Learning legacy

Lessons learned from the London 2012 Games construction project

The Old Ford Water Recycling Plant and non-potable water distribution network

Abstract

The Old Ford Water Recycling Plant (WRP), located next to the main site of the London 2012 Olympic and Paralympic Games, is the UK's largest community wastewater recycling scheme. It treats wastewater from the Northern Outfall Sewer and feeds in to a non-potable network that connects to the Olympic Park for toilet flushing and irrigation, and to the Energy Centre for cooling water.

The scheme was set up as part of the Olympic Delivery Authority's (ODA's) Sustainable Water Strategy, which had a target to reduce potable water by 40 per cent. The combined effect of all water saving measures achieved 58 per cent, clearly exceeding the target.

The project was jointly funded by the ODA and Thames Water Utilities Limited (Thames Water), with the ODA taking delivery responsibility for the distribution network and Thames Water for the WRP.

The project required extensive consultation and development of bespoke standards for:

- water quality;
- distribution network design and component/ancillaries; and
- demarcations for the pipework, sleeves and fittings.

The ODA worked closely with the Environment Agency and the Health Protection Agency to establish licensing requirements for direct re-use of reclaimed wastewater, standards that had not previously existed in the UK.

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London suffers regular hydrological drought and has been classified by the Environment Agency as seriously water stressed.

Introduction

Context

London is in the South East of England, an area which suffers regular hydrological drought and which has been classified as 'seriously water stressed' by the Environment Agency[4]. London's main water supplier, Thames Water, recognised this within their Water Resources Management Plan[7], identifying London's limited access to new fresh water supplies to support its expanding population.

Water stress in the area is also expected to increase as a result of climate change[1] and it was in this context that the ODA set itself a challenging target to reduce potable (drinking) water consumption on the Park by 40 per cent (measured against industry standards).

Domestic water usage in the UK averages 150 litres per person per day, of which only 2.5l are for drinking uses. Theoretically, the remaining 147.5l of water (used for toilet flushing and cleaning, for example) can be sourced from an alternative or non-potable (non-drinking) water source, that uses less energy to treat and does not have to comply with the UK's very strict drinking water quality guidelines (monitored and controlled by the Drinking Water Inspectorate).

The previous Government's water strategy Future Water[1] and the Code for Sustainable Homes actively encouraged the use of rainwater and greywater harvesting to supplement some of this demand.

Increasingly, non-potable water is being used in the UK's commercial buildings (such as Terminal Five at Heathrow Airport). It is also being used in industrial and irrigation applications where lower quality water is commercially justified and a maintenance and supply agreement is in place that requires water quality testing and controls to avoid contamination of potable water supplies.

Elsewhere in the world, 'non-potable' for direct reuse is becoming more common: in the USA water recycling systems are becoming more prevalent as 'basement' solutions for non-potable water re-use in high-density buildings. Driving these installations, in part, has been the popularity of the Leadership in Environmental and Energy Design (LEED) building certification scheme[5].

In Singapore and California this has been taken one step further – reclaimed water is being returned for drinking water abstraction, albeit diluted and treated further with reverse osmosis membranes and ultra violet light.

In the UK, Thames Water has also been successfully trialling a community-based scheme at Beddington Zero Emissions Development (BedZED) that uses 25 cubic metres of water per day.

The Olympic Park

Water strategy

The ODA set a target to reduce potable water usage on the Park by 40 per cent (which subsequently became a town planning target) via a strategy that focused on water efficiency first.

Although the Games venues generally achieved a reduction of between 30–50 per cent through the use of water-efficient fittings, the impact of several large water consumers, namely the Energy Centre (for process cooling) and Eton Manor (for the post-Games artificial hockey turf), did not benefit from the efficiency measures and this meant that the overall water efficiency level was 18 per cent.

The Aquatics Centre was also a large water consumer but it benefited from independent water recycling using the swimming pools' filter backwash. Each venue's relative contribution to Park-wide water targets are shown in Figure 1.

- 24% Aquatics Centre
- 27% Energy Centre
- 8% Handball Arena
- 9% Olympic Stadium
- 16% Eton Manor
- 7% Parklands
- 2% Velodrome
- 7% Main Press Centre

Figure 1: Breakdown of the water footprint of the Park based on assumptions in venue planning submissions

The ODA commissioned feasibility studies into alternative water supply options and designs for a non-potable water distribution network. It also financed an extensive consultation process with the water's potential end users to establish their water quality needs and to overcome any real or perceived barriers to using non-potable water.

Table 1 shows the different uses made of non-potable water and Figure 2 shows the relative proportion of potable and non-potable water used at each venue.

It was clear from the water model and the variety of end users that a large-scale non-potable water solution was needed to deliver ODA's 40 per cent target.

End user	Type of use
* Olympic Stadium	Irrigation
Handball Arena	WC flushing
Velodrome	WC flushing
Parklands and Public Realm	Irrigation
Eton Manor	WC flushing and irrigation
Main Press Centre	WC flushing
Energy Centre	Cooling water demand
** Aquatics Centre	WC flushing
Athletes' Village	Irrigation and pond top up

* Due to the uncertainty around transformation of the Olympic Stadium, the toilets were not part of the non-potable network.

** The Aquatics Centre had an independent water recycling system using the pools' filter backwash water.

Table 1: End users of non-potable water on the Park

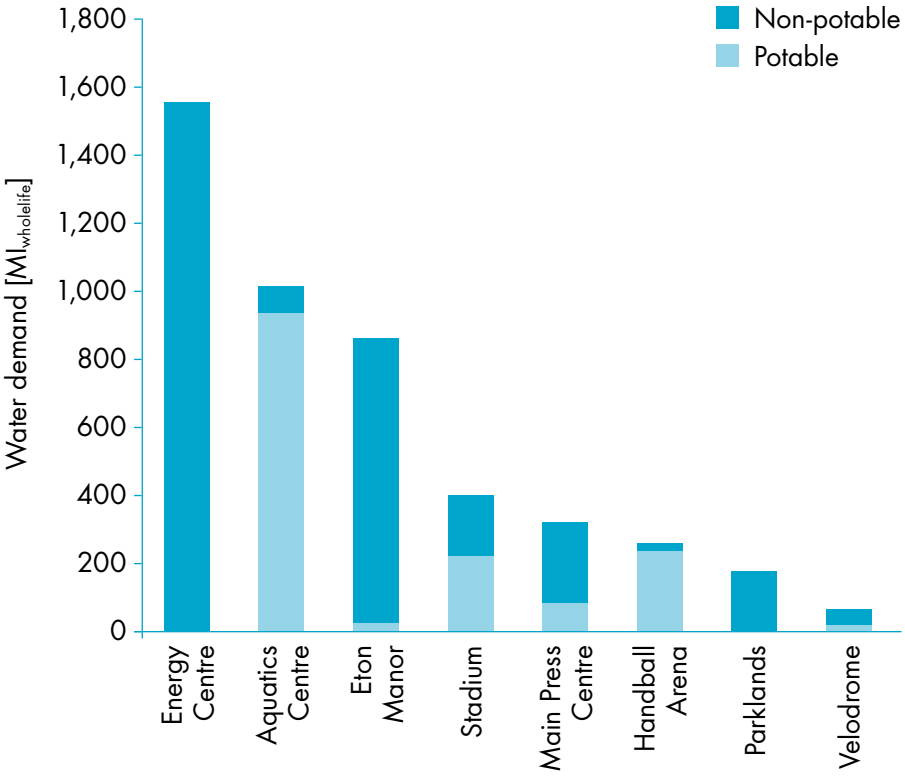


Figure 2: Breakdown of potable and non-potable water consumption (25-year lifecycle) for the Park's venues

Reviewing the Park's non-potable water options

The ODA required an early decision on network capacity, which stimulated much debate. Most of the discussion centred around:

1 Should the solution meet the requirements of the target (that is, to contribute to the 40 per cent target with minimal investment)?
2 Should the solution meet the requirements of the Park (that is, to service all venues)?
3 Should the solution meet the requirements of the Park's long-term legacy community (that is, with a demand up to eight times greater than that required for solution 2)?

Because the non-potable water distribution network had to be delivered alongside the other utilities (for economy and viability reasons), there was a limited timeframe for delivery. A final decision was made to deliver solution 2 (to meet the requirements of the Park), which optimised the infrastructure without the consequences of an oversized network, such as a bigger carbon footprint caused by increased pumping.

Note: The additional requirements for solution 3, when added to the uncertain timeframe and size of future developments, were considered unacceptable to Thames Water who would need to adopt the network and operate the WRP after the Games.

As the design of the non-potable water distribution network progressed, the ODA began negotiations with Thames Water on the source of wastewater, the type of treatment process and where to locate the treatment facility.

Feasibility studies into water sources indicated that the most cost-effective solution was to use groundwater, for which there were several sources, including an existing borehole at Old Ford, near the Olympic Stadium.

When the ODA began reviewing the options with Thames Water it became clear that research in this area was vitally important because of water stress in South East England.

However, further investigation of all the Park's groundwater sources clearly indicated that the viability of this option was limited because:

– Water quality would be unsuitable for the Energy Centre (potentially the Park's largest water consumer).
– Water treatment would be more energy intensive than potable water from Coppermills, which benefits from economies of scale, and yet has a lesser water quality than potable water.
– Drawing water from a water source that is part of Thames Water's drought resilience supply would create a conflict of demand and detract from the intention to reduce the potable water shortage in London.
– Groundwater is incompatible with the Government's criteria for the supply of non-potable water under the Code for Sustainable Homes.

Greywater[a] was quickly ruled out as a non-potable water source because of the infrastructure needed to collect separate wastewater streams, which would be in addition to the non-potable supply network. For similar reasons, a site-wide rainwater harvesting network was considered unsuitable, although there were several localised systems on the Park. Rainwater and greywater were also considered to have insufficient flow to meet the Park's non-potable water demands.

Early feasibility studies had also ruled out wastewater reclamation ('blackwater') due to risk and cost constraints. However, when the ODA began reviewing the options with Thames Water it became clear that research in this area was vitally important because of water stress in South East England. The Park presented an ideal opportunity for Thames Water to:

– scale up the Membrane Bioreactor (MBR) technology being used at BedZED (a sustainable development site in South London); and
– test the technical and commercial viability of establishing community-scale wastewater reclamation facilities in the UK.

a Greywater refers to wastewater generated from activities such as laundry, dishwashing and bathing.

Environmental and commercial benefits

In order to deliver the required wastewater treatment facilities, Thames Water invested £5 million to initiate a seven-year research and development project. The additional funding provided the necessary capital to make wastewater reclamation a viable opportunity for the ODA. Several key environmental and commercial benefits were considered:

- The final water quality was expected to be superior to the groundwater option and therefore more suitable for use at the Energy Centre (following some upgrades by the ODA[b]).
- MBR had reduced chemical requirements compared with groundwater treatment.
- The energy demand of the MBR was comparable to the offset energy required to treat the equivalent amount of drinking water at Copper Mills and wastewater at Beckton Sewage Treatment Works.
- There was no requirement for a 'new' water source.
- The existing sewer infrastructure, namely the Northern Outfall Sewer, had a constant and predictable supply of sewage[c] – for example, when compared to the difficulties of installing new infrastructure to collect greywater and rainwater from multiple venues.

Consultation showed that the greatest concerns about using reclaimed wastewater were quality and controls.

Non-potable water quality

Consultation showed that the greatest concerns about using reclaimed wastewater were quality and controls.

Following extensive research and technical advice, the final set of water quality parameters were, for the most part, aligned with the United States' (US) Environment Protection Authority's (EPA) guideline 'Urban Re-use' (in accordance with Table 4–13 [including all recommendations, recommended limits (Table 2–*7*, using long-term use limits where a distinction is made)] of the US EPA Guidelines for Water Reuse, EPA/625/R-04/108 September 2004 for non-potable water[10]).

The US EPA standards provide a very high quality of reclaimed water suitable for unrestricted urban reuse. However some additional parameters were added and others adjusted further to help meet the needs of certain potential customers. The key water quality parameters and alterations are shown at Appendix A.

To achieve this water quality, the main technology in the WRP was an MBR. MBR treatment for wastewater reclamation involves pre-treatment (including screening and settling of solids), MBR (nutrient removal, membrane ultra-filtration and aeration) and post-treatment (carbon filters and chlorination for disinfection).

The plant provided all the systems required for fully functioning and automated treatment and pumping (including all mechanical and process equipment, electrical equipment, and control and instrumentation equipment). The WRP was designed to achieve an average flow of 0.574 megalitres per day, with storage to achieve the peak day demand of 0.813Ml/d. Further information and a process diagram are in the Technical summary section.

b The Energy Centre had specific issues with chloride and conductivity which limited the number of cycles of its process cooling water. In order for the Energy Centre to use non-potable water, the ODA funded enhancements which included upgrading the electric chiller and absorption chiller materials to stainless steel, additional treatment plant, an additional water booster set and pipework to accommodate the additional non-potable water supply.

c The Northern Outfall Sewer is a combined sewer and as such includes surface water drainage. The MBR does operate more efficiently on a 'pure' sewage input, but the minor loss in efficiency is outweighed by the benefits of a consistent and surplus supply.

In order to address the SNCI status issue, John Lyall Architects was instructed to design a treatment facility that was sympathetic to its surroundings.

WRP location

When the decision was taken to proceed with wastewater recycling, the difficult task of where to locate the WRP started. To set this in motion, the ODA commissioned a site selection study which considered the following requirements and restrictions:

- Required footprint of 1,000 square metres plus construction access.
- Good access for a connection to the Park's non-potable water distribution network (including consideration of rivers and utility corridors).
- Within close proximity to the Northern Outfall Sewer or the Primary Foul Sewer Pumping Station with a suitable solution for connections.
- Optimisation of gravity feeding.
- Town planning consideration.
- Land ownership and the necessary land-take for the Games.

Finding a suitable location proved difficult due to the advanced stage of master planning and a lack of unallocated land on the Park. The site selection study recommended Old Ford (a Site of Nature Conservation Importance (SNCI)), near to the Olympic Stadium, as the most suitable location.

In order to address the SNCI status issue, John Lyall Architects was instructed to design a treatment facility that was sympathetic to its surroundings (for example, by including natural materials, timber and gabion basket cladding and a biodiverse 'living roof'). The London Wildlife Trust was also engaged to advise on enhancing the habitat features within Old Ford, including the provision of a pond and a nature trail. The treatment facility became known as the Old Ford Water Recycling Plant or Old Ford WRP.

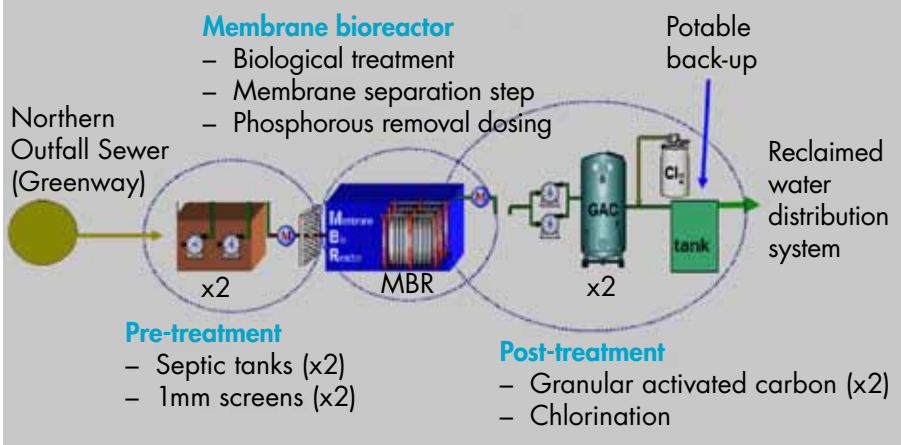


Figure 3: The Old Ford WRP process

The Old Ford WRP will provide recycled water to the Park for non-potable use

Thames Water demonstrated that the expected operational carbon footprint was comparable to the net carbon footprint for processing an equivalent amount of drinking water and wastewater from local sources.

Old Ford was conveniently located just off the Park, in close proximity to the Northern Outfall Sewer and in a good operational location for connection to the non-potable water distribution network.

Because this was the first time that a non-potable water distribution network had been installed on this scale, it was necessary to establish stringent guidelines for network connections and demarcations to ensure that the guidelines were closely monitored and assured during installation and commissioning. Details of these features are in the Technical summary section.

All but one of the permanent venues on the Park can use non-potable water to flush toilets. However, the Aquatics Centre is not serviced by the non-potable water distribution network because it has its own abundant non-potable water supply (reclaimed from the filter backwash process). Also, it would have been problematic to integrate the Aquatics Centre (located in Zone 1) into the distribution network because of the restricted utility corridors through bridge H05 (where the utilities enter Zone 1 from Zone 2).

Localised rainwater harvesting infrastructures were also installed at the Velodrome and the Handball Arena which could be topped up by non-potable water via the distribution network.

For more information, see the 'Rainwater harvesting at the Velodrome' micro report.

The 'as-built' alignment of the Park's non-potable distribution network is at Appendix B.

Carbon footprint of Old Ford WRP

Because of the ODA's growing concerns about the carbon footprint associated with wastewater reclamation, Thames Water was asked to review the net operational carbon footprint of the proposed WRP.

Thames Water's study[9] demonstrated that the expected operational carbon footprint was comparable to the net carbon footprint for processing an equivalent amount of drinking water and wastewater from local sources.

For example, in order to treat the expected demand at Old Ford WRP (0.574Ml/day), the study suggested a carbon footprint in the range of 243 to 1,184kg$CO_{2\text{-}e}$/d (taking into account both MBR and granulated activated carbon technologies). This compared to 369kg$CO_{2\text{-}e}$/d, which was the total to treat the same volume of potable water at the Coppermills Water Treatment Plant plus the equivalent wastewater at Beckton Sewage Treatment Works.

The comparative findings on operational carbon are summarised in Table 2. Desalinisation was also presented in the results as the decision to proceed with the Old Ford WRP was not based solely on a comparison to existing potable water resources. Consideration was also given to the important research component of the site and the need to collect data on water reclamation to compare against other future water sources, such as desalinisation.

Thames Water stated that, because of the state-of-the-art technology at Old Ford and the significant operational lessons learned from the MBR operation at BedZED, they expected to optimise the Old Ford WRP towards the bottom range of the carbon intensity (Table 2), around 350kg$CO_{2\text{-}e}$/d.

For context, Thames Water had commissioned their first desalinisation plant in 2010 to supply water to London. Table 2 shows that to treat an equivalent volume of 'Brackish tidal estuary water', desalination technology was estimated to produce a minimum of 501kg$CO_{2\text{-}e}$/d.

Treatment type		Expected operational $CO_{2\text{-}e}$ for 574m³ [kg$CO_{2\text{-}e}$/d]	References
Beckton Sewage Treatment Works		171	TWUL (2009)
Coppermills Drinking Water Plant		198	
Desalination plant	Brackish	240–300	Pearce, GK (2008)
	Brackish – tidal estuary	501–681	
	Seawater – medium salinity	690–1,201	Wilf, M (2007)
	Seawater	1,081	
MBR		208	Black & Veatch (2010)
		241–1,148	EA (2009b)
		300–1,051	Wilf, M (2007)
Granulated activated carbon		36	EA (2009a)

Table 2: Carbon footprint analysis of MBR treatment against potable supplies and desalinisation[9]

The different stages of water processing through the Old Ford WRP

Summary and key challenges

An overview of the water reclamation cycle is shown at Figure 4 (blue boxes).

By choosing to install a WRP, the ODA expected to exceed its 40 per cent target and facilitate Thames Water to operate the largest community-based non-potable direct re-use project in the UK.

Figure 5 shows an initial 18 per cent 'reduced demand' on the Park from water efficiency measures. The WRP had been designed to deliver a minimum of 46Ml per annum and, combined with rainwater harvesting and swimming pool backwash recycling, was expected to reduce the overall baseline by a further 40 per cent, bringing the total reduction to 58 per cent against industry standards.

For more information, see the 'Olympic Park Water Strategy' learning legacy research paper.

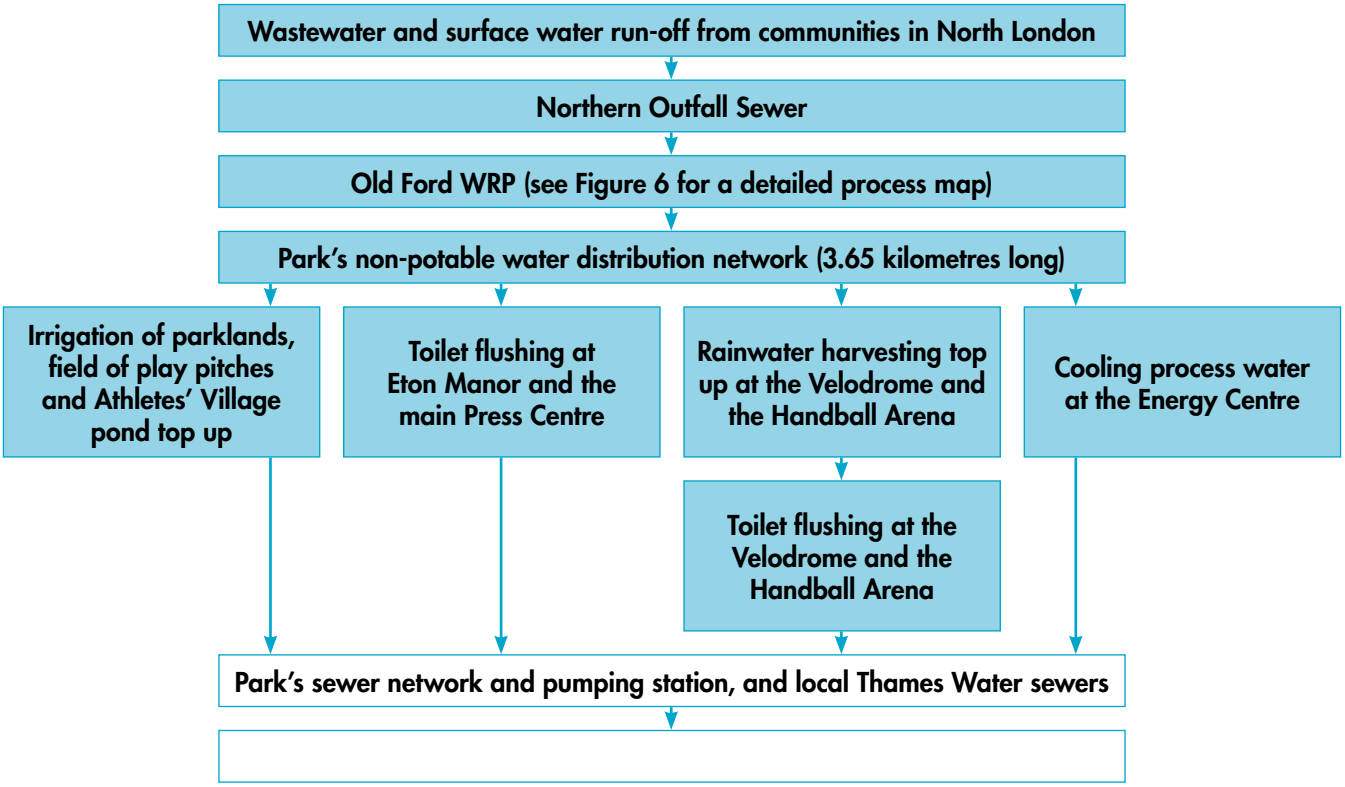


Figure 4: Overview of the water reclamation cycle

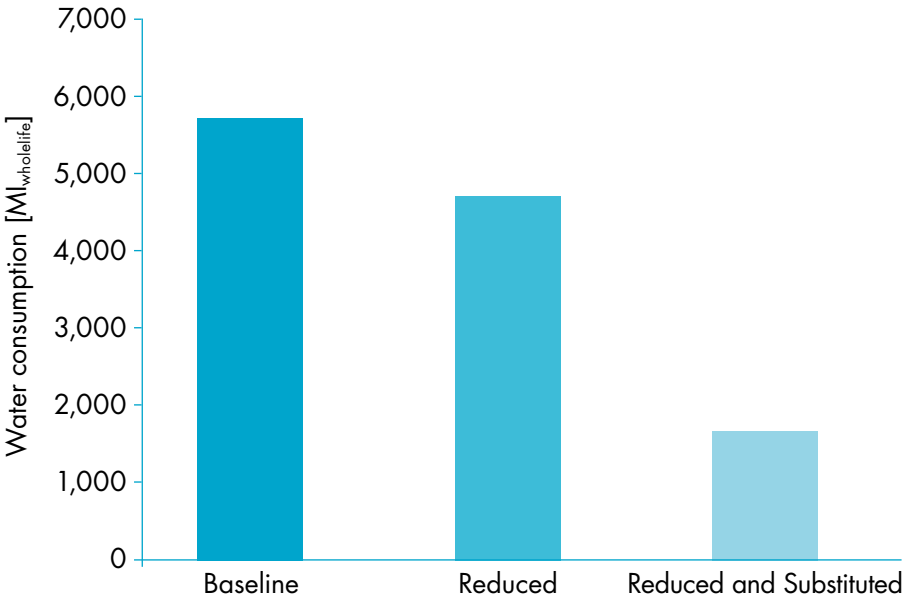
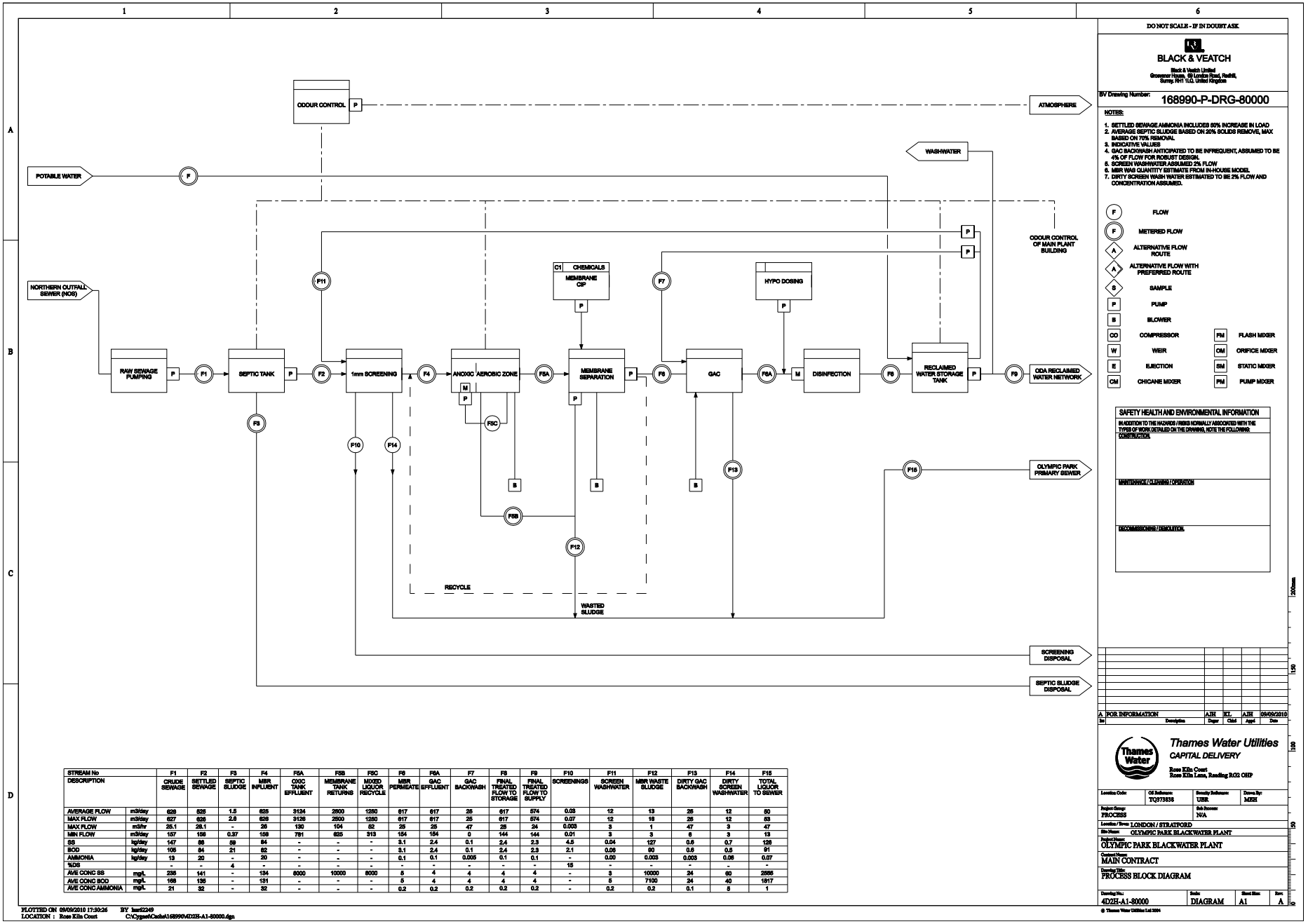


Figure 5: The Park's operational water footprint



STREAM No		F1	F2	F3	F4	F5A	F5B	F5C	F6	F6A	F7	F8	F9	F10	F11	F12	F13	F14	F15
DESCRIPTION		CRUDE SEWAGE	SETTLED SEWAGE	SEPTIC SLUDGE	MBR INFLUENT	OXIC TANK EFFLUENT	MEMBRANE TANK RETURNS	MIXED LIQUOR RECYCLE	MBR PERMEATE	GAC EFFLUENT	GAC BACKWASH	FINAL TREATED FLOW TO STORAGE	FINAL TREATED FLOW TO SUPPLY	SCREENINGS	SCREEN WASHWATER	MBR WASTE SLUDGE	DIRTY GAC BACKWASH	DIRTY SCREEN WASHWATER	TOTAL LIQUOR TO SEWER
AVERAGE FLOW	m3/day	626	626	1.5	625	3124	2500	1250	617	617	25	617	574	0.03	12	13	25	12	50
MAX FLOW	m3/day	627	626	2.8	626	3126	2500	1250	617	617	25	617	574	0.07	12	18	25	12	53
MAX FLOW	m3/hr	26.1	26.1	-	26	130	104	52	25	25	47	25	24	0.003	3	1	47	3	47
MIN FLOW	m3/day	157	156	0.37	156	781	625	313	154	154	0	144	144	0.01	3	3	6	3	13
SS	kg/day	147	88	59	84	-	-	-	3.1	2.4	0.1	2.4	2.3	4.5	0.04	127	0.6	0.7	128
BOD	kg/day	105	84	21	82	-	-	-	3.1	2.4	0.1	2.4	2.3	2.1	0.06	80	0.6	0.5	81
AMMONIA	kg/day	13	20	-	20	-	-	-	0.1	0.1	0.005	0.1	0.1	-	0.00	0.003	0.003	0.06	0.07
%DS		-	-	4	-	-	-	-	-	-	-	-	-	15	-	-	-	-	-
AVE CONC SS	mg/L	235	141	-	134	6000	10000	6000	5	4	4	4	4	-	3	10000	24	60	2566
AVE CONC BOD	mg/L	168	135	-	131	-	-	-	5	4	4	4	4	-	5	7100	24	40	1917
AVE CONC AMMONIA	mg/L	21	32	-	32	-	-	-	0.2	0.2	0.2	0.2	0.2	-	0.2	0.2	0.1	5	1

Figure 6: Process diagram for Old Ford WRP

Because a community-scale wastewater reclamation project for non-potable direct re-use had not previously been implemented on this scale in the UK, there were considerable challenges and issues to be considered and overcome. These included:

- the timeframe for delivery of the Park's non-potable water distribution network, particularly given that the network had to be delivered alongside the other utilities;
- the commercial viability of non-potable direct re-use, made possible through joint funding by the ODA and Thames Water;
- water quality concerns about the choice of MBR treatment, in particular:
  - irrigation: plantlife water quality parameters
  - field of play: human health water quality parameters
  - toilet flushing: water clarity, odour and human health
  - Energy Centre process cooling: water quality (conductivity, chloride and hardness) and commercial implications
- town planning requirements, addressed largely through the design of the Old Ford WRP by John Lyall Architects:
  - Old Ford land issues, habitat requirements and a biodiverse living roof (working with London Wildlife Trust to overcome these)
  - residents' concerns about odour and visual impact
- a lack of consistent or detailed guidance, due in large part to non-potable direct re-use being an emerging field – to overcome this, the ODA and Thames Water worked closely to create bespoke water quality guidance;
- governance from the EA and Health Protection Agency (HPA) – this resulted in the development of a Water Safety Plan approach;
- management of the differences between the legacy and Games water demand profiles and optimisation of the requirements for the network;
- research requirements to understand the carbon footprint of the energy-intensive MBR treatment;
- clear demarcation of the non-potable water distribution network to avoid cross-contamination with the potable water distribution network during construction and after the Games; and
- the Delivery Programme and risks associated with undertaking an innovation project.

Governance from the EA and Health Protection Agency resulted in the development of a Water Safety Plan approach.

Technical summary

The non-potable water distribution network

The non-potable water distribution network distributed the recycled wastewater from the Old Ford WRP around the Park to end-use customers. The interface for connections to end-use customers was at metered connection pits where water was supplied at a minimum pressure of 2bar. These pits were located outside the customer's premises and provided the delineation of ownership.

Thames Water owned the non-potable water distribution network up to the revenue meter (under the terms of a self-lay agreement with the ODA) and the customer owned the pipework downstream of the revenue meter (similar to the standard potable water arrangement).

Water samples were taken periodically at the washout in the connection pit adjacent to the revenue meter by Thames Water, who own and operate the network. The non-potable water distribution network within the Park was 3.65km in length and predominantly routed within the utility service corridors (see Appendix B for the location plan of the non-potable water distribution network 'as-built' alignment).

The pipework was routed through designated sleeves at seven bridge crossings (F02, F06, F07, H17, E13, L07 and U07). There was also one under-track crossing below the Woolwich rail line to the north-west of the Olympic Stadium. The non-potable water distribution network within the Park was connected to the non-potable water pipework at a meter chamber located within Old Ford WRP.

The network was designed by Arup, approved by Thames Water and installed by McNicholas Construction Services Limited. The detailed design of the non-potable water distribution network was primarily based on estimated non-potable water customers' legacy average demands, but also took into account the estimated non-potable water customers' Games time average demands.

These are summarised in Table 3.

Non-potable water demand assessments (Ml/day)						
Connection reference	Stakeholder	Use	Games		Legacy	
			Peak	Average	Peak	Average
Zone 9						
09-AVC-09	Athletes' Village	Top up to Athletes' Village stilling pond	0.203	0.071	0.104	0.036
Zone 7						
07-ETM-01	Eton Manor	Toilet flushing and legacy FoP irrigation	0.010	0.010	0.158	0.028
07-LPR-08-3	L&PR	North Park Zone 7 irrigation	0.108	0.083	0.018	0.012
Zone 6						
06-LPR-08-2	L&PR	North Park Zone 6 irrigation	0.150	0.116	0.025	0.016
06-LPR-08-4	L&PR	North Park Zone 6 (EDF3 Headhouse) irrigation	0.003	0.003	0.003	0.003
06-PFD-03	Primary Foul Drain	PFD flushing	0.000	0.000	0.043	0.043
06-VPK-02	Velopark	Rainwater harvesting top-up	0.040	0.004	0.060	0.003
Zone 5						
05-HBL-05	Handball Arena	Rainwater harvesting top-up	0.061	0.009	0.022	0.004
05-MPC-04	MPC	Toilet flushing	0.076	0.076	0.076	0.076
05-LPR-08-1	L&PR	North Park Zone 5 irrigation	0.120	0.092	0.020	0.013
Zone 4						
04-LPR-08-7	L&PR	South Park Zone 4 irrigation	0.072	0.055	0.012	0.008
04-LPR-08-6	L&PR	South Park Zone 4 irrigation				
04-CHP-06	Energy Centre	CCHP process water	0.248	0.248	0.248	0.248
Zone 3						
03-STA-07	Olympic Stadium	Irrigation and field of play irrigation	0.100	0.100	0.100	0.100
Zone 2						
02-LPR-08-5	L&PR	South Park Zone 2 irrigation	0.180	0.139	0.030	0.020

Table 3: Venue demands for the non-potable network on the Park

The Water Supply Regulations Schedule 2 item 14 (1) states that 'Any water fitting conveying – (a) rain water, recycled water or any fluid other than water supplied by a water undertaker; or (b) any fluid that is not wholesome water; shall be clearly identified so as to be easily distinguished from any supply pipe or distributing pipe'.

In order to clearly identify the pipework, sleeves and fittings, the Network designers, Arup, specified the following based on available guidance (for example, the Water Regulations Advisory Scheme) for non-potable water:

– Pipework
– Non-potable water pipes shall be black polyethylene with longitudinal green stripes and diameters vary in the range 32mm–180mm Outside Diameter (OD). Pipes shall be installed with identification markings facing upwards.
– Marker tape for the non-potable water distribution network shall be green, PVC or heavy gauge polyethylene sheeting, at least 150mm wide, incorporating a corrosion resistant tracing system, and printed with the words "CAUTION – NON-POTABLE WATER MAIN BELOW" in bold capital letters throughout its length at intervals not exceeding 700mm. The marker tape shall be located 500mm above the pipe, with the exception of the pipework in the VTP assemblies, where the marker tape shall be a minimum of 200mm above the pipe due to reduced pipe cover.
– Pipe jointing shall be butt-fusion welding wherever possible, otherwise electrofusion coupling. Pre-formed Polyethylene bends are permitted. The transition from Polyethylene to Ductile Iron at fittings shall be made using flange adaptors specifically designed to provide an anchored joint, for example Viking Johnson Aquagrip.
– The non-potable water pipework shall be installed at a minimum depth of cover of 900mm and a maximum depth of cover of 3,000mm.
– The maximum Working Pressure of the non-potable water distribution network is 9bar.

– Sleeves
– Pipework shall be installed in a steel sleeve where appropriate (such as crossing other utilities) and shall not be blue in colour.

– Fittings
– Pipe fittings shall be flanged Ductile Iron.
– Pipe fittings shall not be blue in colour.
– Only left hand close valves are to be used.
– Valves shall be mounted horizontally.
– The ductile iron cover of each chamber shall be cast with the words "NON-POTABLE WATER" in bold capital letters.

– Above Ground Infrastructure
– No marker post/plate is required to demarcate the location of valves, meters and washouts.

Non-potable water distribution network commissioning: Following completion of the installation of the non-potable water distribution network, the pipework was pressure tested to 13.5bar and the pressure test witnessed by a Thames Water representative.

Pressure testing was carried out in accordance with Section 5 of the 'Pressure Testing of Water Supply Pipelines and Sewer Rising Mains' document[13] and no swabbing, flushing or disinfection was required for the non-potable network.

The water source for the plant was taken from the Northern Outfall Sewer, which is the main sewer collecting crude wastewater from North East London.

Old Ford WRP

The water source for the plant was taken from the Northern Outfall Sewer, which is the main sewer collecting crude wastewater from North East London and transporting it for treatment at the Beckton Sewage Treatment Works.

The WRP design was based on the 'live' Thames Water research and development recycling plant at BedZED, and incorporated:

- septic tanks
- 1mm screens
- membrane bioreactor (biological treatment and membrane filtration)
- granular activated carbon
- disinfection (prior to distribution into the non-potable water distribution network)

The crude wastewater abstracted from the Northern Outfall Sewer was first treated in the septic tanks, which had been designed to remove any rags and gross solids through a settlement process. The resulting settled sewage was then passed through 1mm screens to remove any solids that could cause damage to the membranes.

Afterwards the wastewater went through a biological treatment followed by a membrane filtration MBR. MBR technology was well known for its advantages over conventional wastewater treatment plants with respect to smaller footprint and significantly better and more consistent water quality.

MBR technology used membranes to retain the activated sludge[d] in the biological process and could operate with much higher sludge retention times, approximately five times higher than conventional wastewater plants.

This technology resulted in a significantly higher removal of contaminants from the wastewater. Additionally, the ultra-filtration membranes with a nominal pore size of 0.04µm acted as a physical barrier, resulting in a product that was virtually free of solids and pathogens.

MBRs have been widely used for non-potable water re-use applications around the world, most significantly at the 2008 Beijing Olympic Games, where water from MBR treatment plants was used to supply water features, landscaping and agriculture. Thames Water already had experience in operating and optimising MBR technology, treating wastewater for non-potable use at BedZED.

In addition to MBR technology, the product water at the Old Ford site was further treated by a conventional granular activated carbon process. The major attribute of carbon is its ability to remove a wide variety of organic compounds and colour by adsorption. This is a proven cost-effective technology in the water/wastewater industry.

The high quality reclaimed water produced by the plant was disinfected using sodium hypochlorite before being sent to the Park's non-potable water distribution network. This ensured a chlorine residual throughout the network to minimise any potential biofilm growth and kept the water disinfected.

d Activated sludge is a treatment process that involves introducing oxygen to the sewage to promote microbes that breakdown the organic matter to flourish.

By installing the non-potable water distribution network and supporting Thames Water with the installation of the Old Ford WRP, the ODA not only exceeded its ambitious sustainability target but also facilitated an exciting new research project for the UK.

Conclusions

The benefits of MBR technology for industrial and municipal wastewater treatment are well versed, even though non-potable direct re-use of the water is almost non-existent in the UK apart from a few pilot projects. By installing the non-potable water distribution network and supporting Thames Water with the installation of the Old Ford WRP, the ODA not only exceeded its ambitious sustainability target but also facilitated an exciting new research project for the UK.

The long-term research that Thames Water undertook at Old Ford will provide an evidence base for commercial, operational, and regulatory decisions on the role of water recycling in the UK. London 2012 not only proved to be a key driver in sustainability but it was also an opportunity to introduce to the public the concept of direct re-use of non-potable water.

The Games established good-will with consumers and regulators to overcome some significant barriers to the project. The ODA and Thames Water undertook steps with the EA and the HPA to establish licensing requirements that were otherwise non-existent in the UK for direct water re-use. The regulatory framework for this has become a precedent that, along with the water quality and the utility standards developed, can be used for future projects as part of the immediate learning from this project.

Furthermore, this work provided much needed data for Thames Water to assess operational and environmental concerns which could then be compared with alternative 'new' water sources in London to meet increasing demands and provide drought resilience.

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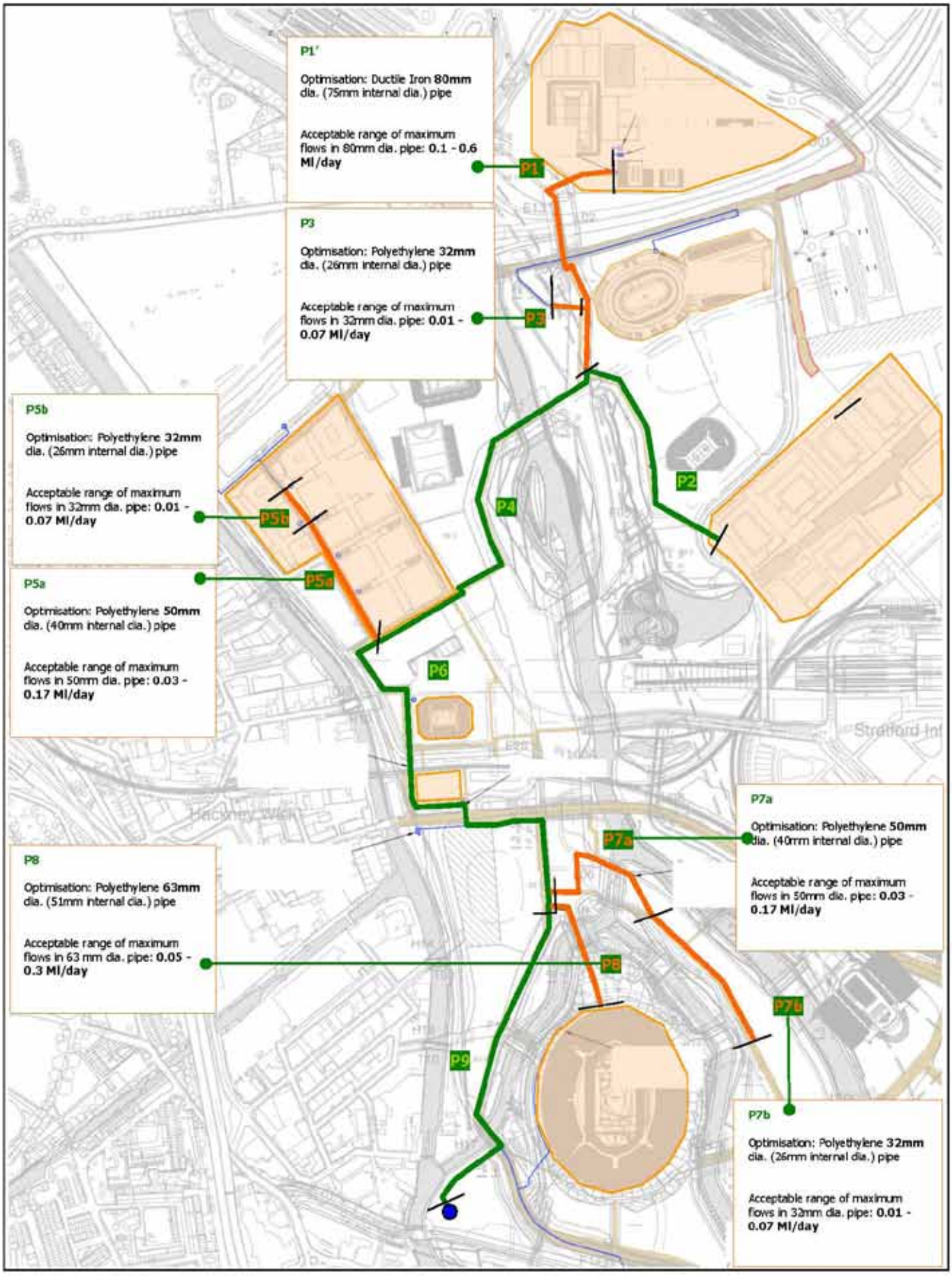
Appendix A – Non-potable water quality parameters

Parameter	Level	Unit	Percentile	Comment
US EPA core water quality parameters				
Aluminium	5	mg/l	90%ile	
Arsenic	0.1	mg/l	90%ile	
Beryllium	0.1	mg/l	90%ile	
BOD	<=10	mg/l	95%ile	
Cadmium	0.01	mg/l	90%ile	
Chlorine	1	mg/l	n/a	After 30 minutes contact time at the outlet of the contact tank
Chromium	0.1	mg/l	90%ile	
Cobalt	0.05	mg/l	90%ile	
Colour	Clear		95%ile	Defined as 20mg/l Pt Co
Lead	5	mg/l	90%ile	
Lithium	2.5	mg/l	90%ile	
Manganese	0.2	mg/l	90%ile	
Molybdenum	0.01	mg/l	90%ile	
Nickel	0.2	mg/l	90%ile	
Odour	Odourless		90%ile	Defined as 0 OU/m^3
pH	6.5–9.0		90%ile	
Selenium	0.02	mg/l	90%ile	
TDS	1,000	mg/l	90%ile	
TSS	5	mg/l TSS	95%ile	
Turbidity	<=2	NTU	95%ile	NTU (nephelometric turbidity units)
Turbidity	5	NTU	n/a	Maximum level at the inlet to the contact tank
Vanadium	0.1	mg/l	90%ile	
US EPA water quality parameters, where UK drinking water standards take precedence				
Boron	1	mg/l	90%ile	
Copper	2	mg/l	90%ile	
Zinc	5	mg/l	90%ile	

Parameter	Level	Unit	Percentile	Comment
US EPA water quality parameters, with deviations				
Chlorine in the distribution network	>0.3, <1.5	mg/l	n/a	
Faecal coliform	14	No./100ml	n/a	Thames Water only measured E-Coli as a surrogate for faecal coliforms Thames Water agreed to median values for the last seven days for which analysis had been completed to be zero per 100ml and not to exceed 10/100ml in any one sample
Fluoride	1 to 15	mg/l	90%ile	
Iron	1	mg/l Fe	90%ile	
Pathogens viable	None *		n/a	Thames Water agreed to median values for the last seven days for which analysis had been completed to be zero per 100ml Total and Faecal Coliforms Note: Thames Water monitored the membrane integrity to ensure that significant breakthrough did not occur
* US EPA compliance exceptions				
Additional water quality requirements				
Bicarbonate / Alkalinity	500	mg/l HCO_3	90%ile	
Calcium	250	mg/l Ca	90%ile	DWS
Chloride	250	mg/l Cl	90%ile	DWS
Conductivity	1,000	uS/cm	90%ile	DWS Indicator Parameter 2,500uS/cm
Hardness	450	mg/l $CaCO_3$	90%ile	
Magnesium	50	mg/l Mg	90%ile	
Phosphorus	2.5	mg/l P	90%ile	
Reactive silica	25	mg/l SiO_2	90%ile	
RSC	1.25	mEq/l	90%ile	
SAR	3	mEq/l	90%ile	
Sodium	200	mg/l Na	90%ile	DWS
Sulphate	250	mg/l SO_3	90%ile	DWS
Sulphide	0.05	mg/l S	90%ile	
Total coliforms	0	No./100ml	n/a	Median value
Total nitrogen	30	mg/l as N	90%ile	

Appendix B – The Park's non-potable network



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The construction of the venues and infrastructure of the London 2012 Games is funded by the National Lottery through the Olympic Lottery Distributor, the Department for Culture, Media and Sport, the Mayor of London and the London Development Agency.

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Published March 2012
Ref: ODA 2012/031