best be understood as "that which objects, that which disturbs the smooth running of things" (Žižek, 2006: 17). Drawing on our case study analysis, we demonstrate that even as effluent becomes an important resource, it remains potentially disruptive to water management and thus requires institutions to control technical, legal, and socio-economic conditions to a greater extent than conventional potable supplies.

Our approach seeks to integrate scholarship on water governance with critical insights from waste studies. Waste scholars alternatively understand garbage, filth, and sewage as negative externalities of modern urban capitalism (Melosi, 2000; Hawkins and Muecke, 2003); as unjust environmental hazards (Bullard, 1990); as key commodities in a global trade (O'Brien, 1999); as lobbying tools for marginalised people (Bulkeley et al., 2007; Gutberlet, 2008; Moore, 2009); as aesthetic artefacts of consumerist societies (Engler, 2004); and as matter 'out of place' (Douglas, 2004; Hawkins, 2006). Recently, scholars have suggested that waste is more than an inert template – the "stuff that is being governed, or that which is the outcome of policy" (Gregson and Crang, 2010: 1027). In this view, scholars emphasise the materiality of waste as politically important, "whether because of its inherent qualities (risk, hazard, filth), or because of its indeterminacy (as out of place, disorder, abject), as that which disturbs or disrupts socio-spatial norms" (Moore, 2012: 781). We argue that – despite advanced treatment – recycled effluent is a parallax object: a material force with the potential to disrupt the power geometries embedded in municipal water management. Consequently, successful IPR schemes must stabilise a particular mode of water governance, one in which recycled effluent is highly regulated and heavily policed.

The paper is organised as follows. First, we trace the historical transformation of effluent: from a source of pollution and municipal aggravation during the 19th century urbanisation, to a 'repurified' and 'renovated' resource for contemporary cities. We then analyse four prominent IPR schemes – drawn from Australia and the US – to identify the key components that mark successful implementation of IPR projects. In the final sections, we discuss the implications of governing wastewater as a municipal resource, including the role of public participation amid the consolidation of institutional control and techno-scientific expertise.

FROM POLLUTED TO PURE: THE HISTORY OF RECYCLED EFFLUENT

The roots of recycled effluent reach back to early periods of urbanisation. During the Renaissance, Leonardo da Vinci drew blueprints to flush waste from Roman cities, with the idea that an 'odourless city' signalled a new, modern phase of urban development (Sterner, 2008). In 16th century France, cities issued regulations that required citizens to "clean up in front in one's house" and "give [dirty] waters chase with a bucketful of clean water to hasten their course" away from settled areas (Laporte, 2002: 5). The Spanish colonial government developed sewerage networks in Mexico City, patterned after ancient Aztec infrastructure, to rid the downtown core of wastewater and secure conditions for commerce and growth (Agostoni, 2003).

In spite of early efforts to manage waste, it was not until the 19th century – when rapid urbanisation and industrialisation led to high population densities – that faecal matter became an object of centralised municipal control. Three factors drove this transformation. First, the rapid spread of life-threatening diseases – such as cholera, yellow fever, and typhoid – forced city leaders to focus on new waste disposal methods at broader scales. At the time, miasmic theory dominated understandings of the origin and transfer of diseases: sanitarians believed that detritus, filth, and trash generated 'poisonous exhalations' and bad air (or miasmas) that, in turn, triggered the spread of disease through crowded urban neighbourhoods (Melosi, 2000, 2001, 2011; Agostoni, 2003; Engler, 2004; Benidickson, 2007). Consequently, physicians and hygienists argued for the construction of universal, integrated disposal systems to contain, convey, and control human waste. By 1880, the germ theory of disease had largely supplanted miasmic concepts – shifting the focus from filth to bacteria – but this paradigm did not radically alter modern sewage disposal techniques, which still rely on expensive, water-based, large-scale networks (Gandy, 1999; Melosi, 2011).

Second, the political economy of waste pushed effluent into municipal control. In the medieval era, households and small-scale entrepreneurs – such as night-soil collectors – were responsible for the removal or recycling of waste products (Melosi, 2000; Okun, 2000; Sterner, 2008). During the 19th century, large companies tried to establish a foothold in water provision, but most failed to generate profit due to the spatially extensive, capital-intensive nature of sewage disposal (Gandy, 1999, 2002). In response to private-sector withdrawal, civic reformers lobbied for increased state control over urban water provision and sanitation, arguing that private entities ignored water quality and perpetuated socio-spatial inequalities of access (Gandy, 1999; Melosi, 2000; Engler, 2004; Benidickson, 2007).

Finally, urban waterworks became municipal symbols of moral purity, order, and progress (Melosi, 2000, 2011; Agostoni, 2003). By the mid-19th century, Paris and London had built extensive water and sewer infrastructure, cementing their role as global icons of urban modernity (Gandy, 1999; Graham and Marvin, 2001; Harvey, 2003). Civil engineers in the US and Australia followed the English model and constructed large-scale, subterranean waterworks and sewers (Melosi, 2000; Engler, 2004; Dingle, 2008). In Mexico City, the construction of a massive drainage system from 1897 to 1911 promised absolution from moral and religious failures caused by miasmas, and offered visible proof of the city as a symbol of power, order, and progress (Agostoni, 2003). Sewage was hidden from society, flushed into subterranean networks and kept separate from potable water, out of public sight and mind (Gandy, 1999; Kaika and Swyngedouw, 2000).

Remaking effluent

By the latter half of the 20th century, wastewater reappeared in urban planning and management as a safe, sustainable, purified, and potentially valuable commodity (Table 1). For cities, the planned non-potable reuse of effluent accelerated in the 1970s, proposed by water supply managers, water engineers, and government officials responding to growing water demand, severe droughts, technological advancements, and more stringent environmental regulations.[1] Managerial options for water reuse also included the augmentation of potable water supplies through surface-spreading basins, blends with reservoirs, or by direct injection into the water supply network (Kasperson and Kasperson, 1977; Traves et al., 2008; Crook, 2010; Leverenz et al., 2011; NRC, 2012; Price et al., 2012). Planned IPR began in California in 1962 via groundwater recharge of potable aquifers (Crook, 2010). The first direct potable reuse system in the world was established in Windhoek, Namibia in 1968 (Law, 2003). Shortly thereafter a number of IPR projects were established in the United States. Since then, IPR has spread to South Africa, Belgium, England, and Singapore.[2] Currently, several IPR projects are in development or under serious consideration in Australia and the US (Marks et al., 2008; Rodriguez et al., 2009; Hurlimann and Dolnicar, 2010a; Ormerod and Scott, 2012).

Table 1. The shifting discourses of wastewater.

From	To	Example
Risky	Safe	"The [recycled effluent] is safe. We have very stringent water quality standards. This is not [Los Angeles Department of Water and Power] saying the water is safe, this is the [California] Department of Health, which throws you in jail if you're violating health standards" (Sheppard, 2000).
Polluted	Purified	"As pure as distilled water" (general manager of the Orange County Water District Michael Marcus quoted in Glennon, 2009: 166); It is "about as pure as [water] can possibly be" (California State Assemblyman Michael Duvall quoted in Athavaley, 2008); "Reuse? The result is as pure as distilled water" (Michael Marcus quoted in Archibold, 2007).
Linear	Sustainable	"Authorities used to pump partially cleaned wastewater into the ocean, but now water goes through a three-step purification process to make it fit for human consumption" (PBS NewsHour, 2008).
Externality	Commodity	"The days are over when we can consider wastewater a liability. It's an asset. And that means figuring out how best to use it" (Peter Gleick quoted in Royte, 2008).

Formal wastewater regulations are credited as key catalysts in the transformation of effluent (Khan and Roser, 2007; Radcliffe, 2010; Apostolidis et al., 2011; Bischel et al., 2012). For example, after the US Clean Water Act (CWA) was passed in 1972 – a 'milestone event' in the global history of reclaimed water (Asano, 1998) – US federal agencies conducted research in water recovery and innovative treatment technologies, as every level of additional treatment reduced the marginal cost of reclaiming wastewater (Kasperson and Kasperson, 1977). The World Health Organization followed suit, issuing guidelines for reuse in 1973, 1989, and 2006. By 1980, the US Environmental Protection Agency (US EPA)

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[1] Non-potable agricultural reuse has long been utilised in India, Israel, Mexico, Australia, US, and other countries. For example, Californian farmers used reclaimed water to irrigate crops (corn, barley, alfalfa, cotton, and pasture) as early as 1912 (Asano, 1998).

[2] Planned IPR projects were established in southern Los Angeles County, CA (Montebello Forebay Groundwater Recharge Project) in 1962; in Orange County, CA (Water District's Water Factory 21) in 1976; in Fairfax County, VA (Upper Occoquan Sewage Authority) in 1978; in Reno, NV (Tahoe-Truckee Sanitation Agency Reclamation Plant) in 1978; and in El Paso, TX (Fred Harvey Water Reclamation Plant) in 1985. IPR projects were launched in Atlantis, Western Cape, South Africa (the Atlantis Water Recharge Management Scheme) in 1979; in Essex, England (the Chelmer scheme) in 1997; in Singapore (NeWater) in 2000; and in Wulpen, Belgium (Torreele Reuse Plant) in 2002.

issued the first federal water reuse guidelines, revised in 1992 and again in 2004.[3] While US drinking water standards apply to all potable water supplies, several US states (e.g. California, Florida, Hawaii) have also developed regulations specific to reuse, even though the absence of US state guidelines does not prohibit reuse projects (NRC, 2012). Although relatively late in formal recognition of wastewater as a resource, in 2008 Australia was the first nation to develop guidelines to specifically address augmentation of drinking water supplies with recycled effluent (NRMMC/EPHC/NHMRC, 2008; Radcliffe, 2010), just in time for the implementation of the Western Corridor Recycled Water Project (WCRWP), discussed in the following section.

In remaking effluent, the current scope of unintentional potable reuse is particularly important. Dozens of rivers – including the Yangtze in China, the Thames in England, the Murray-Darling in Australia, the Rhine in Europe, and the Mississippi and Colorado in the US – contain large volumes of discharged effluent, leading to 'unplanned' or 'de facto' reuse for downstream cities (Law, 2003; Jiménez and Asano, 2008; NRC, 2012).

> To understand the basics of contemporary water infrastructure is to acknowledge that most American tap water has had some contact with treated sewage. Our wastewater treatment plants discharge into streams that feed rivers from which other cities suck water for drinking. By the time New Orleans residents drink the Mississippi, the water has been in and out of more than a dozen cities; more than 200 communities, including Las Vegas, discharge treated water into the Colorado River. That's the good news (Royte, 2008).

Technical and procedural distinctions between planned and unintentional potable reuse have also become particularly important. Planned IPR projects are subject to stringent treatment standards and high levels of regulation (Khan and Roser, 2007), so much so that by the late 2000s recycled effluent was promoted as 'repurified', 'renovated', and even 'designer' (Grenoble, 2009; Rodríguez et al., 2009), with a quality preferable to existing water supplies (Saywell, 2002; Zimmerman, 2008) and that, for some, rivalled bottled water (Royte, 2008; Grenoble, 2009). IPR projects, formerly seen as a 'last resort' (NRC, 1998), are now considered as safe or safer than existing drinking water supplies with regard to contamination from chemicals and microbial agents (NRC, 2012).

In sum, several factors enabled the transformation of recycled effluent: rapid urban growth, demand for new water supplies, new regulatory institutions, and technological advancements and expertise. Planned reuse has led to the creation of a new commodity, which is increasingly subject to processes of marketisation and speculation (Scott and Raschid-Sally, 2012). To better understand the governance components that enable potable reuse of effluent, in the next section we evaluate several IRP schemes from the US and Australia.

CONTEMPORARY CASES OF IPR GOVERNANCE

Each IPR project is distinctive – with diverse customers, supply portfolios, legal and regulatory structures, infrastructure and storage capabilities, and ratios of recycled to raw water; nonetheless, Drewes and Khan (2012) identify six common components in planned potable reuse:

1. *Sewage collection system*, which includes compliance with permitting and regulatory policies aimed at reducing water pollution;
2. *Conventional wastewater treatment* (also known as secondary treatment), which includes physical, chemical, and biological processes aimed at minimising pathogens and organic matter in order to meet regulatory requirements (such the US Clean Water Act) for effluent discharge into waterways;

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[3] The US EPA expects to publish the next Guidelines for Water Reuse in late 2012 (US EPA, n.d.).

3. *Advanced water treatment,* aimed at removing additional pathogens, organic chemicals, nutrients, and dissolved solids in order to meet various IPR treatment objectives. Examples include microfiltration (MF) via membrane technology, reverse osmosis (RO), ultraviolet light, and advanced oxidation processes;
4. *Environmental buffer*, the natural system for storage (retention time and possibly additional treatment) and blending (dilution) of recycled water, which can include surface reservoirs, aquifers, river-bank infiltration, or wetlands;
5. *Drinking water treatment plant*, for treating the augmented water supply before delivery to customers;
6. *Overarching monitoring programme*, aimed at ensuring water quality is suitable for human consumption at all times.

While the above factors are important, they are largely technical and infrastructural, thereby only partially characterising IPR schemes. To draw out further commonalities, we analyse and compare four planned potable reuse projects: two in South East Queensland, Australia and two in Southern California, United States (Table 2). The projects were selected for several reasons. First, in addition to sharing the six components identified above, the Queensland and California cases are characterised by rapid urbanisation and suburban development, frequent and prolonged drought, and government programmes that actively encourage reuse. Second, the selected cases include a mix of planned and already implemented projects, serving both large and mid-sized urban populations.

Table 2. Selected case studies.

Project	Implementation	Customers	Flow quantity and ratio
Orange County Groundwater Replenishment System, Southern California	Upgraded in 2008 at cost of US$481 million	2.2 million	265 million litres per day (ml/d; 20% recycled water; Currently expanding to provide additional 114 ml/d
El Monte Valley Mining, Reclamation, and Groundwater Recharge Project (El Monte Valley Project), Southern California	Proposed 2014; Estimated cost of US$200 million	250,000	19 ml/d; 50% ratio
Toowoomba Water Futures Initiative, South East Queensland	Proposed 2005; Estimated cost AU$68 million	95,000	Reclaimed water proposed to be added to Lake Cooby, one of three water storage facilities for Toowoomba
Western Corridor Recycled Water Project, South East Queensland	Completed in 2008 at a cost of AU$2.5 billion	1 million	Capacity of 232 ml/d; no blend yet; reclaimed water only added to Lake Wivenhoe if dam levels drop by 40%; expected ratio 10-25%

Third, the selected cases utilise between 10 and 50% effluent, which are high by international standards but represent more likely examples of blends in future IPR schemes. The Singapore NEWater project is often credited as a prominent case study (Law, 2003, Khan and Roser, 2007; Rodriguez et al., 2009); however, critics are quick to note the Singapore blend of 1% effluent to raw water "is a token amount by any standard and difficult to view as a precedent for other communities planning to rely on sewage water as a significant water supply" (Manners and Dowson, 2007).

Finally, the cases share several demographic and biophysical challenges. The California cases draw water from the Colorado River, a historically drought-prone basin known for bitter political battles over water allocation (Overpeck and Udall, 2010). The US Southwest is the driest and fastest-growing region in the nation: on average, California gains a new resident every minute, an impressive growth rate, but one that lags behind neighbouring states of Nevada and Arizona (Glennon, 2009). Within the Colorado basin, a number of cities are currently implementing or seriously considering potable reuse: including Tucson and Scottsdale, in Arizona; Reno and Las Vegas, in Nevada; Aurora and Cottonwood, in Colorado; and Cloudcroft, in New Mexico. In addition to the existing federal legal and regulatory framework for water reuse, California has approved state policies to encourage reuse.

Like California, Queensland is Australia's sunshine state, home to the world-famous Gold Coast and many tourists, retirees, and real estate interests. South East Queensland is the fastest-growing region of Australia, attracting more than 1000 new residents per week (Spearritt, 2008). South East Queensland is also home to the first planned potable reuse projects in Australia. Following the 'great millennium drought' of 2002-2009, community support for water recycling projects increased dramatically, and the government fast tracked several capital works projects aimed at expanding regional water supplies (Traves et al., 2008; Radcliffe, 2010; Apostolidis et al., 2011). Though IPR was not even listed as a possible reuse option in the 2006 national guidelines (Hurlimann and Dolnicar, 2010a), by 2007 the National Water Commission had changed its position, stating that the use of recycled effluent for drinking water was feasible, minimal-risk, and safe (NRMMC et al., 2008).

Orange County Groundwater Replenishment System, California

As the largest and most successful water purification project, the Orange County Groundwater Replenishment System (GWRS) is recognised as "a model for the world" (Farrell, 2008). Located in Southern California, the GWRS uses the most advanced water treatment technology available and served as the model for the El Monte Valley Project and the Western Corridor Project (described below), Singapore's NEWater project, and others. The GWRS produces over 265 ml/d of recycled water for blending via groundwater recharge (Drewes and Khan, 2012).

The Orange County Water District (OCWD) is a special district (separate from Orange County administrative jurisdiction) that serves 2.2 million residents in more than 20 Southern California cities. The district was established in 1933 by a special act of the state legislature, which granted the OCWD authority to manage its own affairs and entities, including the large groundwater basin beneath North-Central Orange County and the Santa Ana River (Grebbien, 2004). Groundwater overdraft was a perennial problem in the area, and by the 1970s the high costs of importing Colorado River water for aquifer recharge prompted the OCWD to consider other options.

In 1976, the OCWD launched Water Factory 21, an advanced treatment plant that included a constructed seawater barrier via direct injection of 60 ml/d (Law 2003; Drewes and Khan, 2012). After successful operation for 28 years, Water Factory 21 was decommissioned in 2004 and replaced by the GWRS in 2008. Jointly funded by the OCWD and the Orange County Sanitation District (the public agency responsible for wastewater treatment), the GWRS increased system capacity and substituted membrane processes for the physical and chemical processes at Water Factory 21 (Drewes and Khan, 2012). Such state-of-the-art technology did not come easy: the upgrade cost US$481 million and took years of planning (Barringer, 2012).

To its credit, the OCWD anticipated political challenges to the expansion and intentional use of recycled effluent. In preparation, the OCWD spent 10 years and US$4 million on public outreach (Farrell, 2008), and actively engaged community members and federal, state, and local government officials.

> [The district] hired consultants, polled the public and discovered common concerns. The water officials went to the 19 affected municipalities and gave presentations to their city councils. They then moved on to state and federal officials. Some 1200 presentations and tours later, the recycled water began to flow from taps (Kix, 2012: C3).

The GWRS is remarkable in that it met almost no public resistance when it came into fruition (Farrell, 2008). The district is currently embarking on a US$142.7 million project expansion of the GWRS that will create an additional 114 ml/d. Construction is estimated to be completed in late 2014 (GWRS, n.d.).

The El Monte Valley Mining, Reclamation, and Groundwater Recharge Project, California

The proposed El Monte Valley Project was spearheaded in 2005 by the Helix Water District, a private water company that serves over 250,000 customers across several cities in southern San Diego County and in unincorporated areas of eastern San Diego County (Smith and Rasmus, 2011). Like Los Angeles and Orange counties to the north, San Diego imports roughly 90% of its water supply from the Colorado River. In an effort to provide more assured supply, the Helix Water District designed an IPR scheme capable of producing 19 ml/d via MF, RO, ultraviolet light, and hydrogen peroxide disinfection with subsequent groundwater recharge, by 2014 (Raftery, 2010; Smith and Rasmus, 2011). In addition to supplying roughly 15% of demand with recycled water, the El Monte Valley Project outlined a sand and gravel mining plan that would excavate and sell nearly 7 million m^3 of sand over 10 years in order to generate funding and offset the costs of the project, which included habitat restoration and a recreational area (Helix WD, 2011; Yates, 2011).

In contrast to the GWRS, public meetings for El Monte Valley Project were contentious. Widespread opposition to 10 years of sand and gravel mining complicated the proposal (Yates, 2011). Public information materials for the project drew heavily and directly on materials originally developed for the GWRS; yet unlike the GWRS, the El Monte Valley Project introduced new debates regarding land use and environmental quality. Residents voiced concerns over water quality threats, particularly in local wells, but their apprehension extended to numerous potential impacts, ranging from dust contributing to valley fever, to increased truck traffic, to the potential for dam failure. Because sand and gravel are widely used construction materials that were in high demand,[4] some citizens also questioned whether the mining project was a means or an end to continued urban growth (Raftery, 2010). At the same time, environmental organisations, such as the local Surfrider chapter, which focused on protecting oceans and coastal zones, publicly endorsed the IPR project. For example, Surfrider representatives stated, "it’s not toilet-to-tap, it’s toilet-to-treatment-to-treatment-to-treatment-to-treatment-to-treatment-to-tap. It’s a really important concept for people to understand that we are already drinking wastewater, depending on the source of the water we already import" (in Yates, 2011).

Helix Water District anticipated partnering with Padre Dam Municipal Water District (Padre Dam) for recycled water supply. Padre Dam currently provides water, wastewater collection and treatment, and water recycling for a handful of communities in eastern San Diego County. The project planned to pump recycled water from the Padre Dam and blend it with groundwater via recharge basins in the El Monte valley. The proposed IPR project required an upgrade and expansion of the current Padre Dam water recycling facilities and the construction of groundwater recharge facilities (Helix WD, 2011). Initial project estimates projected the cost to be US$200 million. The project obtained grants from the federal U.S. Bureau of Reclamation and the County Water Authority, and intended to offset costs via sand and gravel mining. Nonetheless, the project was suspended in September 2011 due to revenue shortfall and

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[4] Sand is a basic ingredient in cement. According to Helix Water District (2011: 3) mining would "help alleviate very short local supplies of Portland Cement Grade (PCC) sand as identified by the State and County".

concerns over reclaimed water supply availability, as the project details were refined and the projected costs of advanced water treatment rose from 1200 to US$1850/acre feet (Pearlman, 2011).[5]

Toowoomba Water Futures Initiative, Queensland

With a population of 95,000 and nicknamed 'Queensland's Garden City', Toowoomba is located 127 km west of Brisbane, the provincial capital (Hurlimann and Dolnicar, 2010a; Price et al., 2012). In the midst of declining water availability and regional population growth, the Toowoomba City Council launched the Water Futures Initiative in 2005. The project included construction of an advanced water treatment plant to recycle effluent and implement potable reuse (Hurlimann and Dolnicar, 2010a; Price et al., 2012). The AU$68 million plan was supported by federal, state, and local government officials, who hoped that Toowoomba would become a model for future water management programmes (Toowoomba Regional Council, 2005; Hurlimann and Dolnicar, 2010a). Within weeks of the announcement of the Water Futures Initiative, the opposition group *Citizens Against Drinking Sewage* was formed and began actively organising against the project. In response to public upset, in 2006 Malcolm Turnbull, then Parliamentary Secretary to the Prime Minister, proposed a referendum to let voters decide the fate of the Water Futures Project (Hurlimann and Dolnicar, 2010a). At that time, the combined capacity of water storage serving Toowoomba was at record low levels (23% capacity) and citizens were subject to severe water restrictions, including a ban on hosepipe use, filling pools, and washing buildings or paved surfaces (Price et al., 2012).

Despite the water restrictions and forecasted shortages, in 2006 Toowoomba voters flatly rejected the proposed IPR scheme, with 62% voting against the project (Price et al., 2012). Hurlimann and Dolnicar (2010a: 292) cite several factors that contributed to defeat, including local politics, vested interests, information manipulation (by the rejection campaign), and serious concerns related to the issue of waste.

> Residents had health concerns. They were not sure if they could trust science; they were irritated that the Toowoomba Council refused to state that the water was 100% safe and stated that they felt like 'lab rats'. Furthermore, they were concerned that there were no official guidelines for the quality of recycled drinking and that a 25% component of recycled water in tap water is very high by international standards.

In addition to health concerns, opponents of the project feared the community's reputation and image would be tarnished by the taboo of waste. Residents worried the community would be labelled 'Shit City' or 'Poowoomba', and that the project would result in a loss of business, tourism, and continued development (Hurlimann and Dolnicar, 2012a).

Western Corridor Recycled Water Project, Queensland

The Western Corridor Recycled Water Project (WCRWP) is billed as the largest water reuse project in the Southern Hemisphere and the third largest in the world (Australia's largest water recycling project nears completion, 2009). The project includes three advanced wastewater treatment plants, two of which supply water to power stations for industrial use. Two plants are capable of pumping recycled water to Lake Wivenhoe, Brisbane's largest potable water source. The project includes advanced technology of microfiltration (MF), reverse osmosis (RO), and ultraviolet advanced oxidation (UVAOP). Construction began in 2006 with a plan to initiate IPR by 2008 (Traves et al., 2008).

The Queensland government (Premier Bligh) first proposed a referendum on the proposed potable pipeline in March 2007, but then promptly reversed position and proceeded without the plebiscite. Amid community backlash and a season of significant rainfall, the state government reversed positions again in 2008, deciding that the WCRWP will only supplement drinking water supplies when, or if,

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[5] An acre-foot is roughly equivalent to 1230 m^3 or 325,000 gallons.

Wivenhoe dam levels fall by 40%, a position that effectively 'mothballed' the IPR scheme (Johnstone, 2009). The government spent AU$2.5 billion on WCRWP infrastructure, but now will only implement IPR as a last resort (Radcliffe, 2010). Designed to provide 232 ml/d, the project is only delivering on average 112 ml/d (largely to the power stations) and is actively seeking additional customers (Johnstone, 2009). Excess water, a reported 25 ml/d, is released into the Brisbane River (Helbig, 2011). The lack of demand reflects the comparably high costs of recycled water. The WCRWP has 200 km of subterranean infrastructure in place to implement IPR, but has failed to actually execute the potable plan (Roberts, 2008). Citizens may not be yet drinking recycled water, but taxpayers are bearing the financial burden for the massive government investment in physical infrastructures as well as the costs associated with increased energy required to produce potable-quality recycled water (Madigan, 2012).

Despite such setbacks, the WCRWP has emerged as a global symbol of environmental sustainability and economic efficiency. As CEO Keith Davis notes, "We've combined two climate independent water sources [recycling and desalination] to produce a pure source of water that will directly assist population growth, economic growth and water supply for generations" (cited in Anonymous, 2009: 25).

In an effort to "reduce dependence on imported water sources, or to correct the balance between available water sources and projected growth" (Marks, 2006: 139), potable reuse projects are typically planned in anticipation of population growth and subsequent water shortages. As noted by Traves et al. (2008: 156), it was only when "the region's broader water resource requirements were highlighted by the unprecedented drought that the [IPR] project became not only viable, but a necessary part of the region's water future". Such crises of water scarcity – real or perceived – are used to successfully promote new potable reuse projects, or to revisit, dust-off, and implement previously failed plans. Ironically, with the completion of the Toowoomba Pipeline project, which transports water from the Wivenhoe dam to the Cressbrook dam, residents of Toowoomba are now connected to the larger regional water grid and consequently may be supplied with recycled water if dam levels fall below 40% of capacity (Hurlimann and Dolnicar, 2010b).

Critics of the WCRWP include Professor Patrick Troy, an esteemed urban and social researcher. Troy maintains that viable alternatives to the project included reducing demand and increasing the use of rainwater tanks and greywater to meet outdoor water needs.[6] Premier Bligh rejected Troy's critique, claiming "These are ill-informed comments by somebody *who has no experience in the field of water treatment.* The water processes that have been put in place to underpin our project are the best in the world" (Roberts, 2008, our emphasis). In this quote, Professor Troy is judged to be incapable of understanding the very sophisticated technical aspects of water recycling, despite Troy's expertise in water technologies, planning, and urban policy. As Bligh's quote illustrates, the large-scale solution is heavily favoured by governments, despite the fact that Australians tend to favour rainwater harvesting over water recycling (Hurlimann and Dolnicar, 2010b).

Together, the four case studies reveal key techno-scientific, legal, and socio-economic factors that characterise the governance of planned potable water reuse (Table 3). Several insights are relevant here. First, while some engineers describe IPR as a 'decentralised' approach to water management (e.g. EPRI, 2009), our analysis suggests that IPR in fact relies on a centralised infrastructural configuration of existing, universal, and integrated water and wastewater networks. Not surprisingly, planned potable reuse projects exhibit an inherently 'Western bias'. Most examples are geographically limited to urban settings in developed countries, such as the US and Australia (Traves et al., 2008; Drewes and Khan, 2012).[7] Despite the fact that some developing countries (such as China, India, and Mexico) have

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[6] Greywater is the household based practice of recycling of domestic wastewater from bathroom sinks, tubs, or washing machines, not including toilet (or 'black') water.

[7] Even in California, IPR accounts for less than 1% of the existing water reuse projects (Drewes and Khan, 2012). The NRC (2012) estimates that just one-tenth of 1% of municipal wastewater undergoing treatment in the US is recycled, equivalent to 1268 ml/d.

Table 3. Key factors in IPR governance.

Category	Indicator	Comments
Technoscientific	Existing infrastructure networks with extensive coverage	IPR works only through grid-based delivery mechanisms and, therefore, may exacerbate water access inequalities in cities with fragmented or 'splintered' networks.
	Treatment technologies and capacity	Includes MF, RO, hydrogen peroxide disinfection, UVAOP, etc. Creates new market for advanced technologies, which must be purchased by utilities.
	Expert knowledge	Engineering expertise required, not only to operate the plant but also to assure the public of the safety of recycled effluent. In cases where public trust breaks down, such as in the El Monte Valley Project and the Toowoomba Water Futures Project, the IPR project fails.
Legal	Existing institutional framework for regulating water rights and quality	Must include effective monitoring and enforcement mechanisms. In all cases, federal laws and treatment standards predated IPR proposals, and were often used as evidence to sway public support.
	Strong federal presence	Both the US and Australia follow a federal legal tradition. While all cases used the rhetoric of 'local' water solutions, the projects relied heavily on federal laws, regulations, norms, and research dollars.
Socio-economic	Rapid urbanisation	All cases featured high population growth, which paradoxically ensures both future water demand and customers.
	Financing	Requires considerable financing, usually from the government (e.g. through bonds), ratepayers, or taxpayers (e.g. via ballot initiatives), though the private sector could also be a future source.
	Lack of inexpensive supply alternatives	For example, retired agricultural water rights or water banks. Supply-side alternatives are preferred over demand management, which reduces future revenue accrued to utilities.
	Political support	Coordinated support from local, regional, and federal representatives.
	Public support (or acquiescence)	A number of the IPR systems in California were established decades before public consultation was considered critical to project success. More recently, public opposition has threatened the viability of newly proposed projects.

incorporated reclaimed wastewater for non-potable applications (such as irrigation of parks and amenities), many of their cities are characterised by fragmented or 'splintered' water provision networks (Bakker, 2010), thereby limiting IPR as a universal water supply strategy.

Second, support from elected officials and the public is key to success of the IPR project. Consequently, the practice of rebranding wastewater is crucial for reuse advocates. For example, the WateReuse Association, a US-based research and advocacy group, recently developed and released a seven-minute educational video in an effort to engineer acceptance to potable reuse. Entitled *Downstream*, the video plays on the notion that all water on earth is recycled and new technological solutions are key to a sustainable future.[8] Endorsement from public representatives is also important. According to Wade Miller (2008: 7), executive director for the Wate Reuse Association,

> [c]ommunities have rejected several proposed projects involving indirect potable reuse over the past decade. These include Tampa Bay (Florida, USA), San Diego (California, USA), East Valley (California, USA), Dublin San Ramon (California, USA), and Toowoomba (Queensland, Australia). In at least four of the five cases, lack of political support by local elected officials was a crucial factor.

Finally, the private sector is poised to play a highly influential role in water management through IPR projects, in direct and indirect ways. In most IPR cases, citizens pay for investment in treatment systems through a mix of rate hikes and federal, state, and local subsidies and taxes. But preliminary evidence from other cities also indicates strong private sector involvement, particularly from the real estate sector. For example, in Tucson, Arizona, the home-building industry was fiercely opposed to a ballot measure initiative (Proposition 200) that proposed a ban on any future potable reuse, including limits on new water connections (O'Dell, 2007).[9] Numerous city, county, and state officials representing Tucson also publicly opposed the 2007 initiative (Kelly, 2007). Proposition 200 was eventually defeated. Following the crushing defeat, John Kromko, a former Arizona state legislator who wrote the ballot measure and advocated the prohibition, suggested that the city of Tucson should control growth rather than find new ways to feed growth with water that is claimed to be 'safe' and 'free of contaminants'. "We really don't know how safe it is", he said, "and if we controlled growth we would never have to worry about drinking it" (Archibold, 2007). In Toowoomba, where voters failed to approve the IPR ballot measure, prominent opponents of the project included the former president of the Chamber of Commerce and a former local mayor and millionaire property developer (see Hurlimann and Dolnicar, 2010a for a detailed account of Toowoomba's experience). For the private sector, IPR facilitates urban growth and development by providing a means of assured water supply, and in effect transforming waste into a resource without radically altering the power dynamics of water governance or the political economy of growth.

DISCUSSION: WASTE MATTERS IN WATER GOVERNANCE

Municipal water resources development presents the so-called 'iron triangle' of mutually reinforcing relationships, as federal agencies, state politicians, and local elites exert influence over water policy making, to the point where their interests often drive decision-making (Waller, 1995; Molle et al., 2009). In the context of planned potable reuse, however, waste *itself* is a key fulcrum for control, disruption, and contestation in water governance. For example, in the El Monte valley case, recycled effluent unsettled the imagined purity and safety of potable water, and required a discursive rebranding even though residents had been inadvertently drinking treated wastewater (via the Colorado River) for decades. Ultimately, the El Monte Valley Project failed. In contrast, the success of the GWRS is largely

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[8] *Downstream* and other advocacy information can be accessed at www.athirstyplanet.com.

[9] The initiative, called The Tucson Water Users Bill of Rights chiefly sought to limit future water connections, repeal a garbage fee attached to the water bill, and prohibit reclaimed water from being used as drinking water.

attributed to their extensive public relations campaign that discursively 'cleansed' recycled effluent in advance of the project's launch. In this way, the GWRS serves as the literal and figurative model for success. In both cases, the materiality of effluent was clearly at stake in the promotion of recycled water supply.

Because of its abject materiality, recycled effluent requires greater levels of institutional control and thus concentrates power in the hands of water experts. In the case studies, it is evident that IPR schemes rely on existing, large-scale, centralised infrastructure; retain techno-scientific expertise and state control; favour augmenting supply over mitigating demand; and ultimately preserve the political economy of water consumption. In effect, IPR projects perpetuate and even accelerate what scholars call the 'modernist' paradigm of water governance (Graham and Marvin, 2001; Melosi, 2001; Stenekes et al., 2006; Molle, 2008; Molle et al., 2009; Bakker, 2010).

> Predicated on an assumption of abundant water supplies, this paradigm emphasised the development of hydraulic technologies to meet the inevitable growth in water demands engendered by modernisation. A commitment to social equity and universal provision necessitated significant government regulation, government ownership, and/or strict regulation of water resources development and water supply provision (Bakker, 2010: 31).

For some experts, recycled effluent is seen as a 'new' paradigm for urban water management (e.g. Harremoës, 2000; Asano, 2005; Hanak, 2007; EPRI, 2009; Glennon, 2009; Rodriguez et al., 2009). However, our analysis suggests that IPR in fact preserves 'old' infrastructural ideals and institutional configurations – what Bakker describes above as modernist water governance. Wastewater reuse is thus an extension – and not a paradigmatic shift – of previous efforts to supply growing urban areas with sufficient water resources, but because the process utilises sewage, successful IPR projects must be shored up through technical, legal, and socio-economic tactics that lead to even more concrete investment in inflexible infrastructural solutions and heavily regulated and centrally controlled governance, which allow for continued urban growth and development.

These conditions mean that despite calls for increased public participation in water management, IPR projects secure – rather than displace – the expert-driven paradigm of water governance. For example, all of the case studies reveal serious tensions when the public role in decision-making disrupts the need for increased institutional control. In places where citizens vote on approval or financing of water projects (e.g. through plebiscites or ballot initiatives) the public has used recycled effluent to reject projects and undermine techno-scientific expertise (Stenekes et al., 2006; Hurliman and Dolnicar, 2010a). Not surprisingly, many decision-makers consider the public to be an irrational, uninformed body that must be convinced to acquiesce to new but scientifically proven technologies (Russell and Lux, 2009). Negative psychological reactions – such as the 'yuck factor' – are viewed as attitudes to discipline and control (Marks and Zadoroznyj, 2005; Marks, 2006). Like other water supply alternatives, IPR is still "pursued through a technically based institutional framework, which stresses acceptance from public" (Stenekes et al., 2006: 108), but the inherent presence of waste often entrenches divisions between lay and expert knowledge.

In the tradition of modernist water governance, effluent is seen by experts as an inconvenience to be overcome through technological innovation. Over the past decade, membrane technologies, capable of producing high-quality water and meeting stringent health regulations (Law, 2003; Wintgens et al., 2005), have replaced physical and chemical processes in water treatment. Advances in membrane technology have, in turn, spurred efforts to diffuse planned potable reuse to regions other than the US and Australia (Wintgens et al., 2005). Some consider membrane treatment to be the "wave of the future" (Grebbien, 2004: 57), or "a water purification breakthrough not unlike the computer chip for the communications industry" (Helix Water District, n.d.). From an engineering perspective, membrane treatment removes all *matter* of concern.

Given such advances in treatment technology, some experts speculate that IPR may soon take a backseat to direct potable reuse (DPR) projects, in which effluent is treated to required drinking water standards and then directly added to municipal supply without intervening storage or 'environmental buffers' (Crook, 2010; Leverenz et al., 2011; Tchobanoglous et al., 2011; NRC, 2012). Currently, the only case of DPR is located in Windhoek, Namibia, but the cost-effectiveness of DPR is attracting broad attention (NRC, 2012). For example, the Director of Helix WD stated that the costs of the El Monte Project would be reduced substantially if regulations allowed for DPR (Pearlman, 2011). Consequently, "Helix Water District will actively seek legislative and/or regulatory revisions which would allow direct potable reuse by collaborating with agencies that have similar projects or water supply objectives" (EMV, n.d.). Some experts speculate that given advances in treatment technologies, "retention and blending requirements currently imposed on many potable reuse projects will become less significant in quality assurance" (NRC, 2012: 98). Others believe that for communities that lack physical capacity for indirect storage, DPR will become an inevitable part of the water supply portfolio (Leverenz et al., 2011). DPR practices are considered to be more universally applicable because they do not rely on environmental buffers, which have site-specific attributes that affect water quality, planning, and management. While such technological optimism and the inertia built into contemporary water infrastructure, therefore, make continued use of IPR and expanded use of DPR appear inevitable, our case studies indicate that using wastewater as a resource to augment municipal supplies will continue to be a contentious process. This is because managing wastewater is as much about dealing with the matter of waste as it is about producing clean water.

CONCLUSION

Water managers increasingly view recycled effluent as a way to enlarge drinking water supplies in rapidly growing urban areas. Although such projects were once seen as an option of last resort, now engineers consider water augmented with recycled effluent to be as safe as, if not *safer* than, conventionally sourced water supplies. At the moment, only a few cities across the world intentionally enhance drinking water supplies with highly treated wastewater. To better understand this new convergence of water and wastewater management, this study compared four planned potable reuse projects: two in Queensland, Australia and two in California, United States. This analysis demonstrated that such large technical systems are seemingly obdurate and yet subject to negotiation. Rapid urban growth, when combined with the techno-scientific, legal, and socio-economic conditions described above, is likely to broaden the prospect of future planned potable reuse projects in developed countries. Nonetheless, as the distance between the toilet and tap shrinks, organised resistance to potable reuse projects may be capable of disrupting the otherwise normal functioning of technocracy in representative governments.

In this article, we have attempted to identify key governance factors of IPR projects to highlight how waste disrupts and stabilises existing practices and ideologies of water resources management. While recycled effluent has experienced a series of discursive and material transformations since the 19th century, it remains a parallax object: a material force that disrupts the power geometries embedded in municipal water management. As we demonstrate here, however, the power of waste to "disturb the smooth running of things" (Moore, 2012: 793) does not inevitably lead to the collapse of water management. Rather, in some cases the materiality of waste has required institutions to control techno-scientific, legal, and socio-economic conditions to an even greater degree than in previous decades. The most successful cases of IPR implementation, then, both preserve and extend existing modes of modernist water governance, which is characterised by large-scale, centralised infrastructure, state and techno-scientific control, and a political economy of water marked by supply augmentation and unchecked expansion. Our analysis suggests that future IPR projects must 'police' the potentially disruptive nature of effluent – both in the form of pathogens and public resistance – resulting in contexts where the disruption of norms and management is clearly anticipated, highly regulated, and heavily controlled.

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