

Critical Review Analysis and Assessment of Lake Conjola Dredging Activity

***Prepared for:* Shoalhaven City Council and Shoalhaven Natural Resources & Floodplain Management Committee**

***Prepared by:* Conjola Community Association (CCB) – August 2017**

Executive Summary

Arising from community concerns with lake entrance closures, frequent flooding and water quality throughout the 1990's, Shoalhaven City Council commissioned the *Lake Conjola Entrance Study* by Patterson Britton Partners, 1999 (PBP) and this is regarded as being the most comprehensive scientific investigation into the lake's entrance processes.

Acting on the Study's key recommendation of implementing a 'Managed Entrance', Council initiated the first Stage of this option by way of undertaking limited configuration dredging and entrance opening works in the same year.

The resultant outcome being, an open entrance in the 'Regime Entrance State' for 11 years between 1999 and 2010, and no reported major flooding during this time.

As follow up to this initial Stage, Manly Hydraulics Laboratory (MHL) prepared two reports (MHL1159 and MHL1161REF) in 2003 that provided the technical framework necessary to implementing the second Stage in order to achieve a 'Managed Entrance'.

Unfortunately, both MHL reports did not receive the requisite support from the relevant Agencies of the day and the PBP recommended 'Managed Entrance' option did not proceed beyond the initial dredging/entrance opening Stage in 1999.

Subsequent to this, Council adopted an *Interim Entrance Management Policy* in 2003, which effectively 'formalised' the same emergency entrance opening practices that pre-dated the *Lake Conjola Entrance Study* 1999.

Importantly, prior to the adoption of the *Lake Conjola Interim Entrance Management Policy 2003*, PBP reported 8 lake closures in the 60 years between 1938 and 1998 – a further 11 lake closures have since occurred in the 18 years between 1999 and 2016.

This increased frequency of lake closures and associated low level flooding events caused considerable concern to the local community once again - as it did in the 1990's. This concern was expressed in 2013, by way of a petition signed by more than 3,000 Local Residents and Tourists requesting the lake entrance be dredged once again – particularly given the previously successful outcome of the 1999 works.

Further to this, during *the Estuary Management Plan* review process in 2013, the local community also successfully sought to have trial dredging written into the *Estuary Management Plan 2015* with the aim of emulating natural ebb and flood channels in the entrance, so as to maintain a more persistent opening.

Other affected communities similarly expressed their concerns by way of petition and in 2013, Council commissioned the *Shoalhaven Citywide Dredging Feasibility Study, 2014* which recommended limited dredging of Lake Conjola entrance - amongst other waterways.

Subsequent to this, NSW Government grant funding was successfully sought by Council under the 'Rescuing our Waterways' programme. However, so as to satisfy programme funding criteria, the original aim of trial dredging in Lake Conjola was altered to that of improving navigation access to Cunjurong Point boat ramp and providing a source of sand for the renourishment of Mollymook Beach.

As such, the *Shoalhaven Dredging REF* prepared in 2015, proposed the dredging of a northerly navigation channel in an unprecedented location with revised scope of works to reflect this alteration to the original trial dredging aim.

The limited dredging activity in Lake Conjola commenced in May 2016 and was completed in September 2016.

In October 2016 and August 2017, the Conjola Community Association (CCB) conducted two audits into dredging outcomes. On both occasions the CCB reported notable improvements in areas of most concern to the community. These being, water quality, biodiversity, flood mitigation and an open entrance – amongst other things.

However, both audits revealed restricted tidal access through the dredged northerly navigation channel as well as, gradual constriction of the channel and erosion of the adjacent foreshore.

Further to these audits, the CCB conducted a critical review analysis of dredging outcomes with respect to key management areas written into the Community's *Estuary Management Plan* and *Interim Entrance Management Policy*.

This assessment concludes that dredging has contributed to improvements in six (of eight) management areas of the *Estuary Management Plan*. Namely... **Water Quality; Erosion and Sedimentation; Flooding; Lake Ecology; Recreation and Tourism; and Lake Entrance Condition.**

As well as, improvements in six (of eight) management areas of the *Interim Entrance Management Policy*. Namely... **Storm Washover; Water Quality; Flooding; Wastewater and Sewage Overflows; Development Consent and Lake Entrance Management; and Opening Protocol.**

Importantly, whilst both these documents preference managing the estuary and entrance by way of natural processes as opposed to artificial interference, the limited dredging activity has contributed to improvements in key management areas nonetheless.

Moreover, although limited dredging activity is an artificial process, it nevertheless mimics the natural processes of flood scour and sand transportation typically associated with a smaller flood event - albeit, in a more controlled manner and without the negative financial and social impacts of low-level flooding upon the Community.

Similarly, the artificial process of a mechanical entrance opening mimics the natural process of a flood 'break-out' through the entrance sand berm typically associated with a flood event.

So in summary, whilst the limited dredging of a northerly navigation channel within the lower estuary of Lake Conjola has not satisfactorily achieved the stated project objective of improved navigation access, the dredging activity has nevertheless contributed to improvements in overall lake conditions in Lake Conjola.

Background Overview

Due to the increased frequency of low level flood events (12) and entrance closures (11) between 1999 and 2016, the local community has continually sought Shoalhaven City Council's advice and support on improved flood mitigation plans and policies. To which end, a feasibility study into dredging was commissioned by Council in 2013 in response to heightened community concerns expressed in a 3,000 signature petition. The resultant report *Shoalhaven City-wide Dredging Feasibility Study* by Peter Spurway and Associates, 2014 identified Lake Conjola as one of three priority estuarine sites that would benefit from limited configuration dredging activity.

Subsequent to Shoalhaven City Council's unanimous adoption in April 2014 of the *Shoalhaven Citywide Dredging Feasibility Study*, Council successfully sought NSW State Government Grant Funding from the 'Rescuing our Waterways' programme in the same year, to undertake limited configuration dredging in three priority sites - Lake Conjola, Currumbene Creek and Sussex Inlet.

To which end, Royal Haskoning DHV (RH) was commissioned to prepare a Review of Environmental Factors into the proposed limited configuration dredging activity in the nominated priority sites. In the course of preparing their report, *Shoalhaven Dredging REF 2015*, RH referenced findings and recommendations from the *Lake Entrance Study 1999* prepared by Patterson Britton Partners (PBP1999) and found hydrographic surveys of the lake's entrance in February/March 2015 indicated that the prevailing entrance conditions were close to that of the 'Regime Entrance State' with RH using this detail as input to developing a...

"... dredge footprint to enhance present regime state."

This being one of four naturally occurring entrance conditions in Lake Conjola identified and mapped by PBP in PBP1999¹, and is described as follows...

"... the steady end state that the entrance naturally and gradually establishes in the absence of any sudden changes caused by major floods and storms. This is a state of near equilibrium and should be the aim of any sustainable management plan."

Upon completion of the *Shoalhaven Dredging REF 2015* (REF2015)² in March of that year, the project was then put to tender by Council in April 2015 with a view to commencing dredging activity at Lake Conjola in July 2015 with completion by September 2015.

However, due to delays in the tendering process an extension of time for the grant funding was sought and approved with dredging activity eventually commencing in May 2016.

Unfortunately, during this 10 month delay, the open lake entrance conditions deteriorated from the prevailing 'Regime Entrance State' in March 2015 to reported closure on 11th August 2015.³

In late August 2015, Lake Conjola experienced a major flood event with lake water levels reaching 1.95m AHD – nearing the 1971 Flood of Record level of 2.4m AHD.

This event immediately created a post-flood entrance condition previously identified by PBP as the 'Flood Scoured Entrance State', which rapidly transitioned through the 'Intermediate' and 'Regime Entrance States' by January 2016 and imminent closure by March 2016.⁴

This is despite RH estimating as much as 100,000m³ of sand having been transported out of the entrance delta during the major flood event of late August 2015 – such is the extent of heavy sand shoaling which remains throughout the entrance delta.

This aside, upon completion of the dredging activity in September 2016, the Conjola Community Association (CCB) immediately undertook an audit of lake conditions and later sought advice from Council on 19th October, 2016 on post-dredging monitoring parameters and reported the following observations by way e-correspondence...

“... CCB is happy to report that post-construction lake conditions are excellent, in so far as greatly improved tidal flushing, reduced water turbidity and improved biodiversity. This is particularly evidenced by downstream and upstream water clarity improvements beyond ‘the steps’ and the return of seagrass beds to shallow areas not seen in years. Similarly, anecdotal evidence from local anglers indicates the presence of open water fish in the lake also – although these are proving harder to catch.

This aside though, navigability of the newly constructed channel is very much subject to tidal conditions within the lake. Evidence indicates restricted access through the newly constructed navigation channel during very low tide moments and is limited to smaller paddle craft such as kayaks, canoes and paddle boards. Any larger water craft – powered or other, find navigation also problematic. Access for these latter water craft improves during higher tide moments, but not without associated and/or occasional problems. Powered vessels are at times required to plot a course along the centreline of the navigation channel where water is deepest which on occasion has resulted in near conflict between vessels. All of which suggests the design profile dimensions of the navigable channel need to be carefully monitored lest the navigation channel become unnavigable at any time. I trust this update on lake conditions and navigation channel assists as input to determining post construction monitoring parameters...”

Subsequent to these initial community observations in October 2016, Council provided the Shoalhaven Natural Resources & Floodplain Management Committee (SNR&FMC) meeting on 6th June 2017 with additional information in their *Shoalhaven dredging monitoring update and Rescuing our Waterways Program Funding update 2017*. In this report, Council provided a summary matrix of post-dredging monitoring for Lake Conjola as follows...

“... Lake Conjola Entrance

Overall dredge design area square metres = 12,699 square meters... Net volume of sand required to cut to meet design m³ = 5,631 m³ Dec 2016 / 11,978 m³ Feb 2017... Average cut depth (m) to meet design 0.470 metres Dec 2016 / 0.951 metres Feb 2017... Number of cubic (sic) of sand that has filled in dredge channel since Dec 2016 6,454m³... Height of dredge channel that has infilled since Dec 2016 0.481 meters... At the time of writing this report, a further survey has been scheduled.”

In the absence of any further post-dredging monitoring information being available from Council, the CCB offers the following additional observations as input to determining whether the dredging has been successful or other. Whilst the same improvements in lake conditions that were observed in September 2016 and reported in October 2016 are still in evidence, a number of further observable and notable changes to both entrance and catchment conditions have since occurred.

As at 20th August 2017, these were...

... An open entrance maintained by reasonable tidal flows through the dredged navigation channel as evidenced by a reduced *M2 Tidal Constituent* as at 29th August, 2017 operating between 'Possible' and 'Imminent Closure', indicating a constricted entrance and entrance channel.; ⁵

... Improved low-level flood mitigation evidenced by three post-dredging rainfall events, each delivering more than 100mm rain in 24 hours, with no resultant low-level flooding. More specifically, these rainfall events occurred in July 2016 - 120mm; February 2017 - 105mm and March 2017 – 116mm. Conversely, prior to dredging there were five rainfall events each delivering less than 100mm in 24 hours which did result in low-level flooding. These occasions being in March 2011 – 40mm; March 2012 – 90mm; June 2012 – 50mm; June 2013 – 100mm and August 2014 – 70mm. ⁶

... Noticeable scour effects of the southern ebb channel upon the southern shoreline. This is despite no direct linkage / connection to either the dredged northerly navigation channel or entrance opening; ⁷

... Perceived increase in the number and type of bi-valves, such as oysters and mussels in the Lake;

... Less reported complaints regarding boat traffic conflicts and noise along the southern foreshore and ebb channel;

... Evidence of mangrove communities in and around up and downstream locations;

... No reported lost business days or property damage usually associated with low-level flood moments;

Given these additional observations as at 20th August 2017, the prevailing lake conditions still suggest that dredging activity has had a positive effect upon the lake in terms of improved tidal flows/range, bio-diversity and flood mitigation – notwithstanding the shortcomings of a constricted navigation channel.

These observations aside, the CCB conducted a critical review analysis of dredging outcomes with respect to the key management areas written into the Community's *Estuary Management Plan* (EstMP) and *Interim Entrance Management Policy* (EntMP) documents.

Importantly, this analysis, utilising relevant research studies and reports available to the CCB, indicates that the limited dredging activity has delivered beneficial outcomes across...

... Six (of eight) key management areas in the *Estuary Management Plan*. Namely, **Water Quality; Erosion and Sedimentation; Flooding; Lake Ecology; Recreation and Tourism** and **Lake Entrance Condition**. And;

... Six (of eight) entrance processes in the *Interim Entrance Management Policy*. Namely, **Storm Washover; Water Quality; Flooding; Wastewater and Sewage Overflows; Development Consent and Lake Entrance Management**; and **Opening Protocol**.

Review Analysis of Dredging Outcomes assessed against Estuary Management Plan / Interim Entrance Management Policy Management Areas and Objectives

Taking each document in turn...

Estuary Management Plan Review Analysis

At the time of adoption, the 1998 EstMP was founded upon six community identified management areas of significance to Lake Conjola, each with a stated Management Objective as follows...

1. **Water Quality**... *Ensure that the water quality in Lake Conjola, Berringer Lake and Pattimore's Lagoon is maintained at a standard that protects and maintains the ecological, recreational and aesthetic values of these water bodies.*
2. **Erosion and Sedimentation**... *To minimise erosion from the foreshores of the Lake and catchment and maintain and delineate navigable channels within the Lake.*
3. **Flooding**... *Minimise the impact of flooding on individuals and existing and future development and to minimise the impact of development on flooding while maintaining a sustainable ecosystem.*
4. **Lake Ecology**... *To maintain or enhance aquatic flora and fauna values of the Lake.*
5. **Recreation and Tourism**... *Maintain and encourage a range of safe and compatible recreational opportunities that are consistent with the ecological and aesthetic values of the Lake.*
6. **Lake Entrance Conditions**... *Aim to achieve a more natural opening regime with minimal human intervention which takes into account flooding, water quality and ecological concerns.*

Additionally, so as to ensure that new information, planning requirements and issues are incorporated into the EstMP, it is necessary to undertake regular reviews of the strategies and actions adopted at any one time. Accordingly, this review analysis includes the revised management areas adopted in 2015. Taking each of the foundation and revised management areas in turn, the CCB provides the following assessment...

1. **Water Quality.**

The 1998 EstMP identified and categorised the key factors determining estuary water quality as...

- *catchment inflows;*
- *point source pollutants;*
- *physical water exchange;*
- *internal Lake processes.*

Given these, the following assessment addresses each of these key factors in turn...

The restored tidal flows and range have greatly increased flushing and improved water clarity.

The post-dredging tidal range is now more in line with those reported by BMT WBM for an open entrance in their *Lake Conjola Flood Study 2007* (BMTWBMFS). More specifically, BMT WBMFS established Mean Water Levels of 0.29m AHD when the lake is open (0.95m AHD for fifty per cent of time lake is closed) and this has had the effect of exposing sandy beach profiles for extended periods of time. Wave action (boat, wind and ocean surge) in the water way is now more regularly absorbed by these exposed sandy beaches rather than the upper level sub and surface soils of foreshore embankments. Reduced erosion of these riparian landforms by wave action has reduced sediment deposition into the waterway and improved water clarity.⁸

Additional benefits of this improved tidal range are the flushing effects it provides in the dilution and dissipation of pollutants. This is particularly evidenced by the following extracts from *Earth 2 Water Groundwater Monitoring Report 2012* (E2W) report on the Conjola Regional Sewer Scheme (CRSS)...

“... natural attenuation processes are interpreted to mitigate nutrient impacts at Pattimore’s Lagoon and Caravan Park/estuary due to hydrodynamics at tidal areas with large flushing effects (i.e. mixing of saline and fresh groundwater at the interface, increased rainfall recharge/runoff) along the flow path...”

Whilst the CRSS has greatly improved water quality conditions since implementation, its operations do impact on water quality from time to time, particularly in regard to Total Nitrogen (TN) and Total Phosphate (TP) readings within the Lake. E2W noted that between 2008 and 2012 TNs were consistently very high (0.3 -0.5µg/l) and exceeded guidelines during peak nutrient loads and was explained by E2W as follows...

“... The risk of adverse impacts at the site varies due to the sensitivity of each receptor (lagoon estuary and beach) and groundwater contaminants (primarily nitrogen/phosphorous concentrations). The estuary (moderate risk) and beach (low risk) receptors are relatively close to the trench and associated plume. E2W believe that further precautions are required for the estuary, especially during mouth closure (stagnant water and algal blooms)... E2W interpret that the potential risk to aquatic ecosystems (e.g. higher nutrients/algal blooms at Pattimore’s Lagoon or estuary) is likely to increase during the periodic mouth closures (especially summer) and the peak nutrient loads (TP/TN, exfiltration area) associated with Christmas holidays. Pattimore’s Lagoon is likely to be more vulnerable to water quality degradation due to poor flushing...”

The dredged navigation channel has also assisted with the maintenance of an entrance channel over time, directing tidal flows in to and out of (to a lesser degree now due to growth of the southern ebb channel) of the entrance.

In light of the above, the CCB is of the opinion there are several beneficial water quality outcomes associated with dredging, in so far as making a positive contribution toward this key management area and the stated management objective therein.

2. Erosion and Sedimentation.

The 1998 EstMP determined the possible causes of sedimentation and erosion as...

- *sediment generation;*
- *bank erosion;*
- *wind waves;*
- *boating activities.*

Most of the possible causes of erosion have been previously addressed and assessed in the previous management area of **Water Quality**. Notwithstanding this, the CCB is of the opinion there are several beneficial erosion and sedimentation outcomes associated with dredging, in so far as making a positive contribution toward this key management area and the stated management objective therein.

Notwithstanding this, there are visible signs of foreshore erosion to be found along the northern shoreline of the dredged navigation channel⁹ and along the southern shoreline of the ebb tide channel.¹⁰ Whilst both these locations are particularly vulnerable to continued erosion, the former is largely due to the alignment and position of the navigation channel and the latter largely due to natural processes at work around the extensive shoaling in the delta.

Subsequent to the EstMP review process, these first two management areas of **Water Quality** and **Erosion and Sedimentation** are now combined as one management area headed **Catchment Inputs and their Impacts**. The only additional information provided with this new management area that can be assessed in the context of this dredging review, is that of acid sulphate soils.

Given this, the dredging activity followed a design depth to invert of channel well above the depth which surface acid sulphates are known, or likely to occur.

As such, the CCB is of the opinion that the dredging activity has had no impact upon this additional management area and as such, can be regarded as having made a positive contribution toward it and the over-arching stated management objective therein.

3. Flooding.

The *Lake Conjola Flood Study 2007* (BMT WBMFS) identified two main causes of flooding, these being... intense rainfall in the catchment (catchment flooding) and flooding from severe ocean conditions (ocean flooding) causing elevated ocean water levels to extend into the Lake. BMT WBM's further study in 2015, *Lake Conjola Flood Risk Management Study and Plan* (BMT WBMFRM) defines both flood types and identifies a third cause of flooding...

... Catchment Flooding: Flooding from runoff generated from significant rainfall in the catchment contributing to flows into Lake Conjola.

... Ocean Flooding: Flooding from very high ocean water levels, typically as a combination of big tides and storm surge.

... Low-level Persistent Flooding: Flooding of the lowest parts of the foreshore areas from gradual rises in Lake level during periods of entrance closure or under potentially higher tidal conditions with sea level rise and an open entrance.

This aside, for six years now, the CCB has been documenting significant rainfall events and collecting available data on corresponding lake water levels, tides and moon phases for the purposes analysing those combinations that have resulted in a flood event between March 2011 and March 2017.

This data collection exercise has yielded information on eleven significant rainfall events over the period. Eight of which occurred prior to dredging activity and three that occurred after completion of dredging activity.¹¹

Five of the eight significant rainfall events prior to dredging activity, recorded **100mm or less of rainfall within 24 hours and resulted in low-level flooding** - March 2011 (40mm rain); March 2012 (90mm rain); June 2012 (50mm rain); June 2015 (100mm rain) and August 2014 (70mm rain).

Conversely, all three of the significant rainfall events that occurred near or after completion of dredging activity recorded **100mm or more of rainfall within 24 hours and resulted in no low-level flooding** – July 2016 (120mm rain); February 2017 (105mm rain) and March 2017 (116mm rain).

Importantly, tide heights and moon phase conditions for these five pre-dredging and three post-dredging significant rainfall events were very similar and thus reliable for the purpose of comparison.

In light of this, the CCB is of the opinion there are several beneficial low-level flood mitigation outcomes associated with dredging, in so far as making a positive contribution toward this key management area and stated management objective therein.

Further to this last point, the ongoing EstMP review process recognised that flooding remains a very important and ongoing issue for the Lake Conjola community and recommended that strategies and actions for this management area be continually reviewed and developed. Notwithstanding additional information provided with the review of this management area, the CCB remains of the opinion that dredging activity can be deemed to have made a positive contribution toward this new management area and over-arching stated management objective.

4. Lake Ecology.

Ecological issues identified during the development of the 1998 EstMP for Lake Conjola were:

- *Perception in reduction of seagrass beds; and*
- *Perception of a decline in fish populations.*

Previous studies have noted that increased recreational boating over shallow seagrass beds is a likely contributor to decline in some areas, however natural fluctuations are also likely to be a factor.

In line with this, PBP1999 identified the variable nature of seagrasses over time. As did Gavin Heycox in his November 1994 study *Lake Conjola Seagrasses*, in which he also raised concerns about increased water turbidity (due to erosion/sedimentation) having negative impact upon seagrass beds due to reduced sunlight penetration – even at shallow depths.

As already noted, water clarity has improved since completion of dredging activity and seagrass beds have also been observed in shallow areas not seen in years. Similarly, the reported presence of open water fish by anglers is further evidence of improved biodiversity.¹²

In light of this, the CCB is of the opinion there are several beneficial ecological outcomes associated with dredging, in so far as making a positive contribution toward this key management area and the stated management objective therein.

Subsequent to the EstMP review, this management area has been revised to include the collective term for all living things (plants, animals, and microbes) found in Lake Conjola and its catchment. This expanded management area is now headed ***Biodiversity and Ecosystem Protection and Rehabilitation*** and includes additional strategies and actions to manage terrestrial habitats, riparian habitats, aquatic habitat and fish.

Previous assessments provided on ***Water Quality; Erosion and Sedimentation;*** and ***Flooding*** management areas have largely addressed the additional information noted in this expanded management area. Given this, the CCB is of the opinion that these assessments are equally applicable to the new ***Biodiversity and Ecosystem Protection and Rehabilitation*** management area.

As such, the CCB remains of the opinion that dredging activity can be deemed to have made a positive contribution toward this new management area and over-arching stated management objective therein.

5. Recreation and Tourism.

During development of the 1998 EstMP, conflicts associated with recreation activities were identified as follows;

- *Conflict between passive and active recreation activities;*
- *Cumulative impacts of development around the Lake; and*
- *Informal boat launching.*

The strategies developed around recreation and tourism focused on equitably sharing the resources of the Lake and formalising current uses to ensure the resources are protected and conserved in the future.

Given this, comments provided to Council in e-correspondence dated 19th October 2016, indicate the dredged navigation channel to the north has served to separate boaters from swimmers and shore based anglers. Whereas previously, these user groups regularly came into conflict when sharing the southern ebb channel.

Moreover, given its northerly location, the dredged channel has also served to distance boat traffic and associated noise away from the southern shoreline of the estuary. However, the performance capabilities of the navigation channel are dependent upon the presence of a satisfactory tidal range which is usually associated with an open and less constricted Lake entrance.

However, due to tidal influences upon navigability through the dredged northern channel and the lengthening of the southern ebb tide channel, increased boat traffic has been reported in and along the southern shoreline. As such, potential conflict between boats and other user groups is now more likely in and around this southern channel - unless navigable conditions through the northern channel improve.

This aside, anecdotal evidence suggests the improved lake conditions appear to have had a positive effect on the local business economy, in so far as increased occupancy levels amongst the four Tourist Parks that operate in Lake Conjola as well as increased income amongst small businesses.

Further to this, there have been no reported business interruptions or damaged property usually associated with low-level flood moments – as these events have not occurred since dredging.

Subsequent to the EstMP review, this management area has been expanded and renamed **Access, Recreation and Tourism** and includes additional strategies and actions to improve access to the Lake whilst protecting and sustaining the recreational and environmental values of the waterway.

As well as, maintaining and encouraging a range of safe and compatible recreational opportunities that are consistent with the ecological and aesthetic values of the Lake.

Importantly, this revised management area included an action recommendation that explored options for dredging to improve navigation and safety.

In light of this, the CCB is of the opinion that dredging activity has improved access, recreation and tourism conditions on, in and around the Lake and can be deemed to have made a positive contribution toward this new management area and over-arching stated management objective therein.

6. Lake Entrance Conditions.

The issues identified during the development of the 1998 EstMP in relation to the Lake entrance are outlined below:

- *Perceived deterioration of water quality when the entrance is closed;*
- *Flood risk when entrance is closed;*
- *Impacts on aquatic ecology of artificial opening regime;*
- *Reduced entrance scour from increased opening frequency; and*
- *The position and frequency of artificial entrance openings.*

Further to comments provided to Council in October 2016, Lake entrance conditions at the time of dredging the northerly navigation channel between May and September 2016 were constricted and in the imminent closure phase.

Importantly, these conditions have improved since dredging, as evidenced by the post-dredging *M2 Tidal Constituent* recorded in August 2017 being above that recorded in March 2016 prior to dredging activity commencing.¹³

This suggests that the restored tidal flows associated with the dredged northerly navigation channel have contributed to maintaining an open entrance. Subsequent to this, noticeable improvements in water clarity (and arguably quality), aquatic ecology and low-level flood mitigation have been realised and no artificial entrance openings have occurred since dredging activity was completed in September 2016.

In light of this, the CCB is of the opinion that dredging activity has improved lake entrance conditions and can be deemed to have made a positive contribution toward this key management area and over-arching stated management objective therein.

Subsequent to the 1998 EstMP review, this management area was expanded and renamed **Lake Entrance Management** and additional management strategies and actions recommended. One of these action recommendations was dredging, the aim of which was to emulate the natural ebb and flood channels in the entrance in order to maintain a more persistent opening.

In light of this, the CCB is of the opinion that dredging activity has improved lake entrance conditions and can be deemed to have made a positive contribution toward this new management area and over-arching stated management objective therein.

This aside, another action recommendation for this management area included the continued review of entrance management practices to ensure they are in line with best practice guidelines, NSW Government requirements and available research.

Further to this last point, in terms of available research and best practice guidelines, the CCB refers to PBP1999 recommendations for an open managed entrance and Narrabeen Lagoon Entrance and Replenishment of Collaroy-Narrabeen Beach practices, respectively. Briefly, taking each in turn...

PBP1999 determined that the 'Regime Entrance State' should be the aim of any sustainable management plan and that the *Managed Entrance* option had the lowest cost and most positive flood mitigation / water quality benefit. It was also the only option to have had a benefit/cost ratio greater than 1.0.¹⁴

The Narrabeen Lagoon Entrance and Replenishment of Collaroy-Narrabeen Beach is an example of an open managed entrance option outlined in PBP1999 and executed in line with today's best practice guidelines. In terms of relevance, entrance processes and conditions at Narrabeen Lagoon are very similar to those at Lake Conjola, as evidenced by the following extract...¹⁵

"... The entrance to Narrabeen Lagoon becomes periodically filled with marine sediment when the amount of sand moving into the lagoon entrance exceeds the amount of sand being removed by the outgoing tide. The closure of the lagoon entrance for extended periods can have quite significant socio-economic and environmental impacts on the lagoon and surrounding areas, including:

- *Increases in the severity of flooding of low-lying residential/commercial areas surrounding the lagoon, as well as creeks*
- *Reductions in Lagoon water quality due to impaired tidal flushing from the entrance*
- *Decrease in biodiversity due to reduced access through the entrance*

There have been nine major clearance operations at the lagoon entrance since 1975, with the most recent in 2006, during which approximately 45,000m³ of sediment was removed and transported to selected locations..."

The costs of this open managed entrance option are shared between OEH (two-thirds) and Northern Beaches Council (one-third).

The proposed open entrance management option of 1999 and entrance management practices at Narrabeen Lagoon are explored in more detail in the **Recommendations** section of this review.

7. Adapting to Climate Change – New Management Area.

Subsequent to the 1998 EstMP review, this management area was necessarily adopted in light of predicted climate change/sea level rise.

The potential effects of climate change on the physical, chemical and biological processes of coastal lakes has been investigated by Haines and Thom in their 2007 study "*Climate change impacts on entrance processes and behaviour of intermittently open/closed coastal lagoons in NSW*" (H&T2007) and briefly outlined below...

- *Increased rainfall intensity could increase the delivery of sediments and nutrients from the catchment;*
- *Changes to ocean water levels will impact on foreshore erosion;*
- *Long term strategic planning required to improve community resilience to climate change; and*
- *Increased Lake water levels resulting in inundation of fringing wetlands and their landward retreat if there are no intervening human structures.*

At this point in time, the CCB is unable to make a validated assessment of impacts of dredging activity upon this new management area. Other than, offer the opinion that the dredging activity has not contributed to climate change/sea level rise.

This aside, and in light of the positive contributions dredging has had in entrance management/ low-level flood mitigation/erosion and sedimentation management areas, dredging activity may at some future time play a role in adapting to predicted changes.

8. Cultural Heritage – New Management Area.

As above, this newly adopted management area is also the result of the 1998 EstMP review.

Both indigenous and non-indigenous people place cultural values on natural areas including aesthetic, social, spiritual and recreational values. Cultural values may be attached to the landscape as a whole or to individual components such as plant and animal species used by indigenous people. They may consist of both physical remains and non-physical manifestations such as knowledge, stories and memories. Indigenous people have utilised the resources of the area for the last 20,000 years, especially the Lake and coastline. Conjola National Park contains a large number of indigenous sites including middens, campsites, rock-shelters and grinding grooves. Non - indigenous people have used the area for industry and recreation since the 1800s, particularly logging, fishing and informal camping and beach activities along the coast.

Despite this, and in the absence of any specific identified strategies or actions for Lake Conjola, it was recommended that the management areas contained within the *2009 Conjola National Park Management Plan* be incorporated into the Estuary Management Plan.

Again, at this point in time, the CCB is unable to make a validated assessment of impacts of dredging activity upon this new management area. Other than to suggest, that the activity itself has not contributed to a loss of, or damage to known heritage sites and /or cultural artefacts. This aside, and in light of the positive contributions dredging has had in entrance management/ low-level flood mitigation/erosion and sedimentation management areas, dredging activity may at some future time play a role in protecting low lying heritage sites and cultural artefacts.

Interim Entrance Management Policy Review Analysis

Council adopted an *Interim Entrance Management Policy* in 2003 (EntMP), which effectively 'formalised' the same emergency entrance opening practices that pre-dated the *Lake Conjola Entrance Study 1999* by Patterson Britton Partners. This Policy aims to...

- *Minimise risk to public safety associated with excessive inundation of foreshores and associated infrastructure as a result of low level flooding*
- *Minimise interference with natural entrance opening processes and minimise associated impacts on ecological processes*
- *Minimise risks to public health associated with excessive bacterial contamination of water*
- *Minimise interference to the local ecological community*
- *Satisfy local community values*
- *Articulate the procedures to be initiated for entrance operations including entrance break outs*
- *Articulate key responsibilities for management of the entrance*
- *Detail the procedures for monitoring the Lake Entrance.*

In terms of ongoing management, the EntMP seeks to manage against risks associated with low-level flooding and impacts associated with poor water quality; it does not seek a permanently open entrance. The long term entrance management policy is to reflect strategies intended to improve entrance stability using the natural processes of the Lake.

This aside, the EntMP has eight management areas developed to address the following entrance processes...

- *Storm Washover*
- *Wind Blown Sand*
- *Water Quality*
- *Flooding*
- *Wastewater and Sewage Overflows*
- *Community Awareness*
- *Development Consent and Lake Entrance Management*
- *Opening Protocol*

Taking each entrance process in turn...

1. Storm Washover

Storm washover is one of the most prevalent causes of periodic closure of the Lake entrance. The prescribed management action is to increase the height of the entrance berm/sand dune south of the entrance, so as to mitigate storm waves overtopping this protective barrier. Additional to this, the entrance sand dune is to be densely vegetated to prevent sand being remobilised.

Entrance conditions immediately prior to dredging were typical of the 'Storm Washover Entrance State' with the southern ebb channel less active due to being partly perched by 'fanning' of sand moving through the delta shoals and indirectly connected to the entrance.

As such, the entrance was particularly vulnerable to reduced tidal flows and a nett infeed of sand placing the entrance in 'Imminent Closure' phase.

As dredging activity was limited to creating a northerly navigation channel, the perched condition of the southern ebb channel was not addressed by dredging even though included in the *Project Summary* section of the funding application.¹⁶

However, the northerly dredging activity did provide a quantity of sand to be redistributed along the southern foreshore between the boat ramp and the entrance dune as prescribed – but not revegetated.

As such, the dredged sand placed along the southern foreshore was not stabilised and thus remained vulnerable to other entrance processes of tidal and wind erosion. Both of which have predictably occurred as evidenced by the significant scouring of dredged sand placed along the foreshore and movement of wind blown sand into the entrance shoals.¹⁷

In light of this, the CCB is of the opinion that the northerly dredging activity has improved entrance conditions and provided a source of sand from within the Lake's compartment for managing this entrance process. However, these positive contributions have been diminished by other entrance processes not being addressed at time of the works.

2. **Wind Blown Sand**

Wind blown sand is a significant contributor to the build-up of sand in the entrance shoals and the prescribed management action to address this entrance process is to vegetate the sand dunes so as to reduce sand movement by wind.

At this point in time, the CCB is unable to make a validated assessment of impacts of dredging activity upon the management of this entrance process. Other than to suggest, that the activity itself has not contributed to the movement of wind blown sand.

This aside, and in light of the positive contributions dredging has made in other management areas, dredging activity can play a role, in so far as providing a source of sand from within the Lake's compartment for the purposes of managing most of the identified entrance processes and renourishment of nearby beaches.

3. **Water Quality**

Water quality has the potential to decline if the entrance, dune and riparian vegetation, and bank stabilisation are not managed effectively.

In light of previous assessment provided in **Water Quality** management area of the Estuary Management Plan, the CCB is of the opinion that the dredging activity has similarly improved water conditions at the entrance.

Notwithstanding this, bank erosion along both the northern and southern foreshores has occurred since completion of the dredging activity.

The CCB is of the opinion that the location of the dredged navigation channel has been a significant contributor to bank erosion along the northern foreshore, as have the natural tidal flows through it.¹⁸ Conversely, bank erosion along the southern foreshore is largely due to the natural migration process of the southern ebb channel north toward the entrance¹⁹ and to a lesser extent the dredging activity on the northern side.

4. Flooding

In light of the previous assessment provided at the **Flooding** management area of the Estuary Management Plan, the CCB is of the opinion that the dredging activity has similarly improved mitigation of low-level flooding. This is evidenced by an absence of low-level floods and no artificial entrance openings since completion of dredging activity.

5. Wastewater and Sewage Overflows

Continued improvements to the CRSS have reduced impacts of overflows into the waterway. However, in light of *E2W* findings regarding elevated TN and PN levels cited in the previously provided assessment at the **Water Quality** management area of the Estuary Management Plan, the CCB remains of the opinion that an open entrance is also important in mitigating impacts of wastewater and sewage overflow into the Lake and that the dredging activity has maintained a stable open entrance.

6. Community Awareness

Due to a perceived lack of factual understanding of the issues surrounding the management of entrance processes Council has committed to ongoing education of the Community in this regard.

Notwithstanding this, the rationale behind the proposed northerly alignment of the dredged navigation channel was not well explained to the Community by Council or RH at the time of community consultation - and remains somewhat of a mystery.

As such, the CCB is of the opinion that the provision of a detailed rationale behind the location of the dredged northern channel would improve Community understanding.

Moreover, as the northern location of the dredged navigation channel is unprecedented, the Community can only refer to the 1998/1999 dredged channel location²⁰ and associated positive outcomes for the purposes of precedence and comparison with this most recent and any future dredging activity.

7. Development Consent and Lake Entrance Management

The EntMP has adopted a wholistic approach to ongoing development that supports restoring the Lake to as natural a regime as possible and in so doing, preferences natural processes to artificial interference in managing the Lake's entrance.

Notwithstanding this, whilst limited dredging activity is an artificial process, it nevertheless mimics the natural processes of flood scour and sand transportation typically associated with a smaller flood event - albeit, in a more controlled manner and without the negative financial and social impacts of low-level flooding upon the Community.

Just as the artificial process of a mechanical entrance opening mimics the natural process of a flood 'break-out' through the entrance sand berm typically associated with a flood.

This aside and in light of the previous assessment provided in the **Lake Entrance Management** management area of the Estuary Management Plan, the CCB remains of the opinion that the limited dredging activity has improved entrance conditions and helped maintain a stable open entrance.

8. Opening Protocol

Adopted entrance opening protocols are necessarily reviewed and improved so as to reflect changes to environmental conditions, NSW Government requirements, best practice guidelines and available research. As part of this ongoing review process, potential sources of funding are also investigated as a means to fund improvements to adopted protocols.

A most recent review recommendation was to trial limited dredging, the aim of which was to emulate the natural ebb and flood channels in the entrance in order to maintain a more persistent opening.

However, as dredging activity is not an adopted protocol in either the EstMP or EntMP, the only available source of government funding for this trial was the 'Rescuing our Waterways' programme. In order to satisfy funding criteria under this programme, the original aim of emulating the natural ebb and flood channels in the entrance in order to maintain a more persistent opening was altered to that of providing improved navigation within the lower estuary.

Notwithstanding this, the CCB is of the opinion that dredging activity has improved lake entrance conditions and stability despite the original aim of the dredging trial being altered to satisfy funding criteria.

Recommendations

In acknowledgement of the many positive outcomes associated with this limited dredging trial in Lake Conjola, the CCB recommends the *Estuary Management Plan* and *Interim Entrance Management Policy* documents be reviewed accordingly, so as to include limited dredging activity as a management strategy / action across relevant management areas.

Once written into these documents, this will serve to increase the various funding options available to Council for further dredging trials / activity in Lake Conjola.

As the original aim of trial dredging was altered and remains untested, future dredging activity should emulate natural ebb and flood channels in the entrance, so as to maintain a more persistent opening. In other words, as prescribed in the *Managed Entrance* option (PBP1999 and MHL1159).

Even though the 1999 trial aim of a *Managed Entrance* was similarly altered, the dredging activity stage of the trial proved itself successful in terms of achieving and maintaining a persistent entrance opening for 11 years. Moreover, the *Managed Entrance* option was the only option of thirteen investigated to return a positive nett benefit : cost ratio greater than 1.0. This cost benefit analysis has also partly proven itself given the open entrance conditions over 11 years.

The CCB is of the opinion that precedents for a *Managed Entrance* at Lake Conjola have been established in the both the 1999 and 2016 dredging trials. As such, the CCB recommends the original source material (MHL1159 and 1161) be updated in terms of today's best practice guidelines using Narrabeen Lagoon entrance management protocols as input to a *Managed Entrance* at Lake Conjola.

References

Patterson Britton Partners 1999 *Lake Conjola Entrance Study*

Manly Hydraulics Laboratory MHL1159 2003 *Entrance Management Plan*

Manly Hydraulics Laboratory MHL 1161 2003 *Lake Conjola Entrance Management Dredging Works Review of Environmental Factors*

BMT WBM *Lake Conjola Floodplain Risk management Study and Plan: Sensitivity Report 2006*

BMT WBM *Lake Conjola Flood Study 2007*

Earth 2 Water Environmental & Ground Water Consulting *Third Annual Monitoring Report CRSS Annual GW Monitoring 2012*

Peter Spurway & Associates 2014 *Shoalhaven Citywide Dredging Feasibility Study*

Royal Haskoning DHV 2015 *Shoalhaven Dredging REF 2015*

GHD 2015 *Lake Conjola Estuary Management Plan Review June 2015*

GHD 2013 *Interim Entrance Management Policy August 2013*

P E Haines and B G Thom 2007 *Climate change impacts on entrance processes and behaviour of intermittently open/closed coastal lagoons in NSW*

AECOM for Department of Climate Change & Energy & Efficiency 2010 *Coastal Inundation at Narrabeen Lagoon Optimising adaptation investment*

ANNEXURES - Critical Review Analysis and Assessment of Lake Conjola Dredging Activity

No:	Content
1	Patterson Britton Partners <i>Lake Conjola Entrance Study 1999</i> – Four naturally occurring Entrance conditions
2	Royal Haskoning DV originally proposed configuration dredging plan per <i>Spurway 2014</i> and <i>REF2015</i> as opposed to approved navigational dredging plan per ' <i>Rescuing our Waterways</i> ' Programme
3	Manly Hydraulics Laboratory <i>M2 Tidal Constituent for Lake Conjola Entrance (2007-2017)</i> depicting August 2015 entrance closure
4	Aerial image depicting February 2016 ' <i>Imminent Closure</i> ' entrance condition prior to commencement of dredging activity in May 2016
5	Aerial image depicting June 2016 ' <i>Imminent Closure</i> ' entrance conditions nearing completion of dredging
6	Lake Conjola Water Level, Rainfall, Tides and Moon plots depicting significant rainfall events between 2011 and 2017 - 3 post-dredging rainfall events of 100mm or more within 24 hours resulting in no low level flooding and 5 pre-dredging rainfall events of 100mm or less within 24 hours resulting in low level flooding
7	Image depicting post-dredging scour effects associated with natural northerly migration of southern ebb channel 2016
8	Image depicting improved water clarity (quality) through the dredged navigation channel 2016
9	Image depicting northern foreshore erosion due to location of dredged northern navigation channel 2016
10	Image depicting southern foreshore erosion due to natural process of southern ebb channel migration 2016
11	Lake Water Level, and Rainfall Plots cross referenced with <i>M2 Tidal Constituent</i> for the period 2010 - 2017
12	Image depicting seagrasses and improved water clarity (quality) post dredging August 2017
13	<i>M2 Tidal Constituent</i> Plot Jun 2010-Aug 2017 depicting improved entrance conditions post 2016 dredging activity
14	Patterson Britton Partners <i>Lake Conjola Entrance Study 1999</i> illustrating 6 preferred Entrance Management Options / Benefit : Cost Analysis of these 6 and 7 other Entrance Management Options investigated / Assessment Summary of all 13 Entrance Management Options investigated
15	Brochure to Residents - OEH/Warringah and Pittwater Councils : <i>Community Guide to Clearance of the Narrabeen Entrance Lagoon</i> outlining aim of and procedures for an open managed entrance in 2011
16	Shoalhaven City Council – 2014 Application for Funding under ' <i>Rescuing Our Waterways</i> ' Programme for Configuration Dredging for Beach Nourishment – Lake Conjola/Mollymook Beach

No:	Content
17	Image depicting reclaimed southern dune foreshore and active southern ebb channel even though not directly aligned with or connected to entrance
18	Image depicting foreshore erosion / sedimentation and constricted access conditions of dredged northern navigation 2016
19	Image depicting post dredging entrance conditions 2016
20	Image depicting location and alignment of 1999 dredged channel per schematic of approved <i>Lake Conjola Entrance Stage 1 Entrance Works 1999</i>