6. Assessment of Issues in the Estuary

6.1 Extent of estuarine reaches and background

The NOW submission suggests the Hunter Estuary can be broadly divided into four segments as follows: (refer Figure 6.1):

- **(A) Hunter River Tidal Pool.** The Hunter River upstream of Raymond Terrace including the Hunter River and Paterson River Tidal Pools (this 60km length of river supports over 200 licensed users and an unknown number of basic rights users – i.e. stock and domestic basic landholder rights.).
- **(B) Williams River Arm.** Raymond Terrace to Seaham Weir (an area currently impacted by reduction in the medium and low flows passing Seaham Weir and the weir itself).
- **(C) Raymond Terrace - Hexham Bridge**. Raymond Terrace to Hexham Bridge (this is an area of lesser oceanic influence where the freshwater/saltwater interface would normally occur as a result of cumulative flows from the Hunter and Williams Rivers).
- **(D) Hexham Bridge - River Mouth.** Hexham Bridge to River Mouth (a marine dominated area which experiences periodic freshwater flows). The Ramsar wetlands are connected to the estuary within this reach.

To provide a context for discussing the impacts of Tillegra Dam on the estuarine reaches and to address the issues raised in submissions it is prudent to provide some further background on the water flow, estuarine mixing and flushing processes that influence salinity variability within these four reaches.

The segments or estuarine reaches are shown in Figure 6.1 along with the variation in tidal prism and salinity concentrations, which essentially reduce with distance upstream from the mouth and a summary of the freshwater inputs to the estuary from the Hunter River at Greta, the Paterson River at Gostwyck and the Williams River at Seaham.

The physical estuarine processes that determine transport and mixing within an estuary are complex. The transport and mixing processes within the estuary are determined by physical form, tidal mixing, wind mixing, surface heating and cooling and freshwater flows. Accurate modelling of the water flow velocities and salinity concentrations require robust representation of these processes.

Across the submissions there appears to have been confusion about the relative impacts of the Williams River flows at various locations along the Hunter River Estuary. It is important to specify the location of the area of interest related to specific issues. This is required as the balance between the oceanic tidal processes, that energise the estuary from the ocean and the freshwater inflows, which energise the estuary from the catchment can vary substantially along the system.

In the following sections the relative contribution of the Williams River inflow to total freshwater flow in the Hunter River is estimated for each reach. Note that this relative contribution diminishes with increasing distance downstream of Seaham Weir.

This context and definition of reaches is used in the discussions of the following sections.

6.2 Summary of issues raised downstream of Seaham Weir

Numerous submissions raised concerns regarding the impact of Tillegra Dam on the Williams and Hunter Rivers downstream of Seaham Weir. The issues raised are summarised as follows:

- **Estuary modelling.** A number of submissions received during the exhibition process indicated that ELCOM modelling (steady state computational modelling) was unsatisfactory to inform the impacts assessment process. On this basis, submissions indicated that no confidence was held in the conclusions reached by Hunter Water that there would be no impacts to the Hunter Estuary. NOW expressed concern that the model was not adequately calibrated and did not adequately address the range of inflow conditions. (Section 6.2.1)

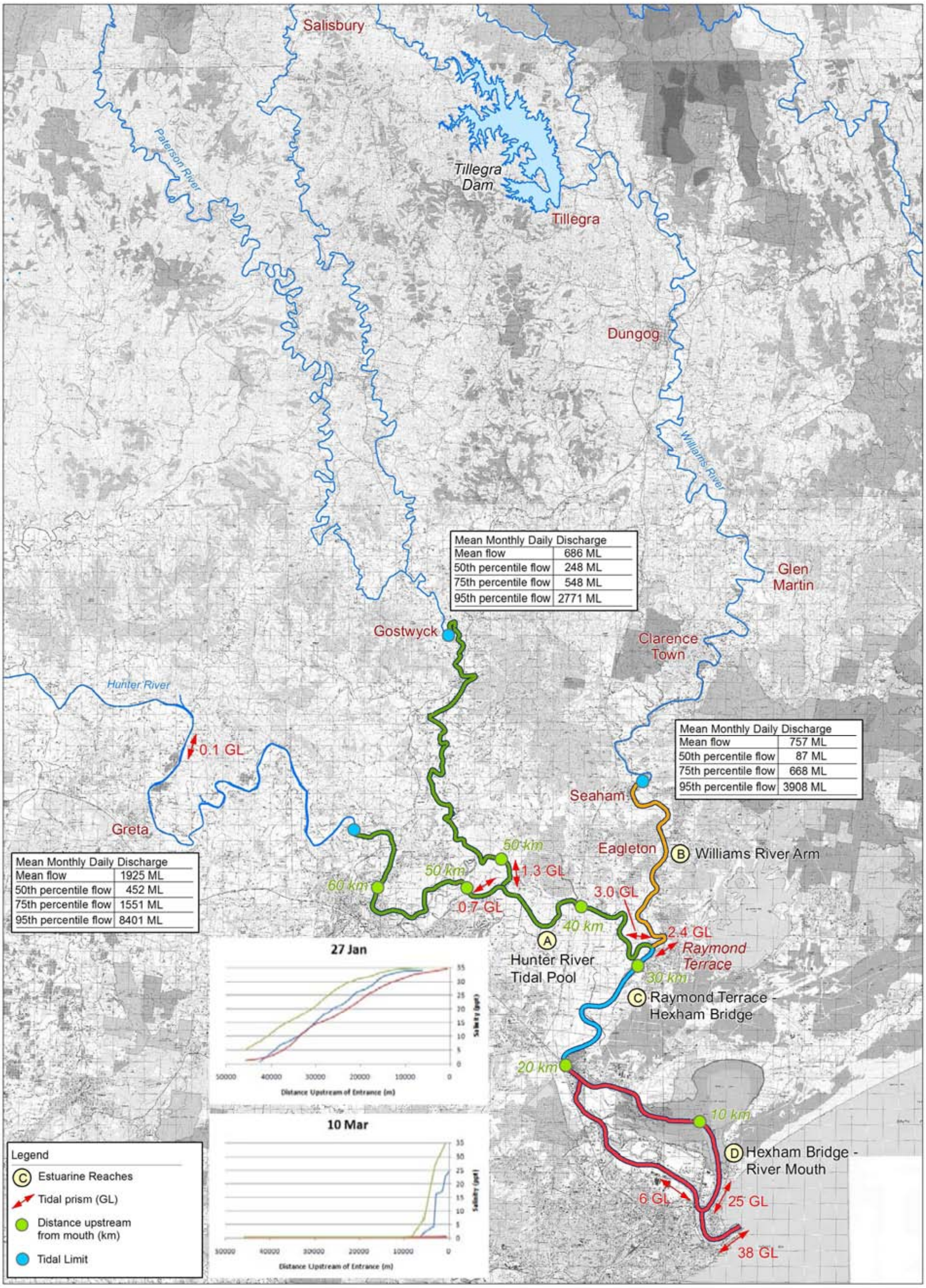

Figure 6.1 Estuarine reaches (Source: Manly Hydraulics Laboratory, 2003 and BMT WBM, 2010)

- **Hunter River Tidal Pool:** a number of submissions were concerned that Tillegra Dam would increase salinity levels and reduce the availability of water to irrigate from the tidal pool of the Lower Hunter and Paterson Rivers. Respondents thought further investigations into the relative contributions of the Hunter River and the Williams River to the Hunter River Tidal Pool was required (Section 6.2.2).
- **Williams River Arm:** submissions were concerned that the preferred environmental flow releases at Tillegra Dam would not flow downstream of Seaham Weir. Respondents were concerned that limited details were provided on the likely impacts of reduced flows on the lower reaches of the Williams River, for example changes in salinity and dissolved oxygen concentrations (Section 6.2.3).
- **Commercial fishing:** submissions were concerned that the reduction of freshwater flow to the Hunter Estuary would have flow-on impacts to the commercial fishing industry, in particular prawn catches (Section 6.2.4).
- **Climate change:** submissions suggested the reduction in freshwater flow would be further exacerbated by climate change or by increased demand for water use by upstream users and that further assessment should be undertaken (Section 6.2.5).

6.2.1 Estuary modelling

A number of submissions received during the exhibition process indicated that ELCOM modelling (steady state computational modelling) was unsatisfactory to inform the impacts assessment process. On this basis, submissions indicated that no confidence was held in the conclusions reached by Hunter Water that there would be no impacts to the Hunter Estuary. NOW expressed concern that the model was not adequately calibrated and did not adequately address the range of inflow conditions.

Computer model simulations of the estuary were carried out as part of the environmental assessment (refer Appendix 6) for Tillegra Dam to assess the sensitivity of the Ramsar listed wetlands to potential hydrological and water quality changes within Ramsar sites within the tidally dominated segment of the Lower Hunter River Estuary (BMT WBM 2009) some 40 kilometres downstream of Seaham Weir.

This modelling utilised the three dimensional (3D) hydrodynamic model ELCOM that explicitly resolves the vertical variations in water velocities and salinity concentrations deemed to be important processes for dispersion. Due to the computational complexity, however, this type of 3D model is only able to simulate relatively short periods of a few weeks. Hence the long term variability in salinity must then be inferred from model results simulating a few specific two week inflow scenarios. This approach demonstrated that Tillegra Dam would have negligible impact on salinity in the Lower Hunter River Estuary near the Ramsar wetland sites.

The model was calibrated against water levels and available salinity data and the NOW concerns related to the quality of calibration in the upper reaches, near the tidal limits, of the model domain have subsequently been addressed by WBM who provided additional clarification to NOW. The NOW concerns regarding the assessment of the temporal variability in salinity both near the Ramsar sites of the lower estuary and in the Hunter/Patterson Rivers Tidal Pool (upstream of the Williams river confluence with the Hunter River) have been addressed through additional modelling (BMT WBM, 2010).

Additional TUFLOW-FV Modelling

To address concerns relating to the adequacy of the original ELCOM modelling further modelling was undertaken. The additional modelling was used to determine the longer-term impacts of the proposed flow changes at Seaham Weir on the Hunter River Tidal Pool and broader estuary. Comparison of salinity and water levels in the Ramsar Wetlands was also provided to complement the ELCOM modelling undertaken for the EA Report.

The NOW commissioned development of a 2 dimensional (2D) depth-averaged TUFLOW-FV model of the estuary to assist in their assessment of a range of flow variations on salinity regimes in the estuary as part of the water sharing planning process. NOW agreed to allow HWC access to this 2D model to assess impacts on the salinity regimes at various locations around the estuary associated with different Tillegra Dam/Seaham Weir flow release scenarios and sea level rise scenarios. HWC supplied flow data at Seaham Weir on the Williams River. Model runs were undertaken for the period 1940 to 2007 but the primary focus was on the long dry decade (1940 -49) found to be the driest of the 67 years of daily river inflow data.

The model was run for a number of scenarios to determine salinity concentrations and water levels at key of interest in response to varying river inflows and tidal conditions. Modelling scenarios included the assessment of the following scenarios (BMT WBM, 2010):

1. Baseline/current conditions
2. Baseline/current conditions plus Sea Level Rise projection at 2020
3. Baseline/current conditions plus Sea Level Rise projection at 2050
4. Tillegra at 2050 demand (120 GL/yr). Tillegra releases transparent to 30%ile (100 ML/d), Chichester to 95%ile (20ML/d) and Seaham to 85%ile (20ML/d). Uses 1500ML/d tower and 100mm target freeboard at Tillegra
5. Tillegra at 2050 demand (120 GL/yr). Tillegra releases transparent to 30%ile (100 ML/d), Chichester to 95%ile (20 ML/d) and Seaham to 50%ile (100 ML/d). Uses 1,500 ML/d tower and 100 mm target freeboard at Tillegra
6. Tillegra at 2050 demand (12 0GL/yr). Tillegra releases transparent to 30%ile (100 ML/d), Chichester to 95%ile (20 ML/d) and Seaham to 85%ile (20 ML/d). Uses 1,500 ML/d tower and 100 mm target freeboard at Tillegra, plus provision of a 2.5 GL/yr Environment Contingency Allowance (ECA) for 10 days using a 'natural' pattern
7. Tillegra at 2050 demand (120 GL/yr). Tillegra releases transparent to 30%ile (100 ML/d), Chichester to 95%ile (20 ML/d) and Seaham to 85%ile (20 ML/d). Uses 1,500 ML/d tower and 10 0mm target freeboard at Tillegra, plus Sea Level Rise projection at 2050.

Results of the modelling are presented for the Hunter River Tidal Pool area upstream of Raymond Terrace and for the lower estuary areas related to the Ramsar wetlands sites. The model produces a salinity time series for the 10 year driest decade at each model mesh location (some 5,000 mesh points). Results at selected locations were extracted from the model output files and analysed statistically to allow comparison of the various scenario runs. A summary of the results is provided in the following sections.

Hunter River Tidal Pool Results

Salinity time series were extracted at 10 sites located within the proximity of licensed users of the Hunter River Tidal Pool. A 'spells analysis' was undertaken to characterise the salinity regime within the tidal pool for each of the seven model scenarios identified above. A 'spell' was defined as the time a particular threshold salinity (eg 1 ppt) is exceeded. Analysis results considered the number (frequency), magnitude (concentration), duration and period between high spells.

The following findings were noted for sites within the tidal pool area (BMT WBM 2010):

- The frequency of salinity spells exceeding 1 ppt (ie considered a medium salinity condition) within downstream reaches of the tidal pool, near the confluence of the Paterson River and Hunter River, is greater than other upstream locations (eg near Maitland and Woodville)
- A greater number of spell events exceeding 1 ppt within the tidal pool area occur under projected Sea Level Rise (SLR) conditions when compared to the baseline (existing) condition. SLR projections for the year 2050 result in more frequent high spells than that predicted for 2020 conditions
- The frequency of high spells for future scenarios under existing tidal boundary conditions, but different Williams River flow regimes, are comparable to the baseline (existing) scenario. This result is consistent across a majority of reporting sites assessed within the tidal pool
- The mean salinity of high spells for all future scenarios were consistent with baseline conditions and in some cases less. For sites situated in the lower reaches of the tidal pool near the confluence of the Paterson River and Hunter River, the average salinity during high spell events was greater, which is attributed to their proximity to downstream tidally driven variations of salinity
- SLR conditions were predicted to result in an increase to the average duration of high spells for some reporting sites when compared to the baseline conditions. The increase is, however, marginal and typically less than five days

- The average duration of spells was lowest for sites downstream of the Hunter River confluence where salinity was simulated to remain less than 1 ppt for a period of 50 days on average. The mean duration between high spells upstream of the confluence was approximately 100 days. Further upstream near Maitland and Woodville, the average duration between spells exceeding 1 ppt increases significantly to between 300 days and 450 days. Under Scenario 5 (ie 50%ile transparent flow at Seaham Weir), the average duration between spells reaches approximately 800 days near Woodville indicating that increased flow conditions at Seaham Weir may lower salinity for some upper reaches of the Paterson River when compared to baseline conditions.

Ramsar wetlands results

The model salinity results for locations downstream of Seaham Weir (Eagleton and Raymond Terrace) and near the Ramsar wetlands for the two Seaham Weir release strategies (Scenarios 4 and 5) are compared with the baseline conditions (Scenario 1) in Table 6.1.

Table 6.1 Statistical summary of salinity results

Reporting Site	Scenario 1/ Baseline		Scenario 4*		Scenario 5**	
	Avg Daily Max	Avg Daily Min	Avg Daily Max	Avg Daily Min	Avg Daily Max	Avg Daily Min
Eagleton	2.3	1.9	2.2	1.7	1.8	1.4
Raymond Terrace	6.7	3.6	6.6	3.5	6.4	3.4
Hexham	16.3	8.0	16.4	8.0	16.1	7.7
North Arm (upstream)	22.1	12.6	22.4	12.7	22.2	12.4
South Arm	25.0	19.1	25.2	19.3	25.1	19.4
North Arm (downstream)	33.6	22.5	33.7	22.8	33.7	22.6

* Seaham Weir transparent to 85th percentile (20 ML/d)

** Seaham Weir transparent to 50th percentile (100 ML/d)

Comparing results for scenario 4 (post Tillegra) with the baseline conditions indicates the salinity increase of up to 0.3 ppt salinity in the Lower Hunter River adjacent to the Ramsar sites and in the Williams River Arm a slight decrease of around 0.1 ppt salinity. This apparent dichotomy is explained by the change in flow regime at Seaham Weir and its relative impact on different locations within the estuary.

Scenario 5 introduces additional transparent release flows from Seaham Weir (up to 100 ML/d) that effectively means more low flows enter the Williams estuary than for current conditions and scenario 4. As such a further reduction in salinity in the Williams River arm of the estuary would be expected. In the lower estuary results would be similar to baseline or current conditions as increased low flows at Seaham are of less influence further downstream. These downstream estuarine reaches require high freshwater flows to counter the upstream salt propagation associated with the strong tidal mixing.

Conclusion

The additional modelling has re-affirmed the original ELCOM modelling results. The TUFLOW-FV shows that there would be negligible changes to the dynamic salinity structure of the estuary as a result of the project. In fact the modelling shows that there would be minor improvements to the Williams River arm of the estuary through additional water being made available to the environment through the proposed construction of a new vertical slot fishway at Seaham Weir.

In effect, the model demonstrates the previous work by Professor Finlayson to be correct in that the overriding control point for Williams River flows to the estuary is Seaham Weir. This control point exerts and substantively influences the types of flows that reach the estuary regardless of whether Tillegra Dam is constructed. Further, the portion of affected flows to the wider estuary from the Williams River is very small in comparison to all sources of water to the estuary.

6.2.2 Hunter River Tidal Pool

A number of submissions were concerned that Tillegra Dam would increase salinity levels and reduce the availability of water to irrigate from the tidal pool of the Lower Hunter and Paterson Rivers. Respondent's thought further investigations into the relative contributions of the Hunter River and the Williams River to the Hunter River Tidal Pool is required.

Downstream of the Williams and Hunter River's confluence changes to freshwater flows would be negligible and thus the availability of water and salinity levels would remain similar to the existing system. Results of the hydrodynamic modelling undertaken as part of the EA on the Ramsar listed wetlands in the Hunter Estuary (refer Appendix 6 to the EA Report) and the subsequent TUFLOW-FV modelling presented above (refer Section 6.2.1), demonstrate that the Tillegra Dam project has virtually no effect on the Hunter River Tidal Pool.

No significant impacts have been identified as a result of the proposal downstream of Seaham Weir, however, it is acknowledged that the existing flow impacts caused by Seaham Weir since the mid 1960s are a matter which would be addressed under the water sharing planning process.

Flows to the Hunter River Tidal Pool

To further assess the affect of Tillegra Dam on the flows to the Hunter River Tidal Pool the flow data for Hunter River and Paterson River gauging sites at Greta and Gostwyck, respectively, were extracted from the NOW Pinneena (Ver.9) database. These data were combined with the flows past Seaham Weir estimated by the HWC hydrology and water operations models. Flows past Seaham Weir were estimated for the existing and for the future preferred release regime at Tillegra Dam.

As the primary interest here is to gauge the impact on the tidal pool and particularly flushing, the daily flow data were aggregated to monthly mean daily flows at each site as shown in Figure 6.2. Denoting the data sets as:

- qGreta- for the flow at Greta on the Hunter River
- qGostwyck - for the flow at Gostwyck on the Paterson River
- qS Obs - for the flows at Seaham Weir on the Williams River for current flows
- qS 20 - for the flows at Seaham Weir on the Williams River for post dam flows (transparent releases to 20 ML/d at Seaham Weir)
- qH Obs - for the total flow entering the Hunter River Tidal Pool from the three arms of the river for current flows (calculated using the formula qH Obs = qGreta + qGostwyck + qS Obs)
- qH Post - for the total flow entering the Hunter River Tidal Pool from these three arms of the river post Tillegra (calculated using the formula qH Post = qGreta + qGostwyck + qS 20)
- qH Post F- for the total flow entering the Hunter River Tidal Pool from the three arms of the river post Tillegra during filling (calculated using the formula qH Post F = qH Obs – historic Tillegra flows)

The ratio of flow at Seaham to the total flow in the Hunter River Tidal Pool (qS/qH) for the current (qS Obs) and post Tillegra (qS 20) scenarios provides a measure of the likely reduction in flow to the estuary post Tillegra Dam as shown in Figures 6.2 and 6.3.

Results show that the relative contributions of the Williams River flows to freshwater flows to the Hunter River Tidal Pool are highly variable for the period 1985 to 2000 ranging between zero and 60%, however, on average the William River flows account for around 23% of the flow to the Hunter River Tidal Pool. It should be noted that total flow estimates into the Hunter River Tidal Pool are conservative as the runoff from a large area of catchment downstream of gauging stations have not been taken into consideration.

Figure 6.3 shows the monthly mean daily discharge for the Hunter River Tidal Pool plotted against the ratio of

Seaham flow to Hunter River Tidal Pool inflow for the pre and post Tillegra Dam scenarios. The figure shows little correlation between the two especially in higher flows when mean monthly discharge in the Hunter River Tidal Pool is greater than 1,000 ML/d.

Table 6.2 shows a range of statistics for the flows past Seaham and the flows to the Hunter River Tidal Pool pre Tillegra and post Tillegra Dam during standard operation and during the filling period. The results show that for monthly mean flows greater than the 5th percentile exceedence in the Hunter River Tidal Pool (16,204 ML/d) the flow to the Hunter River Tidal Pool would be reduced by around 1.5% during standard operation of the dam. For low flows (364 ML/d mean monthly flow) there would an increase in the freshwater input to the Hunter River Tidal Pool as additional releases would be made following the proposed construction of a new vertical slot fishway at Seaham Weir.

As the relative contribution of Williams River flow to the total Hunter River Tidal Pool flow would not be significantly reduced following operation of Tillegra Dam there would not be any changes to the dynamic salinity structure within the tidal pool and the estuary as a result of the project.

Flows to the Hunter River Tidal Pool during the filling period

To assess the affect of Tillegra Dam on the flows to the Williams and Hunter River Tidal Pool during the filing period it was assumed no flows would be released from the dam to provide a conservative estimate of the reduction in Williams River flows. In reality Williams River flows to the estuary are controlled by the operation of Seaham Weir. The weir was designed to primarily capture low flows and small freshes and prevent the ingress of salt into the original Williams River tidal freshwater pool and to allow high flows to past to the estuary to mitigate upstream flooding.

Hence it is not possible to directly assess the contribution of the Williams River flow at Tillegra to the total flow entering the Hunter River Tidal Pool during the filling period. A conservative estimate of the potential contribution may be derived by subtracting the historic Tillegra flow from the total Hunter River Tidal Pool inflow. This potential reduction is the maximum that may occur during the filling period if none of the water passing Tillegra was to flow to the tidal pool and ignores the proposed releases at Seaham.

Column 3 of Table 6.2 demonstrates that during the filling period when a significant portion of high flows at Tillegra would be trapped by the dam the maximal reduction in the total flow to the Hunter River Tidal Pool would be less than 7.1% for flows greater than the 25th percentile exceedence flow and less than 6% for the flows greater than the 5th percentile exceedence. At low flows there would be no change as the Tillegra Dam release strategy allows these low flows to pass through the dam.

It is acknowledged the reduction in flows would be exacerbated during the filling period as the dam would capture the majority of higher flows, however, this would still only represent a small decrease in total Hunter River Tidal Pool inflows.

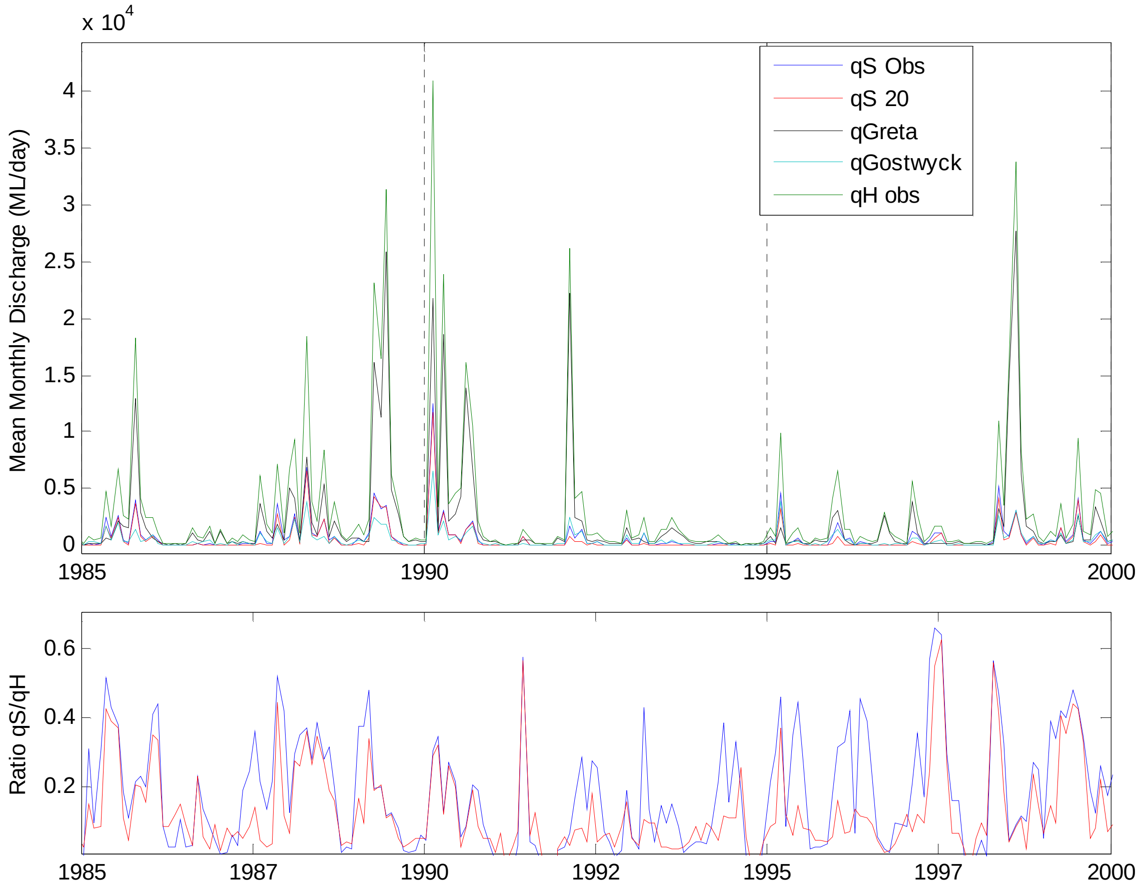

Figure 6.2 Mean monthly discharge (ML/d) for the Hunter, Paterson and Williams Rivers.

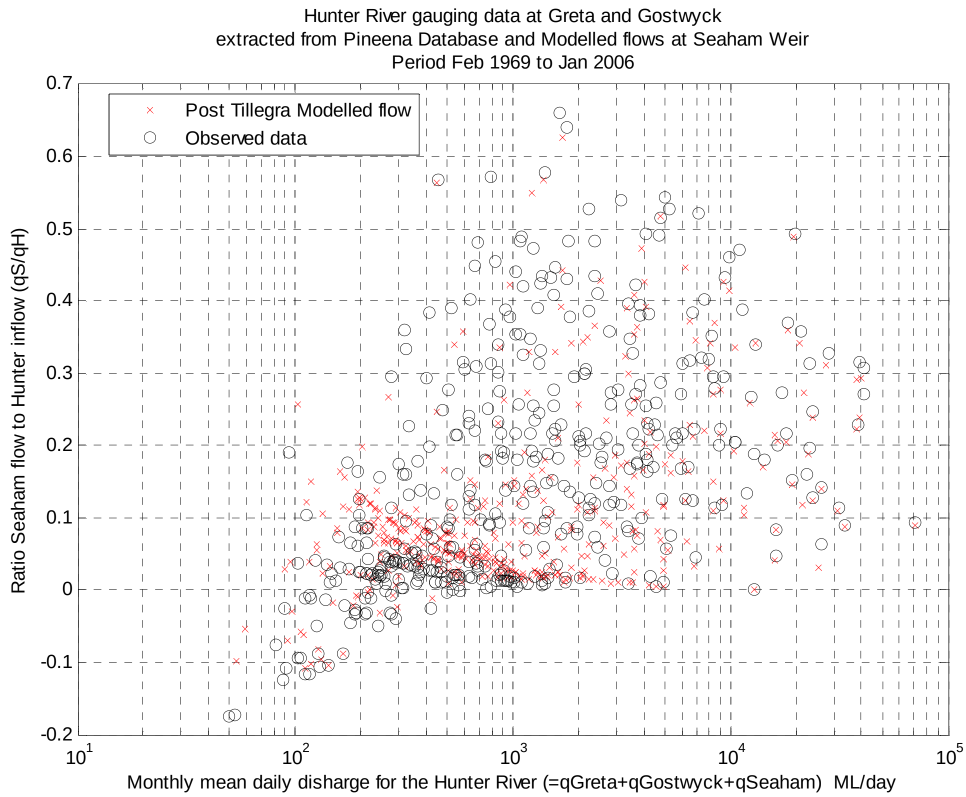

Figure 6.3 Mean monthly discharge (ML/d) for the Hunter River Tidal Pool against the ratio of Seaham Flows to the Hunter River Tidal Pool pre and post Tillegra Dam

Table 6.2 Statistical summary of flows past Seaham Weir to the Hunter River Tidal Pool

Hunter Tidal Pool *Monthly mean (ML/d)*	Pre Tillegra Dam		Post Tillegra Dam (Standard operation)		Post Tillegra Dam (Filling)	
	Hunter River Tidal Pool (qH obs)	Ratio Seaham (qS obs)/Hunter River Tidal Pool (q H obs)	Hunter River Tidal Pool total post Tillegra (qH post Till)	Ratio Seaham (qS 20)/Hunter River Tidal Pool post Tillegra (q H post Till)	Hunter River Tidal Pool post Tillegra Filling (qH post Till Fill)	Max reduction in flow to the Hunter River Tidal Pool
Mean of all flows	3302	23%	3145	18%	-	-
Mean of flows <75th percentile exceedence *(364 ML/d)*	222	2.9%	226	5.8%	-	-
Mean of flows >25th percentile exceedence *(2,841ML/d)*	10,677	23.8%	10,280	19.4%	10,015	7.1
Mean of flows >5th percentile exceedance *(16,204 ML/d)*	28,353	23%	27,827	21.5%	26,761	6.0

6.2.3 Williams River Arm

Submissions were concerned that the preferred environmental flow releases at Tillegra Dam would not flow downstream of Seaham Weir. Respondents were concerned that limited details were provided on the likely impacts of reduced flows on the lower reaches of the Williams River, for example changes in salinity and dissolved oxygen concentrations.

Flows past Seaham Weir

The environmental flow releases from Tilllegra Dam would essentially end up in Seaham Weir Pool and would either be extracted to Grahamstown Dam or passed over the weir to the Williams River Arm of the estuary.

Following construction and operation of Tillegra Dam at full demand, extraction from the weir pool would increase from aprroximately 30 GL/yr to 61 GL/yr. Annual mean flows to the Williams River Arm of the estuary would decrease from approximately 275 GL/yr to 216 GL/yr, representing a 20% reduction in freshwater flows.

It is noted that Seaham Weir already influences flows to the estuary, however, the current operation of the weir is in accordance with licence conditions. The licence requires HWC to operate the weir pool within specified levels. Water extraction from the weir pool via Balickera Canal to Grahamstown Dam is dependant on weir pool level and inflow rates. Following the construction of Tillegra Dam the operation of the weir pool and water extraction would be in accordance with licence conditions.

Modelling scenarios demonstrate that the overriding control point for flows to the estuary is Seaham Weir. This control point exerts and substantively influences the types of flows that reach the estuary regardless of whether Tillegra Dam is constructed. The existing flow impacts caused by Seaham Weir since the mid 1960's are a matter that would be improved through the water sharing planning process and review of the Seaham Weir licence requirements.

Section 8.13 in Working Paper A of the EA Report details the current operation of Seaham Weir. A summary is provided as follows. Currently freshwater flows past Seaham Weir into the Hunter Estuary are assumed to comprise gate releases, flow through the fishway, uncontrolled releases and additional losses (possibly from weir leakage). A hydrology study undertaken by HWC (HWC 2006), to determine the component flows into and out of the weir pool, show the modified flows across the study period (1 Jan 1999 to 30 Sept 2005) range from zero to around 55,000 ML/d. Weir outflow is around 10 ML/d when the gates are closed and up to 3,000 ML/d for brief periods (hours) when the gates are open. The 10 ML/d comprises 5 ML/d through the fishway and an additional 5 ML/d derived as a loss through the weir. It is assumed this loss flows through the weir as it is a semi-permeable structure.

The EA Report also presents several different flow curves for alternate discharge regimes which could be adopted for Seaham Weir (refer Section 6.7, Working Paper D of the EA Report) and provides a starting point for future negotiations regarding the releases past Seaham Weir. The new fishway proposed at Seaham Weir would improve connectivity between the weir pool and the estuary downstream as there would be a net increase in volume passed downstream. Flow through the fishway would be approximately 20 ML/d compared with the existing fishway which passes around 5 ML/d.

HWC acknowledge that further investigations into Seaham Weir releases needs to be undertaken which would inform the water sharing plan at a later date. Improvement in the operation of Seaham Weir is seen as a separate issue to the Part 3A assessment of Tillegra Dam.

A downstream monitoring program below Seaham Weir is incorporated into the Statement of Commitments detailed in Appendix 1 of the EA Report. Salinity, dissolved oxygen, nutrients, and other physico-chemical parameters will be monitored to determine baseline conditions which will inform the environmental release strategy for Tillegra Dam and Seaham Weir.

Predicted impacts

Subsequent to the EA assessment modelling of salinity concentrations in the Hunter Estuary, including the Williams River Arm was undertaken (BMT WBM 2010). Results indicate salinity concentrations at Eagleton (approximately in the middle of the Williams River Arm of the estuary) would be slightly less under a number of proposed flow scenarios at Seaham Weir when compared to the existing case (refer Table 6.3). Scenario 1 represents current conditions while Scenario 4 represent transparent releases to the 85th percentile (20 ML/d) and Scenario 5 represents transparent releases to the 50th the percentile (100 ML/d).

Table 6.3 Salinity concentrations at Eagleton under selected model scenarios

Reporting Site	Scenario 1		Scenario 4*		Scenario 5**	
	Avg Daily Max	Avg Daily Min	Avg Daily Max	Avg Daily Min	Avg Daily Max	Avg Daily Min
Eagleton	2.3	1.9	2.2	1.7	1.8	1.4

* Seaham Weir transparent to 85th percentile (20 ML/d)

** Seaham Weir transparent to 50th percentile (100 ML/d)

The potential decrease in salinity would result from an increase in the occurrence of low flows into the estuary when compared to the existing situation. Weir outflow would increase from 10 ML/d to 20 ML/d following construction of the new fishway.

The downstream monitoring program from Seaham Weir would focus on the area approximately 500 metres downstream of Seaham Weir as well as to the confluence of the Williams and Hunter Rivers as any observed impacts would be exacerbated in this reach. Further detail of the proposed monitoring program is provided in Section 9.

Management of Seaham Weir

Hunter Water has currently committed to releasing fully transparent flows from Tillegra Dam for 70% of the time on an annual basis. Outside of this time, flows would still occur however they would be capped at 100 ML/d, unless a transfer of water is made between Tillegra Dam and Grahamstown Dam. Effectively all low and moderate flows entering the dam would be released as soon as they occur upstream. High flood flows would be captured and stored for release after the event has occurred. The water from these flows would however still be released to the river at some stage (during transfers) and would therefore provide an environmental benefit to the river (refer Section 4.3.3 for further information on the preferred release strategy at Tillegra Dam).

Seaham Weir is currently managed in accordance with current licence requirements. It has been shown that the overriding control point for flows to the estuary is Seaham Weir and that the weir significantly influences the flows to the estuary regardless of whether Tillegra Dam is constructed. The existing flow impacts of Seaham Weir would therefore be addressed through the water sharing planning process.

In addition to the preferred release strategy at Tillegra Dam Hunter Water would commit to ongoing discussion with NOW and I&I NSW regarding the management and operation of Seaham Weir. These commitments include:

- Additional modelling of flow scenarios for the full hydrological time series for the Hunter, Patterson and Williams River in consultation with NOW and I&I NSW
- Improvement in the connectivity between the Williams River and the estuary by performing an upgrade of Seaham Weir. This will occur through the construction of a vertical slot fishway which would also increase movement of water between the weir pool in the low flow class, by about 20 ML/d.
- An additional minimum release of 2,500 ML/yr at Seaham Weir. This volume of water will be held in the dam as an environmental contingency allowance (ECA) to mitigate any unforeseen impacts on tidal pool irrigators, commercial fishermen or the Ramsar wetlands. This provides a significant safety factor in the management of environmental flows to the estuary.

This dedication is comparable to other ECAs held with NSW State Water storages for use for environmental flow purposes. For example, Lostock Dam on the Paterson River currently holds an allocation of 2,000 ML of water for use for critical environmental events.

Conceivably the water could be used to increase transparent or translucent flows across Seaham Weir, or through its release as a flushing high flow event. Hunter Water will take the advice of both government agencies to ensure that the ECA provides the best outcome for the river, wetlands, the estuary and as a consequence for the community.

Currently, the *NSW Water Management Act 2000* provides for an adaptive management approach to be taken for water resource use and sharing. Hunter Water commits to continue working within this framework to ensure that the environmental health of the Williams River is maintained. The commencement dates for the ECA, the operational rules for release, carry over provisions and general management arrangements would be incorporated into the HUAWSP.

6.2.4 Commercial fishing

Submissions were concerned that the reduction of freshwater flow to the estuary would have flow-on impacts to the commercial fishing industry, in particular prawn catches.

The impacts of reduced freshwater flows to the estuary have been addressed through the application hydrodynamic models as described in Section 6.2.1. Results show there are no detectable changes to the dynamic salinity structure of the estuary as a result of the project.

A study on the influence of rainfall on the distribution and abundance of the School Prawn was undertaken by Ruello (1973) which correlated total annual rainfall with prawn catch (not seasonal) and concluded that the observed correlation is the result of the cumulative effect of annual rainfall on prawn reproductive potential, recruitment, growth and survival. Of those effects, growth would not be directly influenced by increased river flow in the cooler months, because prawns do not grow during these months. There is little else that can be isolated in terms of effects of seasonal flows as separate from cumulative flows.

The likely reduction in freshwater flows to the estuary as a result of the project is shown in Figure 6.2. The contribution of the Williams River to total Hunter freshwater flows would be reduced on average by around 5% following operation of Tillegra Dam. There would be little change in the inter-annual variability in flows.

Additionally as noted in Table 6.2 the monthly mean flows greater than the 5th percentile exceedence in the Hunter River (16,204 ML/d) would be reduced by only 1.5% as a result of the project. It is noted also there would be minor improvement to estuary end of system flows through additional water being made available to the environment through the proposed construction of a new vertical slot fishway at Seaham Weir.

Given the proposed reduction in freshwater flows downstream of the Williams and Hunter River's confluence there is not expected to be a detectable impact on the commercial fishing industry.

6.2.5 Climate change

Submissions have suggested the reduction in freshwater flow would be further exacerbated by climate change or increased demand for water use by upstream users and that further assessment should be undertaken.

Climate change modelling by the DECCW is insufficiently developed to reliably predict climate change effects on a localised scale as noted within the EA Report. Hunter Water considers that the existing assessment of a 10% reduction in rainfall and its influence on determination of catchment yield, which incorporated comprehensive sensitivity testing considering a range of factors including rainfall variability (refer Section 3) is adequate for planning purposes. The yield estimates formed the basis for development of the preferred environmental flow release strategy.

As part of the sensitivity analysis for the ELCOLM modelling work (refer Section 4.2, Appendix 6 to the EA Report) climate change scenarios were included in the investigations to demonstrate relative changes to water level and salinity as a result of increases to mean sea level. Additional TU-FLOW modelling included assessment of the sea level rise projections at 2050 for the pre and post Tillegra Dam flows. Results demonstrate that the impact of sea level rise on salinity in the estuary is much greater than the effects of any changes to flow associated with Tillegra Dam.

Issues realting to increased demand for water by other users with the Hunter River catchment and any subsequent information relating to climate change that becomes available would be managed through the water sharing process.