Appendix G

Risk Analysis

Contents

G1 Risk Assessment

G1.1 Introduction

The Phase 2 Terms of Reference identify risk assessment as a tool to be utilised during the studies. Specifically, it envisages that the assessment can identify high risk items with the potential to adversely affect the potential of a particular site as a desalination water supply for the region.

What is risk? – the following two quotes neatly encapsulate the concept and the need for a considered approach to managing risk:

AS/NZS 4360 – *Risk Management* definition of risk:

"The chance of something happening that will have an impact upon objectives."

A quote from Sir Michael Latham, 1994:

"No construction project is risk free. Risk can be managed, minimised, shared, transferred or accepted. It cannot be ignored".

As defined by AS/NZS 4360, risk consists of two components: consequence(s) and likelihood. Consequences relate to what might happen in a particular situation, and likelihood indicates how often it is likely to happen. When consequences and likelihood are combined, a measure of risk is obtained.

G1.2 Objectives

The objectives agreed for this aspect of Phase 2 studies were broader than called for by the Terms of Reference. However, it was agreed this would help address "what if" questions that might arise and potentially challenge the study conclusions.

Rather than focusing on risks only to project delivery at the sites, the agreed objectives were instead framed as the risks to this study's objective – namely, the identification of the most suitable site for the regional desalination plant. This has two aspects:

- Risks to the validity of conclusions being drawn from the study, based on the input assumptions regarding the scope of the project as well as the working assumptions identifying key characteristics at each site; and
- Risks inherent to eventual construction and operation of a desalination plant at the selected site.

The assessment does not, however, extend to assessing risks to the broader, ultimate objective of long term water supply security for South East Queensland. It is assumed that the project itself has been proposed as a reasonable action to mitigate those risks, and therefore need not be dealt with in this study.

G1.3 Approach

Risk analysis can be undertaken to various degrees of refinement. Analysis may be qualitative, semi–quantitative or quantitative or a combination of these (in ascending order of complexity). A qualitative analysis was adopted for this planning phase of this Phase 2 study. This may be further developed into a quantitative analysis in future (for example to develop a risk-based cost estimate or, at later stages, a risk-adjusted price).

Qualitative analysis uses word form or descriptive scales to describe the magnitude of potential consequences and the likelihood that those consequences will occur. In practice, qualitative analysis is often used to first obtain a general indication of relative levels of risk.

The AS/NZS 4360 approach to risk management was adopted, which can be represented as shown in Figure 1.

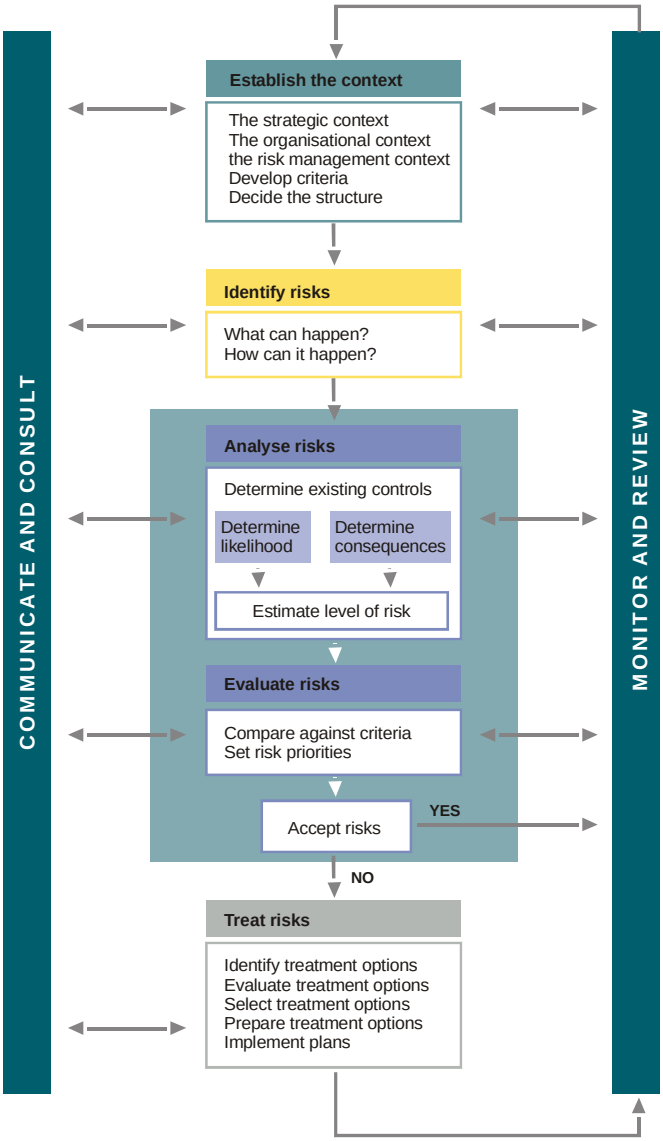

Figure 1: Basic risk management process

Of the overall approach outlined, the following specific phases were undertaken in the risk assessment workshop, held 21 October 2008, with a particular focus on risks to the validity of study conclusions so that the results could be considered in the overall ranking process.

G1.3.1 Establishment of Risk Management Context

This step established the strategic, organisational and risk management context in which the rest of the risk assessment took place. This included confirmation of objectives, and confirmation of the risk assessment criteria to be adopted for the project (levels of likelihood and consequence).

G1.3.2 Risk Identification

Discussion was conducted on potential risks using a facilitated 'brainstorming' approach, prompted by pre-defined "risk heads" (whether asset, risk type/source or project phase) and seeded by pre-workshop reflection by the study team.

G1.3.3 Risk Assessment

Risk analysis involves combining consequences and likelihood to yield a measure of risk, in the context of existing control measures. Each of the identified risk items were assigned a level for consequence and likelihood, for each of the sites, and in light of the risk controls already in place or that would be expected to be in place as standard (e.g. to ensure

legislative compliance, etc). The risk matrix also includes potential project benefits largely relating to an improvement in expertise over time.

The risk analysis matrix and risk assessment criteria used to grade risks into various categories are provided in Section G1.6.

G1.4 Identified Risks – Study Conclusions

Table 1 summarises the risks identified as High, Very High or Extreme for the analysis of the base scenario considered at each site. In some cases there is the potential for costs to be reduced and produce a benefit to the project. The full register of risks and proposed mitigation measures are provided in section G1.6.2 . Note that a combined assessment has been undertaken for sites located at the mouth of the Brisbane River (Site D, Site G and Site H) given that they in close proximity and are similar in nature in terms of their industrial/commercial setting. Scoping of requirements for Phase 3 studies will in part aim to reduce study related risks by identifying areas for further investigation to eliminate uncertainty including the need for a risk based cost estimation exercise.

Table 1: Summary of significant identified risks to the validity of study conclusions

Hazard / Risk / Opportunity	Site A	Site B	Site C	Sites D, G and H	Site E	Site F
Technology developments reduce estimated cost	High +	High +	High +	High +	High+	High+
Water Grid connection needs and design developments reduce estimated cost [1]	High +					
Site flora / fauna movements over time create unidentified impacts					High	
Known flora / fauna achieve protected status, creating unidentified impacts					High	High
Ground conditions are worse than expected, increasing estimated cost		High			High	
Detailed assessment of environmental impacts and approval requirements means a tunnelled intake/outfall design is adopted	High	N/A#	High	N/A#	N/A#	High
Changes to marine designations mean intake/outfall design is changed				High		
Conservation status limits site development (CID not secured)			High		High	High
National park status limits site development			High		Very High	Extreme
Mitigation of feed water quality issues increases estimated costs[2]		High		High		

Only a tunnelled option has been investigated for these sites

Similar risks apply for any scenario, with the exception of:

[1] This item represents the combined risk/opportunities from several workshop line items relating to network connections
[2] This item was identified subsequent to the main risk assessment process

- Risks where tunnelled intake/outfalls may be the best mitigation (relating to Sites A, C & F, where the risk assessment above assumes a sea-bed laid intake/outfall and therefore high risk of increased costs);
- Risks relating to network connections (relating to Sites E & F, where the opportunities at higher capacities may increase).

G1.5 Identified Risks – Design, Construction & Operation

Risk identification and assessment of project delivery risks and potential mitigation measures has been undertaken on a broad level to cover all eight sites investigated in this study. The outcome of this risk assessment including broad mitigation measures has been tabulated in Section G1.6 and is summarised below

The risk assessment identified the following sites and associated high risk elements where likelihood are a C or above and consequence are rated as 3 or above and therefore have a high or above risk rating.

G1.5.1 Site A - Marcoola

No high risk items were identified at this site.

G1.5.2 Site B - Kawana

Appendix E highlighted issues relating to the planning designations at this site. Kawana is subject to an approved site management plan and there are legal implications in altering this to enable the construction of a desalination plant.

Another high risk item for Kawana relates to the potential for contaminated material at the site due to being used previously as a landfill. Although the site has undergone some remediation further works will be necessary to ensure that the site is fully decontaminated. Insufficient engineering and management around this issue could cause problems including release of landfill gases during construction or operation affecting both programme and costs.

G1.5.3 Site C - Bribie Island

Bribie Island requires the construction of a product water pipeline across to the mainland and also a longer intake and outfall when compared to sites further north. This study has also assumed the need for a jetty to transfer equipment and staff to and from the mainland given that the existing bridge is not expected to have the load and capacity for construction traffic.

There is an increased design and construction risk associated with providing a marine crossing for the product water pipeline at this site. This product water pipeline extends through areas designated as ‘Ramsar wetland’ which is likely to increase difficulty of obtaining the necessary environmental approvals. The current method for the construction of the pipeline is trenching and this method may need further reviewing following further investigations and based on the discussions with regulatory authorities.

Construction of the pipeline across to the mainland, construction of a jetty and general extended work in the marine environment will increase exposure to marine hazards and therefore higher risk of programme extension and increased costs. The implication of working in the marine environment is discussed in further detail Section G1.5.7.

G1.5.4 Sites D, G & H - Mouth of the Brisbane River Sites

High risk elements associated with these sites include potential approval delays related to operating in close proximity to Moreton Bay. Although the preliminary design has aimed to avoid areas of high sensitivity there will be a high onus on the developer to show that there are no detrimental impacts on the marine environment in order to obtain the necessary approvals. This could have significant implications for the programme delivery.

In terms of construction and operation another high risk element associated with these sites relates to water quality variations and consequential implications for the operation of the desalination plant. While the intake location for these sites has been chosen to capture suitable quality water, there is still a high risk associated with poor flushing in Moreton Bay and potential contaminants from the rivers feeding into the bay.

The lengths of intake and outfall at these sites are significant and require increased works in the coastal/marine. Furthermore tunnelling pipes for such extensive distances will As with the island sites this is considered a high risk activity which is discussed in more detail in Section G1.5.7..

G1.5.5 Site E - North Stradbroke Island

This site has numerous high risk elements associated with it. Native title claims exist on the site and along much of the pipeline corridor. The need to undertake negotiation under the *Native Title Act 1993* and resolution of claims either through negotiation or litigation will increase the programme and potential costs for development at this site.

There is also a possibility that either the site or the much of the pipeline corridor could be declared a national park which would severely prohibit development at this site. North Stradbroke Island is considered to be an area of high environmental value. Hence there will be a need for significant investigations to prove that there will be no detrimental impact from the plant and associated infrastructure and such investigations will impact programme and costs.

This product water pipeline extends through areas designated as 'Ramsar wetland' which is likely to increase difficulty of obtaining the necessary environmental approvals. The current method for the construction of the pipeline is trenching and this method may need further reviewing following further investigations and based on the discussions with regulatory authorities.

From an engineering perspective there are significant risks associated with development at this site. These high risk elements include potential geotechnical issues relating to both development on the site and the construction of the intake and outfall. The site is elevated and would involve major works for tunnelling of the intake and outfall below 18 Mile Swamp. The magnitude and complexity of the works required at this site increases the likelihood of issues arising during construction.

In terms of the site itself, which was formerly mined and has since been rehabilitated, there is increased risk of inadequate geological support given that the focus of rehabilitation at this site has been to establish the ecosystem and not for further industrial development. Problems include soil displacement and long term settlement affecting the foundations on which the desalination plant is constructed. Accounting for these geotechnical conditions could prove significantly costly and cause programme delays for what is already the most expensive site for construction of a desalination plant.

Energex has also identified difficulties in providing the required power infrastructure to site. Construction at this site would also involve works in the marine environment to connect the plant with mainland water infrastructure and transport of equipment and labour to site which has already been identified as a high risk element and is discussed in Section G1.5.7.

G1.5.6 Site F – South Stradbroke Island

For the most part similar risks affect Site F as do Site E. In terms of approval, it is likely that Site F will receive a National park designation due to Council/EPA's intention to acquire the site for nature conservation purposes making construction of a desalination plant at this site extremely difficult. Site F is considered to be of high environmental value and therefore all environmental approvals for power infrastructure, product water pipelines and intake and outfall will place significant onus on the developer to prove that there are no detrimental impacts.

This product water pipeline extends through areas designated as 'Ramsar wetland' which is likely to increase difficulty of obtaining the necessary environmental approvals. The current method for the construction of the pipeline is trenching and this method may need further reviewing following further investigations and based on the discussions with regulatory authorities.

Energex has also identified this as a high risk site for installation of power infrastructure to the island, which has no existing power supply.

G1.5.7 Key Generic Risks

Of the risks detailed above, extended works in the marine environment should be highlighted as key risks to sites where this applies. While all sites are exposed to some level of risk due to the operation in the coastal environment, risks of operating for prolonged periods in open water can be significant. The risk of operating in an open marine environment which can be extremely costly are largely due to:

- Unpredictable meteorological conditions which could result in stand down time and impacts to construction timeframe
- Lack of adaptation of land based workforce (designers, clients and contractors) and operational procedures to the marine environment[3]

These risks are of particular significance to the three island sites. Management and mitigation of such risks will require early hazard identification and engineering around the management of these risks. A construction management plan should be tailored to account for all potential risks of operating in such an environment. Further work in Phase 3 should seek to elaborate and implement risk mitigations measures into early design.

Another activity which has the potential to affect the construction time frame is tunnelling works requiring the use of a Tunnel Boring Machine (TBM). Tunnelling has been investigated at all sites and may ultimately be adopted as the preferred method due to its reduced environmental impacts. Risks to this construction method include those associated with unpredictable and changing geological conditions. Shorter tunnels are likely to be less exposed to such risks as opposed to longer tunnels. Geotechnical investigations are necessary including comprehensive desk studies, site investigation and survey and ground investigation the results from which should be analysed by suitably qualified professionals. This would be key in identifying potential geotechnical hazards and should be accompanied by a separate geotechnical risk assessment specifically for tunnelling works which should be integrated into the early tunnel design process.

G1.5.8 Summary

In summary the numbers of high risk elements identified for each site include:

Site A – Marcoola – 0

Site B – Kawana – 2

Site C – Bribie Island – 2

Site D, G & H – Mouth of the Brisbane River Sites – 4

Site E – North Stradbroke Island – 8

Site F – South Stradbroke Island - 6

Risk identification and assessment of project delivery risks and potential mitigation measures is more effectively undertaken when a specific project has been defined (in this case, the selection of a site, plant capacity and project programme) and when design

[3] *Construction Risk in Coastal Engineering*, Jonathan Simm & Ian Cruickshank and Contributor Jonathan Simm, Thomas Telford 1998

beyond the conceptual stage is undertaken. Given the stage of study and the uncertainty in time frame associated with the eventual construction of the desalination plant more detailed risk assessments are recommended for each site being investigated in Phase 3.

G1.6 Supplementary Information

G1.6.1 Risk analysis matrix and risk assessment criteria tables

Table 2 Risk Analysis Matrix

		CONSEQUENCES							
		Opportunity			Risk				
LIKELIHOOD		High	Moderate	Minor	Insignificant	Minor	Moderate	Major	Catastrophic
		-3	-2	-1	1	2	3	4	5
Rare	A	L+	L+	L+	L	L	L	M	M
Unlikely	B	M+	L+	L+	L	L	M	M	H
Possible	C	M+	M+	L+	L	M	M	H	H
Likely	D	H+	M+	M+	M	M	H	H	E
Frequent/Almost Certain	E	H+	H+	M+	M	H	H	E	E

Table 3 Risk Evaluation Criteria

Level of Risk	Recommended Level of Management Attention
E - Extreme	IMMEDIATE senior management attention needed, action plans must be developed, with clear assignment of individual responsibilities and timeframes.
H - High	Senior management attention needed, action plans must be developed, with clear assignment of individual responsibilities and timeframes.
M - Medium	Risk requires specific ongoing monitoring and review, to ensure level of risk does not increase. Otherwise manage by routine procedures.
L - Low	Risk can be accepted or ignored. Manage by routine procedures, however unlikely to need specific application of resources.
L+	Minot Cost Opportunity
M+	Moderate Cost Opportunity
H+	High Cost Opportunity

G1.6.2 Workshop Risk Register – Specific Site Risks

RISK REGISTER																							
					BASE RISK LEVELS																		
					Site A (Marcoola) Lot 753 CG3375			Site B (Kawana) Lots 9 & 12 SP174900			Site C (Bribie) Lot 64 SP104224			Site D, G & H (Mouth of Brisbane River			Site E (N Stradbroke) Lot 17 MD2688 & 18 MD1474			Site F (S Stradbroke) Lot 49 SP193294		
ID	HAZARD / THREAT (Risk Description)	FAULT / FAILURE / CAUSE (Reference and Notes)	RISK EVENT / IMPACTS / CONSEQUENCES (Impact)	MITIGATION MEASURES	P (Likelihood)	C (Consequence)	RL (Ranking)	P (Likelihood)	C (Consequence)	RL (Ranking)	P (Likelihood)	C (Consequence)	RL (Ranking)	P (Likelihood)	C (Consequence)	RL (Ranking)	P (Likelihood)	C (Consequence)	RL (Ranking)	P (Likelihood)	C (Consequence)	RL (Ranking)
E: Inherent Site Risks (Approvals, Planning & Regulatory)																							
E1	native title exists	change to native title claim status	ILUA, delay, cost, possible no-go	Liaise with statutory agency							A	4	M				C	4	H	B	4	M
E2	Ability to gain approval to construct on site	mining lease	cannot use site	Liaise with Mining Lease holder													A	5	M			
E3		mining lease	Obtain entitlement														A	2	L			
E4	Conservation land use designation limitations on site	CID not secured	cannot use site	Liaise with statutory agency							B	5	H				B	5	H	B	5	H
E5	Approved site management plan restricts site use	inability to change site mgmt plan	cannot use site	Undertake further legal investigations				D	5	VH												
E6	national park created	national park created	delay, cost, no permit granted	Liaise with statutory agency	A	4	M	A	4	M	B	4	M	A	4	M	C	4	H	E	4	VH
E7	EPBC approval	not obtain approvals	delay, cost, programme	Liaise with statutory agency	B	2	L	B	3	M	C	3	M	C	4	H	D	4	H	D	4	H
E8	Approval to use full site not granted	no vegetation offset site available	limited clearing, smaller plant	Liaise with statutory agency	B	1	L	C	1	L	B	1	L				C	3	M	C	3	M
E9	Marine environmental designations change	Legislation	negate sea bed laid option, move outfall location, impact cost and programme	Liaise with statutory agency	B	3	M	B	3	M	C	3	M	D	4	H	C	3	M	C	3	M
E10	marine park approval	not obtain approvals	delay, cost, programme	Liaise with statutory agency	A	2	L	A	2	L	C	3	M	C	3	M	D	4	H	D	4	H
E9	ERA16 - licence to discharge	not obtain approvals	delay, cost, programme	Undertake more detailed dispersion modelling study including near field modelling and potential 3D modelling of effluent	B	2	L	B	2	L	B	2	L	C	2	M	B	2	L	B	2	L

Not Applicable

RISK REGISTER

ID	HAZARD / THREAT (Risk Description)	FAULT / FAILURE / CAUSE (Reference and Notes)	RISK EVENT / IMPACTS / CONSEQUENCES (Impact)	MITIGATION MEASURES	BASE RISK LEVELS																	
					Site A (Marcoola) Lot 753 CG3375			Site B (Kawana) Lots 9 & 12 SP174900			Site C (Bribie) Lot 64 SP104224			Site D, G & H (Mouth of Brisbane River			Site E (N Stradbroke) Lot 17 WD2688 & 18 WD1474			Site F (S Stradbroke) Lot 49 SP193294		
					P (Likelihood)	C (Consequence)	RL (Ranking)	P (Likelihood)	C (Consequence)	RL (Ranking)	P (Likelihood)	C (Consequence)	RL (Ranking)	P (Likelihood)	C (Consequence)	RL (Ranking)	P (Likelihood)	C (Consequence)	RL (Ranking)	P (Likelihood)	C (Consequence)	RL (Ranking)
F: Inherent Site Risks (Design & Construction)																						
F1	Presence of contaminated material e.g. landfill etc	Ground investigation - error or scope limitation	Need for significant re-design and/or possible re-location - time and cost	Undertake significant soil testing and commission remediation works if contaminated material found	B	2	L	D	3	H	B	2	L	C	3	M	C	3	M	B	2	L
F2	Geotechnical Constraints	Complex geotechnical conditions not realised during design	Need to potential development of alternate route, changes to cost, time and programme	Detailed technical investigations including site specific geotechnical survey work	B	2	L	C	3	M	C	3	M	B	2	L	D	3	H	B	2	L
F3	Difficulty in providing marine crossings for pipelines	Insufficient marine geotechnical investigation; particularly relevant for island sites requiring marine crossings	Need for significant re-design and/or possible re-location - time and cost	Undertake extensive geotechnical survey; understand previous issues in laying infrastructure from island to mainland	B	2	L	B	2	L	D	3	H	C	3	M	D	3	H	D	3	H
F4	Difficulty in providing power to the site	Insufficient infrastructure in proximity	Significant further engineering works necessary to provide power to site	Undertake more detailed investigations and costing for provision of power to site	B	1	L	C	2	M	C	3	M	A	1	L	D	3	H	D	3	H
F5	Requirement for additional infrastructure (Roads, bridges, jetties) for site access	Access to the site is not possible through existing infrastructure	Expansion of study scope, increase in risks associated with construction, increase cost and programme	Understand capacity of existing infrastructure to meet site access requirements and undertake separate scoping study to assess ways to accessing sites	B	2	L	B	1	L	C	3	M	B	1	L	D	3	H	D	3	H
F6	Unexpected marine environmental impact during subsequent detailed studies	Inadequate investigation of the marine ecosystem	Expensive and time consuming retrospective actions; poor public perception	Undertake extensive marine benthic, marine ecology survey work and understand sensitivities of marine ecosystem to changes in water quality	B	2	L	B	2	L	B	2	L	C	3	M	C	3	M	C	3	M
F7	Unpredictable changes in water quality (contamination from alternate sources etc)	Contamination from other nearby discharges	Fouling of membranes; increased maintenance cost; increased plant downtime	Long term water quality monitoring plan; operational plan to monitor short term deterioration in water quality	B	2	L	C	2	M	B	2	L	D	3	H	B	2	L	B	2	L
F8	Unpredictable changes in water quality (contamination from oil spills)	Contamination from potential oil spills	Fouling of membranes; increased maintenance cost; increased plant downtime	Contingency operational measures at plant involving potential shut down of plant	B	4	M	B	4	M	C	4	H	C	4	H	B	4	M	B	4	M
F9	Exceptionally adverse weather conditions (e.g. flood, storm surge)	Construction risk mitigation strategy does not recognise site conditions and allow for weather conditions	Time and cost, particularly due to effect of non-productive time for labour stood down in poor weather conditions along the coastal sites	Develop operational strategy around likely weather conditions	B	2	L	B	2	L	C	3	M	B	2	L	C	3	M	C	3	M
F10	Adverse maritime conditions e.g. high winds, heavy seas [Island sites only]	Inability bring labour, plant and materials to island sites on a daily basis	Time and cost - principally productivity	Set up monitoring program to understand offshore weather conditions and changes in waves and winds	B	2	L	B	2	L	C	3	M	B	2	L	C	3	M	C	3	M
F11	Adequacy of existing utilities connection points	Inadequate understanding of demand and network connection node and/or ineffective discussions/negotiations with non-water utilities	Time and cost	Undertake a more detailed study to understand regional demand and capacity of the exiting raw water network including future upgrades to determine most suitable location for connection; undertake hydraulic modelling to understand requirements for pumping	C	2	M	C	2	M	C	2	M	B	1	L	B	2	L	B	2	L

G1.6.3 Typical construction & operation risks

Design / Construction		
HAZARD / THREAT	**FAULT / FAILURE / CAUSE**	**RISK EVENT / IMPACTS / CONSEQUENCES**
Discovery of contaminated material e.g. landfill, asbestos etc	Ground investigation - error or scope limitation	Need for significant re-design and/or possible re-location - time and cost
Discovery of poorer than anticipated ground conditions	Ground investigation - error or scope limitation	Need for significant re-design and/or possible re-location - time and cost
Discovery of contaminated ground water	Ground investigation and/or ground water monitoring programme - error or scope limitation	Need for significant works to intercept, treat and dispose groundwater - time and cost
Archaeology discovered during works e.g. excavations	Inadequate investigation or uncharted activities	Disruption to construction activity as authorities are consulted and mitigation measures introduced - time and cost
Exceptionally adverse weather conditions (e.g. flood, storm surge)	Construction risk mitigation strategy does not recognise site conditions and allow for weather conditions	Time and cost, particularly due to effect of non-productive time for labour stood down in poor weather conditions along the coastal sites
Adverse maritime conditions e.g. high winds, heavy seas	Inability bring labour, plant and materials to island sites on a daily basis	Time and cost - principally productivity
Damage to permanent and temporary works due to fire, including bush fires	Inadequate buffer zones around works perimeter to contain spread of bushfires	
Unable to commission plant due to failure to provide power	Inadequate power supply reserved by client or provision failure by utility	Commissioning and operational delays - construction time and cost, and lost revenues during operation phase
Diversions to services or modifications to permanent works	Uncharted services	Time and cost
Estimating/pricing errors	Change in labour/materials/plant costs	
Estimating/pricing errors	Inflation (i.e. differential inflation due to market factors and/or timing)	
Estimating/pricing errors	Changes in taxation	
Design creep / scope evolution	Inadequate review of the design and assessment of design development to establish if it still meets original requirements	Time and cost
Inadequate cost control	Failure to achieve target costs	
Inadequate cost control	Mismatch between defined brief and cost plan	
Inadequate cost control	Inadequate risk contingency	
Inadequate cost control	Inflation figure is inadequate	
Inadequate cost control	Cost escalation	
Inadequate resources	Failure to secure necessary resources (labour, plant and materials)	
Alternative site access	Need for alternative site access	Additional costs / delay
Working hours	Restricted construction working	Time and cost
Underground services	Not identified by utilities	Time and cost
Adequacy of existing utilities connection points	Inadequate hydraulic modelling for network integration and/or ineffective discussions/negotiations with non-water utilities	Time and cost
Staffing and resource constraints	Attracting and retaining staff in the desalination market will continue to be problematic	Disruption to construction activity as staff rotate in/out of the project, and knowledge is 'lost'

Operation		
HAZARD / THREAT	**FAULT / FAILURE / CAUSE**	**RISK EVENT / IMPACTS / CONSEQUENCES**
Site area inadequate for plant expansion	Selection of site only capable of sustaining initial development (not allowing for future expansion due to production volume and/or water quality drivers)	Cost if solution can be tailored to site, or general impact on operations if expansion cannot be accommodated on site
Working hours	Restricted construction working e.g. major plant overhaul, extensions, emergency repairs	Higher operating expenditure and reduced operational flexibility
Failure to meet water quality targets	Contractor design error or omission	Impact on commercial viability and subsequent requirement for retro-fit or significant investment in unplanned capital expenditure
Failure to meet water quality targets	Feed water quality changes	Potential temporary loss of production and subsequent requirement for retro-fit or significant unplanned capital expenditure
Staffing and resource constraints	Attracting and retaining staff in the desalination market will continue to be problematic	Disruption to operational activity as staff leave the client, and knowledge is 'lost'
Management constraints	Lack of resources and management structure to manage plant and interface with grid at a high/strategic level	Sub-optimal process and outcomes - lost opportunity for efficiency gain and underperformance in delivery of operating expenditure
Integration	Other infrastructure may impact on this scheme, e.g. reliance on design life of mainland network, roads, bridges, power	Cost and operations
Integration	Other projects may impact on this scheme, e.g. network rationalisation, provision of new water treatment works	Cost and operations
Damage to works due to fire, including bush fires	Inadequate buffer zones around works perimeter to contain spread of bushfires	
Consumables costs higher than anticipated	Variations in water quality over operational life of plant	Impact on commercial viability and subsequent requirement for retro-fit or significant investment in unplanned capital expenditure
Lifecycle costs higher than anticipated	Underestimation by contractor and/or adverse water quality impacts resulting in frequent asset maintenance interventions	Impact on budgets for programme of preventative maintenance (PPPM), capital maintenance and asset replacement
Technical obsolescence	Different forms of process evolve through technological improvement resulting in the reduction in scheme life	Impact on commercial viability and subsequent requirement for retro-fit or significant investment in unplanned capital expenditure
Plant over-sized	Inaccurate demand predictions	Plant under-utilized impacting on commercial viability and operational regime
Plant siting not aligned with demand growth/requirements	Inaccurate demand assumptions	Plant under-utilized / increased water transfer costs impacting on commercial viability and operational regime
Adverse maritime conditions e.g. high winds, heavy seas	Inability bring operators and/or deliveries to island sites	Cost and operations
Extreme climatic events e.g. storm surge, cyclone	No fault (assuming adequate provision of typical water industry flood defence to 100/200 year flood events)	Production failure and/or cost of repair
Vandalism	Inadequate provision of security features in design and/or weak operational control	Production failure and/or cost of repair

G1.6.4 Qualitative Risk Analysis and Evaluation Criteria Risks

Qualitative Risk Analysis and Evaluation Criteria

ARUP

Consequence Scale

Descriptor		Insignificant	Minor	Moderate	Major	Catastrophic
Example Details Descriptions	**Financial (Costs & Revenue)**	Negligible financial consequence (< 1% of budget or revenue) [< $20 M]	Minor financial consequence (1 to 5% of budget or revenue) [$20 - $100M]	Moderate financial consequence (5 to 10% of budget or revenue) [$100 - $200M]	Major financial consequence (10 to 25% of budget or revenue) [$200 - $500M]	Huge financial consequence (>25% of budget or revenue) [> $500M]
	Programme	Little or no delay	Short delay (increases duration by >2.5%) [> 1 month]	Significant delay (increases duration by >10%) [> 4 months]	Major delay (increases duration by >25%) [> 10 months]	Project halted or huge delay (increases duration by >100%) [> 3 years]
	Safety	No injuries	First aid treatment / out-patients	A number of injuries / hospitalisation	Extensive injuries / hospitalisation / long-term treatment	Fatality / significant irreversible effects to a number of persons
	PR / Profile	Some complaints but project, client, stakeholder reputation intact	Adverse local publicity or media attention	Attention from media and/or significant concern by local community / criticism by NGOs	Significant adverse regional and State media coverage / community and NGO outcry	Serious adverse international and/or national coverage / community and NGO outrage
	Relationships	Stakeholders irritated but no formal complaints	Resolved at working level	Resolved at senior management level	Legal recourse or Departmental Head intervention	Government level intervention
	Build Quality	Cosmetic repairs / rectification	Minor repairs / rectification	Major repairs / rectification - including structural	Substantial re-build	Total replacement
	Operational Impacts	Negligible impact / no significant impact on personnel	Minor change to operations / some inconvenience to personnel	Requires a change in operations, work routines and schedules	Major disruption to operations, work routines and practices - additional resources may be required	Operations not possible or facility closed / impact on the well-being of personnel
	Environment	No effects or effects which are below levels of perception, within normal bounds of variation or within the margin of forecasting error.	These effects may be raised as local issues but are unlikely to be of importance in the decision making process. However, they are of relevance in enhancing the subsequent design of the project and consideration of mitigation measures.	Important considerations at a regional level. Mitigation measures and detailed design may ameliorate some of the consequences upon the affected communities or interests.	Important considerations at a state scale. Mitigation measures and detailed design work are unlikely to remove all of the effects upon the affected communities or interests.	Associated with sites and features of national importance. Typically mitigation measures are unlikely to remove such effects.
	Property / Assets	Negligible damage to or loss of assets	Minor damage to or loss of assets - some repairs may be required	Moderate to high damage to or loss of assets - requires specialist / contract equipment to repair or replace	Significant / permanent damage to assets and/or infrastructure	Widespread, substantial / permanent damage to assets and/or infrastructure
	Social / Cultural Heritage	Negligible social or cultural impacts	Minor medium term social impacts on local population, mostly repairable with appropriate management/remediation	On-going social issues / permanent damage to structures or items of cultural significance	On-going, serious social impacts / significant damage to structures or items of cultural significance	Widespread, on-going, significant serious, irreversible social impacts
	Legal	Some minor non-compliances and breaches of regulation	Minor legal issues, non-compliances and breaches of regulation with option for legal recourse	Serious breach of regulation with investigation or report to authority with prosecution and/or moderate fines possible	Major breach of regulation / major litigation	Significant prosecution and fines / very serious litigation including class actions
	Systems, Information and Data	Negligible loss of or damage to IT and communications - no loss of data	Minor loss of or damage to IT and communications - some data retrieval may be required	Moderate to high loss / damage to IT and communications - some data may be permanently lost & workarounds may be required	Major loss / damage to IT and communications - data permanently lost, significant catch-up, business continuity plans required to be implemented	Extensive loss / damage to IT and communications assets and infrastructure - data permanently lost, widespread disruption to business

Likelihood Scale

Descriptor	Description of Frequency
Rare	May occur only in exceptional circumstances - can be assumed not to occur during period of the project (or life of the facility)
Unlikely	Event is unlikely to occur, but it is possible during period of the project (or life of the facility)
Possible	Event could occur during period of the project (or life of the facility)
Likely	Event likely to occur once or more during period of the project (or life of the facility)
Frequent / Almost Certain	Event occurs many times during period of the project (or life of the facility)

ARUP

RISK ASSESSMENT

Risk Matrix

CONSEQUENCES									
LIKELIHOOD		Moderate (+)	Minor (+)	Insignificant (+)	Insignificant	Minor	Moderate	Major	Catastrophic
		-3	-2	-1	1	2	3	4	5
Rare	A	L+	L+	L+	L	L	L	M	M
Unlikely	B	M+	L+	L+	L	L	M	M	H
Possible	C	M+	M+	L+	L	M	M	H	H
Likely	D	H+	M+	M+	M	M	H	H	VH
Frequent/ Almost Certain	E	H+	H+	M+	M	H	H	VH	E