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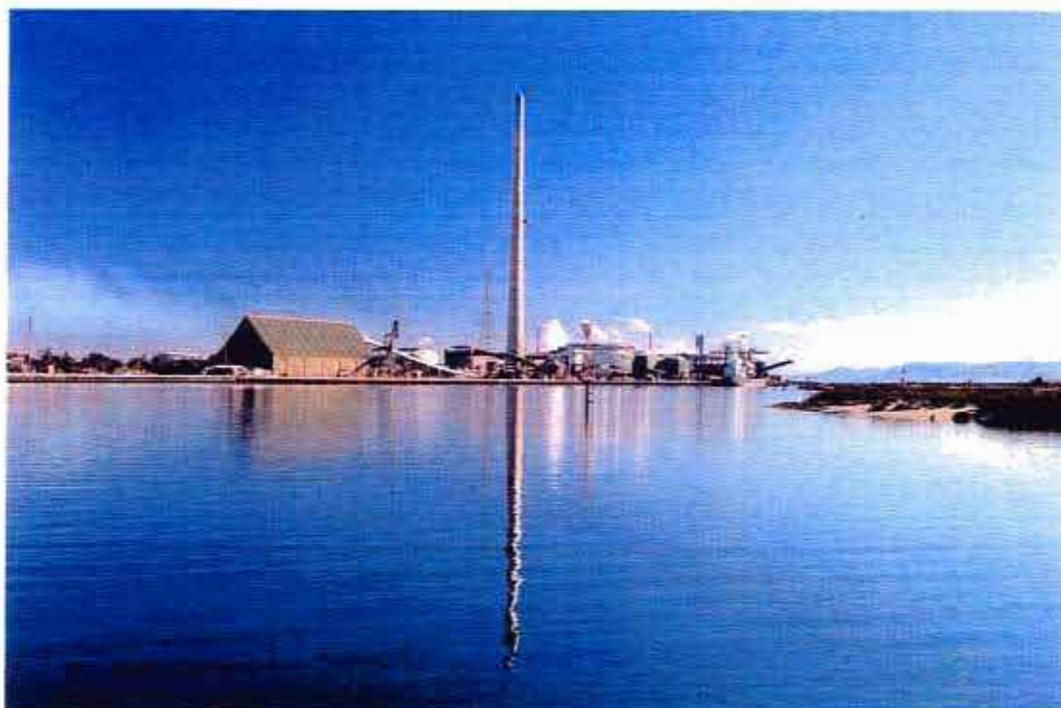
resources & energy

NYRSTAR PORT PIRIE SMELTER

Port Pirie Water Recycling Feasibility Study

301000-00052

29-Apr-08



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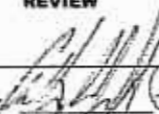
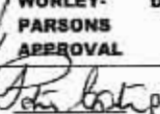
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PROJECT 301000-00052 - NYRSTAR - PORT PIRIE WATER RECYCLING

REV	DESCRIPTION	ORIG	REVIEW	WORLEY- PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
0	Issued to client	 B. Zaid	 A Dai-Corobbo	 P J Carter	08-04-08		



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1. EXECUTIVE SUMMARY

WorleyParsons was engaged by Nyrstar Port Pirie on behalf of the Port Pirie Regional Council, the Southern Flinders Ranges Development Board and Nyrstar as project partners to undertake a feasibility study on water recycling opportunities within the region.

The availability of future water supplies is a critical business issue for the Port Pirie Smelter and for economic growth within the region. This study is seen as a key opportunity to indicate how the region can reduce its reliance on water sourced from the Murray River.

The Port Pirie region recognizes the potential threat to the water supply and through this feasibility study has evaluated ways in which it may reduce its dependence on water sourced from the Murray by up to 1,349 ML/yr, which is a reduction of 64% in the current demand. Implementation of the recommendations in this report will reduce the impact of further government imposed water quota reductions which could have negative effects on economic development in the region.

This study, which spanned several months, identified opportunities to recycle water from two main sources, the Port Pirie wastewater treatment plant (WWTP) and the Nyrstar process effluent treatment system (PETS). A number of water recycling options were considered, including separate treatment of these wastewater streams.

This study indicated that the optimal outcome was achieved by combining both the streams and treating them in a reverse osmosis facility because this option:

- Delivered the maximum amount of recycled water back to the Port Pirie regional community;
- Could be delivered with a lower capital cost than other water recycling technologies; and
- Was quicker and easier to install than the other options available.

This study was based on an extended programme of analysis of the PETS plant effluent stream by an external accredited laboratory. Data on the wastewater treatment plant effluent was supplied by SA Water for the period covering 2007.

The recovery and purification of both recycled water streams can be achieved with an investment of \$ 10.4 M, with a cost sensitivity of $\pm 30\%$. The technology selected is based on reverse osmosis, supported by micro filtration for pre-treatment of the feed streams. The power requirements for the project will be 0.7 MW.

We have reviewed potential locations for the reverse osmosis plant and believe it should be located on the southern boundary of the Nyrstar Smelter for the following reasons:

- The availability of a suitable area within close proximity to power supplies and a secure location within the Nyrstar boundary which would provide protection from vandalism;
- Ease of disposal of the reject stream;
- It represents the shortest available location to feedwater streams coming from the Nyrstar PETS plant and Port Pirie WWTP; and
- Most direct pipeline route along Gertrude Street to Memorial park and oval, which is seen as a potential irrigation site for this recycled water stream.



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The following positive benefits for the Port Pirie region have been highlighted by this feasibility study:

- There is potential to recover 70% of the combined wastewater streams from the Port Pirie WWTP and Nyrstar PETS plant, which totals 1,349 ML/yr;
- This recycled water stream, which will be of sufficient quality to use as process water in the Nyrstar smelter and for irrigation systems in the town, represents 64% of the region's mains water drawn from the Morgan-Whyalla pipeline.



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2. INTRODUCTION

The Port Pirie Smelter is committed to reducing blood lead levels within the Port Pirie Community, specifically for children between 0 - 4 years of age as part of the ten by 10 project.

A significant part of the ten by 10 project is to allow the Port Pirie community to:

- Wash down surfaces as opposed to sweeping;
- Water parks, ovals, lawns etc to reduce dust generation; and
- Continue dust suppression programmes on selected roads.

These activities are contingent on the availability of water. Using recycled water to irrigate key public areas delivers a net social benefit to the Port Pirie community and at the same time greatly assists in meeting or accelerating the requirements of the ten by 10 project.

Drought conditions have reduced flows into the River Murray to the point where there is insufficient water available for domestic, industrial and agricultural use. The sustainability of the River Murray is currently under intense debate, with a number of water restrictions currently in place. This suggests that there may be a reduction in the volume of water in the Morgan – Whyalla pipeline, which in time will impact on the community's ten by 10 project.

One of the desired outcomes of this study was to assist the region reduce its reliance on water sourced from the River Murray and at the same time greatly assist in meeting or accelerating the requirements of the ten by 10 project.

The total volume of mains water delivered to the Port Pirie region is in the order of 2.1 GL per annum. The major sources of mains water usage have been identified as:

- Nyrstar Port Pirie Smelter (1.6 GL/yr); and
- Port Pirie township (0.5 GL/yr).

Both the smelter and the township currently discharge their treated effluent streams into the Spencer Gulf. These flows have been identified as potential sources of water for recycling.

The key stakeholders in the community have a requirement that this project produces visible benefits for the local region. One way this can be achieved is through a community greening project, by collecting and treating wastewater from the Nyrstar PETS plant and SA Water WWTP for use as irrigation water.

The balance of this feasibility study discusses the approach that WorleyParsons has used in evaluating the various water recycling technologies available. A single, go-forward option has been identified, which, if implemented, will return up to 1,349 ML/yr of water back to the Port Pirie community.

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FEASIBILITY STUDY****3. STUDY SCOPE**

At the initial meeting between Nyrstar, Port Pirie Regional Council, Southern Flinders Ranges Development Board and WorleyParsons Services, a project execution plan was developed and was subsequently approved for the water recycling feasibility study. The scope included:

- Data gathering on all wastewater streams that could be treated and re used;
- Determining waste stream characteristics;
- Reviewing desalination technologies available and identifying the best option available;
- Determining the size of the recycle plant, both in terms of water recovery rates and indicative plot plan;
- Determining power requirements for the recycle plant; and
- Determining cost estimates to an accuracy of $\pm 30\%$.

The information was to be incorporated into a final report that discussed the feasibility of using recycled water for the town and lead smelter in ways that would minimise the net demand for water from the Morgan-Whyalla pipeline.



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4. WASTEWATER SOURCES & TREATMENT REQUIREMENTS

There are two wastewater streams available for recovery and treatment; the Nyrstar process effluent treatment system (PETS) and the Port Pirie Township wastewater treatment plant (WWTP). The total volume of wastewater available from these areas has been determined to be 1,850 ML/yr. This is a very large volume if treated and recycled appropriately, and has the potential to significantly reduce the amount of mains water sourced from the River Murray.

4.1 Nyrstar PETS Plant Effluent

The Nyrstar PETS plant is designed to reduce the level of heavy metals and other environmentally sensitive contaminants prior to discharge. This is achieved by lime dosing, flocculation and clarification. The volume of effluent available for treatment is 830 ML/yr.

The PETS plant is located on the northern boundary of the Nyrstar site.

4.2 Port Pirie Township WWTP Effluent

Sewerage wastewater in the Port Pirie collection system is highly saline. It has a total dissolved solids level in the order of 21,000 mg/L. The source of the salinity is believed to be from infiltration of salt water into the old sewer pipes.

The Port Pirie wastewater treatment plant (WWTP) is operated by SA Water and produces tertiary treated effluent to Class C standard. The volume of wastewater discharged from this plant is 1,020 ML/yr.

A brief summary of the two streams is shown below for comparison purposes.

Table 4.1 Comparison of PETS and WWTP wastewater sources

Source of Water	Volume, ML/yr	TDS, mg/L	Other contaminants
Nyrstar PETS Effluent	830	19,200	Trace metals
Port Pirie WWTP effluent	1,020	21,490	Bacteria, pathogens, nutrients

4.3 Pre-treatment Requirements

Feedwater quality and contaminant loads are a key factor in determining pre-treatment requirements for wastewater recycling plants. This study was based on an extended programme of analysis of the PETS plant effluent stream by an external accredited laboratory. Data on the wastewater treatment plant effluent was supplied by SA Water for the period covering 2007. The results of this analysis are presented in Appendix A.

As both streams have a relatively similar TDS levels, they will be blended in a feed tank prior to subsequent treatment. The WWTP stream is expected to contain significant concentrations of bacteria, nutrients and pathogens. These and other contaminants will be removed by using micro filtration prior to reverse osmosis.



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5. REVIEW OF DESALINATION TECHNOLOGIES

Desalination is a process that removes dissolved compounds from a variety of feedwater sources, such as mains water, seawater, brackish or treated effluent. Water produced through desalination has a wide variety of uses and can be utilized for

- Irrigation;
- Industrial use; and
- Domestic consumption (after appropriate post-treatment).

It is a relatively mature technology and is used in many countries around the world to augment existing water supplies. Desalination covers a number of technologies, which can be broadly classified as:

- Membrane (i.e. reverse osmosis);
- Thermal (e.g. multi-stage flash distillation); and
- Solar.

Membrane and thermal desalination are the most common types of plants utilized in the world today. These technologies are proven and are mature. These options are reviewed further.

5.1 Membrane Desalination Technologies

The most common form of membrane desalination is reverse osmosis, which has become more widespread around the world today.

Reverse osmosis (RO) removes salts from water by pumping it through a semi-permeable membrane sheet at high pressure. The membrane acts as an extremely fine strainer: retaining the salt on one side, whilst allowing purified water to pass through.

A typical RO unit can recover around 50% of the inlet water through each pass, whilst the balance is discharged as concentrated brine. Early RO systems were known for their high power consumption, but advances in membrane technology have reduced energy requirements considerably. Of the new desalination plants installed around the world, reverse osmosis is the most commonly used technology because it is usually cheaper to install and operate than other technologies available.

5.2 Thermal Desalination Technologies

Thermal desalination works by heating the water and evaporating it, then cooling the vapour via a condenser to form pure water. Any salts or other contaminants are left behind with the feedwater.

Thermal desalination units come in three main types, namely:

- Multi Effect Distillation (MEF);
- Multi Stage Flash (MSF); and
- Vapour Compression (VC).



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One of the disadvantages of thermal desalination is the amount of energy required to evaporate large amounts of water, as the process essentially changes water from a liquid to a vapour. These types of plants are only located in regions of the world where there is an abundance of cheap fuel or waste heat such as steam.

5.3 Capital Costs

Membrane plants require significant capital investment. Coupled with this are the high energy requirements and ongoing operation/maintenance costs. However, when compared to thermal desalination, reverse osmosis plants are more cost effective and are relatively simple to operate.

As low energy reverse osmosis membranes have become more widely available in recent years, the ongoing energy requirements have fallen significantly, as has the cost of the membrane elements themselves.

The specific capital costs associated with the desalination project for the Port Pirie Region include:

- The recycling Plant (either reverse osmosis or thermal desalination);
- Pipeline infrastructure to transport the wastewater from the PETS and Port Pirie WWTP to the recycling plant;
- Pre-treatment equipment to remove nutrients, bacteria, pathogens and organic matter;
- The power supply, MCC, power cables and sub-station infrastructure;
- Brine disposal system;
- Product water pipeline system; (pipes, tanks etc); and
- Environmental permits and licences.

5.4 Selection of Go-Forward Option

Thermal and desalination technologies were evaluated extensively for this project. Thermal desalination is a large consumer of energy and is commonly seen in parts of the world where there is an abundance of cheap fuel or waste heat such as steam.

We evaluated several options to supply energy for a multi-effect distillation. As an example, the excess steam generated by the Nyrstar Slag Fumer boilers was considered but, the water recovery rates were too low (typically 10 – 20%) compared to other technologies available.

Reverse Osmosis required less energy per kL of water produced and also recovered a higher percentage of the feedwater streams available and was chosen for this reason.

This study indicated that the optimal outcome was to combine both the streams and treat them in a reverse osmosis facility because this option:

- Delivered the maximum amount of recycled water back to the Port Pirie regional community;
- Could be delivered with a lower capital cost than other water recycling technologies;
- Was quicker and easier to install than the other options available; and

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- Was better suited to treatment of nutrient rich water sources.

The following table summarizes the main differences between thermal and membrane desalination for the Port Pirie region.

Table 5.1 Comparison - Thermal vs. Membrane desalination

	Multi-stage flash distillation[^]	Reverse Osmosis[*]
Energy Consumption	~13 Kwh/m ³	3.05 Kwh/m ³
Water recovery	185 – 370 ML/yr	1,349 ML/yr
Cost	> \$10M	\$10.4 M
Reject water quality	80,000 – 180,000 mg/L	72,000 mg/L
Potential to expand capacity	Low	High

^{*} Based on current project findings, [^] Source by: Krishna, H.J., 1989. "Introduction to Desalination Technologies", Texas Water Development Board.



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6. DESIGN OPTIONS FOR REVERSE OSMOSIS PLANT

During the preliminary design, a number of potential options were considered. The issues that influenced the final decision which was based on cost, quantity and volume of water were;

- Plant layout and configuration; and
- Feedwater quality and level of pre-treatment required.

The preferred case for the design of the reverse osmosis plant is based on one unit with a single pass through two stages. This type of design has been commonly used on recent plants constructed in Australia.

6.1 Single Versus Blended Feedwater Sources

There are two main water sources available for treatment and re-use within the community. The first option is to utilize PETS effluent only which would deliver up to 584 ML/yr of product water. It is estimated that the use of PETS effluent only, whilst reducing recycled water volumes by more than 55% , would reduce the capital cost estimate by \$4.2M to \$6.2M. This is a significant difference which must be balanced by the community needs and the desired project outcomes.

The other, more attractive option for the region would be to utilize both the PETS and WWTP streams which has the potential to recover and supply up to 1,349 ML/yr of water back into the community.

The higher water volume does deliver a significantly improved cost benefit, and for this reason was selected as the preferred case.

6.2 Single Train Versus Multiple Train RO Units

The preliminary design for the reverse osmosis unit has been based on a single train, single pass configuration. This is the most economical plant design. However, it may lack the reliability and flexibility required by the end users. Operational experience suggests the availability factor for a single train unit can be as low as 88%. Options are available to split the reverse osmosis plant into two or three trains, thereby increasing plant availability to 95 or 98%.

Reverse Osmosis plants require regular maintenance, membrane cleaning and on-line disinfection, all of which require periods of downtime. A single train unit will reduce plant production to zero during these periods and may pose a production risk to others relying on this water source.

A solution is to have multiple trains, where one train at a time can be safely shutdown with the others continuing to operate. This has the benefit of being able to provide product water at all times, albeit at a reduced rate during maintenance periods.

Our cost estimates on these types of configurations indicates that each train added to the project will increase the capital cost estimate for the reverse osmosis plant by 30%. Alternatively, sufficient onsite storage capacity could alleviate lower plant availability. Cost estimates suggest that 1.8 ML storage tanks would cost in the vicinity of \$1.1 million and provide 0.5 days production capacity. This price estimate has been included in the project capital cost.



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7. REVERSE OSMOSIS PLANT PRELIMINARY DESIGN

The original scope for the feasibility study called for the evaluation of water recycling from two primary sources, namely the:

- Nyrstar PETS plant, and
- Port Pirie WWTP.

Two scenarios were considered for evaluation as follows:

- PETS & WWTP streams combined to produce 3.7 ML/day (1,349 ML/yr) of purified water; and
- PETS effluent stream only, producing 1.6 ML/day (584 ML/yr) of permeate.

The 1,349 ML/yr design assumed that both feed streams will be treated through the reverse osmosis plant. Each feed stream has been designed with a separate pumping station to transport water to the reverse osmosis plant. The two streams will be combined in a common feedwater tank which contains a mixer to ensure consistent water quality.

The design assumed all pumping units will have a spare backup. A preliminary reverse osmosis plant design is shown in figure 7.2.

Feedwater from this tank will be dosed with selected treatment chemicals, and then pumped to the microfiltration unit which will remove a significant portion of the contaminants. The effluent from this plant will then be suitable for treatment through the two stage reverse osmosis plant.

The reverse osmosis plant has been designed to incorporate an Energy Recovery Device (ERD). This device will recover the energy from the high pressure brine stream and transfer it to the feedwater stream. These energy recovery devices have been developed recently and have the potential to reduce the power requirement for the plant by up to 50%. This will have a significant impact on the ongoing operating costs of the plant.

The product (permeate) water will be sent to a storage tank, where it will be disinfected prior to pumping and distribution to the nominated users within the Port Pirie township.

The design data is summarized below in table 7.1

Table 7.1 RO Plant Summary

Key data	
Maximum total production capacity	3.7 ML/d (1,349 ML/yr)
Capital Cost (based on using both water streams combined)	\$10.4M
Plant plot plan	360 m ²
Feedwater to RO Plant	5.1 ML/day
RO stage 1 recovery	2.6 ML/day
RO stage 2 recovery	1.0 ML/day
Total RO water recovery	3.7 ML/day (70%)
Power requirement (total plant)	695 KW



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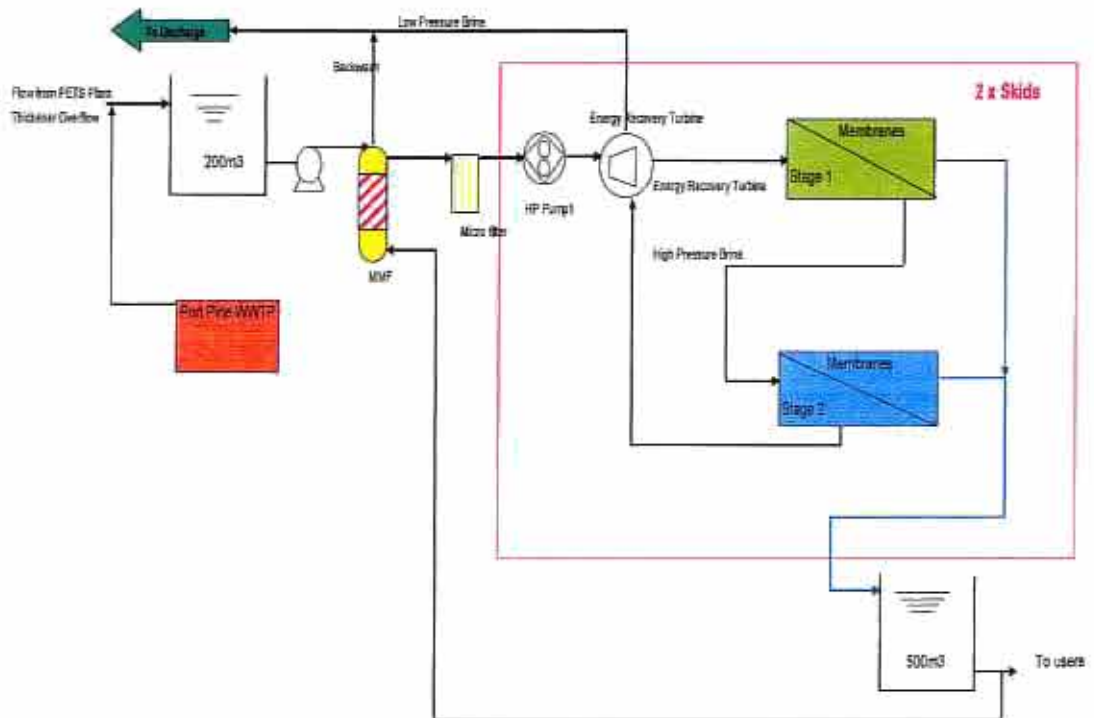
Maximum electrical consumption (nominal)

3.05 KWh/m³

Water data

Feed water temperature	20°C
Feed water quality	21792 mg/l TDS
Product (permeate) water quality	<200 mg/l TDS <50 mg/l Na <100 mg/l Cl <1.0 mg/l Boron <5.0 mg/l K <1.0 mg/l NO ₃ 6.4 pH
Final water quality (after addition of hypochlorite)	<300 mg/l TDS

Figure 7.2 RO Plant Design Summary



**NYRSTAR PORT PIRIE SMELTER
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We have reviewed potential locations of the reverse osmosis plant and believe it should be located on the southern boundary of the Nyrstar Smelter for the following reasons:

- Availability of a suitable land area within close proximity to power supplies;
- Ease of disposal of the reject stream;
- Secure location within the Nyrstar boundary which would provide protection from vandalism;
- Shortest available location to feedwater streams coming from the Nyrstar PETS plant and Port Pirie WWTP; and
- Most direct pipeline route along Gertrude Street to Memorial park and oval, which is seen as a potential irrigation site for this recycled water stream.

The storage yard located south of the Copper SX Building on the Nyrstar site has been identified as a suitable area large enough to accommodate the reverse osmosis plant. The ground in the yard is level and is close to the switch yard and switch room servicing the Copper SX and electrowinning processes. It is also central to the WWTP Plant, the PETS plant and the Port Pirie Township Memorial Park. A map indicating its relative location is attached in Appendix F. Maps are also provided which indicate the proposed pipeline routes for the various feedwater streams, as well as the effluent and product water routes.

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Reverse Osmosis plants are high energy users, particularly when treating highly saline water streams because they require a higher net pressure differential to force the water through the membrane sheets. This requires a higher pressure feedwater pump which demands a higher power draw.

For these reasons, it is important that a suitable high voltage (415V) energy supply is available close to the plant. A sub-station has been identified within the southern boundary of the Nyrstar site which may be able to supply the power needs for this project. The capacity of this sub-station has been evaluated as part of this study. Cost estimates have taken into account expenditure required to upgrade this sub-station or provide a high voltage power cable to the reverse osmosis plant MCC cabinets.

We have included an energy recovery device (ERD) to reduce the electrical demand. Use of such equipment will reduce the power requirements for the reverse osmosis plant by up to 50%, which has been estimated at over 200 kW for the full plant design.

Power requirements for this project are expected to be sourced from the national grid. To minimize greenhouse gas emissions, we would recommend renewable energy supplies be considered. This can be further evaluated during the detailed design stage of this project.

The total energy requirements for the reverse osmosis plant, pre-treatment systems and transfer pumping stations have been estimated to be 695 kW. A detailed breakdown of the power requirement has been shown in Appendix G.

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The Reverse Osmosis plant is designed to produce water of a very high quality. In some cases, the quality of the water is better than the mains water currently supplied to the Port Pirie Region. The quality of both water sources is compared in the table below.

Table 10.1 RO water quality vs. Mains Water

Chemical Parameter	Reverse Osmosis Water*	Mains Water^
pH	6.7	6.5
TDS, mg/l	170	316
Total Hardness, mg/l as CaCO ₃	4	77
Chloride, mg as Cl ⁻	99	89
Silica, mg/l as SiO ₂	0.01	2

* Based on reverse osmosis projections. ^Based on Mains water test report by GE Water dated 13-10-2006

The RO projection software does not take into account rejection rates for trace metals contained in the PETS plant effluent stream. Removal is dependent on a number of conditions such as pH and chemical composition. The product water should not be used for the irrigation of food crops without additional pilot test work to validate its applicability.

Our technical evaluations indicate trace metal rejection rates to be greater than 90%. As an example, rejection of lead by FILMTEC membranes has been reported to be >90%. (Source: Technical fact sheet, The Dow Chemical Company, form No. 609-00240-204).



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11. POTENTIAL RO WATER USERS

The projected output from the RO plant treating both effluent streams simultaneously and operating at a recovery rate of 70% is 1,349 ML/yr. If PETS plant effluent is selected as the sole feedwater source, this is reduced to 584 ML/yr.

Irrespective of the final volumes of water available for reuse, some potential users of this recycled water streams have been identified as:

- Port Pirie Township Memorial Park and Oval (with onsite 500kL storage);
- Port Pirie Township Old Rail Yard;
- Road sprays for dust suppression and ten by 10 initiatives; and
- Industrial use within the Nyrstar Smelter complex.

Supply of recycled water to end users will be variable and is affected by the availability of the effluent streams to the reverse osmosis plant.

Usage of recycled water within the Nyrstar smelter is wide and varied, and could include options such as:

- Feeding the existing demineralisation plant; and
- Process water use within the refinery and smelter.

In all cases, this would act as a direct substitute for mains water which would significantly reduce the amount of water sourced from the River Murray.

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Reverse osmosis technology produces two water streams, the product water (commonly referred to as permeate) and the brine discharge water which is also referred to as the reject stream.

The reject water stream is typically 3 to 4 times the salinity of the incoming feedwater, although this is highly dependent on the recovery rate. It carries the saline compounds from the feedwater, in addition to various chemicals used in the pre-treatment stages.

The following chemicals are typically used in reverse osmosis plant;

- Sulphuric acid for pH control;
- Sodium hydroxide for membrane cleaning;
- Sodium metabisulfite for dechlorination;
- Antiscalant to minimise membrane fouling;
- Biocides to minimize bacterial growth; and
- Sodium Hypochlorite for disinfection.

The concentration of these treatment chemicals is typically less than a few parts per million with only a few products dosed on a continuous basis. Most are used intermittently depending on plant performance. Based on information available from similar plants around Australia, we do not anticipate any adverse impacts on the environment. However, the EPA may require additional work on the effluent stream to be completed before they approve the project.

As part of the preliminary engineering designs, it is anticipated that the reject streams from the reverse osmosis plant, as well as pre-treatment units will be discharged via a single pipeline to the existing Nyrstar PETS effluent discharge point.

The effluent stream from the reverse osmosis plant would include;

- Reject stream from the reverse osmosis unit;
- Backwash from multi-media filters;
- Discharge from the CIP (clean-in place) unit; and
- Backwash from the micro filtration unit.

A full chemical analysis of the permeate and reject streams is tabulated in Appendix D.

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The investment in a treatment plant designed to recover and purify both recycled water streams from the WWTP and PETS plant is \$ 10.4 M, with a cost sensitivity of $\pm 30\%$.

Table 13.1 Overview of Capital Cost Estimate

Description	AUD \$
Direct Cost – pipes & pumps	\$4,022,656
Direct Cost – Reverse Osmosis plant	\$3,835,986
Engineering, Procurement and Construction Management Fees	\$842,593
Contingency (19%)	\$1,704,867
Total	\$10,406,102

Engineering, procurement and construction management fees have been factored at 19% of all total direct costs for work out of our Adelaide and Perth offices. WorleyParsons recommend a contingency of 15% be applied to the pipeline and 30% for the RO Plant cost estimates.

If PETS effluent was used as the sole feedwater source for the project, the capital cost estimate would be reduced by \$4.2M to \$6.2M, but would also reduce the recycled water available for use by 55%. This is a significant difference which must be balanced by the community needs and the desired project outcomes.

Pipe racks within the Nyrstar site which have been nominated to carry feedwater/reject pipelines require structural assessment to ensure overloading does not occur. There is also a need to conduct survey, soil and geotechnical work to establish ground conditions for the pipelines coming from the WWTP and going to Memorial park as this was not included in the scope of work. The costs to conduct these works have not been factored into the cost estimate.

We recommend that a short term pilot trial utilising micro filtration/reverse osmosis be conducted to validate the pre-treatment process and to determine the impact of variations in feedwater quality on the operations. Vendor information suggests that a 4 week pilot trial would cost in the order of \$40k.

A full, detailed breakdown of the capital cost estimate is shown in Appendix E.



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Operating costs have been estimated including labour, energy/power, waste disposal, plant maintenance, general management and consumables (chemicals, filter cartridges etc). Membrane replacement is expected to be required every five years on average at an expected cost of \$250k.

Table 13.2 Estimated Annual Operating Costs

Plant Size	1,349 ML/yr	584 ML/yr
Total OPEX \$/kL	0.98	1.08



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14. CONCLUSIONS / RECOMMENDATIONS

The feasibility study that was conducted into water recycling opportunities within the Port Pirie Region found that it is feasible to recycle water from two main sources, the Port Pirie wastewater treatment plant (WWTP) and the Nyrstar process effluent treatment system (PETS) using reverse osmosis. This has the potential to recover 70% of these wastewater streams, which in combination totals 1,349 ML/yr.

The recycled water stream, which will be of sufficient quality to be used as process water in the Nyrstar smelter and for irrigation systems in Port Pirie, represents 64% of the region's mains water drawn from the Morgan-Whyalla pipeline. The total amount of recycled water represents 84% of Nyrstar's mains water usage.

The recovery and purification of both recycled water streams can be achieved with a cost investment of \$ 10.4 M, with a cost sensitivity of $\pm 30\%$. The technology selected is based on Reverse Osmosis, with micro filtration being required for pre-treatment. The power requirements for the project have been calculated to be 0.7 MW.

We believe that the project should qualify for financial support from the Federal Government as it satisfies the following criteria:

- "Delivers substantial and lasting volumes of water, with water saved to be delivered for environmental purposes;
- Helps secure regional economies and supports local communities facing reduced water supply; and
- Delivers value for money".



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Appendix A – RO Feedwater Quality



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Table A - RO Feedwater Quality, mg/L

WORLEYPARSONS PETS PLANT / NYRSTAR PORT PIRIE SMELTER	1 PETS O/FLOW 13/2/08 08- FE10251	2 PETS O/FLOW 14/2/08 08- FE10252	3 PETS O/FLOW 17/2/08 08- FE10253	4 PETS O/FLOW 18/2/08 08- FE10254	5 PETS O/FLOW 19/2/08 08- FE10255	Average	Port Pirie WWTP (Mean)	Average
FLOW						95	125	220
Ammonia (NH ₄)							7.0	7.0
Potassium	470	510	440	490	510	484		484
Sodium	6100	4100	4400	7000	7400	5800	6955	6456
Magnesium	450	300	360	530	560	440	839	667
Calcium	890	830	850	840	720	826	264	518
Strontium	4.6	1.8	3.3	9.5	9	5.6		5.6
Barium	0.033	0.026	0.033	0.065	0.063	0.044		0.0
Carbonate	<LoD	0.4	0.3	2.4	1.6	1.1		1.1
Bicarbonate	<LoD	29.6	21.7	37.5	40.3	32		32.3
Nitrate (NO ₃)	4.0	3.9	2.6	6.6	5.8	4.6		4.6
Chloride	8500	5200	6300	10000	11000	8200		8200.0
Fluoride								
Sulphate (S)	1500	1400	1400	1300	1200	1360		1360.0
Reactive Silica (as SiO ₂)	0.19	0.71	0.71	0.39	0.91	0.6		0.6
Boron				1.7		1.7		1.7
pH	8.9	8.1	8.1	8.8	8.6	8.1	8.3	8.2
Aluminium	0.11	0.14	0.075	0.16	0.022			
Copper	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01			
Hardness mg equivalent CaCO ₃ /L	4100	3300	3600	4300	4100			
Iron	< 0.05	< 0.05	0.07	< 0.05	< 0.05			
Phosphate ortho (P)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05			
Phosphate total (P)	0.12	0.12	0.07	0.18	0.09			
Total Dissolved Solids	20000	15000	16000	22000	23000	19200	21492	20502
Turbidity(NTU)	< 1	7.3	< 1	2.5	< 1		16	



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Appendix B – RO Product Water Quality



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Table B - RO Water Quality

Chemical Parameter	Concentration in Permeate, mg/l
Total Dissolved Solids (TDS), mg/l	170
pH	6.5
Sodium, mg/l as Na	58
Magnesium, mg/l as Mg	2
Calcium, mg/l as Ca	1
Strontium, mg/l as Sr	0.01
Barium, mg/l as Ba	0
Carbonate, mg/l as CO ₃	0
Bicarbonate, mg/l as HCO ₃	0.5
Nitrate, mg/l as NO ₃	1
Chloride, mg/l as Cl	99
Fluoride, mg/l as F	0
Sulphate, mg/l as SO ₄	1
Silica, mg/l as SiO ₂	0.01
Boron, mg/l as B	0.5
Carbon Dioxide, mg/l as CO ₂	0.2
Ammonium, mg/l as NH ₄	0.3
Potassium, mg/l as K	5



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Appendix C - RO Plant process Flow Diagram (PFD)



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12. BRINE COMPOSITION AND DISPOSAL

Reverse osmosis technology produces two water streams, the product water (commonly referred to as permeate) and the brine discharge water which is also referred to as the reject stream.

The reject water stream is typically 3 to 4 times the salinity of the incoming feedwater, although this is highly dependent on the recovery rate. It carries the saline compounds from the feedwater, in addition to various chemicals used in the pre-treatment stages.

The following chemicals are typically used in reverse osmosis plant:

- Sulphuric acid for pH control;
- Sodium hydroxide for membrane cleaning;
- Sodium metabisulfite for dechlorination;
- Antiscalant to minimise membrane fouling;
- Biocides to minimize bacterial growth; and
- Sodium Hypochlorite for disinfection.

The concentration of these treatment chemicals is typically less than a few parts per million with only a few products dosed on a continuous basis. Most are used intermittently depending on plant performance. Based on information available from similar plants around Australia, we do not anticipate any adverse impacts on the environment. However, the EPA may require additional work on the effluent stream to be completed before they approve the project.

As part of the preliminary engineering designs, it is anticipated that the reject streams from the reverse osmosis plant, as well as pre-treatment units will be discharged via a single pipeline to the existing Nyrstar PETS effluent discharge point.

The effluent stream from the reverse osmosis plant would include:

- Reject stream from the reverse osmosis unit;
- Backwash from multi-media filters;
- Discharge from the CIP (clean-in place) unit; and
- Backwash from the micro filtration unit.

A full chemical analysis of the permeate and reject streams is tabulated in Appendix D.



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13. COST ESTIMATE

The investment in a treatment plant designed to recover and purify both recycled water streams from the WWTP and PETS plant is \$ 10.4 M, with a cost sensitivity of $\pm 30\%$.

Table 13.1 Overview of Capital Cost Estimate

Description	AUD \$
Direct Cost – pipes & pumps	\$4,022,656
Direct Cost – Reverse Osmosis plant	\$3,835,986
Engineering, Procurement and Construction Management Fees	\$842,593
Contingency (19%)	\$1,704,867
Total	\$10,406,102

Engineering, procurement and construction management fees have been factored at 19% of all total direct costs for work out of our Adelaide and Perth offices. WorleyParsons recommend a contingency of 15% be applied to the pipeline and 30% for the RO Plant cost estimates.

If PETS effluent was used as the sole feedwater source for the project, the capital cost estimate would be reduced by \$4.2M to \$6.2M, but would also reduce the recycled water available for use by 55%. This is a significant difference which must be balanced by the community needs and the desired project outcomes.

Pipe racks within the Nyrstar site which have been nominated to carry feedwater/reject pipelines require structural assessment to ensure overloading does not occur. There is also a need to conduct survey, soil and geotechnical work to establish ground conditions for the pipelines coming from the WWTP and going to Memorial park as this was not included in the scope of work. The costs to conduct these works have not been factored into the cost estimate.

We recommend that a short term pilot trial utilising micro filtration/reverse osmosis be conducted to validate the pre-treatment process and to determine the impact of variations in feedwater quality on the operations. Vendor information suggests that a 4 week pilot trial would cost in the order of \$40k.

A full, detailed breakdown of the capital cost estimate is shown in Appendix E.



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Operating costs have been estimated including labour, energy/power, waste disposal, plant maintenance, general management and consumables (chemicals, filter cartridges etc). Membrane replacement is expected to be required every five years on average at an expected cost of \$250k.

Table 13.2 Estimated Annual Operating Costs

Plant Size	1,349 ML/yr	584 ML/yr
Total OPEX \$/kL	0.98	1.08