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Tamar Lake Feasibility Studies
Final Report – Part 2

Environmental, Technical, Economic and Funding Studies

September 2017

This unretouched photo by Jim Collier, was taken shortly after the Trevallyn Dam was emptied down the Gorge for maintenance purposes, and shows what Tamar Lake would look like if implemented.

Tamar Lake[1]

The ONLY solution to the Upper Tamar sediment accumulation and water turbidity problem

Tamar Lake Inc. believes Launceston and the Tamar Valley community deserves a clean, green, silt free and low turbidity waterway from Low Head to Launceston. It has determined in this study that the Tamar Lake strategy is the only economic solution to the current high rate of sediment accumulation, muddy turbid waters and low water quality in the Upper Reaches.

1.0 Introduction

The natural environment and Colonel Paterson have dealt Launceston a card that is no longer palatable to the Launceston community.

By siting Launceston at the confluence of the Tamar and North and South Esk Rivers, Colonel Paterson may have solved his drinking water problem, but he also subjected the city to the 6000-year history of silt accumulation around the head of the Tamar – Inveresk, Glebe flats etc. are all silt beds built up over those 6,000 years.

The hydrodynamic processes of the tidal Tamar Estuary ensure that any silt or pollutants entering this confluence from the North and South Esk catchments, will tend to migrate to the area we now call Home Reach and the Yacht Basin at the head of the Tamar.

These natural processes, flocculation[2] and asymmetrical tidal flows, cause the fine particle silt entering the Tamar through the Cataract Gorge, Tailrace, and North Esk to flocculate (form flocs of "mud") in the mixing zone from Tamar Island to Freshwater Point (where the salt concentration in the marine waters is of sufficient strength to cause flocculation), which is then "pumped" upstream by the asymmetrical tidal action into the Lower North Esk, Home Reach and Yacht Basin areas.

European settlement has exacerbated this natural process by reducing the tidal prism with built infrastructure around Home Point, and because of poor land management practices in the catchments.

A history of dredging and raking from the 1880s to today have not made any permanent impression on the volume of silt stored in the Lower North Esk/Home Reach/Yacht Basin area, and in the Upper Reaches section from Freshwater Point to the Tailrace with 39,300[3] tonnes (120,000 m^3) of new silt entering the Tamar each year.
Whether the South Esk has flowed through the Cataract Gorge or Tailrace has made very little difference to the end result as the normal volume of water flowing down the South Esk is swamped

[1] It is not a stagnant lake, but freshwater storage reservoir on a fast-flowing freshwater river fed from a catchment covering 20% of the State by the South Esk, North Esk, Meander, and Macquarie Rivers, and by Brumbys Creek, and the Poatina Tailrace.

[2] **Flocculation** - The process by which individual particles of clay aggregate into clot-like masses or precipitate into small lumps of mud called flocs. **Flocculation** occurs as a result of a chemical reaction between the clay particles and another substance, usually salt water.

[3] Foster (1986) Report on Sedimentation Processes and confirmed in the GHD Report for Upper Tamar River Sediment Evaluation Study of 1999 for the Launceston Council.

by the much stronger tidal prism, except in times of floods when the flood waters will top the Trevallyn Dam and push the flocculation zone further downstream.

It was on this historical premise and based on a study of all the reports prepared for the Launceston Council from Foster in 1986 to BMT WBM in 2010, that the not-for-profit, community funded, Tamar Lake Inc., was formed to investigate the feasibility of a strategic transformational solution to the continued silt accumulation that involved the removal of the flocculation zone and asymmetrical tidal action from the Upper Reaches with the formation of a large freshwater reservoir by siting a barrage[4] situated at the south end of Long Reach, near Bell Bay, to separate the freshwater catchment flows from the tidal estuary.

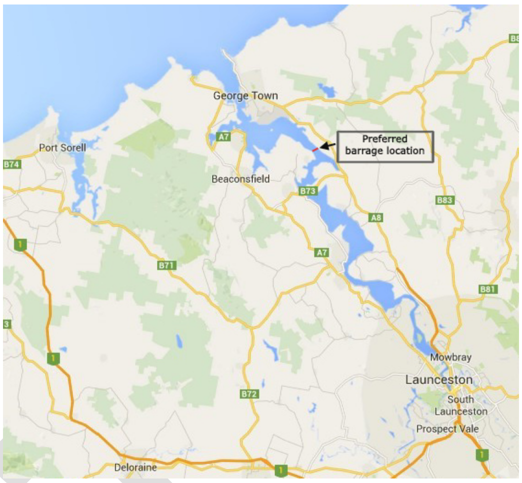

Figure 1- Barrage Location

After 7 years of technical and scientific evaluations and $500K of member funded and pro bono consultancies performed by world class specialists, this final feasibility report, shows that Tamar Lake provides not only a permanent solution to the silt accumulation problem and makes a substantial contribution to improving the water quality in the Upper Reaches, but also provides the basis for an economic transformation of the whole Tamar Valley.

A complete list of the studies carried out is shown in Appendix D.

1.1 Australian and International precedents

In the process of carrying out these studies, Tamar Lake Inc. referred principally to the recently constructed barrage sites at Marina Bay in Singapore (2008) and Cardiff Bay in Cardiff, Wales (1999) as having similar previous characteristics as the Upper Reaches of the Tamar – sediment laden, polluted, tidal estuary with limited navigation capabilities.

In both cases, the formation of the freshwater lake has stimulated unprecedented economic activity around the lake that has transformed not only the local economy but, in the case of Cardiff, has attracted high rates of high net-worth immigration from other countries in the EU.

Also included in the study, was the Seine River in France because of the size of the 370km long, 6 lakes, 7 barrage constructions, illustrated what was possible.

Because of the potential for algal growth in this large freshwater lake, the study also looked at two local constrained river systems in Lake Burley Griffin in Canberra and the 10 weir Murray River system in the three southern mainland states.

[4] A barrage is a special form of weir with a series of gates that facilitate the passage of flood waters and allow for the control of the water height behind the barrage. Under normal, non-flood conditions, the water level is maintained no higher than the current normal high tide. The Tamar barrage incorporates a ship lock that allows ships to transit the barrage.

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Contents

2.0 Executive summary:

The studies carried out for Tamar Lake Inc have shown that the only effective long-term strategy for the Tamar River Recovery Plan is to implement the Tamar Lake Strategy in parallel with attempts to reduce the frequency of the overflows from Launceston's combined stormwater/sewerage system (CSO), and prior to the Launceston Sewage Improvement Plan (LSIP) in the 5 to 10-year time frame, and the NRM North Water Quality Improvement Plan (WQIP) in the longer term.

This transformational Tamar Lake Strategy involves using a barrage to separate the Tamar River into a 60km long freshwater reservoir with a constant high tide water level and a shortened 20km long tidal estuary off Bass Strait.

The economic justification for doing this comes not only from the boost to direct revenues and the employment generated for the whole Northern Tasmania, but from the indirect benefits to the Launceston area from the ability to manage the effects of sedimentation, water quality, sea level rise, and flooding in the upper reaches of the Valley.

2.1 Environmental studies[5]

While the Tamar Lake project will require a substantial transformation for the ecology of the Tamar, this report shows that there is no threat to listed species that could not be managed, and that the environmental beneficial effects of this transformation far outweigh any detrimental effects.

2.1.1 Environmental impact

The environmental impact studies showed that while there will be some displacement of natural ecological values, no listed species will be threatened and the freshwater habitats (including the Tamar Island Wetlands) will be greatly expanded. The only species to die will be the imported rice grass.

In any discussions about the environmental impact of the Tamar Lake project, it is not sufficient to make generalisations about the change in the ecology of the Tamar, but to consider the balance of benefits and detriments, and to focus on specific sections of the water course.

In a Tamar lake environment, there would be three sections:

1. The currently ecologically dead (except for eels), heavily polluted mostly freshwater section between Freshwater Point and Cataract Gorge, that will be transformed into a clean, low pollution, low new sediment accumulation, Tamar Lake environment with the potential for freshwater fish species to thrive
2. The estuary area downstream of the barrage between the barrage and the estuary entrance that is currently listed as a nursery ground for protected sharks and rays, and has a fantastic under water coral and salt water species environment, should not be effected in a Tamar lake scenario.
3. The area between Freshwater point and the barrage which will undergo the major change of a constant water level, eradication of the rice grass terraces, and the transition from a variable saltwater environment to a constant level freshwater environment.

[5] **Environmental studies** are a multidisciplinary academic field which systematically **studies** human interaction with the **environment** in the interests of solving complex problems.

2.1.2 Eradication of rice grass terraces

While area 3 above, between Freshwater Point and the barrage, will undergo a significant change from a variable salinity tidal section to a constant water level freshwater reservoir, this will also bring a very positive environment benefit in that the introduced pest Rice Grass that thrives in this area will be eradicated over time, and native species will return.

2.1.3 Sedimentation management and water turbidity[6]

With the fine particle silts flowing in suspension in the freshwater from the catchments, the report shows that this strategy ensures that there will be no new silt accumulation in either the resultant reservoir or downstream of the barrage, and that the water turbidity in the lake will normally be of a level that exceeds the EPA approved water quality targets for the Tamar Estuary.

With the entrance to the Trevallyn Power Station penstock situated 2 metres below the top of the Trevallyn Dam, coarse sand and sediments that once flowed down the Cataract Gorge and deposited in the Yacht Basin before the construction of the dam, are now trapped behind the dam, except in times of flood when the waters top the dam.

2.1.4 Water quality

The impact on water quality in a Tamar Lake environment compared with the current estuarine environment revolved around two Zones[7] of the Tamar – Zone 1 – from Cataract Gorge and the lower North Esk to Tamar Island, and an area in Zone 3 between the barrage and upstream to Hillwood.

2.1.4.1 Zone 1

The studies showed that the installation of the barrage removes the asymmetrical tidal flows in this zone and moves the flocculation zone from around Tamar Island to beyond the barrage in Long Reach.

This results in improved one-way flushing of the Yacht Basin/Home Reach/North Esk area with a greatly improved water quality within this area with clear, low turbidity water; a more rapid flushing of any CSO overflows downstream (with even greater improvement if the flows down the Cataract Gorge are increased from 2.5m^3 to 25m^3 as most stakeholders would like to see); and most of the pollutants entering the Tamar from the catchments (which represents 80 % of all new pollutants entering the Tamar) bypassing Home Reach with passage down the Tailrace and then straight downstream with one way flow out to Bass Strait.

These results should be achieved within 12 months of the closing of the barrage gates, but does not obviate the need for the implementation of the LSIP, WQIP and CSO programs in the longer term.

2.1.4.2 Zone 3

Any large body of retained freshwater, lake or reservoir, suffers from the threat of late summer algal bloom growth on the surface of the water, reducing the amenity value and forming anoxic (low dissolved oxygen levels) at depth which threatens the local ecology in that area.

The 3 D modelling carried out for this report, identified that Tamar lake would not be an exception to this threat, despite the very large annual average water flows through the lake (50% of the annual flows of the Murray River) from the large catchment area flushing the lake on an average 8 times per year; and despite the normally low water temperatures of a cool temperate climate and elevated catchment area, for the waters entering the Tamar.

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[6] **Turbidity** is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of **turbidity** is a key test of water quality.

[7] **NRM North – Tamar Estuary Water Quality Report Card**

The area identified of concern is the stretch of water up to 20kms behind the barrage, but specifically Moriarty's Reach back to the Batman bridge.

Tamar Lake Inc., in its studies for this report, examined a number of international barrage installations to see how they handled this situation, and also identified locally that the prominent water bodies of Lake Burley Griffin with its Scrivener Dam and the Murray River with its 10 weirs and locks have frequent summer outbreaks of algal blooms and requires active management programs.[8] (see Appendix x for a detailed discussion on Canberra's Lake Burley Griffin.)

Canberra had a significant outbreak of algal blooms in May 2014 which closed the lake to swimming, water skiing and windsurfing for a period of time.

Despite this being an expected outcome, Tamar lake Inc. invested a large amount of their limited funds on investigating both in-lake water strata mixing strategies and barrage operating strategies in an attempt to provide mechanisms to reduce the potential frequency and duration of any algal bloom outbreaks in Zone 3 with some limited success.

This issue is dealt with very thoroughly in the main body of the report, but the limiting factors in proceeding further in our understanding of the effects over time of this issue were costs and limited capabilities in the Tamar Estuary 3D model.

2.1.5 Sea level rise and navigation

The studies also showed that the barrage would protect the communities upstream of the barrage (including the low-lying areas around Launceston) from a sea level rise of up to 0.8m due to Global Warming, and that private and commercial vessels requiring a draft of up to 5m would be able to travel from Bass Strait to the Launceston Seaport 24 hours per day, 7 days per week via the lock in the barrage.

2.2 Technical studies[9]

Technical studies were carried out initially to understand the scope of the impact of the proposal in the areas of hydrodynamics, water quality, siltation and flooding.

2.2.1 Hydrodynamics

The Tamar Estuary is a body of water approximately 55 km long from its entrance into Bass Strait to the upstream tidal limit on the North Esk River, (straight line distance between Low Head and St Leonards) covering a total area of around 90 km^2.

The total volume of the Tamar Estuary is approximately 740 gigalitres (below Mean Sea Level).
The dominant process affecting the regular (tidal) hydrodynamics of the Tamar estuary is the entry and passage along the estuary of tides from Bass Strait. These tides are predominantly semi-diurnal. There is considerable amplification of tides as they propagate along the estuary to the tidal limits upstream of Launceston.

The tidal prism at a section in an estuary is the average volume of water that enters and leaves during tidal water level oscillations. With mean tidal range for the system of around 3 m the tidal prism of the entire Tamar Estuary is around $2x10^8$ m^3 or 200 gigalitres.
In the Tamar River, as is common in such estuaries, the tidal wave becomes progressively more asymmetrical as it propagates upstream. That is, its shape in terms of variation of both the water surface level and the tidal current speed becomes more peaked but of shorter duration during the

[8] **Canberra's Water Quality Management Plan – 2011, and the Murray/Darling Management Authority**
[9] **Tamar Lake Preliminary Technical Assessment - R.B18703.001.02.TamarLake.doc - February 2012**

flooding tide and smaller but of longer duration during the ebbing tide. This provides a mechanism for the differential transport of sediments and pollutants, with dominant tide-induced transport in the upstream direction.
As such, during naturally occurring dry weather conditions, tidal flows can lead to movement of sediments (and pollutants) to the upstream parts of the estuary where they can settle out in areas where currents are too weak to keep them mobilised.

The Tamar Lake proposal would construct a barrage on Long Reach, creating a freshwater reservoir upstream and reducing the tidal exchange downstream of this point. The tidal prism at the proposed barrage location is currently 1.1x108 m^3 or 110 gigalitres. With the barrage in place the tidal prism would be reduced by approximately half at Low Head (from around $2.0x10^8$ m^3 to around $1.0x10^8$ m^3) and would be reduced to zero immediately downstream of the barrage.

The studies have shown that this would reduce the peak tidal current in the estuary from 6km/hr to 1km/hr.

2.2.2 Flood effects

A study into the effects the barrage will have on flood levels showed that with normal operation of the flood gates in the barrage, there is a positive mitigation on flood levels in Launceston for both the current sea level conditions, and assuming a future rise in sea level of 0.8m.

With the ability to lower the level of the lake to mid tide level to create a buffer of more than 45,000 ML of flood waters, coupled with the removal of any tidal effects upstream of the barrage, there is up to a 1.0m reduction in flood levels along the length of the lake for a 200-year ARI flood event.

The time required to lower the level of the lake to 0 AHD level (between 1.2m and 1.5m below normal high tide depending on location on the river) is between 4 and 12 hours depending on whether current tidal levels or a sea level rise scenario. With heavy rainfall in the upper reaches of the North and South Esk rivers taking up to 3 days to reach the Tamar, there is ample time to lower the lake level to form the buffer.

The report shows that the ability to buffer floodwaters for the more frequent low to moderate flood events (5 to 50 years) will also prevent topping of the banks of the low-lying areas of Launceston on the "wet" side of the new levee system – Glebe flats, Seaport Boardwalk, Royal Park, Newstead etc. - with the benefit of mitigating the costly damage to property in this area.

2.2.3 Transition time of the lake from saltwater to freshwater

It is estimated in the study, that once the barrage is installed and the gates are closed, the lake will transition from salt to fresh water in 4 to 12 months, depending on rainfall in the catchment.

The studies showed that with the removal of the current flocculation zone from Tamar Island/Freshwater Point to downstream the barrage, and the complete removal of the asymmetrical tidal action, the incoming new silt from the catchment travels in suspension one way through the lake and beyond the barrage gates, provided the gates are opened on an ebb tide.

The net result in this area is an almost clear freshwater lake with a constant level just below the current normal high tide level.

2.3 *Economics*[10]

2.3.1 Economic benefits

Since 2010 Tamar Lake Inc. has commissioned two significant studies to investigate the potential economic outcomes of the implementation of Tamar Lake.

- NERA Economic Consulting – Economic Prefeasibility Study (April 2013)
- KPMG – Economic Impact Update (July 2014)

Both reports concluded that the implementation of the Tamar Lake would deliver significant economic benefits.

NERA estimates that the potential economic benefit of the Tamar Lake Project is approximately $553m. The estimated capital cost of the barrage is approximately $320m, indicating that the economic benefits of the Project would exceed its capital costs.

KPMG in 2014 investigated the high level economic impact of the Tamar Lake Project. It builds on the pre-feasibility study by NERA by quantifying the net economic benefits of the project. KPMG's analysis found that during its first three years (2019-2021), direct expenditure on barrage construction and irrigation scheme construction, the Project would contribute approximately $313.51m in net additions to Gross State Product (GSP) and support 856 jobs. On an ongoing basis, net additions to GSP and jobs would result from capital works, combined operations of the barrage and irrigation scheme suppliers, and operations of the irrigation scheme users. The favourable impact on tourism would more than offset the adverse impact on existing fisheries, and in net terms, would contribute approximately $112.48m in net additions to GSP and support 716 jobs.

2.3.2 Where will Launceston be in 10 to 30 years' time without the implementation of the Tamar Lake project?

Assuming the LSIP is implemented in the 5 to 10 years' time frame, and assuming the CSO project manages to substantially reduce the frequency of overflows from the STPs, with 80 % of the pollutants entering the Tamar sourced from the catchment, and with new sediments of 40,000 tonnes per annum (120,000m^3) continuing to accumulate in the area between Freshwater Point and Cataract Gorge, the Upper Reaches of the Tamar will continue to be a highly polluted, high turbidity, section of the river that is continuing to infill with sediment, thus reducing navigation depth, and restricting recreational and aesthetic amenity. A very costly program of dredging and dumping of spoils into Bass Strait is the only alternative solution for sedimentation.

2.3.3 International barrage installations

Tamar Lake Inc. commissioned a study into other successful barrage installations around the world which looked at barrages in Singapore, Cardiff, Boston and the Seine River in France.

While Singapore (2008) and Cardiff (1999) are recent constructions and have been very successful commercially, the Seine River System, which is composed of 7 barrage/lock installations forming a 120km long tidal estuary and 6 lakes covering a total 370km between Paris and the English Channel, is the example that best demonstrates what can be achieved to improve the water quality and the amenity of a long waterway. This is covered in more detail in Appendix E.

In both the Singapore and Cardiff situations, the stimulus to economic growth, and specifically the development around the shores of the lakes with the installation of the barrages, has been enormous. It is expected that the Tamar Lake project would have a similar stimulative effect (but on a smaller scale) particularly in the areas north of the city to Legana/Dilston around the shores of the lake.

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[10] NERA Final Report_10 April 2013.pdf
KPMG - FINAL-TLI14-Tamar Lake Economic Impact Report-R3006.pdf

2.4 Funding

Acknowledging the significant level of funding required to implement the project, Tamar Lake Inc. commissioned AECOM in February 2017 to estimate the potential for value capture funding methods to contribute to the funding of the Tamar Lake project.

This report concluded that given the current indicated construction cost of $320 million, the benefits to property values alone from the project greatly exceed its costs:

- The uplift in median residential property values in Launceston following construction of the Project and stabilisation of values is conservatively estimated to be $1 billion.
- The uplift in median unimproved commercial land values in the Launceston CBD within 500m of the riverfront following construction of the Project and stabilisation of values is estimated to be $434m.

AECOM identified the following potential value capture funding methodologies to be applied to the Tamar Lake project:

- Selling development rights and / or density above existing zoning controls.
- Sale of government-owned land that is enhanced or made developable by the project.
- Captured through public taxation system such as land tax and stamp duty, (possibly captured through sharing value uplift with surrounding landowners).

The encouraging outputs from this AECOM study support further work being undertaken into the application of value capture funding to the Tamar Lake project. Tamar Lake Inc. recommends this work be included in the broader socio economic study that would be initiated as part of preparation of formal business case for the development of the Tamar Lake.

In addition to the value capture methodologies noted above, Tamar Lake Inc. believe a number of other funding sources would be available to support the capital and ongoing operating costs of the project including:

- Selling water entitlements to users of the proposed irrigation scheme
- Federal, State and Local Government funding contributions driven by the:
  - the improved environmental outcomes achieved from the project;
  - capital costs avoided relating to flood damage and sediment management;
  - capital costs avoided relating to water treatment and pollution management; and
  - improved public amenity.

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3.0 Results of Tamar Lake environmental, technical and economic and funding studies

A list of all the reports compiled by our consultants over the last 7 years is shown in Appendix D; copies are available on application to Tamar Lake Inc.

In brief, the extensive feasibility studies have shown the following results.

3.1 Environmental

3.1.1 *Natural values assessment of the Tamar Valley*

A 2012 Tamar Lake Study carried out by Dr. Andrew Costen of BMT WBM[11] involved the sourcing, compilation and synthesis of publicly available data and information to:

- Identify and characterise the biological and geodiversity values within the study area.
- Determine the existence of conservation significant or otherwise noteworthy species or communities.
- Identify the potential effects of the construction and operation of the Tamar Lake concept on the adjoining and adjacent natural values which may represent benefits or constraints to the development of the concept.
- Provide a summary of the likely environmental assessment and information requirements to further progress the project.

3.1.2 **Ecological assessment of threatened species and potential ecosystem impacts[12]**

A further study in 2012 by Dr Mark Breitfuss sought to assist Tamar Lake Inc. through:

- Providing a provisional assessment of potential threats and impacts of the proposed lake to key threatened species and guilds.
- Identifying current threatened species management plans, their relevance to the Tamar Lake concept, and potential Environmental Impact Assessment implications.
- Identifying a range of ecological issues associated with changing the state of an ecosystem from saline or brackish to freshwater.

Breitfuss Reports:

"The Assessment (Costen, 2012) identified a range of species that have been or may be found in the area of the proposed Tamar Lake. We have further assessed the ecological requirements of these species, and their likely use of habitat affected by the project to determine whether the project will potentially impact them (Table 1).

There is uncertainty about the current presence of a number of these species, and whether the impacts of the project would be positive or negative. Field surveys will be required as part of any Environmental Impact Assessment process and consideration will have to be given to mitigating adverse impacts.

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[11] **The Tamar Lake Concept – A Natural Values Desktop Assessment – BMT WBM R.M8555.001.01, June 2012**

[12] **Further Ecological Assessment of Threatened Species and Potential Ecosystem Impacts – Dr Mark Breitfuss – June 2012**

For example, the Dwarf Galaxias (*Galaxiella pusilla*) prefers still or slow moving fresh water with abundant aquatic vegetation. It may be present in the rivers feeding the proposed Tamar Lake and would be affected by any loss of aquatic vegetation due to changed water levels. In this instance, a mitigation measure may be to progressively establish new areas of aquatic vegetation to offset the loss. The same may be said for the Australasian bittern (*Botaurus poiciloptilus*) and great-crested grebe (*Podiceps cristatus*). It may also be the case that the new freshwater conditions will improve the population status of these species in the longer term if associated with aquatic and emergent vegetation enhancement. Confirmation of this benefit would require monitoring and possibly research.

Habitat modification in the surrounding landscape will have had a greater impact on the populations and ongoing conservation status of threatened species such as the spotted tailed quoll (*Dasyurus maculatus maculatus*) and the Swift parrot (*Lathamus discolour*). Tamar Lake Inc. may consider enhancement or restoration of terrestrial habitat as part of a comprehensive environmental approach to the project, but this should not be considered to mitigate any other effects of changing the ecosystem state of the Tamar River."

The key findings from this report are shown in Table 1. below:

Threatened species occurring in the region, their conservation status, and assessment of potential project impact

Species name	Common Name	Conservation Status		Occurrence, habitat, and potential impact
		EPBC Act	TSP Act	
Likely to be impacted				
Prototroctes maraena	Australian Grayling	V	V	EPBC Protected Matters search tool and habitat mapped in study area by Natural Values Atlas. Species migrates between fresh and salt water during life cycle. This species will be impacted by project if present unless a fish ladder is incorporated in the barrage wall to allow passage from the fresh to saline waters.
Potentially impacted				
Galaxiella pusilla	Dwarf Galaxias	V	V	Habitat mapped in study area by Natural Values Atlas. Species is known to occur well to the east of study area. Prefers still or slow-moving water with abundant aquatic vegetation. Some potential to be impacted if present if habitat degradation occurs
Litoria raniformis	Green and Golden Frog	V	V	Habitat mapped in study area by Natural Values Alas. EPBC protected Matters search tool and database records
Botaurus poiciloptilus	Australian Bittem	E		EPBC Protected Matters search tool and two old (>30 yrs) database records. Generally, a solitary species that occurs in densely vegetated freshwater wetlands. Only rarely in tidal wetlands. If present, impacts resulting from the project are considered likely to be minor and potentially positive.
Numenius madagascariensis	Eastern Curlew	M	E	EPBC Protected Matters search tool and database records. Large wader species that prefers saline habitats (particularly mudflats, mangroves and estuaries). Impacts associated with project uncertain and may be negative or positive
Sternula nereis nereis	Fairy Tern	V	V	EPBC Protected Matters search tool and database records. This species nests/roosts in sheltered beaches, spits and banks above the high tide mark. Also occurs in inlets and saline or brackish lakes. Impacts associated with project uncertain and may be negative or positive
Migratory Waders *Actitis hypoleucos* *Arenaria interpres* *Calidris acuminata* *Calidris canutus* *Calidris ferruginea* *Calidris ruficollis* *Charadrius bicinctus* *Charadrius mongolus* *Gallinago hardwickii* *Heteroscelus brevipes* *Limosa lapponica* *Numenius phaeopus* *Pluvialis fulva* *Pluvialis squatarola* *Xenus cinereus*	Common sandpiper Ruddy Turnstone Sharp-tailed Sandpiper Red Knot Curlew Sandpiper Red-necked Stint Double-banded Plover Lesser Sand Plover Latham's Snipe Grey-tailed Tattler Bar-tailed Godwit Whimbrel Pacific Golden Plover Grey Plover Terek Sandpiper	M		EPBC Protected Matters search tool. No database records available but some species at least will forage and roost in the project area and surrounds. Impacts uncertain and may be negative if intertidal mudflats are lost, or positive if new areas created.

Table 1

Note: Conservation status abbreviations: EPBC Act – Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*; TSP ACT – Tasmania's *Threatened Species Protection Act 1995*; E – Endangered; V – Vulnerable; R – Rare; M – Migratory.

3.1.3 Note on Australian Grayling in the Tamar

In Table 1 above, Dr Breitfuss identified a vulnerable threat to the Australian Grayling in a Tamar Lake environment.

With an inability to identify any recent sightings in the Tamar Estuary, desktop research has indicated that it is unlikely there are any colonies in the current Tamar environment.

A report by Hydro Tasmania in 1999 provided the following:

The Australian grayling (Prototroctes maraena) is a diadromous species and needs unimpeded access from salt water to fresh water to complete its life cycle. It is listed as "vulnerable" in the Threatened Species Protection Act 1995 and the Endangered Species Protection Act 1992. These classifications are due to concerns raised by the extinction of its New Zealand counterpart which has never been fully explained (McDowall, 1996), and to the decrease in available habitat resulting from instream barriers to migration. P. maraena occurs in coastal rivers Statewide and is widespread in eastern and northern coastal areas and occasionally on the west coast. The exact spawning area of P. maraena is unknown but is assumed to be in freshwater. Larvae are washed downstream and have a marine stage lasting up to 6 months. Juveniles then migrate upstream to inhabit the upper zones of estuaries and clear freshwater streams (McDowall, 1996).

Hydro influence on P. maraena in the South Esk catchment may result from Trevallyn Dam preventing migration. However, the effect that this has on the regional viability of the species is largely unknown, as there has been little research done into its current and probable past distributions and habitat utilisation. Recent study has revealed that the species is more common than was earlier believed, however it is still listed as potentially threatened by ASFB.

Given this, it seems unlikely that Australian Grayling would habitat in the current Tamar estuary because, requiring clear freshwater for spawning, they are unlikely to spawn in the freshwater end of the Tamar due to the heavy levels of pollution and turbidity, and passage to the clearer fresh waters of the South and North Esk rivers is blocked by the Trevallyn Dam and St Leonards weir.

It seems probable that, provided an effective fish ladder is built into the wall of the Tamar Barrage, the waters of Tamar Lake would be far more conducive to spawning, and with the 20km long estuary section, the Tamar Lake environment would be far more supportive for the propagation of the species.

Research into the cohabitation of Grayling with other freshwater fish has not been done at this stage.

3.1.4 Summary of the ecology considerations

The studies carried out to date by Tamar Lake Inc. has not identified any major threats to listed species that could not be managed during and after the implementation of the project.

Dr Breitfuss concludes:

"The Tamar Lake proposal would see a largely brackish estuarine river ecosystem converted into a freshwater lake. This will result in changed habitat conditions for a number of species, and there will be some species that will benefit and some species in the region that will possibly be detrimentally affected. The presence of threatened species in the region does not automatically mean that they will be affected by this proposal, and such species can be summarily dealt with in a future development application.

The Environmental Impact Assessment (EIA) process will require a range of surveys and modelling to determine whether there will be an impact and to what extent this impact will occur. The EIA process will also require consideration of the types of mitigation that will occur to reduce or offset impacts. We have identified some of the information requirements and mitigation measures that would be required for two threatened species (Australian Grayling and Green and Golden Frogs) and one guild of protected species (migratory wading birds).

There is the potential for a range of unintended ecological, human health, and greenhouse gas emission consequences associated with the project. The information provided in this report is intended to assist Tamar Lake Inc. (*and any prospective proponent*) in understanding the range of possible ecosystem level impacts that may need to be considered and mitigated through the EIA process. This will help Tamar Lake Inc. in scoping the studies that should be conducted, and in thinking about the wider implications and opportunities of the proposal. For example, activities in the wider catchment will play a greater role in the ongoing condition of a future lake, and the design of any barrage should include the capacity for flushing anoxic water".

3.1.5 The Rissik report

Assessment of the comprehensiveness of the potential environmental impacts, threats and risks identified in the Tamar Lake reports.[13]

Following the preparation of the Costen and Breitfuss reports, NRM North commissioned a peer review of these reports by Dr David Rissik.

Dr Rissik identified a number of key issues, many of which have been addressed in subsequent studies.

The key issues and their resolution are:

- **Water quality in Zone 1**

  Water quality in Zone 1 – see the prediction in this section that water quality and turbidity will be greatly improved even before the implementation of the LSIP and WQIP, with the one way flushing downstream more effective than the asymmetric tides locking the pollutants into the upper reaches.

- **Sedimentation downstream the barrage**

  The Zone immediately below the barrage is most likely to be impacted by sedimentation as the flocculation zone will be moved to the area below the barrage where freshwater is released from the barrage into the salt water. – Our 3 D studies have shown that as long as the freshwater with silt in suspension is released on an ebb tide, the silt will remain in suspension out into Bass Strait and not flocculate.

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[13] David Rissik - November 2014

- **Passive acid sulfate soils (PASS)**
  Any sediment removal within the lake or construction of the barrage infrastructure will need to consider the impact of Passive Acid Sulfate Soils which have the potential to release acid when exposed to oxygen and consequently result in contamination of the lake environment. – At the time of construction, there will not be any sediment accumulations at the barrage site. A Tamar Estuary SeaMap provided by NRM North shows only reef and cobble in this area.

- **Saltmarsh colonies**
  Subtropical and Temperate Coastal Saltmarsh has officially been added to the list of threatened ecological communities under section 181 of the Environmental protection and Biodiversity Conservation Act 1999. – There is no saltmarsh community currently identified within the proposed Tamar Lake area.

- **Gambusia**
  Gambusia is a pest fish species which has colonised a number of areas within the Tamar Estuary (Tamar Island Wetlands and adjacent farm dams and drains). Under a Tamar lake scenario, the habitat for Gambusia is likely to expand significantly posing a significant risk of infestation of the pest species, particularly via human translocation to other areas in Tasmania and impacts on native fish and frog species. - Jawahar Patil of the University of Tasmania is running a $500K program to eradicate Gambusia and has completed the first 2 years of what is estimated to be a 3-year program. He has completed the laboratory modelling and is expected to move into field trials late in 2017. He is cautiously optimistic of success.

3.2 Sedimentation management

3.2.1 Upper Reaches

Previous studies, carried out for the local authorities over the last 50 years, had identified that the accumulation of silt flowing into the Tamar from the catchments, is deposited in the flocculation zone between Tamar Island and Freshwater Point, then is “pumped” upstream to the Home Reach/Yacht Basin area by the asymmetrical tidal action, particularly in the summer periods of low flows down the South Esk.

With the entrance to the Trevallyn power station penstock situated 2 metres below the top of the 33-metre-high Trevallyn Dam, except in times of flood topping the dam, the only sediment entering the Tamar from the South Esk catchments is the fine particle silt in suspension in the fresh water, with the coarser sand and gravels trapped in the bottom of Trevallyn Lake.

Installing a barrage moves the flocculation zone beyond the barrage and removes any asymmetrical tidal action in the Upper Reaches.

Studies carried out for Tamar Lake Inc, has confirmed that this change will eliminate the deposition of new silt in the Upper Reaches, and with the long term scouring of residual silt, there will be a net export of silt into Bass Strait with each major flood event.

The studies also show that over time, with each flood event that tops the Trevallyn Dam, residual silt on the bed of Home Reach/Yacht Basin will be eroded downstream, never to return.

Mechanical agitation in the form of raking could be used to increase the rate of erosion of this residual silt.

The net result in this area is an almost clear freshwater lake with a constant high tide level.

3.2.2 Home Reach 12-month sediment accumulations – maximum inflows[14]

The diagrams below (figures 2 and 3) show the comparison between the current tidal and the proposed Tamar Lake 12-month sedimentation accumulations.

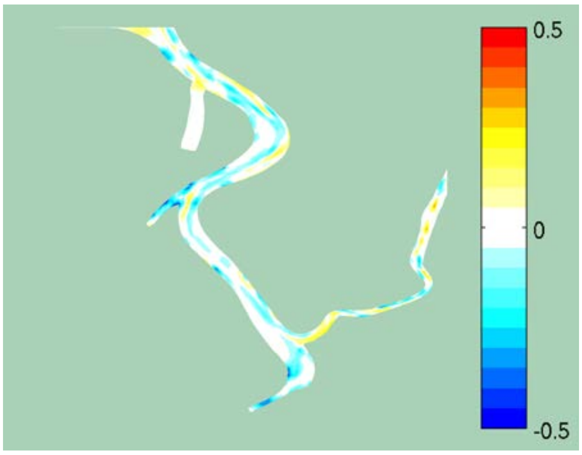

Figure 2- Home Reach - Tidal Environment

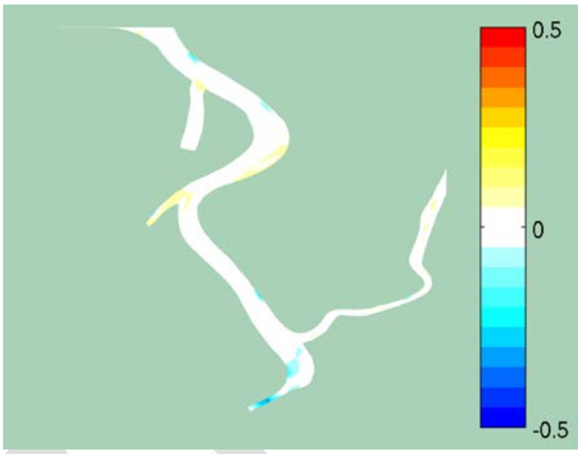

Figure 3- Home Reach - Tamar Lake Environment

3.2.3 Home Reach 3 months sediment accumulations - summer inflows[15]

3.2.3.1 Launceston Flood Authority Report[16]

The Launceston community is very aware of the renewal of sediment deposits in Home Reach after a raking or flood event has moved some of the sediment further down river.

To determine the extent of transport of silt after a raking program, the Launceston Flood Authority carried out a silt-tracing study over a 2-month period between September and December 2014. The red silt tracer was released near Home Point, and the yellow silt-tracer was released near Stephenson's Bend.

At the end of the two months trial period, the dispersal of the silt-tracer was as shown in the diagrams below. This confirmed that any raking in Home Reach simply moved some of the silt downstream, but that the majority was "pumped" back upstream and into Home Reach and the lower North Esk by the asymmetric tidal action.

This study was carried out during a particularly dry spring season, but normal flows would simply have moved some of the silt a little further downstream. See Figure 4 below.

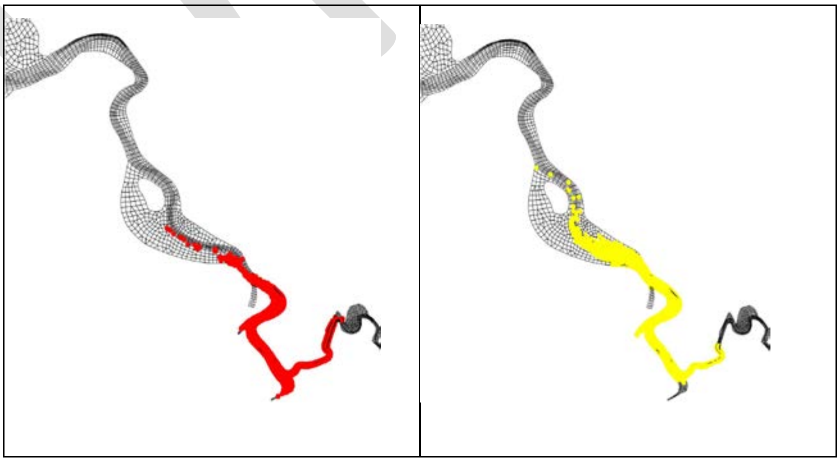

Figure 4 - Sediment Transport in a tidal environment

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[14] **3 D Hydrodynamic Studies – BMT WBM – Michael Barry – January 2016**

[15] **3 D Hydrodynamic Studies – BMT WBM – Michael Barry - January 2016**

[16] **Final Report - LFA - Tamar Estuary Sediment Study (11 5 15R)**

3.2.3.2 Tamar Lake 3 D Modelling – 3-month dry period sedimentation

In addition, Tamar Lake Inc. carried out a 3D modelling scenario of this sediment transport. The results below (figures 5 and 6) confirm that in a Tamar Lake environment there is no transport upstream during a 3-month dry period.

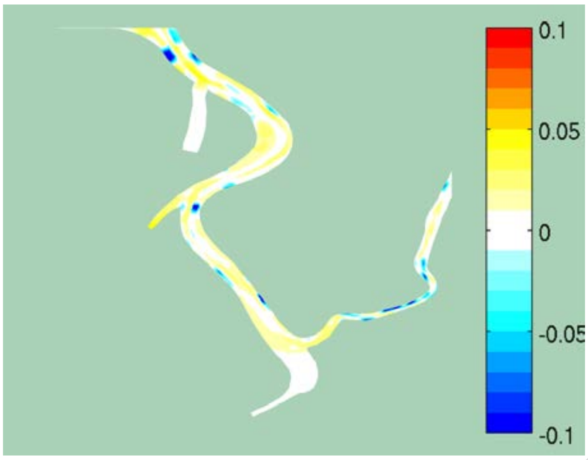

Figure 5 -Home Reach – Tidal Environment

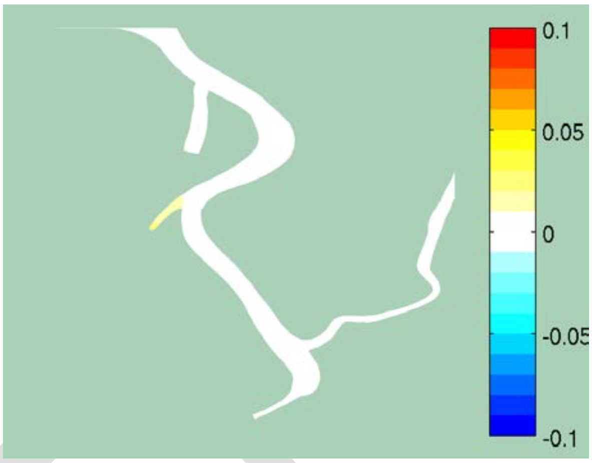

Figure 6 - Home Reach – Tamar Lake Environment

3.2.4 Barrage downstream

As new silt from the catchment enters the Tamar principally in times of heavy rainfall, this silt suspended freshwater travels through the barrage gates as they are opened on an ebb tide, and are carried out to Bass Strait with limited mixing (and hence flocculation) due to the greatly reduced tidal prism in this area. See figures 7 and 8.

The net result is no reduction in water clarity of this pristine marine environment, and even less silt deposition than in the current tidal environment.

3.2.4.1 Estuary 12-month Sediment Accumulations – Maximum inflows[17]

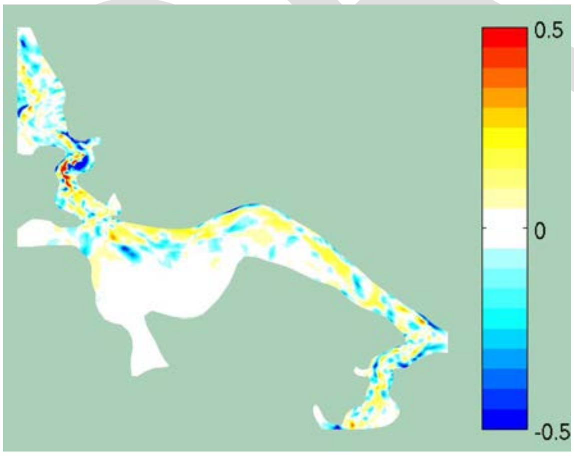

Figure 7 - Estuary – Tidal Environment

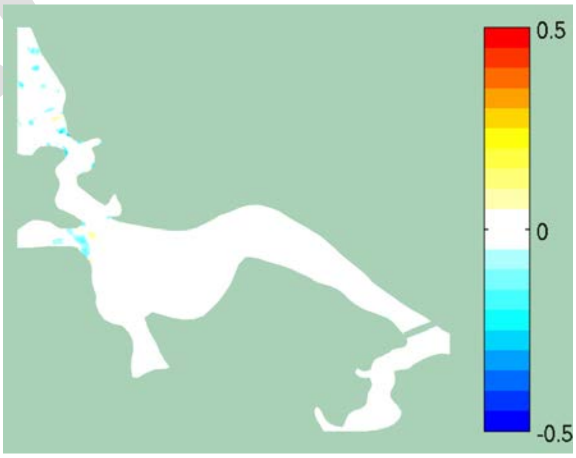

Figure 8 - Estuary – Tamar Lake environment

[17] **3 D Hydrodynamic Studies – BMT WBM – Michael Barry - January 2016**

3.2.5 Water turbidity[18]

The studies have shown that the turbidity of all the water in the lake, after a suitable period of flushing, will be the same as the current North and South Esk inflows.

This is illustrated in the sample photos (right) with the red lid being the current turbidity in the Yacht Basin at Royal Park, and the green lid being the turbidity of the North and South Esk rivers upstream of the weir and dam, and hence the expected water clarity of the whole of Tamar Lake. These results have been confirmed with the 3D modelling showing the comparison in the following chart, figure 10, between the current estuary environment and the Tamar Lake environment for the full length of the valley.

Figure 9 - Actual Water Turbidity

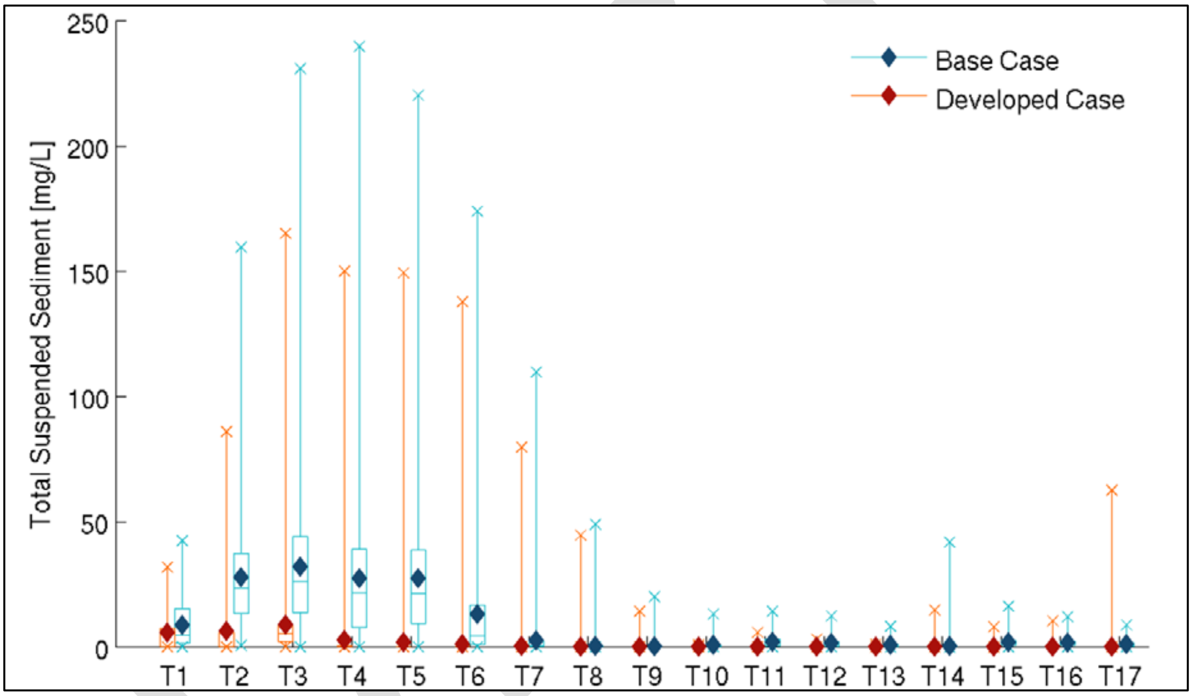

Figure 10 – Modelled Water Turbidity

- Base Case (blue) is the current estuary turbidity
  - Developed case (red) is Tamar Lake turbidity
  - T1 is Cataract Gorge
  - T17 is Low Head

[18] **3 D Hydrodynamic Studies – BMT WBM – Michael Barry – January 2016**

3.3 Water quality

For these feasibility studies, Tamar Lake Inc. examined the projected water quality at both ends of the lake for the Tamar Lake implementation in comparison with the current tidal environment and with reduced pollutants forecast with the implementation of the LSIP and WQIP[19].

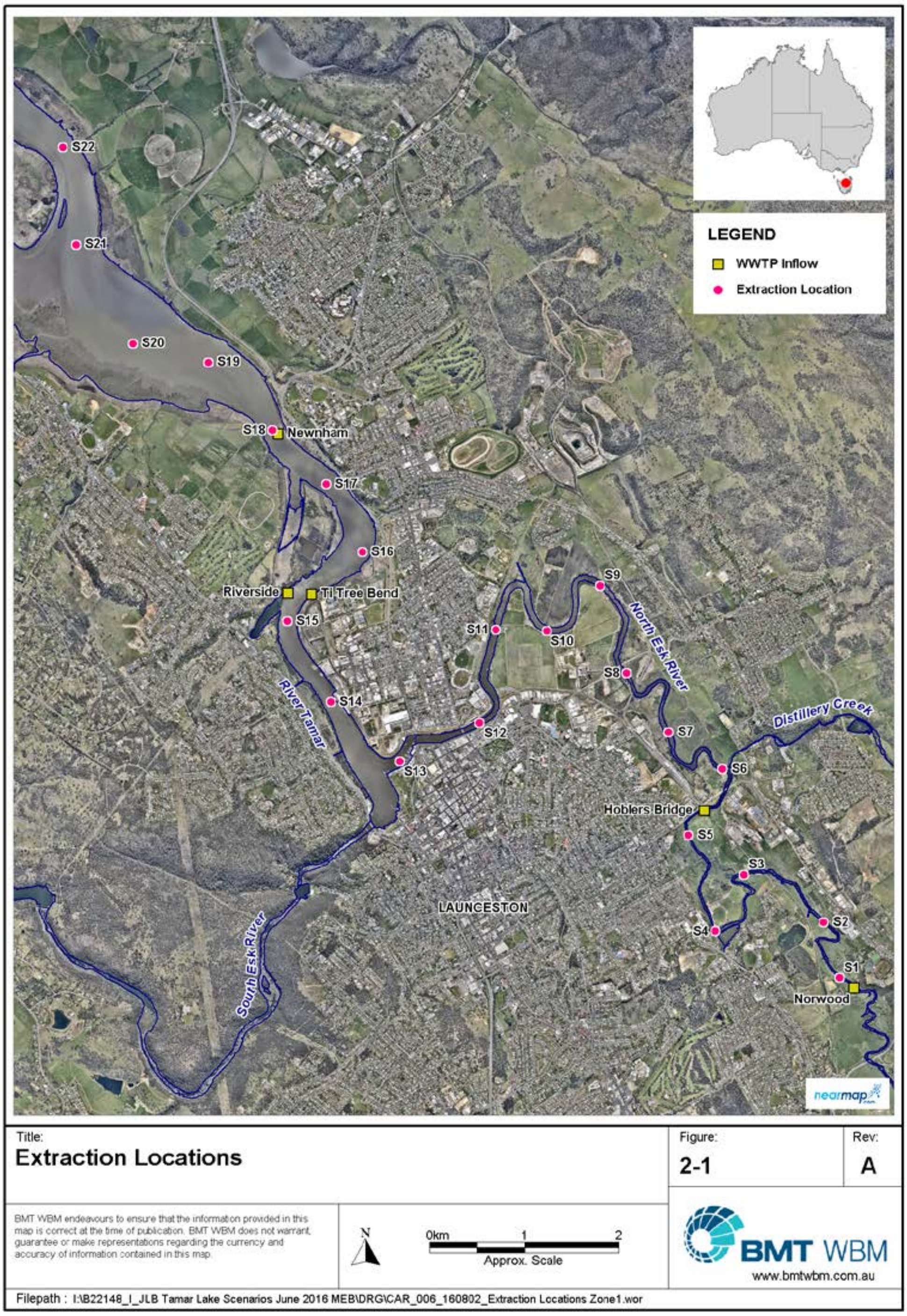

Figure 11- Zone 1 extraction chart

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[19] **NRM North Water Quality Improvement Plan - 2015**

3.3.1 Zone 1 – North Esk Weir at St Leonards to Tamar Island – see figure 11

3D modelling studies by BMT WBM[20] looked at the water quality in Zone 1, (the southernmost zone of the Tamar) comparing the current tidal estuarine water quality (D rating from the NRM North 2016 water quality report) against the projected Tamar Lake water quality with three scenarios:

- Baseline - Current tidal estuary water quality – yellow dots
- Scenario 1 - Tamar Lake before the implementation of the LSIP. – dark blue dots
- Scenario 2 - Tamar Lake after the implementation of the LSIP and before the implementation of the WQIP. – light blue dots

The projected pollution input reductions with the implementation of the LSIP and the WQIP, obtained from the WQIP report, were**,** including STPs, 17% for Total Nitrogen (TN), 27% for Total Phosphorous (TP), and 24% for Enterococci (ENT).

For these studies, it was assumed the water flowing down the Cataract Gorge was increased from 2.5 cumecs to 20 cumecs, to show the worst case, with some of the South Esk catchment sourced pollutants flowing down Home Reach.

With 80% of any new pollutants entering the Tamar doing so down the Tailrace from the South Esk catchments, or downstream of the Tailrace (Ti Tree Bend and Riverside STPs) and with the absence of the asymmetrical tidal action in a Tamar Lake environment "pumping" these pollutants (Nitrogen, Phosphorous and enterococci) back into the Home Reach/Yacht Basin/North Esk area, the water quality in this area is improved and should go close to matching the B rating in Zone 2.

With the implementation of LSIP, there is no longer any discharge from the Norwood and Hoblers Bridge STPs into the North Esk so that any pollutants entering the Home Reach/Yacht Basin/North Esk area do so only from urban runoffs and any possible Combined System Overflow (CSO) situations from the Margaret Street, Esplanade and Forster Street outlets.

Even in this CSO situation, the one-way flow northwards from the North Esk together with the increased flows of 20 cumecs from the Cataract Gorge down Home Reach ensure that these pollutants (including solids) clear Home Reach rapidly instead of being locked in by the asymmetric tidal action.

These results for TN, TP and ENT are shown in figures 12, 13 and 14 below. – S1 is located at Norwood and S22 is Tamar Island.

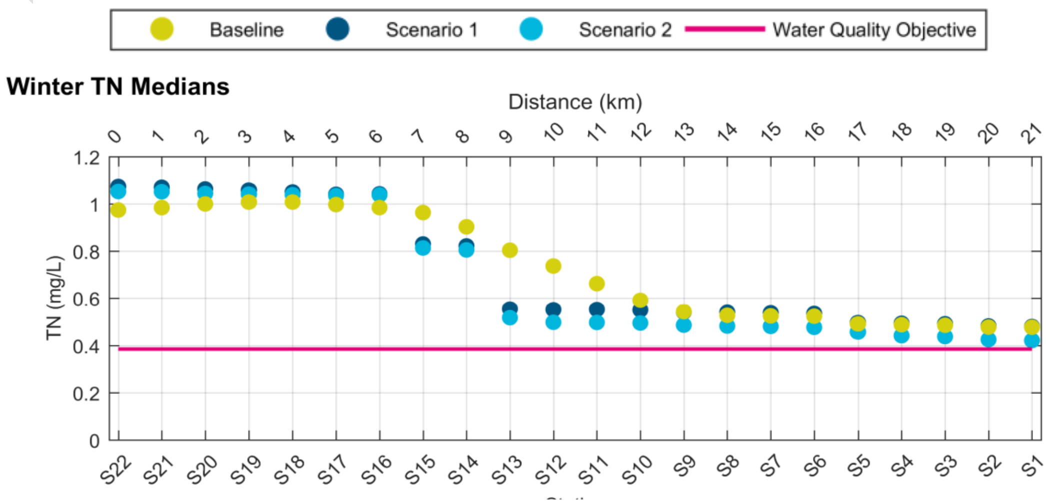

Figure 12 - Total Nitrogen - winter

20 **Tamar Lake Zone 1 Water Quality Report – BMT WBM R B22148 – August 2016**

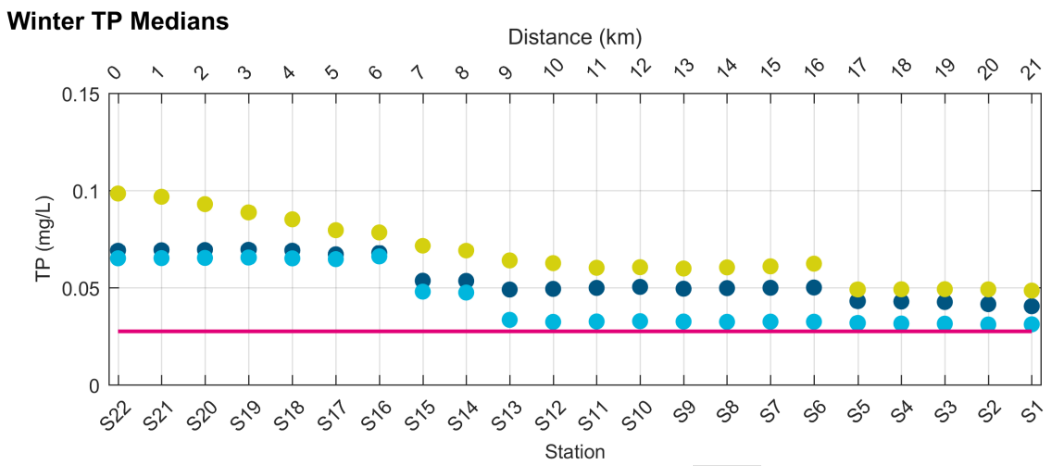

Figure 13 - Total Phosphorous - winter

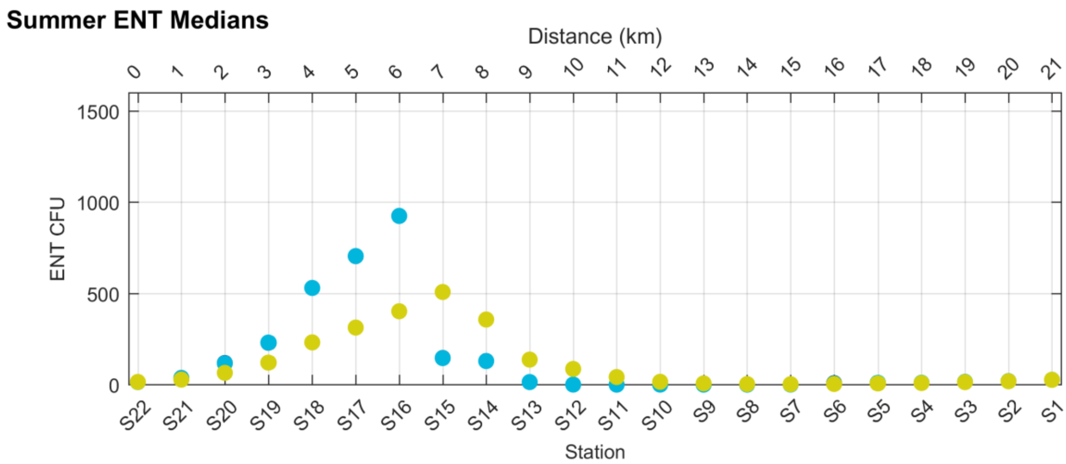

Figure 14 - Enterococci - summer

3.3.1.1 The key points to note in these charts are:

- In all the above cases, the points S14 and S15, are located in Home Reach and show the reduction in TN, TP and ENT in this area from the current estuary scenario (yellow dots) to a Tamar Lake scenario (blue dots).

- The elevated yellow dots in the area S9 to S15 (Lower North Esk to Home Reach) are all due to the asymmetric tides "pumping" pollutants from the Tailrace and the STPs back upstream.

- In Figure 13 for TP, the reduction in phosphorous discharges from the Hoblers Bridge (S6) and Norward (S1) STPs with the implementation of the LSIP converting these STPs to pumping stations only, is very noticeable, with the North Esk in a Tamar Lake environment (light blue dots) achieving the water quality EPA target (red line).

- The other key point to notice is that if the Cataract Gorge flows were modelled at the current 2.5 cumecs, the light blue dots in all three scenarios for points S14 and S15 in Home Reach would reduce to the same level as points S1 to S13; that is almost achieving the EPA target for water quality, with the water quality being determined by the flows from the North Esk catchment.

- The disparity on the enterococci chart (figure 14) for points S16 to S20 has not been explained by our consultants, but may reflect a discharge situation for the Ti Tree Bend STP which is located at S16.
  Even with this discharge, it should be noted that with the one-way flow downstream the water quality is the same as the estuarine situation by the time the pollutants reach Tamar Island.

3.3.2 Zone 3 - upstream of the barrage

At the other end of the lake, and for a distance of some 20 to 30 kilometres upstream of the barrage, water quality modelling by BMT WBM[21] predicted that there was high risk of late summer algal growth on the surface of the lake due to the high level of nutrient pollution in the freshwater and the potential for thermal stratification/dissolved oxygen depletion at depth.

The report identified that the source of pollutants was not only from the catchment and the STPs, but also in the form of nutrient sediment flux from the residual and likely migration of accumulated sediments on the bed of the Tamar. The maximum rates of sediment flux used in this modelling were determined from case studies from Australian and North American sources. Subsequent peer review of the modelling work recommended that existing sediment release properties be measured in the Tamar to add confidence to the model predictions. This is not withstanding the fact that the modelling undertaken by BMT WBM was of a future lacustrine[22] state where sediment accumulation has occurred in zones that are currently of limited sediment thickness upstream of the barrage, making measurements of the current state of limited value. This is due to the migration of residual sediments, not new deposits.

In their conclusions to the water quality study, BMT WBM noted that the proposed lake presents water quality behaviour that is consistent with that often observed and modelled in deep, fresh (usually water supply) water bodies. This includes the following broad attributes:

- Strong summertime thermal stratification. This is the fundamental issue at the heart of the water quality dynamics predicted by the model
- Significant subsequent depletion of dissolved oxygen at depth, with the development of ecologically toxic anoxic waters
- Remineralisation of organic matter within and on top of bottom sediments – this occurs to distances of several kilometres upstream of the barrage
- Supply of nutrients to the water surface where their abundance, together with light and warm temperatures leads to significant primary production and algal activity.

BMT WBM recommended that TLI undertake studies into the possibility of using destratification techniques to break up the thermal stratification to reduce the oxygen depletion at depth and reduce the potential for late summer algal blooms on the surface. Preliminary investigations commissioned by TLI around potential destratification of Tamar Lake indicated that any such system would likely be of significant scale.

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[21] Tamar Lake Scenarios Update – BMT WBM – MB 20921 – 27th January 2016
[22] Of or relating to a lake

3.4 Destratification studies

In response to this suggestion by BMT WBM, Tamar Lake Inc. commissioned a range of studies and 3D modelling scenarios that first looked at how these issues are handled at other barrage systems around the world, then applied these results to a study that looked at the extent, cost and effectiveness of implementing a range of destratification measures in Tamar Lake upstream of the barrage, then modelled a range of alternative scenarios that attempted to reduce the risk of late summer algal blooms by using barrage operating strategies.

3.4.1 In-lake destratification measures

In response to this recommendation, TLI initially commissioned BMT WBM[23] to carry out research on the mechanical mixing, air bubble diffusers, and oxygen injection techniques used as destratification measures adopted in barrage installations in other parts of the world, and investigate the possibility of using similar in-lake measures for the Tamar Lake project.

The conclusion reached from this initial research by BMT WBM, and agreed by TLI, was that because the size and depth of the Tamar lake, the effectiveness of these measures would be limited, and the capital and running cost too prohibitive, to consider this as a solution to the destratification requirements.

3.4.2 Barrage operating strategies

BMT WBM then carried out, in a separate study[24], a range of destratification scenarios that envisaged freshwater releases from the lake to the estuarine environment through the flood gates at the top of the barrage, and from the lower 2 metres through a pipe in the base of the barrage wall to enhance the flushing of the cold, dissolved oxygen reduced water downstream and encourage mixing to reduce stratification.

Catchment inflows used were based on:

- The current pollution inputs
- Forecast input reductions assuming the implementation of the LSIP
- Forecast reductions assuming the implementation of both the LSIP and the WQIP.

The results presented were based on four scenarios:

1. The current estuarine environment
2. Freshwater released only from the top 2 metres of the lake through the flood gates
3. Freshwater released only from the bottom 2 metres of the lake through a pipe in the base of the barrage at the lowest point
4. Freshwater released on the fly from both the top and bottom outlets controlled in a complex set of rules by measurements from a Dissolved Oxygen (DO) sensor at the lowest level of the dam.

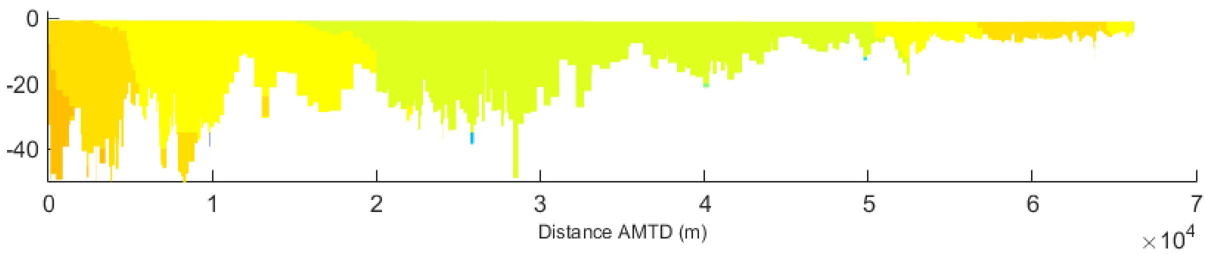
The graphical results of these studies are shown in figure 15 below.

[23] Research on Destratification Systems – BMT WBM R B20921 – February 2016
[24] Tamar Lake Inc. Destratification Scenarios – BMT WBM – R. B22148 - August 2017

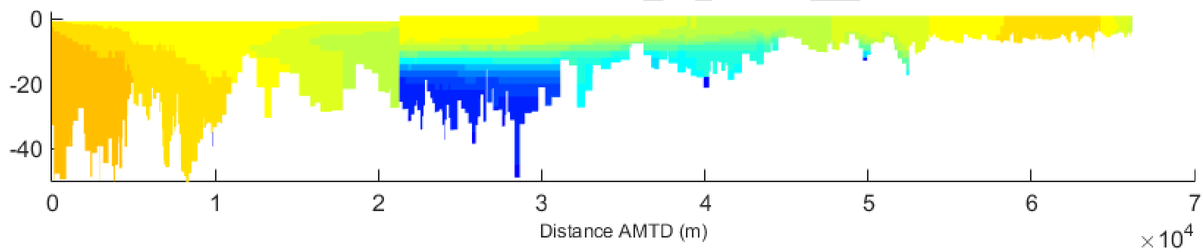
3.4.3 Destratification effects just upstream of the barrage

Dissolved oxygen (DO) mg/l – vertical axis is the depth in metres; the barrage is at the 22km distance from the estuary opening. Worst case – late summer

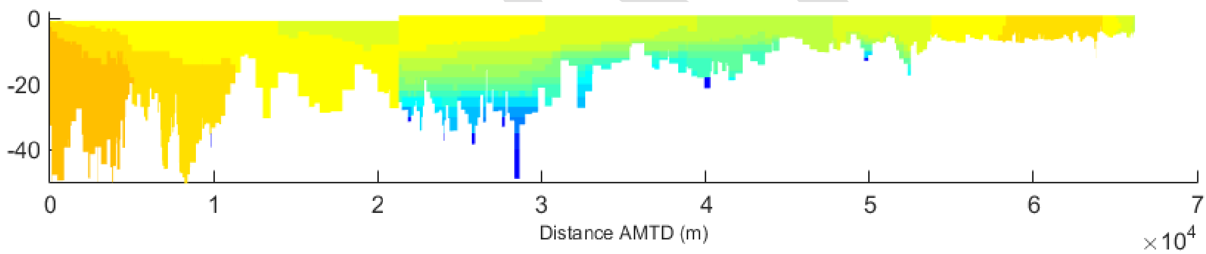
1. Baseline – Tamar Estuarine environment – no barrage



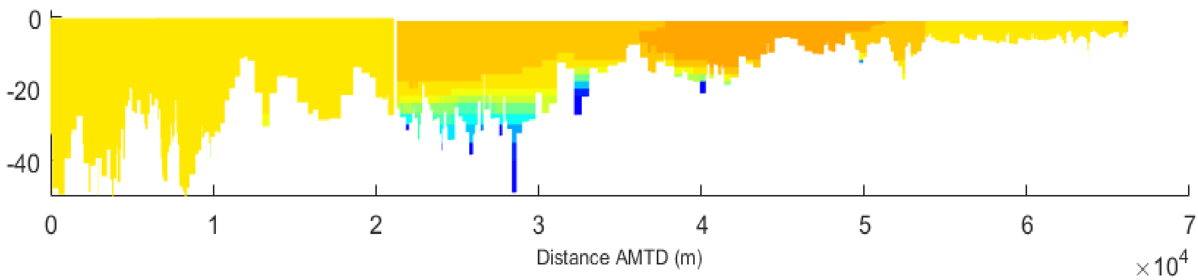
2. Scenario 1 – Tamar Lake environment – barrage release through top 2 metres



3. Scenario 2 – Tamar lake environment – barrage release through bottom 2 metres



4. Scenario 3 – Tamar Lake environment – barrage release 'on the fly' through top and bottom of barrage depending on measured DO levels on the bottom of the lake. The sensor measured DO levels placed at the lowest point of the lake. This is the very worst-case scenario



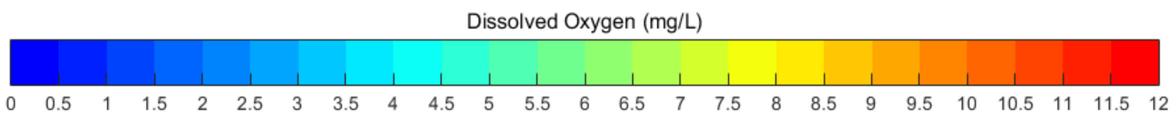


Figure 15 - graphical results of barrage operating strategies

3.4.4 Water quality and barrage operating strategies - summary.

The graphical results of the investigation into the use of barrage operating strategies to reduce the duration and frequency of algal bloom risk in the area just upstream of the barrage by reducing thermal stratification and oxygen depletion at depth, are shown in Figure 15 above.

While there appears to be a substantial reduction in anoxic conditions in the lake down to the 20-metre depth, anoxic conditions still exist from the 20-metre mark to the bed of the lake.

In summary, BMT WBM in the conclusion to their report (Tamar Lake Inc. Destratification Scenarios) stated that *despite the execution of a large number of scenarios that examine a variety of barrage discharge controls, the following outcomes remain:*

- *Summertime thermal stratification persists in the proposed lake, which is the fundamental driver of water quality issues within the lake*
- *Associated depletion of dissolved oxygen at depth, with the development of ecologically toxic anoxic waters still occurs*
- *Remineralisation of organic matter within and on top of the sediments persists*
- *Supply of nutrients to the water surface where their abundance, together with light and warm temperatures still leads to significant primary production and algal activity. This algal activity could include blooming of any number of species, including those harmful to humans.*

In addition to the above, the pipe structure and control rules considered here introduce the risk of moving large volumes of poorly oxygenated water from upstream of the barrage to the downstream receiving environments. The system therefore would act as a conduit for delivering low DO water from upstream of the barrage to downstream receiving environments. Low DO water is an acute toxicant to aquatic fauna and flora, and as such these releases present an additional and significant environmental hazard to the region.

3.4.5 Summary of destratification studies

While acknowledging from the commencement of this feasibility project that, as with any large body of constrained freshwater, there was the risk of dissolved oxygen reductions at depth and a breakout of algal blooms on the lake surface during the summer months, Tamar Lake Inc. has investigated very thoroughly the possibility of reducing that risk, and limiting the frequency and duration of any degraded water quality conditions just upstream of the barrage that may restrict the ability of local flora and fauna to survive and the reduce the amenity value of the lake in this location.

Within the constraints of the current Tamar Estuary 3D Model, the investigative level of this report and the funds applied, this has been achieved but not with the results desired.

3.4.6 Limitations of the 3D modelling carried out in this study.

Before discussing the limitations on the 3 D modelling carried out in these investigations of water quality at the northern end of the Tamar Lake, a review of the environmental influences that determine the susceptibility of the lake to algal blooms is reviewed.

- Water input flow and rate of lake refreshment
- Source and rate of nutrients (phosphorous and nitrogen) delivery to the lake
- Water depth at the area under investigation
- Lake bed composition at the area under investigation
- The temperature of the top layer of the water at the area under study, and the thermal difference between the top layer and the bottom layer.

The studies showed that the most susceptible time for the Tamar is between December and March each year.

Looking at each of the above issues in detail for the Tamar Lake situation:

3.4.6.1 Water inputs

Average input of freshwater from all sources is 3,400 GL (ref WQIP) which, with a storage volume behind the barrage of 405 GL, provides a refreshment rate of 8 times per annum. This rate however is much lower in summer and higher in winter.

This is a high volume of water flow by Australian standards, being about 50% of the inputs from the Murray River catchments to the Murray, not including the feed from the Snowy Mountains scheme. The Murray catchment is many times the size of the Tamar catchment.

3.4.6.2 Source of nutrients

When this report[25] was first received the principal source of the nutrients nitrogen and phosphorous was expected to be from the catchments and STPs.

The report however, showed that in a Tamar Lake environment, of a total 15,375 tonnes of nitrogen entering the water column in summer, only 12% was sourced from the catchment with the balance (13,619 tonnes) leached from the sediment bed in the area of reduced dissolved oxygen levels, with that figure increasing to 32% of a total 20,015 tonnes in winter because of the increased water flows from the catchment.

The corresponding figures for the current estuary environment were 55% of a total of 3,229 tonnes from the catchment in summer and 81% of a total 7,869 tonnes in winter, with the balance (1,473 tonnes) being from the sediment bed.

3.4.6.3 Water depth

The maximum water depth of the area just upstream of the barrage is 30 metres with a generally accepted view that any lake depths over 10 metres compounds the risk of algal bloom formations.

3.4.6.4 The temperature of the top layer of the water at the area under study

The difference between the top layer and the bottom layer which is determined by the temperature of the water entering the lake, the ambient air temperature, and the amount of radiation from the sun striking the surface.

[25] Tamar Lake Scenarios Update – BMT WBM – MB 20921 – 27th January 2016

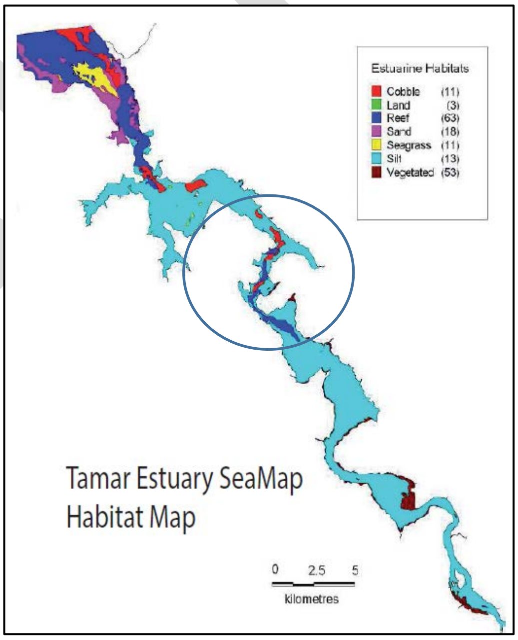
3.4.7 Actual scenario model for this study

The above conditions for the model used for these studies assumed the following:

- **Water flows** – typical summer water flows obtained from the calibration of the model based on actual measured water flows for the year from July 2010 to June 2011.

- **Nutrient sources**
    - **New nutrients entering the Tamar** from the catchment were obtained from the calibration of the model for the estuary and were the same for both the estuary and the Tamar Lake situation with scenario runs assuming both the current nutrient loads and the forecast reductions due to the implementation of the LSIP.
      The model predicted that the input load is 1976 tonnes of Total Nitrogen (TP) per annum and 313 tonnes of Total Phosphorous (TP).

    - **Nutrients entering the water column from the sediment bed** - The maximum rates of sediment flux used in this modelling were determined from case studies from Australian and North American sources. Using these case studies, the predictions used were 13,619 tonnes of TN and 1473 tonnes of TP.

      Subsequent peer review[26] of the modelling work recommended that existing sediment release properties be actually measured in the Tamar to add confidence to the model predictions.

      The argument to use actual measured sediment was strongly enhanced by the understanding that the model assumed some future point in time when the residual sediment load is more evenly distributed over the bed of the lake by maximum water flow events, including a thick covering over the current cobble and reef beds from T8 to T11, which produced the elevated levels of nitrogen and phosphorous shown in Figures 16 and 18 below. The base case is the current estuarine system, and the developed case is for the Tamar Lake environment.

      While not affecting the anoxic conditions at depth in this area, these elevated levels of both nitrogen and phosphorous, which determine the algal bloom risk, were therefore based on some hypothetical future point in time after the barrage is closed and not on the conditions at the time of closing, and up until that hypothetical future point in time. No attempt has been made in these studies to model these variables over time at this stage.

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[26] **Review of BMT WBM Tamar Lakes Scenarios Update – Dr Tony Church – February 2016**

- The effect of reduced nutrient flux on TN and TP levels in the water column is illustrated in figure 17 below. A scenario was run assuming the sediment flux for the lake scenario was reduced to the much lower flux rates for the estuary environment. It should be noted in figure 17, that the level of nitrogen in the in the water column in this lake scenario is much closer to the EPA standard for water quality (green line). The same situation applies for phosphorous in figure 19.

Total Nitrogen – Summer

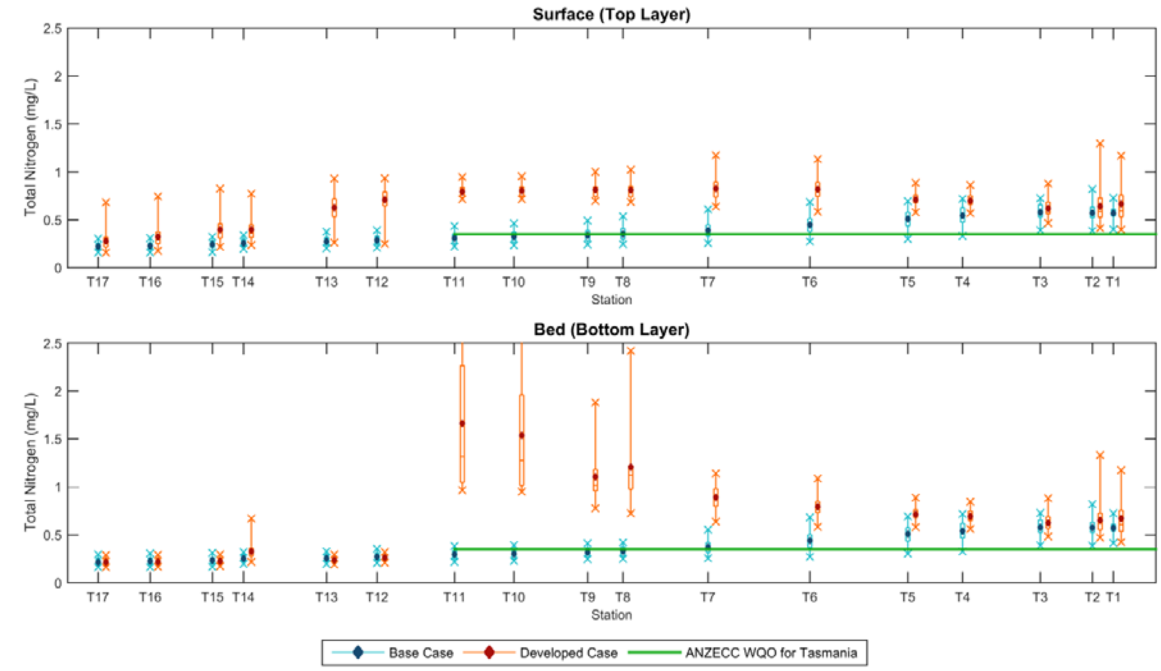

Figure 16 - Total Nitrogen – estuary (blue) versus lake (orange)

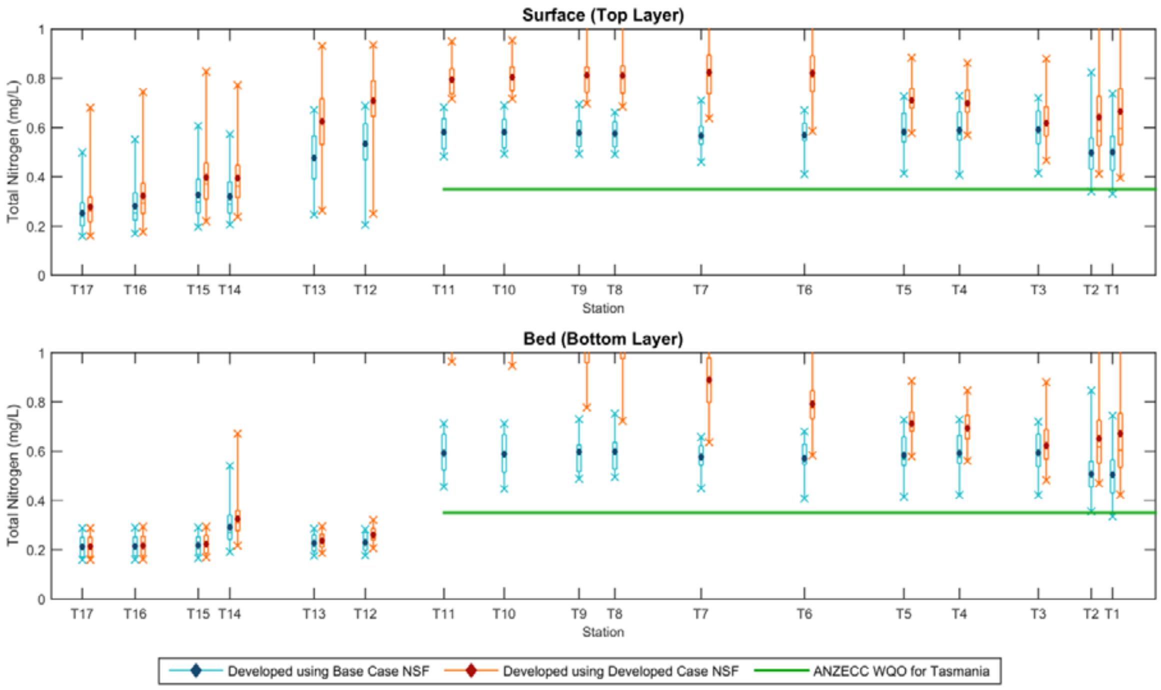

Figure 17 – Total Nitrogen summer - lake- high sediment flux (orange) versus low flux (blue)-
note expanded vertical scale

Total Phosphorous – summer

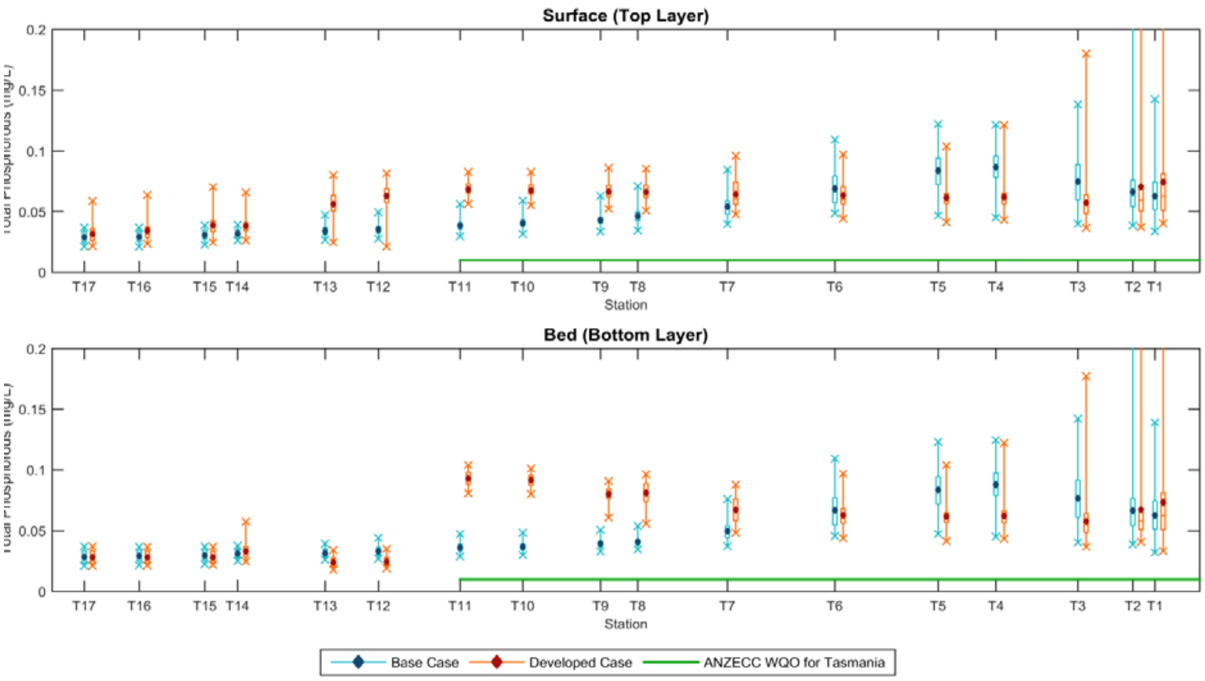

Figure 18 - Total Phosphorous – estuary (blue) versus lake (orange)

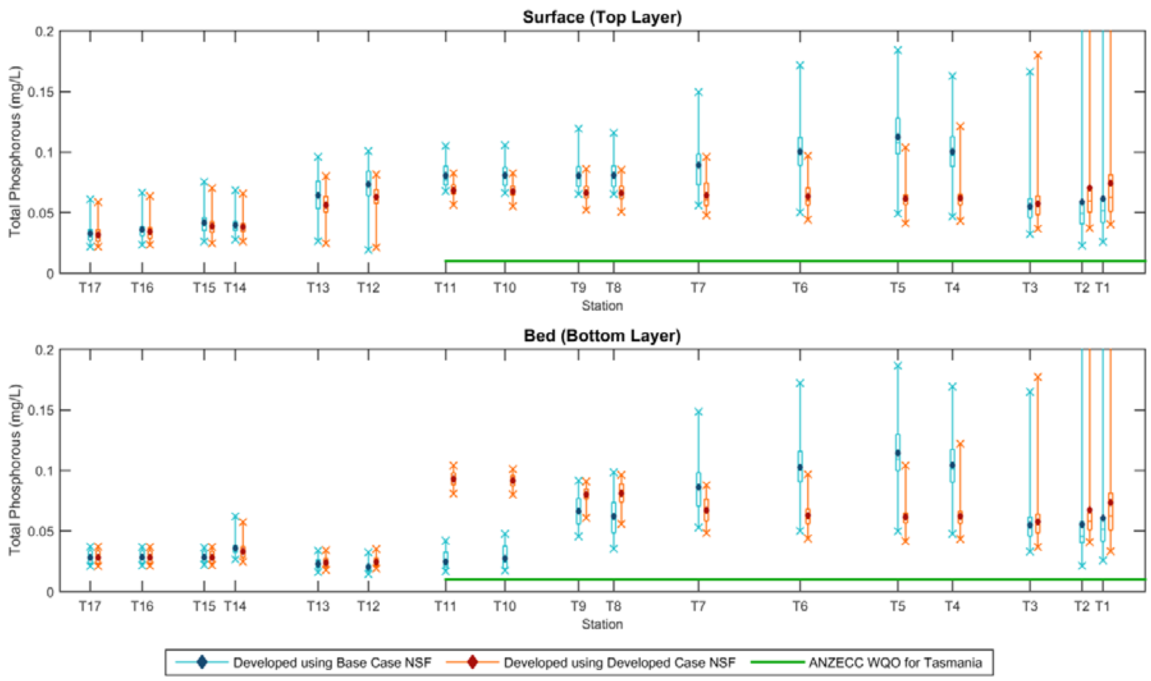

Figure 19 – Total Phosphorous – summer- lake environment - high sediment flux (orange) versus low flux (blue)

Key questions

1. **The question is, what levels of nitrogen and phosphorous in the water column will result immediately after the construction of the barrage with just cobble and reef beds; and how will this vary over an extended time frame – 10 to 50 - years as the cobble and reef is covered in sediment?**

2. **With an input load of only 1976 tonnes of TN per annum (before WQIP), and with 13,619 tonnes of TN leaching from the sediment bed each year and flowing out to sea, how many years will it be before the sediment bed load reduces to that of the input load, and what effect will this have algal bloom risk?**

3. **The same applies to TP with only 313 tonnes of new input load from the catchment, and 1473 tonnes of TP flowing out to sea, what effect will this have on algal bloom risk over time?**

3.4.8 Water temperature

The water temperature chart, figure 20, shows the summer surface and water temperatures at both the bed and the surface, with a freshwater surface water temperature about 2 degrees above that of the estuarine system in the T9 to T11 markers with the barrage being just to the right of T12, and the bottom temperature about 5 degrees below, with a stratification of 10 degrees for the freshwater environment and around 1 to 2 degrees for the saltwater environment due to the twice daily flushing of the tidal flows.

These water temperatures were computed based on the average ambient temperature, and radiant sun over the specific three-month summer period 2010 – 2011.

The water temperatures during winter are shown in corresponding chart in figure 21 with little variation between the estuarine and Tamar Lake environments with increased water flow and much lower ambient temperatures.
It is this thermal stratification that forces de-oxygenation of the lower layers (benthic layer) and the leaching of the nutrients from the sediment bed. These nutrients then bubble to the surface and if the temperature is high enough and the sunlight strong enough, causes algae suspended in the water to bloom on the surface.

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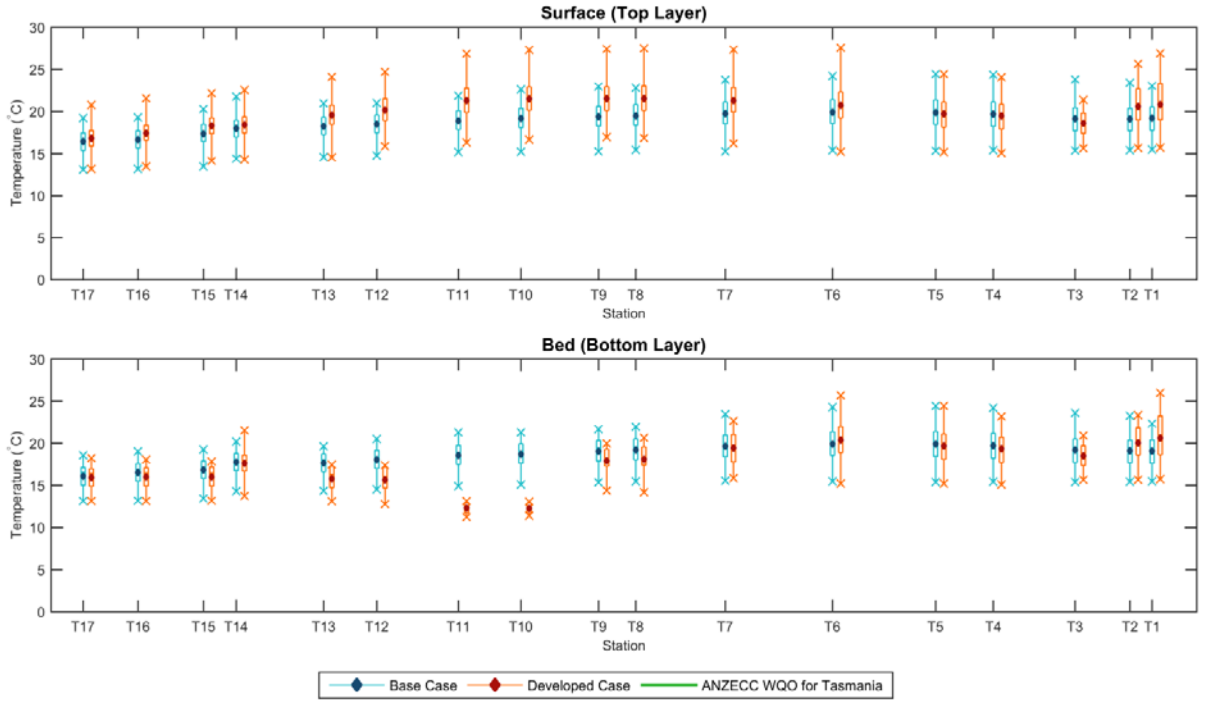

Figure 20 - Water Temperature - summer

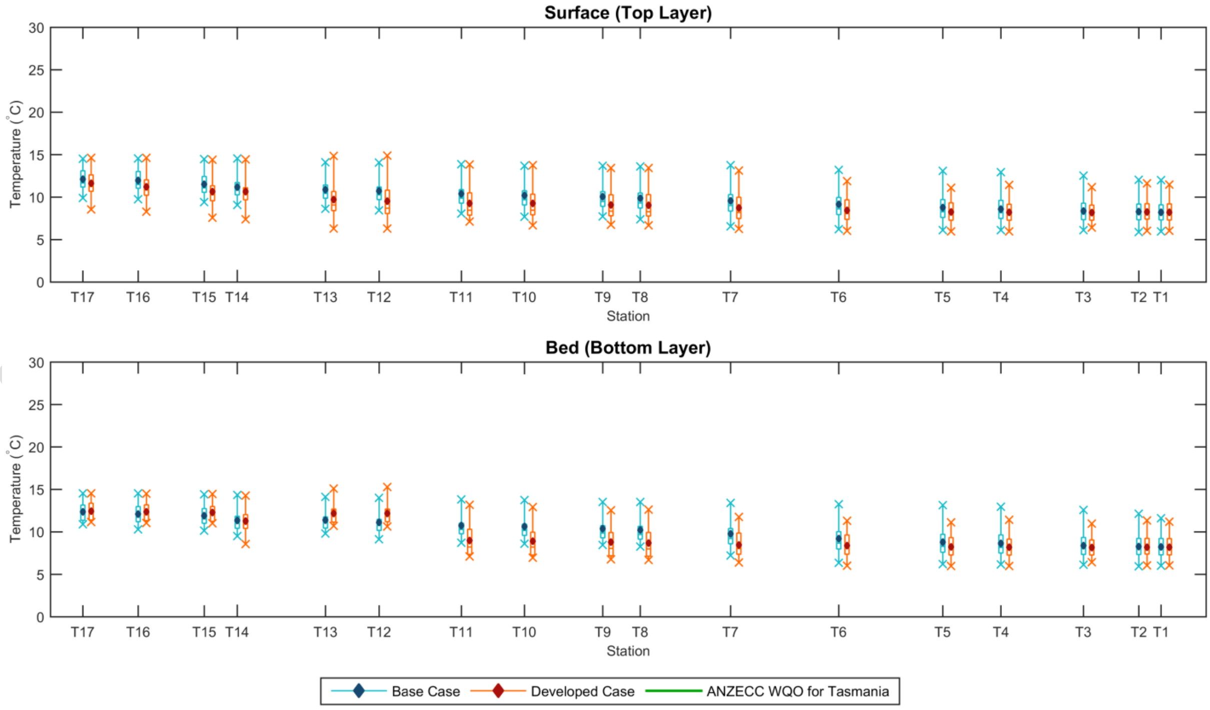

Figure 21 - Water Temperature - winter

The above charts were all modelled under the specific weather conditions for the year July 2010 to June 2011, which, according the meteorology charts for that year had a hot summer about 2 degrees above normal.

When looking at the possible frequency and duration of algal bloom threats, t**he question is what would the probability be, not in just this one year, but over a 10 or 20-year time span?**

3.5 Review of the limitations of this specific water quality modelling project

This model provided a snapshot of the expected threat of degraded water quality for the area just upstream of the barrage for the year 2010/11 for temperature and water flows, but with some hypothetical lake bed sediment qualities N years after the closure of the barrage gates, and used book values for sediment flux release rates from other Australian and international case studies.

The same applies to the probable reduction in nutrient sediment flux rates over time with the annual nutrient load leached from the sediment greatly exceeding the new source of supply from the catchment.

Because of the above, this scenario modelled is very much a worst-case scenario for this snapshot and gives no indication of how this threat may vary over time.

This is compounded if the LSIP and WQIP programs are also implemented in this time frame with forecast reductions of input loads to the Tamar from the greater catchment area, including STPs, of 17% for Total Nitrogen, 27% for Total Phosphorous, and 24% for Enterococci, despite an attempt made in the model runs to factor these reductions into the modelling.

Despite the very substantial effort made by Tamar Lake Inc. to show how the frequency and duration of oxygen depletion at depth and algal bloom growth events may be reduced for this specific snapshot using a variety of destratification techniques, we do not have a picture of the level of threat immediately after the barrage gates are closed, or for any period, say 30 years, after the implementation of the Tamar Lake project.

3.5.1 Possible future modelling

When the issue of how/if the magnitude, composition and duration of summertime algal blooms might be investigated over longer temporal scales, and under varying summer weather conditions, was raised with our consultants and modellers, BMT WBM, they made the following observations:

Two potential options exist for investigating the proposed Tamar Lake.

- ***Extend the TUFLOW FV model***

  TUFLOW FV, although three dimensional and detailed, can be executed over a decadal period. Indeed, BMT WBM has affected such simulations for several clients including Sydney Water, where the entire Hawkesbury Nepean river system from Pheasants Nest and Broughtons Pass (~200 m AHD) to the ocean boundary at Barrenjoey was simulated. This TUFLOW FV model was calibrated over a 2-year period, but then one hundred (100) ten-year simulations were executed and provided to Sydney Water as part of the commission.

  Naturally, this is no small undertaking, but it is possible and TLI may wish to consider extending the existing TUFLOW FV model to encompass a decadal simulation, with variable summer meteorology. This would provide the highest quality outcome, and the model would need no additional calibration or validation. The obvious disbenefit is that this approach is computationally intensive and scenarios would take some time (likely several days to a week each) to complete.

- ***One dimensional model***

  Prior to the wider adoption of three dimensional models such as TUFLOW FV, one dimensional lake models were used extensively throughout academia and consulting. These models simulate only the vertical dimension, and treat the simulated lake as a series of horizontally homogeneous layers. These layers do capture the lake volume accurately (they follow a hypsometric curve) and each computes its own hydrodynamic and water quality

quantities. Vertical mixing and stratification processes are simulated, as is light and all relevant water quality processes.
The key advantage of one dimensional models is that they have a small computational overhead and so can easily be run for periods up to or exceeding 100 years. BMT WBM has undertaken such simulations in the past for various domestic customers. Of course, the meteorological forcing over this 100 years can comprise a mixture of real and synthesised data in order to capture the desired range of climatic conditions, as is sought by TLI. The key disadvantage of one dimensional models is that they cannot resolve lateral lacustrine processes such as intrusions or meteorological processes such as sheared wind or radiative fields. In the context of TLIs enquiry however, this is most likely a second or third order issue.
An example one dimensional model is the General Lake Model. It has been co-developed by AED at the University of Western Australia. AED also developed the water quality model used in the existing Tamar Lake TUFLWO FV model deployed in this study.

3.6 Water quality – recommendations for future action

As a result of these preliminary studies into the water quality upstream of the barrage in a Tamar lake environment, Tamar Lake Inc. would like to make the following recommendations to a prospective proponent for any future work in this area.

1. Conduct a field study to measure the actual sediment flux release rates in the Tamar River in the freshwater and tidal water areas over a range of locations, including the current cobble and reef section near the barrage, for both summer and winter weather conditions, then apply these actual flux rates in a re-run of the models presented in this report to gain a picture of the what the algal bloom risk would be during the summers in the years immediately following the closure of the gates.

2. Attempt to project these results, say over a 30-year period, with assumptions made, or modelling carried out, about the longitudinal spread of the sediment bed along the lake during this period, and with the reduction in nutrient flux rates because of the large excess of sediment flux over new sediment input loads.

3. Model the assessment for the potential for algal bloom outbreaks under a variety of weather conditions over an extended period of time, say 10 years, and assuming the conditions modelled in 2. above.

This extra modelling will not be a simple or inexpensive exercise, with the proponent asking whether any attempt to predict the future rate and duration of algal bloom events beyond the first few years of Tamar Lake operations is economically and socially necessary.

3.7 Rice grass in the Tamar

Rice grass was introduced to the Tamar in 1947 with the goal of stabilising mudflats, reclaiming inter-tidal lands and improving navigation. The plant spread rapidly throughout the estuary, and now represents Tasmania's (and Australia's) largest infestation, covering 415 ha out of a total 590 ha state wide. See figures 22 and 23.

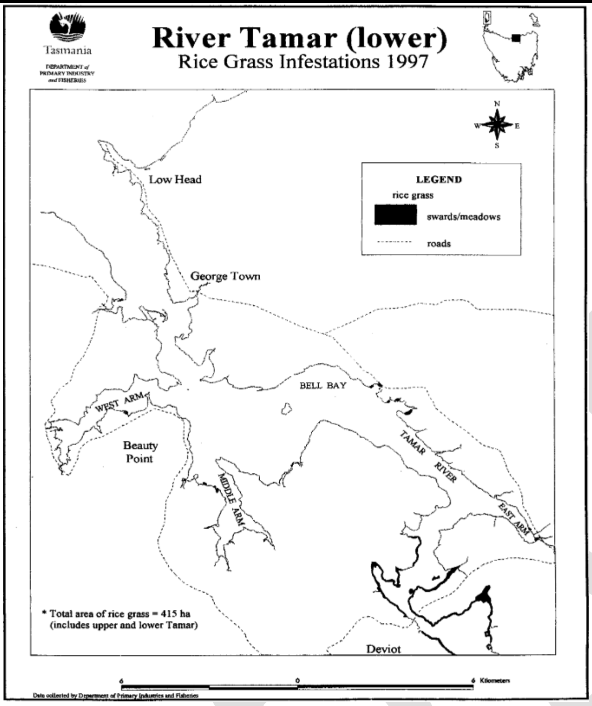

Figure 22- Rice Grass infestations - lower estuary

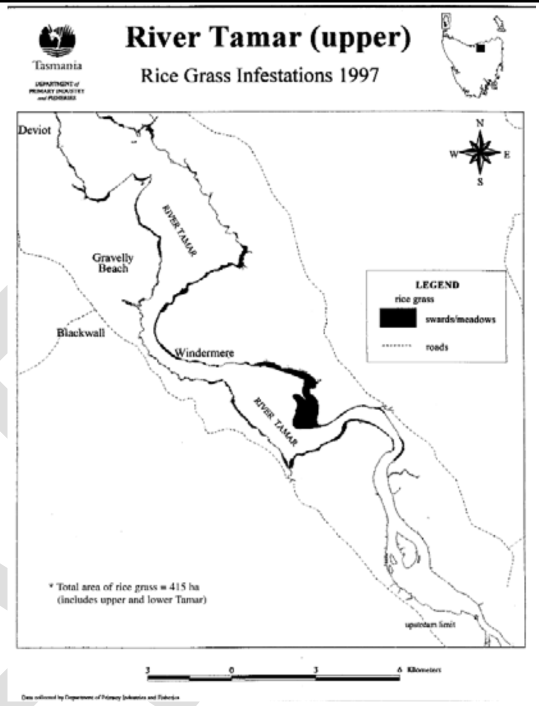

Figure 23- Rice Grass infestations - upper estuary

Rice grass is typical of an invasive weed species. Its dense growth habit and rhizome/root network act as a trap for sediments and debris altering the natural rate, magnitude and location of sediment deposition and erosion. These processes elevate shorelines and river banks to create terraces and marsh islands by promoting deposition and accretion which may have considerable impacts on the hydrodynamics and ecology of estuaries, aquaculture, wild fisheries, tourism and recreation.

Tourism and recreation have also been impacted by the spread of rice grass. For example, in the River Tamar, well-established infestations inhibit public access to the shoreline, many private boat ramps and jetties have been rendered non-functional and several once popular sandy beaches (e.g. Gravelly Beach) have been transformed to muddy rice grass meadows. Thus, rice grass has reduced the utility value and aesthetic appeal of the River Tamar shoreline and has effectively reduced its attractiveness to residents and tourists.[27] See figures 24. and 25. below.

In a freshwater Tamar Lake environment, the rice grass will die off and decay, allowing the re-colonisation of native species, and restoring the aesthetic presentation of the full width of the waterway with a permanent high-water level. The terraces formed by the rice grass infestation will be exposed to limited erosion over time with major flood events (due to root system still binding the silt bed), but mechanical raking or excavation may be used to restore the original near bank navigation depth for boat access.

[27] State of the Environment (SoE) Tasmania 2003 - Rice Grass Management in Tasmania

Figure 24 - High tide at Rosevears

Figure 25 - Low tide at Rosevears

3.8 Sea level rise

The barrage provides a protection against a sea level rise of up to 0.8m for the whole of the Valley upstream of the barrage. With the crest of the flood gates in the barrage set at 2.2m AHD, the gates provide for protection against the highest spring tide with an additional clearance of 0.8m to accommodate the predicted sea level rise.

This is particularly important for the low-lying areas of Invermay as shown in the Coastal Risk Australia forecast chart for the year 2100 (Figure 26 below).

The flood levee system, recently completed for this area by the Launceston Flood Authority, does offer some protection against the highest spring tide with one-way valves blocking reverse flow through the stormwater system into the below water level areas of Invermay shown in the dark blue shading of figure 26 below. This is unlikely to be as effective as the barrage gates blocking the spring tides and sea level rise for the whole valley upstream of the barrage.

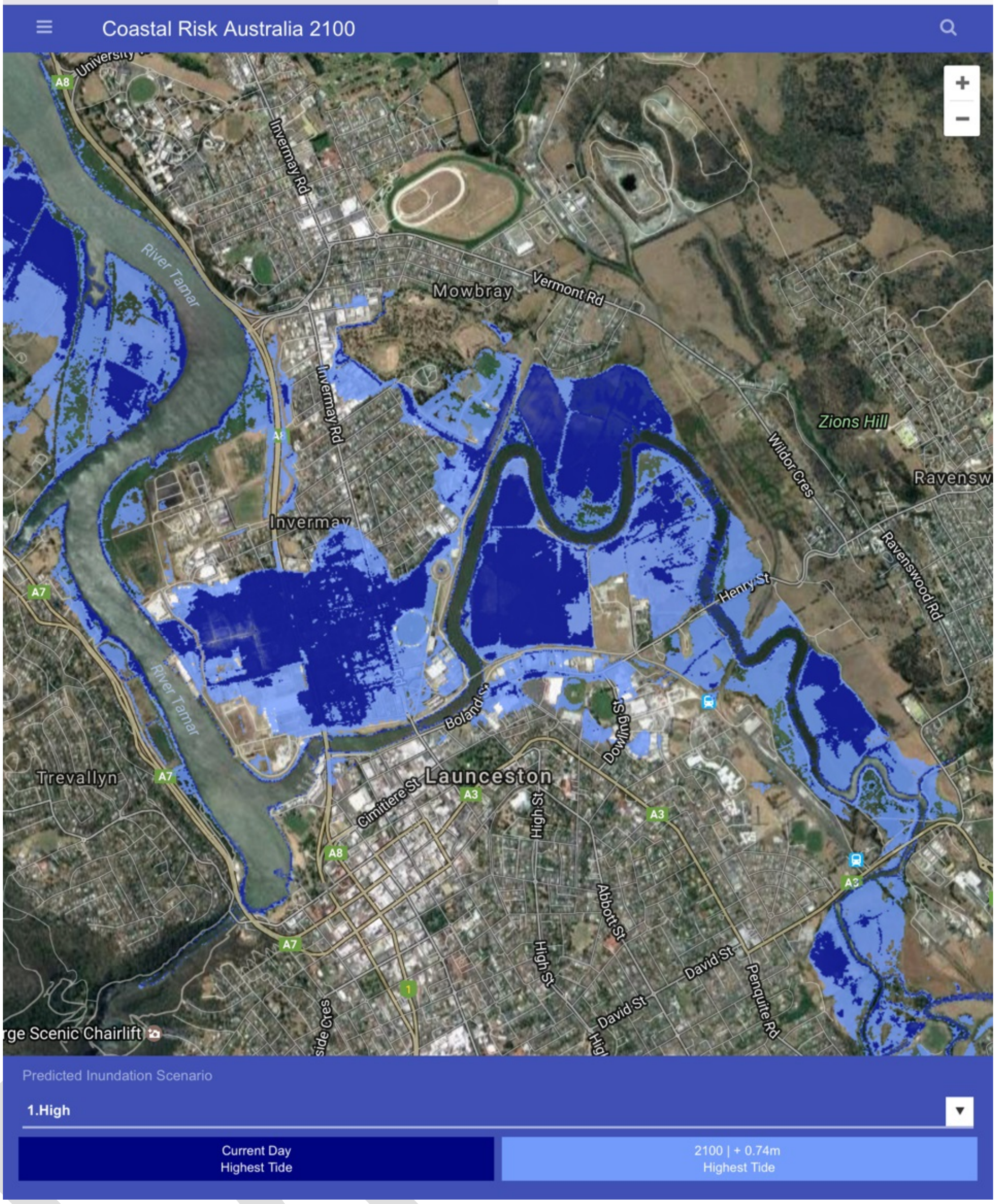

Figure 26 - Effect of Sea Level rise of 0.74m in Launceston

3.9 Technical

3.9.1 *Flood Mitigation*[28]

The Tamar Lake flood modelling has shown that with normal operation of the flood gates in the barrage, there is a mitigating effect on flood levels in Launceston, for either the current sea level conditions or assuming a future rise in sea level of 0.8m. See Table 2 below.

Barrage in operation			**Metres relative to current flood levels**
Flood Height Impact (m)	Current	10 year	-0.5 to -1.0 whole of lake
		20 year	-0.5 to -1.0 whole of lake
		50 year	-0.1 to -0.25 Launceston, -0.25 to -0.5 rest of lake
		100 year	-0.1 to +0.1 Launceston, -0.1 to -0.5 rest of lake
		200 year	-0.1 to +0.1 whole of lake
Flood Height Impact (m)	Sea level rise	10 year	-0.5 to -1.0 Launceston, -1.0 to -2.0 rest of lake
		20 year	-0.5 to -1.0 Launceston, -1.0 to -2.0 rest of lake
		50 year	-0.5 to -1.0 whole of lake
		100 year	-0.1 to -0.25 Launceston, -.25 to -1.0 rest of lake
		200 year	-0.1 to +0.1 Launceston, -0.1 to -0.5 rest of lake

Table 2 - Flood Level Impacts

With the ability to lower the level of the lake to mid tide level to create a buffer of more than 45,000 ML of flood waters, coupled with the removal of any tidal effects upstream of the barrage, there is up to a 1.0m reduction in flood levels along the length of the lake. Table 13 summarises the forecast flood levels with the barrage in place for all flood events from a 10-year ARI event to a 200 year ARI event, compared to levels without the barrage.

The report shows that ability to buffer floodwaters for the more frequent low to moderate flood events (5 to 20 years) will enable the prevention of floods topping the banks of the low-lying areas of Launceston on the wet side of the new levee system – Glebe flats, Seaport Boardwalk, Royal Park, Newstead etc.

3.9.2 Fresh water supply

With a freshwater storage volume of 450 GL, and an annual input flow of between 1500 and 4000 GL from a catchment of approximately 20% of the area of Tasmania, the Tamar Lake opens up huge opportunities for commercial development in the industrial, agricultural, residential, and tourism sectors of the economy.

Freshwater recreational fishing will also receive a significant boost.

With the current freshwater supply to the Tamar Valley north of Launceston being limited to a small pipeline down each side of the river from Launceston, Beauty Point and the Bell Bay Port and Industrial zone are in a position to greatly benefit from an almost unlimited freshwater supply.

As the economic studies show, a Tamar Valley Irrigation scheme has the potential to greatly expand the area of the Valley under cultivation for wine, perennial horticulture including apples, pears, cherries and berry fruits, and irrigated pasture for dairy production.

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[28] **Tamar Lake Flood Modelling - BMT WBM – Philip Pedruco – November 2014**

3.9.3 Marine navigation

With a lock in the barrage able to accommodate vessels as large as the Wyuna or the Queenscliff ferry, and water level in the lake at the current high tide level, 24 hours a day navigation along the whole of the current watercourse for vessels with a draft up to 5m will be achievable with a higher margin of safety than at present.

With an 80% reduction in the very large tidal flows at the Bell Bay port, the task of berthing ships and the risk of grounding of vessels berthing at the wharves is greatly reduced.

With a forecast reduction in tidal flows just upstream from George Town from 6km/hr to less than 1km/hr, it will be possible to establish a large cruise liner (2000 to 3000 passengers) mooring facility in the sheltered area opposite Lagoon Beach, and adjacent to the shipping channel with a depth of 27 metres.

Using the vessel's tenders, passengers could be unloaded at George Town or Beauty Point for shopping, or for day excursions to Launceston and other parts of the north of the State.

3.10 Economics

Since 2010 Tamar Lake Inc. has commissioned two significant studies to investigate the potential economic outcomes of the implementation of Tamar Lake.

- NERA Economic Consulting – Economic Prefeasibility Study (April 2013)
- KPMG – Economic Impact Update (July 2014)

Both reports concluded that the implementation of the Tamar Lake would deliver significant economic benefits.

3.10.1 NERA Economic Consulting – Economic Prefeasibility Study (April 2013)

This report estimated the total economic valued added of the Tamar Lake (before taking account of its anticipated cost of implementation) to be $553m.

These benefits were forecast to be derived from:

- Irrigated agriculture;
- tourism;
- use of water of industrial processes; and
- residential and commercial property appreciation.

The total forecast benefits also included avoiding the cost of flood and sediment management.

The report also identified the potential negative impact that the implementation of Tamar Lake could have on the current salmon farming enterprise operated at Rowella. Conservatively the study assumed that this operation would cease. The total economic value added benefit of $553m was estimated after accounting for the potential closure of this salmon farming operation.

3.10.2 KPMG – Economic Impact Update (July 2014)

This study analysed and modelled the potential economic impacts of the Tamar Lake over an 18 year period. It assumed the construction of the barrage would commence in 2019 and concluded that:

- *During the first 3 years (2019-2021), direct expenditure on barrage construction and irrigation scheme construction would contribute approximately $313.51m in net additions to Gross State Product (value added), and support the employment of 856 jobs;*
- *On an annual basis, for the period 2021-2035, on average, capital works relating to irrigation scheme connections would contribute approx. $2.08m in net additions to GSP p.a., and support the employment of 14 jobs p.a.;*
- *Combined operations of the barrage and irrigation scheme suppliers would, on average, contribute approx. $3.1m in net additions to GSP p.a., and support the employment of 15 jobs p.a. for the period 2022-2028, increasing to $3.46m p.a. and 17.5 jobs p.a. for the period 2029-2036;*
- *Operations of the irrigation scheme users would, on average, contribute approx. $5.15m in net additions to GSP p.a., and support the employment of 38 jobs p.a. for the period 2022-2028, increasing to $14.1m p.a. and 96 jobs p.a. for the period 2029-2036; and*
- *The favourable impact on tourism would more than offset the adverse impact on existing fisheries, and in net terms, would contribute approx. $112.48m in net additions to GSP p.a., and support the employment of 716 jobs p.a.*

It should be noted that these economic benefits result only from the construction of the barrage, and subsequent operations in the agriculture and tourism sectors over the 15 years.

The NERA economic study carried out for Tamar Lake Inc forecast a net increase in residential and commercial property values in Launceston and the upper Tamar Valley at $333 Million over the same period due to the formation of the Tamar Lake.

The substantial boost to construction and the service industries resulting from this perceived increase in household net asset values, has not been included in the KPMG results.

3.11 Funding

3.11.1 Value capture funding methods

Acknowledging the significant level of funding required to implement the project, Tamar Lake Inc. commissioned AECOM in February 2017 to estimate the potential for value capture funding methods to contribute to the funding of the Tamar Lake project.

Value capture funding methods are a relatively new concept in Australia. Traditional approaches to funding methods for new or improved infrastructure have used funds entirely sourced out of general taxation revenue, meaning all taxpayers share the burden of paying for the infrastructure despite the fact that many of them will not use or directly benefit from it.

By identifying and quantifying the value created from the development of the new infrastructure, and connecting it with the costs of the infrastructure, value capture mechanisms can help deliver projects through a fairer model.

The findings from this initial study conducted by AECOM were as follows:

The local housing market is affordable and that the stimulus provided by the project would attract new residents seeking housing, second homes or retirement living to the area. Land use planning studies show that locations along the River could be activated and upgraded to accommodate additional growth.

The recently initiated Launceston City Deal between the Commonwealth and Tasmanian governments will provide a series of projects and programs that can be leveraged to support the Tamar Lake Project. There is the potential for programs associated with the City Deal to contribute directly and indirectly to Project, such as:

- *Federal and State government grants*
- *Complementary land use planning and zoning programs*
- *Economic development strategies*
- *Environmental and estuarine management programs*

Case studies of similar projects in other parts of the world demonstrate that business-led or citizens' initiatives such as Tamar Lake Inc. evolve into publicly funded and managed projects with citizens' advisory boards. The citizens' advisory boards provide a means for project initiators like Tamar Lake Inc. to continue to positively influence their projects as management and funding responsibilities evolve over time. Tamar Lake Inc. should anticipate this evolution and position itself as the key influencer for the Project.

Local and state government agencies involved in land use planning, natural resource management, the environment and economic development should be brought into the project as early as practical. Supportive land use and infrastructure investment plans, value capture funding mechanisms, and funding and financing options require strategic positioning and long lead times to be effective. Early action by TLI to align the Project with the Launceston City Deal should be pursued.

Given the current indicated construction cost of $320 million, the benefits to property values alone from the project greatly exceed its costs:

- *The uplift in median residential property values in Launceston following construction of the Project and stabilisation of values is conservatively estimated to be $1 billion.*
- *The uplift in median unimproved commercial land values in the Launceston CBD within 500m of the riverfront following construction of the Project and stabilisation of values is estimated to be $434m.*

AECOM identified the following potential value capture funding methodologies to be applied to the Tamar *Lake project:*

- Selling development rights and / or density above existing zoning controls.
- Sale of government-owned land that is enhanced or made developable by the project.
- Captured through public taxation system such as land tax and stamp duty, possibly captured through sharing value uplift with surrounding landowners).

The encouraging outputs from this AECOM study support further work being undertaken into the application of value capture funding to the Tamar Lake project. Tamar Lake Inc. would recommend this work be included in the broader socio-economic study that would be initiated as part of preparation of formal business case for the development of the Tamar Lake.

3.11.2 Other funding sources

In addition to the value capture methodologies noted above, Tamar Lake Inc. believe a number of other funding sources would be available to support the capital and ongoing operating costs of the project including:

- Selling water entitlements to users of the proposed irrigation scheme
- Federal, State and Local Government funding contributions driven by the:
  - the improved environmental outcomes achieved from the project;
  - capital costs avoided relating to flood damage and sediment management;
  - capital costs avoided relating to water treatment and pollution management; and
  - Improved public amenity.

The economic studies undertaken to date support the strong potential this project has to raise the necessary funding required to build and operate the barrage.

A comprehensive study on the funding sources for capital and ongoing operating costs of the project would form part of a full business case which should be developed to properly assess the potential for this project.

4.0 Barrage

4.1 Barrage location

The general location of the barrage in the Rowella/Long Reach area has been determined by the strategic requirements of flood mitigation, silt transport and economic costs/benefits.

As shown earlier in this document, the Long Reach site is now the preferred option, but alternative sites, and community acceptance must be explored before a final site is chosen.

Figure 27 - Preferred barrage site

4.2 Barrage Design

The following design parameters have been provided C D M Smith, the designers and implementers of the Marina Barrage in Singapore.

4.2.1 Construction materials and cost

The barrage, located in the Long Reach section of the river (see figure 27,) will be constructed with a concrete faced rock wall for the deep and non-operational section of the total 800-metre-long barrage, with the 350-metre-wide gate section and the two locks constructed of pre-formed concrete on the much shallower rock ledge section off the West shore.

CDM Smith have provided a preliminary cost estimate of $320m, with 75% of the labour and materials locally sourced, 20% from interstate, and 5 % internationally. This figure includes a 50% contingency cost factor, but does not include the cost of the pipe in the base.

4.2.2 Barrage functions

The functions that the barrage must perform are:

- To provide a clear separation between the freshwater lake environment and the saltwater estuary environment for all tidal events up to a sea level rise of 0.8m.

- The ability to pass all normal and up to 200-year ARI flood flows without negatively affecting flood levels upstream in Launceston.

- The ability to maintain a constant water level in the lake, but to operationally vary that water level from current mid to high tide level.

- The ability for small leisure craft and larger commercial vessels to transit the barrage via locks.

- The ability for migrating fish and eels to transit the barrage for life cycle purposes.

4.2.3 Barrage components

To achieve the above functions, the following components will be incorporated in the barrage design.

- *Crest Level*
  Crest level of at least 2.2 metres AHD to block current tidal levels plus provision for a sea level rise of 0.8 metres.

- ***Spillway gates***
  Size - 10 vertical lift gates each 35 metres wide by 5.2 metres high

- ***Flood safety control***

  The flood analysis carried out by our consultants, BMT WBM, has shown that with normal operation of the gates, there will be no detrimental effect on flood levels in the valley south of the barrage or in Launceston, when compared with flood levels in the current tidal regime.

  However, if for some reason the gates are unable to operate, the barrage presents as a weir with a crest at 2.2m AHD, in which case the flood levels in Launceston and the Valley could be increased by as much as 1.0m for a 200 year ARI flood event.

  To prevent this from ever occurring, the barrage will be designed to be completely fail safe. This will occur at two levels:

  Redundancy/backup
  The system has 10 independently operated gates, with a backup power supply from a diesel-powered generator.

Fail Safe
Under normal operation, each of the 10 vertical lift gates will be constrained in the vertical plane by a shear pin or bolt. Should any, or all, of the gates fail to operate with rising flood waters, the water pressure will cause the shear pin/bolt to break and allow the gate to pivot on a horizontal plane about an axis at the top of the gate, allowing unconstrained flow down river to relieve potential flooding.

The design of this mechanism will be included in the detailed design of the barrage.

- ***Locks***
  The barrage will be fitted with two locks for the passage of boats and small ships up and down the river. To reduce cycle time, the small lock will accommodate pleasure powerboats and yachts, with a larger, less frequently used lock for the commercial tugs, ferries, tourist boats etc. The small lock will be user operated with suitable security.
  A preliminary estimate of the lock sizes are:
    - Small lock – 40m long by 8m wide
    - Large lock – 70m long by 18m wide
- ***Footbridge/bike path***
  An elevated footbridge/bike path will be constructed on top of the wall; integrated into the vertical lift gate assembly; and mounted on top of the lock gates.
  This will provide passage for pedestrians and cyclists except when a lock is in operation

- ***Fish Ladders***
  Fish ladders, principally for the passage of eels and Australian Grayling will be incorporated in the wall.

4.3 Conclusion

The series of consultant studies into, and 3 D modelling of, the Tamar Lake strategy covered in this document has conclusively shown that the implementation of the project is technically, scientifically, and environmentally feasible, and that if implemented, has the potential to enable a major economic transformation of Launceston and the Tamar Valley.

While Tamar Lake Inc. considers that it is imperative that both the LSIP and the NRM North Water Quality Improvement Plan (WQIP) be completed as soon as possible to reduce the quantity of pollutants flowing into the Tamar, our studies have shown that even with the current pollution loads, the water quality in the Home Reach/Yacht Basin/Lower North Esk area is greatly improved within 12 months with the Tamar lake implementation.

A project plan for this assessment, prepared by the Launceston based federal MPAA and our environmental consultants Epic Environmental, are shown in Appendices A & B.

In Appendix C, this study has also shown that an alternative location for a barrage at Freshwater Point should be considered. In this assessment, it is also recommended that the modelling be carried out to determine the viability of a barrage at Freshwater Point be considered as a lower cost, more environmentally acceptable option, but with the potential for major consequences for flood mitigation, structural foundations for the construction of the barrage and for continued silt accumulation below the barrage.

5.0 Appendix A

5.1 Federal and State Government approvals process

The Federal Government's Major Project Approvals Agency (MPAA), located in Launceston, has prepared a 3 year project plan for obtaining both State and Federal approvals for the Tamar Lake project for assessment as a Project of State Significance (POSS) and has estimated the total government fees at between $250K and $500K, depending on the quality of the submission.

An overview of the project plan is shown in the Gantt chart below.

5.2 Proponent requirements and cost assessment

Under the assessment as a POSS, the proponent is required to prepare an Integrated Impact Statement (IIS) which will be then assessed under the federal EPBC Act.

The Tamar Lake environmental consultants, Epic Environmental, has provided indicative costs for the Proponent to complete the IIS.

The total costs have been estimated at between $2.5m and $3.3m with the breakdown shown in Appendix B.

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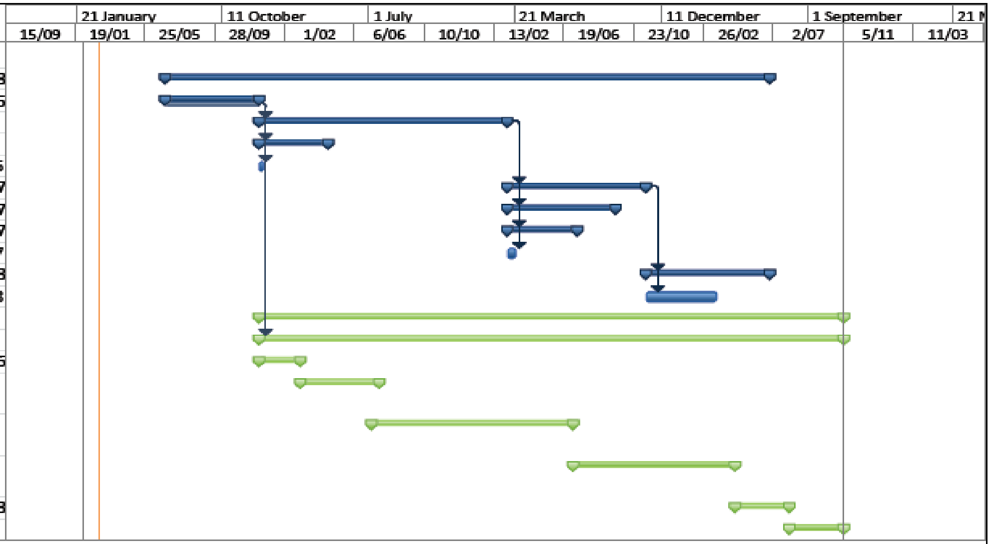
ID		Task Mode	Task Name	Duration	Start	Finish
1			Tamar Lakes Inc.			
2			Commonwealth Government	779 days	Wed 1/07/15	Mon 25/06/18
3			FIRB	121 days	Wed 1/07/15	Wed 16/12/15
9			EPBC	320 days	Thu 17/12/15	Wed 8/03/17
13			Sea Dumping	89 days	Wed 16/12/15	Tue 19/04/16
21			Historic Shipwrecks	5 days	Thu 17/12/15	Wed 23/12/15
22			Customs	178 days	Thu 9/03/17	Mon 13/11/17
25			EPBS	140 days	Thu 9/03/17	Wed 20/09/17
29			Quarantine	90 days	Wed 8/03/17	Wed 12/07/17
32			Importation of Machinery	10 days	Thu 9/03/17	Wed 22/03/17
33			Heavy Vehicle	160 days	Tue 14/11/17	Mon 25/06/18
36			Overseas workers	90 days	Tue 14/11/17	Mon 19/03/18
37			Tasmanian Government	753 days	Thu 17/12/15	Mon 5/11/18
38			Project of State Significance	753 days	Thu 17/12/15	Mon 5/11/18
39			Order for the project to be considered a PoSS	53 days	Thu 17/12/15	Mon 29/02/16
46			Preparation of Guidelines for Intergrated Assessment	102 days	Tue 1/03/16	Wed 20/07/16
56			Preparation of Integrated Impact Statement by Proponent	260 days	Thu 7/07/16	Wed 5/07/17
58			Assessment of Impact Statement by Commission	208 days	Thu 6/07/17	Mon 23/04/18
67			Ministerial Decision	70 days	Tue 24/04/18	Mon 30/07/18
72			Recommendation for additional conditions	70 days	Tue 31/07/18	Mon 5/11/18



Project: Tamar Lakes v3
Date: Tue 3/03/15

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Deadline
Split	External Tasks	Inactive Summary	Manual Summary	Progress
Milestone	External Milestone	Manual Task	Start-only	
Summary	Inactive Task	Duration-only	Finish-only	

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6.0 Appendix B

Table 1: Indicative order of costs for Integrated Impact Statement – Tamar Lake Project Package	Integrated Impact Statement (IIS) Components	Indicative Order of Costs (Ex GST)
PM	Project management for the term of the project	$100,000
Package 1 - Initiation		
1.1	Project inception meeting	$5,000
1.2	Production of application to TPC for POSS	$10,000
1.3	Draft determination on POSS direction	NA
1.4	Prepare draft project referral under the EPBC Act	$25,000
1.5	Finalise and submit project referral under the EPBC Act	$10,000
1.6	Determination on referral and integration with TPC	$10,000
Cost Range – Upper		**$80,000**
Cost Range - Lower		**$50,000**
Package 2 - Guidelines		
2.1	Develop draft IIS guidelines	$15,000
2.2	Publish draft IIS guidelines and conduct public exhibition	$8,000
2.3	Review submissions and finalise IIS guidelines	Cannot be determined until public comments are received
2.4	Final IIS guidelines released	$7,000
2.5	Prepare Project Management Plan (finalise schedule)	$10,000
2.6	Prepare IIS delivery guidelines and call for tenders	$15,000
2.7	Engage technical specialists	$10,000
Cost Range - Upper		**$70,000**
Cost Range - Lower		**$50,000**
Package 3 – Assessment		
3.1	Executive summary	$5,000
3.2	Introduction, abbreviations & glossary	$10,000
3.3	Legislative framework	$5,000
3.4	Justification for the project	$5,000

Package	Integrated Impact Statement (IIS) Components	Indicative Order of Costs (Ex GST)
3.5	Description of regional environment	$15,000
3.6	Public consultation	$5,000
3.7	Project description	$15,000
3.8	Major construction phase activities	$20,000
3.9	Major commissioning and decommissioning phase activities	$20,000
3.10	Site selection and alternatives	$15,000
3.11	Description of existing environmental values (desktop)	$10,000
3.12	Impact assessment methodology	$5,000
3.14	Environmental risk assessment	$15,000
3.15	Economic impacts and management measures	$150,000
3.16	Social and community impacts and management measures	$5,000
3.16 a	Social impact assessment	$150,000
3.16 b	Consultation report	$50,000
3.17	Sustainability assessment	$20,000
3.18	Climate, natural hazards & climate change	$30,000
3.19	Historic heritage assessment	$70,000
3.20	Indigenous heritage assessment	$90,000
3.21	Air quality & GHG assessment	$50,000
3.22	Noise (terrestrial & underwater) & vibration assessment	$100,000
3.23	Land use, soils (including ASS/PASS investigation), geology and topography	$120,000
3.24 a	Terrestrial flora assessment	$100,000
3.25 b	Estuarine flora assessment	$100,000
3.25 c	Marine flora assessment	$100,000
3.26 a	Terrestrial fauna assessment	$100,000
3.26 b	Estuarine fauna assessment (including intertidal species)	$50,000
3.26 c	Marine fauna assessment (including benthic and megafauna)	$150,000
3.26 d	Aquatic fauna assessment (freshwater)	$50,000
3.27 a	Water resources – surface flooding assessment	$300,000
3.27 b	Water resources – hydrodynamic modelling	$400,000
3.27 c	Water resources – pollution modelling	$200,000
3.27 d	Water resources – groundwater modelling	$150,000
3.28	Transport (including shipping)	$80,000
3.29	Waste	$80,000
3.30	Health, safety and hazard assessment and management	$20,000
3.31	Cumulative and consequential impacts	$20,000
3.32	Environmental Management Plans	$50,000

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Package	Integrated Impact Statement (IIS) Components	Indicative Order of Costs (Ex GST)
3.33	Monitoring plans	To be determined
3.34	Commonwealth – MNES section	$10,000
3.35	Conclusions	$5,000
3.36	Commitments	$5,000
3.37	Cross reference to guidelines	$5,000
3.38	Draft IIS published for public comment (including collation of appendices, references, conclusions and recommendations, advertising, and publishing costs)	$250,000
3.39	Conduct public exhibition	$8,000
3.40	Collate submissions and prepare response	Cannot be determined until public comments are received
3.41	TPC public hearing	NA
3.42	Submit Supplementary Information Document	Cannot be determined until public comments are received
3.43	Negotiate conditions of draft Integrated Assessment Report (IAR)	$8,000
3.44	TPC release draft IAR for public exhibition	NA
3.45	TPC public hearing	NA
Cost Range - Upper		**$3,300,000**
Cost Range - Lower		**$2,500,000**

7.0 Appendix C

7.1 Alternative Barrage Location – Freshwater Point

In many ways, locating a barrage at Freshwater Point is a more logical location as this is the point on the Tamar River where there is normally the maximum rate of salinity transition from the freshwater end of the river to the saltwater estuary environment, with a promise of minimising the ecological change that a barrage would incur.

While no detailed analysis has been done on a Tamar Lake with the barrage in the location shown in Figure 21, a rough comparison could be made between the regime features and benefits for this location compared wth the detailed anaysis carried out for the barrage at Rowella.

This comparison is shown in table next page.

Figure 27- Alternative barrage location at Freshwater Point

7.2 Feature Comparison – Freshwater Point versus Long Reach locations

Feature	Freshwater Point location	Long Reach location
Sediment accumulation	No new silt upstream	No new silt upstream
	Increased silt deposition between barrage and Whirlpool Reach; probable flocculation and asymmetric tide	No new silt between barrage and Bass Strait; elimination of flocculation and asymmetric tide
Turbidity	Clean, green freshwater in lake; some increased turbidity downstream due to flocculation	No turbidity between Yacht Basin and Bass Strait
Navigation	Assume single lock for leisure craft, 5 metres depth in lake; same as Long Reach lake	5 metres depth from Seaport to Bass Strait through 2 locks
Ecology	Minimal change, particularly for migratory birds and aquatic life	Very significant change but no listed species threatened
Flooding	This is the big question – can a barrage be designed in this location that has no detrimental effect on 200 year flood events in Launceston	Flood studies show no detrimental effect
Barrage cost	400 metres span, but unknown foundation for construction, most likely a thick silt bed	800 metres span constructed on rock foundations
Economic benefits	Launceston would have the same aesthetic and aquatic benefits as the larger lake, but Tamar Valley irrigation benefits would be minimal	Major irrigated agricultural benefits
Water quality	This is the major benefit over Long Reach, as the much larger rate of the lake flushing and shallow water depth would not promote algal bloom growth	The promotion of algal blooms just upstream of the barrage is the major hurdle to overcome for this location
Freshwater	Adequate freshwater upstream of the barrage, but would need to be piped to the larger irrigable areas downstream of the barrage	Almost unlimited freshwater availability along the 60 km length of the lake, and particularly adjacent to the Bell Bay Industrial zone

8.0 Appendix D

8.1 Tamar Lake studies to date

Since the formation of Tamar Lake Inc in 2010, the following studies have been commissioned and carried out, with the results available from our web site www.tamarlake.com.au/Project/project-status in .pdf format by clicking on **Part 2 – Summary of Technical, Environmental, and Economic Reports.**

Studies carried out to date:

- Preliminary Technical Assessment – 35 pages
  BMT WBM – Dr. Ian Teakle – February 2012

- Prefeasibility Study for water transfer by a "Submarine River" from Tasmania to Victoria
  – Via Marina, September 2012

- Natural Values Assessment – 160 pages
  BMT WBM - Dr. Andrew Costen - June 2012

- Ecological Assessment of threatened species and potential eco-system impacts – 35 pages
  CDM Smith - Dr. Mark Breitfuss – June 2012

- Tamar Lake Economic Study – 39 pages
  NERA Economic Consultants – Greg Houston – April 2013

- Tamar Lake Agricultural Benefits – 14 pages
  Macquarie Franklin – Lance Davey – March 2013

- Barrage siting and costing – CDM Smith - Marco van Winden – March 2012

- Tamar Lake Economic Impact – 35 pages
  KPMG – Martin Rees – July 2014

- Tamar Lake Flood Modelling – 15 pages
  BMT WBM – Philip Pedruco – November 2014

- **Environmental Impact – Peer review by NRM North – November 2014**
  The Tamar Estuary and Esk Rivers (TEER) program of NRM North has conducted a peer review of the Tamar Lake Inc of the environmental studies carried out by BMT WBM and CDM Smith.

- **Research on Destratification Systems – BMT WBM - Michael Barry - R. B20921 – February 2016**

- **Review of BMT WBM Tamar Lake Scenarios Update – Tony Church and Associates – February 2016**

- **3 D Hydrodynamic Studies – BMT WBM – Michael Barry - January 2016 and August 2017**
  With the agreement of the manager of the stakeholder owned 3D Hydrodynamic model of the Tamar, NRM North, BMT WBM has modelled a range of Tamar Lake scenarios that looks at the effect of the formation of the Tamar Lake on sediment transport and water quality compared with the current tidal environment with the same input flows.

The specific scenario modelling carried out to date includes:

1. The concentration of suspended sediments near the water surface and near the bed for the 17 TEER program water quality sites from Cataract Gorge to Low Head.

2. Sediment accumulation for the 12 months July 2010 to June 2011 for two locations:
    a. The Home Reach section from the North Esk to Tamar Island

    b. The estuarine section from the barrage in Long Reach to Low Head

3. Sediment accumulations for a 3-month dry period from January 2009 to March 2009 for the Home Reach section from the North Esk to Tamar Island

4. Impact of the barrage on water levels downstream of the barrage

5. A range of water quality scenarios for the 17 sites Cataract Gorge to Low Head comparing the current estuarine case against the proposed barrage case

6. Estimate of the transfer time from a salt water estuarine system to a freshwater lake system after construction of the barrage

7. Global Research on destratification systems for mitigating the risk of Algal Bloom

8. Investigation of a range of destratification methods for reducing the risk of late summer algal blooms by controlling the release of reduced dissolved oxygen water through outlets at the base and top of the barrage.

9. Investigation of the water quality in Zone 1 in a Tamar Lake environment versus the current estuarine environment.

9.0 Appendix E

9.1 Barrage and ship lock installations around the orld

There are a large number of barrage/ship lock installations around the world constructed on existing rivers to provide benefits that range from improving navigation passage depth, forming irrigation and freshwater supply ponds, blocking tidal surges, generating electricity from tidal flows (where the tidal range is sufficient to be economical), flood mitigation and reducing the sediment deposition in the river from sediment flows from the catchments, or a combination of these benefits.

A common characteristic of these in-river constructions is that there is little or no inundation of the natural environment along the banks of the river that existed before the barrage construction and the water level drop across the barrage is typically only a few metres.

This is in contrast to high level dam construction to form lakes and for electricity generation that have the disadvantage of inundating the natural environment behind the dam when it is constructed.

The Tamar Lake project is an example of the first category with a barrage blocking the saltwater tidal flows from Bass Strait and forming a freshwater pond behind the barrage with a water level below the previous tidal level that provides a constant navigation depth for boating and a freshwater supply for irrigation while almost eliminating sediment deposition upstream of the river entrance.

Other examples similar to Tamar Lake include the Marina Barrage in Singapore, the Cardiff Bay barrage in Cardiff, Wales, and the Seine River in France.

With the Cardiff population of around 300,000, this barrage installation is closest in scale to the Tamar Lake proposal (although the tidal range of 9 to 14 metres in contrast to the Tamar range of 3 metres, posed other challenges), with the Seine River in France with the population in the Seine River basin of 17 million, at the other end of this scale.

9.2 Cardiff Bay Barrage, Wales.

9.2.1 Background

Cardiff has the second largest tidal range in the world of 9 to 14 metres, and has two rivers, the Taff and the Ely, discharging their silt laden freshwater into the Bay. Prior to the construction of the barrage, the Bay emptied twice each day exposing extensive mud flats, and severely limiting commercial and private navigation into and out of the harbour.

In 1999 the construction of a barrage across the entrance to the Bay was completed forming a freshwater lake of $2km^2$ in area.

The completion of the barrage has stimulated the re-generation of the previously run down industrial area with attractions such as the Wales Millennium Centre, the National Assembly for Wales, shopping centres and parklands. The lake has now become a major facility for all water sports and a safe haven for yachting and pleasure boat activity.

Figure 28 Cardiff Bay

Figure 29 - Cardiff Barrage

9.2.2 Why Cardiff Bay Barrage?

In 1987 the decision was made to improve Cardiff Bay from it's dreary, run-down reputation into a thriving exciting waterfront. This decision was not only made for economic reasons but for environmental ones also, as the exposed mud flats provided the Bay with a strong sewage smell and unsightly scenery.

Therefore, in 1987, the CBDC, Cardiff Bay Development Corporation was established by the, at that time, Welsh Secretary, Nicholas Edwards. Its mission was to:

"…Put Cardiff on the map as a superlative maritime city which will stand in comparison with any such city in the world, enhance the image and economic well-being of Cardiff and Wales as a whole.." .

The main reason for the project was economical. Studies showed that ' business and investment come to aesthetically pleasing areas, in particular the sea and lakes..'. This meant the scheme would definitely benefit the area economically as Cardiff Bay was once a prosperous port and still had the potential to be a successful and attractive area to both businesses and tourists. Before the project was completed, it was estimated that 1.6 billion pounds of investment would be made, 30,000 jobs would be created and 4 million square feet of office space would be used. The Bay would provide visitor potential and local communities would benefit. These totals have been exceeded and are still growing today, visitors come from all over Europe to visit 'The Bay' and local communities have benefited by means of employment and living in a cleaner environment.

9.2.3 Population growth

Except for a time of decline during the 1970s and 1980s, (just before the construction of the barrage) Cardiff's population has continually grown since 1801. In 2008, it was the fastest-growing local authority in Wales with a growth rate of 1.2%. Between 2001 and 2011, Cardiff grew by 46,000, which was 25% of the country's growth, and it now represents 30% of the country's growth. 90% of the growth in the country is due to migration, not natural growth.

9.2.4 Technical

The barrage spans a total distance of 1.2kms across the entrance to the Bay, with 900m being rock and sand filled embankment and 300m for locks and sluice gates. It cost approx. £200m to construct in 1999 Pounds ($700m AUD in 2016 approx).

The following materials were used in the barrage construction:

Concrete – 135,000m^3

Rock armour – 250,000m^3

Sand – 1,700,000m^3

The structure has 3 locks each 40 metres long with two 8 metres wide and one 10.5metres wide.

As the estuary has a high tidal range, the lock gates are up to 16m high to enable boats to pass through at all stages of the tide.

In addition to the locks, there are five sluice gates 9 metres wide and 7.5 metres high which control the level of the water in the Bay.

In addition to providing a barrier to prevent seawater entering the bay, the gates are used to mitigate the effect of flood waters flowing down the Taff and Ely Rivers.

A fish pass is provided for migrating fish.

9.3 The Seine River in France

The Seine River in France is 7 times the proposed size of the Tamar Lake scheme.

A 370km long clean/green silt free waterway from Paris to the English Channel at Honfleur with 7 barrage/ship locks and 6 lakes enabling large river cruise liners to transit the waterway from the centre of Paris to the English Channel.

With climate and rainfall conditions very similar to Northern Tasmania, and average river flows about the same as the South Esk, today the Seine presents as a clean, wide, deep (9 to 10 metres) waterway the 370 km from the Eifel Tower to the English Channel. It is the source of drinking and industrial freshwater for the developed areas of Paris and other cities and towns on the river, and agricultural irrigation for the extensive farmlands in the greater Seine Basin.

However, this has not always been the case. It was only 40 years ago that the Seine River was declared “dead”. Levels of pollution from industry and agriculture were dangerously high; native fish had disappeared; plant life was dying and the water was unsafe for swimming. (Is this familiar?).

Today, the city of Paris organises fishing contests and swimming races in the Seine on summer afternoons.

Burdened and supported by a population of 17 million in the Seine Normandy Basin, an extensive development of point source sewage treatment infrastructure and an on-going program of farm management practice improvement has cleaned up the Seine.

From a navigation and freshwater supply viewpoint, the river has been segmented into a tidal estuary that allows ocean going container and bulk freight ships to load and discharge their cargoes at the port of Rouen, 120 kms upstream from the mouth; and a series of 6 freshwater lakes with a total of 7 barrage/lock combinations between Rouen and Paris that not only provides a secure supply of freshwater for domestic and agricultural applications, but also a constant navigation channel depth for freight barges and river cruise liners all the way to Paris.

Much of the credit for the improvement in the health and amenity of the river has been given to the administrative decision in 1964 to form six river management authorities to be responsible for each of the six natural hydrographic lake units formed by the barrage. The average size of each lake unit is 40kms, about the same length as Tamar Lake.

Before the installation of the first barrage in the late 1800s, the river in Paris consisted of a small, shallow channel of continuous flow, bordered by sandy banks. Today, despite the low average flow, the depth of the lake is tightly controlled at 9.5 metres, and the entire width of the river between the built-up banks is normally filled with water. The water level in Paris is 24 metres above sea level, with each of the seven barrages dropping the lake levels by 3 to 4 metres. The same maximum drop as the single barrage forming the proposed Tamar Lake.

From a tourist viewpoint, the entire waterway is a clean, low turbidity passage with no sign of silt accumulation on the sand and gravel banks until the estuary mouth, where the very large tide of 7 to 10 metres with storm surges even higher is posing a problem for the authorities with huge volumes of coarse sand forcing its way a short distance up the estuary and tending to block the passageway into the English Channel. This is constantly dredged. This is unlikely to be a problem at the entrance to the Tamar, and our 3D modelling has confirmed this issue.

9.4 Lake Burley Griffin in Canberra

9.4.1 Where would Canberra be without Lake Burley Griffin?

Constructed in 1964, the Scrivener Dam impounds the water flowing in the Molonglo River into a large freshwater reservoir, with a maximum depth of 18 metres, called Lake Burley Griffin, which has greatly enhanced the recreational amenity and lifestyle benefits of our Nation's Capital.

However, with a rapidly growing urban population and a farming intensive catchment area for the Molonglo River, water quality has been, and still is, a significant problem for the community, with high levels of nutrients from the catchments and residual sediments in the bed causing frequent late summer outbreaks of algal blooms on the surface.

In May 2014, after a warmer than usual summer, Lake Burley Griffin was closed with a high level of algae in the water banning swimming, water-skiing and wind surfing. Boating activities were permitted.

The National Capital Authority, which is responsible for the management of the Lake, has developed a Water Quality Management Plan – 2011 (WQMP) to reduce urban and catchment sources of pollutants entering the waterway, and is making slow progress in its endeavours.

Figure 30- Scrivener Dam

The key question is: would the government of the time proceeded with the formation of Lake Burley Griffin if they knew the lake would occasionally be closed due to algal pollution on the surface?