

– FINANCIALIZING DESALINATION: Rethinking the Returns of Big Infrastructure

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Abstract

Against the trend prevalent during the 1990s and 2000s, large-scale infrastructural projects have made a comeback in the water sector. Although sometimes framed as part of a broader sustainable transition, the return of big infrastructure is a much more complicated story in which finance has played a crucial role. In the following article, we explore this encounter between finance and water infrastructure using the case of Britain's first experiment in desalination technologies, the Thames Water Desalination Plant (TWDP). On the surface, the plant appears to be a classic example of the successes of normative industrial ecology, in which sustainability challenges have been met with forward-thinking green innovations. However, the TWDP is utterly dependent on a byzantine financial model, which has shaped Thames Water's investment strategy over the last decade. This article returns to the fundamental question of whether London ever needed a desalination plant in the first place. Deploying an urban political ecology approach, we demonstrate how the plant is simultaneously an iconic illustration of ecological modernization and a fragile example of an infrastructure-heavy solution to the demands of financialization. Understanding the development of the TWDP requires a focus on the scalar interactions between flows of finance, waste, energy and water that are woven through the hydrosocial cycle of London.

Introduction

In 2011 Thames Water began operating Britain's first major experiment in desalination technology, the Thames Water Desalination Plant (TWDP). Requiring a budget of £270 million (Vidal, 2011; Thames Water, 2012), many initially viewed the plant as a costly, environmentally destructive, vanity project for Thames Water that would simply entrench wasteful water use when investments were urgently needed for upgrading a crumbling piped-water network across the city. However, in a remarkable turnaround, the plant is now viewed within the industry as a tremendous success, receiving several important accolades including an award for the 'Most Sustainable Project' in 2009 and 'Desalination Plant of the Year' in 2011, both presented by the prestigious water consultancy Global Water Intelligence (Acciona Agua, 2014). The story behind this turnaround is fascinating. On the one hand, it is a classic tale of normative industrial ecology and ecological modernization, in which barriers become solutions and the challenges of sustainability are met with forward-thinking innovations combining profit making with green technologies. On the other hand, however, beneath industrial ecology's alchemical tale, is a somewhat baser (albeit no less interesting) process. The TWDP can be seen to be utterly dependent on a byzantine financial model, which has shaped Thames Water's investment strategy over the last decade or more. As Allen and Pryke (2013) refer to it—in a twist on Meek (2012)—Thames Water has become increasingly reliant on an investment model that turns households into human revenue streams. Investment decisions have come to be decided less by appropriate needs (and far less by concerns for some abstract notion of sustainability); instead, they have

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focused on the most effective means to guarantee a range of investment opportunities within an increasingly leveraged set of infrastructural assets. The unfolding story of the Thames Tideway Tunnel, otherwise known as the ‘super sewer’, costing an estimated £4.2 billion (Griffiths, 2014), is likely to be a fascinating new chapter in this epic of our times. Beneath the glitter, and beneath the tales of alchemy, this article returns to the fundamental question of whether London ever needed a £270 million desalination plant in the first place. In so doing, we aim to contribute to the growing body of critical geographic scholarship on water infrastructure (e.g. Feitelson and Rosenthal, 2012; McEvoy and Wilder, 2012; Swyngedouw, 2013; McDonnell, 2014) by highlighting the importance of financialization processes in producing and sustaining new infrastructural arrangements (Loftus and March, 2015). In other words, we aim to shed light on the apparent return of big infrastructure under conditions of financialization.

Thames Water’s (2012) argument in favour of the TWDP is clear and simple: the population of London is expanding; rainfall levels are far lower than most people in the UK recognize; and climate is changing. All in all, Thames Water (*ibid.*) underscores that the capital is classed as ‘seriously water-stressed’ by the Environment Agency, which means that demand could outstrip supply if a sustained period of low rainfall occurs in the coming years. If the utility is not to over-exploit already stressed aquifers, alternative supplies will, Thames Water claims, have to increase. Desalination, which has been through a revolution in efficiency and a massive geographical expansion over the last two decades (March, 2015), is (according to this story) the most obvious solution to secure London’s supply without falling into the social and environmental problems associated with the twentieth century hydraulic paradigm (Saurí and del Moral, 2001). However, although Thames Water’s case for constructing the plant appears clear and simple, it cannot be separated from the recent prioritization of large infrastructure projects over more mundane strategies of demand management and leakage reduction. Thames Water is far from unique in changing its priorities: indeed, many now recognize that big water infrastructure is back. The seemingly unjustifiable expense of the project—an expense that is necessarily passed onto the consumer—needs to be situated within a growing appetite for large infrastructural projects, from dams to desalination plants and super-sewers. Concurring with Merme *et al.* (2014), we will argue that a radical shift in the financing model of water infrastructure must be seen as one of the key influences on this shifting model of provision.

The ‘household as human revenue stream’ story is one of several narratives that we wish to consider. Proudly boasting its deployment of the finest technologies, Thames Water has acquired a competitive advantage within what is now a lucrative market for desalination contracts around the world, contracts that it was estimated would be worth US \$31 billion by 2015 and with a potential annual growth rate for capital expenditure of around 19% until 2025 (Gottelier, 2014). Intriguingly, however, the plant was not constructed by Thames Water; rather it was built by one of the largest Spanish infrastructure companies, Acciona, which has a prominent role in the Spanish desalination market (March *et al.*, 2014). Thus, although symbolic capital is important, it doesn’t provide an adequate basis for explaining why the plant was constructed. We will therefore demonstrate that the Beckton desalination plant should be interpreted within a broader process of interlinking separate infrastructural networks around water, energy and wastewater (Chertow, 2000; Monstadt, 2009), and that these physical interlinkages are intrinsically bound up in the process of financializing water infrastructure and utilities. In short, the desalination plant’s physical and financial health depends on interlinking sectors that were formerly separate. Understanding the TWDP therefore requires focusing on the scalar interactions between finance, waste, energy and water that weave the hydrosocial cycle of London.¹

1 The hydrosocial cycle encapsulates all the processes by which water becomes and reveals itself as a socio-nature (Linton and Budds, 2014).

In what follows, we begin by considering literature on industrial ecology and urban metabolism before turning to financialization. Following this, we will provide a more detailed review of the recent development of water supply in London, focusing specifically on the TWDP. Subsequently, we will consider the complex infrastructural interlinkages within the wider Thames Gateway Water Treatment Works, looking at physical flows of water, energy and waste. We will then return to the financial model upon which these interconnections depend before concluding by bringing together the interlinking of infrastructure with a network of financial and political actors, extending from the human body to the commanding heights of the global economy. Interlinking urban infrastructure in the case of the Beckton plant is reliant upon and driven by a distinct shift in the system of accumulation of which infrastructure is a part.

Reworking urban metabolisms

The use of metabolism as metaphor and process has some of its deepest roots within Marxist approaches to socio-ecological relationships; however, this is certainly not the only area in which the concept has been advanced (Castán Broto *et al.*, 2012; Newell and Cousins, 2015). In fact, at least five (often divergent) bodies of work can be viewed as key sources for research on metabolism in recent years: ecological economics (e.g. Martínez-Alier, 2009); urban ecology (e.g. Grimm *et al.*, 2000); urban political ecology (e.g. Heynen *et al.*, 2006); environmental sociology, through a focus on the metabolic rift (e.g. Foster, 2000); and industrial ecology (e.g. Kennedy *et al.*, 2007). The latter uses principles from biological systems in order 'to optimize the flows and transformations of materials and energy within and across the boundaries of industrial systems' (Dunn and Steinemann, 1998: 661). Urban metabolism can thereby be defined as 'the sum total of the technical and socio-economic processes that occurs in cities, resulting in growth, production of energy, and elimination of waste' (Kennedy *et al.*, 2007: 44). The foundation of industrial ecology rests on modelling urban systems through natural systems in order to minimize demands on resources and sinks, and to increase efficiency. 'Natural systems', it is claimed, are cyclical and efficient, in contrast to urban systems which are deemed to be linear and less efficient in their use of physical natural flows, thus negatively affecting the natural systems upon which they survive, thereby generating both resources and sinks for the waste generated. In short, industrial ecology 'seeks to better integrate industrial and municipal processes with each other, and with the natural system' (Dunn and Steinemann, 1998: 663). At the methodological level, as Castán Broto *et al.* (2012: 853) claim, industrial ecology 'has made major contributions to the methods for accounting for material and energy flows and the optimization of the "metabolism" of industrial systems through industrial symbiosis, whereby the waste output from one industry can become an input for another, providing both cost savings and environmental benefits' (see also Dunn and Steinemann, 1998). One of the main contributions of industrial ecology is the accounting of flows of a given system under the label of material flow analysis (MFA), i.e. the quantification of physical flows for a given system, be it at national level or (more recently) urban level.

However, and notwithstanding the multi-scalar analyses of the complex web of relations across scales of physical resources that sustain the functioning of cities (see Kennedy *et al.*, 2007), industrial ecology generally overlooks the complex scalar financial arrangements that sustain those metabolisms. As Castán Broto *et al.* (2012) highlight, the political and social drivers of material and energy flows are frequently ignored. Thus, a depoliticized account emerges, which naturalizes urban processes and situates the driver of change in technology rather than in politics. Absent is an analysis of how environmental change is influenced by the power relations and financial mechanisms that are unevenly distributed across scales, and which sustain these architectures. Against this backdrop, urban political ecology 'challenges urban metabolism as a mere

process of biophysical exchange unrelated to social and historical context' (*ibid.*: 857). In other words, urban political ecology helps to shed light on the linking of human bodies with infrastructural networks, as well as the financial networks that extract rent from urban metabolisms. Urban political ecology captures both the circulations of physical flows and their dialectical relations with financial flows and structures of power.

Different readings of metabolism can help to abstract different sets of processes from the concrete case of the TWDP and enable fundamentally different narratives to be constructed. In what follows, and after a succinct review of the literature on financialization plus a brief introduction to the TWDP charting its development from planning stage to completion, we will demonstrate how the desalination plant can be read as a success story of modern green engineering in which energy use has been localized; however, we will show how such a reading overlooks the fragile yet extensive financial and political networks on which the desalination plant (and the hydrosocial cycle of London) relies. It is this latter analysis that has the greatest bearing on future development of infrastructure projects in London and which should prompt a fundamental rethink of the construction of the Thames Tideway Tunnel in coming years.

Financialization

Although there is often disagreement about the precise meaning of the term financialization (see Lee *et al.*, 2009), it is widely recognized that since the 1980s there has been an efflorescence of financial transactions and an apparent shift in the locus of profit making (Foster, 2007; Lapavistas, 2014) which has encouraged a much more speculative form of capitalism, more dependent on rent extraction and less obviously tied to the creation of surplus value within the 'real economy'. David Harvey (2005: 161) considers financialization to be one feature of 'accumulation by dispossession', writing that 'deregulation allowed the financial system to become one of the main centres of redistributive activity through speculation, predation, fraud and thievery'. Earlier, in *The Condition of Postmodernity*, Harvey (1989: 196) noted that 'if we are to look for anything truly distinctive (as opposed to "capitalism as usual") in the present situation, then it is upon the financial aspects of capitalist organization and on the role of credit that we should concentrate our gaze'. Reflecting the growth in these financial aspects of capitalist organization, Aalbers (2008) has demonstrated the profoundly geographical features of the financial crisis, as well as the role of mortgage markets in shaping the crisis (Aalbers, 2011). Christophers (2013) has sought to 'place finance in global capitalism' through his research on the geographies of banking practices, while more recently (Christophers, 2014; 2015) reviewing the state of the art on the geographies of finance. Meanwhile a growing body of work has emphasized the profound shifts taking place within both public service provision and also relations with 'nature' (Loftus and March, 2015). Thus, finance has been seen to play an increasingly important role in how people access basic resources such as water, and in both environmental governance and the production of historically and geographically specific natures (Labban, 2010; Sullivan, 2013; March and Purcell, 2014).

On the role of financialization in the water sector, March and Purcell (2014) have focused on the complicated role of finance in shaping the recent investment decisions of Aguas de Barcelona, whereas Allen and Pryke (2013) have focused on the 'financialisation of household water' in the case of Thames Water. Bayliss (2014; 2015) has provided a more detailed study of the role played by financialization in relation to a range of different water and sewerage companies in England and Wales. Applying the systems of provision approach to the water sector in England and Wales, Bayliss (2015) notes that water quality and quantity has improved since privatization in 1989; however,

she argues that such improvements have come about through a massive increase in consumer bills. Over the last decade, the impact of these rising bills has been exacerbated by a fall in wages. Although capital spending on infrastructure has increased in several instances, this spending cannot explain the rise in bills. Instead, rising bills are related to failures in the regulatory process (the 2009 price review failed to forecast sustained low interest rates) and reflect the demands of the increasingly geared utilities. Incredibly complex corporate structures enable debt to be packaged and sold on to different parts of the same utility, maximizing profits while minimizing the corporation tax payable. In particular the creation of special purpose vehicles, through the establishment of offshore companies in the Cayman Islands, has enabled the debt used in the purchase of a utility to be offloaded onto the utility itself. Increasing debt has been used to finance shareholder dividends (Allen and Pryke, 2013), which leads to an overall decline in equity. Thames Water's decisions whether or not to invest in individual infrastructure projects cannot be divorced from this broader context, as we will argue later in the article. Indeed, we will show that it has had a profound influence on the need for such plants as the TWDP. However, in developing this argument we wish first to consider the narratives of success that show a profound localization of the inputs on which the hydrosocial cycle of London depends.

Engineering the sustainable ideal

The TWDP is generally considered to be the UK's first serious experiment in large-scale desalination (Acciona Agua, 2014). Its construction began in 2008 after initial planning objections from the mayor, Ken Livingstone (supported by broader public opinion), were finally overcome. Although the national government had approved the construction of the facility, Livingstone mounted a legal challenge to reverse planning permissions for the desalination plant. It took a change of mayor before the plant was finally approved in 2008 (Greater London Authority, 2007; BBC, 2010). The planning review of the facility in 2005 cited the strategic objectives of the London Plan (Greater London Authority, 2004) as the basis for opposition. Challenging supply-oriented perspectives (while not ignoring calls to expand water infrastructure), the London Plan advocates greater emphasis to be placed on leakage reduction and demand management, minimizing the use of treated water, stressing instead the need to maximize rainwater-harvesting opportunities and prioritize greywater recycling systems. Livingstone had personally questioned Thames Water's claim that there was a genuine shortfall in supply and that the facility would be needed in response to this. As the *Financial Times* reported: 'The mayor has refused permission for the plant, claiming it was unnecessary to build an "energy and carbon guzzling" plant on protected land when the company was leaking 915m litres of clean water a day from its pipes' (Sherwood, 2006). Both leakage prevention and demand management were emphasized as necessary alternatives by the mayor, as opposed to costly new technologies (Greater London Authority, 2007). Thames Water rejected such a position, claiming that the disruption caused by an overhaul of leakage reduction would outweigh the benefits, a claim rebutted by Livingstone who suggested that the company was frightened of upsetting its automobile-dependent customers for whom there would be inevitable disruption if more fundamental repairs of the piped network were initiated (Sherwood, 2006). Thames Water then went on to claim that, against the backdrop of drier and hotter summers, London's population would rise by 700,000 by 2021 (Vidal, 2011; Thames Water, 2012), leading to an increase in consumption by both households and businesses. In the 2005 planning report, it is noted that Thames Water Utilities Limited had identified 'a gap of some 150 mega litres per day (150 ML/d) between the demand and actual supply of water, *even after potential savings from leakage are taken into account*' (Mayor of London, 2005: 5, emphasis added). Indeed, the utility appeared convinced that metropolitan London would face 'a high risk of severe water shortages' (Jowit, 2010). The figure of 150 ML/d

conveniently matched the planned output of the new facility, which Thames Water (2012) concluded would be ‘available to help provide the capital’s supplies for the future—whatever the weather’.

Beyond the contrasting visions of supply-side solutions (Thames Water) versus demand management (Ken Livingstone and the Greater London Authority), the main sticking point in the original negotiations remained the ‘energy and carbon guzzling’ (as Livingstone described it) nature of the development. Thames Water initially submitted estimates of the energy usage of the facility that appeared to further undermine the ambitions of the London Plan (Greater London Authority, 2004), which sought to increase the share of the city’s energy demands covered by renewable sources. In the original application, Thames Water ruled out the construction of an on-site facility, as well as the use of photovoltaic energy, concluding that the only source of renewable energy on site would be wind (Mayor of London, 2005: 10). The 2005 planning report therefore concluded ‘[t]hat Newham Council be advised that for reasons set out in the body of this report, the latest application provides no additional proposals to deliver a sustainable and efficient management of water supply in London and is contrary to the interests of good strategic planning in London’ (*ibid.*: 1). Linking water and energy in a more virtuous cycle became increasingly important, not only so that Thames Water could confront the arguments of its opponents within the Greater London Authority but also for the obvious reason that it would enable the utility to reduce production costs.

Thames Water’s strategy in response to these challenges has been multi-pronged. First, the utility vowed to source all its energy needs from locally sourced biofuels (BBC, 2010), thereby dramatically reducing its overall demand for non-renewable energies and localizing the source of energy. Secondly, and more recently, an energy start-up—Beckton Combined Heat and intelligent Power (CHiP)—has located adjacent to the TWDP (20C, 2013; Thames Water, 2013a). This new entity sells energy to Thames Water, generated from the fat that would otherwise have caused costly blockages (or ‘fatbergs’) within London’s sewerage network. Finally, in anticipation that a further major infrastructural expansion (the Thames Tideway Tunnel) will get the go-ahead, Thames Water has embarked on a further expansion of the Beckton site, constructing a wind turbine generating 8% of the energy needs of the plant, as well as a thermal hydrolysis plant (THP) in which solid waste will be heated to 160 degrees Celsius, enabling biogas energy to contribute further to the required supply (Thames Water, 2013b; 2013c). In resolving such difficulties through a focus on the water–energy nexus (i.e. the increasingly interlinked nature of water and energy), Thames Water is now able to claim it is the largest green energy self-generator within the M25 (the motorway that encircles Greater London), producing in excess of 15% of its own energy and able to use the power generated from its own treatment process to drive the plant itself (Freyberg, 2012).

Before considering the differing ways of interpreting the TWDP, it is important to note the choice of location for the desalination plant, given that Beckton will eventually form a central part of the next phase of development in Thames Water’s mega-infrastructure plan. Lying on a tidal stretch of the Thames estuary, the TWDP is able to abstract brackish water from the river ensuring a lower salt concentration—the variation in salt content of the water flowing up and down the Thames fluctuates between 0.08 parts per thousand (0.008% ppt) and 2.35 parts per thousand (0.235% ppt) (Lane *et al.*, 2007). The brackish water then passes through a pre-treatment facility before undergoing the main filtration and reverse osmosis process in which pre-treated water is forced through a four-stage process, with a conversion rate of 84% (Acciona Agua, 2014). Desalted water undergoes a remineralization process before being pumped to the Woodford Reservoir, nine miles northwest of Beckton. It can then enter the piped network following further treatment. Back at Beckton, waste products (mostly

hyper-saline water) can then be mixed with treated sewage effluent before being pumped into the Thames.

In addition to being found on the tidal reaches of the Thames, the TWDP is located within London's largest wastewater treatment site and one of the largest sewage treatment plants in Europe. Treating the waste of over 3.5 million customers, the Beckton Sewage Treatment Works covers a large expanse of land just over a mile downstream from the Thames Barrier (Thames Water, 2012). The site is central to London's wastewater operations as, first, the Lee Tunnel stormwater overflow and, subsequently, the Thames Tideway Tunnel will deposit far greater volumes of wastewater at this single site. In order to cope with this additional wastewater, a 60% increase in the capacity of the site is anticipated by 2021 (*ibid.*). Whereas the desalination plant marked the crossing of one Rubicon in the first decade of the twenty-first century, the latest—and far larger—challenge confronting Thames Water and its customers concerns plans for the £4.2 billion Thames Tideway Tunnel (Griffiths, 2014). With a proposed annual increase in customer bills of around £80–100 (in addition to bill increases resulting from the TWDP) the plans for this new 'super sewer' were originally referred to OFWAT, the economic regulator of the water sector, and relied on planning permission being granted by the Department for Environment, Food and Rural Affairs and the Department for Communities and Local Government, only clearing these final hurdles in September 2014 (BBC, 2014). Importantly, the project assessor, Chris Binnie, who had supported the scheme a decade earlier, recently branded it a stupendous waste of taxpayers' money (*ibid.*). Binnie concluded (in rather similar terms to those with which we began this article) by stating: 'I do not know why there is such a bandwagon rolling' (*ibid.*). The answer, we would suggest, may well lie in the financialization of infrastructure, of which both the super sewer and the TWDP are crucial examples. Prior to being given the go-ahead for the super sewer, Thames Water established yet another tier to its multi-level 'wedding cake structure' (see Allen and Pryke, 2013) in order to raise capital to be able to finance the construction of the scheme. Unsurprisingly, given that the main focus of the Beckton site has been on wastewater treatment, and that the 'super sewer' will now provide an even greater volume of wastewater at the site, there is speculation as to whether or not the desalination plant will eventually purify treated wastewater to the level at which it could circulate within the potable water network. Whether this speculation is justified or not, it is clear that Beckton is the perfect location for formerly separate sectors of the urban infrastructural system to begin to integrate more closely. In the sections of the article that follow, we narrate the tale of London's desalination saga through the lens of industrial ecology before turning to urban political ecology in order to understand the plant as both iconic exemplar of ecological modernization and as a fragile example of an infrastructure-heavy solution to capital's increasing need for speculative gains.

Archetypal industrial ecology

'In London ... they can do nothing better with the excrement produced by 4 1/2 million people than pollute the Thames with it, at monstrous expense.'
Marx (1981: 195)

Writing over 150 years ago, Marx noted the rupture in ecological systems manifest in the process of urbanization. The metabolic rift, as Foster (1999) would later term it, resulted in human waste being thrown into watercourses, rather than being returned to the soil as was the custom prior to urbanization. Intriguingly, with recent advances in tertiary treatment systems, new wastewater treatment technologies would appear to engineer a solution to the rupture in ecological systems underscored by Marx. Utilities are now able to reuse part of the sludge derived from wastewater treatment

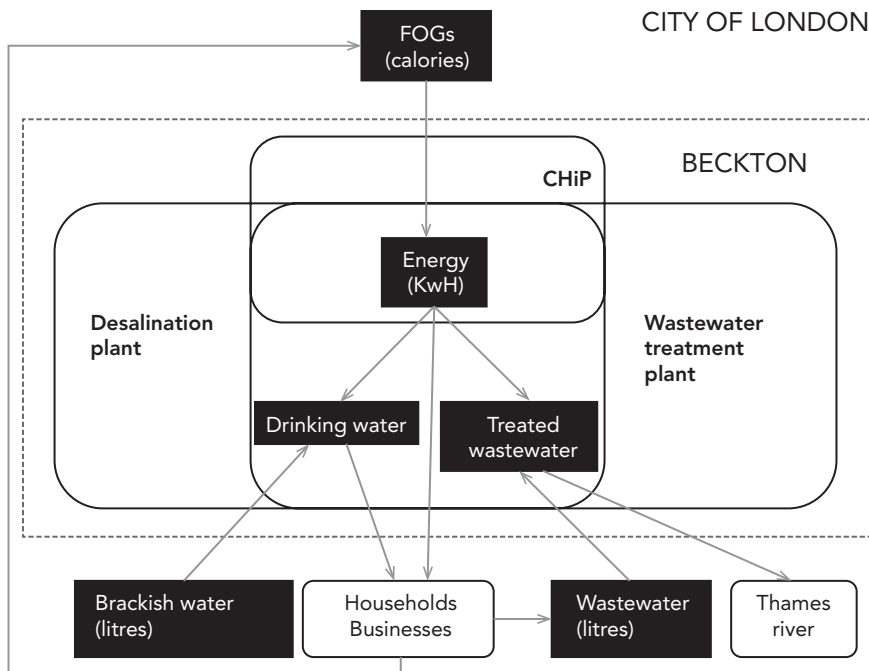


FIGURE 1 Schema of the flows involved in the production of desalted water and the treatment of wastewater at the Beckton site (authors' own elaboration)

plants as a fertilizer and soil conditioner for agricultural land (thanks to its richness in organic matter, trace elements and nutrients). Nevertheless, if one metabolic rift has been mitigated, concerns over the energy demands needed to sustain the urban water cycle remain. Along these lines, recent debates on water management have highlighted the crucial need to take the water–energy nexus into account when planning for further water infrastructure development (see e.g. Siddiqui and Diaz Anadon, 2011). McDonnell (2014) presents, in that sense, a very detailed narration of how, in countries such as the United Arab Emirates, it is impossible to understand the huge changes in the landscape brought about by desalination if its integration with the energy sector is not taken into account. The massive development of desalination plants in water-stressed countries and the proliferation of energy-intensive water and wastewater treatments have put energy requirements into the spotlight (March, 2015). Indeed, the main criticisms of desalination technologies remain focused on the high energy consumption required and the greenhouse emissions released if this energy does not come from renewable sources (see e.g. Meerganz von Medeazza, 2004; Sadhwani *et al.*, 2005; McEvoy and Wilder, 2012). This has resulted in some scholars qualifying desalination as an example of ‘maladaptation’ (Barnett and O’Neill, 2010). Ken Livingstone was clearly onto something.

Albeit indirectly, the infrastructure that now comprises the Beckton site (which includes the TWDP) has responded to the nineteenth century debates on the metabolic rift, as well as directly engaging in twenty-first century debates on the water–energy nexus. The resulting infrastructural fix captures the normative essence of industrial ecology and its visions of urban metabolism through a revolutionary solution that overcomes London’s water supply problems, avoids ‘fatbergs’ in the sewerage system and contributes to the making of London as a low-carbon city. Thus, in Figure 1 we can observe the interlinking of different infrastructures and physical flows that enable London’s water supply system to function during periods of drought, as well as treated

wastewater ready to be discarded safely to the River Thames. The project of the Beckton CHiP (20C, 2013; Thames Water, 2013a) and the agreement with Thames Water to use recovered fats, oils and greases (FOGs) to supply over half of the energy needs for the desalination and wastewater treatment plants represents a further step. Not only does this enable the integration of two different utilities (water and energy) but it also means that energy production can be downscaled to the local sphere, as the fuel would be partly obtained from restaurants and food outlets within the limits of the city.

As has been argued, Beckton is the perfect location for assembling these formerly separate networks and encapsulates the ideal of infrastructural integration, enabling the claim that this is a win-win solution for the different economic actors as well as for Londoners. The new integrated infrastructural ideal is framed within an apparent shift towards a more sustainable and low-carbon city in which energy and clean water (either for drinking purposes or for pumping back into the river) can be produced using a variety of renewables, including among those energy sources local fat that was formerly a major cost for Thames Water (through clearing of blocked sewers). Such alchemy has been widely celebrated by the managers of the companies involved in the project for two primary reasons. On the one hand, the integrated ideal is celebrated as a down-scaling of socio-environmental relations: in this account both water and energy can be provided locally. On the other hand, the integrated ideal transforms a risk and a nuisance (fat) into a valuable resource. In an archetypal urban ecological case study, the problem becomes the solution. Along those lines, the CEO of 20C, the company designing and managing the CHiP plant, argued the project is ‘good for us, Thames Water and its customers and the environment. Renewable power and heat sourced in London, generated in London and used in London’ (Thames Water, 2013a).

Both 20C and Thames Water evoke and fetishize the local scale, and the commercial director for Thames Water can argue that the project is a win-win solution for the manner in which it provides ‘[r]enewable power for two of our critical services and a means of tackling the ongoing operational problem of so-called “fatbergs” which are responsible for over 40,000 blockages a year in our sewage network’ (*ibid.*). Although such a narrative can easily be interpreted through debates over de-politicized environmental technocratic management (March and Ribera-Fumaz, 2014), more importantly, claims of the universal benefits of the physical symbioses outlined above serve to deflect attention from crucial questions as to: (1) whether the infrastructural developments are necessary in the first place; and (2) who will pay for them if they are constructed. Claims that the plant is urgently needed can, we would argue, be treated with a degree of scepticism when alternatives received such short shrift, and when a considerable degree of uncertainty remains over London’s potential future water needs. In spite of the fact that the plant is only to function as a back-up solution in periods of severe and prolonged stress (Vidal, 2011), a further desalination plant is being considered for the south bank of the Thames estuary (Thames Water, 2014). To return to the question of who will pay for the return of big infrastructure, however, requires a new level of abstraction. Here we need to look a little further into the complex financial arrangements under which Thames Water now operates.

Financializing infrastructure

As we have sought to emphasize, the story narrated above—one that is pushed heavily by Thames Water, 20C and their investors—could easily be included in the many handbooks of industrial ecology. This tale is one of increasing localization, the development of a circular economy and the realization of urban sustainability. The environmental hinterland from which water and energy resources have been drawn is shown to gradually decrease, generating a virtuous cycle of inter-sector linkages at an altogether more rational ecological scale. Beckton becomes the crucial location where such infrastructures can be interlinked and at which this localization is made possible.

In a strange paradox, the continued opposition to the Beckton plant from the leader of the Green Party in the Greater London Assembly appears to hold back the environmental progress being made by debt-leveraged financial entities. Financiers, not green politicians, apparently have the solutions to what once appeared intractable environmental problems.

However, the financial model upon which Thames Water and the other players in the Beckton narrative is built moves in the opposite direction to this alchemical tale of localization. Through tracing this financial model, we see the contradictions upon which any claims to a green solution clearly falter. Within the financial model, one witnesses a process of internationalization, which is dependent on local consumers paying increased tariffs within a tightly regulated sector operating within national boundaries. Torrance (2008) alludes to the seemingly contradictory scalar tendencies within the production of financialized infrastructure, demonstrating that it relies on a model of glocal governance in which financial instruments become increasingly globalized, at the same time as the returns, which are guaranteed from the infrastructure, are themselves increasingly dependent on local regulatory mechanisms. Thus, in the case of water in England and Wales, OFWAT continues to set the inflation-linked model of tariffs. At the same time, teachers' pensions in Ontario as well as the sovereign wealth funds of Abu Dhabi and China rely on a steady rate of returns, which can only be increased through opening up new sectors for profitable investment such as London's infrastructure (see also Allen and Pryke, 2013). If this glocalization emerges in relation to new forms of regulation, it also needs to be understood alongside the production of new urban natures and the historically and geographically specific practices—such as the building of infrastructure—upon which scale is produced.

Torrance (2008; 2009) elaborates on the argument that infrastructure has become increasingly financialized, demonstrating that roads, pipes, airports and electricity networks all provide a relatively secure and safe set of returns for the investor who is less interested in risk taking. Sovereign wealth funds and pension schemes have been drawn to such investments because of the security offered and the length of time over which they will mature. In the case of England and Wales, investing in water utilities provides an additional inflation-linked guarantee of steady returns. Nevertheless, Torrance notes a shift in the manner in which the low-risk model operates and points to the emergence of an 'Australian finance model', pioneered by Macquarie Bank, and rolled out in the 2000s. As she goes on to write: 'Assuming that debt is available at an attractive rate, many in the infrastructure sector leverage their investments with a high level of debt, greatly increasing equity returns but making the investments financially riskier. The rationale for investing in infrastructure is diluted in such a case, since infrastructure assets become less stable and riskier due to the increased financial risk' (Torrance, 2009: 82). This new model increasingly relies on relatively low rates of inflation and interest, which have become far more prevalent among the economies of the global North since Torrance was writing, indeed the norm for the last decade or more. This new finance model has its roots in the early 1980s, when private investors began acquiring equity in Australian roads (*ibid.*: 81). With the wave of privatizations that occurred in many states during the 1980s and 1990s, Macquarie Group was well placed to manage investment portfolios in infrastructure, while simultaneously becoming one of the sector's principal investors in its own right. This is the background to Macquarie Group's acquisition of Thames Water in 2006 from the German engineering and utility giant RWE. With Macquarie Group's purchase, Allen and Pryke (2013: 419) write that:

Thames Water's households became central to a model of financialised infrastructure that is as far removed from the idea of shareholder capitalism that drove the early privatisations of British Telecom and gas as it is from the

notion that individuals have progressively been turned into financial subjects ... Rather it is a model where it would seem that the households themselves are the financial asset, a 'human revenue stream' as Meek (2012) expressed it, one which has been packaged and sold to global investors through the techniques and practices of financialisation.

Allen and Pryke (*ibid.*) therefore provide a rigorous case study of the model of debt refinancing that Torrance (2008; 2009) had earlier alluded to and is detailed by Bayliss (2014; 2015) and March and Purcell (2014). The financial structure of the Thames Water group now resembles a 'wedding cake' in which Thames Water is owned by Kemble Water Limited, which itself is owned by Kemble Water Holdings Limited (the creation of a special purpose vehicle, a crucial part of the new financing model emphasized by Bayliss, 2015, means that Thames Water Cayman Finance Limited is one of the two buttresses for this model). A consortium of international investors, of which the largest is Macquarie Group, owns Kemble Water Holdings Limited. Other investors include a variety of pension funds from Canada, Australia, Spain and the Netherlands. More recently, in December 2011, the Abu Dhabi Investment Authority bought a 9.9% stake, followed soon after by the China Investment Corporation (also a sovereign wealth fund) which acquired an 8.68% stake in January 2012. When British Telecom's pension scheme acquired a 13% stake, Macquarie Group's overall share in Kemble Water Holdings Limited was reduced to 26% (Allen and Pryke, 2013). Within this structure, the dual role of Macquarie Group is intriguing: it combines an ability to craft financial packages based on securitized assets that might be attractive to its clients, while also being able to channel funds to Kemble Water Holdings Limited. As Allen and Pryke (*ibid.*: 426) write, the group 'is able to generate their own income stream from investors worldwide, while the Kemble Consortium as a whole, in turn, derives benefit from the financial products engineered by Macquarie to capture the revenue streams generated by Thames Water's households'.

Over the last decade and a half, new financial mechanisms have enabled infrastructure to be enrolled within a capitalist system of accumulation in ways clearly not envisaged in the early years of privatization. Indeed, infrastructure has become one of the crucial sites for mopping up over-accumulated capital within the global economy over the last two decades (Torrance, 2009). In this regard, the claim that finance would become crucial to the manner in which capital can flow through fixed infrastructure was foreseen in Harvey's (1982) *Limits to Capital*. As Harvey wrote back then, a well-developed financial system enables capital to switch effortlessly between sectors of the economy in search of the highest rates of profit. With growing crises initiated by a falling rate of profit and growing evidence of over-accumulation, it thereby became possible to switch capital from a primary to a secondary circuit, a process that Harvey initially interpreted through Lefebvre's theses on the rise of urbanization (Harvey, 1978). In infrastructural investments, capital is able to find precisely the kind of temporal fix sought (an investment that delivers returns over a much longer period of time, while also temporarily 'fixing' key aspects of the crisis of over-accumulation) by diverting it away from forms of direct production. With the globalization of such a system, a temporal fix can work simultaneously across geographical space, enabling a shift of capital from one area of the globe to another. Although Castree and Christophers (2015) see some positive aspects to an emerging socio-ecological fix, as finance can provide the resource for sustainable transformations, it can also be seen as part of an ongoing process of accumulation by dispossession in which ecologies are produced out of an increasingly risky, heavily leveraged and fundamentally undemocratic financial model. Thames Water's financial model therefore represents a new manifestation of, indeed a step-change in, what Swyngedouw (2005) refers to as the transformation of local waters into global money.

The political implications of such a shift are many. Allen and Pryke (2013) point to the development of a model geared more towards providing benefits to investors than consumers, and one that increasingly loses sight of the needs of consumers. Through OFWAT's tight regulation of the water sector in England and Wales, a form of 'ring-fenced politics' has emerged which is dominated by a narrow technocratic reading of perceived gains for all. Again, the alchemy provided by a win-win situation in which environmental gains are made through the foresight of enlightened financial entities that can guarantee secure returns for their investors is almost impossible to criticize. In the process, however, the political comes to be sutured by the ongoing practice of a post-politics. Nonetheless, if this post-politicization and the new financial model are crucial parts of the story of glocalization in the post-political regulation of water utilities in England and Wales, they do not comprise the complete story. In a final twist to the vexing question of why Thames Water chose to build the TWDP in a city such as London, we need to turn to the relationship with emerging Spanish actors in order to understand how both infrastructural connections and financial connections have been facilitated by the TWDP's internal relationship with Spain. This final chapter in our narrative takes us far away from the blithe tales of technological prowess circulated by Thames Water and industrial ecologists. Instead, it necessitates a further level of abstraction, focusing (perhaps surprisingly) on the domestic politics of Spain, bound up as this politics is in the efforts to engineer a hydrosocial landscape that balances the demands of different interest groups (Swyngedouw, 2015). To begin this chapter, we need to first hone in on the impact of financialization upon the operation of Spanish water operators and the emergence of Acciona as one of the crucial actors in the development of the TWDP against the backdrop of a Spanish desalination boom.

March and Purcell (2014) demonstrate how, just as French utilities were well placed to benefit from the water privatizations of the 1990s, the water providers of several large Spanish cities such as Barcelona were able to bid for new concession contracts as they appeared across the global North and South. This competitive advantage was most clearly visible in a Latin American context, where other newly privatized Spanish firms such as Telefónica were proving highly successful. To cite the example drawn on by March and Purcell (*ibid.*), AGBAR (Sociedad General de Aguas de Barcelona) was part of a successful bid for the concession contract to operate the Buenos Aires municipal water network in 1993, in a consortium comprising several international companies. However, AGBAR's investment model began to shift after the collapse of the Buenos Aires concession. Intriguingly, the utility increasingly took on some of the characteristics of the Australian model. Thus, only five years after acquiring Bristol Water, AGBAR sold its majority stake in the former to the Canadian global infrastructure fund Capstone. Only a few months after this sale, Capstone sold 20% to the Japanese company Itochu. In a further twist, Capstone's debt was initially brokered by Macquarie Group and a major increase in the interest payments was built into the original agreement. Thus, although apparently benign, one can begin to see how the risks entailed in the so-called Australian model have enormous implications for the way in which infrastructure that is geographically rooted in the UK comes to circulate as a financial asset and is 'flipped' by different globalized funds. As March and Purcell (2014: 17) write: 'Capstone's actions shine a light on the ... risks of financialisation in the water sector: when the asset's yield drops below its price (cost+interest) it reveals fictitious capital for what it is—the speculative claim upon future profits'. Increasingly frequent changes of ownership characterize the need to maximize—and cash in on—these speculative gains. Speculation therefore extends well beyond the projected returns on a tightly regulated water market within a given infrastructure network; it also captures the expected returns on future infrastructural developments, which is where the expectations of profits to be gained from increasingly interlinked infrastructures, across different sectors, begin to emerge. The TWDP is not only linked

to Barcelona through Macquarie's broking role. More importantly, the entire regional raw-water supplier ATLL (including Barcelona's desalination plant) was leased in 2012 to an international consortium led by the same Spanish infrastructure company, Acciona, that constructed the TWDP (at the time of writing the adjudication of ATLL's lease was before the courts, with the final decision uncertain). Thus, Acciona's technologies and scientific expertise were put to work in London, at the same time as a financialized model of water provision—in which Thames Water is surely at the apex—can be seen to have been transported from Australia to Barcelona via London.

Each of these financial and infrastructural actors clearly operates within differing, although increasingly interlinked, regulatory contexts. Crucially, the opening up of different sectors of the economy, forms of infrastructure and aspects of service provision relies on political decisions made at a range of scales. The implications of the Thatcher administration's decision to fully divest water infrastructure in England and Wales were thus enormous, not only for the provision of water in those two countries, but also for water services in cities as disparate as Buenos Aires, Manila, Jakarta or Durban. Furthermore, decisions made in Spain over the last decade have profoundly shaped the economics of desalination around the world. Although the specifics of these shifts are dealt with in greater detail elsewhere, it is important to note that the Socialist Party of Spain (PSOE) gained power in the 2004 elections on a platform of abandoning the Partido Popular's (PP) pursuit of an inter-basin transfer from the River Ebro. Desalination, under the so-called AGUA programme, offered a solution to the problem the new government faced over the potential shortfall in water resources. Desalination also provided the PSOE administration with an opportunity to champion an emerging sector of the Spanish economy and for companies to put to work the over-accumulated capital then washing about within the Spanish economy. On the basis of this technonatural fix, as Swyngedouw (2013; 2015) has referred to it, Spanish companies could therefore become leaders in desalination technology and their expertise could be exported around the world (March *et al.*, 2014; March, 2015). This process has accelerated since the early 2000s, even though desalination was not viewed with the same enthusiasm by the ensuing PP administration (with water transfers being restored as a political objective). Looking at the historical geographies of the development of desalination in London, we therefore need to situate it within political decision-making in the UK as well as in Spain and Australia. A Spanish infrastructure company therefore became the main actor in the construction of a desalination plant for an increasingly globalized financial entity comprising investors from Australia, Canada, Abu Dhabi and China, albeit one seemingly localized—in name and location—on the River Thames. The desalination plant internalizes the changing relations of global infrastructure provision. Any genuinely adequate narrative must therefore go well beyond Beckton, the River Thames and London to encompass the changing ownership of roads in Australia, the election of the PSOE in Spain, the unionization of teachers in Ontario and, more recently, the deployment of government grants in the UK for renewable energy transitions.

Conclusion

In concluding, we would like to return to the question with which we began: why build a desalination plant in London? On the one hand, if we accept the testimony of Thames Water, the answer is simple. Population demands, a changing climate and low rainfall place enormous pressures on a water network that dates back to the Victorian era. However, such a response fails to address the question as to why such a large energy-intensive infrastructural project provides the best solution to the water needs of London. Why not invest money in renewing meters, fixing leaks, rainwater harvesting, educational campaigns and so on? A complementary justification can be found if the project is interpreted through the lens of industrial ecology. Industrial

ecology's narrative points less to the needs of Londoners and more to the ecological benefits to be gained from interlinking infrastructural sectors that had previously been separated. The problem around the intensification of the water–energy nexus brought about by the desalination plant is inverted. Indeed, through overcoming the initial challenges of building a plant that localizes energy needs, a virtuous solution has emerged in which the initial problem becomes the solution. Thus, Thames Water would appear to have responded to its critics by developing a single site within which wastewater can be transformed into clean drinking water thanks to the fat which prevents the flow of wastewater. The metabolic rift, that so concerned Marx, has been challenged through the linking of water and energy in a virtuous cycle. As several key players have pointed out, this provides a win-win situation in which the environmental footprint of the plant is gradually reduced. The TWDP would appear to represent a zenith in the technical skills of a company committed to the principles of ecological modernization and integrating infrastructural solutions across sectors.

Nevertheless, this response similarly fails to answer the question of why the desalination plant was built: it is simply inadequate to say it was built because it could be built in a more sustainable way. In the course of this article we have constructed a fundamentally different answer that we hope demonstrates the agility of urban political ecology frameworks in theorizing the latest shifts in infrastructure provision. Although recently coming under fire for a 'methodological cityism' (Angelo and Wachsmuth, 2015) urban political ecology has never been constrained by the urban form but has, rather, developed an approach that always moves beyond the local to understand the broader ensemble of socio-ecological relations out of which specific urban forms are produced. Using the example of the TWDP—one infrastructural form—we have sought to understand the broader sets of relations that constitute a fundamental shift in the provision of services and the make-up of infrastructure in contemporary capitalist societies. We cannot overestimate the importance of this shift towards financialized infrastructure, which constitutes a fundamentally different relationship between citizen and state, and between resources and everyday life. Developing such an analysis, we located the symbolic capital acquired by Thames Water in the competitive bidding for new concession contracts. However, more fundamentally, we pointed to a financial model that moves in precisely the opposite direction from the localization of the resource base celebrated in the alchemical narrative of the TWDP. Through heavily leveraging infrastructural assets, Macquarie Group (Thames Water's principal owner) has been able to maximize returns for overseas investors. Just as Spanish companies have benefited from the boost given by national government to desalination, so they have been able to expand into other parts of the globe. Speculative capital now stalks the globe in search of new sources for profitable investment: the entire Thames Gateway Water Treatment Works has been enrolled in a financialized system of accumulation that seemingly subjugates sustainable transformations to the enlargement of the process of accumulation through the deployment of state-of-the-art green technologies and a heavily leveraged financial model. Paradoxically, the result has been the construction of a desalination facility that, in spite of all its technical superiority, was far from the most pressing need of London's hydrosocial cycle and will be paid for by households that are increasingly treated as sources from which further rents can be (locally) extracted and (globally) circulated and appropriated. For households in London, the result has been, and will continue to be, a rise in tariffs in spite of the tight regulation enacted by OFWAT. For those elsewhere in the world it may well be a rise in enclaves of premium service provision as highlighted in Boland (2007) and a further isolation of the archipelagos that Bakker (2003) saw emerging alongside privatization in the global South. Nevertheless, if the privatization process has been the key structuring argument in critical scholarship on (water) utilities and infrastructure over the last quarter of a century, we argue that the focus of attention needs to shift to financialization in

order to understand the scalar and uneven production of infrastructure in the twenty-first century. As Aalbers (2015) recently noted, it is critical to understand how the financialization of the global economy is linked with the financialization of the state, different economic sectors, companies and daily life. Infrastructure cuts across these spheres and emerges as a privileged object through which to scrutinize the typically opaque processes of financialization.

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