FARQUHAR INLET, OLD BAR

Entrance Opening Management Plan

Prepared By

WorleyParsons
resources & energy

For Greater Taree City Council and the

Estuary and Coastline Management Committee

The preparation of this report has been a cooperative effort between Council, Government Agencies and Community Groups and facilitated by Greater Taree City Council through the Estuary and Coastline Management Committee. Members of the committee are identified below:

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Project: FARQUHAR INLET, OLD BAR
ENTRANCE OPENING MANAGEMENT PLAN

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Draft Report for EMC Review	WJH	CRT		8/5/09		
B	Final Draft for Public Exhibition	WJH	CRT		12/11/09		
C	Final Report	WJH	CRT		28/05/10		

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1. INTRODUCTION

The location of Farquhar Inlet is shown in **Figure 1**. The inlet is situated at what is considered to be the southern entrance of the Manning River.

Concerns regarding the water quality at Farquhar Inlet and the associated state of the local oyster industry were raised by the community during the consultation phase of work that was undertaken by Patterson Britton & Partners (*now WorleyParsons*) in preparing the *'Manning River Estuary Management Study'* (*GTCC, 2009*).

It is understood that frequent and extended closures of the oyster harvest areas in recent years have led to a reduction in the profitability of the shellfish industry. In addition, the condition of water quality at Farquhar Inlet is seen by the community to impact on the recreational value of the lower estuary in the vicinity of Old Bar and has a potential impact on tourism.

The Manning River Estuary Management Study acknowledged these issues and the concerns of the local community. The Estuary Management Plan that was developed from the study identified the need for further investigation and the development of an Entrance Opening Management Plan for Farquhar Inlet. Greater Taree City Council subsequently engaged WorleyParsons to undertake these investigations and to develop the Plan.

This document serves as the Entrance Opening Management Plan (*EOMP*) for Farquhar Inlet. It documents the current situation and the issues surrounding the current management of the entrance. It also describes and assesses a range of options that could be implemented to manage the entrance so that the frequency of the water quality and recreational issues that have occurred over recent years is reduced. The Plan provides recommendations for the future management of the entrance. The area covered by the Plan is identified in **Figure 2**.

FIGURE 1

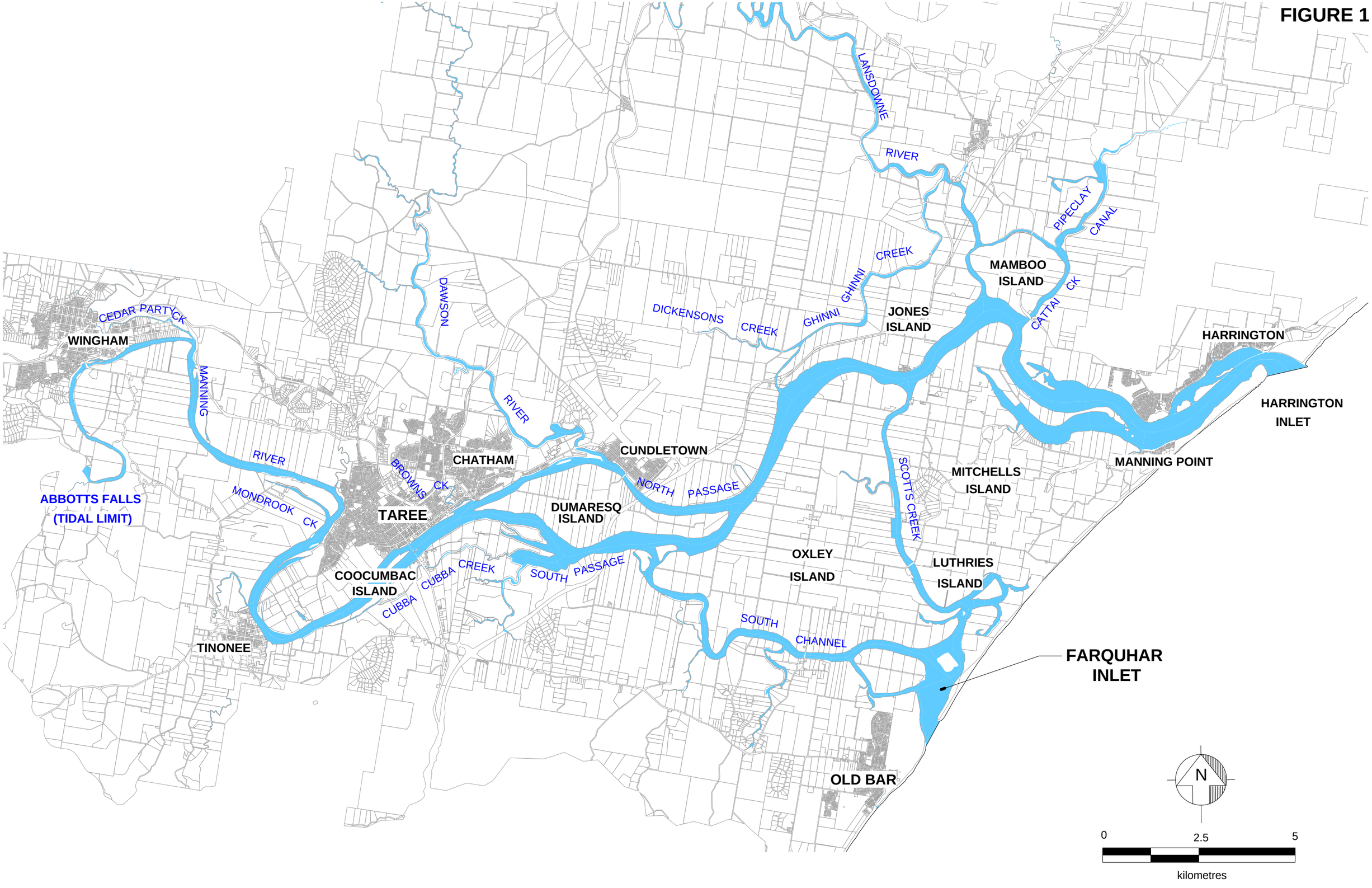

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Figure 1 - Location.wor

LOCATION OF FARQUHAR INLET

FIGURE 2

Note: Aerial photography taken in May 2005

N

0 0.5 1

kilometres

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Figure 2 - Farquhar Inlet.wor

FARQUHAR INLET STUDY AREA

2. BACKGROUND

The Manning River Estuary drains a catchment area of 8,420 km². The estuary includes both the Lansdowne and Dawson Rivers, and comprises a complex system of inter-connecting channels that extend across a broad flat floodplain. The estuary is unique as it has two natural ocean entrances, one at Harrington and the other 12 kilometres to the south near Old Bar. The southern entrance is known as Farquhar Inlet.

The main entrance at Harrington is permanently open and has an artificial breakwater on the northern bank. Farquhar Inlet is untrained and has a history of periodic closure. Prior to opening works in April 2008, Farquhar Inlet had been blocked for some time by the back beach berm at Old Bar Beach.

Ocean entrance conditions have been the topic of much discussion since European settlement of the area in the early 1800s. The basis for this discussion has varied at different times over this period and has also varied according to the locale of those that have raised concerns.

The concerns that have been raised include:

- concerns over navigability, particularly at Harrington;
- concerns about flooding and the potential for a second permanent entrance to reduce the perceived flood risk; and,
- concerns over long flushing times and associated impacts on water quality.

These concerns and the times when they have been raised, are typically a reflection of the condition of each of the entrances. For example, current concerns about flushing times and poor water quality appear to be more significant in the minds of the community due to the long period since the last major flood (*back in 1990*), and the subsequent reduction in frequency of opening of Farquhar Inlet since that time.

Accordingly, it is important to understand the history of the condition of each entrance over time, and the variability in that condition which is directly linked to the natural estuary processes that control it.

2.1 HISTORY OF ENTRANCE CONDITION

Based on historical records, Farquhar Inlet appears to have been severely restricted or closed for approximately 20% of the time over the last 170 years. However, this is considered to underestimate the actual period of closure over this period due to extended periods where no monitoring has occurred or where limited data is available. This estimate of the period of closure is also influenced by episodes of mechanical opening of the entrance and therefore, also underestimates the closure time that would naturally occur.

A brief description of the change in entrance condition for the Farquhar Inlet is as follows:

- Never trained ➔ No breakwater
- Earliest European records date to 1818 and indicate entrance at that time was open sufficiently to allow access for sailing craft
- **1818 – 1981** ➔ Entrance open 26 times out of 38 records of entrance conditions; viz.,:
  - 1886 to 1920 ➔ Open
  - 1920 to 1924 ➔ Closed (*although opened in 1921*)
  - 1924 to 1926 (*large seas*) ➔ Closed
  - 1926 to 1929 ➔ Closed (*although opened in 1927*)
  - 1929 to 1941 ➔ Open (*although closed in 1939*)
  - 1942 to 1946 ➔ Closed
  - 1949 to 1981 ➔ intermittently Open (*closed on at least two occasions*)
  - 1981 to 1983 ➔ Open, but heavily constricted
  - 1985 ➔ Closed
  - 1986 to 1991 ➔ Open
  - 1992 to present ➔ Periodically Closed
- Air photo evidence since 1940 indicates that entrance position (closed and open) has fluctuated along Old Bar Beach.

2.2 PREVIOUS INVESTIGATIONS

In recognition of community concerns about the entrance conditions at Farquhar Inlet and Harrington, GTCC and its predecessor have undertaken a range of studies that have investigated options for improving channel entrance conditions. These investigations have included consideration of the benefits that would be afforded by building new breakwaters and training walls, undertaking periodic channel dredging and constructing pilot channels to alleviate flood risks.

These investigations extend back many years and can typically be linked to representations made to a range of government departments by community groups and industry.

For example, in 1987 the then Public Works published a study titled, *'Manning River Entrance Study - Background & Issues of Concern'*, which highlighted the following "issues of concern":

- heavy shoaling and treacherous entrance conditions at the permanent entrance at Harrington;
- the impact that the entrance at Old Bar has on flood levels and the time of inundation for various locations on the river;

- the effect, both positive and negative, that the entrance at Old Bar has on local oyster and other farming industries;
- the impact that the entrance at Old Bar has on the entrance at Harrington;
- general concerns about the detrimental effect to the local community and business that the continued shoaling and erosion problems have had along various reaches of the river and its entrances.

In more recent times, Council's Estuary Management Committee has overseen detailed investigations to address these issues. In that regard, the following studies have been prepared under the stewardship of the Committee:

- *'Manning River Estuary Processes Study'* (*1997*)
- *'Manning River Estuary Management Study- Numerical Modelling Investigation'* (*2001*)
- *'Manning River Floodplain Management Study & Plan'* (*2001*)
- *'Manning River Estuary – Pilot Value Management Report'* (*2002*)
- *'Economic Scoping Study – Manning River Entrance Improvement Project'* (*2003*)
- *'Harrington Northern Breakwater Investigation'* (*2004*)
- *'Manning River Estuary Management Study (Part 2) and Plan'* (*2009*)

These investigations have considered the technical aspects of various proposals to address each of the issues raised in the 1987 Report, as well as the economic and social benefits and impacts of proceeding with works to improve navigability and increase entrance opening frequency.

The fundamental outcome from these investigations is that major works would be required at Harrington and Farquhar Inlet to improve estuary flushing times and entrance navigability. It also needs to be recognised that these works would require further justification on environmental grounds, and are likely to require a commitment for ongoing maintenance (*for example in the case of dredging of the entrances*) in order for them to be viable.

WorleyParsons are also undertaking investigations to assess coastal hazard and erosion at Old Bar and further north to Harrington and beyond. A draft of the *'Old Bar Hazard Definition Study'* has been prepared (*GTCC, 2008*). WorleyParsons has also prepared a draft report to document investigation into options for the management of these coastal hazards. Although potentially linked to a number of the options presented in this report, the coastal hazard assessment and investigation of coastal management options is being treated as a separate issue to management of the Farquhar Inlet entrance.

Notwithstanding, it is recommended that any Review of Environmental Factors or Environmental Impact Statement for future entrance management options that involve significant works at Farquhar Inlet should consider the impact of the works on coastal processes in the vicinity of the entrance.

2.3 RECENT ENTRANCE OPENING WORKS

The mechanical opening of Farquhar Inlet has occurred on a number of occasions since the 1950s. The Greater Taree City Council currently employs a flood notch system for management of the Farquhar Inlet. This system was established during the development of the Floodplain Management Study and Plan for the Manning River and is implemented solely as a floodplain management measure.

The system involves the periodic excavation of a flood notch at the back of the beach berm during closed entrance conditions. If and when flooding behind the beach berm reaches a specified level, a narrow channel is then excavated between the notch and the ocean, causing floodwaters to exit the estuary and scour the entrance. The purpose of the flood notch system is to minimise the potential impact of flooding in the lower estuary.

In recent times, the entrance was opened in late 2004 when a minor flood event inundated the excavated notch and Council authorised mechanical opening of the entrance. The opening subsequently closed in late 2005.

More recently, under the Waterways Program, the NSW Department of Lands offered assistance to GTCC to undertake emergency works under the infrastructure SEPP to open the entrance at Farquhar Inlet. The objective of the works was to address community concerns about the deteriorating water quality and health of the lower estuary caused by the absence of tidal flushing and to improve access for recreational boating in the lower estuary.

The emergency works were to offer temporary relief during the preparation of this Entrance Opening Management Plan. It was planned that they would involve the mechanical creation of channels within the inlet delta to link South Channel to an entrance that would be mechanically opened during suitable flow conditions.

A total of $60,000 in funding was made available by GTCC and the NSW Government to undertake the works. A Review of Environmental Factors (*REF*) was also prepared by the NSW Department of Lands (*NSW DoL, 2008*). The community based Farquhar Inlet Management Group (*FIMG*) also raised about $50,000 to contribute towards the emergency works.

However, prior to commencement of the works a minor flood event caused water levels to rise in the inlet and overtop the existing flood notch. Minor earthworks were undertaken on 25th April 2008 to break through the beach berm and create a pilot channel (*refer* **Figure 3**). The escaping water subsequently scoured a larger entrance, restoring tidal flow between Farquhar Inlet and the ocean. It is understood that these minor works were undertaken using a land-based excavator and cost approximately $1,200.

In August 2008, a 20 metre wide and 1 metre deep channel was excavated within the inlet in an attempt to maintain the flow of water between the entrance and South Channel / Oyster Reach (*refer* **Figure 3**).

FIGURE 3

Note: Aerial photography taken in May 2008

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Figure 3 - Recent Works2008.wor

RECENT WORKS TO OPEN FARQUHAR INLET

The position of the works was determined based on the alignment of a small existing channel. The excavated material was used to form three small sand islands to the north of the channel.

However, despite these additional channel works, the entrance tended to migrate north and approached closure against the existing vegetation at Farquhar Park due to minimal rainfall in the upper catchment and sand deposition from southerly ocean swells. Further attempts were made to keep the entrance open by reconnecting the entrance to a channel from Scotts Creek in the north and re-excavating the beach berm. However the entrance closed about two days later (*November 2008*) and these works were abandoned.

The entrance was once again opened mechanically in February 2009 because of elevated river levels from rainfall across the Manning River catchment. It is understood that the peak flood level at Farquhar Inlet was about 1.3 mAHD. The entrance has remained open since this time.

It is understood that a separate REF is currently being prepared by the Farquhar Inlet Management Group (*FIMG*) for works to dredge or excavate an entrance and channel at the southern end of Farquhar Inlet, against the existing “soft rocks”. The FIMG consider that a southern entrance more closely reflects the natural location for the entrance and therefore would remain open for longer and with less maintenance. It is also claimed that an entrance opening in the north has only ever been created by mechanical means. Similar works are discussed in greater detail in **Section 6.7** of this report.

3. COMMUNITY CONSULTATION

3.1 PREVIOUS CONSULTATION

A significant amount of community consultation has been undertaken by Council and WorleyParsons as part of work to prepare the Manning River Estuary Management Study and Plan.

As a result, many of the concerns and views of the community regarding the entrance conditions at Farquhar Inlet have been identified.

Notwithstanding, a large part of work to prepare this Plan has involved additional consultation with key stakeholders and the general public of the Manning River catchment, and particularly the community of Old Bar and surrounding areas.

3.2 CONSULTATION WITH KEY STAKEHOLDERS

Consultation was undertaken with a range of key stakeholders, which included:

- Liaison with the Department of Lands (*DoL*) regarding the recent works to open the entrance in 2008.
- Working closely with Council's engineering staff to discuss the technical merit of potential entrance management options.
- Consultation with the Farquhar Inlet Management Group (*FIMG*) to discuss potential options for managing the entrance.
- Liaison with the Farquhar Park Management Committee.
- Consultation with the Manning River Development Board, which involved discussion of the objective to have two permanent entrances at Harrington and Farquhar Inlet.
- Consultation with representatives from the Jones Island and Coopernook community to discuss the potential impact of entrance conditions at Old Bar on flooding issues in the vicinity of Jones Island.
- Consultation with representatives from community groups, such as oyster farmers, tourism operators, commercial fishers. This involved attendance at several meetings and site inspections to discuss the issues that are significant to each group.
- Liaison with the Oyster Farmers Association (*OFA*) and NSW Food Authority to obtain water quality data for the Lower Manning River in the vicinity of Farquhar Inlet.

3.3 PUBLIC MEETINGS

Aside from direct consultation with key stakeholders and representatives from community groups, a public meeting was held in December 2008 at Old Bar. The aim of the meeting was to outline the potential options for management of the entrance and to gauge community support for them.

It also served as an opportunity for community members to suggest additional management options.

These comments were taken on board and incorporated into this Entrance Opening Management Plan. Of particular assistance were the numerous anecdotal reports and observations on historic entrance behaviour, such as the length of time the entrance remained open after mechanical opening was undertaken.

3.4 ESTUARY AND COASTLINE MANAGEMENT COMMITTEE MEETINGS

Meetings were held with the Estuary and Coastline Management Committee (*ECMC*) to initially present the proposed approach to investigations to prepare the Entrance Opening Management Plan.

Progress updates and the findings of investigations, including the assessment of management options, were presented and discussed during subsequent meetings with the Committee.

The Committee has also been closely involved in the review of the draft versions of this document, which were prepared in May 2009 and November 2009.

4. AVAILABLE DATA

In addition to the information contained in previous investigations and provided by key stakeholders and the community, a range of data has been gathered and considered in the development of the Entrance Opening Management Plan.

This data includes:

- Historic aerial photography for the Farquhar Inlet;
- Tide and river gauge data that show water level information at various locations throughout the Manning River estuary;
- Rainfall data for several rain gauges located within the Manning River catchment;
- Water quality data gathered by the NSW Food Authority as part of a monitoring program for the shellfish industry in the lower Manning River;
- Information on the behaviour of flooding within the Manning River estuary; and,
- The results of numerical modelling of estuarine hydrodynamics in the vicinity of Farquhar Inlet.

4.1 HISTORIC AERIAL PHOTOGRAPHY

A list of the historic aerial photographs that were obtained and examined as part of the assessments detailed below is as follows:

- December 1940
- January 1965
- May 1970
- September 1972
- March 1974
- December 1976
- July and November 1979
- September 1980
- June 1981
- August 1983
- April, August and November 1986
- June 1989
- June 1993
- May 1996
- February 1997
- May 2000
- July 2004
- November 2006
- May 2008

The available aerial photographs were used to confirm and verify anecdotal reports of the entrance condition throughout the past 60 years. Observations were made as to the location of the entrance in each photograph, the predominant location of the entrance (*which may or not be influenced by the choice of location for mechanical opening*) and any trends in behaviour for the movement of the entrance at Farquhar Inlet.

A copy of the available airphotos are provided in **Appendix A**. Also included is a copy of a bathymetric survey, which is reported to have been undertaken by John Armstrong in 1827. It is understood that the survey shows the depth in feet to the bed level at low tide.

4.2 TIDAL INFORMATION AND RIVER WATER LEVELS

Continuous tide gauge data was obtained from the Manly Hydraulics Laboratory (*MHL*) for a range of gauges on the Manning River for the period between January 2000 and January 2009.

Specifically, the data was obtained for gauges at (*refer* **Figure 4**):

- Farquhar Inlet;
- Harrington;
- Croki;
- Dumaresq Island;
- Taree; and,
- Wingham.

The tide gauge data was used to correlate river levels at the entrance and upstream with rainfall data for the catchment and, where possible, water quality data to observe any link between them.

River levels currently influence the protocols for mechanically opening the entrance at Farquhar Inlet. Increased water levels also need to be considered in their capacity to undertake scour of the entrance once opening has occurred.

4.3 RAINFALL DATA

Daily read rainfall data was gathered for the Taree Airport rainfall gauge and several other gauges located throughout the Manning River catchment (*refer* **Figure 5**). The data was supplied by the Bureau of Meteorology (*BOM*).

This data was used to determine any impact of rainfall in the catchment on water quality parameters in the vicinity of Farquhar Inlet.

FIGURE 4

CEDAR PARTY CK
Wingham
MANNING
RIVER
ABBOTTS FALLS
(TIDAL LIMIT)
MONDROOK CK
DAWSON
RIVER
BROWNS CK
Dumaresq
NORTH PASSAGE
DUMARESQ
ISLAND
Taree
COOCUMBAC
ISLAND
CUBBA CUBBA CREEK
SOUTH PASSAGE
LANSDOWNE
RIVER
DICKENSONS CREEK
GHINNI GHINNI CREEK
JONES
ISLAND
Croki
MAMBOO
ISLAND
PIPECLAY CANAL
CATTAI CK
Harrington
HARRINGTON
INLET
SCOTTS CREEK
MITCHELLS
ISLAND
OXLEY
ISLAND
LUTHRIES
ISLAND
SOUTH CHANNEL
Farquhar
FARQUHAR
INLET

LEGEND

Farquhar
H Tide gauge and identifier

N

0 2.5 5
kilometres

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Figure 4 - Tide Gauges.wor

LOCATION OF TIDE GAUGES IN THE LOWER MANNING RIVER

FIGURE 5

LEGEND

- Rainfall gauge and identifier
- Streamflow gauge and identifier
- Catchment/ Sub-catchment Boundary
- Waterways

208009 BARRY
60128 BARRY
208027 U/S MEASURING WEIR
208007 NOWENDOC
60104 NOWENDOC (1971+)
60069 COOPLACURRIPA (1961+)
208011 MACKAY
60137 BRETTI (1993+)
208005 ROCKS CROSSING
60118 ROCKS CROSSING (1945+)
60093 UPPER LANDSDOWNE (1969+)
LANDSDOWNE
60147 KILLABAKH (2003+)
60153 MOPPY LOOKOUT (2008+)
56006 DOON AYRE
60177 MT GEORGE (1929+)
208003 DOON AYRE
KILLAWARRA
WINGHAM
60141 TAREE AIRPORT (1997+)
60152 COBARK (2008+)
60075 UPPER BOWMAN (1965+)
208006 FOREBESDALE (CAUSEWAY)
60015 GLOUCESTER (1888+)
61413 CAREYS PEAK (2008+)
60155 WAUKIVORY (2008+)
60042 CRAVEN

COOPLACURRIPA RIVER
MUMMEL RIVER
ROWLEY'S RIVER
NOWENDOC RIVER
BARNARD RIVER
DINGO CREEK (WEST)
DINGO CREEK (EAST)
PIGNA BARNEY RIVER
LITTLE MANNING RIVER
LANGDOWNE RIVER
HARRINGTON INLET
MANNING RIVER
BOWMAN RIVER
GLOUCESTER RIVER
BARRINGTON RIVER
AVON RIVER
FARQUHAR INLET

N

0 10 20

kilometres

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Figure 5 - Rainfall Gauges.wor

LOCATION OF RAINFALL AND STREAMFLOW GAUGES IN THE MANNING RIVER CATCHMENT

4.4 WATER QUALITY DATA

Water quality data for the lower Manning River estuary has been gathered by the Oyster Farmers Association (*OFA*) and the NSW Food Authority since 2003. This data collection program has involved the measurement of salinity and faecal coliforms at key oyster growing areas on Scotts Creek, the South Channel and the Manning River.

The locations of the active water quality sampling sites are shown in **Figure 6**.

The oyster industry relies on this information to ensure that food safety criteria are maintained for shellfish harvesting.

4.5 FLOOD INFORMATION

An ESTRY flood model was developed as part of the *'Manning River Flood Study'* (*1991*). The results from this model are documented in the Flood Study Report and also in the *'Manning River Floodplain Management Study'* (*in draft 1995*).

Specific information has been taken from these reports to determine the floodplain management role of current flood notch protocols for the Farquhar Inlet entrance.

Details of the behaviour of flooding, such as flood level information, was also obtained for Farquhar Inlet from these reports.

4.6 RESULTS OF ESTUARINE HYDRODYNAMICS MODELLING

A detailed investigation of estuarine hydrodynamics was completed and documented in the report *'Manning River Estuary Management Study- Numerical Modelling Investigation' (2001)*.

The investigation involved the development of an RMA-2 model for the lower Manning River estuary, including the entrance at Farquhar Inlet. The results of the modelling were used to determine flushing times for various locations throughout the estuary for historic entrance conditions and also for a range of options to dredge an entrance at Farquhar Inlet (*GTCC, 2001*).

The 2001 study also investigated sediment transport in the vicinity of Farquhar Inlet for the entrance opening options.

Although a thorough technical review of the document was not undertaken, it is considered that the results of the modelling investigations are appropriately reliable for the purposes of this Plan.

FIGURE 6

JONES ISLAND

HARRINGTON

MITCHELLS ISLAND

MANNING RIVER

MANNING RIVER

NORTH PASSAGE

DUMARESQ ISLAND

MANNING RIVER

SOUTH PASSAGE

SCOTTS CREEK

OXLEY ISLAND

LUTHRIES ISLAND

SOUTH CHANNEL

PACIFIC OCEAN

OLD BAR

FARQUHAR INLET

12

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23

24

Refer Figures 8 and 11 for water quality data

Refer Figures 9 and 12 for water quality data

LEGEND

20 Water quality sampling site and identifier

N

0 1.0 2.0

kilometres

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Figure 6 - WQ Sampling sites.wor

LOCATION OF WATER QUALITY SAMPLING SITES

5. ENTRANCE MANAGEMENT CONSIDERATIONS

As part of investigations to develop the Entrance Opening Management Plan, it was necessary to consider the following issues regarding the entrance:

- The physical processes that contribute to the closing, opening, scour and movement of the Farquhar Inlet entrance. This included a review of broader scale processes such as catchment hydrology and flooding, as well as local coastal processes in the vicinity of the inlet.
- The water quality processes that affect the inlet and nearby sections of the Manning River estuary, including the consequences of freshwater inflows, flushing time and catchment runoff on the production and harvesting of oysters.
- Other environmental considerations, such as the provision of breeding grounds for migratory birds and the presence of aquatic flora and fauna at the inlet.
- Social and economic issues, such as the impact of entrance closure on navigation and recreation in the lower estuary. Tourism and aesthetic value of the estuary can be influenced by the condition of the entrance.

These issues have been identified through previous work to develop the Estuary Management Plan for the Manning River and through consultation with key stakeholders and the general community.

5.1 PHYSICAL PROCESSES

As discussed above, numerical modelling has been undertaken for estuarine hydrodynamics at Farquhar Inlet and the surrounding tributaries (*GTCC, 2001*).

Conclusions regarding the physical processes of Farquhar Inlet can be made through combining the results of this modelling with physical observations of catchment hydrologic data, such as rainfall data and tide gauge readings.

Aerial photography and anecdotal reports were also used in this assessment.

A conceptual model of the key physical processes is presented in **Figure 7**.

5.1.1 Entrance Opening

Physical processes and considerations related to entrance opening and maintaining an open entrance include the following:

- Current protocols allow for the entrance to be opened mechanically during a flood event prior to natural break-out of floodwaters (*refer Option 1 below*).
- Increased flow from the Manning River catchment increases the scour potential at the entrance, which can assist to maintain an open entrance for a longer duration after opening.

FIGURE 7

LEGEND

- Tidal flows
- Net inflow of marine sediment during open conditions
- Flood flows scour large volume of sediment from inlet

Note: Aerial photography taken in May 2008

N

0 250 500

metres

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Figure 7 - Concept Model.wor

CONCEPTUAL MODEL OF PHYSICAL PROCESSES

- Rainfall and streamflow in the upstream catchment can be monitored to determine an appropriate time for mechanical opening of the entrance to avoid or minimise potential flood impacts.
- Significant and continuing exchange of tidal flow from the estuary to the ocean and vice versa is required to maintain scour of an entrance opening at any location within Farquhar Inlet. The entrance is likely to remain open if ebb tidal discharge exceeds flood tidal flows.
- A straight alignment for channels through the inlet is considered to be more hydraulically efficient and offer increased flow velocities and associated scour of the entrance.
- Extraction of water for irrigation and drinking in the upper catchment may contribute to less flow reaching the inlet, thereby reducing the potential for daily scour of the entrance, if in an open state. However, it is largely considered that this would have minimal effect on entrance processes when compared with other factors.
- Coastal erosion during major and rare ocean storm events can contribute to opening the entrance by the temporary removal of marine sediments.
- A continually open entrance could increase the potential for scour of riverbanks. Although the potential for erosion is not supported by firm data, significant scour of sandy banks at Farquhar Park has been observed in recent times when a northern entrance has existed.
- Residents in the vicinity of Jones Island report that local flooding is worsened during times when the entrance at Farquhar Inlet is open. However, numerical modelling previously completed for the estuary suggests that this would not be the case.

  Tide gauge data recorded at Croki (*Jones Island*) during minor flood events over the past 10 years also indicates that the condition of the entrance at Farquhar Inlet (*i.e., whether it is closed or open*) does not impact on the peak level of flooding at Jones Island. In most cases, the peak level at Croki closely matches the peak level at Farquhar Inlet, for both closed and open conditions.
- The results of numerical modelling for the lower estuary show that opening of the entrance at Farquhar Inlet will have minimal effect on tidal flows through the entrance at Harrington (*GTCC, 2001*). Accordingly, the stability of the Harrington entrance is not expected to be affected by the conditions at Farquhar Inlet.

5.1.2 Entrance Closure

Physical processes and considerations related to entrance closure include the following:

- Closure of the entrance at Farquhar Inlet is largely attributable to the dominant coastal processes that move marine sediments into the entrance. These coastal processes include tidal inflows into the estuary and continual wave action to move sands along the shore towards the entrance and also move sands onshore from offshore locations.

- The accretion of marine sediments forms a tidal delta and a sand spit is eventually formed across the entrance, causing closure.
- In the case of flooding that causes scour and opening of the entrance, coastal processes eventually dominate once again as the flood flow decreases, leading to re-establishment of sediment inflow to the estuary and the subsequent shoaling of inlet channels.
- It is reported, and somewhat confirmed by the results of numerical modelling, that opening the entrance at Farquhar Inlet can lead to increased shoaling from the inflow of marine sediments further into the inlet. In other words, the inflow of sediment into the inlet can be reduced or minimised when the entrance is closed. It should be noted that in this case any accumulated sediment is less readily scoured from the entrance by flooding.

5.1.3 Entrance Movement and Location

Considerations for entrance movement include the following:

- Aerial photographs indicate that entrance has been in several locations between the soft rocks in the south and the vegetated area at the northern limit of the inlet (*refer* **Appendix A**).
- The bathymetric survey information recorded in 1827 (*refer* **Appendix A**) shows that the entrance was located at the southern limit of the inlet at that time. The depth of the channel is noted as 13 feet, or about 4 metres, below low tide level.
- The available airphotos indicate that during the 1970s and 1980s the entrance was predominantly located between the middle and the northern limit of the inlet.
- Between the mid 1990s and early 2000s, the entrance was located near the southern limit of Farquhar Inlet. It should be noted that some time between 1997 and 2000, a significant area of established vegetation was removed at the southern end of the inlet, likely due to coastal erosion or entrance scour. This allowed the direction of the southern entrance to change from facing east to facing more south.
- The available aerial photography indicates that the entrance was largest and potentially most stable during the late 1970s and early 1980s. This condition was likely assisted by flooding that occurred in 1978. The location of the entrance during this time was towards the northern end of the inlet, to the south of Charleys Island.
- The results of numerical modelling for the lower estuary show that an entrance in the middle or northern end of Farquhar Inlet could result in an increased volume of shoaling into the inlet and South Channel, when compared with an entrance at the southern limit of the inlet (*GTCC, 2001*). The results also indicate that a longer pilot channel feeding to the entrance will result in less volume of sediment inflow.

5.2 WATER QUALITY PROCESSES

As discussed above, water quality within the lower estuary behind Farquhar Inlet is a major issue that has been raised by the local community and commercial operators.

However, it should be recognised that the issue of "water quality" can be interpreted in several different ways. For example, with regard to the productivity of the local shellfish industry, "poor" water quality can be characterised by low levels of salinity, which cause shellfish deaths and the closure of harvest areas, which in turn affects profitability.

Whereas the impact of water quality on the recreational value of the lower estuary is considered to be related to the aesthetic appearance of the inlet.

Further discussion of the impact that water quality can have on various aspects and uses of the lower estuary is outlined in the following. One constant in the view of most members of the community is that water quality is considered to be linked directly to the estuarine flushing, or lack thereof, that occurs at Farquhar Inlet.

5.2.1 Estuarine Flushing

The extent of tidal flushing through Scotts Creek and South Channel and within the inlet itself has a major impact on the water quality of Farquhar Inlet.

Closure of the entrance and heavy shoaling within the inlet can lead to a reduction in tidal exchange along these channels and a significant increase in flushing time (*i.e., the time taken for water to move through the waterway*). This can result in the deterioration of water quality, which in turn affects the ecological health of the waterway and its commercial and recreational value.

During times when the entrance is open, the associated tidal exchange results in shorter flushing times for Scotts Creek and South Channel due to the efficient inflow and outflow of water from the ocean. An associated improvement in water quality generally occurs.

Numerical modelling previously undertaken for the lower estuary (*GTCC, 2001*) indicates that the flushing time for Farquhar Inlet is less than 1 day if the entrance is open. Whereas, the flushing time could be more than 31 days if the entrance is in a closed state; meaning that it takes about a month for water to be "turned-over" at Farquhar Inlet, in this case, by flow from Harrington and the Manning River North Passage.

Along Scotts Creek the flushing time can be between 1 and 8 days if there is an open entrance, and up to one month if the entrance is closed. At South Channel the flushing time is typically only 1 to 2 days if the entrance is open (*GTCC, 2001*).

Apart from the flushing capacity of the lower estuary, rainfall and runoff from the local and wider Manning River catchments can also impact on water quality at Farquhar Inlet. The inflow of freshwater associated with significant rainfall and traces of faecal material from

stormwater runoff can affect oyster health and harvesting activities, as discussed in the following.

5.2.2 Water Quality and the Oyster Industry

The Manning River has the following shellfish harvest areas (*NSW FA, 2007*):

- Mangrove Island;
- Mitchells Island;
- Pelican Point;
- Scotts Creek; and,
- South Channel.

The Pelican Point, Mangrove Island and Mitchells Island harvest areas are located near Harrington on the Manning River channel and are therefore, not directly related to water quality issues at Farquhar Inlet (*refer* **Appendix B**).

The Scotts Creek harvest area covers a majority, but not all, of the oyster leases along Scotts Creek (*refer* **Appendix B**).

These harvest areas are Conditionally Restricted, meaning that depuration of harvested oysters is required for 36 hours before they are sent to market.

The South Channel harvest area covers a 5 kilometre length of South Channel and a portion of Scotts Creek (*refer* **Appendix B**). According to information obtained from the NSW Food Authority, it is understood that this harvest area has been closed since March 2005 due to poor water quality and little to no salinity.

The Scotts Creek and South Channel harvest areas are considered to be most sensitive to water quality conditions at Farquhar Inlet.

Currently, the water quality threshold limits for harvesting oysters in the vicinity of Farquhar Inlet are as follows:

- Salinity levels must be 18 ppt (*parts per thousand*) or higher; and/or,
- Faecal Coliform counts must not exceed 70 cfu (*coliform units*).

In other words, if these criteria are not met, the harvesting area can be “closed” and oysters are not to be harvested.

A copy of the specific Harvest Area Management Plans for Scotts Creek and the South Channel that are implemented by the NSW Food Authority are provided in **Appendix C**.

As shown, the NSW Food Authority relies on a “trigger” for closure of the Manning River harvest areas that is based on real time rainfall monitoring. Rainfall can be used as the

trigger due to the potential decrease in salinity and increase in coliforms that can accompany significant rainfall. These relationships are discussed further in the following sections.

The closure of Manning River harvest areas is triggered following more than 25 mm of rainfall within 24 hours at Old Bar or at the Taree Airport AWS (*Automatic Weather Station*).

It is understood that this condition is overly stringent and specific to the Manning River harvest areas, due to the limited capacity for tidal flushing at Farquhar Inlet.

The NSW Shellfish Program (*operated by NSW Food Authority under the Australian Shellfish Quality Assurance Program*) also provides a history of the status of the harvest areas at the Manning River since September 2007. The information indicates that the Scotts Creek harvest area was closed on 5 separate occasions during the period when the entrance was open between April and November 2008 (*refer* **Appendix D**). Most of these closures were triggered by rainfall exceeding the threshold limit.

This shows that opening the entrance does not necessarily translate to a reduction in the number of closures of the harvest areas. As discussed, closures can be triggered solely by rainfall.

However, the information does show that closure times were significantly shortened (*i.e., 2 or 6 days*) once the entrance had been open for about five months. In other words, having an open entrance appears to offer a rapid return to suitable water quality conditions at the Scotts Creek harvest area.

Notwithstanding, it should be recognised that the data set contained in **Appendix D** is limited to that recorded only back to September 2007 and therefore, it doesn't provide a comprehensive set of data from which to draw conclusions.

Due to the continually poor conditions in the South Channel, it is understood that re-opening this particular harvest area will involve a complete re-classification of the area according to a detailed sampling program, so that it can be demonstrated to the NSW Food Authority that the area is again suitable for harvest. In light of recent entrance openings, it is considered that salinity levels may be increasing and therefore, a re-opening of the area could be possible.

However, local oyster growers have indicated that the cost and time associated with collecting and processing the samples (*from both oyster meat and the water column*) is often prohibitive. It is reported that the required sampling program may take up to 18 months because the area has not been monitored for faecal coliforms and E.Coli since its closure in 2005 (*refer data gap in* **Figures 9** *and* **12** *below*).

Notwithstanding, it is understood that the NSW Food Authority may be able to grant an interim classification to the harvest area, at some time prior to completion of the entire re-classification process. The South Channel area is now undergoing continual testing and event testing.

5.2.3 Salinity

Figure 8 and **Figure 9** show recorded salinity data between May 2003 and November 2008 for water quality sampling sites on Scotts Creek and South Channel, respectively (*refer* **Figure 6**). A graph of 24 hour (*daily read*) rainfall is also shown on the figures.

The threshold limit of 18 ppt is marked on the figure, which is considered to be the minimum salinity level required for oyster harvesting.

It should be noted that the data is not monitored continuously and the available data set may not cover every rainfall event.

As shown, there are several instances where salinity levels drop to below the threshold limit. As to be expected, a correlation between rainfall and decreased salinity can be seen. Sometimes the response time for salinity to reach suitable levels is quite rapid. At other times the response can be weeks or months (*refer* **Figure 8** *and* **9**).

As shown in the figures, a significant rainfall event occurred in October 2004, leading to an immediate drop in salinity levels. Mechanical opening of the entrance was undertaken to control the level of flooding in the lower estuary. The subsequent flushing of the inlet resulted in a rapid response of salinity levels to return to above the threshold limit.

Figure 10 shows the recorded salinity levels at several sampling sites along Scotts Creek and South Channel (*refer* **Figure 6**) for a large rainfall event that occurred in May 2003. The chart shows that salinity was below the threshold limit at all sites following this event.

It is understood that that salinity measurements need to be above the threshold 18 ppt for a period of 48 hours in order for a harvest area to be re-opened. Additional monitoring for faecal coliforms in both the water and also shellfish samples is required prior to re-opening, as indicated in the Harvest Area Management Plans (*refer* **Appendix C**).

Based on anecdotal reports, in practice oyster farmers typically resume harvesting about 10 to 12 days after closure of the harvesting area during times when the entrance is open. This timeframe can extend up to 3 or 4 weeks if the entrance is closed.

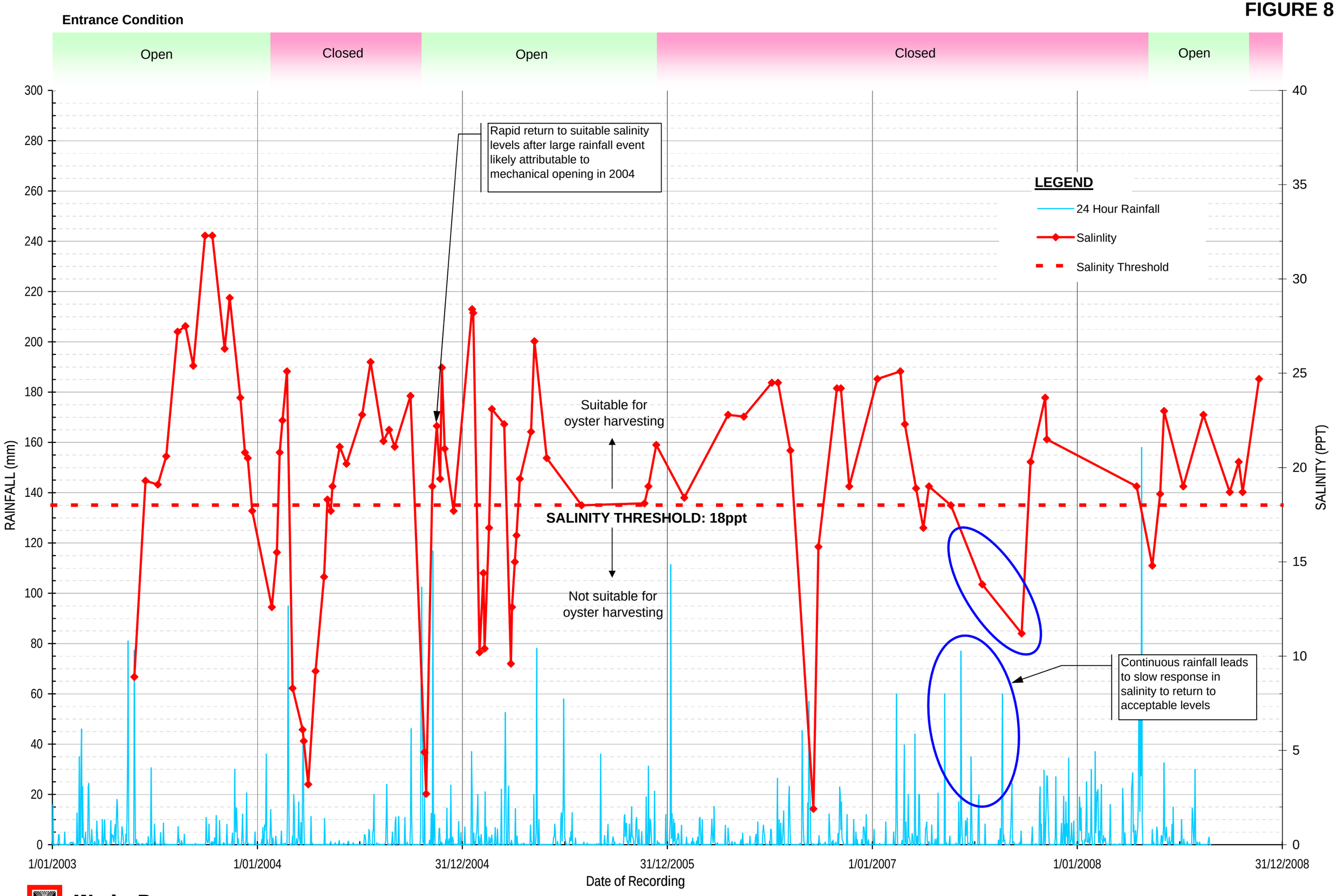
5.2.4 Faecal Contamination

Figure 11 and **Figure 12** show recorded faecal coliform data between May 2003 and November 2008 for water quality sampling sites on Scotts Creek and South Channel, respectively (*refer* **Figure 6**). A graph of 24 hour rainfall is also shown on the figures.

The threshold limit of 70 cfu (*coliform units*) is marked on the figure, which is the required maximum faecal coliform count in water samples for oyster harvesting.

Similar to the salinity data, it should be noted that the data is not monitored continuously and the available data set may not cover every rainfall event.

FIGURE 8



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Farquhar Inlet Water Quality Sampling Data
2008-11-25 Manning River WQ data analysis.xls

SALINITY DATA FOR SCOTTS CREEK - SAMPLE SITE 15

FIGURE 9

Entrance Condition

Open | Closed | Open | Closed | Open

RAINFALL (mm)

SALINITY (PPT)

Rapid return to suitable salinity levels after large rainfall event likely attributable to mechanical opening in 2004

LEGEND

24 Hour Rainfall

Salinlity

Salinity Threshold

Suitable for oyster harvesting

No water quality data was recorded at Site No. 22 between 31/5/2005 & 14/5/2008

SALINITY THRESHOLD: 18ppt

Not suitable for oyster harvesting

Continuous rainfall leads to fluctuations in salinity. Return to acceptable levels is rapid if entrance is open.

1/01/2003 | 1/01/2004 | 31/12/2004 | 31/12/2005 | 1/01/2007 | 1/01/2008 | 31/12/2008

Date of Recording

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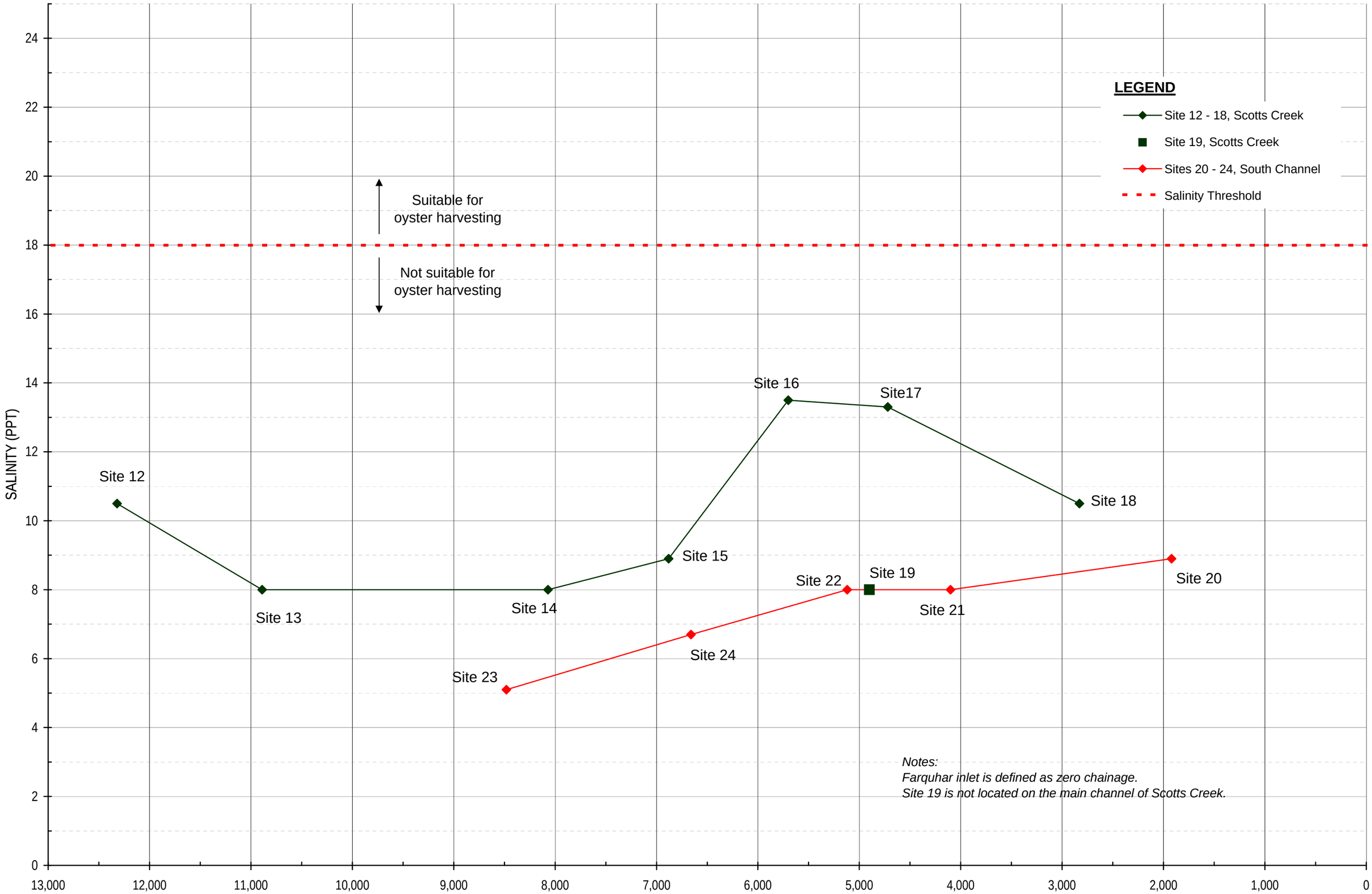
SALINITY DATA FOR SOUTH CHANNEL - SAMPLE SITE 22

FIGURE 10



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SALINITY DATA FOR SIGNIFICANT RAINFALL EVENT (27th MAY 2003, DAILY RAINFALL = 77.3mm)

FIGURE 11

Entrance Condition

Open | Closed | Open | Closed | Open

880 cfu

480 cfu

800 cfu

320 cfu

Significant response to large rainfall event, then rapid return to acceptable levels due to entrance opening works

LEGEND

- Faecal Coliform
- Faecal Coliform Limit
- 24 Hour Rainfall

Examples where rainfall does not translate to faecal coliform levels above limit

Continuous rainfall does not translate to faecal coliform levels above limit in this instance

Not suitable for oyster harvesting

FAECAL COLIFORM LIMIT: 70 cfu (for water samples)

Suitable for oyster harvesting

FAECAL COLIFORM (cfu) & RAINFALL (mm)

300
250
200
150
100
50
0

1/01/2003
1/01/2004
31/12/2004
31/12/2005
1/01/2007
1/01/2008
31/12/2008

Date of Recording

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2008-11-25 Manning River WQ data analysis.xls

FAECAL COLIFORM DATA FOR SCOTTS CREEK - SAMPLE SITE 15

FIGURE 12

Entrance Condition

Open | Closed | Open | Closed | Open

640 cfu

Significant response to large rainfall event, but then rapid return to acceptable levels due to entrance opening

Example where rainfall does not translate to faecal coliform levels above limit

Not suitable for oyster harvesting

Suitable for oyster harvesting

FAECAL COLIFORM LIMIT: 70 cfu (for water samples)

No water quality data was recorded at Site No. 22 between 31/5/2005 & 14/5/2008

LEGEND

- Faecal Coliform Limit
- Faecal Coliform
- 24 Hour Rainfall

FAECAL COLIFORM (cfu) & RAINFALL (mm)

300
250
200
150
100
50
0

1/01/2003 | 1/01/2004 | 31/12/2004 | 31/12/2005 | 1/01/2007 | 1/01/2008 | 31/12/2008

Date of Recording

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Farquhar Inlet Water Quality Sampling Data
2008-11-25 Manning River WQ data analysis.xls

FAECAL COLIFORM DATA FOR SOUTH CHANNEL - SAMPLE SITE 22

As shown, there are several instances where the number of faecal coliforms is above the threshold limit. Usually a correlation between rainfall and increased coliforms can be seen. This is typically due to increased runoff across urban areas and cow pasture following rainfall events. Faecal matter is carried by stormwater into the river system.

However, not all instances of high rainfall result in faecal coliforms above the threshold limit. (*refer* **Figures 11** *and* **12**).

Notwithstanding, **Figure 13** shows the recorded coliform levels at several sampling sites along Scotts Creek and South Channel (*refer* **Figure 6**) for the large rainfall event that occurred in May 2003. The figure shows that coliform counts were significantly higher than the threshold limit at all sites following this rainfall event.

5.3 ENVIRONMENTAL CONSIDERATIONS

Environmental considerations and constraints for Farquhar Inlet include the following:

- Sand islands and spits at the inlet are considered to be critical breeding habitat for Little terns and other migratory birds. Breeding season for the Little Terns is between November and January, meaning that any proposed works at the inlet should be minimised or avoided during this period.

  It should be noted that, if given the chance, foxes regularly prey on Little Tern nests. When this has occurred at Farquhar Inlet in the past, the Terns are reported to have moved their breeding activities to the sand spit at Harrington or other locations.

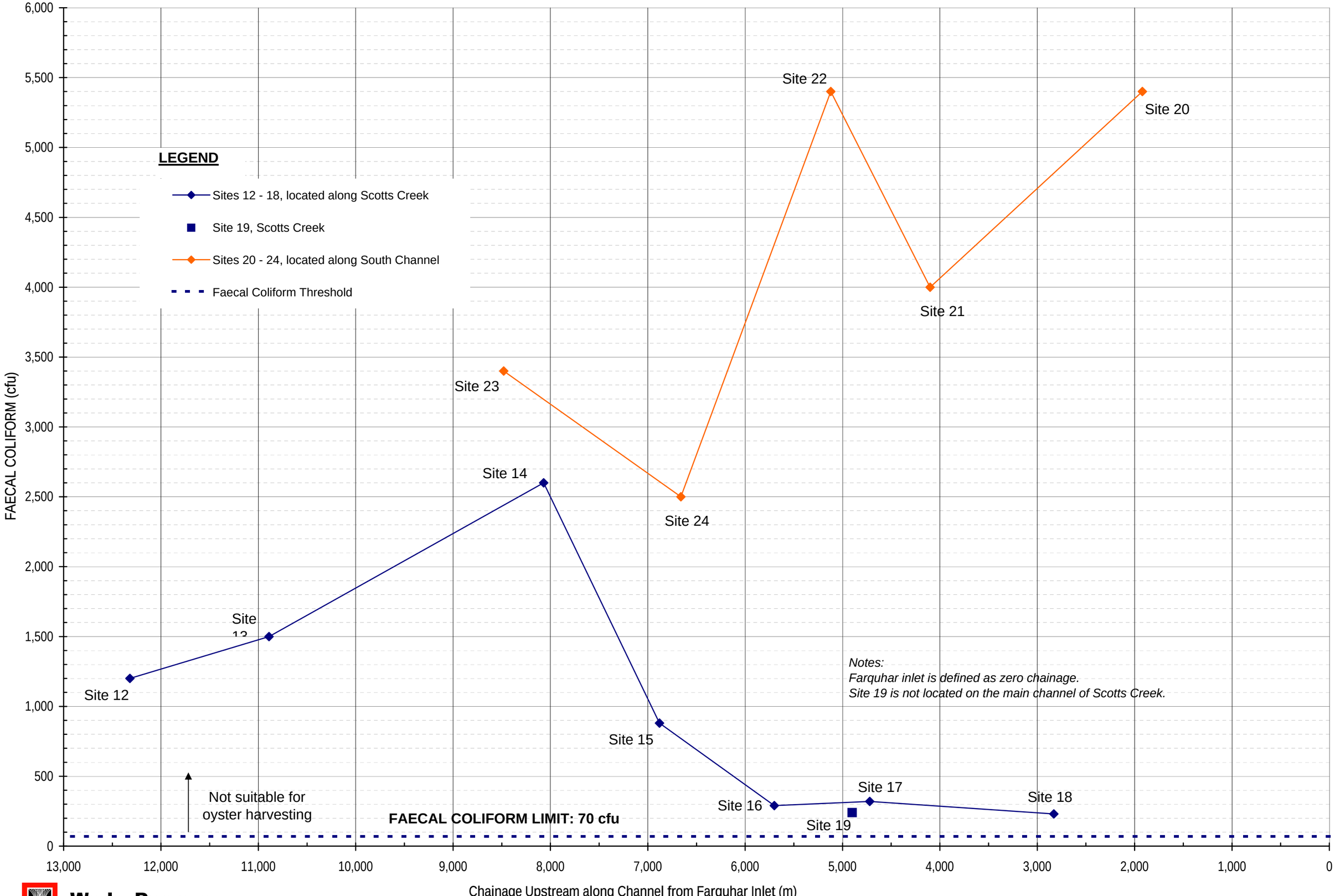
  It is understood that the National Parks and Wildlife Service (*NPWS*) support the creation of an entrance at the southern end of the inlet, which would be beneficial in the management of foxes.

- Aquatic flora, such as seagrass, saltmarsh and mangroves need to be considered when planning and undertaking any physical works at Farquhar Inlet. However, recent aerial photography and site inspections indicate that there is likely to be minimal coverage of these vegetation types within the inlet.

- A small section of saltmarsh has recently been identified near the southern limit of the inlet. However, it is considered that its ecological value is low compared to other areas of the inlet. The floristic diversity of the coastal saltmarsh declines towards the southern limit (*i.e., near the soft rocks*), where a monoculture of a freshwater, occasionally brackish, species of saltmarsh has been observed.

- There is potential for any works at Farquhar Inlet to physically disturb aquatic fauna (*or its food source*). Accordingly, any proposed measures for entrance management need to considered the impact of the works on aquatic fauna such as fish and crustaceans, including the relatively sizable Yabbie population that exists at Farquhar Inlet.

FIGURE 13



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Farquhar Inlet Water Quality Sampling Data
2008-11-25 Manning River WQ data analysis.xls

FAECAL COLIFORM DATA FOR SIGNIFICANT RAINFALL EVENT (27th MAY 2003, DAILY RAINFALL = 77.3mm)

5.4 ECONOMIC AND SOCIAL IMPACT

As discussed above, there is potential for entrance conditions to impact on water quality and thereby affect the productivity of the local shellfish industry at Farquhar Inlet. The exact dollar value of the losses associated with poor estuarine flushing is not known and has not been investigated in detail as part of this study.

Notwithstanding, the Coordinator of the Manning River Shellfish Program indicates that all of the 12 oyster farmers on the Manning River lost between 70% and 99% of their oysters during the 2007/2008 season, due to reduced salinity levels during January and February 2008. The farmers consider this long and enduring "fresh" to be a result of continual rainfall events across the upper catchment in combination with the closed entrance at Farquhar Inlet, through which the freshwater would've otherwise escaped. Instead, the only escape for the freshwater was through Scotts Creek or directly down the North Passage of the Manning River. This apparently kept all areas of the lower estuary fresh for an extended period.

These anecdotal reports are consistent with the harvest area status history (*refer* **Appendix D**), which shows that several harvest areas within the lower Manning were closed for up to 203 consecutive days between November 2007 and May 2008.

One farmer indicates that their individual losses during this time were equivalent to the value of the three years of oyster crops that died in that season, which they estimate to be approximately $300,000.

Based on this example, it is calculated that the total Manning River losses during the 2007/2008 season may have been in the order of $2M to $3M.

It is also reported that since closure of the South Channel harvest area in March 2005, about half of the oyster leases in that area have been surrendered to the Crown. The oyster farmers believe it is not financially viable to retain these leases and risk trying to grow oysters in this area without the Farquhar Inlet entrance being open.

Accordingly, it has been established that immediate measures are required to manage the entrance and assist in reducing these losses to the oyster industry. However, it is also recommended that a detailed analysis of the benefit versus cost for implementing longer-term structural options should be undertaken as part of further investigations into those options.

Apart from the economic impact on the shellfish industry, there is also potential for poor estuarine flushing to impact on the local fishing and prawning industries of the lower estuary.

Tourism operators at Old Bar and other areas within the lower estuary can also be affected by what the public perceive to be declining water quality.

This is related to the popularity of the lower Manning as a recreational fishing spot, a place to swim and engage in various water-based activities and a place to partake in other

recreational activities such as camping. Anecdotal reports from local community members suggest that tourism in recent times is not as strong as it has been in the past. They indicate that tourists are discouraged by the mud that is suspended in the water for extended periods following rainfall events, which may otherwise be flushed out by the tide through an open entrance.

The impact on tourism is also related to the navigability of the inlet and adjacent channels for recreational boat users and the visual amenity of the estuary. As discussed above, an open entrance can increase channel scour by tidal currents, which could potentially improve navigation conditions for boat users. However, it should also be noted that an open entrance can lead to significant inflow of marine sediments and the potential for shoaling of channels further upstream from the inlet.

Access to the beach across the inlet (*i.e., travelling north from Old Bar*) is also an important consideration in developing suitable options for management of an entrance at Farquhar Inlet. The location, or presence, of an entrance can prevent vehicular access from Old Bar to campgrounds north of the inlet on Mitchells Island. However, it should be noted that vehicular access to the campgrounds is still provided from Manning Point (*via the beach*).

6. ASSESSMENT OF ENTRANCE MANAGEMENT OPTIONS

6.1 POTENTIAL ENTRANCE MANAGEMENT OPTIONS

Seven potential management options have been identified through the investigation of available information, consultation with key stakeholders and the community, and consideration of the issues identified above.

The seven potential options are as follows:

Option 1. Existing scenario for flood notch management

Option 2. Periodic excavation of flood notch to a reduced elevation

Option 3. Decision making framework for flood notch and pilot channel

Option 4. Dredging to keep a central entrance open continuously

Option 5. Dredging to form a lake behind the closed beach berm

Option 6. Dredging to form an entrance at the southern limit of Farquhar Inlet

Option 7. Permanent entrance incorporating rock training walls and breakwaters

A description of each management option is provided in the following sections. A discussion of the benefits and potential impacts of each option is also included.

6.2 OPTION 1 – EXISTING SCENARIO FOR FLOOD NOTCH MANAGEMENT

Option 1 is effectively the "do nothing" option, meaning that Council's existing floodplain management strategy of excavating the flood notch would be retained and continued.

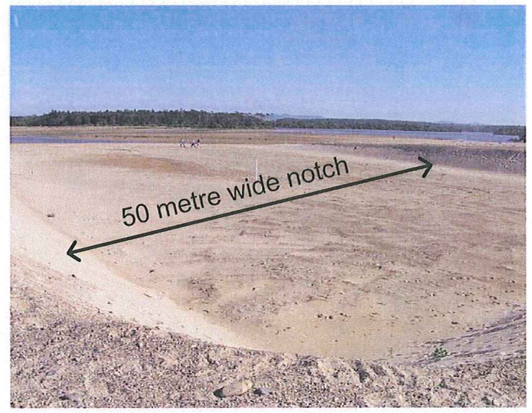
Option 1 is shown in **Figure 14**. As outlined in the *Manning River Floodplain Management Study* (*in draft 1996*), the current protocols involve the periodic excavation of a 50 metre wide pilot channel (*or flood notch*) at the back of the beach berm to an elevation of 2.0 mAHD. The remainder of the dune is to be maintained at a maximum elevation of 2.5 mAHD.

It should be noted that, in practice, the flood notch may be excavated to a level significantly lower than 2.0 mAHD, as was the case prior to the opening in April 2008.

When flood levels at Farquhar Inlet reach an elevation of 2.0 mAHD, Council further excavates a narrow channel between the notch and the ocean to create a small entrance (*refer* **Figure 14**). The erosive power of escaping floodwaters scours a larger channel, typically leading to a significant entrance.

A discussion of the issues and potential impacts of this option is provided in the following.

FIGURE 14



Note: Aerial photography taken in May 2008

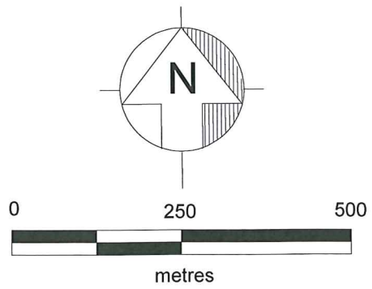


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Figure 14 - Options 1 and 2.wor

FLOOD NOTCH OPTIONS (OPTIONS 1 AND 2)

6.2.1 Impact on Physical Processes at Farquhar Inlet

It is understood that the current flood notch protocols have proven to be an effective floodplain management strategy thus far.

It is estimated that the initial entrance opening and the subsequent works undertaken during 2008 ultimately lead to the removal of up to 200,000 m^3 of sand from the inlet (*pers comm. Department of Lands*). The initial opening works in April 2008 were undertaken during minor flood conditions, which suggests that much of the sediment would have been scoured out of the inlet during the initial opening. The difference between the level of floodwaters ponded in the inlet and the ocean level can be significant during flooding, thereby offering significant scour potential.

Accordingly, the flood notch protocols are considered to be an effective measure in clearing a large quantity of marine sediment from the inlet. However, the timing of these scouring events is subject to the hydrology of the catchment.

As discussed above in **Section 5.1**, under normal tidal conditions (*i.e., without flooding*), the entrance is naturally expected to infill with marine sediments as a result of coastal processes.

It is understood that some basic survey information was collected at the inlet following the mechanical entrance opening in April 2008. However, it is recommended that any option to retain the flood notch incorporates a detailed monitoring program that can be used to estimate both the volume of material that is flushed out immediately following any break-out and also the rate of sediment inflow during normal tidal conditions prior to natural closure.

6.2.2 Impact on Water Quality

Based on recent community concerns and the downturn in the profitability of the local shellfish industry, it is apparent that the existing floodplain management protocols for Farquhar Inlet do not serve to address any water quality issues within the lower estuary.

The absence of major flooding in recent years has limited the potential for mechanical opening and subsequent scouring of the inlet, which would be usually followed by several weeks or months of tidal exchange.

6.2.3 Other Environmental Impacts

It is understood that implementation of the existing flood notch protocols involving excavation of the notch and pilot channel does not have a significant impact on the natural environment at Farquhar Inlet. As discussed above, an REF was prepared by the Department of Lands for emergency entrance opening works undertaken in April 2008. The REF did not highlight any environmental risks that were not manageable.

Notwithstanding, the existing protocols incorporate a requirement to contact the local National Parks and Wildlife Services ranger, the State Park ranger and the Little Tern Warden prior to any works being undertaken, to ensure that there is no shorebird breeding activity at that time.

6.2.4 Impact on Recreation

There is not expected to be any significant impact on the existing recreational and visual amenity of the inlet should Option 1 be implemented and thereby the existing flood notch protocols be retained.

6.2.5 Cost of Implementation

Based on advice from Council, it costs up to **$10,000** to excavate the flood notch to a level of 2.0 mAHD. This cost estimated is based on excavator operation over a two day period. It is understood that the notch requires excavation once every 3 years on average, accounting for the fact that, historically, the entrance has been open for two thirds of the time.

It is estimated that the cost to open the beach berm is only **$2,500** to. This includes equipment mobilisation costs and one half day of excavator operation. It is estimated that the berm requires opening once every five years on average.

A breakdown of the costs for Option 1 is provided in **Appendix E**. This includes an assessment of the costs over a 30 year timeframe.

6.2.6 Monitoring Activities

It is recommended that the implementation of Option 1 include monitoring of sediment transport out of and into the entrance after each manual opening event. It is envisaged that this will require up to three separate visits to the entrance at regular intervals following the opening to record the size and position of the entrance. Each visit would involve taking photographs and notes and some basic measurements using surveying equipment.

The aim of the monitoring would be to assess the effectiveness of the existing flood notch protocols in maintaining an entrance following a mechanical opening event. It would also provide valuable information on the subsequent inflow of marine sediment into the inlet and upstream along adjacent channels (*if any*), leading up to the time of entrance closure.

It is estimated that the cost of such monitoring would be about **$9,000**, which allows two days for each site inspection. It is recommended that monitoring for Option 1 be undertaken once every five years on average, to coincide with any mechanical opening event.

6.3 OPTION 2 – FLOOD NOTCH WITH REDUCED ELEVATION

Option 2 involves the implementation of the flood notch protocols outlined in Option 1, but with excavation of the notch to a lower level than that currently adopted (*refer* **Figure 14**).

Overtopping of a lower flood notch by flooding in the Manning River would be expected to occur more frequently, thus leading to an increased frequency/time of entrance opening and the associated benefits to water quality (*salinity*) in Farquhar Inlet from the associated tidal flushing.

6.3.1 Reduced Flood Notch Elevation

As outlined in Option 1, the current flood notch protocols allows for excavation of a flood notch with an elevation of 2.0 mAHD.

According to flood level information contained in the Manning River Flood Study (*GTCC, 1991*), flooding would be expected to reach this elevation during an event with magnitude between the 20 and 50 year recurrence floods. However, it should be noted that the documented flood levels do not account for closed entrance conditions and therefore, it is expected that design flood levels may reach higher than estimated if flooding was to occur when the entrance is closed.

Numerical modelling that was undertaken for the Manning River Estuary Management Study (*GTCC, 2001*) suggests that the 20 year recurrence flood level at Farquhar Inlet could be as high as 2.9 mAHD during closed entrance conditions. This level is approximately 1 metre above the 20 year recurrence level that is estimated for open entrance conditions (*GTCC, 1991*).

It is understood that the flood notch was excavated down to a level of about 1.5 to 1.6 mAHD prior to the mechanical entrance opening that was undertaken in April 2008. It is reported that survey data gathered in March 2008 shows that the level of the notch was in fact less than 1.0 mAHD. It is understood that community concerns regarding the condition of water quality at the inlet was the main “driver” behind over-excavation of the notch to a lower level than the adopted standard of 2.0 mAHD.

Tide gauge records for April 2008 show that flooding within the closed inlet reached a peak level of about 1.8 mAHD before the entrance was opened by Council. The corresponding peak levels recorded upstream at the Taree and Wingham gauges were about 2.0 and 7.8 mAHD, respectively.

Based on a linear extrapolation of the flood frequency analysis completed for the 1991 Flood Study (*GTCC*), it is estimated that the flood event of April 2008 had a recurrence frequency of about 2 years. This suggests that if a flood notch level just below 1.8 mAHD is adopted, it could be expected that the notch would be overtopped with a nominal depth of water once every 2 years on average (*assuming that the entrance is closed at the time of flooding*).

It is considered that mechanical opening of the entrance on a more frequent basis than this would be less worthwhile because the ponded floodwaters corresponding to a smaller event would not offer sufficient head to properly scour a lasting entrance. As discussed above, further works to prolong the entrance were undertaken within three to four months after excavation and scour of the entrance in April 2008.

It is recommended that Option 2 involve the periodic excavation of a 50 metre wide flood notch to an elevation of 1.6 mAHD. Excavation of the beach berm to open the entrance would be triggered when a flood level of 1.6 mAHD is reached at the Farquhar Inlet tide gauge. This would be expected to happen on average about once every two years, or slightly more frequently.

It is also recommended that monitoring be undertaken to confirm that this elevation is appropriate in terms of the expected frequency of overtopping and its effectiveness to provide sufficient scour of the entrance.

6.3.2 Impacts of Option 2

The implementation of Option 2 would have a similar impact on physical processes, water quality, environmental factors and recreational amenity as Option 1 (*existing flood notch protocols*).

However, it is expected that Option 2 would result in more frequent opening of the entrance, therefore increasing the potential for tidal flushing and the associate benefit to water quality. This may reduce the frequency and length of closures of the shellfish harvesting areas.

Notwithstanding, Option 2 would continue to rely on catchment flooding and the recent water quality issues may continue during extended periods with no significant rainfall events.

6.3.3 Cost of Implementation

- Approximately **$10,000** to excavate the flood notch down to a level 1.6 mAHD. This amount is similar to the existing cost of excavating the notch, as it also would not require more than two days of excavator operation. It is envisaged that the notch would need to be excavated on average once every three years (*refer* **Appendix E**).
- Up to **$2,500** to open the beach berm. This includes equipment mobilisation costs and one half day of excavator operation. For this option it is expected that the berm will require opening once every three years on average, which assumes that the entrance may occasionally be open already when a 2 year recurrence flood event occurs.

6.3.4 Monitoring Activities

It is recommended that the implementation of Option 2 include a monitoring program similar to that proposed for Option 1 (*i.e., involving up to three separate visits to the entrance at regular intervals following the opening to record the size and position of the entrance*).

The primary aim of the monitoring would be to assess the opening the entrance at a reduced flood level in terms of its effectiveness in creating and maintaining an entrance. Sediment inflow into the lower estuary would also be monitored.

It is estimated that the cost of such monitoring would be about **$9,000**, which allows two days for each site inspection. It is recommended that monitoring for Option 2 be undertaken once every three years on average.

6.4 OPTION 3 – DECISION MAKING FRAMEWORK FOR FLOOD NOTCH AND PILOT CHANNEL

Implementation of Option 3 would retain the floodplain management measure of periodically excavating a flood notch at Farquhar Inlet.

However, it also incorporates the development of a decision making framework that would be used to determine when excavation of an entrance is required during instances when flooding within the Manning River system is not the "trigger".

In this way, the decision to open the entrance would be based on both flooding criteria (*as per existing floodplain management protocols*) and also water quality considerations for Farquhar Inlet, which would be applied in conjunction with real-time hydrologic data for the catchment.

In other words, Option 3 also provides for mechanical opening of the entrance based on maintaining or achieving suitable water quality targets for Farquhar Inlet.

6.4.1 Water Quality Considerations and Triggers for Opening the Entrance

As discussed above, the level of salinity within Farquhar Inlet, Scotts Creek, South Channel and other areas within the lower estuary can affect the profitability of the shellfish industry. Shellfish harvest areas are closed following significant rainfall and only re-opened once water quality sampling shows that salinity and faecal contamination have returned to acceptable levels.

The water quality of Farquhar Inlet also impacts on the environmental and recreational value of the inlet. However, it is considered that the oyster industry is most sensitive to water quality conditions.

Accordingly, Option 3 incorporates a "trigger" (*or triggers*) for opening the entrance with the aim of maintaining or achieving the water quality characteristics required for oyster production and harvesting.

The available salinity and faecal coliform sample data (*refer* **Figures 8** *to* **13**) was interrogated against rainfall records and streamflow data to develop a suitable set of triggers that can be applied. The protocols outlined in the existing Harvest Area Management Plans for the Manning River shellfish harvest areas were also been considered (*refer* **Appendix C**).

Rainfall Triggers

The development of trigger values for entrance opening works has considered the following:

- The rainfall triggers outlined below are primarily based on daily read rainfall data from the Taree Airport Automatic Weather Station (*AWS*). Streamflow gauges are located further upstream in the Manning River catchment and may not account for local rainfall and runoff in the vicinity of Farquhar Inlet.
- Salinity was the primary and limiting parameter considered in the development of the rainfall triggers. The available water quality data showed that faecal coliform levels did not always respond to rainfall events.
- Rainfall triggers are to be based on weekly rainfall measurements (*i.e., total rainfall that has fallen during the 7 days prior to a given time*), rather than individual daily rainfall readings. Cumulative and continuing rainfall events are shown to have a significant impact on salinity and water quality conditions. High weekly rainfall could be responsible for the slow return to acceptable salinity levels that occurred during mid to late 2007.
- The water quality and rainfall data indicates that prolonged closures of the Manning River shellfish harvest areas are likely attributable to continuous high rainfall over a period of more than 1 to 2 weeks. Accordingly, development of rainfall triggers has considered a separate trigger for consecutive weekly rainfall readings over three weeks.
- In order for the triggers to respond directly to the needs of the shellfish industry, they should also consider the length of closure of the Manning River harvest areas at any one time. As discussed above, in recent times the Scotts Creek Harvest Area has been closed for up to 203 consecutive days, which had a significant impact on the shellfish industry (*refer* **Appendix D**).
- Opening of the entrance for the benefit of water quality should not occur more than two times in any one year, even if the documented triggers are exceeded on more occasions. This is considered a reasonable approach, in light of the benefit to water quality that two separate opening events in any one year would already have had.
- The triggers for entrance opening works are to be reviewed at a minimum every 5 years. Monitoring activities for Option 3 are to establish the effectiveness and duration of any triggered openings.

Rainfall triggers for entrance opening works could include the following:

(i) The occurrence of weekly rainfall measurements greater than 30 mm for a continuous period of 3 weeks (*21 days*) at the Taree Airport AWS.

As an example, this criterion could theoretically be met by three days of 30 mm rainfall, each occurring a week apart. As another example, it is likely that 6 separate days of 15 mm rainfall, each occurring 3 or 4 days apart, could also trigger the works.

(ii) The occurrence of a weekly rainfall measurement greater than 200 mm at the Taree Airport AWS, meaning that the cumulative rainfall over 7 days prior to any given time must be greater than 200 mm.

The Estuary and Coastline Management Committee (*ECMC*) have reviewed the above triggers and accept that there is a strong correlation between rainfall and salinity levels at Farquhar Inlet.

However, the Committee would be reluctant to adopt an entrance opening trigger based solely on rainfall data, particularly considering the potential for inconsistencies to arise in the interpretation of rainfall records.

Notwithstanding, the ECMC has established that closure of the Scotts Creek shellfish harvest area for more than 120 consecutive days should trigger mechanical opening of the entrance. This criterion is to be combined with the occurrence of a weekly rainfall reading at Taree Airport greater than 80 mm, so that the associated head differential between water levels in Farquhar Inlet and the ocean will facilitate scour of the entrance.

Salinity Trigger

The Committee is of the view that an entrance opening trigger contingent on salinity data provides a more direct indication of the state of water quality at Farquhar Inlet and its suitability for oyster production and harvesting. Salinity data is frequently gathered by local oyster farmers and Council staff have access to the associated testing equipment.

It is recommended that a salinity level of 12 ppt at Farquhar Inlet be adopted as a trigger for opening the entrance. In other words, opening works would be undertaken if salinity levels drop below 12 ppt.

Review of the available salinity data for Farquhar Inlet shows that during the period between 2003 and 2008 there were about 6 separate occasions where salinity fell below 12 ppt for a significant length of time (*refer* **Figure 8**), indicating that this threshold is likely to be breached about once every year on average.

Comparison of this salinity data with local rainfall measurements shows that a daily rainfall of between 50 and 100 mm is required to cause salinity levels to drop below 12 ppt, which is independent of whether the entrance is open or closed.

Comparison with the available tide gauge data indicates that this magnitude of storm will typically lead to river levels at Farquhar Inlet of between 1.0 and 1.2 mAHD. It is considered that the resultant head differential between the inlet level and ocean level will be sufficient to provide scour of the entrance following works to excavate the beach berm.

6.4.2 Flood Notch Elevation and Flood Level Trigger

As discussed above, Option 3 retains the practice of excavating the flood notch. The approximate location of the flood notch is shown in **Figure 15**.

Occurrence of the triggers outlined above may not necessarily coincide with flooding above the current notch level of 2.0 mAHD. Accordingly, it is recommended that Option 3 involve a flood notch with a reduced elevation of 1.0 mAHD. Lowering the notch to this elevation will help to maximise the potential for overtopping of the notch prior to any opening works being triggered by salinity levels or extended closure time of the Manning River shellfish harvest areas. The amount of excavation works required to connect the inlet to the ocean would obviously be increased if the water level in the inlet does not overtop the flood notch. Excavation of the notch should be undertaken as soon as possible following closure of the entrance.

Despite the reduced notch level and the reduced "build-up" of runoff within Farquhar Inlet prior to opening works, it is considered that the resultant differential in head between the inlet and ocean will provide sufficient scouring of the entrance.

Notwithstanding, it is recommended that any "triggered" opening works be undertaken during low tide conditions on the ocean side of the beach berm to maximise the scour potential.

Independent to the water quality triggers outlined above, it is recommended that the existing protocols for floodplain management be revised to trigger the opening works when a flood level of 1.6 mAHD is reached at the Farquhar Inlet tide gauge.

6.4.3 Summary of Entrance Opening Triggers

In summary, Option 3 will involve mechanical opening of the entrance when any of the following conditions are met:

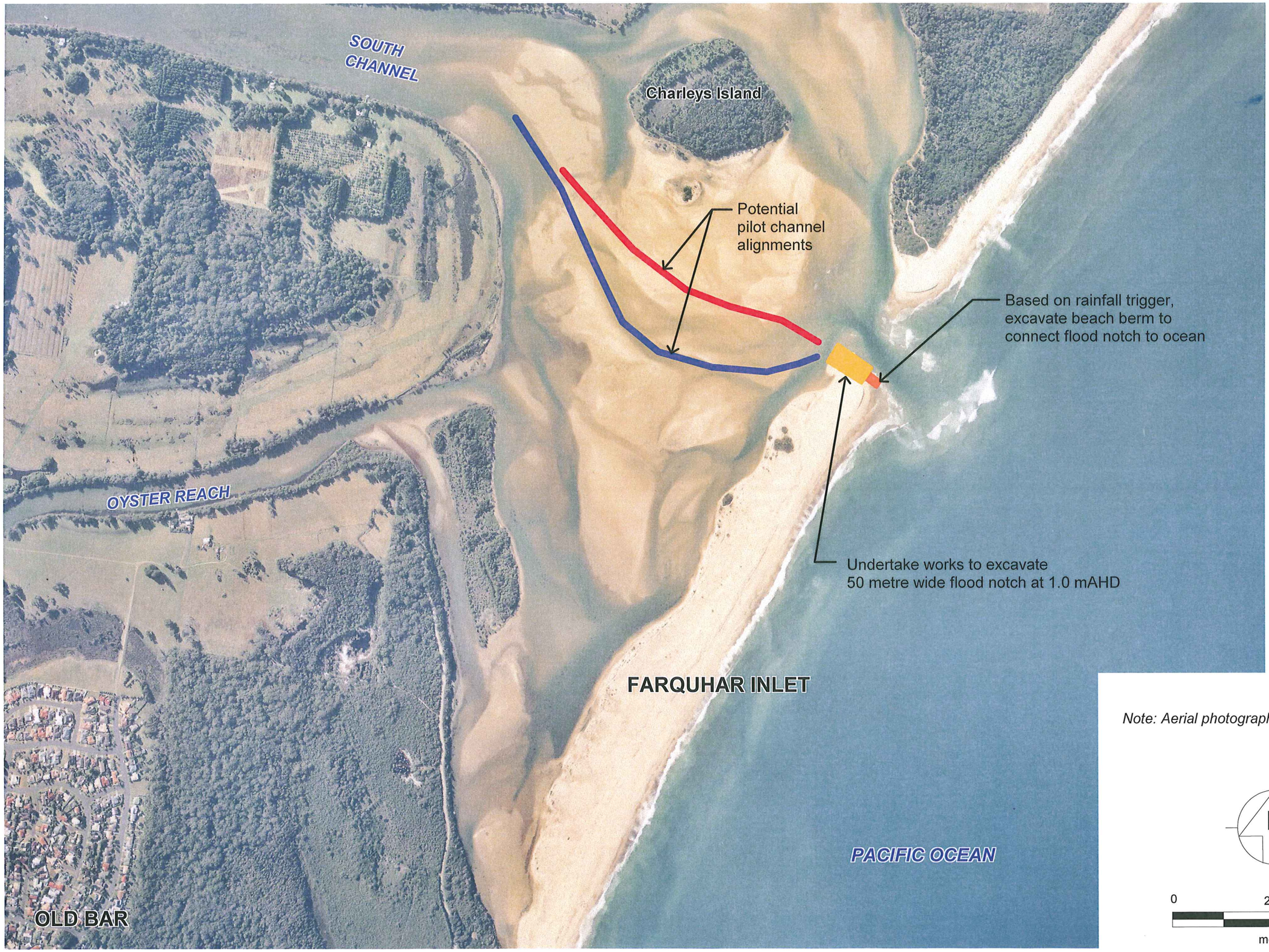
1) A flood level of 1.6 mAHD is reached at the Farquhar Inlet gauge.
2) Salinity levels at Farquhar Inlet fall to below 12 ppt.
3) Closure of the Scotts Creek shellfish harvest area for more than 120 consecutive days, combined with a weekly rainfall reading at Taree Airport greater than 80 mm.

6.4.4 Pilot Channel Excavation

As indicated in **Figure 14**, the existing flood notch protocols allow for the excavation of a notch at a location somewhere between the centre and northern limit of the inlet. This location is considered to offer the most direct path for the passage of floodwaters from South Channel to the ocean, thereby expediting a reduction in river flood levels.

It is recommended that this location be retained for the flood notch that is proposed as part of Option 3. The proximity of the entrance to both South Channel and Scotts Creek is expected

FIGURE 15



Note: Aerial photography taken in May 2008

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Figure 15 - Option 3.wor

OPTION 3 - DECISION MAKING FRAMEWORK FOR FLOOD NOTCH AND PILOT CHANNEL

to optimise the level of tidal exchange between the ocean and the lower estuary, thereby improving water quality conditions within the inlet as quickly as possible.

To increase the potential for the entrance to remain open for an extended period, it is recommended that a pilot channel be excavated through the inlet to facilitate flow between South Channel and the ocean. Two options for the alignment of the pilot channel are shown in **Figure 15**.

The length of the pilot channel would be between 800 and 1000 metres. The channel would be excavated with a width of 20 metres and depth of up to 1.5 metres. It is understood that a channel of this size would not be large enough to be classified as a navigable channel by NSW Maritime. However, navigation is not considered to be a direct objective for these excavation works.

It should be noted that the excavation of a pilot channel may not be required if outflow at the initial opening of the entrance is sufficient to scour and carry a majority of the sediment from the inlet out to sea. If this is the case, it may be more appropriate to excavate the pilot channel at a later stage, up to one month after the opening works.

6.4.5 Impact of Option 3 on Physical Processes

In addition to the considerations outlined above, opening the entrance according to *Triggers 2 and 3* may not result in the level of scour that might occur when the entrance is opened for floodplain management purposes. However, it is expected that the proposed pilot channel would assist entrance scour, if required.

There is also potential for opening the entrance in non-flood conditions to allow marine sediment to enter the excavated entrance and therefore create additional shoaling at the inlet and upstream along nearby channels. This would be of particular concern should the king tides at the end of the year coincide with periods of reduced rainfall across the upper catchment.

Notwithstanding, it is considered that inflowing sediment would block the entrance before large quantities of sand are able to enter and fill up the inlet. Further opening works would be undertaken when trigger conditions are next met.

Regular monitoring of sediment transport following any entrance opening works would form part of Option 3 (*refer below*).

6.4.6 Impact on Water Quality

Trigger 2 is considered to be the most appropriate for meeting the water quality objectives for the oyster industry and Farquhar Inlet in general. Periods of low salinity can result in extended closure times for the oyster harvest areas and therefore, opening the entrance during such times is expected to be most effective.

Due to its reliance on the number of consecutive days of harvest area closure, *Trigger 3* can be considered to be more specific in addressing concerns for the health of the shellfish industry. It effectively acts as a "fail-safe" measure to alleviate the impact of low salinity on the industry during extended periods of harvest area closure.

However, similar to *Trigger 2*, it also relies upon the occurrence of significant rainfall to optimise the potential for ponded runoff to scour the entrance after opening works are completed.

As discussed above, the Manning River shellfish harvest areas are closed when a 24 hour rainfall of more than 25 mm occurs at the Taree Airport weather station. Accordingly, it needs to be recognised that these triggers are not expected to be exceeded every time the harvest areas are closed.

6.4.7 Other Environmental Impacts

Should triggers require that entrance opening works be undertaken during the Little Tern breeding season (*November to January*), an assessment of the breeding activity and potential impact of works is to be completed prior to any commencement of works.

In all cases, the local National Parks and Wildlife Services ranger, the State Park ranger and the Little Tern Warden will need to be contacted prior to any works being undertaken to ensure that there is no shorebird breeding activity at the time, even outside of the typical breeding season.

6.4.8 Impact on Recreation

As discussed, there is potential for an increased frequency of entrance opening to result in the tidal scour of channels within the inlet, which would benefit local boat users. However, it should be recognised that the net inflow of marine sediments could result in additional shoaling upstream along adjacent channels, thereby reducing their navigability.

As discussed in **Section 5**, the location of the entrance can also impact on the recreational value of the beach to the north of Old Bar. Prolonged open conditions at the entrance would prohibit 4WD and pedestrian access to the inlet and the Mitchells Island recreation and camping area from the Old Bar side. Notwithstanding, access to the camping grounds will still be available from Manning Point via the beach on the north side of the entrance.

6.4.9 Cost of Implementation

- Approximately **$10,000** to excavate the flood notch to a level 1.0 mAHD. This amount is similar to the existing cost of excavating the notch, as it also would not require more than two days of excavator operation, despite the additional volume of excavation. It is envisaged that the notch would need to be excavated on average once every three years, which is subject to change according to the frequency and duration of openings (*refer* **Appendix E**).

- Up to **$2,500** to open the beach berm. This includes equipment mobilisation costs and one half day of excavator operation. For this option it is expected that the berm will require opening once every three years on average.
- Approximately **$50,000** to excavate a pilot channel to connect South Channel with the new entrance. This incorporates up to 10 days of excavator operation. It is assumed that excavation of a pilot channel would be required after each mechanical opening event.

6.4.10 Monitoring Activities

Similar to Option 2, the implementation of Option 3 should include monitoring of sediment transport out of and into the entrance after each manual opening event.

The monitoring results would be used to assess the effectiveness of opening the entrance according to the adopted triggers in terms of creating and maintaining an entrance.

It is estimated that the cost of such monitoring would be about **$9,000**, which allows two days for each of three site inspections. It is recommended that monitoring for Option 3 be undertaken once every three years on average (*i.e., following each opening event*).

6.5 OPTION 4 – DREDGING TO KEEP A CENTRAL ENTRANCE OPEN CONTINUOUSLY

Option 4 is shown graphically in **Figure 16**. It would involve:

- The establishment of a permanent but mobile "Mini-dredge" operation at the Manning River, which comprises a small barge dredge with a crew of 4 workers.
- Dredging of the entrance and a suitable pilot channel according to the position and alignment shown in **Figure 16** to establish a sizable entrance. It is envisaged that an excavator will also be required to open the beach berm between the pilot channel and the ocean.
- Utilisation of a booster pump on the dredge to convey dredged material a distance of up to 3 kilometres, potentially for beach nourishment work at Old Bar Beach or other locations within the estuary. The suitability of the dredged sediment for nourishment works would need to be confirmed through additional investigations. The dredge has a flow rate capacity of up to 3,500 m^3/day at 35% density, which is equivalent to a sediment removal rate of about 1,225 m^3/day.
- The use of dredged material to also create sand islands on either side of the pilot channel.
- Yearly maintenance dredging to keep entrance open and remove shoals.

It is envisaged that the dredge would be available for other dredging projects within the estuary, thereby spreading the cost with other projects. A total of 23 potential dredging sites

FIGURE 16

Note: Aerial photography taken in May 2008

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metres

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Figure 16 - Option 4.wor

OPTION 4 - DREDGING TO KEEP CENTRAL ENTRANCE OPEN CONTINOUSLY

from Wingham to the coast have been identified and prioritised as part of a draft Dredging Strategy for the estuary. However, travel between these sites will have to be via "smooth water" routes along Manning River tributaries, as the dredge is not an ocean-going vessel.

6.5.1 Impact of Option 4 on Physical Processes

As discussed above, it has been suggested that the entrance opening works and further works during 2008 lead to the removal of up to 200,000 m^3 of sand from the inlet (*pers comm. Department of Lands*). However, much of the sediment would have been scoured out of the inlet during flood conditions that prevailed at the time of the initial opening works.

Dredging as part of Option 4 would not typically be undertaken during minor flood conditions; the functionality and safety of the dredge could be compromised if this was the case. Accordingly, there is reduced potential for sediment scour to be assisted by floodwater outflows.

The proposed dredging operation would remove up to 30,000 m^3 of sediment in the first year, based on a pilot channel length of 1,000 metres, a width of 30 metres and up to 1 metre depth.

Based on a daily removal rate of 1,225 m^3/day and allowing for 10 days of additional maintenance dredging, it is estimated that about 35 days of dredge operation would be required in the first year. If spare capacity should become available, then the dredge could be moved and used for projects elsewhere within the estuary.

Due to the natural inflow of marine sediment into the inlet when the entrance is open, it is recommended that continued maintenance dredging of up to 25 days per year be undertaken during following years. This would help to ensure that the entrance would remain open continuously. There would also be scope to use the dredge at other locations within the estuary.

Pumping of dredged material to Old Bar Beach may prove beneficial in addressing the existing coastal erosion issues. However, it could also impact on natural sediment transport systems and coastal processes in the vicinity of Old Bar and the inlet.

Further investigations would be required to assess the impact of beach nourishment works in greater detail. WorleyParsons is currently completing a Coastal Hazard Management Plan for Old Bar and adjacent sections of coastline. The findings from the final report should be considered as part of any proposed measures to move the dredged material into the coastal zone at any location.

6.5.2 Impact on Water Quality

According to the results of previous numerical modelling of estuarine hydrodynamics, dredging to maintain a permanent entrance at Farquhar Inlet will significantly decrease the

flushing time for the inlet, South Channel and Scotts Creek (*GTCC, 2001*). This is expected to improve water quality conditions within the inlet and benefit the local oyster industry.

If a permanent entrance can be maintained and the associated benefit to water quality verified, there is perhaps scope for the NSW Food Authority to relax its rainfall triggers for closure of the Manning River harvest areas.

In other words, closure may not be required so frequently and readily at the onset of rainfall, because the lower estuary would now have better capacity to deal with the inflow of freshwater.

Even if this cannot be achieved, the effect of the increased estuarine flushing would be a reduction in closure days and rapid "bounce-back" from fresh or contaminated conditions.

6.5.3 Other Environmental Impacts

There is potential for dredging operations to impact on the following:

- Aquatic flora and fauna at within the inlet, in terms of physical removal of habitat and increased level of suspended sediment.
- Little Tern breeding grounds, both in terms of habitat area and disruption due to noise and sediment suspension. Contact must be made with NPWS, the State Park ranger and the Little Tern Warden prior to the commencement of any dredging works.

Notwithstanding, it should be noted that the creation of islands with dredged material would provide additional breeding sites for these birds. Other shorebirds could also be affected, including the Pied Oyster Catcher, the Beach Stone Curlew and other waders.

Due to the scale of the proposed dredging works and the potential for disruption to the inlet, it is recommended that an Environmental Impact Statement (*EIS*) be prepared for Option 4.

6.5.4 Impact on Recreation

A permanent entrance at the inlet will prohibit 4WD and pedestrian access to the inlet and the Mitchells Island recreation and camping area from the Old Bar side. However, access to the camping grounds would still be available from Manning Point via the beach on the north side of the entrance.

There is potential for a permanent entrance to result in the tidal scour of channels within the inlet, which would benefit local boat users. However, the net inflow of marine sediments could result in additional shoaling upstream along adjacent channels, thereby reducing their navigability. Accordingly, it is recommended that regular maintenance dredging be undertaken to remove any shoals.

6.5.5 Cost of Implementation

- Mobilisation costs of approximately **$44,000** (*excluding GST*), including the use of a crane to lift and install the dredge at the inlet.
- 35 days of operation during the first year for upfront work and maintenance dredging at Farquhar Inlet is estimated to cost approximately **$292,000** (*excluding GST*).
- 25 days of operation per year during subsequent years for inlet and entrance maintenance purposes would cost at least **$233,000** (*excluding GST*).
- This cost estimates includes (*refer* **Appendix E**):
  - ⇒ accommodation and meals for a 4 person labour force for the dredge
  - ⇒ up to 5% downtime, to account for unfavourable weather and other environmental constraints.
  - ⇒ movement of the dredge to Farquhar Inlet on three occasions per year for up to 2 days travelling each time (*although it does not allow for dredging on additional projects*).
  - ⇒ booster pump and piping required to move and deposit material up to 3 kilometres from the dredging location, to be used for 50% of the total operation time.

6.5.6 Monitoring Activities

Option 4 will require monitoring of sediment transport on at least a yearly basis and will naturally form part of the process in selecting areas for regular maintenance dredging.

Similar to Options 2 and 3, it is estimated that the cost of such monitoring would be about **$9,000**, which allows for a total of 6 days of site inspections to take photographs and notes and measurements using surveying equipment (*refer* **Appendix E**).

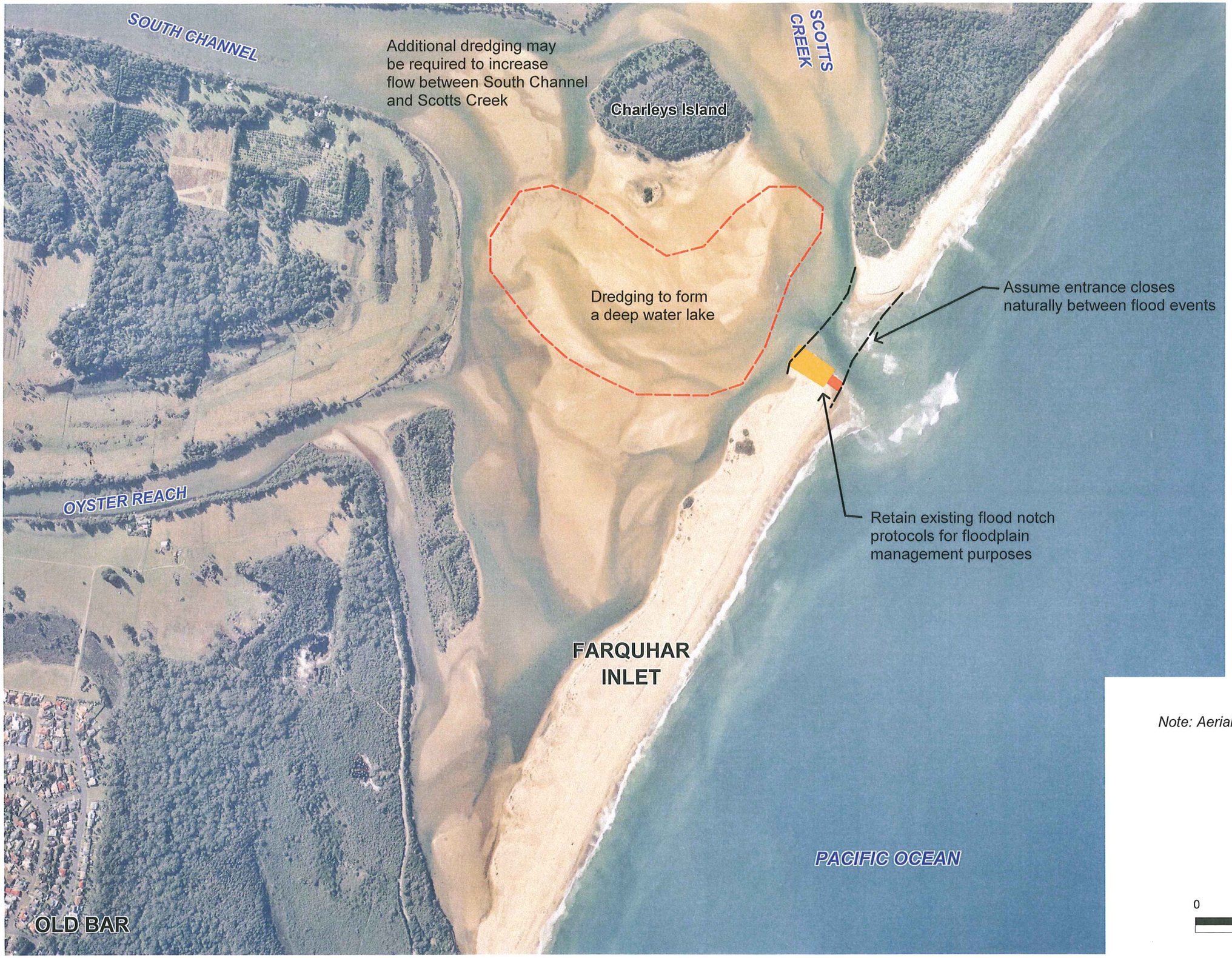
6.6 OPTION 5 – DREDGING TO FORM A LAKE BEHIND THE BEACH BERM

Option 5 is similar to Option 4 in that it would involve the use of a “Mini-dredge” system to undertake dredging at Farquhar Inlet.

However, Option 5 would not incorporate any dredging works to open the entrance, the main rationale being that inflow of sediment into the inlet during the normal tidal cycle would not be expected to occur if the entrance remained in a closed state. Option 5 is shown in **Figure 17**.

Further to this, anecdotal reports suggested that, prior to mechanical opening works that were undertaken during the 1950s, the condition of the closed inlet reflected a deep water lake (*Bill Birrell, 2008*). The “lake” had significant recreational value and water quality was not a major issue or concern amongst the local community at that time. It has been

FIGURE 17



Note: Aerial photography taken in May 2008

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metres

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Figure 17 - Option 5.wor

OPTION 5 - DREDGING TO FORM A LAKE BEHIND THE CLOSED BEACH BERM

suggested that mechanical opening the entrance can disturb the natural balance of tidal flows through the lower estuary.

Contradictory to these anecdotal reports, the available aerial photography for 1940 shows that much of the inlet was shoaled at this time and it is difficult to discern this deep water "lake".

Notwithstanding this, Option 5 would involve the dredging of a lake at Farquhar Inlet, which would require the removal of up to 200,000 m^3 of sand. This equates to at least 160 days of dredge operation.

It is envisaged that the dredged material could be transferred to beach nourishment activities at Old Bar Beach or simply pumped to the ocean side of the beach berm.

6.6.1 Impact of Option 5 on Physical Processes

Proponents for this option consider that a permanent opening at Farquhar Inlet will effectively divide the Manning River tidal flows between the two entrances, leading to reduced scour of the existing entrance at Harrington. There is potential for subsequent siltation of the entrance to occur, which may reduce the navigability of the channel and bar at Harrington. In this way, Option 5 could be effective in maintaining appropriate tidal flows through the river entrance at Harrington.

However, as discussed above, the numerical modelling completed in 2001 (*GTCC*) shows that entrance conditions at Farquhar Inlet are not expected to have a significant impact on tidal flows at Harrington.

At this stage, dredging for Option 5 would be a "one-off" exercise to clear the inlet. In other words, it is not expected that any significant ongoing dredging would be required, primarily because of the absence of sediment inflow from the ocean.

However, it should be recognised that the inlet may need to be opened during flooding of the Manning River. Significant sediment inflow could occur following such an event and additional maintenance dredging may be required in the future. It is assumed that if continued access to the "Mini-dredge" is needed, this can be arranged as part of sharing the dredge between other projects across the estuary.

It should also be noted that the existing flood notch protocols outlined in Option 1 would be retained for this option, to ensure that forming the deep water lake does not have impact on flood behaviour at upstream locations.

6.6.2 Impact on Water Quality

Numerical modelling suggests that long flushing times would not be reduced for Farquhar Inlet if the entrance remains in a closed state (*GTCC, 2001*), despite dredging of the inlet

behind the beach berm. This indicates that water quality objectives described above would not be achieved through the implementation of Option 5.

In order to improve the flushing potential through South Channel and Scotts Creek, additional dredging may be required along these channels to increase their hydraulic capacity and facilitate increased flushing through the lower estuary to Farquhar Inlet. This has been incorporated into the costs outlined below.

6.6.3 Other Environmental Impacts

As discussed, there is potential for dredging operations to impact on the following:

- Aquatic flora and fauna at within the inlet, in terms of physical removal of habitat and increased level of suspended sediment.
- Little Tern breeding grounds, both in terms of a reduction in habitat area and disruption due to noise and sediment suspension. Contact must be made with NPWS, the State Park ranger and the Little Tern Warden prior to the commencement of any dredging works.

  Other shorebirds could also be affected, including the Pied Oyster Catcher, the Beach Stone Curlew and other waders.

Similar to the dredging activities outlined in Option 4, it is recommended that an Environmental Impact Statement (*EIS*) be prepared for Option 5.

6.6.4 Impact on Recreation

The lack of an entrance at the inlet will enable pedestrians and vehicles to access the Mitchells Island recreation and camping area from the Old Bar side.

The impact of Option 5 on the navigability of channels in the vicinity of the inlet is difficult to predict. Further monitoring would be required to assess the impact on shoaling and sediment movement within these channels.

6.6.5 Cost of Implementation

- Mobilisation costs of approximately **$44,000** (*excluding GST*), including the use of a crane to lift and install the dredge at the inlet.
- 160 days of dredge operation is estimated to cost approximately **$1.06M** (*excluding GST*).
- The ongoing cost for any additional maintenance dredging works could be up to **$110,000** per year, based on 10 days of operation per year.
- This cost estimate includes:

  ⇒ accommodation and meals for 4 person labour force

⇒ up to 5% downtime, to account for unfavourable weather and other environmental constraints.

⇒ movement of the dredge to Farquhar Inlet on three occasions per year for up to 2 days travelling each time (*although it does not include additional dredging project costs*).

⇒ booster pump and piping required to move and deposit material up to 3 kilometres from the dredging location, to be used for 50% of the total operation time.

For floodplain management purposes, the costs associated with preparation and operation of the flood notch will continue to apply under Option 5:

- Approximately **$10,000** to excavate the flood notch to a level of 2.0 mAHD, once every three years on average.
- Up to **$2,500** to open beach berm.

6.6.6 Monitoring Activities

Option 5 will require monitoring of sediment transport on at least a yearly basis, which will naturally form part of the process in selecting areas for regular maintenance dredging. Although it is not expected that the entrance will be open for extended periods of time, there is potential for sand movement and shoaling to occur within channels immediately upstream from the inlet, following any opening works for flood management.

Similar to previous options, it is estimated that the cost of such monitoring would be about **$9,000** per year, which allows for 6 days of site investigations.

6.7 OPTION 6 – DREDGING TO FORM AN ENTRANCE AT THE SOUTHERN LIMIT OF FARQUHAR INLET

The results of previous hydrodynamic modelling and associated sediment transport for Farquhar Inlet suggest that an entrance established near the southern limit of the inlet may result in less sediment transport into the inlet during normal tidal flow conditions (*GTCC, 2001*), when compared with an entrance in a central or northern location.

Accordingly, the option to dredge an entrance at the southern limit of the inlet has been investigated. Similar to Options 4 and 5, this option would involve the use of a “Mini-dredge” to dredge material from within the inlet and potentially transfer it to Old Bar Beach or other locations for nourishment activities.

Option 6 has been divided into the following sub-options (*refer* **Figures 18**, **19** *and* **20**):

6A - Dredging works to create and maintain an entrance along the existing "soft rocks" at the southern edge of Farquhar Inlet, north from Old Bar.

6B - 6A combined with construction of a sub-surface training wall and breakwater using geofabric containers. This will require the installation of 10 geofabric "Mega Containers", each with dimensions 25 m (L) x 6 m (W) x 2 m (H).

6C - 6A combined with construction of training walls and breakwaters using a combination of geofabric containers and rock armour. This will require the installation of 10 geofabric "Mega Containers" and a 250 metre length of rock armour training wall and breakwater. The rock training wall and breakwater would have the following dimensions:

- ⇒ 15 metre base width
- ⇒ 3 metre crest width
- ⇒ Height of 3 metres
- ⇒ Side slopes of about 1(V) in 2(H).

It is envisaged that all three options could take advantage of a small existing reef located just offshore from the beach at the southern end of the inlet (*refer* **Figure 18**). There is potential for this rock reef to offer a degree of shelter to the entrance from wave action and marine sediments moving along the coast. The reef could also be used as a base or anchor for breakwater works that are proposed for Options 6B and 6C (*refer* **Figures 19** *and* **20**).

6.7.1 Impact on Physical Processes

As discussed, establishing an entrance along the southern edge of the inlet may result in less sediment transport into the inlet when compared with entrance locations in the centre of the inlet or at the northern limit.

The numerical modelling previously undertaken for the inlet also shows that marine sediment entering through a southern entrance is less likely to propagate as far north as Scotts Creek or South Channel (*GTCC, 2001*).

It is likely that Options 6A, 6B and 6C would also benefit from the existing "soft rock" along the southern boundary of the inlet. These rocks would offer a natural training wall along the southern edge of the channel and sediment scour may be increased adjacent to the rocks, helping to maintain the channel for longer.

The training walls and breakwaters proposed as part of Options 6B and 6C may have the following impacts on physical processes:

- Restriction of entrance movement.
- Increased sediment scour along the base of the entrance channel.

FIGURE 18

Note: Aerial photography taken in May 2008

N

0 250 500

metres

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Figure 18 - Option 6A.wor

OPTION 6A - DREDGING TO FORM A SOUTHERN ENTRANCE

FIGURE 19

Note: Aerial photography taken in May 2008

N

0 250 500

metres

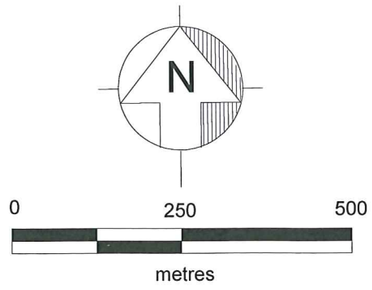
WorleyParsons
resources & energy

Figure 19 - Option 6B.wor

OPTION 6B - SOUTHERN ENTRANCE WITH GEOFABRIC CONTAINER TRAINING WALL AND BREAKWATER

FIGURE 20

Note: Aerial photography taken in May 2008



WorleyParsons
resources & energy

Figure 20 - Option 6C.wor

OPTION 6C - SOUTHERN ENTRANCE WITH GEOFABRIC CONTAINER AND ROCK ARMOUR TRAINING WALLS AND BREAKWATERS

- Impediment to sediment transport along the coast, potentially causing a build-up of sand behind any breakwater sections that protrude from the coastline.

It is recommended that additional investigations, preferably involving detailed 2D modelling, be undertaken to assess the impact of the training walls and breakwaters on sediment transport processes. The modelling could also be used to assess the impact of the works on flood behaviour.

6.7.2 Impact on Water Quality

As discussed above for Option 4, dredging to maintain a permanent entrance at Farquhar Inlet will significantly decrease the flushing time for the inlet, South Channel and Scotts Creek. This is expected to improve water quality conditions within the inlet and benefit local shellfish production.

6.7.3 Other Environmental Impacts

As discussed above in Options 4 and 5, there is potential for dredging operations to impact on the following:

- Aquatic flora and fauna at within the inlet, in terms of physical removal of habitat and increased level of suspended sediment.
- Little Tern breeding grounds, both in terms of habitat area and disruption due to noise and sediment suspension. Contact must be made with NPWS, the State Park ranger and the Little Tern Warden prior to the commencement of any entrance works.

  NPWS has indicated support for an entrance at the southern limit of the inlet, as the channel would form a barrier to foxes coming from Old Bar.

The small section of saltmarsh that has recently been identified will need to be considered as part of any proposal for an entrance near the southern limit of the inlet. It is envisaged that this would involve further assessment to firstly confirm the presence, extent and condition of the vegetation and then if required, determine the potential impact of dredging on the saltmarsh community.

Construction of training walls and breakwaters involving geofabric containers or rock armour could cause significant environmental disruption at the inlet, particularly during installation due to the movement of machinery.

Accordingly, it is recommended that an Environmental Impact Statement (*EIS*) be prepared as part of further investigation of any such measures. A Review of Environmental Factors (*REF*) is considered appropriate for the implementation of Option 6A (*dredging only*).

6.7.4 Impact on Recreation

As discussed in **Section 5**, the location of the entrance can impact on the recreational value of the beach to the north of Old Bar. A permanent entrance located near the southern limit of Farquhar Inlet has the potential to prohibit access to the inlet and the Mitchells Island recreation and camping area from the Old Bar side. Recreational walkers, swimmers, fishermen and 4WDs may be affected in this way.

The Department of Lands has identified that there is also a need to consider the public risks associated with pedestrian access to any hard structural measures such as that proposed as part of Options 6B and 6C.

As discussed above, there is potential for a permanent entrance to result in the tidal scour of channels within the inlet, which would benefit local boat users. However, the net inflow of marine sediments could result in additional shoaling upstream along adjacent channels, thereby reducing their navigability. Accordingly, it is recommended that regular maintenance dredging be undertaken to remove any shoals.

6.7.5 Cost of Implementation

It was determined that Option 6A would require a similar quantity of initial dredging works to that proposed for Option 4. Accordingly, the cost of dredging works would be as follows (*refer* **Appendix E**):

- Mobilisation costs of approximately **$44,000** (*excluding GST*), including the use of a crane to lift and install the dredge at the inlet.
- 35 days of operation during the first year, primarily comprising work at Farquhar Inlet, is estimated to cost approximately **$292,000** (*excluding GST*).
- Option 6A is likely to require continued maintenance dredging, but at a cost less than that required for Option 4, due to the natural scour that would occur along the existing soft-rocks (*about **$192,000** per year*).

It is assumed that initial dredging required as part of Options 6B and 6C would only require 25 days of dredge operation, due to the increased potential for entrance scour associated with the proposed training works and breakwaters. This is expected to cost approximately **$254,000** plus GST, which includes an allowance for equipment mobilisation.

Despite the sediment scour provided along the training wall, it is envisaged that some ongoing maintenance dredging would be required due to the net inflow of marine sediment. This would involve up to 15 days of dredge operation at a cost of about **$150,000** per year for Option 6B and 10 days at a cost of **$110,000** per year for Option 6C.

The cost to install geofabric containers for construction of the training wall and breakwater sections for Option 6B will also include:

- **$360,000** (*excluding GST*) for supply, delivery and installation of 10 (*ten*) geofabric "Mega Containers", assuming that the available dredging equipment can be readily used to fill the containers with sediment.
- Maintenance costs of **$20,000** per year, to account for inspection and repairs to the structure.

Costs to install the geofabric containers and rock for the construction of the training wall and breakwater sections for Option 6C will also include:

- **$360,000** (*excluding GST*) for supply, delivery and installation of 10 (*ten*) geofabric "Mega Containers", again assuming that the available dredging equipment can be readily used to fill the containers with sediment.
- **$2.2M** (*excluding GST*) for supply and installation of rock to construct 250 metres of training wall and breakwater.
- Maintenance cost of **$55,000** per year, to account for repairs to the structures.

6.7.6 Monitoring Activities

Options 6A, 6B and 6C will require monitoring of sediment transport on a yearly basis and will naturally form part of the process in selecting areas for regular maintenance dredging.

It is estimated that the cost of such monitoring would be about **$9,000**, which allows for 6 days of site inspections to take photographs and notes and measurements using surveying equipment (*refer* **Appendix E**).

6.8 OPTION 7 – PERMANENT ENTRANCE INCORPORATING ROCK TRAINING WALLS AND BREAKWATERS

Option 7 involves the use of rock and rock armour to construct training walls and breakwaters on the either side of a southern entrance (*refer* **Figure 21**). In other words, Option 7 can be considered to represent a "fully trained" entrance.

The proposed training walls and breakwater sections would each extend for a length of up to 500 metres along a southern entrance channel. They would be constructed with similar cross-section dimensions to that described for Option 6C. This size of structure is considered to be of medium scale.

6.8.1 Impacts of Option 7

Similar to Options 6A, 6B and 6C, Option 7 also takes advantage of the existing "soft rock" wall and small rock reef at the southern end of Farquhar Inlet as a base for the training wall and breakwater works.

FIGURE 21

Note: Aerial photography taken in May 2008

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Figure 21 - Option 7.wor

OPTION 7 - PERMANENT ENTRANCE INCORPORATING ROCK ARMOUR TRAINING WALLS AND BREAKWATERS

The impacts of Option 7 on physical processes, water quality, the environment and recreation are expected to be similar to those outlined above for Option 6. However, the scale of works associated with Option 7 would be even greater, indicating that the potential impact of the works on the local environment and the hydrodynamics of the entire lower estuary could be significant.

Accordingly, it is recommended that a detailed Environmental Impact Statement be prepared during further design of any such measures. It is also recommended that the additional investigations include detailed 2D modelling of estuary hydrodynamics and flood behaviour.

It should be noted that Option 7 would not involve training walls that extend the entire length of the inlet to South Channel; the costs associated with such a wall would be prohibitive. As a result, there would be no guarantee that the northern wall would be effective in maintaining a channel along the southern edge of the inlet. The "break-out" of floodwaters to the north of the entrance could create a second and possibly third entrance, effectively isolating the north section of wall as an island.

It is recommended that the potential for this to occur be investigated as part of any further modelling investigations.

Construction of rock walls and breakwaters will need to consider the public risks associated with pedestrian access, in addition to navigation issues for a permanent entrance.

6.8.2 Cost of Implementation

The cost to construct training walls and breakwaters using rock and rock armour has been determined according to the following:

- Approximately **$7.1M** (*excluding GST*) for supply and installation of rock to construct a total of 750 metres of training wall and breakwater and 200 metres of training wall against the existing "soft rocks".
- **$250,000** for excavation works for footings and to create a channel between the rock walls.
- Maintenance cost of **$100,000** per year, to account for inspections and repairs to the structures.

6.9 COMPARISON OF ENTRANCE MANAGEMENT OPTIONS

A summary of the costs associated with each entrance management option is provided in **Table 1**, including both upfront costs and the total expected costs over a 30 year design life. The latter incorporates additional items such as maintenance and monitoring costs. Refer to **Appendix E** for a breakdown of costs for each option.

TABLE 1 SUMMARY OF COST ESTIMATES FOR ENTRANCE MANAGEMENT OPTIONS

OPTION	COST ESTIMATES (*exclusive of GST, including 20% contingencies*)	
	UPFRONT (*1st year*)	30 YEAR DESIGN LIFE
1 Existing flood notch	$25,800 *	$203,000
2 Flood notch with reduced elevation	$25,800 *	$258,000
3 Decision making framework for flood notch and pilot channel	$86,000 *^	$858,000
4 Dredging to keep a central entrance open continuously	$487,000	$8.9M
5 Dredging to form a lake behind the closed beach berm	$1.4M*	$5.7M
6A Dredging to form an entrance at the southern limit of Farquhar Inlet	$487,000	$7.5M
6B Dredging to form an entrance at the southern limit of Farquhar Inlet with geofabric container training wall and breakwater	$878,000	$7.2M
6C Dredging to form an entrance at the southern limit of Farquhar Inlet with geofabric container and rock training walls and breakwaters	$3.6M	$9.7M
7 Permanent entrance incorporating rock training walls and breakwaters	$9.1M	$12.9M

Notes:
** Includes allowance to open entrance in case of flood / trigger*
^Allows for pilot channel excavation

As shown, Options 1, 2 and 3 are expected to cost significantly less than Options 4 through 7, both in terms of upfront capital cost and ongoing maintenance costs.

The relatively high design life costs associated with Options 4 through 6C are largely attributable to the requirement for regular maintenance dredging to keep the entrance open to the ocean. The design life costs for these options could be significantly reduced if it is found that ongoing dredging is not required or can occur at a reduced frequency.

The benefits and impacts of each entrance management option, as documented above, have been considered in conjunction with the cost estimates provided in **Table 1**.

This information has been combined and tabulated in the assessment matrix presented in **Table 2** so that a comparative assessment of the options can be made.

TABLE 2 ASSESSMENT MATRIX FOR ENTRANCE MANAGEMENT OPTIONS

CRITERIA / ISSUE	OPTION SCORES								
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6A	Option 6B	Option 6C	Option 7
Environmental									
Impact on coastal processes	5	5	5	5	5	5	4	3	2
Impact on water quality at Farquhar Inlet	3	4	7	9	4	8	8	8	8
Effectiveness to address flooding problems	8	8	8	9	8	8	8	8	8
Impact on aquatic flora / fauna	9	9	7	3	3	4	3	3	3
Social									
Community attitude	4	5	6	6	6	7	7	6	6
Recreation / access	6	6	7	5	8	4	4	5	5
Economic									
Cost, incorporating upfront and design life cost	10	10	9	3	5	4	4	2	0
Benefit to shellfish industry, fishing, tourism	3	3	7	8	5	8	7	7	8
TOTAL SCORE	48	50	56	48	44	48	45	42	40

Notes:

- *Options have been scored on a scale of 0 to 10, with 10 the highest score. Options with positive benefits are scored from 5 to 10. Options with negative impacts are scored from 0 to 5. A score of 5 is considered to have a neutral benefit or be non- applicable or undetermined.*
- *Scores are derived from options assessment and consultation with Council and the Estuary and Coastline Management Committee.*

The impact on coastal processes, as scored in **Table 2**, considers the potential disruption to natural sediment movement along the coast (*breakwater options*). There are also potential benefits associated with the use of any dredged material for beach nourishment works at Old Bar Beach. However, these have not been considered in this assessment as it is considered that management of the entrance should be treated as a separate issue.

As shown in **Table 2**, Option 3 (*decision making framework for flood notch and pilot channel*) received the highest score. It is the only option that received a positive/neutral score for every assessment criteria.

Option 7 (*fully trained entrance*) received the lowest overall score, which is primarily a reflection of the large costs that would be involved and the potential for breakwaters to impact on the environment and coastal processes.

Options 4, 6A and 6B also scored relatively well, indicating that dredging the inlet (*with or without some minor entrance training works*) could also be effective. However, the initial and ongoing costs involved may prove to be a prohibitive factor.

If these options are pursued further, it is recommended that the benefit in sharing the dredge with other projects within the lower estuary be investigated. Further investigation of environmental impacts would also be required, including 2D modelling of estuarine hydrodynamics and sediment transport.

It should be noted that the assessment matrix contained in **Table 2** does not incorporate any difference in weighting for each assessment criteria. If this was the case, it is likely that cost of implementation would get increased weighting, which would further decrease the relative scores for Options 4 through 7.

7. RECOMMENDATIONS

Based on the outcomes of investigations and the assessment documented in the above report, it is recommended that Option 3 be implemented as an immediate measure to improve water quality conditions at Farquhar Inlet.

This option involves adopting the triggers outlined in **Section 6.4** for opening the entrance when critical water quality and flooding conditions occur. Analysis of existing water quality, rainfall and flood level data suggests that this option would be effective in opening the entrance at times when it is necessary to take steps to improve water quality and thereby assist the existing shellfish industry in the lower Manning River estuary.

It is recommended that the impact of any entrance opening works be assessed by way of monitoring the movement of sediment following each opening and also by collating data from the oyster industry regarding future closures of the harvest areas and the profitability of the industry with the management plan in place.

It is also recommended that Options 4, 6A and 6B (*involving dredging of the inlet*) be investigated further in the development of a longer-term solution for the inlet.

In this regard, it is understood that the Farquhar Inlet Management Group (*FIMG*) has recently purchased a dredge for the lower Manning River. The dredge is undergoing refurbishment and is expected to be ready for use shortly.

A Review of Environmental Factors (*REF*) is currently being prepared to assess the impact of dredging works at Farquhar Inlet; likewise for additional dredging projects on the lower Manning River at Cowans, Mudbishops and the Rowing Course.

It is understood that concerns previously raised regarding the potential safety risks of a community operated dredge have been addressed and an agreement has been reached between the Department of Lands and Greater Taree City Council regarding its operation. A hire agreement with a local earthmoving contractor has also been established. The necessary insurances have been obtained and a dredging expert with 40 years experience has been engaged to assist with supervision of the dredging projects. Maintenance of the dredge will be funded partly by the FIMG and Council using existing funding.

At this stage, it is envisaged that the dredge will be used to undertake any channel excavation works associated with Option 3, once the entrance opening triggers have been met. In this regard, the FIMG have suggested that a Sub-Committee of the ECMC be formed to monitor conditions at the entrance and instigate the opening works when required. The Sub-Committee would include engineering staff from Council, the Minor Ports Manager for the Manning River, and representatives from the oyster farming community and the FIMG.

Additional studies will be required to assess the impact of any further dredging works involved with establishing a more permanent entrance (*i.e., Options 4, 6A and 6B*). A detailed analysis of the benefit versus cost for dredging as a longer-term structural option should also be undertaken. It is envisaged that this would involve the compilation of recent harvest data from the local shellfish industry and catch data from fishing and prawning industries.

Although a comparative assessment of Option 5 (*deepwater lake behind a closed berm*) has been included as part of this study, based on the review of available information and the results of numerical modelling for the estuary (*GTCC, 2001*), it is recommended that Option 5 should not be pursued further.

8. IMPLEMENTATION

An implementation schedule for the Farquhar Inlet Entrance Opening Management Plan is provided in **Table 3**, overleaf.

As shown, it is recommended that a community education program be developed and implemented to outline the immediate measures that will be undertaken to manage the inlet, and the direction of future investigations towards a longer-term solution.

Greater Taree City Council will hold primary responsibility for implementing the Plan. However, the Land and Property Management Authority (*LPMA*) would need to be consulted as the landowner for any proposed works over Crown Lands. It is understood that Council may also apply to LPMA for financial assistance under the Waterway Program for maintenance dredging for navigation purposes.

TABLE 3 FARQUHAR INLET ENTRANCE OPENING MANAGEMENT PLAN - IMPLEMENTATION SCHEDULE

ITEM	RECOMMENDED STRATEGY	ACTIONS	ESTIMATED COST	SUGGESTED RESPONSIBILITY	PROJECTED DATE FOR COMMENCEMENT
1	Adopt triggers for entrance opening works as per Option 3: 1. A flood level of 1.6 mAHD is reached at the Farquhar Inlet gauge 2. Salinity levels at Farquhar Inlet fall to below 12 ppt 3. Closure of the Scotts Creek shellfish harvest area for more than 120 consecutive days, combined with a weekly rainfall reading at Taree Airport greater than 80 mm	1. Update exsiting Review of Environmental Factors (REF) for previous opening works to incorporate requirements for Option 3 works, including pilot channel excavation. 2. If entrance in closed condition, excavate flood notch to elevation of 1.0 mAHD. 3. Excavate beach berm when one or combination of triggers are met. 4. Monitor sediment transport into and out of entrance following each mechanical opening event. 5. Oyster Farmers Association to monitor and report to Council the state of the shellfish industry and harvest area opening periods to assess effectiveness of adopted option. 6. Review adopted triggers every 5 years, based on findings of monitoring activities.	$80,000 (*incorporating allowance for pilot channel excavation*)	Greater Taree City Council / Farquhar Inlet Management Group (consult with LPMA)	2010
2	Develop and implement a community education program	1. Prepare a community information brochure to outline the works that will be implemented as part of Option 3. Incorporate graphics and rationale behind chosen option, as appropriate. 2. Distribute brochure to residents at Old Bar and areas in the vicinity of Farquhar Inlet. 3. Upload digital PDF version of brochure onto Council's website so that public can access. 4. Convene a public meeting or drop-in centre to present the findings of the Entrance Opening Management Plan.	$10,000	Greater Taree City Council / Farquhar Inlet Management Group	2010
3	Investigate dredging options for Farquhar Inlet, including Options 4, 6A and 6B. Implement works subject to approvals and funding.	1. Undertake a detailed benefit cost analysis, incorporating cost of dredge purchase/operation (and additional construction works), data from the shellfish, fishing, prawning and tourism industries and the potential to undertake projects elsewhere on the Manning River. 2. If benefit cost analysis shows that options are feasible, undertake investigations to prepare an Review of Environmental Factors or Environmental Impact Statement for the proposed works. 3. Subject to outcomes of REF/EIS, obtain funding for works. 4. Implement chosen works.	$0.5M + *(initial cost for works*)	Farquhar Inlet Management Group with guidance from Council and Estuary and Coastline Management Committee	2011 onwards

* Construction cost estimates are based on WorleyParsons' experience and judgement as a firm of practising professional engineers familiar with the construction industry.
Construction cost estimates can NOT be guaranteed as we have no control over Contractor's prices, market forces and competitive bids from tenderers.
Construction cost estimates may exclude items which should be considered in a cost plan. Examples of such items are design fees, project management fees, authority approval fees, contractors risk and project contingencies (*e.g. to account for construction and site conditions, weather conditions, ground conditions and unknown services*).
Construction cost estimates by WorleyParsons are not to be relied upon. If a reliable cost estimate is required, then an appropriately qualified Quantity Surveyor should be engaged.

9. REFERENCES

- Birrell, B (*2008*), *'Time to Repair River'*; article in opinion section of local newspaper.
- Chow VT (*1959*), *'Open Channel Hydraulics'*; McGraw Hill Book Company, Inc.; Reissued 1988; ISBN 07 010776 9.
- Greater Taree City Council (*1991*), *'Manning River Flood Study – Volume 1*'.
- Greater Taree City Council (*1996*), *'Manning River Floodplain Management Study – Volume 1 (in draft)*'.
- Greater Taree City Council (*2001*), *'Manning River Estuary Management Study – Numerical Modelling*', prepared by WBM Oceanics Australia.
- Greater Taree City Council (*in draft 2008*), *'Old Bar Hazard Definition Study'*, prepared by WorleyParsons.
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- Greater Taree City Council (*2009*), *'Manning River Estuary Management Plan*', prepared by WorleyParsons.
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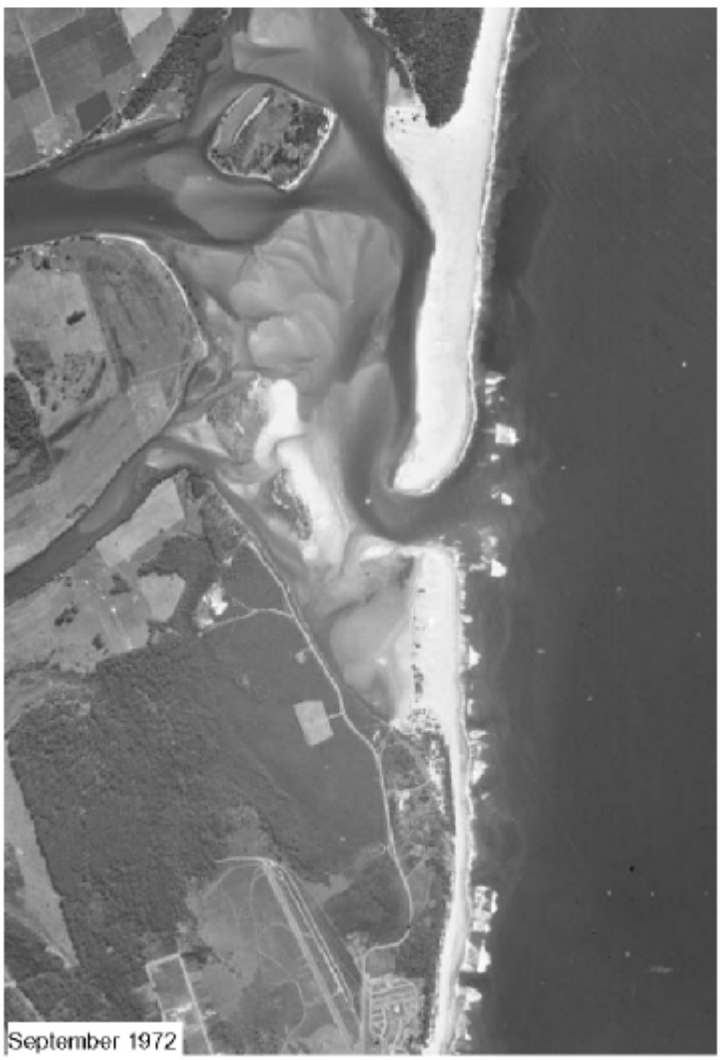
- Manly Hydraulics Laboratory (*2009*), *Tide Data for Farquhar Gauge (208415), Harrington Gauge, Croki Gauge, Dumaresq Gauge, Taree Gauge (208410), Wingham Gauge; January 2000 – January 2009*.
- New South Wales Food Authority (*2007*), *'Addendum to the Sanitary Survey Reports for Mangrove Island, Mitchells Island, Luthrie Island, and South Channel Harvest Areas'*; NSW Shellfish Program.
- New South Wales Department of Lands (*2008*), *'Manning River Entrance at Farquhar Inlet, Old Bard; Emergency Works to Reopen the Entrance – Review of Environmental Factors'*; prepared by Crown Lands Division – Minor Ports Unit.
- New South Wales Government (*2005*), *'Floodplain Development Manual: the management of flood liable land'*; ISBN 07313 03709.

Appendix A – HISTORIC AERIAL PHOTOGRAPHY (*1940 to 2006*)

December 1940

January 1965

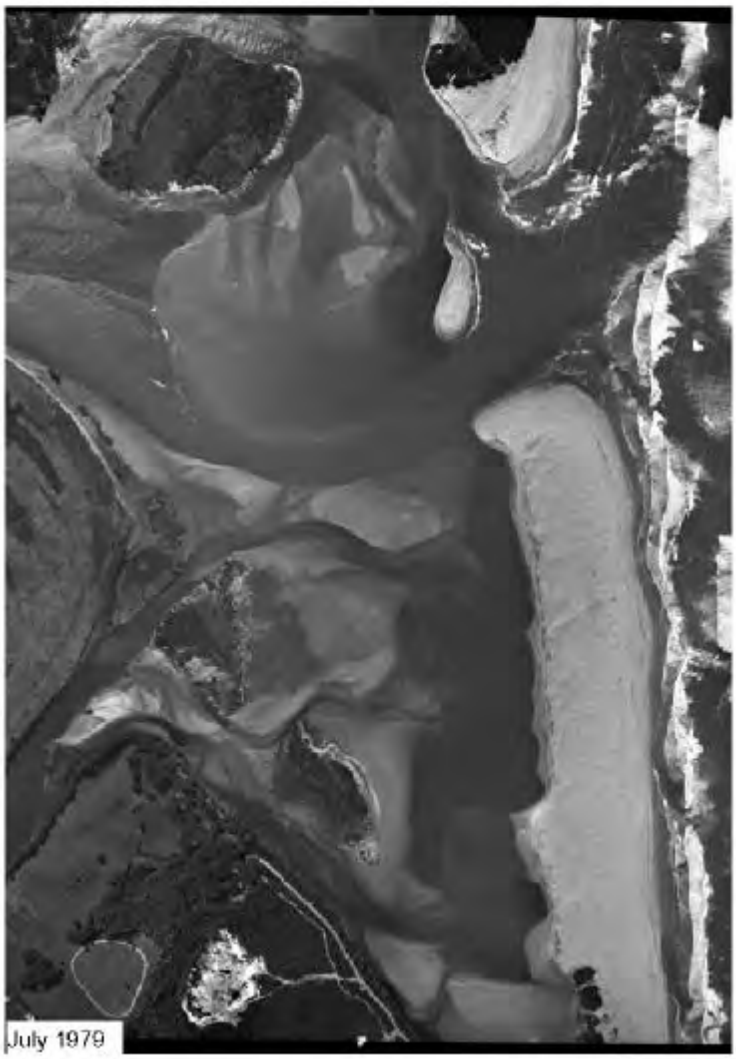
May 1970



September 1972

March 1974

December 1976



July 1979

November 1979

September 1980

June 1981

August 1983

April 1986

August 1986

November 1986

June 1989

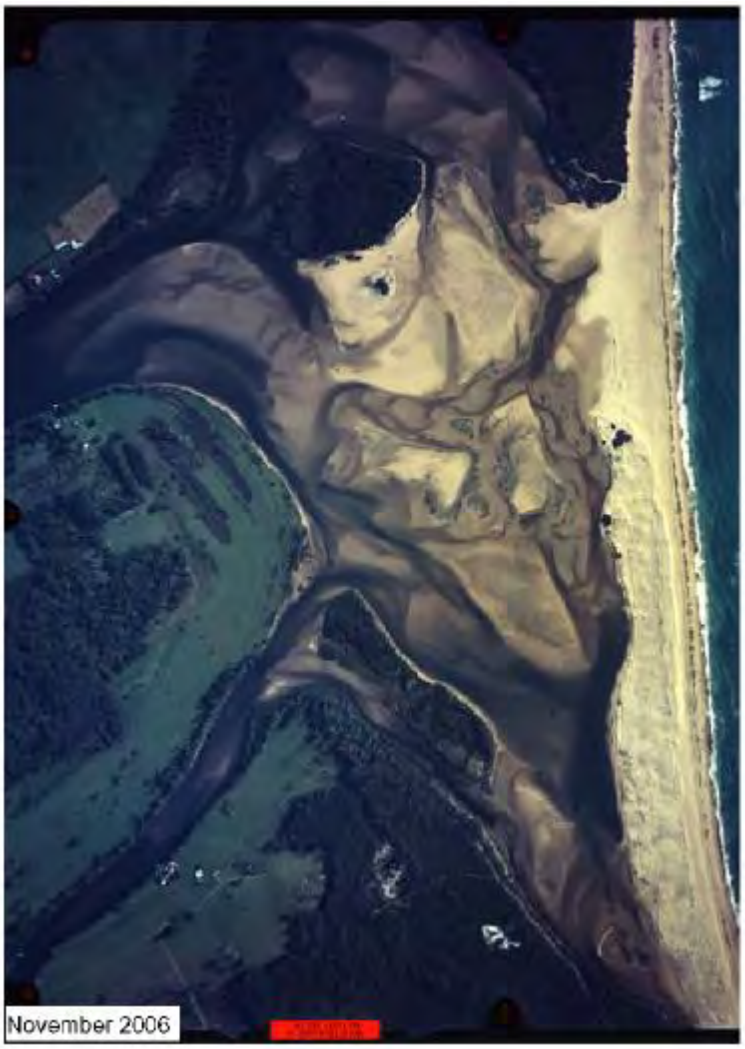
June 1993

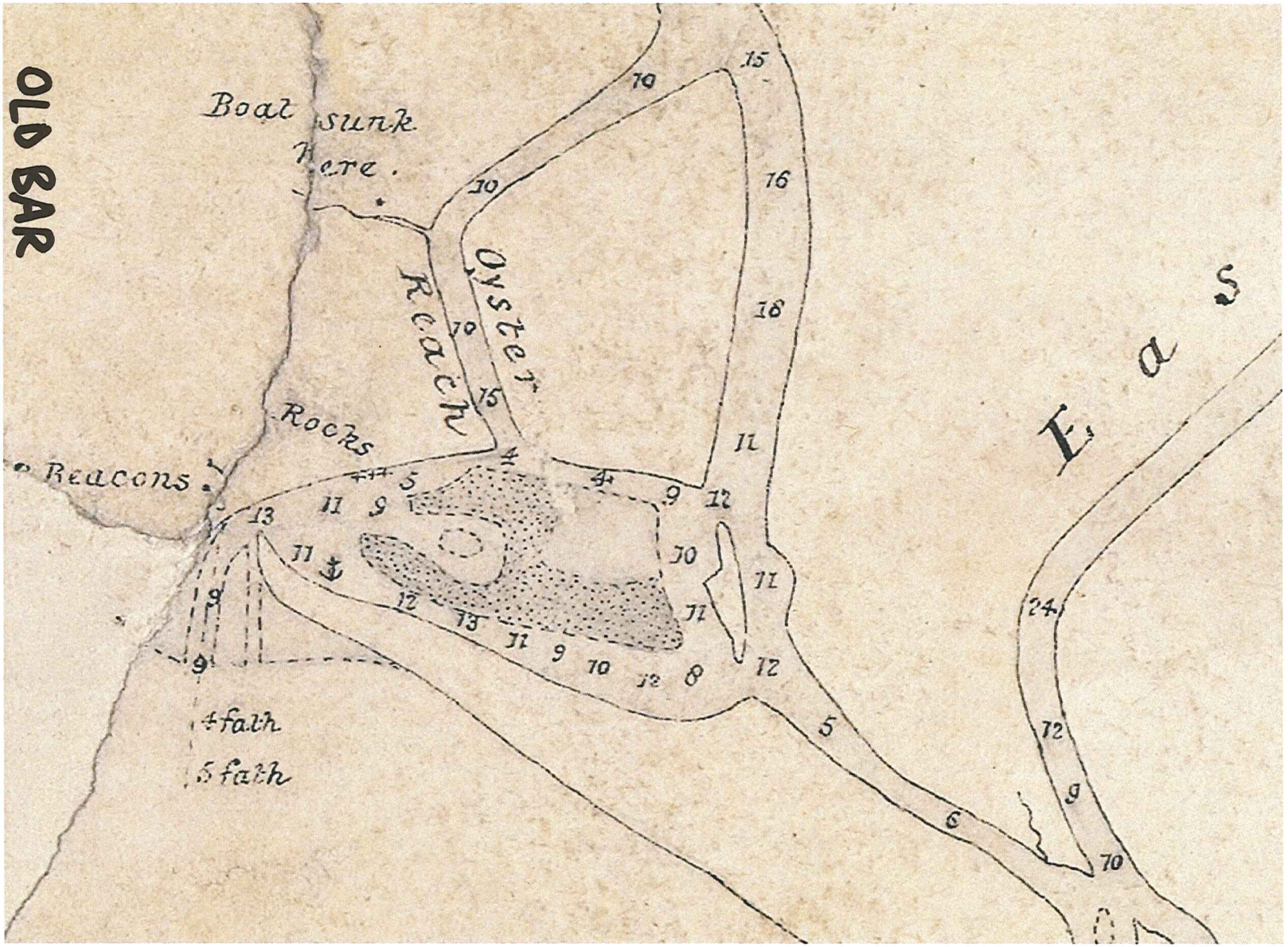

May 1996


Feburary 1997


May 2000

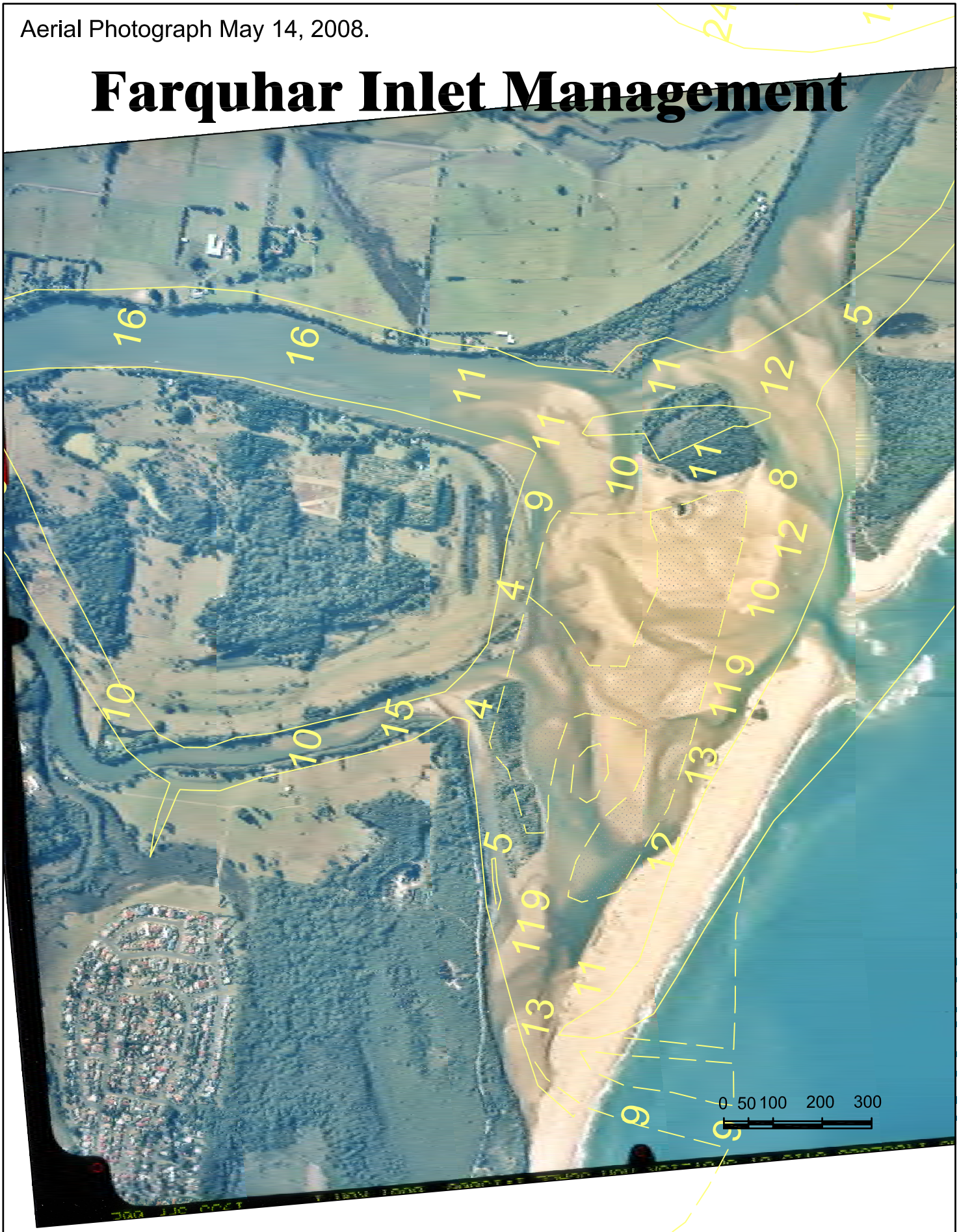

July 2004


November 2006


OLD BAR
Boat sunk here.
Oyster Reach
Rocks
Beacons
4 fath
5 fath
Las
N

Aerial Photograph May 14, 2008.

Farquhar Inlet Management



Overlay of Aerial Photograph taken May 2008
with a tracing of map of Boat Survey of Manning River 1827
by John Armstrong for AA Company
Soundings are in feet most likely below low tide. Note 10' = 3m

Appendix B – SHELLFISH HARVEST AREAS (*Extracted from NSW FA, 2007*)

Map 1A: Manning River Harvest Areas

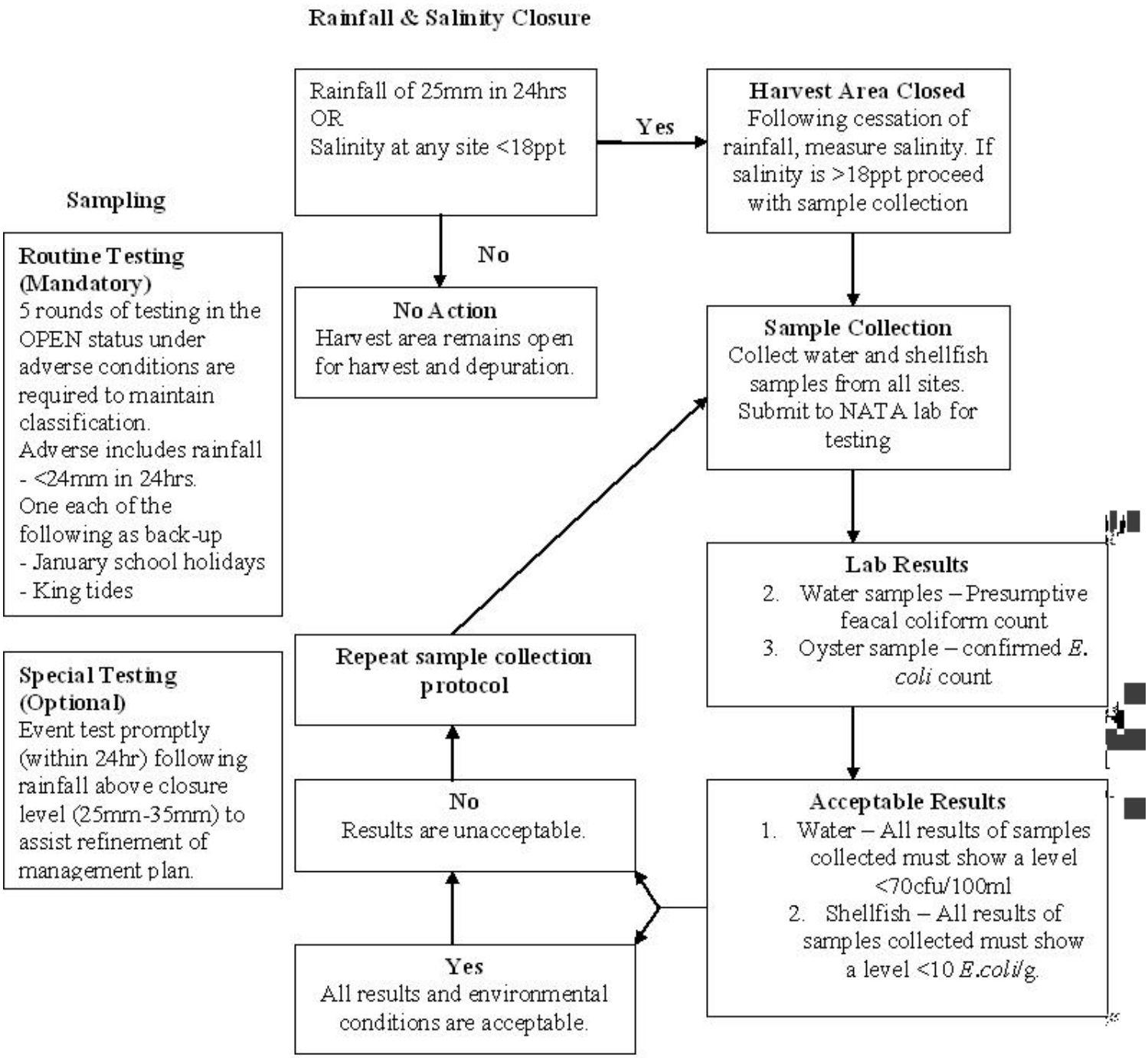
Appendix C – HARVEST AREA MANAGEMENT PLANS FOR SCOTTS CREEK AND SOUTH CHANNEL

Scotts Creek Harvest Area

(Conditionally Restricted)

Manning River

Operation Under Rainfall Conditions



Notes:

1. Rainfall is measured at the **Taree Airport** or **Old Bar** and reported by the Bureau of Meteorology.
2. Formal Closure and re-opening of harvest areas is the responsibility of the NSW Food Authority
3. NSW Food Authority will enforce closures of the harvest area
4. It is the responsibility of each farmer to ensure the area is open prior to harvest
5. Salinity is to be measured on the ebbing tide at least 3 hours after high tide
6. Required water sites are **14** and **15**
7. Required shellfish sites are **33** and **34**
8. The NSW SP staff and local coordinator will liase regarding environmental conditions and sampling arrangements.

South Channel Harvest Area

(Conditionally Restricted)

Manning River

Emergency Management Plan

NOT FOR HARVEST

Rainfall & Salinity Closure

Rainfall of 25mm in 24hrs
OR
Salinity at any site <18ppt

Yes

Harvest Area Theoretically Closed
No samples to be taken during a closure

No

No Action
Harvest area remains open for sample collection only.
No Harvest

Theoretical Re-opening
Sampling closure will be lifted when the salinity returns to 20ppt and 3 weeks have passed since the rainfall event

Harvest area re-open for sample collection
No Harvest

Sampling

Routine Testing (Mandatory)
2 rounds of testing when area would be theoretically OPEN are required to maintain classification.
Adverse includes rainfall
- <24mm in 24hrs.
- Salinity drop to 25-19ppt.

Emergency Management Plan – Not For Harvest

Used to maintain data during times when Farquhar Inlet is closed

Notes:

1. Rainfall is measured at the **Taree Airport** or **Old Bar** and reported by the Bureau of Meteorology.
2. Formal Closure and re-opening of harvest areas is the responsibility of the NSW Food Authority
3. NSW Food Authority will enforce closures of the harvest area
4. It is the responsibility of each farmer to ensure the area is open prior to harvest
5. Salinity is to be measured on the ebbing tide at least 3 hours after high tide (suggest site **23** first)
6. Required water sites are **16**, **17**, **18**, **19**, **20**, **21**, **22**, **23** and **24**
7. **Optional** shellfish sites are **35**, **36**, **37** and **38**.
8. **Algae and biotoxin tests are optional**
9. The NSW SP staff and local coordinator will liase regarding environmental conditions and sampling arrangements.

Appendix D – ZONE STATUS HISTORY FOR MANNING RIVER SHELLFISH HARVEST AREAS

NSW Food Authority
NSW Shellfish Program

PO Box 6682
Silverwater NSW 1811

Ph: 02 9741 4735

Zone status history
(From 10/09/2007 To 10/03/2009)

Program name: Manning River SP
Zone name: Mangrove Island

Reference	Start date and time	End date and time	Duration (days)	Status
05385	27 Sep 2007 3:30 PM	09 Nov 2007 9:30 AM	43	Open
Reasons/Conditions				
27/09/2007 3:30:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
05467	09 Nov 2007 9:30 AM	30 May 2008 1:40 PM	203	Closed
Reasons/Conditions				
9/11/2007 9:30:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06054	30 May 2008 1:40 PM	04 Jun 2008 6:00 AM	5	Open
Reasons/Conditions				
30/05/2008 1:40:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06085	04 Jun 2008 6:00 AM	09 Jul 2008 3:00 PM	35	Closed
Reasons/Conditions				
4/06/2008 6:00:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06142	09 Jul 2008 3:00 PM	29 Jul 2008 12:01 AM	20	Open
Reasons/Conditions				
9/07/2008 3:00:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06173	29 Jul 2008 12:01 AM	15 Aug 2008 1:25 PM	17	Closed
Reasons/Conditions				
29/07/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06210	15 Aug 2008 1:25 PM	04 Sep 2008 12:01 AM	20	Open
Reasons/Conditions				
15/08/2008 1:25:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06231	04 Sep 2008 12:01 AM	30 Sep 2008 2:00 PM	26	Closed

Zone status history
(From 10/09/2007 To 10/03/2009)

Reasons/Conditions				
4/09/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06320	30 Sep 2008 2:00 PM	17 Oct 2008 1:00 PM	17	Open
Reasons/Conditions				
30/09/2008 2:00:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06331	17 Oct 2008 1:00 PM	23 Oct 2008 3:30 PM	6	Closed
Reasons/Conditions				
17/10/2008 1:00:00PM	Closed due to microbiological results of shellfish exceeding the maximum acceptable limit of this program.			
06342	23 Oct 2008 3:30 PM	19 Nov 2008 12:01 AM	27	Open
Reasons/Conditions				
23/10/2008 3:30:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06390	19 Nov 2008 12:01 AM	21 Nov 2008 3:30 PM	2	Closed
Reasons/Conditions				
19/11/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06391	21 Nov 2008 3:30 PM	29 Nov 2008 12:01 AM	8	Open
Reasons/Conditions				
21/11/2008 3:30:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06413	29 Nov 2008 12:01 AM	06 Jan 2009 3:00 PM	38	Closed
Reasons/Conditions				
29/11/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06474	06 Jan 2009 3:00 PM	14 Feb 2009 9:00 AM	39	Open
Reasons/Conditions				
6/01/2009 3:00:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			

Current Status

Reference	Open/Closure Date and Time	Status
06552	14/02/2009 9:00:00AM	Closed

Reasons/Conditions

14/02/2009 9:00:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.

Zone name: Mitchells Island

Reference	Start date and time	End date and time	Duration (days)	Status

Zone status history
(**From** 10/09/2007 To 10/03/2009)

05386	27 Sep 2007 3:30 PM	09 Nov 2007 9:30 AM	43	Open
Reasons/Conditions				
27/09/2007 3:30:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
05468	09 Nov 2007 9:30 AM	14 Mar 2008 9:00 AM	126	Closed
Reasons/Conditions				
9/11/2007 9:30:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
05926	14 Mar 2008 9:00 AM	08 Apr 2008 9:00 AM	25	Open
Reasons/Conditions				
14/03/2008 9:00:00AM	Zone is open for depuration only.			
05927	08 Apr 2008 9:00 AM	18 Apr 2008 2:30 PM	10	Closed
Reasons/Conditions				
8/04/2008 9:00:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
05965	18 Apr 2008 2:30 PM	20 Apr 2008 10:00 AM	2	Open
Reasons/Conditions				
18/04/2008 2:30:00PM	Zone is open for depuration only.			
05970	20 Apr 2008 10:00 AM	30 May 2008 1:40 PM	40	Closed
Reasons/Conditions				
20/04/2008 10:00:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06055	30 May 2008 1:40 PM	04 Jun 2008 6:00 AM	5	Open
Reasons/Conditions				
30/05/2008 1:40:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06086	04 Jun 2008 6:00 AM	15 Aug 2008 1:25 PM	72	Closed
Reasons/Conditions				
4/06/2008 6:00:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06211	15 Aug 2008 1:25 PM	04 Sep 2008 12:01 AM	20	Open
Reasons/Conditions				
15/08/2008 1:25:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06232	04 Sep 2008 12:01 AM	30 Sep 2008 2:00 PM	26	Closed
Reasons/Conditions				
4/09/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			

Zone status history
(From 10/09/2007 To 10/03/2009)

06321	30 Sep 2008 2:00 PM	17 Oct 2008 1:00 PM	17	Open
Reasons/Conditions				
30/09/2008 2:00:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06332	17 Oct 2008 1:00 PM	23 Oct 2008 3:30 PM	6	Closed
Reasons/Conditions				
17/10/2008 1:00:00PM	Closed due to microbiological results of shellfish exceeding the maximum acceptable limit of this program.			
06343	23 Oct 2008 3:30 PM	19 Nov 2008 12:01 AM	27	Open
Reasons/Conditions				
23/10/2008 3:30:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06374	19 Nov 2008 12:01 AM	26 Nov 2008 2:45 PM	7	Closed
Reasons/Conditions				
19/11/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06406	26 Nov 2008 2:45 PM	29 Nov 2008 12:01 AM	3	Open
Reasons/Conditions				
26/11/2008 2:45:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06414	29 Nov 2008 12:01 AM	06 Jan 2009 3:00 PM	38	Closed
Reasons/Conditions				
29/11/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06475	06 Jan 2009 3:00 PM	14 Feb 2009 9:00 AM	39	Open
Reasons/Conditions				
6/01/2009 3:00:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			

Current Status

Reference	Open/Closure Date and Time	Status
06550	14/02/2009 9:00:00AM	Closed

Reasons/Conditions

14/02/2009 9:00:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.

Zone name: Pelican Point

Reference	Start date and time	End date and time	Duration (days)	Status
05384	25 Sep 2007 2:45 PM	09 Nov 2007 9:30 AM	45	Open
Reasons/Conditions				

Zone status history
(From 10/09/2007 To 10/03/2009)

25/09/2007 2:45:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
05466	09 Nov 2007 9:30 AM	14 Mar 2008 3:30 PM	126	Closed
Reasons/Conditions				
9/11/2007 9:30:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
05907	14 Mar 2008 3:30 PM	08 Apr 2008 9:00 AM	25	Open
Reasons/Conditions				
14/03/2008 3:30:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
05925	08 Apr 2008 9:00 AM	18 Apr 2008 2:30 PM	10	Closed
Reasons/Conditions				
8/04/2008 9:00:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
05964	18 Apr 2008 2:30 PM	20 Apr 2008 10:00 AM	2	Open
Reasons/Conditions				
18/04/2008 2:30:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
05969	20 Apr 2008 10:00 AM	19 May 2008 9:30 AM	29	Closed
Reasons/Conditions				
20/04/2008 10:00:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06049	19 May 2008 9:30 AM	04 Jun 2008 6:00 AM	16	Open
Reasons/Conditions				
19/05/2008 9:30:00AM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06084	04 Jun 2008 6:00 AM	09 Jul 2008 3:00 PM	35	Closed
Reasons/Conditions				
4/06/2008 6:00:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06141	09 Jul 2008 3:00 PM	29 Jul 2008 12:01 AM	20	Open
Reasons/Conditions				
9/07/2008 3:00:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06172	29 Jul 2008 12:01 AM	08 Aug 2008 1:50 PM	10	Closed
Reasons/Conditions				
29/07/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06200	08 Aug 2008 1:50 PM	04 Sep 2008 12:01 AM	27	Open
Reasons/Conditions				

Zone status history
(**From** 10/09/2007 To 10/03/2009)

8/08/2008 1:50:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06230	04 Sep 2008 12:01 AM	26 Sep 2008 2:20 PM	22	Closed
Reasons/Conditions				
4/09/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06317	26 Sep 2008 2:20 PM	17 Oct 2008 1:00 PM	21	Open
Reasons/Conditions				
26/09/2008 2:20:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06330	17 Oct 2008 1:00 PM	28 Oct 2008 4:30 PM	11	Closed
Reasons/Conditions				
17/10/2008 1:00:00PM	Closed due to microbiological results of shellfish exceeding the maximum acceptable limit of this program.			
06353	28 Oct 2008 4:30 PM	19 Nov 2008 12:01 AM	22	Open
Reasons/Conditions				
28/10/2008 4:30:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06372	19 Nov 2008 12:01 AM	26 Nov 2008 2:45 PM	7	Closed
Reasons/Conditions				
19/11/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06405	26 Nov 2008 2:45 PM	29 Nov 2008 12:01 AM	3	Open
Reasons/Conditions				
26/11/2008 2:45:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06412	29 Nov 2008 12:01 AM	19 Dec 2008 10:30 AM	20	Closed
Reasons/Conditions				
29/11/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06460	19 Dec 2008 10:30 AM	14 Feb 2009 9:00 AM	57	Open
Reasons/Conditions				
19/12/2008 10:30:00AM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			

Zone status history
(From 10/09/2007 To 10/03/2009)

Current Status

Reference	Open/Closure Date and Time	Status
06553	14/02/2009 9:00:00AM	Closed

Reasons/Conditions

14/02/2009 9:00:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.

Zone name: Scotts Creek

Reference	Start date and time	End date and time	Duration (days)	Status
05400	11 Oct 2007 1:20 PM	09 Nov 2007 9:30 AM	29	Open
Reasons/Conditions				
11/10/2007 1:20:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
05469	09 Nov 2007 9:30 AM	30 May 2008 1:40 PM	203	Closed
Reasons/Conditions				
9/11/2007 9:30:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06056	30 May 2008 1:40 PM	04 Jun 2008 6:00 AM	5	Open
Reasons/Conditions				
30/05/2008 1:40:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06087	04 Jun 2008 6:00 AM	09 Jul 2008 3:00 PM	35	Closed
Reasons/Conditions				
4/06/2008 6:00:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06143	09 Jul 2008 3:00 PM	29 Jul 2008 12:01 AM	20	Open
Reasons/Conditions				
9/07/2008 3:00:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06174	29 Jul 2008 12:01 AM	15 Aug 2008 1:25 PM	17	Closed
Reasons/Conditions				
29/07/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06212	15 Aug 2008 1:25 PM	04 Sep 2008 12:01 AM	20	Open
Reasons/Conditions				
15/08/2008 1:25:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06233	04 Sep 2008 12:01 AM	30 Sep 2008 2:00 PM	26	Closed
Reasons/Conditions				

Zone status history
(From 10/09/2007 To 10/03/2009)

4/09/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06322	30 Sep 2008 2:00 PM	17 Oct 2008 1:00 PM	17	Open
Reasons/Conditions				
30/09/2008 2:00:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06333	17 Oct 2008 1:00 PM	23 Oct 2008 3:30 PM	6	Closed
Reasons/Conditions				
17/10/2008 1:00:00PM	Closed due to microbiological results of shellfish exceeding the maximum acceptable limit of this program.			
06344	23 Oct 2008 3:30 PM	19 Nov 2008 12:01 AM	27	Open
Reasons/Conditions				
23/10/2008 3:30:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06375	19 Nov 2008 12:01 AM	21 Nov 2008 3:30 PM	2	Closed
Reasons/Conditions				
19/11/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06392	21 Nov 2008 3:30 PM	29 Nov 2008 12:01 AM	8	Open
Reasons/Conditions				
21/11/2008 3:30:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			
06415	29 Nov 2008 12:01 AM	06 Jan 2009 3:00 PM	38	Closed
Reasons/Conditions				
29/11/2008 12:01:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.			
06476	06 Jan 2009 3:00 PM	14 Feb 2009 9:00 AM	39	Open
Reasons/Conditions				
6/01/2009 3:00:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.			

Current Status

Reference	Open/Closure Date and Time	Status
06549	14/02/2009 9:00:00AM	Closed

Reasons/Conditions

14/02/2009 9:00:00AM	Closed due to rainfall exceeding the trigger level in the harvest area management plan.

Zone name: Zone A - Manning River

Reference	Start date and time	End date and time	Duration (days)	Status

Zone status history
(**From** 10/09/2007 To 10/03/2009)

5,380	25 Sep 2007 2:45 PM	27 Sep 2007 3:30 PM	2	Open

Reasons/Conditions

25/09/2007 2:45:00PM	Zone is open for harvest and depuration as prescribed in the harvest area management plan.

Current Status

Reference	Open/Closure Date and Time	Status
05834	27/09/2007 3:30:00PM	Closed

Reasons/Conditions

27/09/2007 3:30:00PM	Closed due to the implementation of Harvest area classification.

Zone status history
(**From** 10/09/2007 To 10/03/2009)

Total number of closures resulting from specific reasons

Reason	Number of closures
Closed due to microbiological results of shellfish exceeding the maximum acceptable limit of this program.	**4**
Closed due to rainfall exceeding the trigger level in the harvest area management plan.	**31**
Closed due to the implementation of Harvest area classification.	**1**

Total number of openings resulting from specific reasons

Reason	Number of openings
Zone is open for depuration only.	**2**
Zone is open for harvest and depuration as prescribed in the harvest area management plan.	**34**

Appendix E – COST ESTIMATES FOR MANAGEMENT OPTIONS

Option 1 - Existing Flood Notch Management

Project No.: 7369
Project Name: Farquhar Inlet Entrance Opening Management Plan
Date: 18-May-10

Disclaimer

This cost estimate is based on WorleyParsons' experience and judgement as a firm of practising professional engineers familiar with the construction industry. This cost estimate can NOT be guaranteed as we have no control over Contractor's prices, market forces and competitive bids from tenderers. This cost estimate excludes design fees, project management fees and authority approval fees

Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 26, 200

	Description	Quantity	Rate	Unit	Cost
1	Item Costs				
	- excavate flood notch	2	5,000	day	$10,000
	- excavate to open beach berm during flood	0.5	5,000	day	$2,500
	- monitor sediment transport after opening (survey team / engineers)	6	1,500	day	$9,000
	- further approvals	0	-	-	$0
2	30 Year Design Life Costs				
	- excavate flood notch, once every 3 years on average	10			100,000
	- excavate beach berm, once every 5 years on average	6			15,000
	- monitor sediment transport after opening, every 5 years	6			54,000
				TOTAL	$169,000
				TOTAL (+20% CONTINGENCY)	$203,000

** assuming cost of works will not change over design life*

Option 2 - Flood Notch with Reduced Elevation

WorleyParsons
resources & energy

Project No.: 7369
Project Name: Farquhar Inlet Entrance Opening Management Plan
Date: 18-May-10

Disclaimer

This cost estimate is based on WorleyParsons' experience and judgement as a firm of practising professional engineers familiar with the construction industry. This cost estimate can NOT be guaranteed as we have no control over Contractor's prices, market forces and competitive bids from tenderers. This cost estimate excludes design fees, project management fees and authority approval fees

Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 26, 200

	Description	Quantity	Rate	Unit	Cost
1	Item Costs				
	- excavate flood notch	2	5,000	day	10,000
	- excavate to open beach berm during flood	0.5	5,000	day	2,500
	- monitor sediment transport after opening (survey team / engineers)	6	1,500	day	9,000
	- further approvals	0	0	-	$0
2	30 Year Design Life Costs				
	- excavate flood notch, once every 3 years on average	10			100,000
	- excavate beach berm, once every 3 years on average	10			25,000
	- monitor sediment transport after opening, every 3 years	10			90,000
				TOTAL	$215,000
				TOTAL (+20% CONTINGENCY)	$258,000

Option 3 - Decision Making Framework for Flood Notch

WorleyParsons
resources & energy

Project No.: 7369
Project Name: Farquhar Inlet Entrance Opening Management Plan
Date: 18-May-10

Disclaimer

This cost estimate is based on WorleyParsons' experience and judgement as a firm of practising professional engineers familiar with the construction industry. This cost estimate can NOT be guaranteed as we have no control over Contractor's prices, market forces and competitive bids from tenderers. This cost estimate excludes design fees, project management fees and authority approval fees

Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 26, 200

	Description	Quantity	Rate	Unit	Cost
1	Item Costs				
	- excavate flood notch	2	5,000	day	10,000
	- excavate to open beach berm during flood	0.5	5,000	day	2,500
	- excavate pilot channel (if required)	10	5,000	day	50,000
	- monitor sediment transport after opening (survey team / engineers)	6	1,500	day	9,000
	- further approvals	0	0	-	0
2	30 Year Design Life Costs				
	- excavate flood notch, once every 3 years on average	10			100,000
	- excavate beach berm, once every 3 years on average	10			25,000
	- excavate pilot channel, once every 3 years on average	10			500,000
	- monitor sediment transport after opening, every 3 years	10			90,000
				TOTAL	$715,000
				TOTAL (+20% CONTINGENCY)	$858,000

Option 4 - Dredging to keep a Central Entrance Open Continuously

WorleyParsons
resources & energy

Project No.: 7369
Project Name: Farquhar Inlet Entrance Opening Management Plan
Date: 18-May-10

Disclaimer

This cost estimate is based on WorleyParsons' experience and judgement as a firm of practising professional engineers familiar with the construction industry. This cost estimate can NOT be guaranteed as we have no control over Contractor's prices, market forces and competitive bids from tenderers. This cost estimate excludes design fees, project management fees and authority approval fees

Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 26, 200

	Description	Quantity	Rate	Unit	Cost
1	Dredge set-up				
	- mobilisation	1	34,000		34,000
	- crane for installation	1	10,000		10,000
2	Dredging in first year				
	- open beach berm with excavator	1	5,000	day	5,000
	- dredging shifts	35	6,870	day	240,450
	- booster pump (required half the time)	18	950	day	16,625
	- meals and accommodation for 4 person crew	37	660	day	24,255
	- downtime (5%)	2	3,120	day	5,460
3	Dredging in subsequent years (excluding other projects)				
	- dredging shifts	25	6,870	day	171,750
	- booster pump (required half the time)	13	950	day	11,875
	- meals and accommodation for 4 person crew	32	660	day	21,285
	- movement of dredge within estuary	6	4,080	day	24,480
	- downtime (5%)	1.3	3,120	day	3,900
	- monitor sediment transport (survey team / engineers)	6	1,500	day	9,000
4	30 Year Design Life Costs				
	- further approvals (including REF/EIS)	1	30,000		30,000
	- concept and detail design	1	40,000	item	40,000
	- set-up	1			44,000
	- first year dredging	1			291,790
	- subsequent dredging (excluding other projects)	29			6,765,410
	- monitor sediment transport, every year	30			270,000
				TOTAL	$7,441,200
				TOTAL (+20% CONTINGENCY)	$8,929,000

Option 5 - Dredging to Form a Lake behind the Beach Berm

WorleyParsons
resources & energy

Project No.: 7369
Project Name: Farquhar Inlet Entrance Opening Management Plan
Date: 18-May-10

Disclaimer

This cost estimate is based on WorleyParsons' experience and judgement as a firm of practising professional engineers familiar with the construction industry. This cost estimate can NOT be guaranteed as we have no control over Contractor's prices, market forces and competitive bids from tenderers. This cost estimate excludes design fees, project management fees and authority approval fees

Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 26, 200

	Description	Quantity	Rate	Unit	Cost
1	Dredge set-up				
	- mobilisation	1	34,000		34,000
	- crane for installation	1	10,000		10,000
2	Dredging in first year				
	- dredging shifts (reduced rate for 100+ days continuous dredging)	160	5,750	day	920,000
	- booster pump (required half the time)	80	950	day	76,000
	- meals and accommodation for 4 person crew	24	1,500	week	36,000
	- downtime (5%)	8	3,120	day	24,960
3	Dredging in subsequent years (excluding other projects)				
	- dredging shifts	10	6,870	day	68,700
	- booster pump (required half the time)	5	950	day	4,750
	- meals and accommodation for 4 person crew	17	660	day	10,890
	- movement of dredge within estuary	6	4,080	day	24,480
	- downtime (5%)	0.5	3,120	day	1,560
	- monitor sediment transport (survey team / engineers)	6	1,500	day	9,000
4	30 Year Design Life Costs				
	- further approvals (including EIS)	1	50,000		50,000
	- concept and detail design	1	50,000	item	50,000
	- set-up	1			44,000
	- first year dredging	1			1,056,960
	- subsequent dredging (excluding other projects)	29			3,201,020
	- excavate flood notch, once every 3 years on average	10			100,000
	- excavate beach berm, once every 5 years on average	6			15,000
	- monitor sediment transport, every year	30			270,000
				TOTAL	$4,786,980
				TOTAL (+20% CONTINGENCY)	$5,744,000

Option 6A - Dredging to Form an Entrance at the Southern Limit of Farquhar Inlet

Project No.: 7369
Project Name: Farquhar Inlet Entrance Opening Management Plan
Date: 18-May-10

WorleyParsons
resources & energy

Disclaimer

This cost estimate is based on WorleyParsons' experience and judgement as a firm of practising professional engineers familiar with the construction industry. This cost estimate can NOT be guaranteed as we have no control over Contractor's prices, market forces and competitive bids from tenderers. This cost estimate excludes design fees, project management fees and authority approval fees

Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 26, 200

	Description	Quantity	Rate	Unit	Cost
1	Dredge set-up				
	- mobilisation	1	34,000		34,000
	- crane for installation	1	10,000		10,000
2	Dredging in first year				
	- open beach berm with excavator	1	5,000	day	5,000
	- dredging shifts	35	6,870	day	240,450
	- booster pump (required half the time)	18	950	day	16,625
	- meals and accommodation for 4 person crew	37	660	day	24,255
	- downtime (5%)	2	3,120	day	5,460
3	Dredging in subsequent years (excluding other projects)				
	- dredging shifts	20	6,870	day	137,400
	- booster pump (required half the time)	10	950	day	9,500
	- meals and accommodation for 4 person crew	27	660	day	17,820
	- movement of dredge within estuary	6	4,080	day	24,480
	- downtime (5%)	1	3,120	day	3,120
	- monitor sediment transport (survey team / engineers)	6	1,500	day	9,000
4	30 Year Design Life Costs				
	- further approvals (including EIS)	1	30,000		30,000
	- concept and detail design	1	40,000	item	40,000
	- set-up	1			44,000
	- first year dredging	1			291,790
	- subsequent dredging (excluding other projects)	29			5,577,280
	- monitor sediment transport, every year	30			270,000
				TOTAL	$6,253,070
				TOTAL (+20% CONTINGENCY)	$7,504,000

Option 6B - Dredging to Form an Entrance at the
Southern Limit of Farquhar Inlet
+ Geofabric Container Training Wall and Breakwater

WorleyParsons
resources & energy

Project No.: 7369
Project Name: Farquhar Inlet Entrance Opening Management Plan
Date: 18-May-10

Disclaimer

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Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 26, 200

	Description	Quantity	Rate	Unit	Cost
1	Dredge set-up				
	- mobilisation	1	34,000		34,000
	- crane for installation	1	10,000		10,000
2	Dredging in first year				
	- open beach berm with excavator	1	5,000	day	5,000
	- dredging shifts	25	6,870	day	171,750
	- booster pump (required half the time)	13	950	day	11,875
	- meals and accommodation for 4 person crew	26	660	day	17,325
	- downtime (5%)	1	3,120	day	3,900
3	Maintenance dredging in subsequent years (excluding other projects)				
	- dredging shifts	15	6,870	day	103,050
	- booster pump (required half the time)	8	950	day	7,125
	- meals and accommodation for 4 person crew	22	660	day	14,355
	- movement of dredge within estuary	6	4,080	day	24,480
	- downtime (5%)	1	3,120	day	2,340
	- monitor sediment transport (survey team / engineers)	6	1,500	day	9,000
4	Installation of Geofabric Mega Containers				
	- site preparation	1	5	%	16,248
	- Mega Containers (x10)	10	16,200	bag	162,000
	- delivery of containers	10	5,000	bag	50,000
	- dredging to fill containers	15	6,870	day	103,050
	- meals and accommodation for 4 person dredge crew	15	660	day	9,900
	- site clean-up	1	5	%	16,248
5	30 Year Design Life Costs				
	- further approvals and investigations (including EIS)	1	60,000	item	60,000
	- concept and detail design	1	60,000	item	60,000
	- set-up	1			44,000
	- first year dredging	1			209,850
	- maintenance dredging	29			4,389,150
	- Geofabric Mega Container installation	1			357,445
	- Geofabric Mega Container maintenance	29	20,000	year	580,000
	- monitor sediment transport, every year	30			270,000
				TOTAL	$5,970,445
				TOTAL (+20% CONTINGENCY)	$7,165,000

Option 6C - Dredging to Form an Entrance at the
Southern Limit of Farquhar Inlet
+ Geofabric Container / Rock Training Walls and Breakwaters

WorleyParsons
resources & energy

Project No.: 7369
Project Name: Farquhar Inlet Entrance Opening Management Plan
Date: 18-May-10

Disclaimer

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Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 26, 2008

	Description	Quantity	Rate	Unit	Cost
1	Dredge set-up				
	- mobilisation	1	34,000		34,000
	- crane for installation	1	10,000		10,000
2	Dredging in first year				
	- open beach berm with excavator	1	5,000	day	5,000
	- dredging shifts	25	6,870	day	171,750
	- booster pump (required half the time)	13	950	day	11,875
	- meals and accommodation for 4 person crew	26	660	day	17,325
	- downtime (5%)	1	3,120	day	3,900
3	Maintenance dredging in subsequent years (excluding other projects)				
	- dredging shifts	10	6,870	day	68,700
	- booster pump (required half the time)	5	950	day	4,750
	- meals and accommodation for 4 person crew	17	660	day	10,890
	- movement of dredge within estuary	6	4,080	day	24,480
	- downtime (5%)	1	3,120	day	1,560
	- monitor sediment transport (survey team / engineers)	6	1,500	day	9,000
4	Installation of Geofabric Mega Containers				
	- site preparation	1	5	%	16,248
	- Mega Containers (x10)	10	16,200	bag	162,000
	- delivery of containers	10	5,000	bag	50,000
	- dredging to fill containers	15	6,870	day	103,050
	- meals and accommodation for 4 person dredge crew	15	660	day	9,900
	- site clean-up	1	5	%	16,248
5	Construction of Rock Training Wall / Breakwater				
	- site preparation	1	5	%	98,350
	- rock supply	13,800	90	tonne	1,242,000
	- rock placement	13,800	50	tonne	690,000
	- geotextile underlayer	3,500	10	sqm	35,000
	- site clean-up	1	5	%	98,350
6	30 Year Design Life Costs				
	- further approvals and investigations (including EIS)	1	100,000	item	100,000
	- concept and detail design	1	120,000	item	120,000
	- dredge set-up	1			44,000
	- first year dredging	1			209,850
	- maintenance dredging	29			3,201,020
	- Geofabric Mega Container installation	1			357,445
	- Geofabric Mega Container maintenance	29	20,000	year	580,000
	- Training wall / breakwater construction	1			2,163,700
	- Training wall / breakwater maintenance	29	35,000	year	1,015,000
	- monitor sediment transport, every year	30			270,000
				TOTAL	$8,061,015
				TOTAL (+20% CONTINGENCY)	$9,673,000

Option 7 - Permanent Entrance Incorporating Rock Training Walls and Breakwaters

WorleyParsons
resources & energy

Project No.: 7369
Project Name: Farquhar Inlet Entrance Opening Management Plan
Date: 19-Oct-09

Disclaimer

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Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 26, 2008

	Description	Quantity	Rate	Unit	Cost
1	Excavation of footings / channel				
	- excavator	50	5,000	day	250,000
2	Construction of Rock Training Wall / Breakwater on South Side				
	- site preparation	1	5	%	124,640
	- rock supply	17,470	90	tonne	1,572,300
	- rock placement	17,470	50	tonne	873,500
	- geotextile underlayer	4,700	10	sqm	47,000
	- site clean-up	1	5	%	124,640
3	Construction of Rock Training Wall / Breakwater on North Side				
	- site preparation	1	5	%	196,600
	- rock supply	27,550	90	tonne	2,479,500
	- rock placement	27,550	50	tonne	1,377,500
	- geotextile underlayer	7,500	10	sqm	75,000
	- site clean-up	1	5	%	196,600
	- monitor sediment transport (survey team / engineers)	6	1,500	day	9,000
4	30 Year Design Life Costs				
	- further approvals and investigations (including EIS)	1	150,000	item	150,000
	- concept and detail design	1	150,000	item	150,000
	- excavation of footings / channel	1			250,000
	- Training wall / breakwater construction	1			7,067,280
	- Training wall / breakwater maintenance	29	100,000	year	2,900,000
	- monitor sediment transport, every year	30			270,000
				TOTAL	$10,787,280
				TOTAL (+20% CONTINGENCY)	$12,945,000