SECTION 6

Risk Analysis

PowerWater

6 Preliminary Risk Analysis

This section provides a summary of the preliminary risk analysis undertaken for the Proposed Development and should be viewed with **Section 5, Potential Impacts**.

6.1 Aims and Scope

The overall objective of the preliminary risk analysis was to conduct a comprehensive, scientifically based risk assessment of the environmental, social and financial impacts and potential risks posed by the project during construction, commissioning and operation of the development. Key outputs of preliminary risk assessment for the Proposed Development include:

- Identify key impacts of the Proposed Development.
- Identify key potential risks posed by the Proposed Development.
- Develop a sound, defensible, prioritised strategy (action plan) to progressively reduce the impacts and risk to environmental and social assets. This will focus effort on high impact and high risk issues and events.
- Help focus the Proposed Development on key studies and refine study scopes.
- Provide risk-based feedback to project design.
- Demonstrate progressive risk reduction and value for money.
- Communicate the impacts and risks of the Proposed Development on environmental and social assets to stakeholders (regulators and community).
- Contribute to the PER Environment Management Plan.

To enable the objectives of the risk analysis to be achieved, a stakeholder consultation and risk assessment workshop was held at the Holiday Inn Conference, Darwin on the 5th April 2011, and was attended by representatives from PWC, representatives from the Northern Territory Government (NRETAS) and the URS PER team. The scope of the workshop was to identify and evaluate alternatives associated with the project and initial risks associated with the Proposed Development.

A second workshop took place on the 16th and 17th August 2011. The purpose of the second workshop was to conduct a relatively “high level” comparative assessment of the relative construction costs and risks for both the “trench” versus “drill” model. The results of this financial risk assessment are reported in a separate report, entitled: “*Power and Water Corporation East Point Outfall, Construction Options Assessment*”, draft report, dated 26th September 2011.

During the second risk workshop, some of the assumptions made during the first risk workshop were reviewed on the basis of further knowledge becoming available.

6.2 Preliminary Impact and Risk Assessment

6.2.1 Overview of the Approach

The risk management approach for the Proposed Development risk assessment is based on the RISQUE method which is a widely accepted approach to risk management, often involving the use of a multi-disciplinary “expert panel” for assessing the probabilities and consequences associated with potential risk events.

This approach was selected because it is essentially simple and is able to assess (on a relatively even basis) risks associated with social, environmental, engineering and economic issues and events. Highly complex systems involving feedback mechanisms and multi-faceted inter-relationships have been incorporated into the risk assessment through the use of a team of subject matter specialists.

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In general terms, the RISQUE method is a cyclical process based on the ISO/Australia and New Zealand Standard for Risk Management (ISO 31000:2009) framework, as described in **Figure 6-1**.

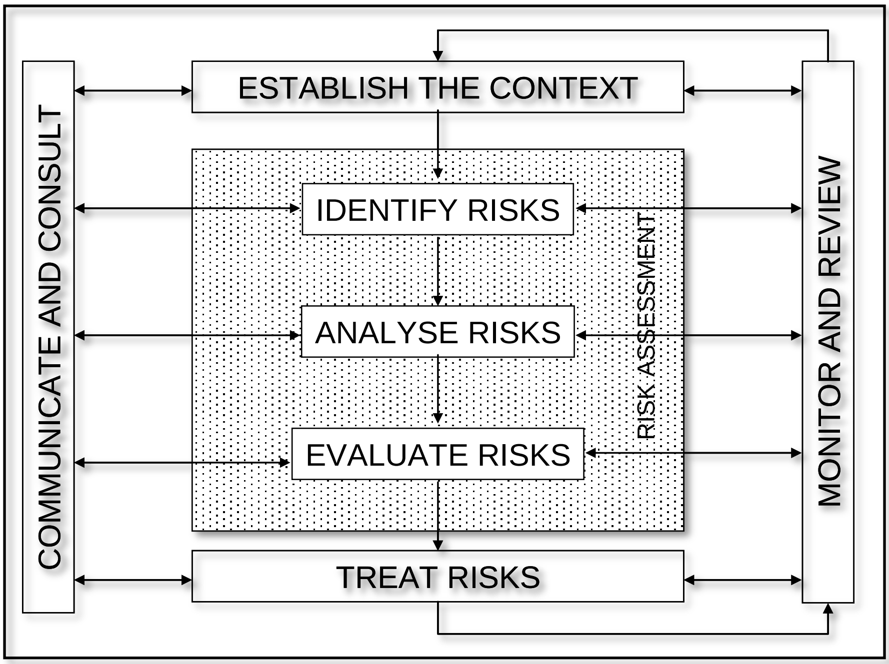

Figure 6-1 Overview of ISO 31000 Risk Management Process

Figure 6-1 shows that the ISO 31000 risk management process is iterative and that the main elements of the process are:

- Communicate and consult with stakeholders at each stage of the process.
- Establishing the context for the project has been described in the project description. This step provides background to the analysis and structure of the risk assessment.
- Identify risks by when, where, why and how risk events could occur. Information was obtained from PWC personnel and from subject matter specialists. The process was essentially workshop-based with support from other discussions, meetings, and reviews that took place outside of workshops, and was facilitated by URS.
- Analyse risks by identifying existing controls, evaluate likelihoods and consequences to determine levels of risk. The level of analysis was relatively simple, involving calculation of risk quotients and adding risks and likelihoods as appropriate, and was performed by the URS risk analyst.
- Evaluate risks by comparing estimated levels of risk with evaluation criteria, consider benefits versus adverse outcomes. The role of the risk analyst in the risk evaluation process was to generate appropriate outputs from the risk analysis that would be useful for stakeholders, including DLP, community and regulators, to evaluate the risk posed by the Proposed Development and to form their views.
- Treat risks as required, to develop and implement specific strategies for increasing benefits and reducing potential costs and to ensure that all material risk events are addressed in the actions contained with the EMP of this EIS.
- Monitor and review the effectiveness of all steps of the risk management process. The client, with support from the risk analyst, will assess changing circumstances.

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6.2.2 What is Risk

Risk is a condition resulting from the prospect of an event occurring and the magnitude of its consequences. Therefore, risk is an intrinsic combination of:

- The likelihood of an event and its associated consequences occurring. This incorporates consideration of the frequency of the event and the probability of the consequences occurring each time the event occurs.
- The magnitude of potential consequences of the event.

In quantitative terms, "risk" is defined by a risk "quotient", which is:

Risk Quotient = Likelihood x Consequence

The risk quotient is therefore a numerical value that describes the level of risk posed by an event. Both likelihood and consequence can be measured in several ways using different techniques, depending on the aims of the risk assessment and the nature of the risk issue. The selected methodologies for assessing likelihoods and consequences in the risk assessments are described in following sections.

Dealing with Uncertainty

As risk is a concept used to describe events that may or may not occur, and for which the scale of potential impacts cannot be accurately predicted, there is always inherent uncertainty associated with the estimation of risk.

Considering the two-dimensional nature of risk (likelihood x consequence), there are two key types of uncertainty in any estimation of risk:

- Uncertainty in the estimated likelihood of an event occurring.
- Uncertainty in the magnitude of the event consequences.

The underlying cause of the uncertainty itself may be a result of a combination of issues such as lack of historical information for similar situations, uncertainty in scientific knowledge, natural variability, or uncertainty due to assumptions inherent in technical models or calculations used for forecasts and predictions. In assessing and measuring uncertainty, one must take into account each of the assumptions made and the extent of its validity.

6.3 Risk Identification

A workshop process with subsequent follow-up and validation was followed to perform the task of risk identification. Subject matter specialists in attendance provided expertise in asset management, construction engineering, terrestrial ecology, social impact assessment, air emissions, cultural heritage, economics, terrestrial hydrology, visual impacts and infrastructure.

The following tasks were performed at the workshop:

- Develop a preliminary list of risk events.
- Identify likelihoods of risk events and the severity of their consequences.
- Analyse the risk.
- Assess the outcomes.

A preliminary list of risk events was developed prior to the risk workshops and was built upon during the initial stage of the workshops.

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6.3.1 Estimating Likelihoods

For more common events are those with a likelihood above a 1 in 10 (10%) chance of occurrence over the life of the project, where the event likelihood is usually estimated to the nearest few precent (e.g. 5% [0.05], 20% [0.2], 70% [0.7]) based on the subject matter expert's experience or knowledge of similar types of events, and documented information in the industry and literature. On the other hand, for more novel, untested activities and events with likelihoods below a 1% chance over the life of the project, an individual expert's experience becomes increasingly less direct as the likelihoods become lower. In these cases, project likelihoods are estimated more conceptually and expressed in order of magnitude terms (e.g. a 1 in 100 or a 1 in 1,000 chance).

To assist in ensuring consistency of approach to making this type of conceptual level estimate for events with lower likelihoods, a Likelihood Guide was supplied to assist participants in estimating likelihoods. As the name suggests, a likelihood guide serves as a guide only, however the application of a single guide across all of the different disciplines and event types ensures greater consistency of likelihood estimates across the whole of the PWC risk assessment. The Likelihood Guide used in the workshop is shown in **Table 6-1**.

Table 6-1 Example of an Alternative Guide to Quantification of Likelihood

Qualitative Description	Order of Magnitude Frequency over a Given Time Period	Basis
A. Certain	1 (or 0.99, 99.9%)	Certain, or as near to as makes no difference
B. Almost certain	0.2 – 0.9	One or more incidents of a similar nature has occurred here
C. Highly probable	0.1	A previous incident of a similar nature has occurred here
D. Possible	0.01	Could have occurred already without intervention
E. Unlikely	0.001	Recorded recently elsewhere
F. Very unlikely	1×10^{-4}	It has happened elsewhere
G. Highly improbable	1×10^{-5}	Published information exists, but in a slightly different context
H. Almost impossible	1×10^{-6}	No published information on a similar case

6.3.2 Estimating Consequence

Consequences tables are used in semi-quantitative risk assessments to help the expert team identify and quantify appropriate levels of impact on a range of asset types, resulting from the occurrence of a potential risk event. The table was developed to achieve a practical level of consistency when estimating consequence levels across different disciplines or environmental assets. The consequences table incorporates qualitative descriptions for different consequence types and levels, and normalises them into a consistent set of quantitative measures.

Table 6-2 shows the qualitative consequence levels (Negligible, Minor, Moderate, Major, and Extreme), a generic qualitative description for each level and the quantitative value assigned to each consequence level.

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Table 6-2 Range of Consequence Levels and Generic Descriptions

Negligible	Minor	Moderate	Major	Extreme
Minimal, if any impact for some communities. Potentially some impact for a small number (<10) of individuals.	Low level impact for some communities, or high impact for a small number (<10) of individuals.	High level of impact for some communities, or moderate impact for communities area-wide.	High level of impact for communities area-wide.	High level of impact State-wide.
0.1 0.3	1 3	10 30	100 300	1000 Plus

The quantitative values show that each subsequent consequence level represents a factor of ten increase in the scale of the consequence, which was a critical factor in ensuring that the levels could be applied consistently across all disciplines. The generic qualitative descriptions describe not only the level of impact but also a description of how widely the impact could be felt, i.e. number of individuals or communities affected, as this is also a key factor in being able to estimate the magnitude of the consequence. For example, the Extreme consequence level refers to impacts that could be felt State-wide.

The key categories of impact in the consequence table include:

- Property and Infrastructure
- Environment
- Social
- Economic
- Public Health and Safety.

In some situations, it was considered that the event, if it were to occur, would have multiple consequences. As an example, excessive noise would have consequences for the local community as well as the environment. In these situations, the consequence values were recorded for each of the categories. These were then summed for each risk issue. For example, a value of 1 for Environment consequences and a value of 10 for Social consequences would give a total value of 11 for the total consequence of the risk issue.

6.4 Risk Identification

6.4.1 Events and Inputs Risk Register

The events risk register is a list of events that could result in impacts and potential impacts from implementation of the Proposed Development. Workshop participants were shown the preliminary list of risk events that was developed prior to the workshop and were asked to add to the list to ensure that all of the key impacts and risk events were captured.

A screening process then followed, where the workshop participants efficiently prioritised the issues with respect to criteria such as: likelihood of occurring, scale of impacts, known community interest, relevance to this specific project, and plausibility of pathways. Priority Level 1 issues were identified as high priority, and Priority Level 3 issues were relatively low priority. Some issues were excluded at that point, without assigning a priority level.

The workshop resulted in the identification of 37 risk events associated with the construction and operation phase of the Proposed Development (see **Table 6-3**).

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Table 6-3 Risk Events for the Duplication of the Proposed Development

Risk Event (brief, indicative description)	Included or Excluded	Reason
Acid sulphate soils	Included	Priority 1
Heritage damage	Included	Priority 1
Pipeline rupture	Included	Priority 1
Open excavation	Included	Priority 1
Disruption to WW services	Included	Priority 1
Aboriginal sacred sites	Included	Priority 1
Natural disasters	Included	Priority 1
Temporary bypasses	Included	Priority 1
Itinerants	Included	Priority 1
Wallaby population	Included	Priority 1
Growth and spread of weed species.	Excluded	Priority 1
Drain/creek crossings	Excluded	Priority 2
Damage to conservation group re-planted areas	Excluded	Priority 2
Vegetation clearing. Destruction of vegetation and loss of habitat	Excluded	Priority 2
Vegetation clearing and construction. Noise	Excluded	Priority 2
Existing infrastructure damage	Excluded	Priority 2
Soil erosion	Excluded	Priority 2
Interferences with services	Excluded	Priority 2
Creation of ponds (mossies)	Excluded	Priority 2
Post construction public safety	Excluded	Priority 2
Decommissioning of existing rising main	Excluded	Priority 2
Seasonal effects	Excluded	Priority 2
Fire	Excluded	Priority 2
Dust	Excluded	Priority 2
Construction traffic	Excluded	Priority 2
CO_2 and other emissions	Excluded	Priority 2
Unauthorised access	Excluded	Priority 2
Land owners	Excluded	Priority 3
Generation of wastes. Inappropriate disposal of wastes	Excluded	Priority 3
Fuel spill	Excluded	Priority 3
Interference with recreational activities	Excluded	Priority 3
Disposal of hydrotest water	Excluded	Priority 3
Trench settlement	Excluded	Priority 3
Mulching leachate	Excluded	Priority 3
Damage to roads and tracks	Excluded	Priority 3
Storm surge	Excluded	Priority 3
Easements and implied easements	Excluded	Priority 3

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There were 11 Priority 1 events, 16 Priority 2 events and 10 Priority 3 events. Of the 37 risk events that were considered for inclusion in the risk assessment, the assessment ultimately considered 11 Priority 1 events in more detail.

The workshop briefly reviewed the Priority 2 and 3 issues immediately after completion of assessment of the Priority 1 risk profile and concluded that detailed evaluation of the remaining risk issues was not required.

The impacts and risk posed by the 11 Priority 1 events were considered in some detail. The probability of each of the 11 Priority 1 risk events occurring over the project activity (construction or operation) was estimated by the relevant specialist and estimates of the level of financial, environmental, social, economic and public safety impact were provided. The subject matter specialist estimates were based on their experience and on likelihood and impact guidelines applied by the semi-quantitative RISQUE method (Bowden, 2001).

The data were entered into a risk model, where risk is calculated as probability x impact level. The resulting risk values for all risk events were output as risk-ranked profiles (see **Chart 5-1**) and tables.

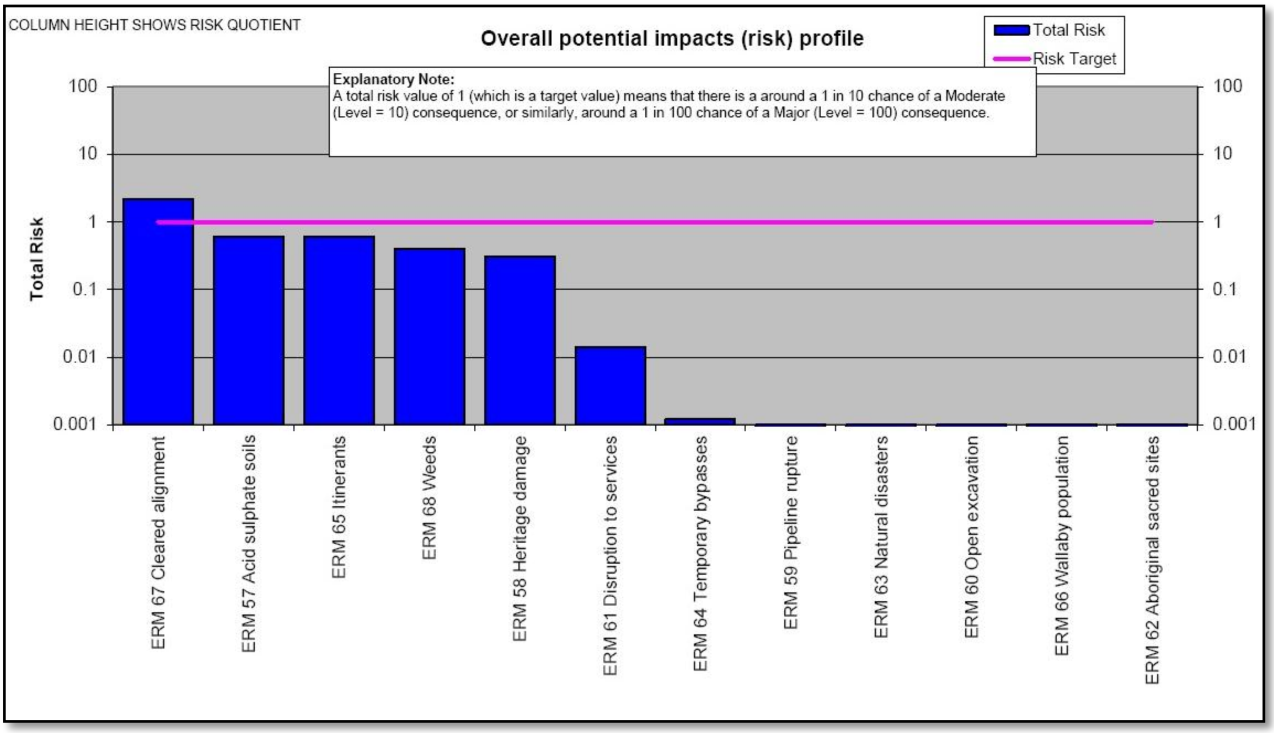

Table 6-4 Overall Potential Impacts (Risk) Profile

Events that have a probability of 1 (or very close to) are expected to occur. These are termed “known events”, whose impacts are also known. Events with a likelihood of less than 1 may or may not occur and are termed “risk events” and their impacts are termed “potential impacts”.

6.5 Impact Analysis

Impact analysis involved quantifying and modelling the probabilities and consequences for each substantive risk event for the Proposed Development. The risk profiles generated by the risk model show all risk events ranked in order of decreasing risk.

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The risk for each risk event is stated as a “risk quotient” and is the likelihood of the event occurring multiplied by the consequence level if the event were to occur. The contribution by time period refers to the proportion of the risk quotient that occurs during the stated project time period to Construction or Operation. The contribution by Asset refers to the proportion of the risk that is posed to the defined community assets: Public health and safety, Economics, Social, Environmental and Property/Infrastructure.

Establishment of a risk target helps stakeholders to understand what level of risk might be considered acceptable in the context of the scale of the Proposed Development.

The risk methodology used for the Proposed Development has been set at a risk level of 1. A risk target of 1 is equivalent to a 10% chance of a Moderate level impact occurring (i.e. consequence value of 10) or a 1% chance of a Major event occurring (i.e. a consequence value of 100). The selected risk target is therefore more conservative than the major project target.

The outcome of the PWC risk analysis concerning impacts and potential impacts assessment is of graph showing the highest risks for the project in order of risk quotient, the level of risk considered acceptable for each event, and the consequences and timing of the risks; i.e. whether the risk was posed to the environment and public health and safety, and whether the issue could occur during construction or operation or both.

All projects will have positive and negative impacts on the wider environment, such as impacts on people and their activities, the natural environment, infrastructure and economics (see **Section 5, Potential Impacts**). Communities and regulators need to weigh the benefits of the project against the anticipated negative impacts.

In this risk assessment we are only considering negative impacts of the project.

Impacts from a project can be separated into two classes:

- Known impacts.
- Potential impacts.

Known impacts are derived from events for which it is practically certain that they will occur at some stage during the life of the project. The chance that these events and their consequential impacts will occur is effectively 100% (or 1). The only real uncertainty lies in the magnitude of impacts when the event occurs. Known impacts on the wider environment from a project need to be identified and reduced to levels that are as low as reasonably practical.

Potential impacts are derived from events that may or may not occur due to project activities. These events are known as risk events. For risk events there is uncertainty as to whether the event will occur in addition to the uncertainty of impact magnitude. The level of risk posed by a project can often be reduced by implementing actions that reduce the likelihood of the risk event occurring and / or actions that mitigate the level of impact if the event were to occur.

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6.5.1 Known Impacts

The identified known impacts included two risk events (see **Chart 6-4**):

1. Cleared alignment/vegetation removal (Total Risk 2.2)

   This refers to the removal of vegetation along the alignment and the maintenance of a cleared area along the alignment. The workshop discussion assumed that the area has already been modified and that there are no endangered floral species along the alignment and therefore the environmental impact will be negligible.

2. Weeds (Total Risk 0.4)

   This refers to the chance of bringing an exotic weed into the construction area as a result of equipment movements, which would then expand into the cleared area. It is assumed that there may be a short term increase in weeds during construction but these will be managed and will return to normal levels post construction.

Only the cleared alignment / vegetation removal (Total Impact 2.2) event was considered to be equal to or above the selected impact target of 1. The ERM Weeds (Total Impact 0.4) event was considered to be of negligible consequence level.

6.5.2 Potential (Risk) Events

Potential impacts are derived from events that may or may not occur due to project activities. Identified potential impacts include (see **Chart 6-4)**:

- Acid sulphate soils.
- Itinerants.
- Heritage damage.
- Disruption to services.
- Temporary bypasses.
- Pipeline rupture.
- Natural disasters.
- Open excavation.

The potential risk events are all under the target level of 1, therefore imposing minor impacts.

6.6 Risk Assessment: Upgraded Ludmilla WWTP and Existing East Point Outfall

This risk assessment considers the impact of combining the Ludmilla and Larrakeyah wastewater streams, treating the wastewater at the upgraded Ludmilla WWTP, and temporarily discharging the treated effluent through the existing East Point intertidal outfall. Discharge through the existing outfall will continue only until such time construction of the new subtidal outfall is completed, currently planned for 2013.

It is noted that the combined discharge will not include any industrial waste, i.e. heavy metals or other chemical contaminants, and hence nutrient and bacteria loading are the key concerns in considering the risk posed by increasing the volume of effluent being discharged into the intertidal zone at East Point.

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The current outfall conditions, based on data obtained by PWC as part of the regular outlet monitoring program between 1 July 2010 and 8 November 2011 are:

Table 6-5 Current Outfall Conditions at Larrakeyah Outfall and Ludmilla WWTP

	Volume ML/day	**Total N** mg/L	**Total P** mg/L	***E. coli*** cfu/100 mL
Larrakeyah Outfall				
Median	3.0	52.1	7.0	7.5×10^6
90th Percentile		56.9	8.3	19.6×10^6
Ludmilla WWTP and East Point Outfall				
Median	9.5	40.0	5.3	80
90th Percentile		48.2	6.8	11,100

The predicted situation after the LWWTP is upgraded and the effluent streams are combined is:

Table 6-6 Current Outfall Conditions at Ludmilla WWTP (Combined Effluent)

	Volume ML/day	**Total N** mg/L	**Total P** mg/L	***E. coli*** cfu/100 mL
Median	12.5	39.0	2.5	10^3
90th Percentile		45.0	4.5	10^4

Note that the LWWTP proposed targets are based on historical data of the WWTP's performance and are the best estimates currently available. With the proposed plant upgrade there will be an improvement in treatment capacity and effluent quality, including an estimated 5 – 10% reduction in nitrogen containing compounds which is not included in the above estimates.

The above figures show a reduction in the existing concentrations for both nitrogen and phosphorus when compared to the proposed combined effluent and a very significant reduction in the estimated bacterial count from the Larrakeyah WWTP. An increase in the median bacterial count is anticipated from the Ludmilla WWTP however the 90th percentile value is expected to remain effectively unchanged.

Converted to daily loadings, these figures indicate a reduction in nitrogen input of 48.5 kg/day or 9%, a reduction in phosphorus input of 40.1 kg/day or 56%, and a reduction in *E. coli* of 22.4×10^9 cfu/day or 99%, the latter resulting from disinfection of the effluent, which is not available at Larrakeyah. Given the subtidal location of the Larrakeyah outfall the annual reduction in phosphorus input (~15 tonnes per annum) is seen as the most significant improvement.

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Table 6-7 Daily Loading to Darwin Harbour

	Total N kg/day	**Total P** kg/day	***E. coli*** cfu/day
Larrakeyah WWTP (existing)	156	21	$22,500 \times 10^9$
Ludmilla WWTP (existing)	380	50.35	7.6×10^9
Total (existing)	536	71.35	$22,508 \times 10^9$
Proposed Combined	487.5	31.25	125×10^9

In terms of the East Point location, the figures show that while there will be a reduction in the concentrations of nutrients discharged from the East Point outfall, the change in loadings is not consistent. Thus the nitrogen loading will increase by 107.5 kg/day or 28%, while the phosphorus loading will decrease by 19.1 kg/day or 38%. As with the harbour generally, the reduction in phosphorus loading is seen as the most significant change.

Based on the indicative figures for bacteria provided above, there will be a significant increase in the bacteria load, however it is noted that the concentrations are still several orders of magnitude below the levels permitted under the conditions of the Waste Discharge Licence and levels may be managed through changes to the disinfection regime.

Table 6-8 Daily Loading to East Point

	Total N kg/day	**Total P** kg/day	***E. coli*** cfu/day
Larrakeyah WWTP (existing)	156	21	$22,500 \times 10^9$
Ludmilla WWTP (existing)	380	50.35	7.6×10^9
Total (existing)	536	71.35	$22,508 \times 10^9$
Proposed Combined	487.5	31.25	125×10^9

Modelling (see **Figure 6-2** and **Figure 6-3**) undertaken for the existing and proposed outfall locations (see sample outputs below) indicates a relatively small area of expansion in the compliance area for a conservative parameter (in this case copper) when discharged at the same initial concentration at the existing (9.5 ML/day) and combined (12.5 ML/day) volumes from the existing outfall location.

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Figure 6-2 Dispersion of a Conservative Parameter at Current Discharge (Average Volume 9.5 ML/day), Dry Weather Flow Conditions

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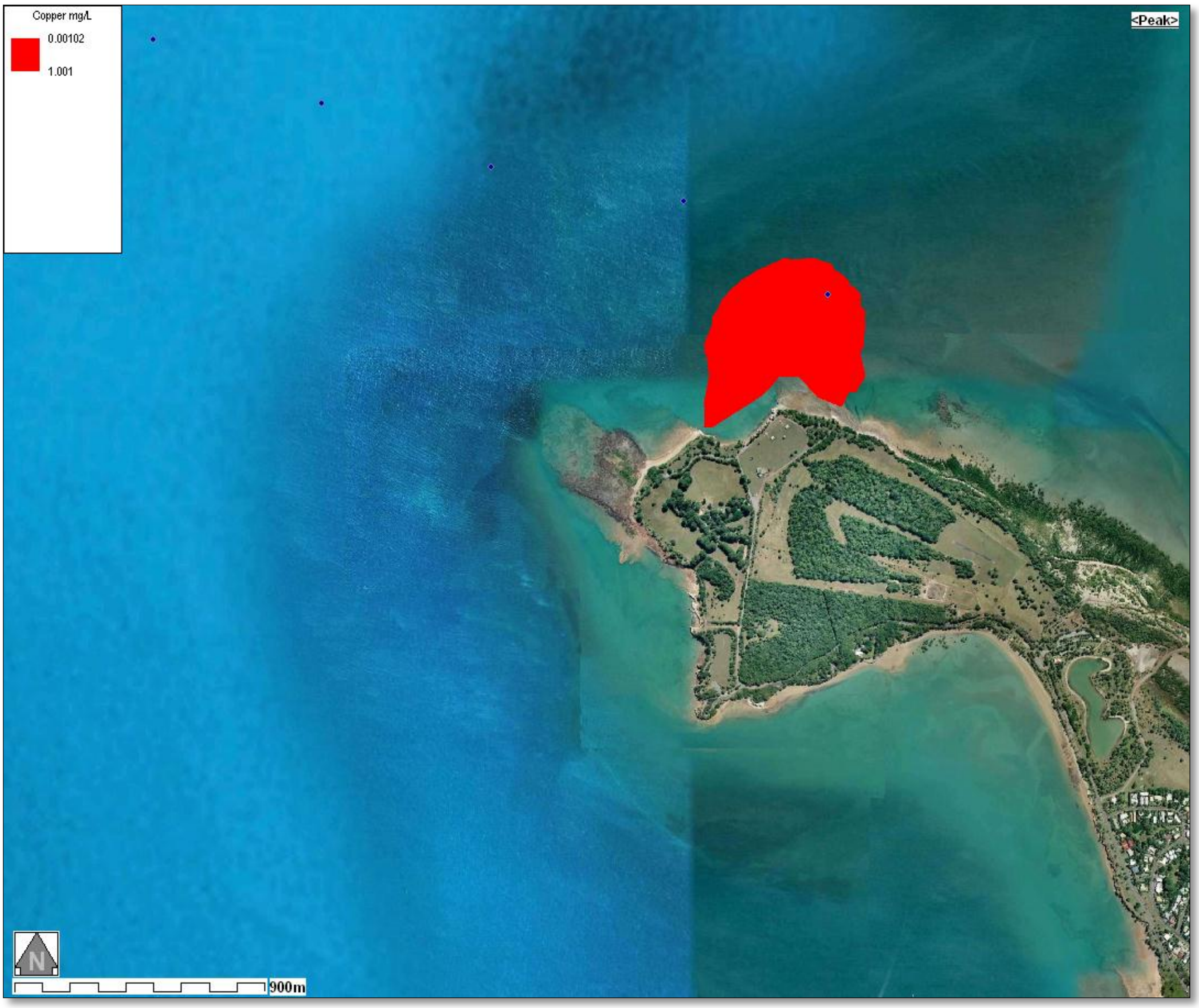

Figure 6-3 Dispersion of a Conservative Parameter at Combined Discharge (Average Volume 12.5 ML/day), Dry Weather Flow Conditions

Nitrogen and phosphorus are major plant nutrients and can promote the development of algal blooms when present in excess. In Darwin Harbour this would apply particularly to the bloom forming species, *Lyngbya majuscula*, which was observed at a number of beaches around Darwin Harbour throughout 2010, including Mindil, Vesteys, Fannie Bay and Casuarina beaches (source NRETAS).

With the presence in Harbour waters of abundant nitrogen (which may be derived by *Lyngbya* either from the water or from the atmosphere) and iron (another essential plant nutrient) which occurs at naturally high levels in Darwin soils, the growth of Lyngbya or other blue green algae is likely to be phosphorus limited and hence a reduction in phosphorus levels, both locally and harbour wide, may be instrumental in reducing the severity of future blooms.

It is concluded that the discharging the combined Larrakeyah and Ludmilla WWTP (upgraded) effluent streams through the East Point outfall will result in a small additional area of elevated concentration of effluent parameters about the outfall location. The anticipated reduction in the phosphorus load is considered to be highly beneficial as treated sewage is considered to be the major contributor to phosphorus loading in Darwin Harbour (source NRETAS).

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In comparison, nitrogen from treated sewage comprises a much smaller portion of the total nitrogen load and accordingly the predicted harbour wide reduction in load will have correspondingly smaller impact. The localised increase in nitrogen load in the vicinity of East Point is unlikely to lead to increased algal growth in the absence of additional sources of phosphorus.

Overall, the impact of discharging the combined effluent from the existing outfall over a limited period (i.e. until completion of the new East Point Outfall, est. 4th quarter 2013) is considered unlikely to lead to long term or irreversible changes in the marine environment at East Point. Modelling indicated that bacteria levels, at the proposed discharge concentration of 10^3 cfu/100mL, will be diluted to a concentration below the water quality trigger value immediately after discharge, i.e. in the immediate vicinity of the outfall.

6.7 Further Works

Another risk assessment workshop will be conducted once technical studies for the proposed extension of the East Point outfall are completed and will form a primary input to the EPO Extension Project Draft PER.

PWC propose to include technical experts in this process with the aim of correctly identifying risk and their associated impact on environmental receptors. The risk assessment will evaluate the construction and operational phases for the effluent rising main.