Institute for Sustainable Futures

UTS UNIVERSITY OF TECHNOLOGY, SYDNEY

Australian Water Recycling Centre of Excellence

Darling Quarter Case Study

Successful sewage recycling within a high profile commercial building

The Darling Quarter story demonstrates that in-building wastewater recycling treatment plants can work well, particularly when the proponents are in a position to learn from previous challenges. The Darling Quarter scheme benefited from knowledge gained through previous in-building water recycling plants and represents the second generation of such plants in terms of technology, configuration and system management.

This case study also highlights the financial value of '6-Star Green Star Office As-Built' credentials. Darling Quarter attracted premium tenants and this enabled the developers to secure a long-term lease at the lowest point in the Global Financial Crisis in 2008.

This study is funded by the Australian Water Recycling Centre of Excellence under the Commonwealths Water for the Future Initiative

DARLING QUARTER

Darling Quarter is in Sydney's CBD.
The blackwater treatment plant commenced operation in November 2011.

CAPACITY	CLASS OF WATER
0.17 ML/d	A

TYPE
Sewer mining; Moving Bed Biofilm Reactor (MBBR), Membrane Bioreactor (MBR), reverse osmosis

USAGE
Toilet flushing, irrigation, and cooling towers

ABOUT THE PROJECT

This national collaborative research project entitled "Building industry capability to make recycled water investment decisions" sought to fill significant gaps in the Australian water sector's knowledge by investigating and reporting on actual costs, benefits and risks of water recycling **as they are experienced in practice.**

This project was undertaken with the support of the Australian Water Recycling Centre of Excellence by the Institute for Sustainable Futures (ISF) at the University of Technology Sydney (UTS), in collaboration with 12 partner organisations representing diverse interests, roles and responsibilities in water recycling. ISF is grateful for the generous cash and in-kind support from these partners: UTS, Sydney Water Corporation, Yarra Valley Water, Ku-ring-gai Council, NSW Office of Water, Lend Lease, Independent Pricing and Regulatory Tribunal (IPART), QLD Department Environment & Resource Management, Siemens, WJP Solutions, Sydney Coastal Councils Group, and Water Services Association of Australia (WSAA).

ISF also wishes to acknowledge the generous contributions of the project's research participants – approximately 80 key informants from our 12 project partners and 30 other participating organisations.

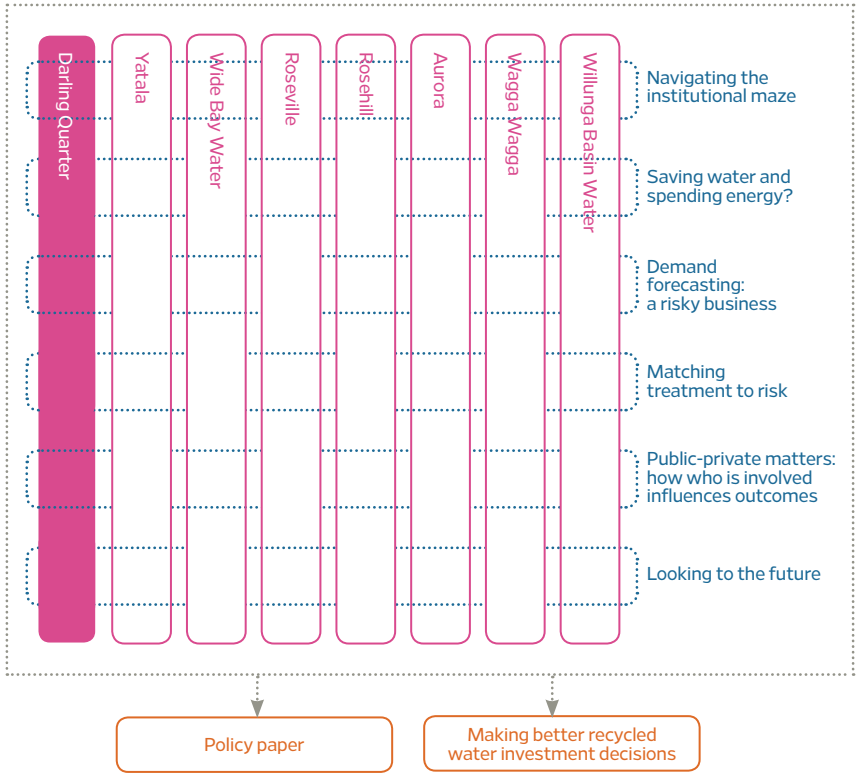
Eight diverse water recycling schemes from across Australia were selected for detailed investigation via a participatory process with project partners. The depth of the case studies is complemented by six papers exploring cross-cutting themes that emerged from the detailed case studies, complemented by insights from outside the water sector.

For each case study and theme, data collection included semi-structured interviews with representatives of all key parties (e.g., regulators, owners/investors, operators, customers, etc) and document review. These inputs were analysed and documented in a case study narrative. In accordance with UTS ethics processes, research participants agreed to participate, and provided feedback on drafts and permission to release outputs. The specific details of the case studies and themes were then integrated into two synthesis documents targeting two distinct groups: policy makers and investors/planners.

The outcomes of the project include this paper and are documented in a suite of practical, accessible resources:

- 8 Case Studies
- 6 Cross-cutting Themes
- Policy Paper, and
- Investment Guide.

For more information about the project, and to access the other resources visit www.waterrecyclinginvestment.com



ABOUT THE AUTHORS

The Institute for Sustainable Futures (ISF) is a flagship research institute at the University of Technology, Sydney. ISF's mission is to create change toward sustainable futures through independent, project-based research with government, industry and community. For further information visit www.isf.uts.edu.au

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Summary

Property developers Lend Lease saw an opportunity to build a premium office building in Sydney between the parklands of Darling Harbour and the central business district. Achieving a '6-Star Green Star Office As-Built' rating was considered critical in order to attract premium tenants.

In the mix of green initiatives, Lend Lease installed a natural gas fuelled trigeneration plant to generate electricity, heating and cooling, and a blackwater treatment plant to mine and recycle sewage for non-potable water uses within the development.

This in-building wastewater recycling scheme benefited from knowledge gained through previous small-scale water recycling plants and represents the second generation in both technology and management. This was the first in-building treatment plant to be licensed and operating under NSW's Water Industry Competition Act (WICA). The plant is operating successfully. It is continuing to improve operational efficiency and has received no complaints to date. This stands in contrast to other pioneering in-building systems which have suffered from odour issues and other technical problems.

The developers succeeded in securing a premium tenant for the building during the worst period of the Global Financial Crisis in 2008.

Drivers

Creating a 'green' building was key to attracting premium tenants, who in turn supported the drive for 'greener' elements

While the Sydney Harbour Foreshore Authority (SHFA) required a 5 star Green Star building, Lend Lease's development business decided to go further and aim for '6-Star Green Star Office As-Built'. This move was supported by the building owner - the Lend Lease managed APPF commercial and an offshore investor. Six stars were seen as vital to secure a premium tenant for the building and in turn, installing a blackwater treatment plant and trigeneration system were considered necessary innovations in order to attain the coveted 6 stars. The tenants, once secured, also played a supportive role in the push for 6 stars. In a similar vein, the building manager noted a desire amongst 'green tenants' to push for 'greener' initiatives in the operational phase to ensure they stay 'green'.

Drivers at Darling Quarter

A greener building attracts premium tenants who want the brightest staff and who are willing to sign a longer-term lease which makes it all stack up

From the building Owners' perspective, Darling Quarter was set to be part of a building investment portfolio, in which all buildings were to have a 5-Star Green Star rating or higher. In 2006, the commercial building market shifted, with a growing demand for green buildings. This led the Owners of Darling Quarter to focus their investment portfolio on green buildings as they attract premium rents, which are not available for older or less well-functioning buildings. Underpinning this desire for green buildings are companies who want to attract the brightest workers. A green, technologically advanced building that is designed with a social atmosphere is seen as a major drawcard for attracting the best staff.

"...young, fresh, clean, green corporate – that's your investment market."

While the presence of a blackwater treatment plant is not a headline feature, it was a key component of the headline "6-Star Green Star Office As-Built".

While the rent is similar to what a tenant would pay for any premium building (without the green aspects), for the Owner, **the 'green elements' are seen as key to ensuring a good high profile tenant, for a longer-term lease**. One interviewee noted that generally speaking, the cost of building a 6 Star rather than 5 Star Green Star building is around 5% more. While this figure has not been calculated for Darling Quarter, it gives an indication of the scale of the additional cost. In the case of Darling Quarter, it appears that the additional cost for building a 6 Star building was worthwhile in order to secure a longer-term tenancy. The green elements of the Darling Quarter buildings not only attracted a premium tenant, but did so **at the lowest point of the Global Financial Crisis in 2008**.

The green elements of the building not only attracted a premium tenant, but did so at the bottom of the Global Financial Crisis in 2008.

A **Guaranteed Maximum Price** was negotiated for the tenant to ensure that costs would not increase above an initially estimated ceiling price, even if greater costs were incurred during construction. This meant that any additional costs, such as additional costs for the blackwater treatment plant were borne by the builders - Lend Lease (LL), or shared between LL, the Owner and the plant's contractors - Veolia.

Non-critical sewer mining scheme fit the bill for potable water reduction

Wastewater recycled through this scheme is used for toilet flushing, irrigation and cooling towers with the aim of minimising potable water use in the Darling Quarter development. The scheme makes use of a Sydney Water sewer main which passes the basement of the site, by diverting sewage from the main through the use of a weir diversion system. Sewer mining was preferred to on-site wastewater recycling as it allowed for smaller storages and greater control on the intake, so that if the plant goes offline, the intake can be shut and the plant's functioning is non-critical. The treatment train includes a Moving Bed Biofilm Reactor (MBBR), a Membrane Bioreactor (MBR) and Reverse Osmosis. The plant extracts 245 kL/day from the trunk main sewer and is designed to produce 166 kL/day of recycled water (at full capacity). Of this, 116 kL/day is to be used for cooling towers and 50 kL/day for toilet flushing and irrigation, however, this will vary seasonally.[1]

Frequent and highly interactive engagement between Lend Lease and Veolia were key to overcoming challenges.

Roles & Relationships

Space constraints and additional treatment units proved most challenging

Fitting the entire treatment system within a room in the building's basement proved to be one of the greatest challenges for the plant contractors, Veolia, and the builders, Lend Lease. This task was made even more difficult as the need for new components in the treatment train arose. A calcite bed, additional chlorination and an odour prevention system were all added to the plant's design after Veolia were contracted. These challenges were **overcome by frequent and highly interactive engagement between Lend Lease and Veolia**, which began as soon as Veolia were contracted.

Bringing the treatment plant contractor on board earlier would have saved money

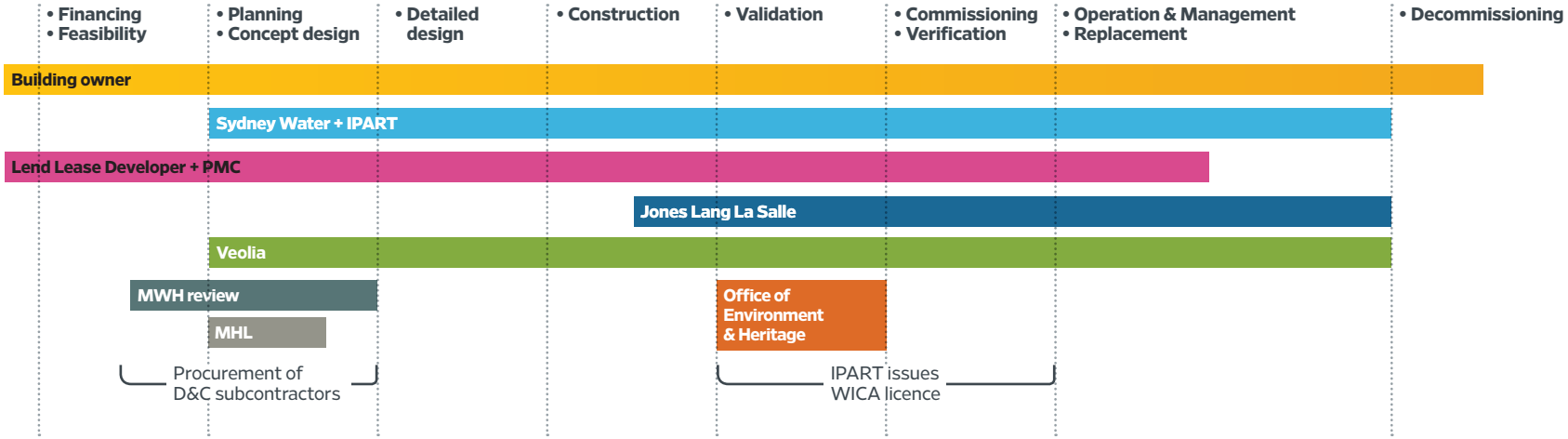
While the highly co-operative relationship between Veolia and Lend Lease enabled both parties to achieve their goal of constructing a successful blackwater treatment plant in a small basement room, earlier engagement of the two parties would have saved a lot of money. By the time Veolia were contracted, the plant room had already been designed, which presented significant spatial constraints. If they had been contracted earlier during the architectural design, major modifications could have been avoided. For example, all of the storage tanks were switched from concrete to stainless steel to save space (amongst other reasons).

On the flip side however, some innovative changes to the plant led to better performance. The shape of the room meant that Veolia opted for a Moving Bed Bio Reactor (MBBR), rather than a traditional Membrane Bio-Reactor (MBR) with activated sludge treatment. The MBBR has exceeded expectations in regard to performance, particularly in relation to membrane performance.

Lend Lease's development business was a key proponent of the blackwater scheme and numerous agencies were involved in the plant's approval

The key proponent of the Darling Quarter scheme is

Stakeholder involvement in project stages



Analysing the influent before going to tender was important for mitigating risk. Surprising constituents could then be accounted for in the plant's design.

the property developers Lend Lease and they have played a pivotal role in overseeing the implementation of the blackwater treatment plant from inception to commissioning. Acting on behalf of the building Owner, Lend Lease contracted Veolia to design, construct and operate the blackwater plant and Jones Lang LaSalle to manage the building and be the tenant's main point of contact. Several state government agencies were involved in approving and licensing the plant, including IPART (the Independent Pricing And Regulatory Tribunal), Sydney Water and the Office of Environment and Heritage. Sydney Water in particular was consulted from early on in the project to establish the viability of sewer mining from their sewers and to set up the agreements regarding sewage extraction and trade waste discharge.

The building Owner's long-term interest in a functioning plant led to their involvement in procurement and a cautious approach to plant design

The building Owner is the only stakeholder with a long-term view of the building's operation. They became **involved with the procurement process to select the Black Water Treatment Plant contractor** due to difficulties they had experienced with previous in-building wastewater recycling plants. The Owner needed to develop a relationship with the BWTP contractor and be comfortable with their selection.

Veolia were chosen for their team's capacity and experience. They were the only company that tendered that had already applied for a WICA licence elsewhere, had locally available maintenance staff and could commit to fitting the plant in the tight space available in the basement.

To plan for the treatment process, improve the potential to hold the BWTP contractor accountable, and ensure no surprises in the plant's influent stream, Manly Hydraulics Lab were called in during the planning phase to undertake a program of testing the quality of upstream effluent in Sydney Water's sewer. This proved a valuable step when their sampling showed the presence of unusual petroleum hydrocarbons in the wastewater, thought to be anti-freeze from stormwater inflow off city carparks. During the concept design phase, another consultant, MWH, was contracted to peer review the plant's concept design and review the offers from tenderers.

Early engagement of the building manager and consultation across roles were key to success

In addition to the building Owner being involved in procurement and the interactive engagement and consultation between Lend Lease and Veolia, other instances of early engagement were identified as key to the plant's success. For example, an engineering manager from Jones Lang LaSalle - the building manager - was brought onto the site 12 months prior to practical completion in order to learn about all of the building's systems in advance of the handover to enable a smooth transition. Veolia also described a process of consulting their operating staff during the development of their designs in order to ensure viability and practicality.

Approvals & Agreements

The approval process represented 'a steep learning curve' for stakeholders and required more time and money than anticipated due to its pioneering nature

From a technological and design perspective, the Darling Quarter treatment plant benefited from previous experiences with in-building wastewater recycling plants. Significant risks, such as mechanical failure, influent quality changes and malodour were avoided by design and careful planning. With regards to approvals, however, the Darling Quarter scheme was pioneering. Darling Quarter was the first scheme licenced under the NSW Water Industry Competition Act (WICA) to commence operation. As it was the first to be commissioned under the licensing scheme, the project presented some challenges, with 'a steep learning curve for everyone involved'. Because it was a pioneering licence, several stakeholders commented that most people involved would have underestimated the time and costs required. The approval stage for Darling Quarter took 9-10 months.

New types of licensing agreements took time to process

Prior to licensing under WICA, Lend Lease contacted Sydney Water Corporation (SWC) to establish the viability of sewer mining at the site. Lend Lease liaised with SWC's engineering arm to discuss potential sewer offtake and discharge points and engaged with SWC's legal arm to set up trade waste and sewer mining agreements between Sydney Water and the building Owner. As these types of agreements with a recycled water provider are relatively new, this process was lengthy. In addition to the WICA process, Veolia and Lend Lease were required to present their plans to the Office of Environment & Heritage as well as Sydney Water for their review and acceptance.

WICA process was found to be easy to follow – IPART provided assistance throughout

Despite the lengthy process and the steep learning curve, the process set out for WICA licensing was easy to follow and IPART engaged with Veolia throughout the process. In situations where a recycling plant is providing water to a single customer, as is the case for Darling Quarter, the WICA process is more straightforward as there are no third party customers involved. IPART's main concerns for Darling Quarter were that the plant met performance criteria at the critical control points and that the plant's operational procedures were adequately prepared.

Critical control points:

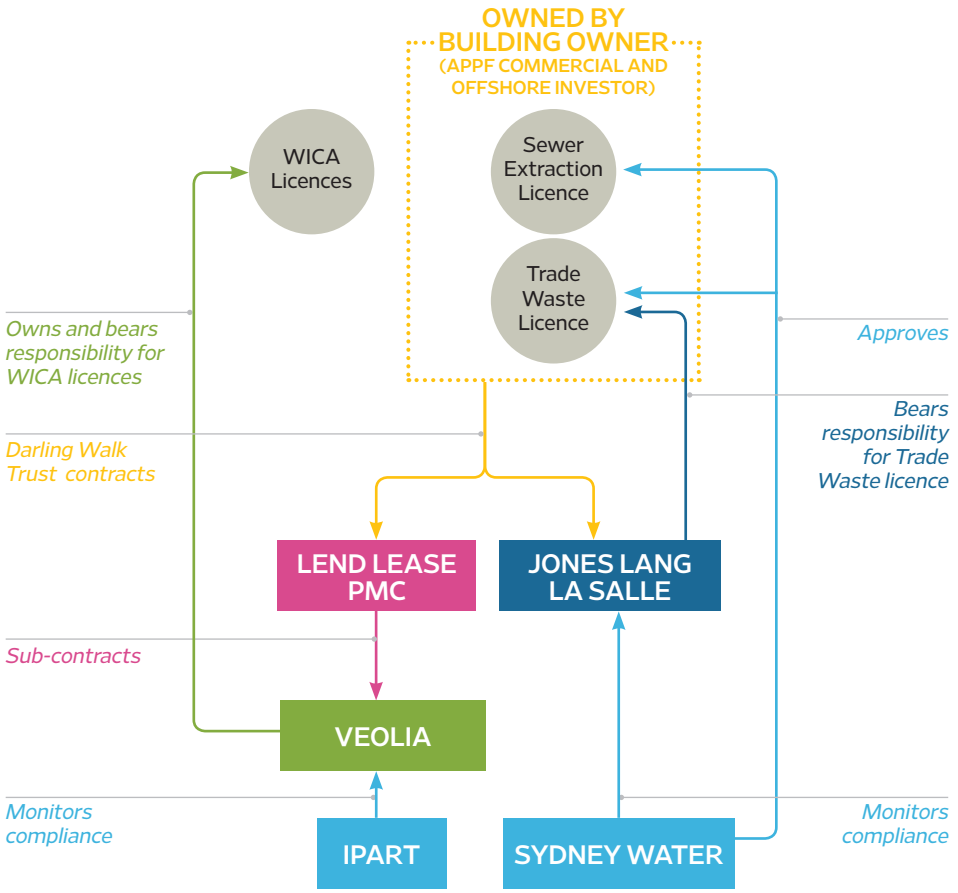
1) Turbidity after MBR (NTU)
2) Conductivity online after RO (microS/cm)
3) UV dose (mL/cm2)
4) Residual free chlorine (mg/L)

WICA process could be improved by a more rigorous audit of the plant's concept design

Stakeholders suggested that the WICA process could be improved by potentially involving a third party auditor at the approvals stage to test the design on paper. IPART does not undertake a thorough engineering and technical audit of the concept design and currently an independent auditor is not involved until the commissioning stage.

Licence and contractual arrangements

The building Owner owns the trade waste and sewer mining agreements, however, Jones Lang LaSalle takes responsibility for these agreements as part of their contract. The building Owner retains ownership of these agreements to allow for flexibility in the longer term, when different contractors may operate the plant and the building in the future.



In the case of Darling Quarter, the auditor's process review during the commissioning phase found that Veolia's contract with Lend Lease ended at the storage tanks. During the audit it was identified that additional chlorination was required at the storage tanks. Additional chlorine dosing and monitoring equipment was added to ensure a greater than 6.5 log (validated) removal of viruses, including adenovirus, is achieved at the point of recycled water delivery to the building. The cost was split equally between Lend Lease, Veolia and the Owner. The plant actually achieves approximately 10 log removal of virus in its daily operations.

Meeting Green Star operational requirements led to contractual delays

In order to achieve the '6-Star Green Star As-Built' accreditation, the Green Building Council of Australia (GBCA) require proof that a licensed maintenance regime with the plant's operator is set in place for the first 5 years. From the perspective of the plant's operator, there is uncertainty regarding operation and maintenance costs e.g. for chemicals, which makes it difficult to lock in to a long-term maintenance agreement. Attaining this signed licence agreement significantly slowed down the process of Green Star accreditation. Ultimately it was agreed that O&M costs would be reviewed annually.

Stakeholders found this requirement from GBCA to be commercially restrictive and perhaps unnecessary, as National Australian Built Environment Ratings System (NABERS) provides a mechanism for operational building ratings.

THE NSW APPROVALS PROCESS

Licencing under the Water Industry Competition Act (currently under review)

Application/approvals stage

1. The plant contractor presents a broad concept design for the plant to IPART
2. IPART issues an interim approval which allows the contractor to start construction
3. The plant contractor (licensee) needs to prove their experience and capability to run recycled water treatment plants, from technical, financial and organisational perspectives.

Auditing/commissioning stage

1. The entire plant design is reviewed further by an independent auditor who verifies the plant's process. This process involves a series of checklists to ensure compliance.
2. The plant is commissioned and the licence is issued

Ongoing compliance

Undertake regular compliance checks to verify the plant's performance

Risks

A mutually agreed "zero risk" approach increased both capital and operating costs, which were shared across stakeholders

A "zero risk" approach was jointly adopted by Lend Lease, the Owner and Veolia with regard to the plant's operation. Each stakeholder had different drivers for this outcome. Lend Lease wanted to apply the lessons they had learnt with blackwater treatment at The Gauge building in Melbourne. For Veolia, this was their first foray into the small scale commercial building market in Australia, so they were focused on ensuring its success. This mutually agreed approach led to the identification of additional risks during the design phases of the project. Concerns about odour from the plant potentially affecting tenant amenity, concerns about residual health risks and concerns about long-term maintenance and operation led to additional plant equipment being installed that increased the planned capital and operating costs. Some of these costs were considered of mutual concern to the three parties - Lend Lease, the Owner and Veolia. For example, it was agreed that the additional chlorine dosing was split three ways between the parties. None of the stakeholders wanted to risk having a malodorous plant or one with inadequate treatment, hence their mutual desire for success.

> "...so they wanted to ensure that this plant had zero risk in terms of public health and also potential issues of odour, which was a key concern for them and for us."

"...everyone's got a vested interest at the end of the day."

See the 'Emerging risks and the costs of managing them after the contracting phase' table to see how risks identified after the initial procurement phase added to costs.

Emerging risks and the costs of managing them after the contracting phase

EMERGING RISKS	CONSEQUENCE	ACTION	COST
Malodour from the plant	Unhappy tenants & bad reputation	Built ventilation system & contained plant to a single room	Ventilation cost $100,000
Potential corrosion of plumbing and water fixtures due to RO water	Damage to water fixtures and plumbing, may require frequent replacement	Added a calcite bed to the treatment train to re-mineralise RO water and prevent corrosion	$7,000 + $5000 / year maintenance
Additional chlorine disinfection required at storage tanks	**Needed to ensure >6.5 log validated virus removal, (including adenovirus) at the point of water delivery**	Chlorine dosing and recirculating pumps added to storage tanks	$60,000 + $5000 / year maintenance
Corrosion of storage tanks / lack of space / ease of maintenance	Concrete tanks become corroded over time, take up more space and are harder to clean	Stainless steel tanks installed instead	$226,000 (SS316 Stainless steel instead of concrete for buffer tank, biological tank and MBBR)
TOTAL: $486,000 CAPEX + $10,000 OPEX PER YEAR			

Corrosion found to be an expensive risk that was worth buffering

The calcite bed was installed as a backup to remineralise the water if there were any problems with corrosion in the building's pipe network. As its operation contributes an additional $5000 per year outside of the original O&M contract, the building manager was initially reluctant to have it running. However, evidence of pitting around valves in the pipe network was discovered within the first year of operation and the building manager subsequently found that it was less expensive to run the calcite bed than pay equipment replacement costs.

Learning from experience allows for certain risks to be designed out, with risk plans for others

"It's a mechanical plant. You never know what's going to happen to it. It can't be perfect. We have an expectation of things failing, but we also have an expectation that they will be fail-safe and thus far everything has failed-safe."

Based on prior experience, sewer mining was assessed as involving lower costs and lower risks than recycling on-site wastewater. Sewer mining reduces the size and therefore the cost of storage required and significantly reduces the risk of mechanical failure leading to major storage and odour problems. In the case of breakdown, the sewer mining operators can shut the intake valve and the plant can go offline. This differs from on-site wastewater treatment where there is often a requirement to treat or store wastewater as the plant is on-line. In addition, the influent water quality at an on-site recycling system can vary and be vulnerable to changes within the building. For example, leaking toilets can reduce the concentration of organic matter in wastewater, which in turn inhibits the effectiveness of the on-site recycling treatment plant. However, this is not an issue at Darling Quarter, as the wastewater is sourced from the trunk sewer main and has more consistent characteristics.

As other in-building plants have experienced odour problems, significant effort went into designing a ventilation

system that would eliminate odour. The floor in the plant room is 100% sealed and the room is under negative pressure, while the air in the room is replaced 12-15 times per hour and is filtered through a carbon bed. In addition, the blackwater tanks are sealed and have a ventilation system that also uses an activated carbon bed to filter the exhaust. The result is that no smell can be detected even inside the plant.

In order to avoid cross-connections, a risk management plan was prepared between Jones Lang LaSalle and Veolia, which requires that every hydraulic contractor that works at the building has to undergo an induction regarding the uses of recycled water (e.g. it cannot be used in washing machines) and the mandatory use of lilac pipes for recycled water.

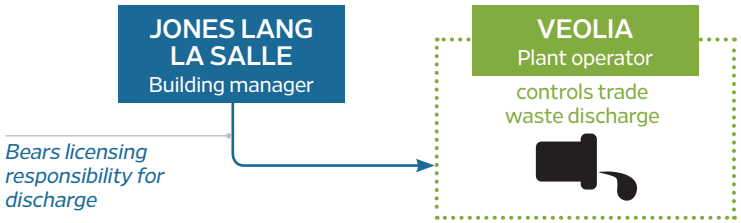
Some awkward risk sharing relationships need streamlining

The building manager, Jones Lang LaSalle, and the plant operator, Veolia have had to work very closely due to institutional requirements regarding who bears responsibility for failure. As the plant discharges solid screenings from its recycling plant back into Sydney Water's sewer system, the plant required a commercial trade waste discharge agreement. It was drawn up between Sydney Water and the Owner. However, as the building manager Jones Lang LaSalle (JLL) acts on behalf of the Owner, JLL are required to report on and explain any breaches of this agreement. This sits oddly considering that JLL have no direct contact with the plant and Veolia control the trade waste discharge. There is a reciprocal relationship between building manager JLL and plant operator Veolia, as both are responsible for ensuring that the other fulfils their responsibilities. Interviewees suggested that this burden of responsibility should either shift to the plant contractor (Veolia) or be shared as part of a three-way agreement between the plant contractor, building manager and Sydney Water.

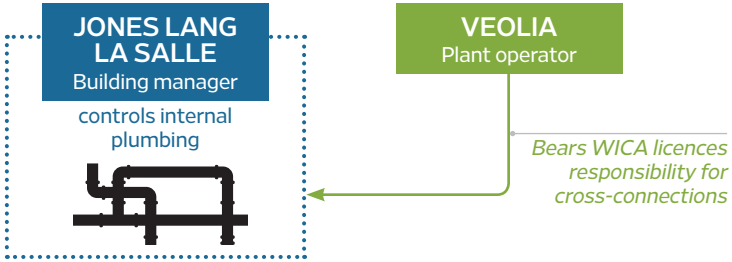
In the case of serious or repeated breaches of this agreement, Sydney Water has the right to switch off the valve that discharges trade waste into the sewer. In reality this would only occur if a series of warnings issued by SWC were ignored.

Awkward risk-sharing relationships

TRADE WASTE FROM BLACKWATER TREATMENT PLANT



HEALTH RISKS FROM CROSS-CONNECTIONS



"...it's a cause of mutual destruction. So if they fail and we fail..."

"whoever's responsible for the licence and whoever's responsible for operating the treatment plant needs to be responsible for that water quality to the tap, or to the toilet."

In another example, Veolia bears the risk of cross-connections occurring in the building's plumbing as part of their WICA operating licence with IPART. However, Jones Lang LaSalle as the building manager controls plumbing and operations within the building. Should a cross connection occur with an impact on human health, Veolia could be issued with fines up to $1 million by IPART.

Costs

Capital costs increased by 30% after various risks were identified and mitigated in the planning stages

Capital costs increased during the planning phase from around $1.5 million to around $2 million, due to the addition of the calcite bed, the odour reduction system, the additional chlorine dosing unit and the change from concrete to stainless steel tanks. The diversion weir that was required to enable sewer mining from the trunk sewer also added $80,000.

Levelised unit costs for capital expenditure on the blackwater treatment plant were calculated at approximately **$4.70 per kilolitre**. This is based on 2010 capital costs of $3,030,000 and discounted water volumes over a 20 year time frame. This estimate excludes land/floor space value, which was estimated to be around $103,000 per annum for 396 square metres of storage in Sydney's CBD.

The levelised unit cost for operating expenditure was calculated to be an additional **$4.80 per kilolitre, based on actual and some estimated costs**. This assumes that 2012 operating costs for chemicals, labour, energy, asset replacement, licensing and trade waste remain constant over the 20 year period. Operating costs were discounted to 2012 dollars over a 20 year period. In all calculations it was assumed that the plant produces 160 kilolitres per day on 350 days per year for 20 years. A 7% discount rate was used.

CAPEX ITEM (2010)	AMOUNT	PAID BY
Plant	$1,600,000	Developer / owner
Extras (Calcite bed, odour reduction, Cl recirculation, diversion weir)	$440,000	Developer / owner /contractor
Building works for plant	$790,000	Developer/owner
Approvals	$200,000	Contractor
TOTAL: $3,030,000		

Operational costs increased after additional units and further specifications were added

While the Darling Quarter scheme benefited from the previous experiences of stakeholders, a learning curve remained with regard to specifying the plant and operational scope accurately at the onset of the project and with regard to estimating costs in light of potential risks and additional components. As previously outlined, additional capital and operating costs arose due to the identification of emerging risks during the planning phase. This increased anticipated operating costs by 30-35%. During construction and the early operational phase, asset replacement costs were incorporated into the annual operating costs to cover membrane replacements every 5 years and the replacement of activated carbon filters every 12-18 months. Including asset replacement in the budget drove annual operating costs up by a further 80%. This resulted in an effective doubling of initial estimates for annual operating costs.

These additional costs reduce the Owner's revenue stream from the tenancy. The lease agreement was set using a Guaranteed Maximum Price and market rates, which means the Owner cannot increase the rent due to higher operating costs.

Operational costs and water fees are independent of volume delivered

Veolia are obliged to achieve a certain level of water availability over the course of a year, however, their monthly fee is not volume-dependent. Veolia have a series of Critical Performance Indicators (CPIs) they are required to meet for JLL and JLL pay them a monthly flat fee on the condition that these are met.

Significant effort to fine tune the plant to reduce energy consumption has yielded results

Lend Lease and Veolia prepared action plans to reduce energy use and they incrementally reduced the plant's energy consumption from 7.8 kWh/kL down to 4.5 kWh/kL in the first year. Internal pumps and blowers for the MBBR and MBR were identified as the highest energy users.

Benefits

Lend Lease
- Market differentiation – tier 1 builder
- Reputation, green kudos
- Sustainability culture attracts staff

Veolia
- Internationally recognised plant
- Market differentiation
- Strong reputation for being able to actually do this (when others have failed)
- Further work
- Learned how to reduce operating costs for plants in the future

Public/environment
- Reduced mains water demand during drought
- For the entire building – reduced carbon emissions

Owner
- Securing a long-term lease with a premium tenant
- Securing a tenant during the GFC
- Secure yield for super funds high profile buildings – increased value of investment portfolio – Reduced risk of asset obsolescence by future-proofing
- Marketing potential for investment fund – will be used to raise more capital for the fund overseas.

Tenant
- 96% staff satisfaction
- Green kudos
- Attract best staff

Risk-averse design avoided some operational costs

The plant was designed to mulch screenings from the sewer and discharge them back to the sewer as part of the trade waste agreement. This process avoids the costs of physical removal from the site. Physical removal would entail occupational health and safety risks as they would require handling by staff on-site. The trade waste fees are currently $2000-$2500 per year, which would appear less than the cost and risk involved with on-site handling and disposal to landfill.

The high quality of recycled water that is produced means that less chemical input will be required to dose the building's cooling systems, reducing chemical costs.

Avoided capital costs are harder to define

It is difficult to define whether the Darling Quarter plant contributes to any broader capital infrastructure costs such as sewer rehabilitation or the ability to delay new infrastructure such as pump stations. In order to capture avoided costs, interviewees suggested that a strategic approach would be required, such that new schemes would be targeted to address weaknesses in the current network.

Reflections

Sustainability objectives might have been met in less costly ways

Some stakeholders felt that the drivers for "doing sustainability" and attaining Green Star ratings could have been met in other less costly and perhaps more effective ways. For example, interviewees suggested that they would have preferred to contribute money towards a government 'kitty' to implement a recycled water scheme on a larger scale or in another place that could have achieved equivalent or greater water savings. The 396 square metres of basement space in Sydney's CBD that is taken up by the plant is expensive and could have higher value uses.

In times of drought, the benefit of the plant is easy to see with regard to water savings. However, when water is overflowing from dams the benefit is more difficult to place. Stakeholders also highlighted the energy consumption

of the plant (including maintenance cars driving around) and the material intensity of the construction (e.g. lots of concrete) and questioned whether it would be holistically green in terms of its life cycle.

Larger scale might present better value for money, but complexity increases risks

In terms of scale, some interviewees questioned the use of such small plants. They suggested that for 20% more in cost, a plant could be built that had triple the output of recycled water. Space constraints and the complexity of arranging external water customers restricted the plant's size.

Darling Quarter's builders were interested in on-selling recycled water to neighbouring buildings. However, the cost of refitting those buildings with lilac pipes and concerns about possible corrosion resulting from the recycled water made this option appear risky. To avoid corrosion issues, the plant's operators would need to operate the calcite bed treatment unit at all times, which would increase operational costs.

In addition to these practical costs and risks, the Owner of Darling Quarter is limited by 'trade and trust' rules. The Owner hold properties in trust for investors, which means they can only hold leases for the benefit of trustees and they therefore do not pay company tax. This means they cannot be a service provider or own a scheme which derives profit. If the Owner were to be involved in a profit-making enterprise, they would breach the trade and trust rules and their tax obligations would change.

Changes to the rating tool significantly affect whether in-building plants are viable

At the time the Darling Quarter plant was built, it was not possible to attain a 6 Star Green Star Office As-Built rating without a blackwater treatment plant. The builders of Darling Quarter now claim that it would be possible to achieve the 6 stars through efficiency, rather than water recycling. These stakeholders highlighted the need to question whether some of the initiatives that achieve Green Star credits are really the right solution for all buildings.

> "Blackwater treatment is probably your belt and braces. It's your ultimate."

Stakeholders indicated a preference to spend more money on Green Star initiatives upfront that require less maintenance than a blackwater treatment plant.

> "As it's turned out, the building arguably would have got across the line for our targeted scores without blackwater."

Interaction between stakeholders, overlapping roles and early engagement of contractors were keys to success

Stakeholders highlighted the close and interactive relationships that enabled the plant to go ahead in the face of difficulties, such as the significant space constraints. Lend Lease and Veolia worked very closely together during the construction phase to ensure that the plant would fit and also to adapt the plant as new risks were identified. Veolia also involved their operating team during the design phase to help ground-truth their design.

The owner's involvement in the procurement phase for the blackwater treatment plant was an unusual step, but

meant that the owner was ultimately satisfied that design and operating risks were reduced. The early engagement of the building manager, Jones Lang LaSalle, 12 months before handover was also cited as a factor contributing to the plant's success.

Individuals with a strong personal commitment made it happen

Finally, it was apparent through interviewing that particular individuals from the core organisations were highly committed to the project and worked tirelessly to minimise risk, reduce costs and improve operations. These individuals had deep experience plus the required knowledge and the foresight to learn from past failures and ensure the success of the plant.

Notes

1. www.myrecycledwater.com.au/about-us/case-studies/darling-quarter-recycled-water-plant