MEMORANDUM

To Tobias Thönelt/ K+S Salt Australia

From Joanna Garcia-Webb/Water Technology

Date 11 December 2018

Subject Seawater Intake Assessment

The following memo provides information on the potential changes in coastal processes within Urala Creek South and offshore of the creek mouth as a result of the seawater intake operating at peak December flow rate of 11.87 m^3/s.

1 STUDY OVERVIEW

The numerical models established for assessment of the existing conditions were used for this assessment. These include the regional model extending offshore approximately 160 km towards the Indian Ocean and the western boundary starting just to the north of Coral Bay, as well as the local model nested within the regional model (Figure 2-1). The following provides a brief overview of the steps taken to undertake this assessment:

- Assessment of wind and evaporation data to select an appropriate representative month of December conditions over the length of available data record,
  - For this assessment, typical dry season conditions during December 2015 were selected to represent the combined effects of tides and wind at the site.
- Simulation of the regional model to prepare boundary conditions for the local model for December 2015
- Refinement of the local model mesh within Urala Creek South
- Simulation of the local model during December 2015 for the following two scenarios:
  - Baseline conditions (seawater intake not included)
  - Scenario (seawater intake operating constantly at peak December rate of 11.87 m^3/s)
- Processing model results for a range of coastal processes including water level, current speed, discharge flow in the creek, bed shear stress and potential for scour as a result of predicted change in current speeds.

1.1 Seawater Intake Flow Rate

Upon consultation with K+S Salt and Enviroworks and based on the information within the PFS reports (Arcadis, 2018), peak December seawater intake rate of 11.87 m^3/s was simulated. The intake location is shown in Figure 2-3; geographic coordinates are provided in Table 1-1.

Table 1-1 Urala South Creek Intake Location (Projection: GDA_1994_MGA_Zone_50)

	Easting (m)	Northing (m)
Urala South Creek Intake Location	257859	7574423

2 HYDRODYNAMIC MODELLING

The MIKE 21 Flexible Mesh (FM) Hydrodynamic model developed during the existing conditions investigations has been utilised for this study. Details of this model were provided in the January 2018 Water Technology existing conditions report.

2.1 Model Mesh

The extent of the regional model is presented in Figure 2-1, with the local model bathymetry illustrated in Figure 2-2.

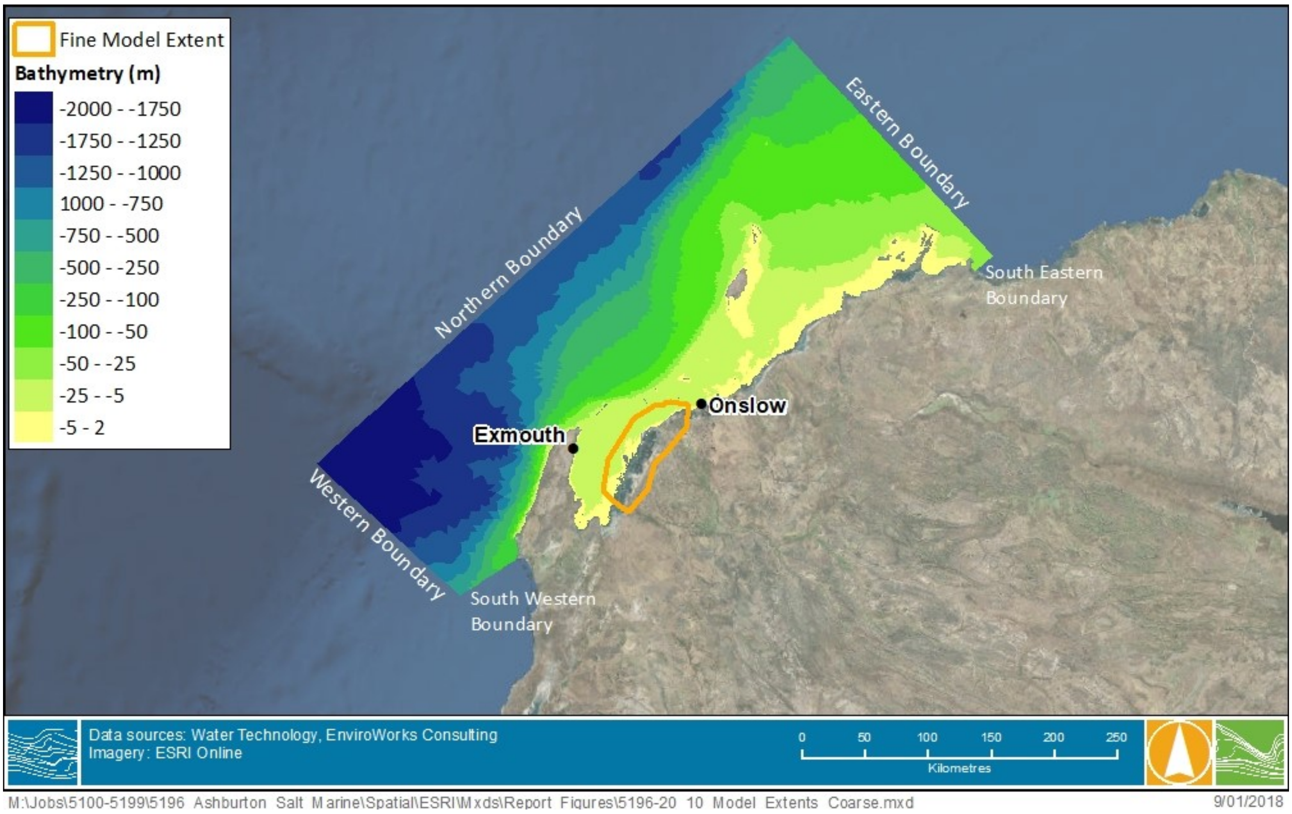

Figure 2-1 Regional Model Bathymetry

For this assessment, the model resolution was further refined in Urala Creek South, where the mesh size is approximately 6 to 8m (Figure 2-3).

2.2 Model Calibration

Although bathymetric data for the Urala Creek South was provided to Water Technology and included in the model mesh, limited availability of recent bathymetric data at the mouth of the creek is considered a model limitation, introducing some uncertainty into the hydrodynamic model. This data limitation resulted in poor calibration of water levels in Urala Creek South when compared against 2017 water level measurements. Therefore, the results of this assessment are considered preliminary only and with the purpose of guiding the extent of the proposed samplings of prawn larvae. The hydrodynamic model will be refined upon receipt of further data to improve model calibration in the creek.

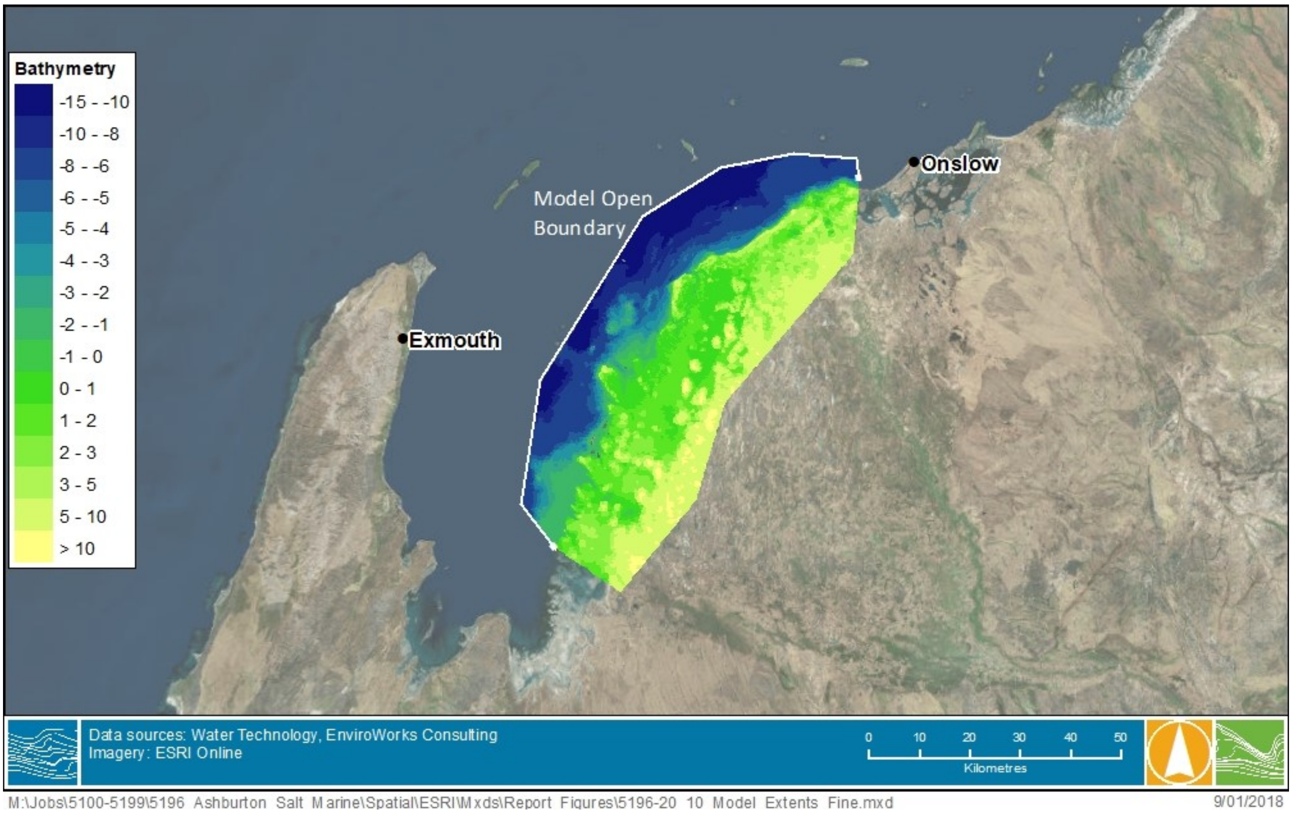

Figure 2-2 Local Model Bathymetry

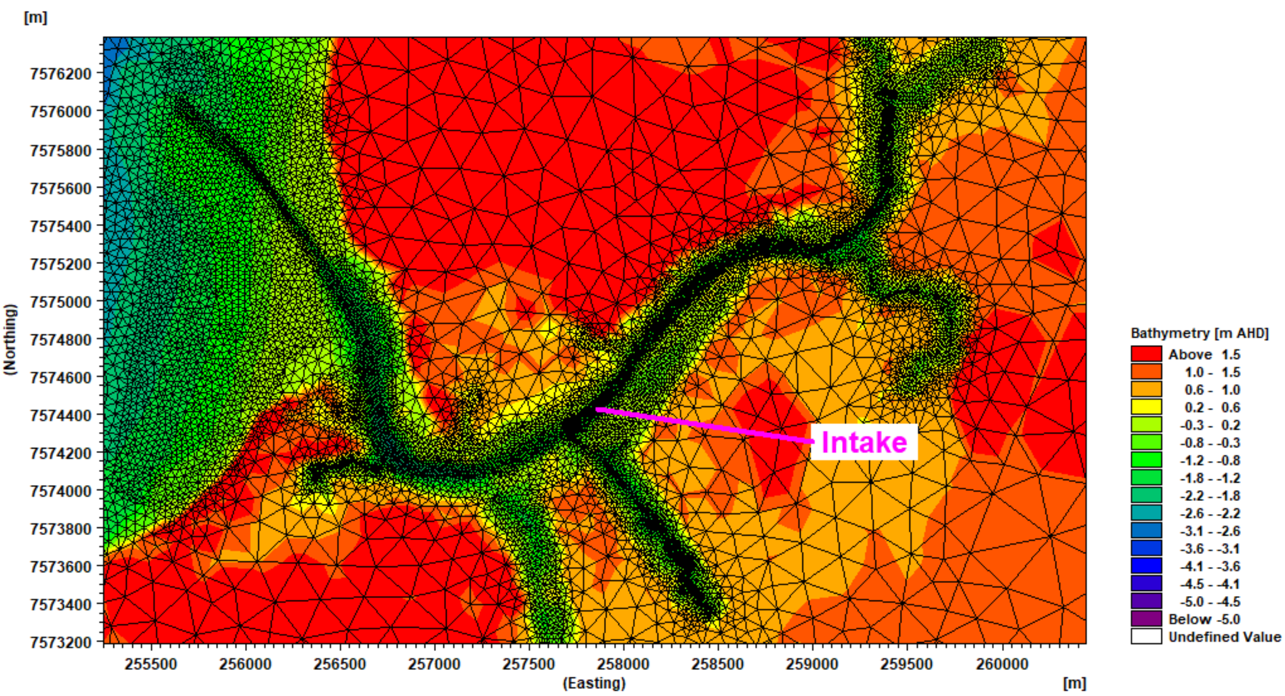

Figure 2-3 Model Mesh in Urala Creek South

3 RESULTS ASSESSMENT

Model results for the baseline conditions (seawater intake not included) and the scenario (seawater intake operating at peak December rates) were reviewed and are discussed in this section.

3.1 Water Level

Spatial variation of modelled water levels for the typical dry season conditions (as modelled for December 2015) for the baseline and the scenario have been prepared and presented in the following plots:

- Difference in maximum water levels over the modelled period for December 2015 (Scenario - Baseline) (Figure 3-1)
- Difference in minimum water levels over the modelled period for December 2015 (Scenario - Baseline) (Figure 3-2)
- Scatter plot of water levels at the seawater intake location for the baseline (x-axis) and the scenario (y-axis) (Figure 3-3)

The model results indicate a decrease in maximum water levels due to the intake, limited to the area within the creek, and limited to an absolute level of less than 0.05m. The model results also indicate minimum water levels can be up to 0.2m lower within the creek and creek entrance due to intake pumping. The impact of the intake is more notable on low water levels where the volume of water in the creek is lower and thus a higher proportion of water is taken up by the intake. This is also presented in the scatter plot of water levels at the intake location (Figure 3-3), where the impact of the seawater intake running at peak December flow rates on the water levels is more evident for low water levels.

As discussed in Section 2.2, water level calibration in Urala Creek South is poor due to the lack of recent bathymetric data at the creek mouth, limiting the tidal exchange of the creek with offshore waters. Although there is likely to be an impact due to the proposed sea water intake, the magnitude of this impact is affected by the limitation in the hydrodynamic modelling as a result of limited bathymetric data.

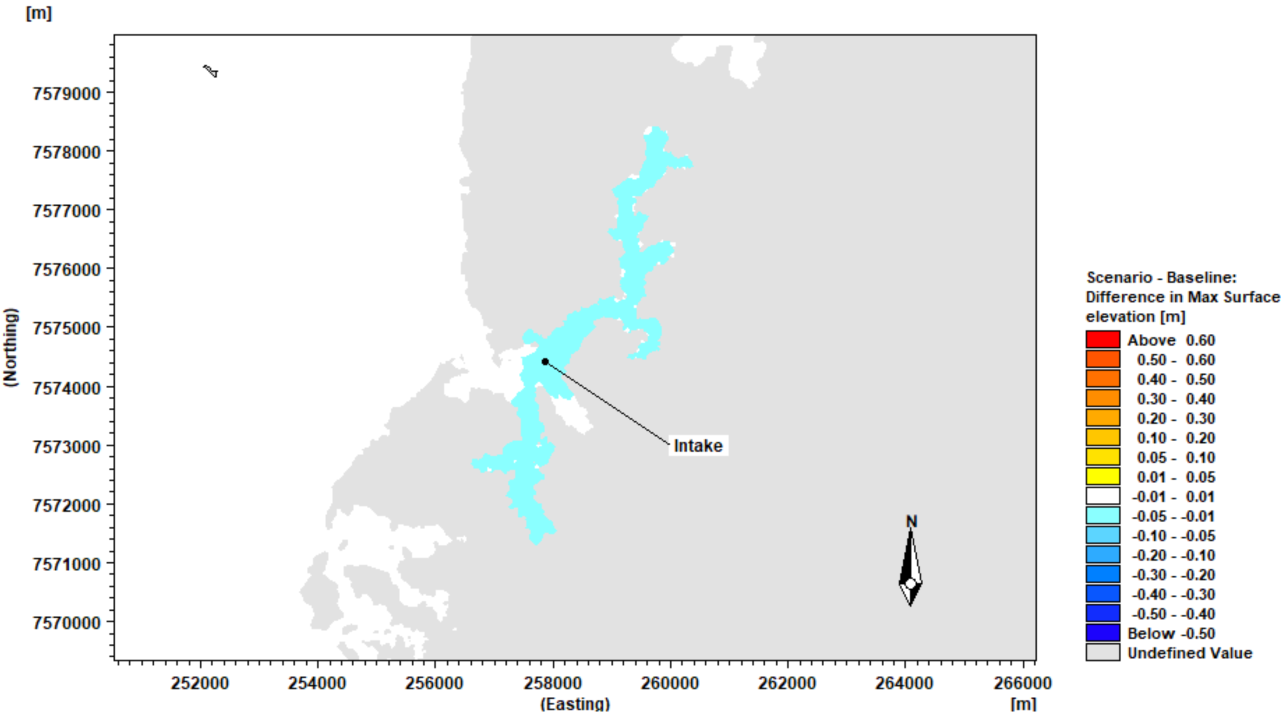

Figure 3-1 Difference in Maximum Water Level (Scenario – Baseline) during December 2015

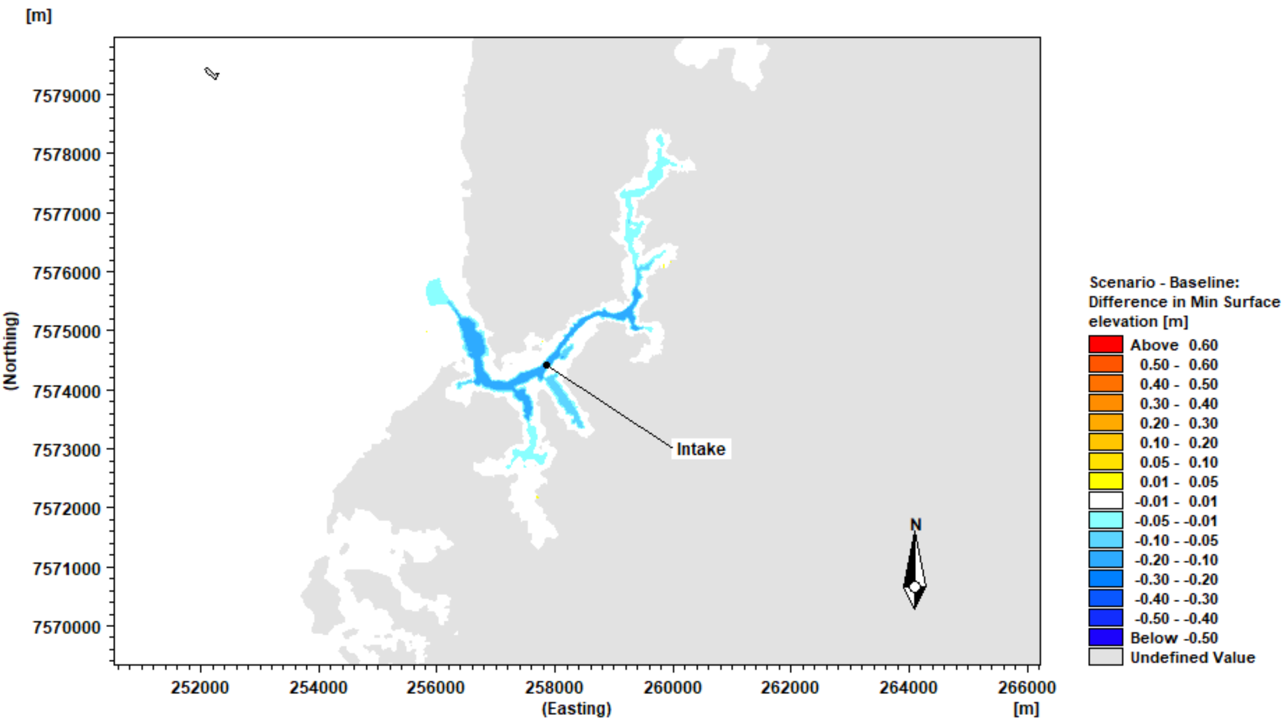

Figure 3-2 Difference in Minimum Water Level (Scenario – Baseline) during December 2015

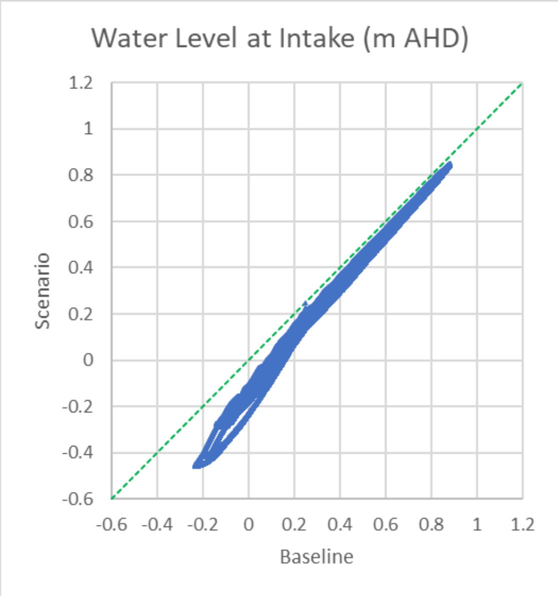

Figure 3-3 Scatter Plot of Scenario versus Baseline Water Levels

3.2 Discharge Flow in Urala Creek South

The impact of the seawater intake operating at peak December rates on the incoming (positive) and outgoing (negative) flow discharge rates (denoted by Q in m^3/s) was reviewed by extracting three discharge lines from the model results at locations shown in Figure 3-4, these are:

- Q1, at the creek mouth
- Q2, 250 m downstream of the seawater intake location, and
- Q3, 1km upstream of the seawater intake

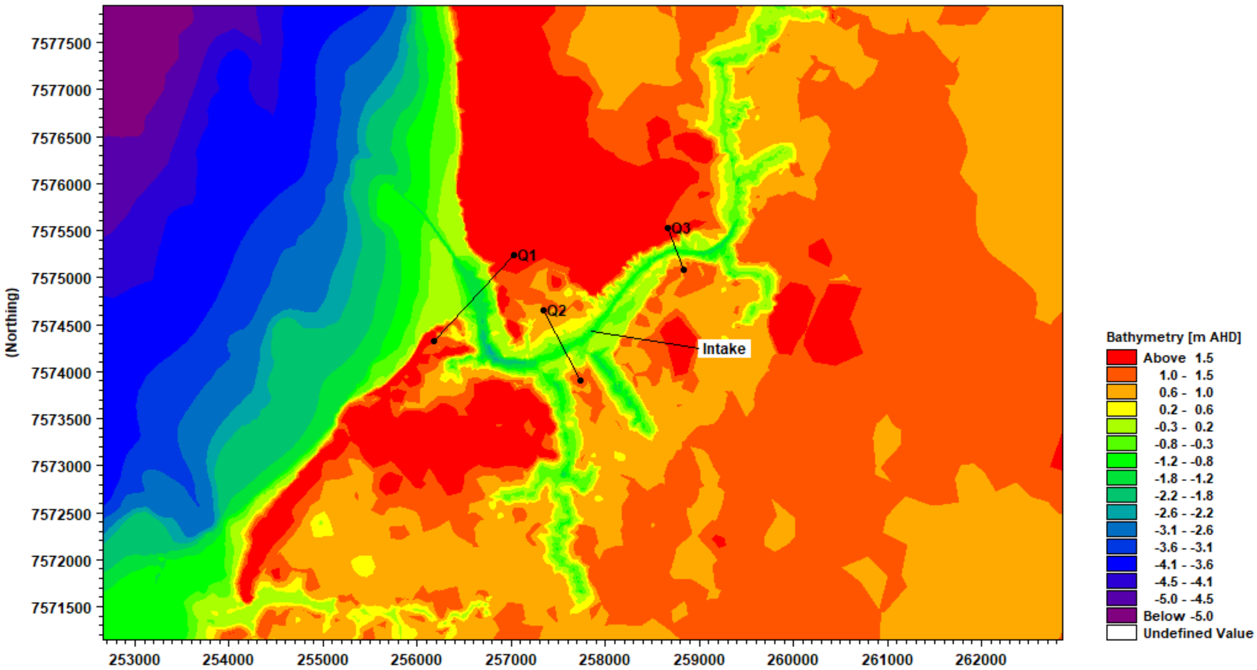

Figure 3-4 Location of the Discharge Lines

The following results are presented here:

- Scatter plots of discharge rate for the baseline (x-axis) in comparison with the scenario (y-axis) in Figure 3-5
- Timeseries plots of discharge rate at Q1, Q2 and Q3 in Figure 3-6
- Timeseries plot of difference in discharge rates (Scenario – Baseline) for Q1, Q2 and Q3 (Figure 3-7)

The model results indicate that the seawater intake increases the incoming discharge rate (during flood tides) and decreases the outgoing discharge rate (during ebb tides), as expected. The magnitude of this change varies based on the tidal level and is presented in Figure 3-7.

In order to quantify the impact of the sea water intake on discharge rates through the creek, 98th percentile discharge rate (i.e. close to the peak discharge) for each cross section is calculated for the baseline conditions. Additionally, 98th percentile difference in scenario discharge rates in comparison with the baseline is calculated. The proportionality of the differences as a result of the intake to the baseline conditions for each cross section is presented in Table 3-1 indicating that the largest impact in proportion to the baseline discharge rates is expected to occur in the vicinity of the seawater intake (Q2).

In the upstream sections of the creek (Q3), the discharge rates stay relatively unchanged, where the largest difference in discharge rates between the scenario and the baseline is less than 10% of the 98th percentile discharge rate of 46m^3/s.

Table 3-1 Comparison of Change in Discharge Rates at Q1, Q2 and Q3 against Baseline Conditions

Cross Section	Baseline: 98th Percentile Discharge Rate (m^3/s)	98th Percentile discharge Rate for "Scenario – Baseline"	% proportion of Change in Discharge Rate
Q1	162	24	15%
Q2	91	20	22%
Q3	46	4	9%

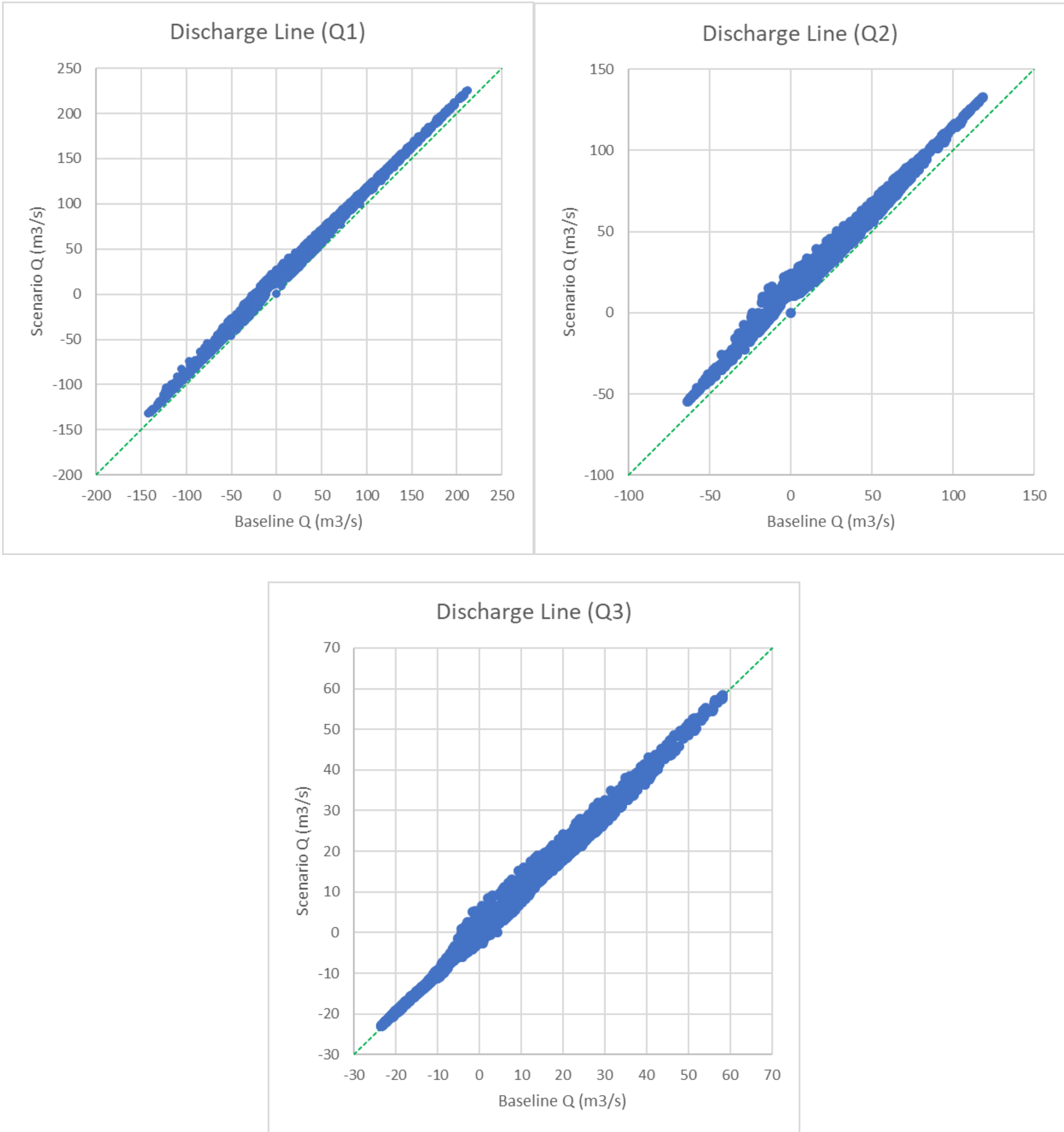

Figure 3-5 Scatter Plots of Discharge Rates in Urala Creek South

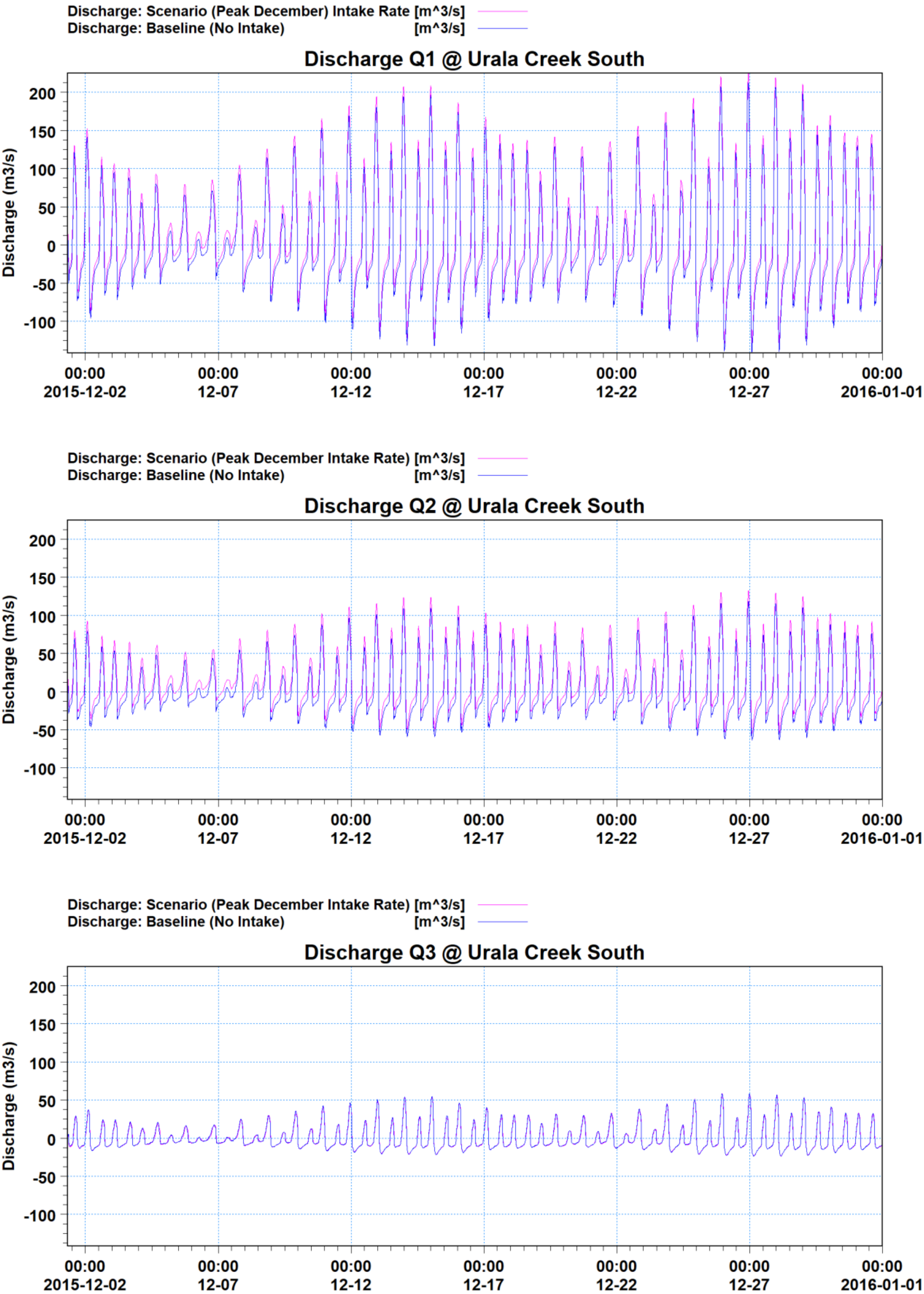

Figure 3-6 Timeseries of Discharge at Q1 (top), Q2 (middle) and Q3 (bottom) locations

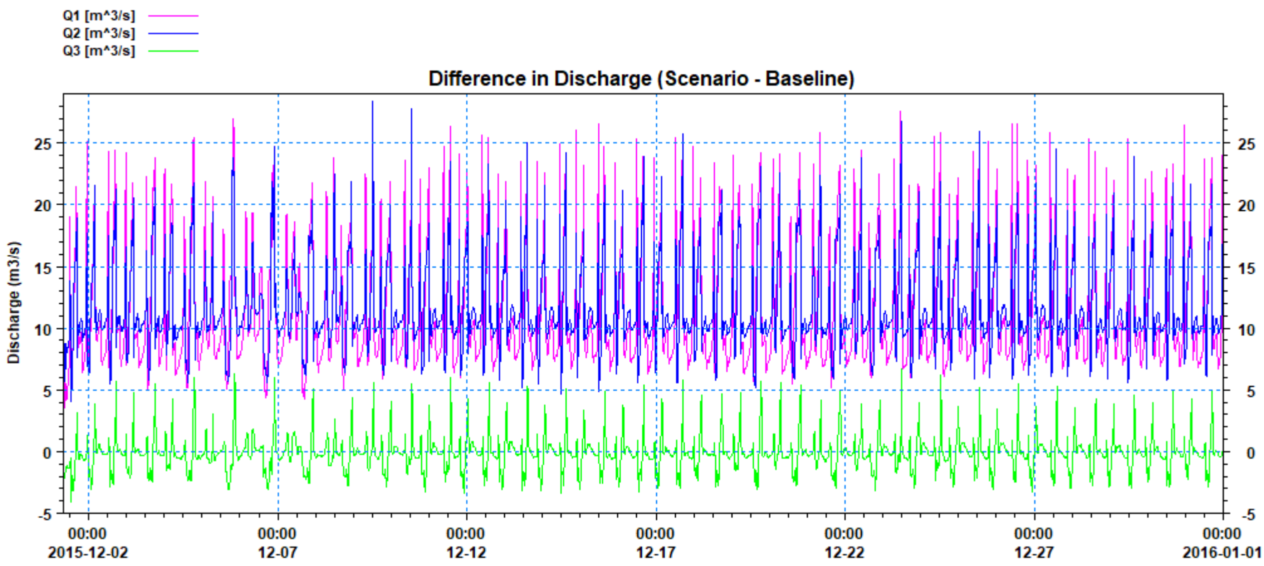

Figure 3-7 Timeseries of Difference in Discharge Rates for Q1, Q2 and Q3 (Scenario – Baseline)

3.3 Current Speed

The spatial variation of modelled current speed for the typical dry season conditions (as modelled for December 2015) for the baseline and the scenario are prepared and presented in the following plots:

- Peak flood currents
  - Baseline (Figure 3-8)
  - Scenario (Figure 3-9)
- Peak ebb currents
  - Baseline (Figure 3-10)
  - Scenario (Figure 3-11)
- Difference in statistical maximum current speed over the model domain for December 2015 (Scenario - Baseline) (Figure 3-12)

Peak flood current speed at the location of the seawater intake is approximately 0.7m/s for the scenario, which is 0.3m/s higher than the baseline peak flood current of 0.4m/s.

Peak ebb current speed at the intake location is approximately 0.4m/s, which is 0.2m/s higher than the peak ebb current for the baseline.

As illustrated in Figure 3-12, maximum current speeds in Urala Creek South and in the vicinity of the intake location are in the order of 0.1m/s higher during incoming (flood) tides when compared against the baseline conditions. Additionally, flood currents near the creek mouth are up to 0.3m/s higher when the seawater is operating at peak December rates.

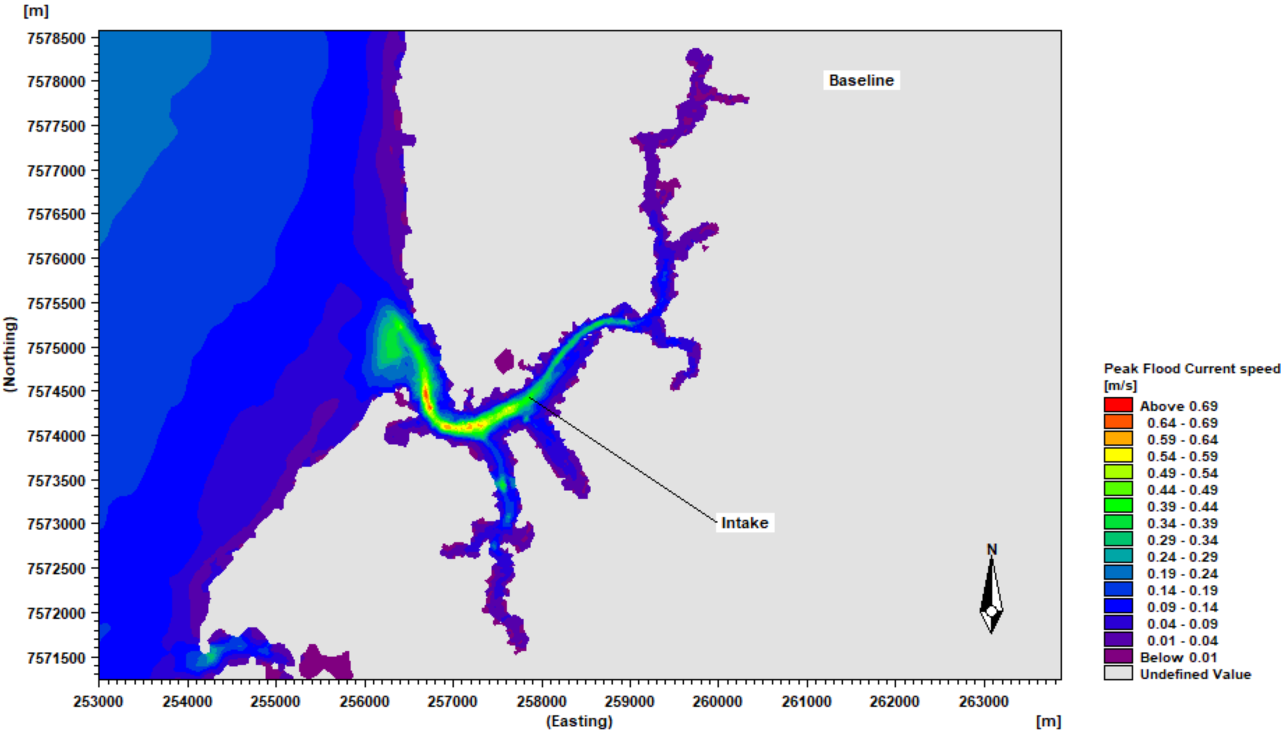

Figure 3-8 Baseline: Peak Flood Currents

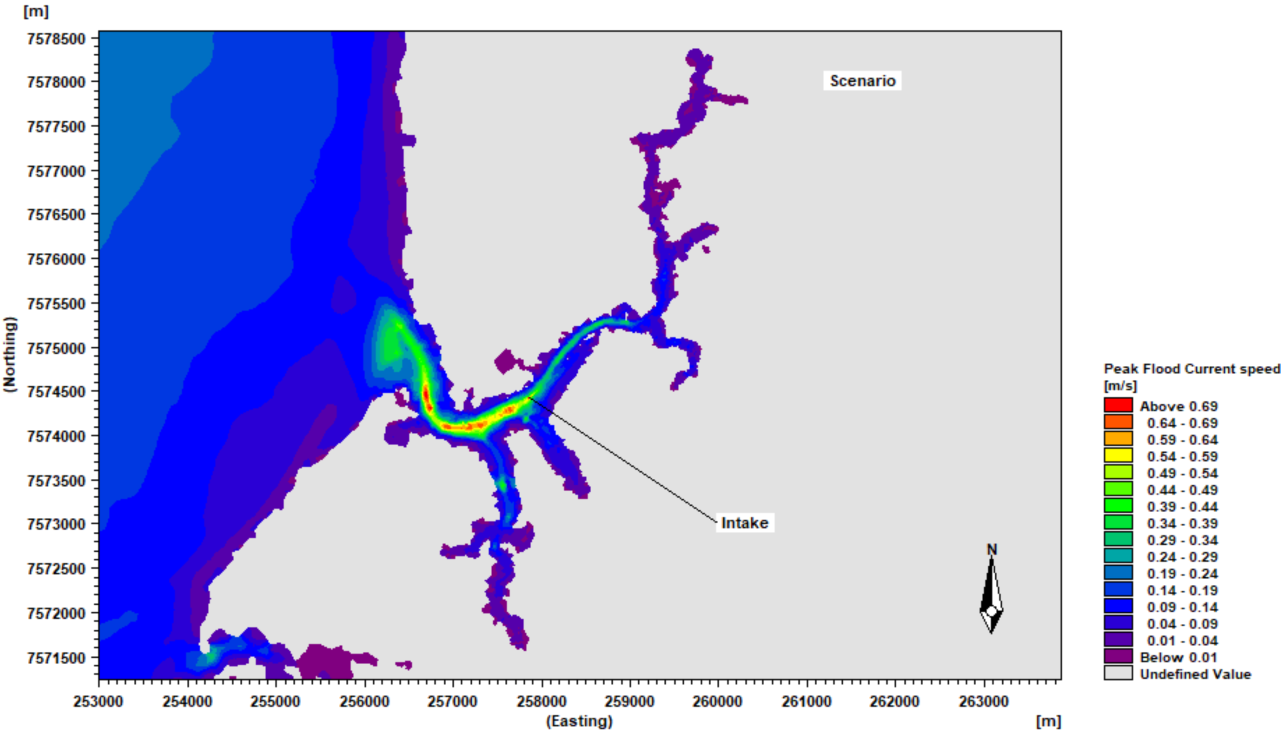

Figure 3-9 Scenario: Peak Flood Currents

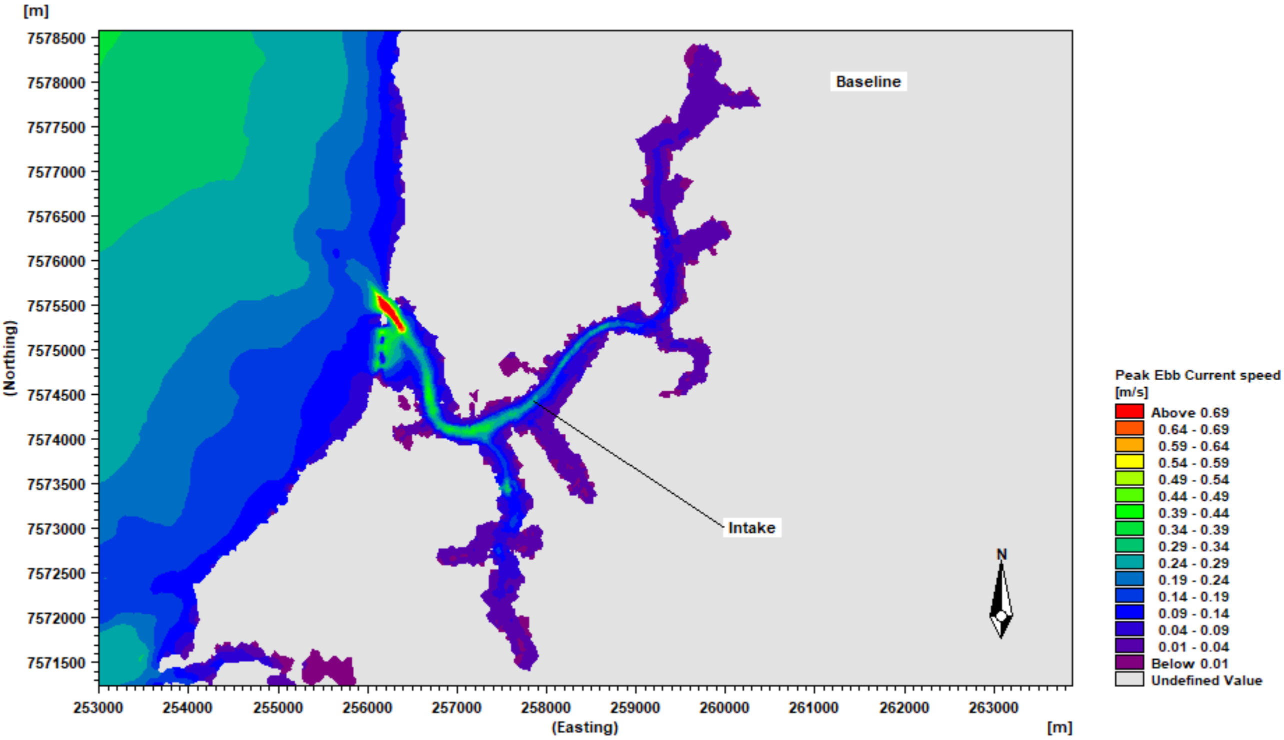

Figure 3-10 Baseline: Peak Ebb Currents

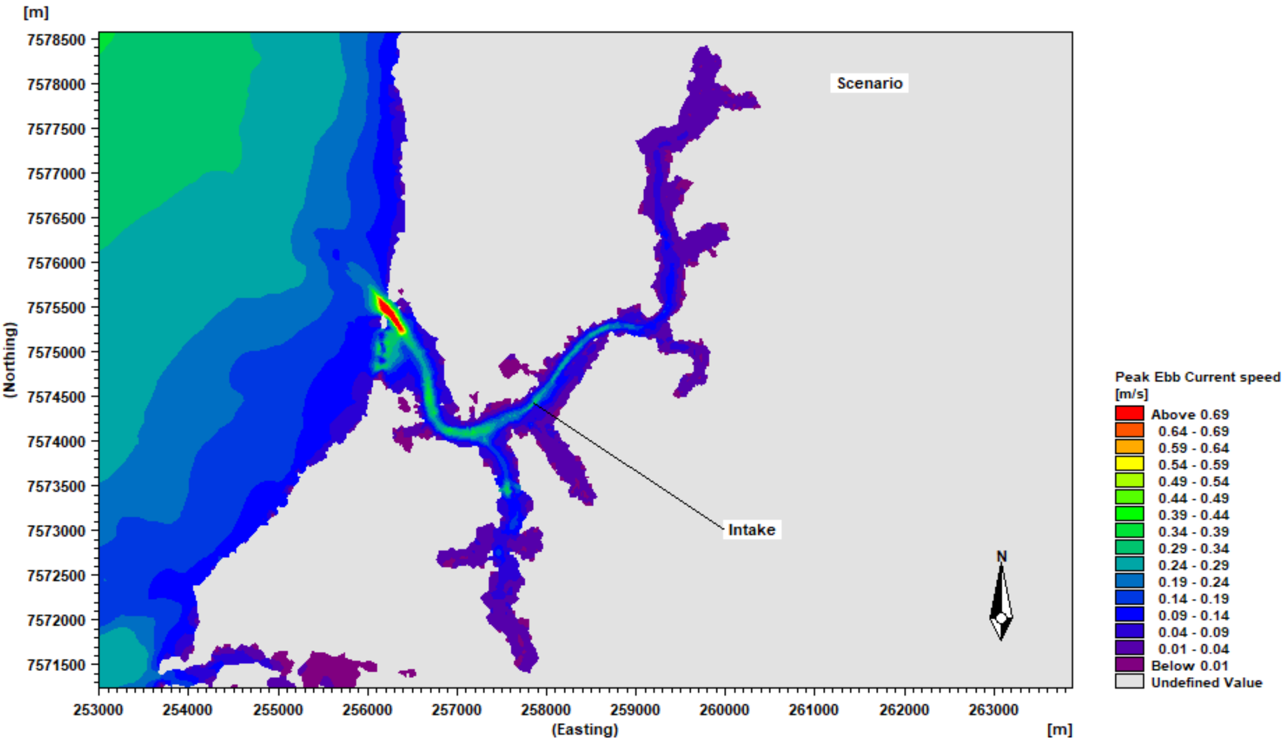

Figure 3-11 Scenario: Peak Ebb Currents

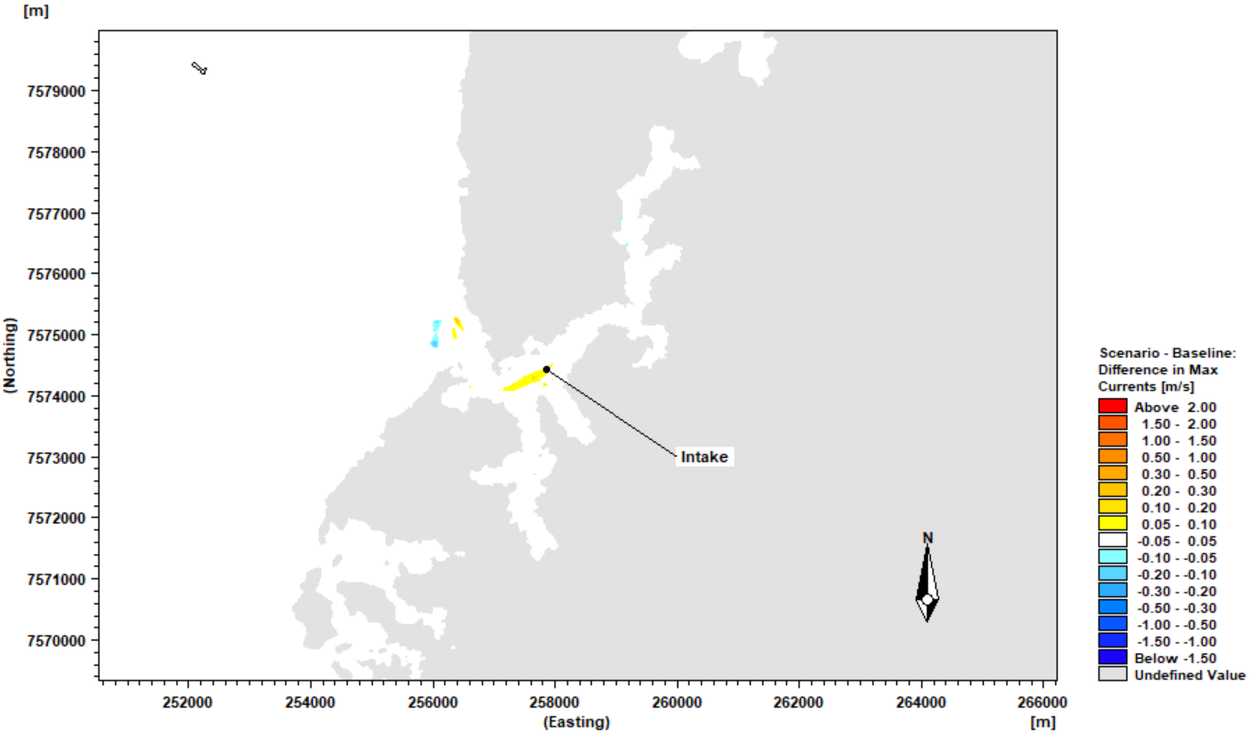

Figure 3-12 Difference in Maximum Currents (Scenario – Baseline) during December 2015

3.4 Bed Shear Stress

The change in maximum bed shear stress during December 2015 as a result of the operation of the seawater intake is presented in Figure 3-13. As expected, the patterns of increase and decrease of bed shear stress due to the intake is similar to that of the current speed (presented in Figure 3-12), with the maximum increase in bed shear stress being directly downstream of the intake as well as near the creek mouth. This is then linked to the change in the potential for scouring of the bed material discussed in Section 3.5.

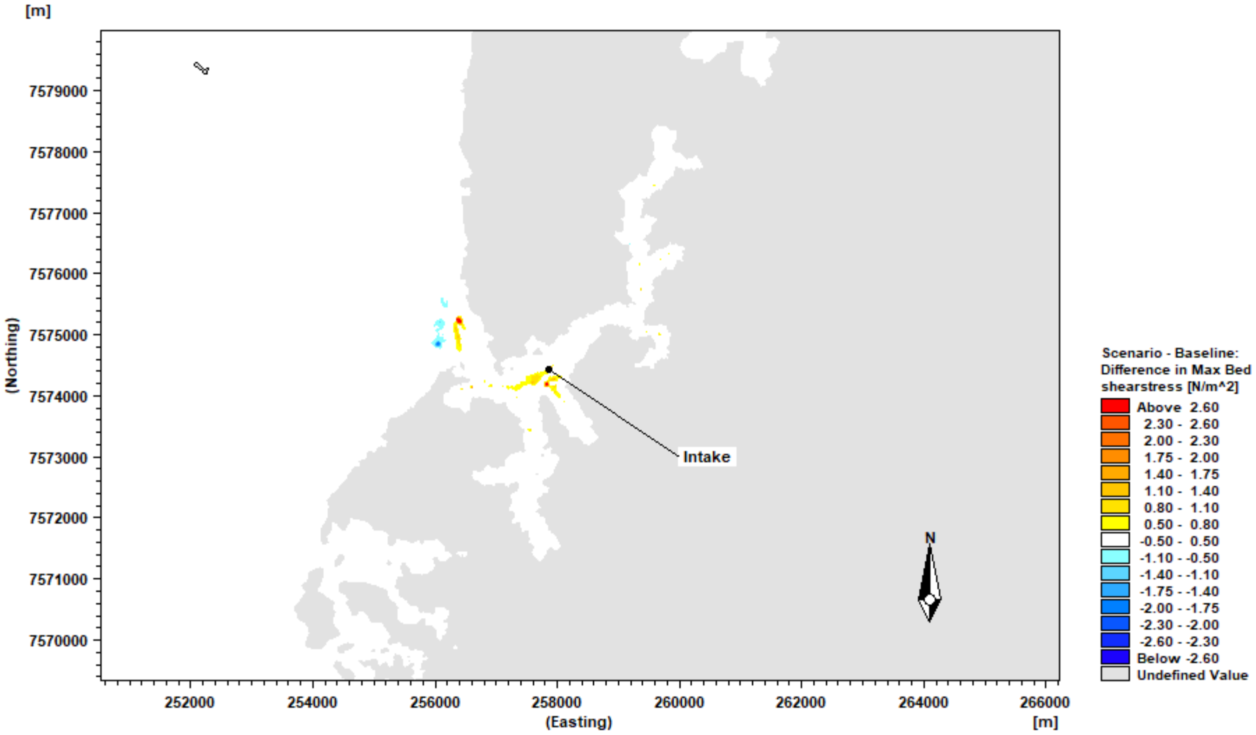

Figure 3-13 Difference in Maximum Bed shear Stress (Scenario – Baseline) during December 2015

3.5 Potential for Scouring of Creek Bed Material

With the increase in flow velocity in a channel, the potential for the movement of the bed material increases. The flow velocity at which this sediment movement is initiated is referred to as the threshold of motion. The equation to calculate this threshold of motion was provided in the existing conditions report (Water Technology, 2018). For this assessment, the zones where there is potential for scouring of the bed material in the model domain was calculated and spatial plots prepared for the following:

- Potential for bed scour during flood tides (potential scour zones indicated in red) for:
  - Baseline (Figure 3-14, top figure)
  - Scenario (Figure 3-14, middle figure)
  - Difference in scour potential between the scenario and the baseline conditions (Figure 3-14, bottom figure)
- Potential for bed scour during ebb tides (potential scour zones indicated in red) for:
  - Baseline (Figure 3-15, top figure)
  - Scenario (Figure 3-15, middle figure)
  - Difference in scour potential between the scenario and the baseline conditions (Figure 3-15, bottom figure)

The analysis of the results indicates the potential for scouring of the creek banks would be increased during the flood tides, whereas during ebb tides, the scouring potential slightly increases for the creek centreline near the intake location and the creek mouth. As noted previously, these findings are subject to the limitations resulting from the lack of recent bathymetric data at the creek mouth, causing uncertainty in model results in the Urala Creek South.

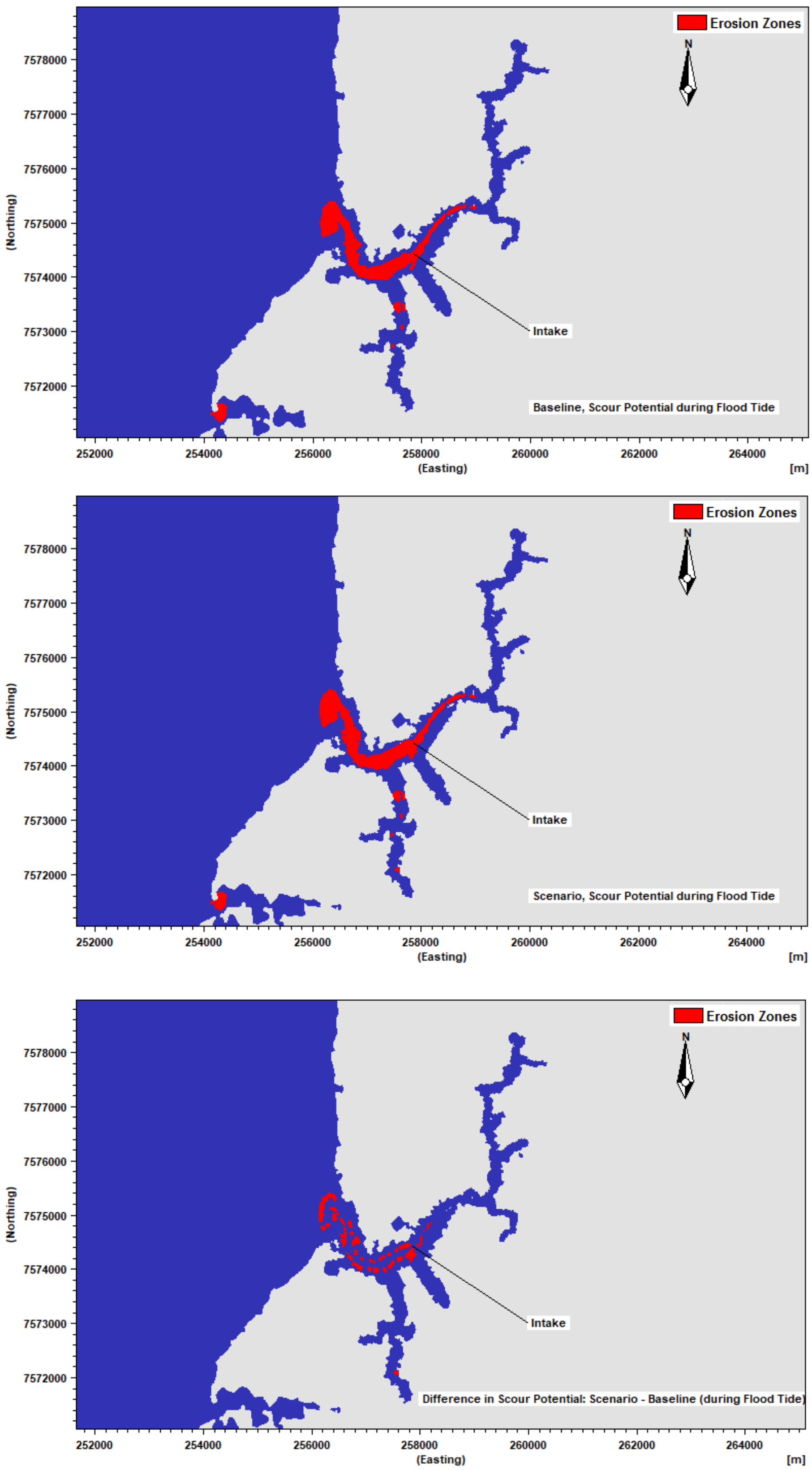

Figure 3-14 Potential for Scour for the Baseline (top) and Scenario (middle) during Flood Tide & the difference in Scour Potential

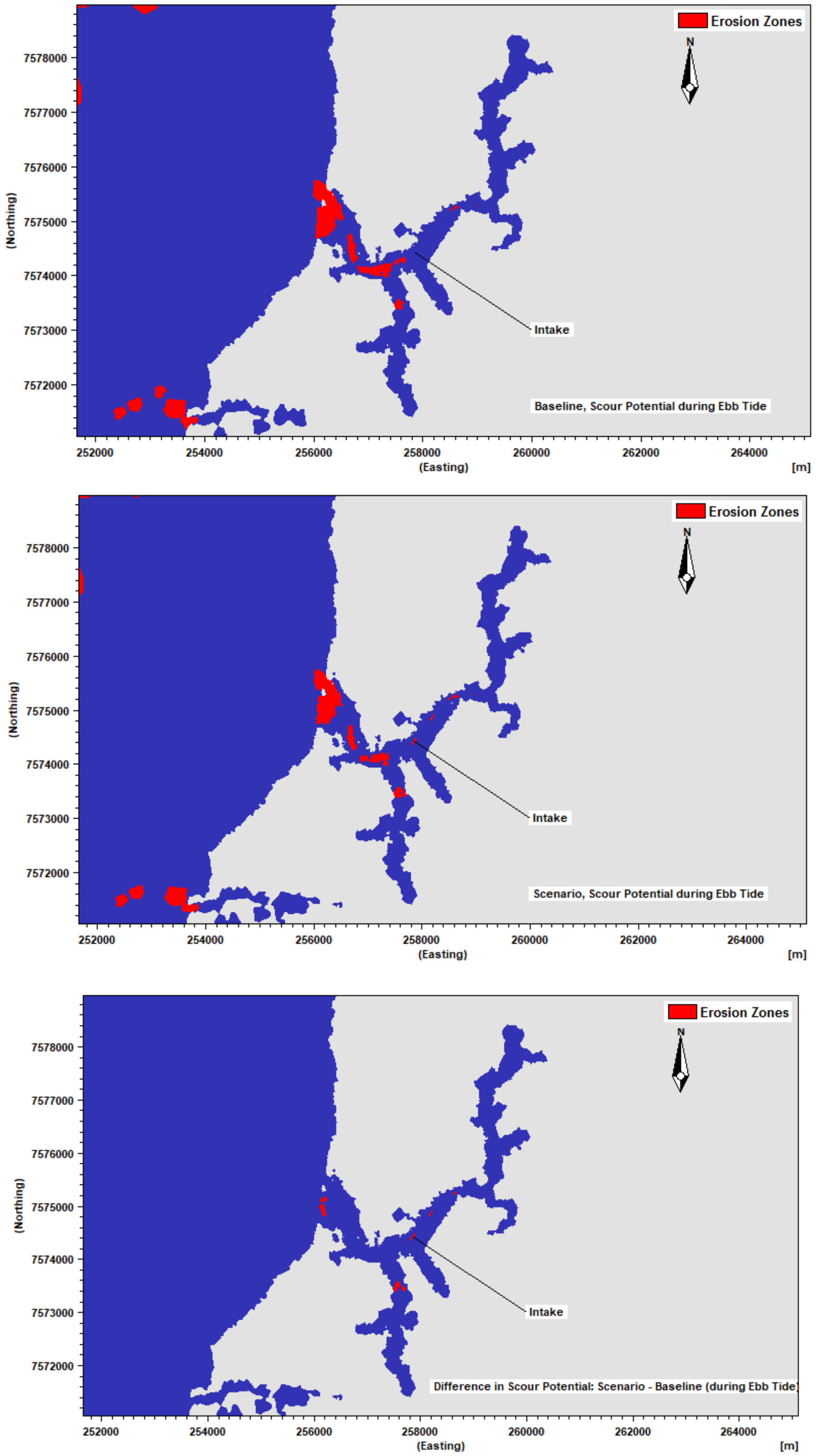

Figure 3-15 Potential for Scour for the Baseline (top) and Scenario (middle) during Ebb Tide & the difference in Scour Potential

4 SUMMARY

The potential changes in hydrodynamics within Urala Creek South and offshore of the creek mouth as a result of the seawater intake operating at peak December flow rate of 11.87 m^3/s has been assessed. The local hydrodynamic model was refined and simulated for the scenarios below:

- Baseline conditions (seawater intake not included)
- Scenario (seawater intake operating constantly at peak December rate of 11.87 m^3/s)

The following summarises the findings of this assessment:

- Water level
  - High tide levels in the creek are expected to be similar to the baseline conditions.
  - Low tide may decrease by up to 0.2m. It is noted that the extent of this change is limited to areas within the creek and just offshore of the creek mouth. As discussed in Section 2.2, modelled tidal exchange in Urala Creek South is limited due to the bathymetric features in the creek mouth which do not represent the recent bathymetric conditions. This in turn affects the magnitude of change due to the sea water intake, however, this preliminary assessment is sufficient to guide the prawn larvae sampling extent.
- Discharge flow
  - On a typical tidal exchange, the flow rate of seawater during flood and ebb tides in Urala Creek South is up to 200m^3/s. The peak December seawater intake of 11.87 m^3/s is roughly 6% of this tidal flow.
  - The model results at the location of Q3 indicate that upstream of the intake (Table 3-1) there is minimal change to the flow of seawater and thus the intake is having little impact on the upstream conditions.
  - The largest change in discharge rates is in the vicinity of the intake where the 98th percentile change in discharge rates is approximately 22% of the baseline (98th percentile) discharge rates.
  - The main change in flow rates across Q1 occurs during peak flood (incoming) tides.
- Current speed
  - It was found that statistical maximum currents over the model domain would increase by almost 0.1m/s in the creek, with 0.3m/s increase within 20m distance to the seawater intake location,
  - At the creek mouth, maximum currents would increase by up to 0.3m/s for the scenario.
- Bed shear stress
  - The increase in currents results in an increase in predicted bed shear stresses within the creek, as expected. This increase is limited to areas within the creek and the creek mouth.
- Potential for scouring of seabed material
  - Potential for scouring of seabed material is expected to increase locally in the vicinity of the seawater intake and the creek mouth. However present limitations in bathymetric data and model representation of the entrance channel and banks mean that the results here are preliminary only.
- It is noted that although bathymetric data for the Urala Creek South was provided to Water Technology and included in the model mesh, limited availability of recent bathymetric data at the mouth of the creek is considered a model limitation, introducing some uncertainty into the hydrodynamic model. Additional bathymetric data at the entrance to the creek mouth will provide greater confidence in the modelling results.

- Based on the above findings, a map is prepared indicating the potential zone of influence of the seawater intake on hydrodynamic conditions in the study area (Figure 4-1), corresponding to areas 1.3-1.4km offshore of the creek mouth. The areas recommended for the sampling of prawn larvae are therefore within Urala Creek South and up to 1.4km offshore of the creek mouth as indicated below.

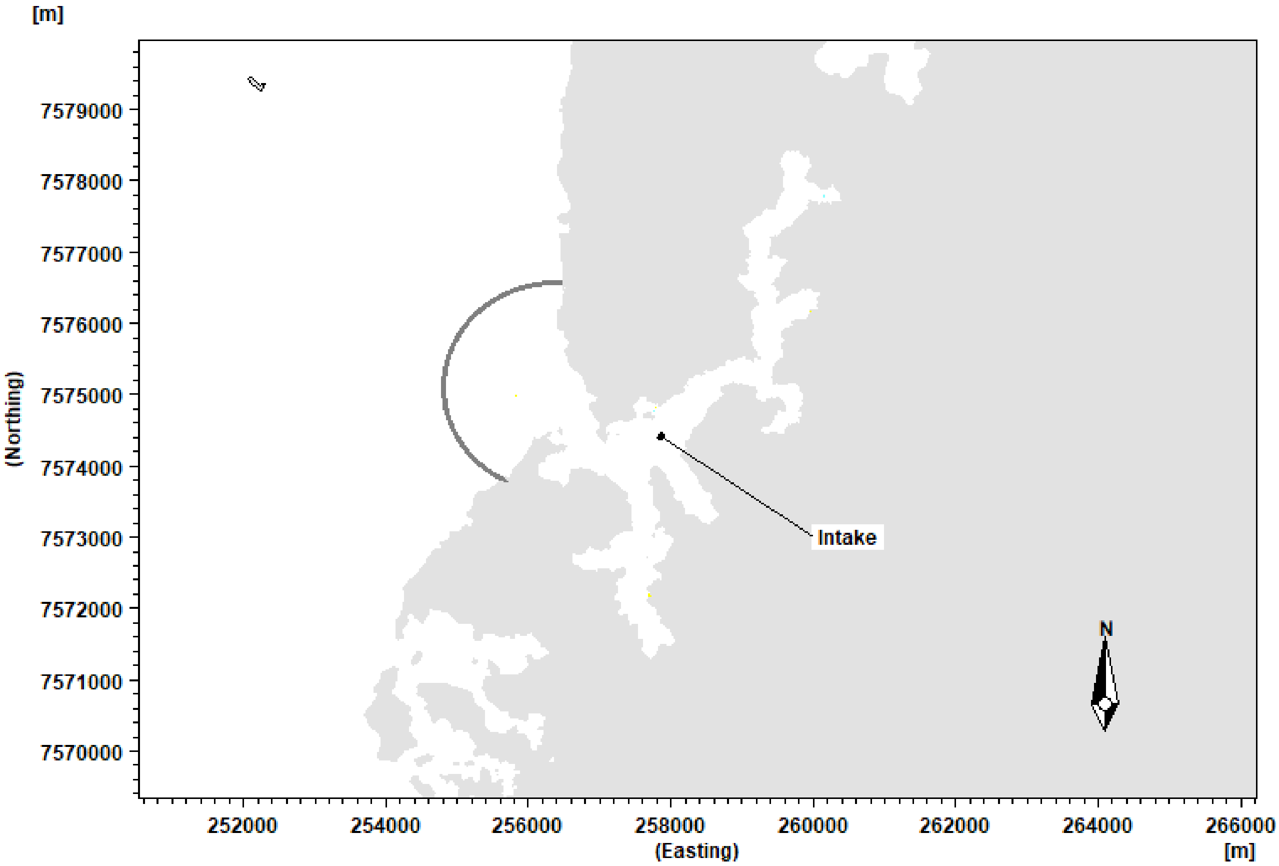

Figure 4-1 Zone of Seawater Intake Influence offshore of Urala Creek South

- It is recommended that additional bathymetric data and co-incidentally measured water levels and current speeds are collected in the vicinity of the creek mouth in order to improve model replication of the tidal exchange through Urala Creek South and therefore provide an improvement to the model calibration in this location.

5 REFERENCES

Arcadis (2018). K+S Ashburton Salt Project, Pre-Feasibility Study (PFS) – Pre-Feasibility Study (PFS) Design Report, Prepared for K+S Salt Australia, 7 May 2018.

Water Technology (2018). *Ashburton Salt Project – Pre-Development Coastal Environment Assessment*, Report from Water Technology prepared for K+S Salt Australia Pty Ltd, 13 January 2018