QGC
A BG Group business

15.0
Brine management strategy

15.0 Brine management strategy

Condition 49g (x): Brine storage locations and volumes, and brine crystal waste management.

The Reverse Osmosis plants produce 90% usable water for potential beneficial use. QGC has a clear strategy for managing the accompanying 10% RO Reject. This RO Reject is further treated into a concentrated brine stream – recovering another 7% to 8% usable water – and the balance must be managed.

15.1 FOLLOWING DEHP REQUIREMENTS

QGC is following the Coal Seam Gas Water Management Policy (June 2010) which sets out DEHP's brine management preference hierarchy as:

- Waste re-use or recycling by chemically processing or treating brine or salt residues to create usable or saleable products (e.g. soda ash)
- Injection of brine into a natural underground structure that is geologically isolated and does not contain groundwater, which does or could supply water for potable or agricultural purposes
- Waste disposal of:
  - Brine solution by piped ocean outfall
  - Solid salt into a suitable existing licensed regulated waste disposal facility
  - Salt into a purpose-built licensed and regulated waste disposal facility on QGC-owned land.

For any proposal for using a method of managing brine or solid salts that is lower than the highest method indicated in the hierarchy, the proponent must demonstrate why each of the more desirable approaches (higher up the hierarchy) could not be used.

The following alternatives – in line with DEHP's waste hierarchy – are being evaluated:

- Selective Salt Recovery (SSR) concept – QGC is actively piloting this concept to separate the various salts to industrial grade purity salts to enable commercialisation. The objective of the pilots is to demonstrate the technical feasibility. The pilots are 100% complete and reviews of the results are being undertaken. The next step is to determine commercial feasibility.
- Ocean Outfall – QGC does not consider this approach viable, given the proximity of a World Heritage Site (Great Barrier Reef) and the different chemical composition of the brine to ocean water
- Re-injection of brine into a natural underground structure – QGC does not consider this approach viable, as it has not yet been able to identify an underground structure which is:
  - Large enough
  - Does not contain groundwater
  - Geologically isolated from aquifers. The geology of the region indicates the presence of such structures is extremely unlikely.

In July 2011, QGC outlined its approach to brine management in a submission to an Australian Senate hearing. The base case outlined was for brine to be managed by crystallisation with long-term storage of salts in a Regulated Waste Facility (RWF) on QGC-owned land. However, QGC explained that it was also pursuing a potentially better salt management solution by actively investigating the feasibility of technical and commercial SSR.

15.2 PROPOSED REGULATED WASTE FACILITY (RWF)

Plans for a Regulated Waste Facility (RWF) are progressing in parallel with the Selected Salt Recovery (SSR) feasibility work. QGC is proceeding with the base case of placing salt into a purpose-built licensed and regulated waste disposal facility on QGC-owned land until such time as SSR is proven to be technically and commercially feasible.

A block flow diagram of the proposed infrastructure associated with the RWF is provided in Figure 73.

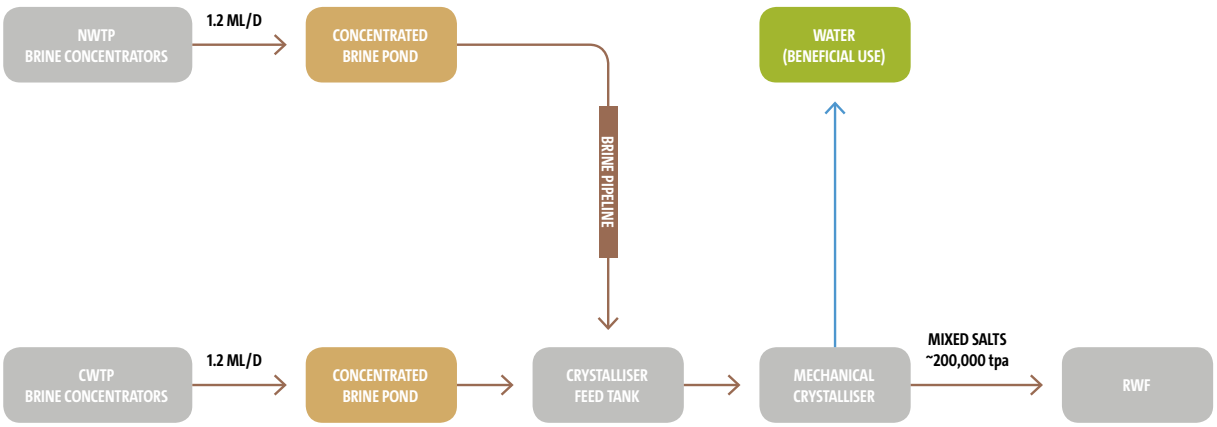


Figure 73 – RWF Block Flow Diagram

15.2.1 PROPOSED LOCATION

The proposed RWF site would be located on QGC-owned land close to the Kenya WTP near Miles. Site selection processes have identified Kangra Hills (about 200 m south of Orana 1 pond and the Kenya WTP) as the preferred site for the RWF. A site location map is provided in Figure 62 (page 212) and Appendix CC.

Mechanical crystallisers will be installed at the Kenya WTP to produce a mixed waste salt from the concentrated brine which could be transported by conveyor to the RWF.

For the Northern gas fields' Woleebee Creek Water Treatment Plant, a brine pipeline to Kenya WTP will be installed, with mechanical crystallisation at the Kenya site.

15.2.2 APPLICABLE CODES

Conceptual design has adopted minimum standards for design, operation and rehabilitation for conventional Queensland landfill facilities accepting general waste and/or some regulated waste for co-disposal and addressing risk areas associated with solid salt disposal. Reference is also made to industrial waste guidelines for facilities in Victoria and New South Wales.

Guideline	Relevant Act	Section
DEHP Guideline (2010) ERA 60-Waste Disposal Landfill siting, design, operation and rehabilitation	Environmental Protection Act 1994 (Qld)	Ch 5A
DEHP Guideline (2010) Environmental Protection Act 1994 – Preparing an environmental management plan for coal seam gas activities	Environmental Protection Act 1994 (Qld)	Ch 5A
	Petroleum and Gas (Production and Safety) Act 2004 (Qld)	Ch 3
	Environmental Protection Regulation 2008 (Qld)	Ch 10
Best Practice Guidelines for Landfills Accepting Category C Prescribed Industrial Waste, prepared by EPA Victoria and dated April 2008	Environment Protection Act 1970 (VIC)	
Draft Environmental Guidelines for Industrial Waste Landfilling, prepared by NSW Environment Protection Authority, dated April 1998	Waste Minimisation and Management Act 1995 (NSW)	
	Waste Minimisation and Management Regulation 1996 (NSW)	
	Pollution Control Act 1970 (NSW)	
DEHP (2010) Coal Seam Gas Water Management Policy	Environmental Protection Act 1994 (Qld)	Ch 5A
	Petroleum and Gas (Production and Safety) Act 2004 (Qld)	Ch 3
EA PEN10002027	Environmental Protection Act 1994 (Qld)	

Table 42 – Guidelines used in RWF conceptual design

15.2.3 SIZING AND PHASING

An RWF conceptual design study has been completed based on salt production of 4.5 million tonnes for the life of the project (refer Appendix CC for concept drawings).

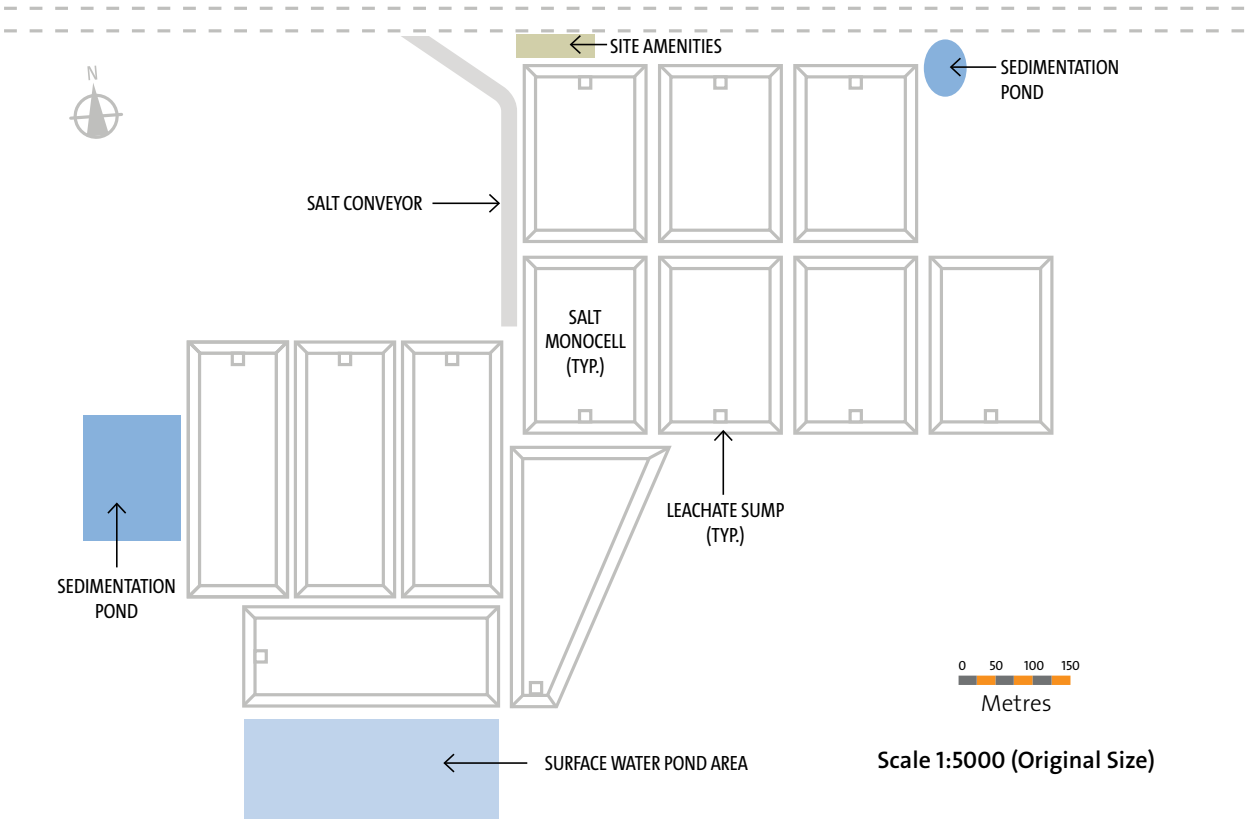
The RWF monocell design strategy is based on the 'dry tomb' concept in that the objective for minimising environmental impacts is to minimise the amount of leachate or brine generated during the life of the facility and to maintain the solid salt within the monocell containment system.

Key objectives in developing a regulated waste disposal facility include:

- Ensuring that the monocell(s) are located above the local groundwater table
- Minimising the monocell(s) footprint
- Rehabilitating the monocell(s) progressively as each is filled.

The site footprint is subdivided into 12 discrete monocells, each with a mixed salt capacity equal to 20 months' production. During site establishment, fencing, access roads and storm water infrastructure will be constructed. The estimated overall site footprint is 100 ha with an estimated total monocell area of approximately 40 ha.

In the following pages, an overview of the RWF is presented. Figure 74 shows the conceptual RWF layout and its key features. Figures 75, 76 and 77 illustrate the barrier design for the base and walls, along with the capping design for each monocell. Figure 78 shows a cross-section with each of these three components in place.



* Proposed on-site mechanical crystalisers at the Kenya East WTP are located outside the shown conceptual RWF layout

Figure 74 – Conceptual RWF layout

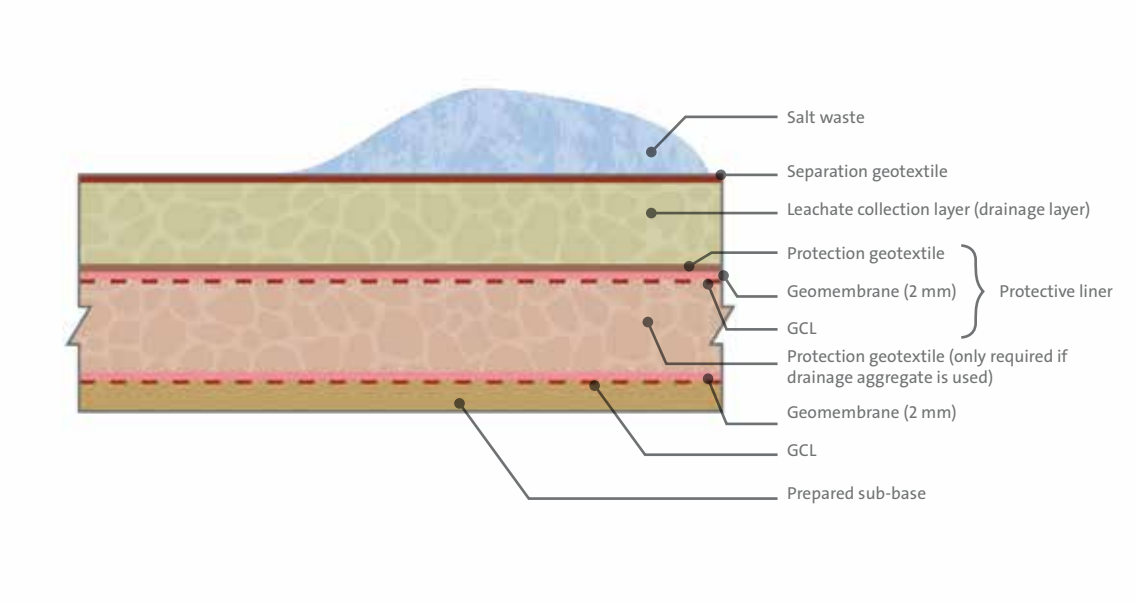


Figure 75 – Conceptual RWF base barrier design

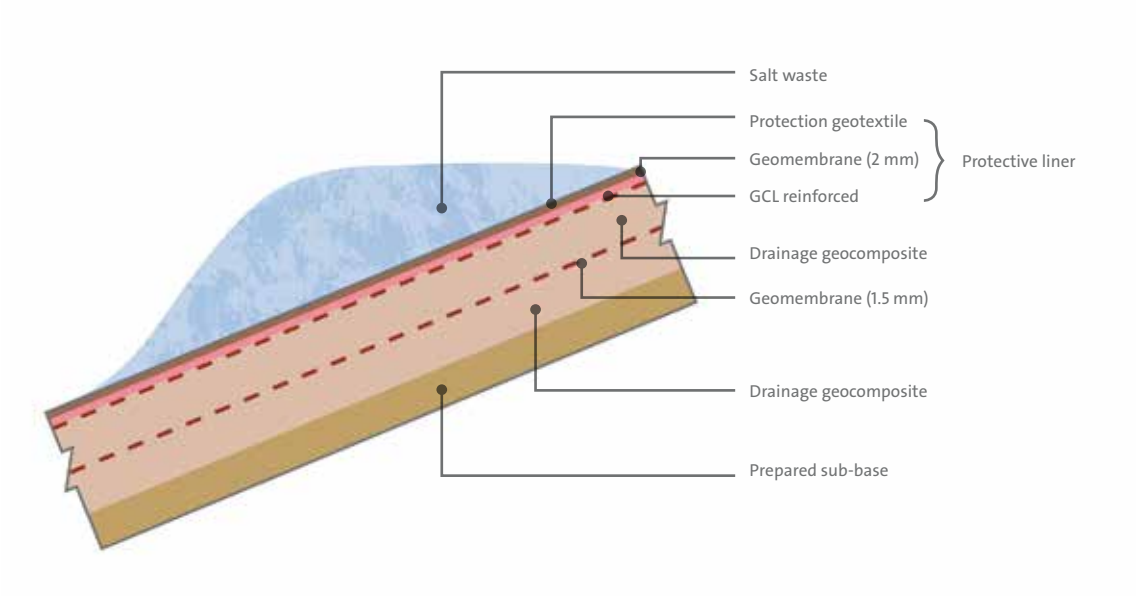


Figure 76 – Conceptual RWF wall barrier design

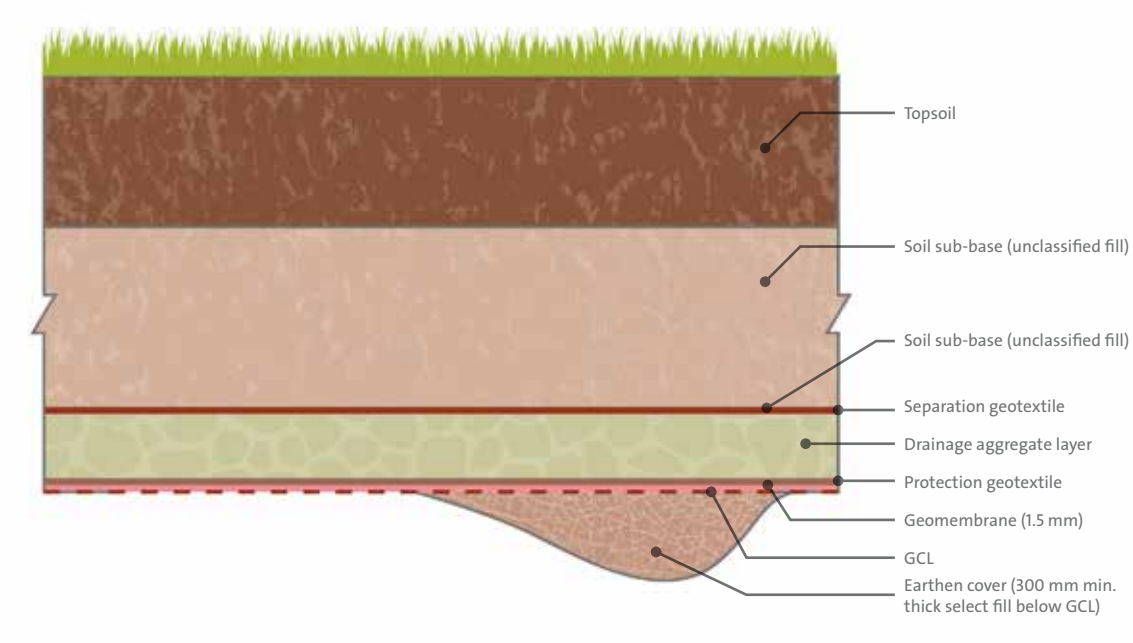


Figure 77 – Conceptual RWF capping design

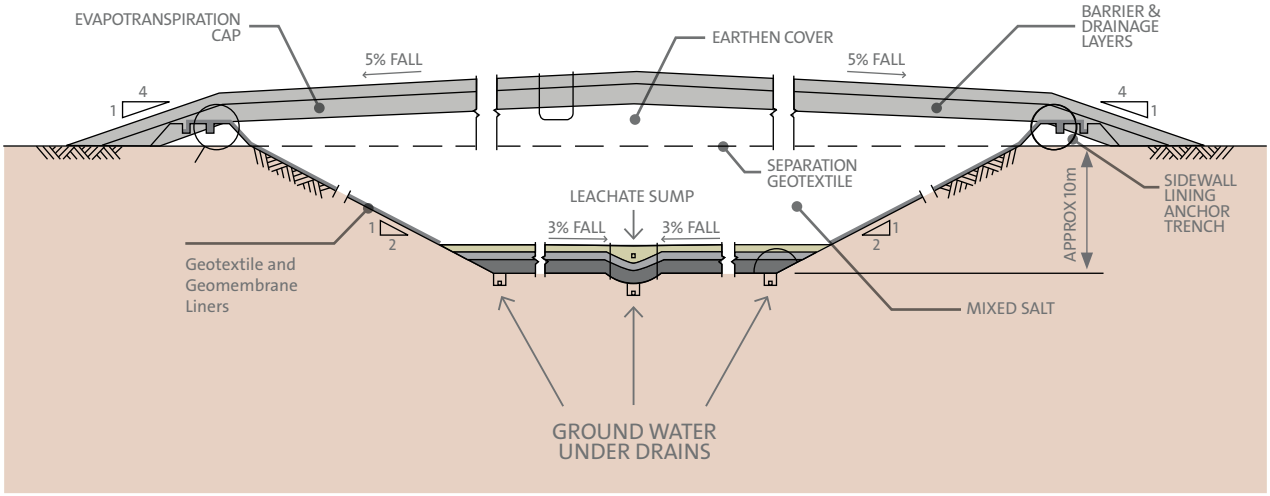


Figure 78 – Monocell cross section

The first monocell area would be cleared and grubbed, followed by excavation and installation of groundwater, leak detection and primary and secondary leachate barrier and collection systems.

As this monocell is being filled, construction would commence on the next monocell. Excavated material would be used for capping previously filled monocells followed immediately by rehabilitation work.

This sequential excavation, construction, filling and rehabilitation process would continue with storm water infrastructure and access roads extended as required.

During the RWF post-closure period, ongoing works will include:

- Final cap inspection for erosion or slumping with corrective action as necessary
- Stormwater drain and pond inspection for erosion and silting with corrective action as necessary
- Leachate removal from leachate extraction risers
- Leachate monitoring in the leak detection systems and from the subsurface drainage system
- Environmental monitoring and groundwater and surface water testing
- Corrective actions as necessary.

An indicative timeline for the RWF project is provided in Figure 79.

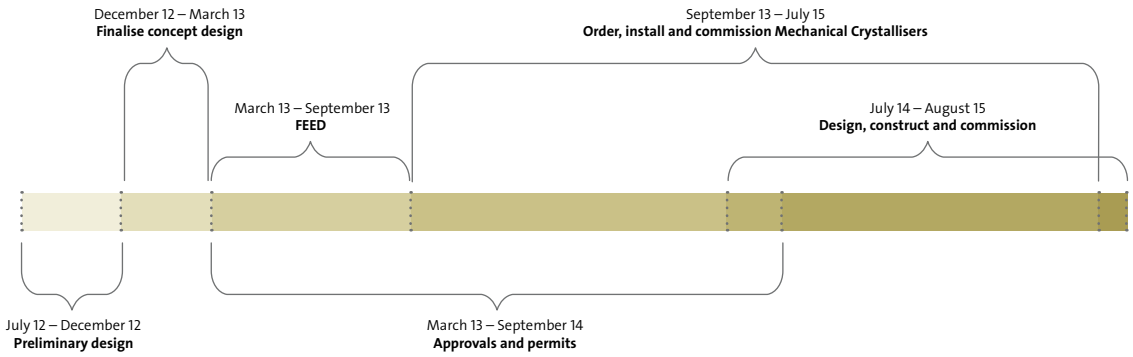


Figure 79 – Regulated Waste Facility Timeline

15.2.4 PERMITTING APPROACH

Environmental Authority PEN100020207 for the Walloon area permits QGC to carry out a Level 1 chapter 5A Petroleum activity, as authorised under the Environmental Protection Act 1994, and prescribed in the Environmental Protection Regulation 2008 (refer Appendix BB). This EA includes:

- ERA 60 (1d) – Waste disposal – operating a facility for disposing of, in a year, more than 200,000 t of regulated waste and any, or any combination of, general waste and limited regulated waste, and if the facility is in a scheduled area – no more than 5 t of untreated clinical waste.

RWF construction and operational approval requires an amendment to include the RWF under the Environmentally Relevant Activity (ERA) 60 – Waste Disposal. As part of DEHP's approval process, QGC must demonstrate an acceptable assessment of the proposed 'waste management hierarchy' in recommending this disposal option.

See Figure 79 for RWF permitting and construction timeline.

	Estimated end date
Pre-lodgement meeting with DEHP	Q2, 2012
Finalise concept design	Q3, 2012
Order mechanical crystallisers	Q4, 2012
Submit EA amendment and updated EMP to DEHP	Q4, 2012
Detailed design	Q2, 2014
Site establishment	Q3, 2014
Construction of first cell	Q4, 2014

Table 43 – RWF permitting and construction timeline

15.3 ALTERNATIVE BEING PURSUED – SELECTIVE SALT RECOVERY (SSR)

The Selective Salt Recovery (SSR) Project prospectively offers QGC one of the best environmental outcomes in CSG water management. While it is the preferred outcome, it is not yet technically nor commercially proven.

The concentrated brine stream is likely to contain about 210,000 mg/L of total dissolved solids made up primarily of sodium bicarbonate, sodium carbonate, and sodium chloride.

The SSR Project aims to separate the salts and recover commercial grade sodium chloride (salt), sodium carbonate (soda ash) and/or sodium bicarbonate (bicarbonate of soda). The fractional crystallisation process on sodium bicarbonate/carbonate streams and on sodium chloride streams (and the other impurities requiring pre-treatment) is unproven technically on a commercial scale–using all three streams containing all three components in the ratios present in CSG water.

QGC formed a $20 million alliance with APLNG and Arrow Energy trialing four separate pilot plant technologies. The trials began in July 2011 and are in final evaluation phases.

Figure 80 – SSR Pilot Plant and bench testing

The Brine Pilot Program objectives are:

- To determine process and equipment requirements to produce suitable commercial quality and yield of selected salts (sodium bicarbonate or sodium carbonate and sodium chloride)
- To determine quantity and quality of waste stream generated to determine disposal options
- To determine operating parameters and costs (labour, fuel, power, reagents)
- To apply scale-up factors on capital and operating cost estimates to determine the viability of one or more SSR plants.

The pilot programs have progressed well and final reports from all proponents have been received. Review of the pilot plant reports is currently being undertaken with results expected by the fourth quarter of calendar 2012.

Outcomes of the pilot program identified compounds within the salts requiring pre-treatment to ensure industrial grade product quality is maintained. A block flow diagram of the full-scale SSR process is provided in Figure 80.

The ongoing evaluation process has determined inclusion of all QGC and APLNG brine as the optimal scope with:

- A concentrated brine pipeline network transporting concentrated brine to a single processing location. With amendment approval in October 2012 to the Queensland Petroleum and Gas Act 2004, permission for brine pipelines to cross tenements has been provided.
- A single full scale SSR plant in the vicinity of Miles. The site evaluation process is in its final stages with the preliminary preferred site being Bellevue, south of the Condamine Power Station. Site location plans are provided in Appendix CC.
- A successful JV agreement with APLNG.

A delivery timeline for the SSR facility is shown in Figure 82.

If QGC changes its brine disposal base case, a WMMP amendment will be lodged with SEWPAC.

Selective Salt Recovery

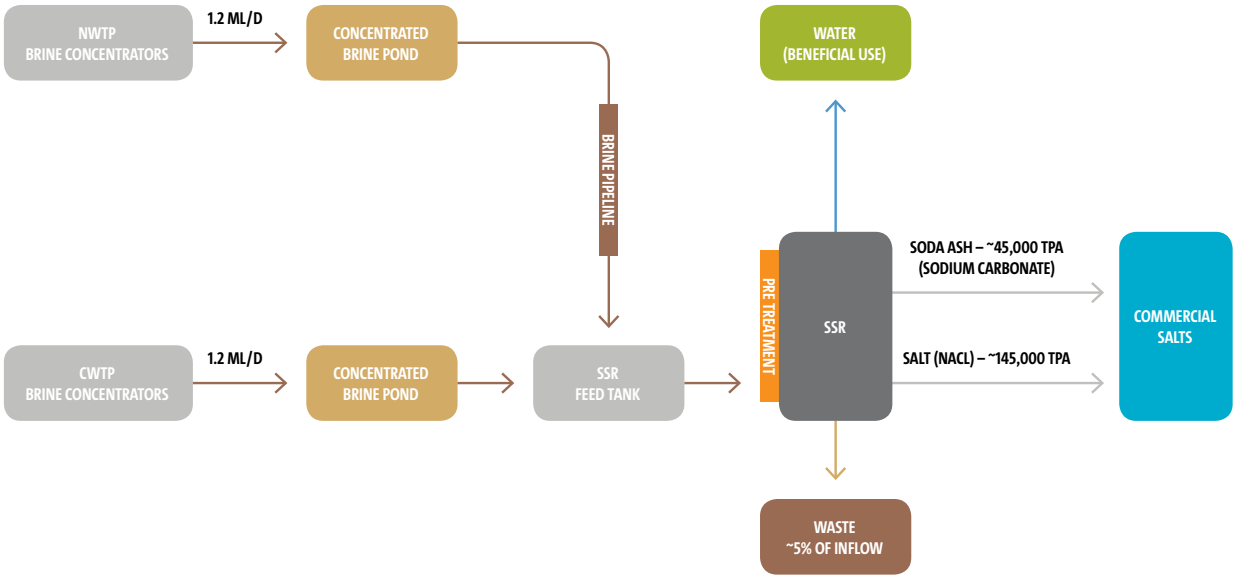


Figure 81 – SSR Block Flow Diagram

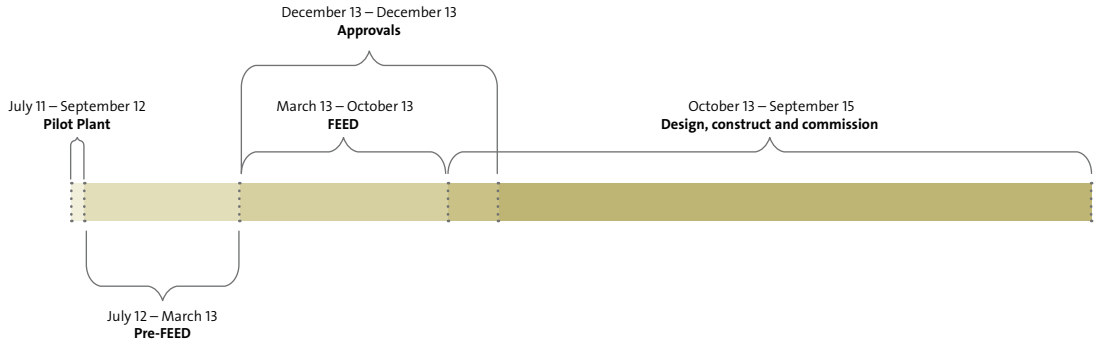


Figure 82 – Selective Salt Recovery Timeline

15.4 BRINE PRODUCTION VOLUMES (ANNUAL)

QCLNG Project brine production volumes are expected to be considerable, varying in direct proportion to raw CSG water extraction and its total dissolved salts (TDS) content. Field Development Plan forecasts (FDP) of predicted raw water volumes are updated regularly as more data becomes available. Chemical analysis of the most recent raw water production allows for predicted brine and salt production to be updated.

Figures 83 and 84 show predicted annual Concentrated Brine (CB) volumes over time for each Water Treatment Plant. In line with raw water production profiles, concentrated brine production peaks in the early years and then declines.

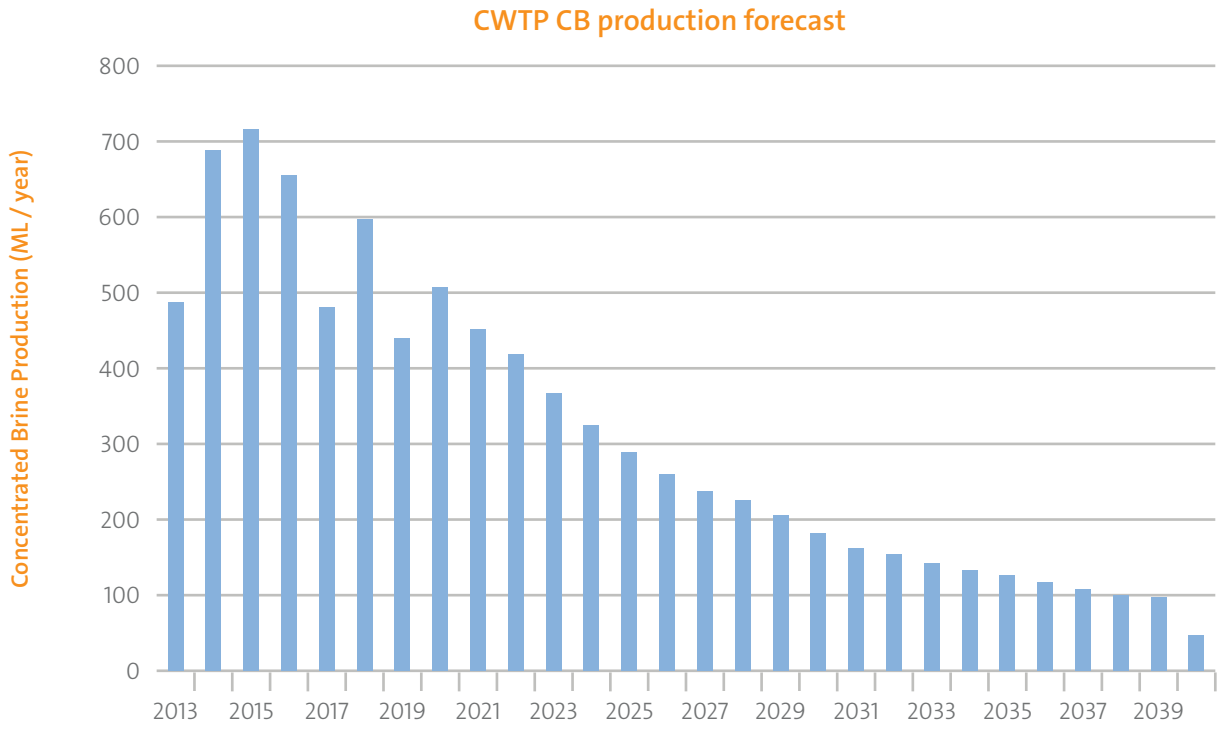


Figure 83 – CWTP concentrated brine production forecast

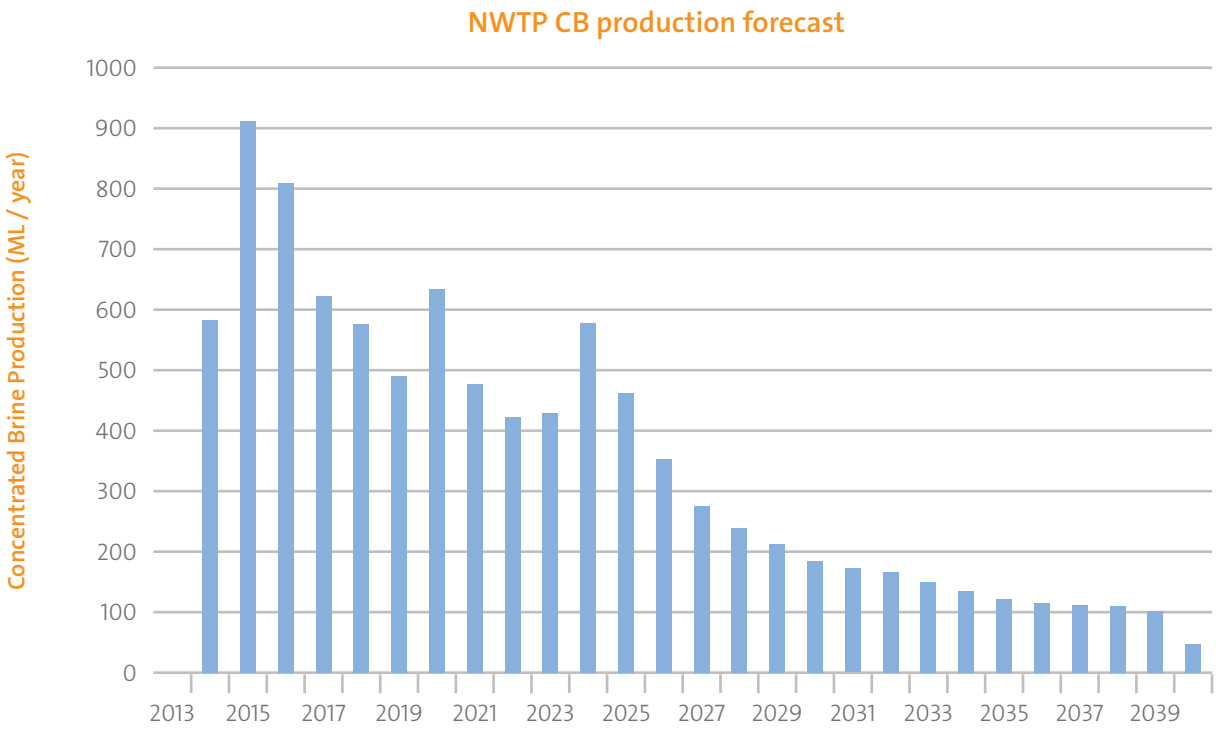


Figure 84 – NWTP concentrated brine production forecast

15.5 SALT PRODUCTION VOLUMES

Currently, salt production estimates for the project are unchanged from the Draft EIS (July 2009) document showing about 4.5 million tonnes of salt over the life of the project. In the Supplemental EIS (July 2010), QGC estimated some 5.4 million tonnes.

15.6 CONCENTRATED BRINE COMPOSITION

As estimated chemical analysis of the total concentrated brine stream based on the combined weighted average from the Kenya WTP and Northern WTP is provided in Appendix CC.

15.7 BRINE PONDS

For each Water Treatment Plant, one lined pond will store RO Reject and is required for the life of the facility as buffer storage between the RO plant and the Brine Concentrator (BC) for use during plant shutdowns. Given the expected 90% availability for the brine concentrator, these ponds are likely to remain empty unless needed as buffer storage.

Additional ponds are being designed to store concentrated brine from the brine concentrators to hold peak flows (relevant in the initial years) before they are fed at a lower feed rate into the crystallisers. This lower feed rate allows the size of the crystallisers to be minimised. These ponds will hold some level during the first 15 to 20 years. Figures 85 and 86 provide an overview of how the ponds will be used.

By 2015, each Water Treatment Plant's planned concentrated brine storages should only reach around 50% to 70% full before commencement of off-take from these ponds to crystallisers and RWF.

Name of regulated dam	Status	Spillway capacity (m^3/s)	Maximum surface area (ha)	Maximum operational volume (ML)	Design storage allowance (m^3)	Mandatory reporting level (RL m)	Maximum depth of dam (m)
Orana 2* (CB Pond)	Approved by DEHP for construction start**	3.2	18.3	1,280	165,000	319.45	13.2
Orana 3 (CB Pond)	Approved by DEHP for construction start**	4.5	20.0	1,040	185,000	319.45	10.3
Total Storage				**2,320**			
Orana 4*** (RO Reject Pond)	Approved by DEHP for construction	4.4	15.6	752	139,155	319.45	9.4

** ORA-C-011-RPT_0 Table 3*
*** Final approval pending submission of final design details.*
**** ORA-C-005-RPT_0 Table 3*

Table 44 – Kenya Brine Ponds under Environmental Authority PEN 100020207

Name of regulated dam	Status	Spillway capacity (m^3/s)	Maximum surface area (ha)	Maximum operational volume (ML)	Design storage allowance (m^3)	Mandatory reporting level (RL m)	Maximum depth of dam (m)
NWTP 3 (RO Reject Pond)	Currently under design	—	~11.5	~ 600	—	—	—
NWTP 4 (CB Pond)	Currently under design	—	~28	~1,200	—	—	—

Table 45 – Woleebee Creek Brine Ponds under Environmental Authority PEN 101741410

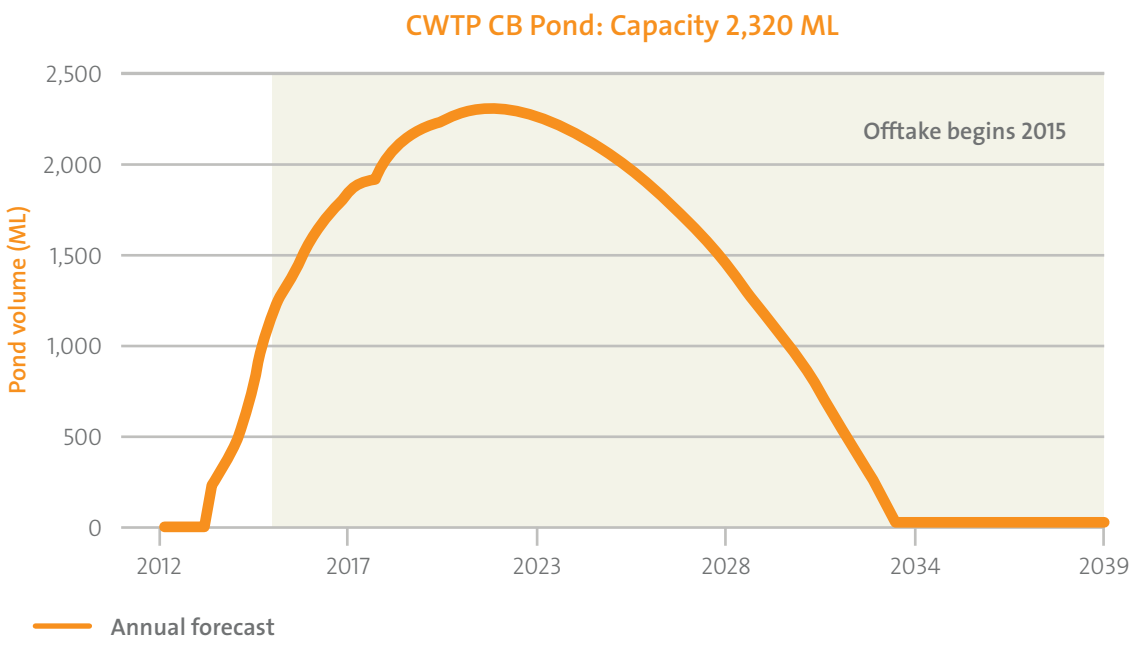


Figure 85 – CWTP Concentrated Brine Ponds volume and capacity

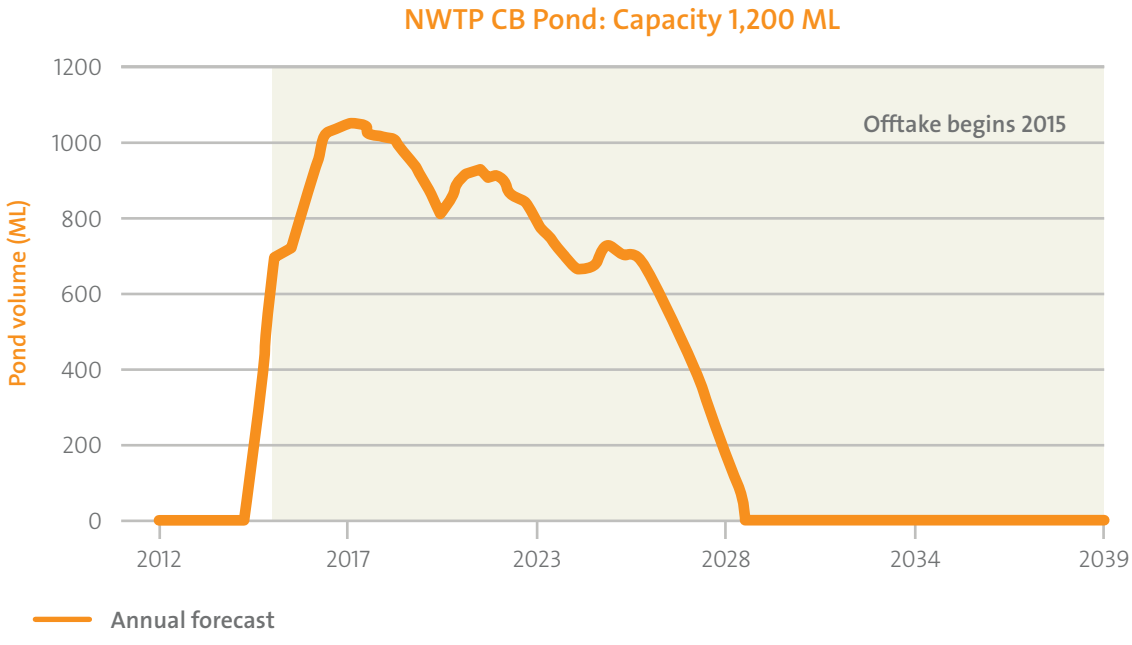


Figure 86 – NWTP Concentrated Brine Pond volume and capacity

15.8 EA APPROVALS AND APPLICABLE CODES

Ponds will be classed as high hazard regulated dams and built in accordance with PEN 100020207 Section D – Dams (Kenya) and PEN 101741410 Section C – Dams (Woleebee Creek) (Refer Appendix CC). In particular:

- (C6/D6) 'All regulated dams must be designed by and constructed under the supervision of a suitably qualified and experienced person in requirements with the most recent version of the 'Manual for Assessing Hazard Categories and Hydraulic Performance of Dams', (DEHP 2010) as amended from time to time.'

Design reports for Kenya brine ponds (Orana 2, 3 and 4) were completed, certified by a suitably qualified person and submitted to DEHP. Location and construction drawings are included in Appendix CC.

15.9 SUMMARY

Major activities that have been undertaken include:

- Development of base case for brine management involving crystallisation with the long-term storage of salts in a regulated waste storage facility on QGC-owned land
- Completion of preliminary engineering design
- The establishment of a $20 million alliance with APLNG and Arrow Energy trialing four separate pilot plant technologies for selective salt recovery
- Selective salt recovery pilots 100% completed. Reviews of final reports due for completion in late 2012.
- Technical feasibility outcomes of the piloting process prompted development of a Stage 2 Collaboration Agreement between the parties involving detailed engineering, commercial and contractual structuring of a full-scale SSR facility.

Commitments	Target completion date
Confirmation that salt regulated waste facility is approved	October 2014
Construction of the first regulated waste facility cell	October 2015

The above commitments are aimed at satisfying Condition 49g x.