Hawkesbury City Council

attachment 1

to

item 175

Navigation Dredging of the Hawkesbury River between 'The Breakaway' and Sackville Ferry Business Case - Draft Report by WorleyParsons dated 31 July 2015

date of meeting: 27 October 2015
location: council chambers
time: 6:30 p.m.

WorleyParsons

resources & energy

EcoNomics

HAWKESBURY CITY COUNCIL

NAVIGATION DREDGING OF THE HAWKESBURY RIVER BETWEEN 'THE BREAKAWAY' AND SACKVILLE FERRY

BUSINESS CASE

Issue No. 1

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Project No: 301015-03616 – Hawkesbury River Dredging Business Case

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0	Issued for Internal Review	LB	CRT		18-07-2015
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LIST OF APPENDICES

ABBREVIATIONS

ASS	Acid Sulfate Soils
AASB	Australian Accounting Standards Board
ASSMP	Acid sulfate soil management plan
BHD	Backhoe dredging
BP	Ben's Point
CC	Cattai Creek
CPI	Consumer Price Index
CSD	Cutter Suction Dredge
DPI	Department of Primary Industries
EC	Ebenezer Church
EIL	Ecological Investigation Levels
EIS	Environmental Impact Statement
EP&A	Environmental Planning and Assessment (Act)
EPBC	Environment Protection and Biodiversity Conservation (Act)
HIL	Health Investigation Levels
HSL	Health Screening Levels
KFH	Key Fish Habitat
LAT	Lowest Astronomical Tide
LEP	Local Environmental Plan
LGA	Local Government Authority
LPI	Land and Property Information
LPMA	Land and Property Management Authority (abolished 2011, now LPI, SPA and Crown Lands)
LOR	Limit of reporting
MCA	Multi-Criteria analysis
MHL	Manly Hydraulics Library

MLWN	Mean Low Water Neap (tide)
MLWS	Mean Low Water Spring (tide)
NAGD	National Assessment Guidelines for Dredging
NEPC	National Environmental Protection
NEPM	National Environment Protection (Assessment of Site Contamination) Measure
NPV	Net Present Value
PRMFP	Public Reserves Management Fund Program
PTB	Pitt Town Bottoms
RMS	Roads and Maritime Services
SAP	Sampling and Analysis Plan
SEE	Statement of Environmental Effects
SEPP	State Environmental Planning Policy
SEWPAC	Department of Sustainability, Environment, Water, Populations and Communities
SF	Sackville Ferry
SG	Sackville Gorge
SP	Sandy Point
SPA	State Property Authority
SREP	Sydney Regional Environmental Plan
TBT	Tributyltin
TSHD	Trailing Suction Hopper Dredging
WBS	Work Breakdown Structure

1. INTRODUCTION

The Hawkesbury River extends from the confluence of the Nepean and Grose Rivers north of Penrith, for around 120 km to Broken Bay, where it enters the ocean. The river forms part of the greater Hawkesbury-Nepean River System, which drains a substantial proportion of the Sydney Basin. It is also an important natural feature of the region that is highly regarded for its aesthetics and significance to the local ecosystem.

The Hawkesbury River is navigable from Windsor to the ocean and supports numerous recreational and commercial boating activities. The 32 kilometre reach from "The Breakaway" (*upstream of the Windsor Bridge*) to the Sackville Ferry river crossing (refer **Figure 1-1**) is particularly valued by recreational users including boaters, water-skiers, wake-boarders and fishers. It is also an important thoroughfare for vessels travelling to and from destinations further upstream.

A range of river users have raised concerns over many years about navigability, particularly in the area upstream of the Sackville Ferry crossing. On 29th March 2011, Hawkesbury City Council resolved to investigate options for dredging the river for the purpose of improving navigability. Council requested that its Floodplain Management Committee identify and prioritise potential locations for detailed investigation between Windsor and Sackville.

On 18th April 2011, Council's Floodplain Risk Management Committee identified and prioritised seven locations for investigation, as follows:

1. Sackville Ferry (SF)
2. Sackville Gorge (SG)
3. Ebenezer Church (EC)
4. Pitt Town Bottoms (PTB)
5. Sandy Point (SP)
6. Cattai Creek (CC)
7. Ben's Point (BP)

These seven priority locations on the Hawkesbury River are shown in **Figure 1-2**.

Apart from a small section of river just north of the Windsor Bridge and potentially an area around Sackville Ferry, it is understood that the Project Area has not been dredged previously.

In August 2012, WorleyParsons prepared a Summary Report which documented the findings from a desktop investigation into the navigability of the Hawkesbury River at each of the identified locations. The investigation involved an assessment of navigability based on the existence of a fairway width of between 50 and 100 metres and a channel bed level of -1.9 m AHD or lower (*i.e., a minimum functional water depth of 1.8 m*). The investigation established that Ben's Point is the only identified priority location that does not comply with these navigation requirements.

The report established that a minimum functional water depth of 1.8 m would ensure that the river is navigable at each of the identified priority areas. Although navigation is somewhat restricted at Ben's Point, the existing controls, including vessel speed restrictions and marker buoys are considered adequate to manage this restriction.

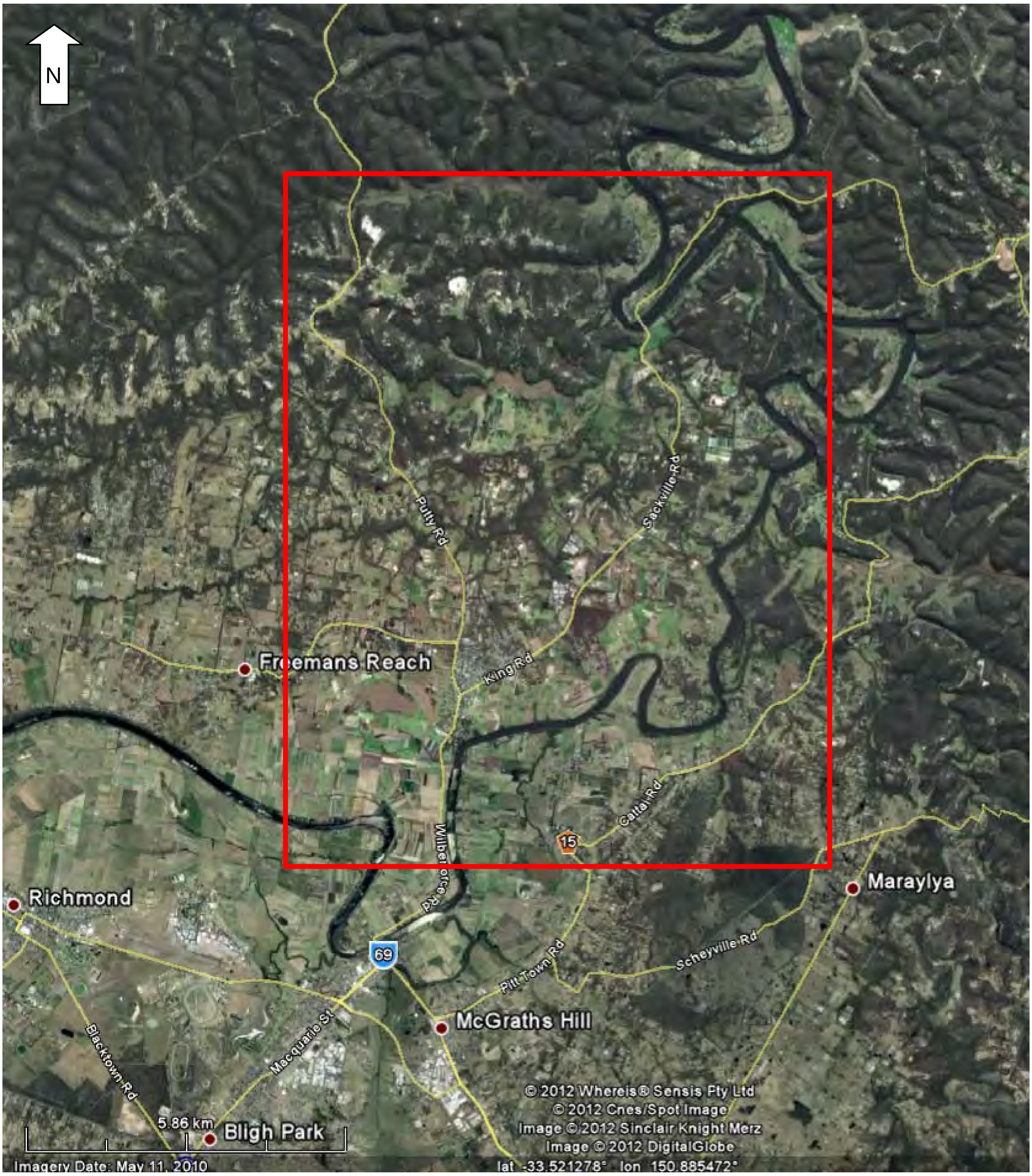

Figure 1-1 Hawkesbury River Dredging Investigations Project Area
(*Source: Google Earth*)

Figure 1-2 Adopted Priority Dredging Locations along the Hawkesbury River
(*Source: Google Earth and Hawkesbury City Council, 2013 / 2014*)

Therefore, a functional water depth of 1.8 m was considered appropriate for this section of the Hawkesbury River and the investigations established that dredging is not required at any of the identified priority locations.

However, if an alternative minimum functional water depth of 3.0 m were to be adopted, along with a required fairway width of 50 m to 100 m, dredging would be required at four of the seven identified priority locations, including Sackville Ferry, Cattai Creek, Pitt Town Bottoms and Ben's Point (*refer* **Figure 1-2**).

Therefore, the available data suggests that it might be necessary to undertake some dredging to ensure a satisfactory functional depth is maintained over time. That is, it may be appropriate to over-dredge in order to ensure navigability into the future.

It was also recognised that the extent of dredging (*i.e., depth*) should consider the benefits afforded by economies of scale. That is, if dredging were to be undertaken to a functional depth of 1.8 m, it might be more economic to dredge to a slightly greater depth in order to provide sufficient volume to make the sale of the dredged material viable. The sale of the material could then be used to fund the dredging cost.

In recognition of this, Hawkesbury City Council decided that further investigations should be undertaken to consider the viability of navigation dredging, including the development of a business case that evaluates the projected costs and any revenue that might be secured from the sale of the dredged material. Council suggested that there would be merit in investigating the potential for provision of a minimum functional water depth of 3 m at mean low water spring tide (*refer letter from Hawkesbury City Council to WorleyParsons dated 2 August 2012*). This alternative minimum functional water depth was flagged as potentially enabling navigation for larger recreational and commercial vessels in the upper reaches of the Hawkesbury River system.

Accordingly, Council engaged WorleyParsons Services Pty Ltd (WorleyParsons) to develop a Business Case for the dredging of the Hawkesbury River between The Breakaway *(upstream of the Windsor Bridge)* to the Sackville Ferry river crossing.

This report documents the findings of these additional investigations, including the quantity of material that would need to be dredged to achieve a functional navigation depth of 3 metres.

2. BACKGROUND

2.1 Previous Investigations

A number of studies and investigations on the Hawkesbury River have been undertaken over the last 40 years or more, including investigations into the potential for dredging and sand extraction. In recent years WorleyParsons have undertaken two investigations into dredging on the Hawkesbury River. These are:

- *'Hawkesbury River Dredging Investigations: Summary Report'* (August 2012)
- *'Hawkesbury River Dredging Investigations: Pilot Sediment Investigation'* (May 2013)

These documents form the background information to this Business Case.

2.1.1 2012 Summary Report (WorleyParsons, 2012)

The Summary Report presents the outcomes of a desktop assessment of the existing navigability of the Hawkesbury River at each of the seven identified priority locations. No community consultation was undertaken as this was not part of the scope of work.

The investigation included:

- an assessment of the existing environment at sites within the Project Area;
- a summary of the legislative setting, including permissibility and potential approvals;
- a summary of the infill rates at sites within the Project Area;
- a commentary on historic bed changes in the identified locations by assessment of comparative hydrographic surveys; and,
- navigation requirements to maintain existing river uses and required vessel drafts and to improve, if necessary, the current navigability of the identified locations.

The report established that Ben's Point is the only site where dredging would be required to ensure a minimal functional water depth of 1.8 m at mean low water spring tide (MLWS tide) and fairway widths of between 50 and 100 m are maintained.

If an alternative minimum functional water depth of 3.0 m were to be adopted, the high level assessment identified that dredging would be required at Sackville Ferry, Cattai Creek, Pitt Town Bottoms and Ben's Point.

The report also noted that in order to achieve a minimum functional water depths of 3.0 m for the Hawkesbury River between Ben's Point and Sackville Ferry, dredging would likely be required along the entire length of this reach of the river.

2.1.2 Pilot Sediment Investigation (WorleyParsons, 2013)

This investigation involved a program of sampling and analysis to determine the physical and chemical characteristics of the sediment across the potential dredge footprint. Bed sediment particle size analysis was undertaken for samples gathered from the river bed at each of the seven priority areas. The analysis established that between 80 and 100 percent of the samples comprised sand sized sediment.

The results of the indicative baseline geo-chemical analysis were used to assess the suitability of the dredge material for beneficial reuse, waste classification for onshore disposal and suitability for disposal within the Hawkesbury River estuary. The analysis did not consider contamination relative to environmental guidelines concentrations.

The investigation also established recommendations for further work that could be undertaken should a dredging proposal proceed. For example, the Pilot Study involved whole sediment concentration testing of composite core samples only and excluded toxicity characteristic leaching procedure (TCLP) testing and elutriate testing. These procedures are likely to be required to determine the potential for onshore reuse or to establish a waste disposal classification for the dredged material.

In addition, the number of samples per area recommended in the relevant guidelines (*refer NAGD* (*Commonwealth of Australia, 2009*) *and NSW Waste Guidelines (DECC, 2009)*) was not met by the collection of one core sample at each of the seven priority locations.

2.2 Previous Assessments of Historical River Changes

Over time, the course and bed profile of a river changes due to many factors including local land uses, water extraction, tidal influences and natural changes brought about by flooding events. Reviews of cross sectional surveys and photogrammetry obtained at various times between 1872 and 1982 were undertaken by Public Works Department (PWD) in the 1980s (*Clarke & Geary, 1987*). Based on a simplistic review of hydrosurvey, the PWD Study noted that the river alignment downstream of Windsor (*Ben's Point priority area*) was basically unchanged over this period, albeit that some subtle variations may have occurred as a consequence of major floods.

Historic dredging for material extraction purposes has occurred, mainly in the reach between Pitt Town Bottoms and Ben's Point. Sand quarrying of the floodplain or on river banks has also occurred at Cattai Creek near Ebenezer Church, and on the meander bend upstream of Sackville Gorge (*Clarke & Geary, 1987*). The PWD Report noted that there appeared to be no more prevalent erosion in these areas of dredging at the time.

2.3 Relevant River Conditions

River conditions can affect the choice of method for dredging and also influence dredging locations and potential volumes. Current river conditions can also give an idea of potential environmental impacts which may arise as a result of dredging the Hawkesbury River and how the river may respond following dredging.

A high level of residential development occurs along the river bank within the project area, along with several caravan parks. Most of these residential and commercial developments have direct access to the river, with numerous boat ramps and pedestrian access ways present. Public boat ramps and jetties are also present. Agricultural land uses are also present along the Hawkesbury River banks, with livestock including horses and cattle, having direct access to the river in some areas.

2.3.1 Vegetation

A site inspection of the river, undertaken for the *Investigations Summary Report* (*WorleyParsons, 2012*) within the project area showed that much of the fringing vegetation along the river has been cleared due to past and existing land uses, although some areas of dense native bushland do remain. A high level of weed invasion, including by lantana and caster oil plant, is present along the river bank in some areas.

Some aquatic vegetation was present along the edges of the river, although marine vegetation including seagrasses and mangroves were not observed during the site inspection and are not expected to occur in the project area (*seagrasses tend only occur in the Hawkesbury River downstream of Berowra Creek*).

2.3.2 Currents

The Hawkesbury River is tidal throughout the study area. As a result, the flow direction of the river changes several times a day. During periods of slack water, when the tide reverses, deposition of any suspended sediments is most likely to occur as the velocity of the water slows to near zero as it changes direction.

2.3.3 Water Levels

Spring tidal ranges in the study area are in the order of 1 metre. For the purpose of this investigation, mean low water spring (MLWS) tide levels have been used when assessing depth of the river for navigation purposes.

The MLWS tide level is the average of the lowest tides over a 24 hour period when the tidal range is at its greatest (*during full moon*). The Lowest Astronomical Tide (LAT) is the lowest level predicted to occur under average meteorological conditions. However, use of MLWS is considered more reasonable for navigation assessment, given that the LAT occurs infrequently and often less than once a year. MLWS tide levels for the study area are presented in **Table 2-1**.

Table 2-1 Mean Low Water Spring Tide Levels 2009 to 2010

Location	Mean Lower Water Springs Tide Level (mAHD)	Tide Reference Station
Sackville Ferry	-0.3	Sackville (212406)
Sackville Gorge	-0.2	Ebenezer (212427)
Ebenezer Church	-0.2	Ebenezer (212427)
Cattai Creek	-0.2	Ebenezer (212427)
Sandy Point	-0.2	Ebenezer (212427)
Pitt Town Bottoms	-0.2	Ebenezer (212427)
Ben's Point	-0.1	Windsor (212426)

Note: MLWS tide levels provided by MHL are +/- 0.05m and have therefore been rounded to one decimal place.

2.3.4 Accretion, Scour and Erosion

Bank erosion appears to be occurring in much of the project area, with bank stabilisation structures of varying quality and type present in many of these areas. At the time of the site inspection (2012), the river appeared highly turbid. The *Dredging Investigations Summary Report (WorleyParsons, 2012)* made an assessment of sediment infill rates based on a review of available literature and studies for the Hawkesbury River. The study suggested that, it is likely that the Hawkesbury River undergoes periods of accretion during low flows, while experiencing net scour due to the effect of flood flows.

Notwithstanding, minor accretion is noted in some surveyed sections, which may be due to sediment supply from local stream bank erosion. In addition, secondary (helicoidal) flows are likely to move sediment from the outside to the inside of river bends, forming shoals on the inside bend from locally sourced sediment.

2.3.5 Sediment Type

A 1976 study, *Sand Resources of the Hawkesbury River System between Windsor and Brooklyn* (*Neville, 1976*) concluded that sediment in the study area is predominantly medium-grained, quartz sand, commonly containing minor impurities of mud and charcoal.

Further investigation was undertaken in the *Pilot Sediment Investigation (WorleyParsons, 2013)* which extracted core samples from each of the seven priority locations within the study area. The investigation found that core samples comprised more than 80%, and up to 100% sand-sized sediment with composite fine fractions contacts comprising between 0% and 16% (*refer* **Table 2-2**).

Table 2-2 Gravel, Sand, Silt and Clay Content in Composite Core Samples

Sample ID (Location)	Gravel (> 2 mm) (%)	Sands – fine to coarse grained (0.06 - 2 mm) (%)	Silt (0.002 -0.06 mm) (%)	Clay (<0.002 mm) (%)
Sackville Ferry	1	98	1	
Sackville Gorge	0	100	0	0
Ebenezer Church	0	86	10	4
Pitt Town Bottoms	4	80	12	4
Sandy Point	0	93	4	3
Cattai Creek	3	96	1	
Ben's Point	1	99	0	0

Source: Hawkesbury River Dredging Pilot Sediment Investigation, WorleyParsons, 2013

2.3.6 Material Quality / River Bed Condition

Acid sulphate soils (ASS) planning maps for the Hawkesbury River show that the whole of the study area is mapped as Class 1 ASS, which are defined as areas with the highest probability of ASS being present. Any works on lands of this class are considered to present an environmental risk *(Ahern et al., 1998).*

Sediment quality investigations undertaken downstream of the project area in the lower Hawkesbury-Nepean River (*Matthai et al., 2009*) suggested an impact from booster biocides used in antifoulants on sediments in areas of high boating activity. Matthai et al (*2009*) found that regionally, only few heavy metals and no organic contaminants were shown to exceed ANZECC/ARMCANZ sediment quality guideline values in sediments of the lower Hawkesbury-Nepean River.

2.3.7 Bathymetry

The most recent complete hydrographic survey of the bed of the river was gathered in 2011. This survey was undertaken by Sydney Water and comprises 85 cross sections of the river channel taken at an average distance between sections of 350 to 450 m. The cross-sections were aligned to correspond with the alignment of cross-sections that were surveyed as part of previous hydrosurveys carried out in 1987 and 1978. The 2011 hydrosurvey is included within **Appendix A** as both cross-sectional profiles of the river and contour mapping of the bed that has been developed from these cross-sections.

Soundings of the river were also obtained in May 2012 by NSW Roads and Maritime Services (RMS). The soundings were gathered at each of the priority locations following minor flooding of the Hawkesbury River. The data was compiled and used to compare with the data gathered in 2011.

This information formed eight cross sections over the project area, one at each of the priority locations, with two at the Cattai Creek priority location. This data is included within **Appendix B**.

Tidal planes from 2009 to 2010 and tide data from May 2012 were utilised to adjust the soundings to Australian Height Datum (AHD) for comparison with the 2011 survey data. Unfortunately, the soundings were far less accurate than the 2011 survey and could not be directly compared to the 2011 survey data as the data was not gathered along the same transect alignment. The soundings did however assist in assessing the current navigability of the river.

Historical hydrosurveys were also gathered in 1987-88 and 1978-80, but these surveys did not cover the full length of the study area. The 1987 survey covers the upstream half of the study area between Windsor and Sandy Point. The 1978 survey covers the downstream half of the study area between Cattai Creek and Sackville Ferry.

An assessment of the current bathymetry of the Hawkesbury River, as reflected in the 2011 and 2012 survey data, indicates the following:

- Channel depths and widths throughout the study area are variable
- Some sections of the river are particularly deep, extending to over 15 metres below Mean Low Water Springs. However, these locations are typically (and as expected) restricted to areas along the outside of meander bends.
- Some areas of the river are very shallow with a functional water depth of less than 2 metres below MLWS. These areas are typically on this inside of meanders where deposition has occurred, but there are notable exceptions such as along the straight reach upstream of Sackville Ferry.
- Straighter reaches of the river tend to have more uniform depths.

3. LEGISLATIVE FRAMEWORK AND RELEVANT GUIDELINES

If dredging of the Hawkesbury River is to be undertaken within the study area, a range of legislation requires consideration. A discussion of potentially relevant legislation was given in the *Dredging Investigations Summary Report (WorleyParsons, 2012)* and a summary of this is provided below along with some additional considerations.

Any dredging undertaken for the purposes of improving navigation would comprises ‘capital dredging’. However, any subsequent ongoing dredging to ensure that the river continues to remain at the same navigable standards would be considered ‘maintenance dredging’. Should a Development Application for dredging be submitted, relevant legislation should be reviewed in light of the specific project details including the location, volume of potential dredge material and capital investment value and to ensure the provisions of current legislation are adhered to.

This Business Case has also considered and provided advice on the Government Agency requirements and the statutory approval pathway.

3.1 Legislation

3.1.1 Acts and Regulations

A summary of Acts and Regulations relevant to the dredging of the Hawkesbury River is presented in **Table 3-1** below. Further local government legislation, not noted here may also be relevant.

Table 3-1 Relevant Commonwealth and State Legislation

Legislation	Comments
Part 4 Environmental Planning and Assessment Act 1979	Part 4 of the *EP&A Act* sets out the development assessment requirements for those developments that require consent. Depending on the location of any proposed dredging, both Hawkesbury City Council and The Hills Shire Council may be the consent authorities for the work if it were to be undertaken under Part 4.
Part 4 Section 91 Environmental Planning and Assessment Act 1979	Development that requires development consent and also an approval from another government department under other nominated legislation is categorised as ‘integrated development’. Section 91 of the *EP&A Act* lists the other nominated required approvals which trigger the integrated development provisions. As dredging would be expected to require approvals under the *Fisheries Management Act 1994* and potentially the *Protection of the Environment Operations Act 1997* as well as others, it would comprise integrated development. Depending on the location of the dredging proposed, both Hawkesbury City Council and The Hills Shire Council may be the consent authorities for the work.

Legislation	Comments
Schedule 4A Environmental Planning and Assessment Act 1979	Consideration of the requirements of Schedule 4A of the *EP&A Act* would also be relevant to establish if the Joint Regional Planning Panel (JRPP) is authorised to exercise consent authority functions of councils.
Part 5 Environmental Planning and Assessment Act 1979	Part 5 generally requires the preparation of a Statement of Environmental Effects (SEE) or an Environmental Impact Statement (EIS), depending on the nature, location and capital investment value of the proposed development. Part 5 required that the environmental impacts of activities are considered. It is likely that an EIS will be required for any dredging works.
Environment Protection and Biodiversity Conservation Act 1999 Environment Protection and Biodiversity Conservation Regulations 2000	Under the provisions of the *EPBC Act*, an action that will have, or is likely to have, a significant impact on a matter of national environmental significance requires approval from the Minister for Environment and undergo an environmental assessment approval process. Relevant to the project, matters of national environmental significant protected under the *EPBC Act* include; world heritage properties, national heritage places, wetlands of international importance (RAMSAR listed), listed threatened species an ecological communities, migratory species protected under international agreements, commonwealth marine areas. A number of matters of national environmental significance occur in the vicinity of the study area, including threatened and migratory species, threatened ecological communities. Two Nationally Important Wetlands and a National Heritage Place are nearby. An assessment of the likely impacts on these matters would be required to determine if dredging was likely to cause a significant impact and thus require referral under the *EPBC Act*. Approval under the *EPBC Act* does not remove the need to seek relevant state and territory and local government authorisations.
Part 7 Fisheries Management Act 1994	Part 7 of the *Fisheries Management Act 1994* requires a permit for a number of activities, including those involving dredging and reclamation work and those involving harm to marine vegetation. If the work were to be approved under Part 4, Section 91, of the *EP&A Act*, the work would comprise integrated development. If any marine vegetation, such as mangroves or seagrasses, was expected to be impacted through the dredging processes, a permit under Section 205 would also be required (it is not expected that mangroves and seagrasses are present in the study area).

Legislation	Comments
Schedule 1, Part 1 Protection of the Environment Operations Act 1997	Should dredging involve extraction of more than 30,000 m^3 per year of extractive materials, dredging work would be declared a scheduled activity pursuant to Schedule 1 Part 1 of the *Protection of the Environment Operations Act 1997* and as such, an Environmental Protection Licence would be required. An Environmental Protection Licence may be obtained for smaller dredging projects in order to protect the principal from prosecution relating to the discharge of pollutants to water.
Section 49 & Section 50 Crown Lands Act 1989	Licences can be issued for the use of Crown land, including for the extraction of materials such as dredging of sand and gravel from waterways under the *Crown Lands Act 1989* (Section 49). Use of such materials for commercial purposes would also attract royalty payments on the materials removed in addition to annual rent paid on licences (Section 50). If no existing Crown lease is in place over the river authorising Hawkesbury City Council to undertake dredging, a licence would be required for the use of the Crown land.
Part 3 Water Management Act 2000 Clause 38 Water Management (General) Regulation 2011	Part 3 of the *Water Management Act 2000* prescribes the approvals required for certain water uses, water management works, controlled activities and aquifer interference. A 'controlled activity approval' is required under the *Water Management Act 2000* for controlled activities undertaken in, on or under waterfront land. However, under Clause 38 of the *Water Management (General) Regulation 2011*, A public authority, is exempt from the requirement to obtain a controlled activity approval and approval under the *Water Management Act 2000* is not required. Nonetheless, as the dredging activities would take place on Crown Land, Office of Water will still be required to assess matters where there is either not a lease, licence, permit or other right in force, or where the statutory instrument does not regulate controlled activities.
Public Reserves Management Fund Act 1987	To be eligible for funding, activities on Crown Land must be consistent with the *Public Reserve Management Fund Act*. Specifically, and relating to the potential dredging works of the Hawkesbury River, that is the cost of maintenance, improvement or development of Public Reserves (whether by direct expenditure or by grants, loans or advances to trustees of the public reserves).
Section 19 Environment Protection (Sea Dumping) Act 1981	The Act stipulates that for disposal of dredged material at sea a permit is required.

3.1.2 State and Regional Plans

Regional Plans are now considered state legislation and considered now as State Environmental Planning Policy (SEPPs). **Table 3-2** presents the SEPPs relevant to the dredge project.

Table 3-2: State Environmental Planning Policies

Legislation	Comments
Clause 69 (3) State Environmental Planning Policy (Infrastructure) 2007	Dredging to improve navigation in the project area would require consent under the provisions of Clause 69(3) of the *Infrastructure SEPP*. The dredging would therefore be subject to the environmental assessment and approval requirements of Part 4 of the *EP&A Act.*
Clause 11(6) and 11(7) Sydney Regional Environmental Plan No. 20 – Hawkesbury-Nepean River (No. 2 - 1997)	Clause 11(6) of the *Hawkesbury-Nepean River SREP* provides development controls, including the requirement for consent, for extractive industries comprising maintenance dredging and extractive operations. Consent is required under the provisions of Clause 11(7) for the filling of land, including through disposal of spoil from dredging, where filling exceeds 1 metre in depth, or an area of 100 m^2.
Schedule 1, Division 5 Sydney Regional Environmental Plan No. 9 – Extractive Industry (No 2 – 1995)	Schedule 1 identifies two locations in the Hawkesbury River which are sand and gravel extraction areas of regional significance.

The aim of the *Hawkesbury-Nepean River SREP No. 20* is to protect the environment of the Hawkesbury-Nepean River system*.* Under this SREP, dredging of the Hawkesbury River would be considered an extractive industry. Extractive industries are prohibited downstream of the Wallacia Bridge in the Hawkesbury-Nepean River with the exception of extractive industries maintenance and dredging operations, meaning:

(a) Dredging operations to ensure that the river is navigable from Broken Bay to Windsor Bridge, if those operations do not create a channel that did not previously exist, or

(b) Dredging operations carried out in the river downstream of the Wallacia Bridge as a consequence of, and ancillary to, works for flood mitigation, bank stabilisation, the construction of bridges or other instream structures (such as marinas) or the withdrawal of water (whether or not the withdrawal is licensed), where extraction is necessary to carry out the works.

Thus dredging within the study area from The Breakaway at Windsor to Sackville Ferry, could be permissible subject to consent.

The *Extractive Industry SREP No. 9* aims to facilitate the development of extractive industries while ensuring consideration of surrounding development and environmental issues. The Extractive Industry SREP provides that extractive industry is permissible with consent of the council in certain areas. As prescribed in Schedule 1, Division 5, two locations in the Hawkesbury River are sand and gravel extraction areas of regional significance:

(i) The land at Windsor covered by Licence Number 74/3, Windsor. Rocla, Hawkesbury River, Windsor.

(ii) The land at Pitt Town covered by Licence Number 82/14, Windsor. Breen Holdings P/L, Hawkesbury River, Pitt Town.

3.1.3 Local Environmental Plans

The project area lies within the Hawkesbury City Council and Hills Shire Local Government Areas (LGAs). Three of the seven locations identified for investigation, Sandy Point, Cattai Creek and Ben's Point, lie wholly within the Hawkesbury LGA. The boundary between the two LGAs lies in the centre of the river at the remaining locations. Thus the LEP for each of the LGAs is relevant.

Within the Hawkesbury LGA, the Hawkesbury River is zoned W1 Natural Waterway upstream of Windsor. Downstream of Windsor, including where the river forms the boundary of The Hills Shire LGA, the River is zoned W2 Recreational Waterway within both Hawkesbury and The Hills Shire LGAs.

3.2 Government Agency Requirements, Approvals, Licences, Permits and Fees

Any Development application would require approval from OEH, Office of Water, Crown Lands, NSW Fisheries and others. Some also require licences and permits.

3.2.1 Department of Trade and Investment, Crown Lands

Under the provision of the *Crown Lands Act 1989*, the beds of all tidal rivers, up to the high water mark, are Crown Land, as are a number of other underwater areas and waterways. Crown Reserves are created to protect and manage important community resources and are administered under the *Crown Lands Act 1989*.

A licence for the dredging of the Hawkesbury River would be granted by Crown Lands. The Crown Lands website provides a breakdown of fees payable for leases, licences and other miscellaneous administration, certificates and notices. A general licence application fee is currently $383.60 (at the time of writing – March 2015). In addition to the licence fee, all licences are subject to a payment of annual rent which is determined on a market value basis and may be subject to annual CPI adjustments as well as full market value reviews at regular intervals.

Licences issued for the extraction of materials for commercial purposes also attract royalty payments on the materials removed, in addition to annual rent.

3.2.2 NSW Fisheries

The Hawkesbury River has been identified as Key Fish Habitat (KFH) by NWS Fisheries. This definition includes all permanently flowing rivers and creeks as well as intermittently flowing rivers, billabongs lakes, lagoons, wetlands, dams, flood channels and flood runners and a number of other water features.

Any person, business, company or local government authority proposing to dredge, excavate or remove material from a waterway requires a permit under Part 7 of the *Fisheries and Management Act*. An application for the permit is made to NSW Fisheries, part of the DPI.

Should the work have been authorised under the Crown Lands Act 1989 or by a relevant public authority such as the NSW Office of Water, it may be possible that a second approval is not required from NSW DPI. However, that public authority is required to consult with NSW DPI before issuing their approval and a permit is still required.

At the time of writing, costs for a permit comprise a $166 application fee plus an administration fee depending on the time taken to assess the application. Assessment fees vary from $166 to $3,597 and NSW Fisheries may charge an additional fee of $69 per hour for work performed beyond the time of original assessment. For permits that have been previously assessed by the Department as Integrated Development Applications in accordance with section 91 of the *Environmental Planning & Assessment Act 1979* (*refer* **Table 3-1**) the assessment fee can be waived, however a permit application (and fee) is still required.

For an appraisal of Integrated Development applications a fee of $250 is payable to NSW DPI. This is in addition to permit fees.

3.2.3 Other Government Approvals

As a navigable river, it is expected that the riverbed is under the care and control of NSW Roads and Maritime Services (RMS), whilst the Crown is the owner of the material comprising the riverbed.

Approvals may also be required from OEH for any influence of heritage items / areas and Office of Water. As the Hawkesbury River is considered a navigable channel, approval may also be required from RMS. While permits are not granted, approval is still necessary. The dredging is likely to become Integrated Development requiring multiple approvals from more than one Government department.

3.2.4 Dredging Disposal at Sea

The loading and disposal at sea of dredged material are regulated under the *Environment Protection (Sea Dumping) Act 1981.* A sea dumping permit is required for disposal of dredged material at sea obtained through the Department of the Environment. Permits are granted with conditions which specify the approved activity, location and volume of material to be dredged and the location of the disposal sites, loading and disposal methods and measures to mitigate impacts, environmental monitoring and reporting.

Permits for disposal to the sea will not be granted if the determining authority sees that opportunities exist for re-use, recycling of, or treatment of material without undue risks to human health or the environment of disproportionate costs (NAGD, 2009). All applications must show that alternatives have been considered and also detail monitoring and testing undertaken.

Costs for sea dumping permits can be high; application fees being $23,500 for volumes of material greater than 100,000 m^3 and $10,000 of the volume of material is less than this.

4. METHODOLOGY

4.1 Assessment of Channel Bathymetry

While previous work has been undertaken to establish the extent to which scouring and / or shoaling of the river appears to be occurring (WorleyParsons, 2012), this has been limited to the localised assessment of comparative cross-sectional profiles of the river from hydrosurvey data gathered at different times over the last 20 to 30 years. Hence, the assessment has been based on a visual comparison of repeated cross-sectional profiles of the river only. Any assessment of the volume of material available for dredging within different reaches of the river requires interpretation between successive river cross-sections.

Accordingly, as part of the current investigation, WorleyParsons undertook further analysis to improve the reliability of the estimated volumes of dredge material for the purpose of the costing that is required as part of the business case. This involved processing the bathymetric data that was gathered as part of the 2011 hydrosurvey to create a three-dimensional model of the terrain of the river bed over the length of the study area (*refer* **Appendix A**).

In conjunction with this, it was also considered appropriate to process the hydrosurveys that were gathered in 1987-88 and 1978-80. As noted previously these surveys did not cover the full length of the study area. The 1987 survey only extends along the upstream half of the study area between Windsor and Sandy Point. The 1978 survey covers the downstream half of the study area between Cattai Creek and Sackville Ferry. Notwithstanding, the combination of both survey provides a representative baseline survey for the period prior from the late 1970s to the early 1980s, and therefore provides a suitable baseline for comparison with the most recent survey in 2011. Comparative profiles of the 2011 and 1978 surveys, and 2011 and 1987 surveys, are included in **Appendix D** for the upper and lower reaches of the river, respectively.

The xyz data gathered to generate each river cross-section was also used to create 3-dimensional computer models of the channel bed for each of the three hydrosurveys. This was undertaken using the 12D software and involved interpolation between cross-sections to generate the bathymetry. In particular, a series of breaklines were developed in the vicinity of meander bends and were used to interpolate bed geometry from cross sectional for areas leading into and out of the meander bend. The breaklines link cross-section to cross-section and were manually drawn to ensure that the channel thalweg, banks and any deposition features or areas of scour are represented. Aerial photography and engineering judgement was used to position the breaklines.

12D models of each of the three hydrosurveys were prepared for analysis. The analysis was undertaken to achieve two separate objectives:

(i) An assessment of where scour or deposition has occurred within the study area based on the volume of deposition and/or erosion in the bed of the river over the period from 2011 to 1978 (*lower section of the study area*) and over the period from 2011 to 1987 (*upper section of the study area*)

(ii) An assessment of the volume of material that would need to be dredged to achieve a functional water depth of 3 metres below MSLW across a fairway width of between 50 and 100 metres.

4.2 Navigability Requirements

Navigation requirements in terms of channel depth and width were assessed and compared with existing conditions on the Hawkesbury River (based on 2011 survey). Although emphasis was placed on the seven priority locations, the entire reach of river within the study area was also considered.

Navigability of the river is assessed on a minimum functional depth at MLWS tide (i.e., minimum function depth is calculated as the MLWS level less the channel bed level) and the width of channel at which this depths occurs, known as the fairway (*refer* **Figure 4-1**). MLWS tide levels for the study are discussed previously in **Section 2.3.3**.

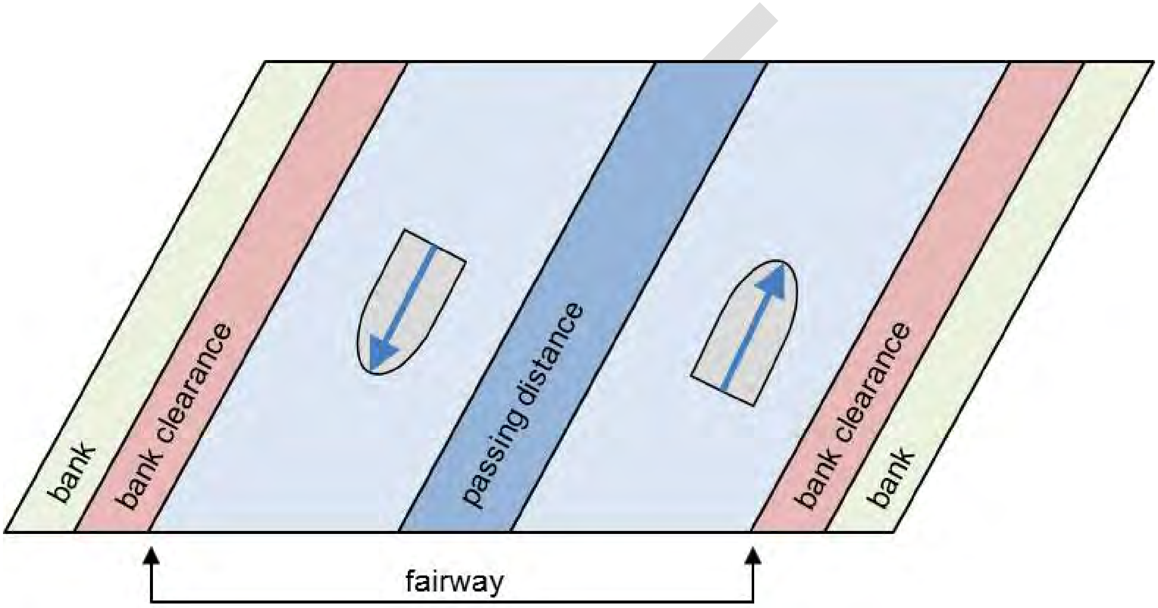

Figure 4-1 Schematic of Fairway Width

When establishing fairway width consideration should also be given to other factors such as the current and prevailing winds as this can affect the drift of a vessel. Fairway widths may need to be increased to allow for this. However, in the instance of the Hawkesbury River, the fairway width is restricted by the bank to bank width of the river. Therefore while deepening may allow for larger vessels, care should be taken in ensuring a suitable fairway width, or restricting the movement of oversized vessels.

An ideal fairway width of 100 m has been assumed to be required. This is consistent with the conclusions determined by WorleyParsons in 2012 and is based on allowing 30 m between passing vessels and 30 m to each bank. In restricted areas a fairway width of 50 m was considered to be acceptable.

Table 4-1 presents the minimum functional water depth for a number of scenarios.

Table 4-1 Navigation Requirement Assumptions – 2010 (Reference: AS 3962-2001)

Vessel	Draught (m)	Under Keel Clearance (m)	Minimum Functional Water Depth (m)
20 m power boat	1.5	0.3	1.8
8 m yacht	1.5	0.3	1.8
45 m power boat	2.6	0.3	2.9
20 m yacht	2.8	0.3	3.0

Note: Under keel clearance is the greater of 300 mm or 10% of the draught.

Based on the above, the following navigation requirements were assumed:

- Acceptable fairway width – 50 m
- Ideal fairway width – 100 m
- Minimum functional depth – 3 m at MLWS

5. DREDGE QUANTITY ASSESSMENT

5.1 Assessment of Historical Changes in Channel Bathymetry

An assessment of the change in channel bathymetry over the period from 1978 / 1987 to present (*as represented by the 2011 survey*) can be provided via comparison of repeat cross-section profiles of the channel and by comparison of terrain mapping of the river bed. Both have been prepared as part of this investigation and are included within **Appendices C** and **D**.

The figures within **Appendix C** show the location and alignment of surveyed cross-sections that were gathered as part of the 2011 survey and the location and alignment of cross-sections gathered as part of the 1978 and 1987 surveys. Unfortunately, significantly less cross-sectional profiling was undertaken as part of the 2011 survey than was the case for the 1987 survey (*upstream section of the study area*). That is, the cross-sections were surveyed much further apart than was the case for the 1987 survey.

For the 2011 survey a total of 85 cross-sections were surveyed over the 34 km length of the river that falls within the study area at an average spacing of 400 m. Of these, 31 cross-sections fall within the 12½ km of the river covered by the 1987 survey. In comparison, a total of 387 cross-sections were surveyed over this 12½ km reach as part of the 1987 survey. Hence, the 1987 bathymetry is based on more than ten times as many cross-sections as the bathymetry defined by the 2011 survey for the same area, and therefore provides a much better representation of the bed terrain.

The downstream 21½ km reach of the study area is represented by a total of 54 cross-sections in both the 2011 and the 1978 surveys. The 2011 cross-sections were surveyed on the same alignment as each of the 1978 cross-sections. Hence, both surveys provide cross-sections of the bed of the river at an average spacing of 400 metres.

Therefore, the combination of the 1978 and 1987 data provides a more detailed representation of the channel bathymetry that existed at that time, compared to the representation afforded by the 2011 survey. In effect, the representation afforded by the 2011 survey is somewhat subjective, being dependent on the actual location of each cross-section profile.

Notwithstanding, it is recognised that these data-sets provide the best data available and have been used to develop an understanding of the changes in bathymetry over the last 30 to 40 years.

The following sections serve as a commentary on the changes observed from the data comparison. The commentary is provided in sections that align with each of the seven priority locations that were identified in the study brief.

5.1.1 Ben's Point

The change in bathymetry in the vicinity of Ben's Point is represented by **Figure C1** of **Appendix C** and Sections 1 to 4 inclusive on **Figure D1** of **Appendix D**. **Figure C1** shows clear evidence of scouring of a large proportion of the bed of the river in the lead into the meander bend (*as depicted by the areas shaded red*) over the period from 1987 to 2011. There is very little evidence of shoaling of this initial 400 metres of the meander bend.

As the river flows out of the meander bend, there is evidence of scouring to a depth of about 1 metre having occurred along the inside of the bend over the period from 1987 to 2011. Interestingly, the bed terrain mapping suggests that deposition of about 2 metres has occurred along the outside of the bend as the river transitions into the straight reach downstream from Ben's Point (*refer* Section 3 of **Figure D1**).

The bathymetric data indicates a depositional trend as the river leaves the meander and flows into the straight. As shown in Section 4 (*refer* **Figure D1**), deposition of up to 1 metre has occurred, although the average deposition across the width of the cross-section is more typically only 0.5 m. The trend for deposition continues to a point about 50 metres downstream of the Bridge Street bridge crossing of the Hawkesbury River at Windsor.

5.1.2 Pitt Town Bottoms

Pitt Town Bottoms is a 2 kilometre long straight reach of the Hawkesbury River located about 5 river kilometres downstream from Windsor. Mapping of the bed terrain changes between the 1987 and 2011 surveys in the vicinity of Pitt Town Bottoms is presented in **Figure C4** of **Appendix C.** A comparison of selected cross-sections compiled from the two surveys is provided by **Sections 5 to 8** inclusive in **Figure D2** of **Appendix D**.

The Pitt Town Bottoms reach has undergone scour between 1987 and 2011, with most scour occurring at the upstream portion of the reach as the river comes out of a 120 degree bend. As shown in Section 5 (*refer* **Figure D2**), scouring has increased the channel depth by up to 3 m at this location, particularly on the inside of the meander bend.

At the downstream area of the reach some minor deposition has occurred as shown by Section 8. However, this is generally no more than 0.2 m.

Figure C4 shows no evidence of significant areas of deposition within the Pitt Town Bottoms reach occurring between 1987and 2011.

5.1.3 Sandy Point

Sandy Point is located about 8½ kms downstream of Windsor and forms one of the tightest meander bends within the tidal section of the Hawkesbury River. The change in bathymetry in the vicinity of Sandy Point is represented by **Figure C6** of **Appendix C** and Sections 9 to 12 inclusive on **Figure D3** of **Appendix D**. The data shows the following trends between 1987 and 2011:

- Scouring has occurred over most of the upstream section of the priority are (*refer Sections 9 and 10*) to depths ranging from 0.5 to 1 metres.
- At the apex of the meander bend, the thalweg has moved from left to right as deposition has occurred on the outside of the meander and scour on the inside (*Section 10*)
- An area of deposition is also evident along the outside of the meander bend between Sections 11 and 12 as the river transitions into the straight that exists downstream from Sandy Point.
- The deposition at Section 11 is up to 2.2 m. As shown in **Figure C6** all of the area that transitions to the straight between Section 11 and 12 has undergone shoaling.

5.1.4 Cattai Creek

The Cattai Creek priority area is located downstream from the mouth of Cattai Creek which is about 12 river kilometres downstream of Windsor. The reach extends for about 1 km and much of the southern bank adjoins Cattai National Park. The change in bathymetry along the Cattai Creek priority area between 1978 and 2011 is shown in **Figure C8** of **Appendix C**. Four comparative cross-section profiles within this area for both surveys are shown in **Figure D4** of **Appendix D**.

The data shows evidence of both scour and deposition occurring within the priority area. The following summarises the key observations in terms of scour or deposition over the period between the surveys:

- A significant amount of scour has occurred in the meander bend located immediately upstream of the mouth of Cattai Creek. As shown in Section 13, the channel has widened as scour of up to 13 m has occurred along both banks.
- An area of deposition is evident near the mouth of Cattai Creek and extends for about 250 metres downstream (*refer* **Figure C8** and Section 14 of **Figure D4**). Some of this may be attributable to sediment discharged from the Cattai Creek catchment and some occurring as a consequence of deposition associated with the channel widening that occurs as flow transition in the Cattai Creek reach from the upstream meander bend.
- The bed terrain difference mapping for the downstream section of the priority area shows evidence of scouring. This is supported by the hydrosurvey comparison provided in Section 16 of **Figure D4** which shows scouring over the period from 1987 to 2011 of up to 1.8 metres.

5.1.5 Ebenezer Church

The Ebenezer Church priority area is located about 14½ river kilometres downstream from Windsor and about 3 kilometres upstream from Sackville Gorge. **Figure C9** of **Appendix C** shows the change in the channel bed bathymetry between 1978 and 2011. Comparative cross-sectional profiles of the river for both surveys are provided as Sections 17 to 20 in **Figure D5**. **Figure C9** shows evidence of deposition along the majority of the priority area. Key points observed from the bed terrain difference mapping are as follows:

- Significant infilling of the channel is evident in the upstream section of the priority area over the period between surveys, as shown by Section 17 (refer Figure D5). The data shows deposition at this location of up to 11.5 m and infilling over the full width of the channel.
- About 500 m downstream, the channel bed flattens and widens and deposition has occurred since 1978. Up to 0.7 m of deposition has occurred on the outside of the meander bend (refer Section 18).
- The thalweg in the vicinity of the apex of the meander bend appears to have transitioned toward the outside bank as a consequence of the sediment that has been injected into this reach and which has led to deposition across the inside of the bend. As a result, there is evidence of scour on the outside bend such as shown by Section 19.

- Deposition of up to about 2.7 m has occurred, but the depth of the river at this location remains over 10 metres for the most part.
- As the river transitions out of the meander bend the bathymetric data indicates that the channel profile flattens out and depths reduce to 4 to 5 m. Deposition is evident in this area, particularly on the inside of the meander where shoaling to depths of about 1.6 m have occurred (refer Section 20).

5.1.6 Sackville Gorge

Sackville Gorge is located about 19 river kilometres downstream of Windsor. The change in channel bed bathymetry in the vicinity of Sackville Gorge between 1978 and 2011 is represented by **Figure C10** of **Appendix C**. Comparative cross-sectional profiles of the river for both surveys are provided as Sections 21 to 24 inclusive in **Figure D6** of **Appendix D**. The data shows the following trends:

- Deposition has occurred on the outside of the meander as the channel thalweg has moved gradually towards the inside of the bend.
- It is likely that the source of some of this deposited material has come from the area of scour immediately upstream of the priority area.
- As evidenced in **Figure C10**, the central section of the channel has scoured to create a deeper central channel through the apex of the meander. At the same time, the data suggests that some deposition has occurred in areas of the channel that adjoin the river banks.
- As the river transitions out of the priority area, there is little variation in the channel cross-section as shown in Section 24. Deposition is generally less than 0.25 m.

5.1.7 Sackville Ferry

Sackville Ferry is located about 30 river kilometres downstream of Windsor. The change in channel bed bathymetry in the vicinity of Sackville Gorge between 1978 and 2011 is represented by **Figure C16** of **Appendix C**. Comparative cross-sectional profiles of the river for both surveys are provided as Sections 21 to 24 inclusive in **Figure D7** and **D8** of **Appendix D**. The following conclusions are drawn from analysis of the data:

- Some minor deposition of up to 0.4 m has occurred along the straight reach upstream of the priority area as the river transitions into the meander bend (refer Section 25).
- Scour has generally occurred through the central area of the meander, as evidenced by the comparative profiles provided as Sections 26 and 27 in **Figure D7**.
- An area of deposition of up to 3.5 m has occurred through the priority area.
- The thalweg of the river has reoriented over the period between surveys as a response to the deposition.

5.2 Volumes Associated with Dredging Options

5.2.1 Option BP1 - Ben's Point

Figure E1 of **Appendix E** shows the extent of the priority area where the functional water depth is less than the 3 metres below MSLW.

Most of the fairway where the functional depth is greater than 3 m is only about 35 m wide. This is considerably less than the acceptable 50 m and only one third of the desirable fairway width.

Approximately 1 m depth of dredging would be required to achieve the navigation criteria. Most of the dredging would be required in the vicinity of Bridge Street bridge crossing. Additional dredging would be required on the inside of the meander bend and at the entrance to the meander at the upstream end of the study area.

A total volume of 46,800 m^3 would need to be dredged from this priority area to achieve the navigation criteria.

5.2.2 Option PTB1 – Pitt Town Bottoms

As shown in **Figure E4**, a fairway width of 80 m exists in the upstream section of this reach. Although narrower than the desirable width of 100 m, the existing fairway width is considered to be acceptable for navigation purposes.

However, by the about 450 m downstream, the fairway reduces to less than 40 m. By the downstream end of the priority area, the entire river cross-section is shallower than the required 3 m functional depth.

The channel is relatively wide and trapezoidal in shape. Current bed levels are typically at an elevation of -3.0 mAHD. Therefore, some minor dredging would be required to maintain a functional depth of 3.0 m below MSLW level and an acceptable fairway width for navigation.

Dredging would need to remove 0.5 to 1 m depth of material. While the depths of dredging required are not as great as for some other priority areas, the Pitt Town Bottoms reach covers a longer distance than other priority areas.

Sections of the river immediately upstream and downstream of the Pitt Town Bottoms priority area are also quite shallow and will require dredging in conjunction with any dredging works that are undertaken within the priority area itself in order to provide a consistent navigable channel as per the criteria.

Therefore, a total volume of 49,150 m^3 would need to be dredged in order to establish a channel through the Pitt Town Bottoms priority area with a functional depth of 3 m across the full width.

5.2.3 Option SP1 - Sandy Point 1

The area where the current functional depth of the river is less than 3 m is shown in **Figure E6** of **Appendix E**.

The fairway width over the length of the meander is generally about 70 m. While this is wider than the minimum fairway width criteria of 50 m, it is less than the desirable fairway width of 100 m. The width of the river at this location is about 90 m and as such dredging to increase the fairway width is limited by the existing width of the bank to bank channel.

The fairway narrows to about 35 m as the river transitions out of the meander bend (downstream end of the reach). Hence, substantial dredging would be required in this area to create a navigable and safe fairway.

In the straight section of the priority area the entire width of the river is shallow and does not have the required 3 m functional water depth. Dredging to an average depth of 1.5 metres would be required over most of this area to achieve the required functional water depth.

A total volume of 140,200 m^3 would need to be dredged from this priority area to achieve the navigation criteria.

5.2.4 Option SP2 - Sandy Point 2

A second option was considered for Sandy Point which involves dredging the area at the upstream end of the priority area where the entire width of the river is shallower than the functional water depth criteria.

A total volume of 32,700 m^3 would need to be dredged from this priority area to achieve the navigation criteria.

5.2.5 Option CC1 - Cattai Creek

Areas within the Cattai Creek priority area where the functional water depth is less than 3 m are highlighted in **Figure E8**.

As noted previously, the area downstream of the mouth of Cattai Creek has undergone deposition which has led to shallowing of the river to depths of only 1.5 m. A volume of 40,100 m^3 would need to be dredged from this priority area in order to achieve a functional water depth of 3 m.

5.2.6 Option CC2 - Cattai Creek

The fairway of the river narrows to about 40 m at the meander between the Cattai Creek and Ebenezer Church priority areas (*about 1 km downstream of the mouth of Cattai Creek*). This is less than the minimum specified fairway width of 50 m and substantially less than the desirable fairway width of 100 m.

In order to achieve the 3 m functional depth and fairway width criteria in this area, a volume of 46,900 m^3 would need to be dredged. If Options CC1 and CC2 are combined, a total volume of 86,900 m^3 would need to be dredged.

5.2.7 Option EC1 - Ebenezer Church

As shown in **Figure E9** of **Appendix E**, the current bathymetry along the Ebenezer Church priority area (as represented by the 2011 survey) meets the navigation criteria for fairway width and functional depth. Therefore no dredging is needed for navigation at the area identified as Ebenezer Church.

However, an area upstream of Ebenezer Church would benefit from dredging. This has been identified as Option CC2.

Downstream of Ebenezer Church, before the river enters the Sackville Gorge reach, the fairway narrows to approximately 60 to 75 m and a pinch point in the fairway of less than 50 m width occurs near the boundary of the Riverside Oaks Golf Course. Depths within the channel reduce to 2 to 2.5 m in this area. Hence, up to 1 m of dredging would be required to increase the functional depth so that it aligns with the specified criteria.

Approximately 48,500 m^3 of material would need to be removed from the river bed at this location to create a 3 m functional water depth.

5.2.8 Option SG1 - Sackville Gorge

Figure E10 of **Appendix E** shows the areas of the channel where the functional water depth is less than 3 m at Sackville Gorge. The fairway on the outside of the meander is approximately 65 m wide. While this is wider than the minimum acceptable limit of 50 m, it is substantially less than the desirable fairway width of 100 m.

By dredging at this location the fairway width could be widened by up to a further 60 m. The depth of dredging would need to be between 0.5 and 2.5 m and a total volume of 59,500 m^3 would need to be dredged from this area.

As the fairway is wider than the minimum criteria, this option would be a lower priority than other areas of the river where the criteria is not met. However, as deposition has been occurring on the outside of the meander, the functional water depth and fairway could be expected to reduce over time. Therefore, dredging is considered to be appropriate for the purposes of maintaining an acceptable fairway width in what is a constrained section of the river.

5.2.9 Option SF1 - Sackville Ferry

The fairway in the central area of the meander bend at Sackville Ferry is approximately 130 m wide and has depths of more than 10 m on the outside of the bend (*refer* **Figures D6**, **D7**, **E15** and **E16**). Therefore, the desirable functional depth and fairway width already exist and no dredging is required in the actual priority area (*as noted on the priority area plan from council shown in* **Plate 1-2**).

However, the long straight reach upstream of the meander bend has experience shoaling, with depths reduced by between 1 and 1.5 metres. As a result the functional water depth of this straight reach is generally only 1.5 to 2 m below MLWS tide level.

Hence, dredging to depths of 1.5 m below current bed levels would be required to achieve the minimum functional depth throughout this reach.

The total volume of material that would need to be dredged in the straight reach to achieve this is estimated to be 173,853 m^3

Dredging within the area is recommended as accretion has occurred in the past and could continue to do so. Due to the trend toward progressive deposition in this area, dredging would likely need to be undertaken as part of an ongoing and structured dredging maintenance program, rather than as a one-off exercise.

5.2.10 Option HR1 - Dredging the Entire River Length within the Investigation Area

Investigations undertaken for this report have established that it will be necessary to dredge from more than just the seven identified priority areas in order to achieve the specified navigation criteria over the length of the study area. While dredging at each of the priority areas to achieve a 3 m functional water depth would provide improvement to navigability on a reach by reach basis, it would not improve the overall navigability of the river.

Additional localised points will need to be dredged to achieve the desirable fairway width of at least 50 m, and 100 m where possible, and a functional depth of 3 m below MLWS tide level. There are some areas, such as Sackville Gorge, where the fairway is less than the desirable 100 m but greater than the minimum acceptable criteria of 50 m.

The volume of material (solid) that would need to be dredged over the length of the study area from Windsor to Sackville Ferry to achieve the navigability criteria is estimated to be 830,700 m^3.

5.3 Summary

Figures contained in **Appendix E** show areas of the Hawkesbury River where the functional depth is less than the 3 m specified for navigation by Hawkesbury City Council. Similarly, there are areas where the specified minimum fairway width of 50 m and the desirable fairway width of 100 m do not exist. As a result, dredging would be required at a number of locations to achieve the specified navigation criteria.

The volumes of material (solid) that would need to be dredged from each priority area and over the entire length of the river within the study area are listed in **Table 5-1**.

At each of the priority areas, with the exception of Ebenezer Church and Sackville Ferry, dredging would be required to both deepen and widen the fairway. Additional areas which would benefit from dredging include:

- An area downstream of the Cattai Creek priority area, referred to as Option CC2;
- An area downstream of the Ebenezer Church priority area and upstream of Sackville Gorge, referred to as Option EC1; and,
- The straight reach upstream of the Sackville Ferry meander, referred to as Option SF1.

Table 5-1 Estimated Dredging Volumes

Option	Area	Volume of Dredge (m^3)
BP1	Ben's Point	46,700
PT1	Pitt Town Bottoms	49,100
SP1	Sandy Point (includes area into meander)	140,200
SP2	Sandy Point (area at upstream of meander only)	32,700
CC1	Cattai Creek	40,100
CC2	Cattai Creek (including additional area downstream)	87,000
N/A	Ebenezer Church	No dredging required
EC1	Ebenezer Church (area downstream of priority area, upstream of Sackville Gorge)	48,500
SG1	Sackville Gorge	59,500
N/A	Sackville Ferry	No dredging required
SF1	Sackville Ferry (straight reach upstream)	173,900
HR1	Entire Project area where functional depth is currently less than 3 m	830,700

6. POTENTIAL DREDGING APPROACHES

6.1 Alternative Dredging Approaches

There are a number of methods that could be employed to dredge the bed of the Hawkesbury River or the purposes of improving navigability. These include the following:

- Land based mechanical dredging
- Barge mounted backhoe dredging
- Cutter suction dredging
- Trailing suction hopper dredging
- Water injection dredging
- Options for transportation of dredge material to land by barge or by pipeline.

Each of these is discussed in the following sections.

6.1.1 Land Based Mechanical Dredging

This approach involves the use of an excavator or backhoe to dredge the river from the top of the river bank. It requires vehicular access to the river bank to allow plant and equipment to access the dredge location. Vehicular access is also required to allow excavated or dredge spoil to be transported to stockpile locations or to disposal sites.

This method has significant limitations as even the longest long-reach excavator will have a maximum reach of about 15 metres from the top of bank. Hence, due to the width of the river it would be difficult to employ this method to undertake the full extent of dredging that will be required. The depth of excavation is also restricted due to limited reach of the excavator and is particularly problematic where high river banks exist.

In this particular case dredging will be required along sections of the Hawkesbury River that adjoin private land and National Park. Therefore, access for plant and equipment to the top of bank in these areas will be problematic and almost impossible over the full length of study area. For these reasons it is unlikely that this method will be suitable for dredging of the Hawkesbury River.

6.1.2 Barge Mounted Backhoe Dredge

Barge mounted backhoe dredge is a mechanical dredger which uses a land based excavator mounted on to a barge. Dredge spoil is captured by the excavator or backhoe bucket as it is pull upwards towards the hull of the barge.

The method is suitable for a range of materials including those with a lower water content and when excavating harder materials such as clays, fractured rocks, soft stone and soils containing boulders. The depth of excavation is limited to the size of the excavator that can be carried by the barge, but can be up to 20 m.

Use of a BHD is usually considered less efficient in terms of dredge material per given time periods when compared to hydraulic suction methods (*refer* **Section 6.1.4**). This method also requires some means of transporting the dredged material to land.

6.1.3 Cutter Suction Dredge (CSD)

A cutter suction dredge is a hydraulic dredger which is able to remove silts, sands and stiff clays and works by a rotating cutter head first loosening the bed material and a suction tube which follows the cutter and "sucks up" loosened material. CSDs can be relatively small, with the minimum dredging depth usually determined by the depth of the pontoon/vessel draught. They are often used over shorter distances than Trailing Suction Hopper Dredges (TSHD) (*refer* **Section 6.1.4**). In addition, they can be more accurate.

Issues with this method can arise when large amounts of aquatic flora cause difficulties with clogging of the head of these types of dredgers. There can also be issues associated with the suspension of sediments causing unacceptable levels of turbidity.

6.1.4 Trailing Suction Hopper Dredging (TSHD)

TSHD is a hydraulic dredger which uses a pump mounted on a barge with a suction pipe lowered onto the river bed. The river bed material is drawn into the pipe under suction. This method of dredging is often highly efficient, especially for loose sandy bed material, sludge, clays or gravel.

A trailing suction hopper dredger generally stores the dredged material in its own hopper which settles out and discharges the left-over water overboard hence the need for dewatering on the shore is eliminated or reduced. Not all TSHDs will operate this way however.

TSHD can be considered more environmentally sensitive that CSD as they create limited suspended sediment and turbidity compared to CSD. However, where the overflow of excess water contains unsettled fines, turbidity in the river can be increased and this should be carefully monitored. They are also not overly accurate and can leave holes in the riverbed which may affect river flow.

6.1.5 Water Injection Dredger (WID)

WIDs is a hydrodynamic technique which works by injecting large volumes of water under low pressure into silt of fine sand in order to resuspend it, therefore are not suitable for dredge material of large particle size or rocks. The dredging depth can be varied and can generally reach down to 20 m.

This method often replies on the natural current and rather than collect and transport sediment to land, the remobilised sediment is encouraged to a new natural settlement location. Given the variability of the tidal currents in the Hawkesbury River, this method is unlikely to be appropriate.

6.1.6 Transportation of Dredged Material to Land

There are a number of methods by which dredged material can be moved to land as outlined below. Given the large area considered in this study, it is likely that more than one on-shore laydown area for dredged material will be necessary, particularly if material is transported to shore by pipeline.

- Transport to shore by pipeline – under high pressure, water is mixed with dredged sediment to pump through a pipeline to the shore. This can increase rates of dredging by reducing time to transport material and can also reduce mobilisation costs (e.g., for barges). However there will be a restricted distance between the dredge and the shore due to length of pipeline and pumping requirements. In addition, there could be impact on other users of the Hawkesbury River obstructed by a pipeline floating on river surface.
- Transport to shore by barge – The barge on which the BHD sits is filled with dredged material and once fill, moves to shore. This decreases the number of vessels required for dredging operations but means than dredging cannot be continuous as the full barge needs to be emptied. Furthermore, as a larger vessel, a barge may require a substantial temporary jetty or mooring at offloading locations compared to use of smaller tugs. In filling the barge the current depth of the Hawkesbury River and the draught of the barge used should be considered.
- Transport to shore by tug and barge combination - Increased distance between dredge and shore, however a temporary jetty or mooring location is required at offloading location and less efficient use of power. This method involves handling the dredge material several times and may therefore not be as efficient as other means.
- Combined barge and pipeline transport – Material dredged from the river bed would be dumped within the channel to create a submerged stockpile closer to the bank. This stockpile would then be re-dredged and piped onshore (or alternatively re-dredged from the shoreline). This may increase the environmental impact of the dredging process, by mobilising more sediment in the water column, and can increase costs if not well planned.
- Rainbowing – using high pressure water pumped from the river the sand become fluid again. The resulting mixture is then sprayed from the bow of the vessel at the desired location. This may be directly into a sediment basin on the bank of the river, or into a tug or barge. The advantage of this method is that no pipe lines are required thus the river is not obstructed for other users, however dredged material will require dewatering on shore.

6.1.7 Dewatering of Hydraulically Dredged Sediment

Hydraulically dredged sediment needs to be separated from water once pumped to land. This can be done by use of a settling basin, dewatering/drying bags or mechanical dewatering equipment. Sediment basins are generally cheaper but material can take longer to settle out and they can also be more land consuming. Once separated from the water, clean water is returned to the river via a return line.

6.1.8 Recommended Dredging Methodology

It is likely that CSD or TSHD would be used for dredging of the Hawkesbury River, as dredging cannot be undertaken from the shoreline, particularly in those areas where deeper dredging is required. Methods of transporting material to shore would be via pipe line or barge. Dewatering methods are likely to be required on shore at laydown areas. Mechanical dewatering would provide a more efficient process but can be more costly.

Use of BHD would be appropriate in some areas, where the dredge depths are shallower. Nonetheless, BHD's would need to be barge mounted and transport barges will be necessary to transport dredged material to shore.

It is recommended that the methodology for dredging be put to the tenderer. This way, a more cost-effective approach can be achieved through flexibility in methodology and encouraging tenderer to be more innovative and competitive.

6.2 Approaches for Disposal

6.2.1 Disposal as Solid Waste

Samples taken in the pilot study *(WorleyParsons, 2013)* were compared to the *Waste Classification Guidelines: Part 1 – Classifying Waste (DECC, 2009)* for the purpose of assessing the proposed dredge material for on land disposal.

Individual results for all contaminants were below the contamination threshold values set for general solid waste (CT1), indicating that the material from all seven priority locations may be suitable for disposal as general Solid Waste. However, due to the insufficient number of samples collected for each priority area in the Pilot Study *(WorleyParsons, 2013),* there may be additional sampling and testing requirements and restrictions applied to the offsite disposal of the sediments at a licensed landfill to meet guidelines.

If dewatering of material is required prior to any onshore disposal, consideration would also need to be given to the quality of the return water and any specific treatment or disposal requirements. These matters would need to be addressed in an environmental assessment for any future proposed dredging and disposal works.

6.2.2 Sea Disposal

While the Pilot Study (*WorleyParsons, 2013*) identified that the concentrations of chemical parameters tested, and for which there is an available corresponding guideline level, were below the NAGD Screening Levels in all sediment samples and for all chemicals tested, it also was noted that a full characterisation of sediments for sea disposal under the NAGD would require additional sediment sampling and testing under a Sampling and Analysis Plan (SAP) approved by the Commonwealth Department of Environment.

Nonetheless, a permit for sea disposal would be required (*refer* **Section 3.2.4**), and given that options exist for reuse of dredged material, it is unlikely a permit would be granted.

6.2.3 Reuse

There is a financial advantage of reuse over disposal as solid waste or sea disposal as extracted material can be sold. Sale of dredged material for reuse can create additional funds which can be put back into the project to offset dredging costs. This has been done successfully in the past for other large scale dredging projects, where the quality of the extracted material is suitable.

The Pilot Study (*WorleyParsons, 2013*) assessed samples taken against the National Environment Protection (Assessment of Site Contamination) Measure[1] (the NEPM), relevant should the dredge material be considered for reuse on land such as on playing fields or as beach nourishment material. NEPM criteria that apply to the Hawkesbury River dredging project include:

- Health Investigation Levels (HIL's[2]) and Health Screening Levels (HSL's3) Category C developed open space or recreational areas; and
- Ecological Investigation Levels (EIL's[4]) for urban residential and open public spaces.

Individual results and the mean concentration of each contaminant for each of the seven priority area sample locations were found to be below the HILs and HSLs Category C. While no reuse criteria are available for tributyltin (TBT), the concentrations of TBT were found to be below the analytical limit of reporting (LOR) in all sediment core samples at all sample locations suggests that TBT is unlikely to be a contaminant of potential concern in sediments in the study area.

Due to the small number of samples collected for each priority area in the pilot sediment investigation, there may be additional sampling and testing requirements and restrictions applied to the dredging and beneficial reuse of the sediments. Additional sampling and testing requirements would need to be addressed in an environmental assessment for any future proposed dredging and disposal works.

To produce saleable sand, the dredged material would require washing and screening. An on-site facility (or facilities) would be required to do so. This laydown and facilities area would ideally need to be close to the river to allow for material transportation directly from transport barges or pipeline and discharge of clean water from dewatering operations, have adequate access or large road vehicles to remove sand for market and have sufficient area for dewatering, washing, screening and stockpiling of sand.

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[1] A draft version of the NEPM released in 2010 was used.

[2] HILs - Health investigation levels are generic and apply across Australia to all soil types generally to a depth of 3 m below surface.

[3] HSLs - Health screening levels for petroleum hydrocarbons depend on physicochemical properties of soil as it affects hydrocarbon vapour movement in soil and the characteristics of building structures. They apply to different soil types, land uses and depths below surface to >4 m and have a range of limitations.

[4] EILs - Ecological investigation levels depend on specific soil physicochemical properties and land use scenarios and generally apply to the top 2 m of soil.

6.2.4 Recommended Disposal Approach

Where possible, it is recommended that dredge material is sold as opposed to disposed of as soil waste as this gives opportunities for the funding of ongoing dredging activities. The cost assessments considered in this investigation have assumed that dredged material will be sold where possible and revenue derived from the sale used to fund the ongoing project.

7. MARKET CONDITIONS FOR SALE OF DREDGED MATERIAL

The ability to utilise the sale of dredged material is dependent on the nature of material dredged and the proximity to a suitable market. If dredged material cannot be sold or beneficially reused, it would need to be side-cast into waters adjacent to the dredge channel, disposed of at sea or disposed of as solid waste (*refer* **Section 6.2**). It is anticipated that any revenue from the sale of dredged material would be expected to be reinvested in the dredging project itself.

7.1 Market Price

Market price is largely affected by market demand, particularly within the local region. As construction continues regardless of the price of sand, demand for sand is rather inelastic, ie construction is not greatly affected by the price of sand. Likewise supply of sand is also rather inelastic as large scale sand extraction operations would likely suffer costs if they temporarily ceased extraction due to low prices. Rather sand would be stockpiled and sold at a later date.

The ‘gate price’ is the sale price of dredge material after extraction and processing and is the price paid by users to the supplier. The gate price should exceed the sum of the following costs in order to generate a return from sale:

- Cost of extracting the dredge material;
- Cost of processing the extracted dredge material;
- Royalty costs, fees, licences etc; and
- Transport costs.

Estimated costs of typical dredge projects undertaken by the former Land and Property Management Authority (LPMA) are shown in **Table 7-1**. These figures identify dredge costs in the order of $10 to $15 per cubic metre (*refer* **Table 7-1**). As such, the gate price would need to be higher than this for any profit to be made through the sale of sand.

Table 7-1 Estimated cost of Typical LPMA Dredging Projects

Category	Quantity	Indicative Cost
Major Dredging	60,000 cubic metres	$600,000 - $800,000
Medium Dredging	30,000 cubic metres	$400,000 - $500,000
Minor Dredging	20,000 cubic metres	$300,000 - $400,000

Source: Moses and Ling, 2010

The price of sand varies across the Sydney markets depending on its location, source and quality, if it has been screened and washed and the required end use. Through contact with sand suppliers in Sydney[5], prices per cubic metre tend to vary between $20 and $40 a cubic metre generally being at the upper end of this bracket. Some of these suppliers are not wholesale and as such the prices would be higher than those gained from the Hawkesbury River sand.

WorleyParsons adopted sale price of $25 per cubic metre based on information presented in the Construction Sand Product Snapshot *(Sydney Construction Materials, 2010).*

7.2 Selling Removed Material

Past dredging projects have sought to reduce overall dredging costs through partnerships and identifying beneficial uses of dredged sediment. Such practices can also have the benefit of funding for more material to be dredged assisting on ongoing project costs. For example, maintenance dredging projects in the Swansea Channel and Myall River utilised commercial sale of dredged material to offset the costs of dredging, as documented by Moses and Ling *(2010).* The Myall River project was completed for a net cost of $295,000. It was estimated that savings of over $250,000 were achieved by the sale of material to the private sector and the reinvestment of this income into the project.

Based on the Myall River example, up to 50% of dredging costs of the Hawkesbury River could potentially be offset through the sale of dredged material, however this is strongly influenced by the quality of dredged material and market demand.

In the case of the Hawkesbury River where the sand quality could be made suitable for construction following washing and screening, the percentage saving may not be expected to be as significant as the Myall River which comprised clean sand which did not require significant processing.

The bed of Myall River is Crown Land, as is the Hawkesbury River, and as such, the commercial sale of the dredged material required special approval from the Crown Lands (then LPMA). This approval was provided with the condition that all funds from the sale of dredged material were reinvested into the project *(Moses and Ling, 2010).*

7.2.1 Encourage Competitive Tendering

Including in the tender document flexible provisions to enable the successful contractor to use and sell dredge material at their will and risk, can have the beneficial effect of reducing tendered rates for the work. This model for tendering was successfully used in The Swansea Channel Project, Lake Macquarie *(Moses and Ling, 2010).* In addition, allowing flexibility in disposal options and allowing consideration for both hydraulic and mechanical dredging, give more variability, and can encourage competitive innovation in the tenders.

[5] Websites for several sand suppliers in Sydney were reviewed for the price of Sydney sand similar to the quality of sand which would be extracted from the Hawkesbury River.

7.2.2 Additional Costs Associated with Sale

As the dredged material is within Crown Land, as well as the licences and permits discussed in **Section 3.2** relevant to the dredging activity, royalty payments on any extracted material sold will be payable to Crown Lands.

Table 7-2 Estimated Additional Costs Associated With Sale of Dredge Material as Opposed to Straight Disposal

Item	Cost per m^3 ($)	Cost per tonne ($)	Comment
Royalties	$0.45	$0.70	Payable to Crown Lands
Washing and Screening (including materials handling)	$ 10.00	$ 6.25	
Longer term stockpiling (for later sale)	$ 2.80		Refer.
Other			Road maintenance contributions

Note: Table above only includes costs that occur with sale of dredged material and not the actual cost of dredging. These costs are additional to the dredging project costs should the dredged material be sold. 1 m^3 of sand is assumed to have a mass of 1.6 tonnes.

7.2.3 Stockpiling Versus Immediate Sale

Given that there is sufficient demand within the Sydney Region for construction sand, it is likely that there will be possibilities for immediate sale and significant stockpiling will not be necessary. However, stockpiling for sale at a later date can have the benefit the vendor by selling when market prices are higher. Planning for sale would be based on speculation sand prices may increase due to increased demand in the building market combined with dwindling supply from other sources. In some instances where other factors are not more influential, holding back sand can limit supply, thus increasing demand and drive up the market prices.

Stockpiled sand can be sold once market prices have risen. Nonetheless, this type of market influencing, based purely on stockpiling of sand from the Hawkesbury River, is unlikely to make a significant price difference in a market where demand already outweighs supply (*refer* **Section** ___Error! Reference source not found.), given that there are other extraction operations within the Sydney Regional area and local Hawkesbury area and also the smaller volume of supply of the Hawkesbury River source compared to other major sand mining operations in the Region.

While holding back supply may not have a significant influence on price, where cost of stockpiling is less than the cost of a low sale price, option to hold back sand for sale later at a higher price could be beneficial. Such as approach would be based on market speculation.

Stockpiling can also give rise to addition risk of damage to material or material loss due to unexpected and unforeseeable events such as flooding, theft, vandalism etc. There is also the financial risk should markets not move in the direction expected. In addition, costs associated with stockpiling may not make stockpiling economically feasible.

Selling processed sand as soon as possible has the benefit of reducing stockpiling costs and also can allow for an immediate injection of funds back into the dredging project thus reducing negative cash flow. Assuming a sale price of $ 25 per cubic metre and stockpiling costs in the order of $ 2.80 per m^3, stockpiling costs will make up for approximately 7.5% of the sale price. As market prices increase, the cost of stockpiling becomes a lower influence on potential profit.

8. COST ASSESSMENT

8.1 Assumptions

The cost of a dredging project can vary significantly as a function of a range of factors including the following:

- Quality of dredged material
- Proportion of contaminants
- Sites conditions
- Access and extraction methods
- Scale of the dredging to be undertaken – depth and area
- Opportunities for sale or reuse
- Stockpiling time
- Availability of contractors and whether they are "geared" to undertake the work
- Fees, licences and royalties
- Market forces at the time

There are also a range of assumptions that invariably need to be made.

The cost estimates that have been developed as part of this investigation are based on the following assumptions:

(i) Average dredge rate per day of 10,000 m^3

This is based on similar projects such as the dredging of Botany Bay in the vicinity of the Kurnell Refinery Wharf (*WorleyParsons, 2012*)

(ii) One large dredging vessel operating at the site only

(iii) No night time dredging

(iv) Transport of dredge material to shore will occur using barges

(v) Dredging is to achieve a navigable fairway with a 3 metre functional depth below MLWS and a minimum of 50 m wide (ideally 100 m where possible)

(vi) Existing bed terrain is defined by the 2011 hydrosurvey

It is known from soundings of the Hawkesbury River undertaken by RMS in 2012 that some change to the river bed geometry occurred in the period after the 2011 survey (WorleyParsons, 2012). *This probably a consequence of the minor flood that occurred in 2012. A further flood occurred in 2013 and may have altered bedforms further. Notwithstanding, the 2011 survey provides the latest most complete definition of channel geometry and has been adopted for the purpose of defining dredge quantities.*

(vii) Washed and screened sand derived from dredging will be stockpiled at selected locations along the river for up to one year (so can be held back for sale at higher price is needed)

(viii) After washing and screening, 90% of the dredged material is appropriate for sale

This assumption is based on the findings of the Pilot Study (WorleyParsons, 2013)

(ix) Adopted Market Price of $25/m^3 for construction sand

(x) Application of a 40% contingency to all costings

8.2 Cost Estimates

An estimate of the costs associated with dredging, including investigations into proceeds from the sale of dredged sand to the Sydney construction market, was undertaken for each of the priority dredging locations. The cost to undertake dredging over the full length of the study area was also determined.

The cost estimates were based on WorleyParsons' experience with similar projects (*such as the dredging of Botany Bay in the vicinity of the Kurnell Refinery Wharf*), reference material (*e.g. 'Rawlinson's Construction Handbook'*) and discussions with vendors and operators. A 40% contingency was added to the WorleyParsons estimate due to uncertainties in the rates and quantities.

In costing, WorleyParsons adopted a market price of $25/m^3. This rate is based on information presented in the Construction Sand Product Snapshot (*Sydney Construction Materials, 2010*).

Costs associated with dredging can vary depending on the volume and nature of material to be extracted, as well as the end use of the extracted material. A large component of dredging costs is associated with site establishment and disestablishment. The cost estimates for each of the priority locations assumes that each area will be dredged independent of the others and as such separate costs for mobilisation and site establishment apply to each site.

Table 7.1 lists the total costs associated with undertaking the dredging required to achieve a functional depth of 3 metres below MLWS across the required fairway width at each of the priority dredge locations. The table also lists the revenues that would be derived from the sale of the dredged material. A detailed breakdown of costs on which these estimates are based is provided in **Appendix F**.

As shown in the detailed breakdown of costs (*refer* **Appendix F**), items related to mobilisation and project set-up are amongst the largest component of the costs. Hence, the economies of scale associated with undertaking Dredging Option HR1 result in significant savings and cost efficiencies; that is, it would be more cost effective to dredge the entire study area rather than individual priority areas, albeit that the up-front capital cost of Option HR1 is substantial at a nett cost of $22.1M.

For most priority areas, the revenue from sale equates to about 15% to 25% of the total project cost. Assuming money made from sale is injected back into the project, savings in the total project costs of about 20% can be achieved for most of the priority areas.

Table 8-1 Estimated Dredging Project Cost Estimates

Dredging Option	Location Description	Volume of Dredged Material (m^3)	Total Project Cost Estimate	Revenue from Sale	Net Cost
BP1	Ben's Point	46,700	$5.2M	$1.1M	$4.1M
PT1	Pitt Town Bottoms	49,100	$5.3M	$1.1M	$4.2M
SP1	Sandy Point (includes area into meander)	140,200	$8.0M	$2.3M	$5.6M
SP2	Sandy Point (area at upstream of meander only)	32,700	$4.5M	$0.75M	$3.8M
CC1	Cattai Creek	40,100	$4.9M	$0.90M	$4.0M
CC2	Cattai Creek (including additional downstream area)	87,000	$7.2M	$2.0M	$5.2M
EC1	Ebenezer Church (area downstream of Ebenezer Church and upstream of Sackville Gorge)	48,500	$5.3M	$1.1M	$4.2M
SG1	Sackville Gorge	59,500	$5.8M	$1.3M	$4.5M
SF1	Sackville Ferry (straight reach upstream)	173,900	$11.4M	$3.9M	$7.4M
HR1	Entire Project area where functional depth is currently less than 3 m	830,700	$40.7M	$18.6M	$22.1M

Note: Full details provided in Appendix F

However, if dredging of the entire study area to achieve a functional depth of 3 metres were adopted, the improved efficiencies combined with the revenue from sales would result in a 45% saving on total project costs.

9. ADDITIONAL FUNDING OPPORTUNITIES

9.1 NSW Office of Environment and Heritage

The NSW OEH offer a range of grants and funding opportunities. Relevant to dredging of Hawkesbury River could be;

- Coastal and Estuary Management Grants under the Coastal Management Program – it is not expected that dredging of the Hawkesbury River, within the study area location, will be eligible for funding under these programs;
- Floodplain Management Grants – funding comes from two programs, the NSW Floodplain Management Program and the Floodplain Risk Management Grants Scheme. Under the Floodplain Management Program, assistance under the program is normally offered by the State Government providing $2 for every $1 provided by local councils. The program aims to manage flood risk. Should dredging be seen as a flood risk management solution then funding may be available through this source; and

9.2 Private or Other Public Authority Sponsorship

Sponsorship can be limed to a particular reserve trust project. The Trust Handbook (2007) notes that sponsorship can be:

- "linked to a particular reserve trust project – such as regeneration of a piece of bushland, replacing warning signs, providing enhanced visitor facilities; or
- monetary or in-kind – such as providing plants for a regeneration project or building materials for maintenance of reserve trust assets."

Sponsors are particularly effective for those reserve trusts where public visitation or promotion of reserve trust achievements is high.

9.3 Crown Land Funding

For Crown Land Reserves, grants and loans are available to Reserve Managers to facilitate development and maintenance and to improve land and facilities. There are several potential additional sources of funding which are outlined in the following.

9.3.1 Rescuing Our Waterways Program

The *Rescuing our Waterways* program is a part of the Government's Sustainable Dredging Strategy and provides a coordinated approach to improve the accessibility and health of our waterways. Through the Program local government can apply for dollar for dollar funding for dredging projects that would make significant improvement to navigability of waterways. As a number of projects compete for funding, funding is allocated on the basis of the benefits that the project can provide; that is not just for improved navigability but also environmental, social and economic benefits where they occur.

Previously Hawkesbury City Council has received funding under the Program, matching Council's contribution, to undertake investigations into dredging at the seven priority locations. The purpose of the funding was to improve navigation along waterways through small to medium scale dredging activities (WorleyParsons, 2012).

The program has previously funded dredging projects including;

- navigation for a range of vessels (recreational, tourism and commercial);
- access to public waterway infrastructure such as boat ramps and wharves;
- tidal flushing and/or tidal range;
- dredging strategies and/or their supporting studies (e.g. sediment hydrodynamics); and
- pre-dredge activities for projects which are eligible and likely to proceed to dredging.

9.3.2 Public Reserves Management Fund Program

The Public Reserves Management Fund Program (PRMFP) is administered by Crown Lands and provides financial support for maintenance and improvement of public reserves. The PRMFP is an annual program, providing grants and low interest loans to eligible applicants through a competitive application process. Guidelines for the PRMFP suggest that requests for funding over $50,000 are more likely to be successful if they are for a loan rather than for a grant. Given the estimated costs for dredging the Hawkesbury River, Hawkesbury City Council would be more likely to obtain a low interest loan than a grant through this program.

Managers of Crown Land Reserves can be eligible to apply for either a grant or loan through the PRMFP. Generally there should be only one application submitted per Reserve and multiple projects or activities for a single reserve should be combined into one application. Should one project / activity encompass multiple reserves, then only one application needs to be submitted. Hawkesbury City Council will need to liaise with the Reserve Manager to arrange any applications through this process.

It is possible that an organisation, such as Hawkesbury City Council, can apply or funding on behalf of the Reserve Trust as long as they have written authority, however, payment will still be made to the Trust and not to the applicant. Therefore should Hawkesbury City Council be successful in securing funding through this program, they will need to arrange with the Trust for disbursement of funds.

Requests for PRMFP monies totalling over $50,000 require the completion of a 'Financial Summary Statement' (excel spread sheet), which includes more detailed financial information about the Reserve Manager. In addition, for project elements between $ 30,000 and $ 250,000 at least three written quotes are required to be submitted with the funding application. For projects costing less than $ 30,000 only one quote is necessary, while projects greater than $ 250,000 an acceptable cost estimate and commitment to procurement via public tender will be required. It is likely that the preferred dredging option for the Hawkesbury River will require public tender.

To be eligible for funding, the activity should be consistent with the Public Reserves Management Fund Act 1987 (refer **Section 3.1.1**). In addition, should funding be granted, terms usually include a time limit for the completion of the activity and post-activity report. Generally it is expected that the reserve trust will need to complete the activity within 12 months of the deposit of funds.

10. ENVIRONMENTAL AND SOCIAL COSTS AND BENEFITS OF DREDGING

Some areas of the river retain significant natural values, in particular around Sackville Gorge. The river is an important natural feature of the municipality and highly regarded for its aesthetics and role in the local ecosystem. While dredging activities have the potential to have adverse effects on the surrounding areas, careful planning of dredging projects can also allow for opportunity to provide environmental and social benefits. For any dredging project on the Hawkesbury River a SEE or EIS will be required under the *EPA Act* (*refer* **Section 3.1**).

10.1 Channel Stability

The cross sectional area of the Hawkesbury channel is naturally changing overtime, as observed from analysis of 1978, 1987-88 and 2011 hydrosurvey data (refer **Appendix A**). Flood events, natural river processes, as well as anthropogenic activities have caused these changes.

Dredging too close to channel banks or land based dredging, could cause river banks to become unstable. Ultimately this would result in increased erosion, usually in the form of bank slips, altering the channel cross-sectional area, changing bank habitats and increasing sediment within the river. Careful dredging techniques, and ensuring a suitable bank slope where banks are naturally formed, will reduce this risk. Previous bank regrading has been subject to erosion with the exception of banks with a suitably engineered toe *(Clarke & Geary, 1987).*

10.2 Water Quality

All dredging activities, by their nature, disturb bed sediment thus causing some increase in suspended sediment within the river. Generally the impact of this is likely to be localised to the active dredge area and is short term occurring at the time of dredging.

Suspended sediment can also be returned to rivers through washing operations, if suspended sediments are not allowed to settle out before “clean” water is returned to the river.

10.3 Fauna and Flora

As a result of increased turbidity due to dredging activities and the subsequent effect on water quality, habitats for particular water borne species may be temporarily altered, thus potentially leading to a reduction the species populations in the area. Given that dredging is a temporary process, and the location of any in river dredging equipment will move over time, this would be a temporary issues localised to the area of dredging at the time. Alteration of bank habitats as a result of dredging is likely to be a longer term issue. However, once a preferred dredging solution is identified, assessment of fauna and bank habitats is likely to be required.

Details of searches for threatened and endangered species and communities are presented in *The Hawkesbury River Dredging Investigations (WorleyParsons, 2012)*. This included searches using:

- OEH Atlas of NSW Wildlife for species listed as threatened under *the NSW Threatened Species Conservation Act 1995;*

- Threatened fish species listed under the *NSW Fisheries Management Act 1994;*
- Department of Primary Industries (DPI) Fisheries record viewer;
- NSW Industry and Investment research surveys in the Hills Shire LGA; and
- Protected Matters Search Tool on the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) web page.

A number of threatened or endangered species were noted at occurring in the project area, including birds, mammals, fish and plant species including a migratory species. Additionally, two Nationally Important Wetlands occur in the project area; Pitt Town Lagoon, south of the Pitt Town Bottoms priority area and Longneck Lagoon, south of the Cattai Creek priority area. One National Heritage Place, First Hawkesbury Farms, is also in the vicinity of the study area.

Implications of the presence of these species and heritage areas may mean restrictions on dredging activity both in the channel and associate on shore facilities and laydown areas. An assessment of the likely impacts on these matters would be required to determine if any proposed dredging would be likely to cause a significant impact and require referral to the Government Minister for the Environment, Heritage and the Arts (the Minister) under the *EPBC Act* (*refer* **Section 3.1**).

With regard to dredging activities the *Matters of National Environment Significance, Significant Impact Guidelines* (Commonwealth of Australia, 2013) state that:

> *"Dredging of a new shipping channel through a World Heritage property, a National Heritage place, through or next to the Great Barrier Reef Marine Park, a RAMSAR wetland, or an area containing nationally listed threatened species or ecological communities, or which involves modifying an area of important habitat for a nationally listed migratory species, is likely to have a significant impact on a matter of national environmental significance. Dredging to maintain existing navigational channels would not normally be expected to have a significant impact on the environment where the activity is undertaken as part of normal operations and the disposal of spoil does not have a significant impact."*

Given that some threatened species have been identified in the project area approval may be required. A full assessment should be undertaken for the Preferred Option. However, where measures to avoid impacts on a matter protected by the EPBC Act are proposed, approval may not be required as long as the project proceeds as *not controlled action 'particular manner'* (i.e. approval is not required as long as the action is taken about in accordance with a manner specified when referred to the Minister).

10.4 Social and Economic Effects

One of the key reasons for investigating the options for dredging the Hawkesbury River is the social benefit associated with increased navigability of the river. Increased navigability will allow for increased tourism and leisure uses, as well as potentially allowing for larger commercial vessels to use the river. As a consequential effect of increased river use, there could be benefit for local business who business is focused around river activities. Increased tourism also leads to an injection in to the local economy.

10.5 Cultural and Heritage Effects

A *Basic Search* of the OEH Aboriginal Heritage Information Management System (AHIMS) showed that no declared Aboriginal places were shown to occur in the project area although a number of Aboriginal sites are recorded in or near the project area *(refer Appendix D of WorleyParsons, 2012).* Some of these Aboriginal places occur on or close to the banks of the river and could be affected if dredging occurs in these areas. An Extensive Search would be required for input into any EIA or similar environmental Assessment for the Preferred Option.

A number of heritage items occur adjacent to the river in both the Hawkesbury and Hills Shire LGAs. These items are identified in the existing and LEPs for these LGAs (*refer* **Section 3.1.3**), as well in the Hawkesbury-Nepean River SREP and on the State Heritage Register.

10.6 Flood Risk

By increasing the potential volume of the channel, there is also potential to provide benefit in terms of reduced flood risk. The potential to dredge the Hawkesbury River to reduce flood levels has been investigated in the past and is outlined in the report titled *Sand Resources of the Hawkesbury River System Between Windsor and Brooklyn (Neville, 1976).* The ongoing Hawkesbury-Nepean Valley Flood Management Review[6] has also considered dredging as an option for reducing flood risk in the Hawkesbury area.

10.7 Other Environmental Effects

As well as the effects discussed above, temporary effects of the dredging project would be associated with:

- Noise from dredging equipment, both in river and on land;
- Increased traffic due to transport of dredged material to locations for end use;

[6] http://www.water.nsw.gov.au/Water-management/Water-availability/Flood-management/Hawkesbury-Nepean-Valley-Flood-Management-Review/Hawkesbury-Nepean-Valley-Flood-Management-Review

11. CONCLUSIONS

Investigations undertaken for this report have established that there are areas of the Hawkesbury River between The Breakaway and Sackville Ferry where functional water depths are less than 3 metres and fairway widths are less than 100 metres. In fact, there are some areas where the fairway width is less than 50 metres.

Therefore, if safe navigation is to be defined by the provision of a fairway width of 100 metres and a functional depth of 3 metres below Mean Spring Low Water, it would be prudent for dredging to be considered in some areas.

This investigation has involved the development of a business case to support dredging where it is warranted. The business case has considered the volume of material that would need to be dredged to achieve the specified navigation criteria, and has combined this with the costs associated with undertaking the associated works and any revenue that might be able to be secured from the sale of dredged material to the market.

The business case has focussed on the 7 priority areas previously identified by Council (*2012 and 2013*), but has also considered other locations within the study area where dredging could be undertaken. The options with the greatest potential to be able to be supported from a business case perspective are as follows:

- Option SP1 – Sandy Point (full meander)
  - Volume = 104,200 m^3
  - Net Cost = $5.6M
- Option CC2 – Cattai Creek plus downstream meander.
  - Volume = 87,000 m^3
  - Net Cost = $5.2M
- Option SF1 – Straight reach leading into Sackville Ferry priority area.
  - Volume = 173,900 m^3
  - Net Cost = $7.4M

In each case, the “Net Cost” includes an allowance for the revenue that would be secured as a consequence of the sale of the sand component of the dredged material to the Sydney construction industry.

Dredging of the entire study area (referred to as Option HR1) is estimated to involve the removal of about 830,000 m^3 of material. This is estimated to cost $40.7M, but would deliver revenue associated with the sale of sand amounting to $18.6M. Hence, the nett cost of the project is estimated at $22.1M.

The business case assessment also established the following:

(i) No profit can be made from the “total” project

(ii) Sale of dredge material could fund 20% to 30% of the project cost in the case of individual priority areas. This increases to 45% in the case of undertaking dredging over the length of the study area as a function of the associated economies of scale.

(iii) The governing factors that influence financial viability are:

- Mobilisation and preliminary costs are significant due to the need to have multiple extraction and stockpile locations along 35 kilometres of river
- Cost associated with disposal of waste (*assumed 10% of dredge material is not suitable and goes to landfill*) are significant
- The larger the volume that can be dredged over one period the larger the % savings of the total project cost which can be made through revenue from saleable material.
- Local land based sand extraction areas exist nearby at Maroota, Calga and Somersby, and serve to provide competition that impacts on the potential sale price for sand that could be dredged from the river. These land based operations typically operate a lower overhead than a water based extractive industry and thereby reduce the viability.

----

12. REFERENCES

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Appendix A. 2011 Hydrosurvey Data

Appendix B. 2012 River Soundings

Appendix C. River Bed Change Terrain Mapping

Appendix D. Hydrosurvey Comparisons

Appendix E. Dredge Volume Analysis

Appendix F. Detailed Costings for Options

Appendix A

Hydrosurvey Data

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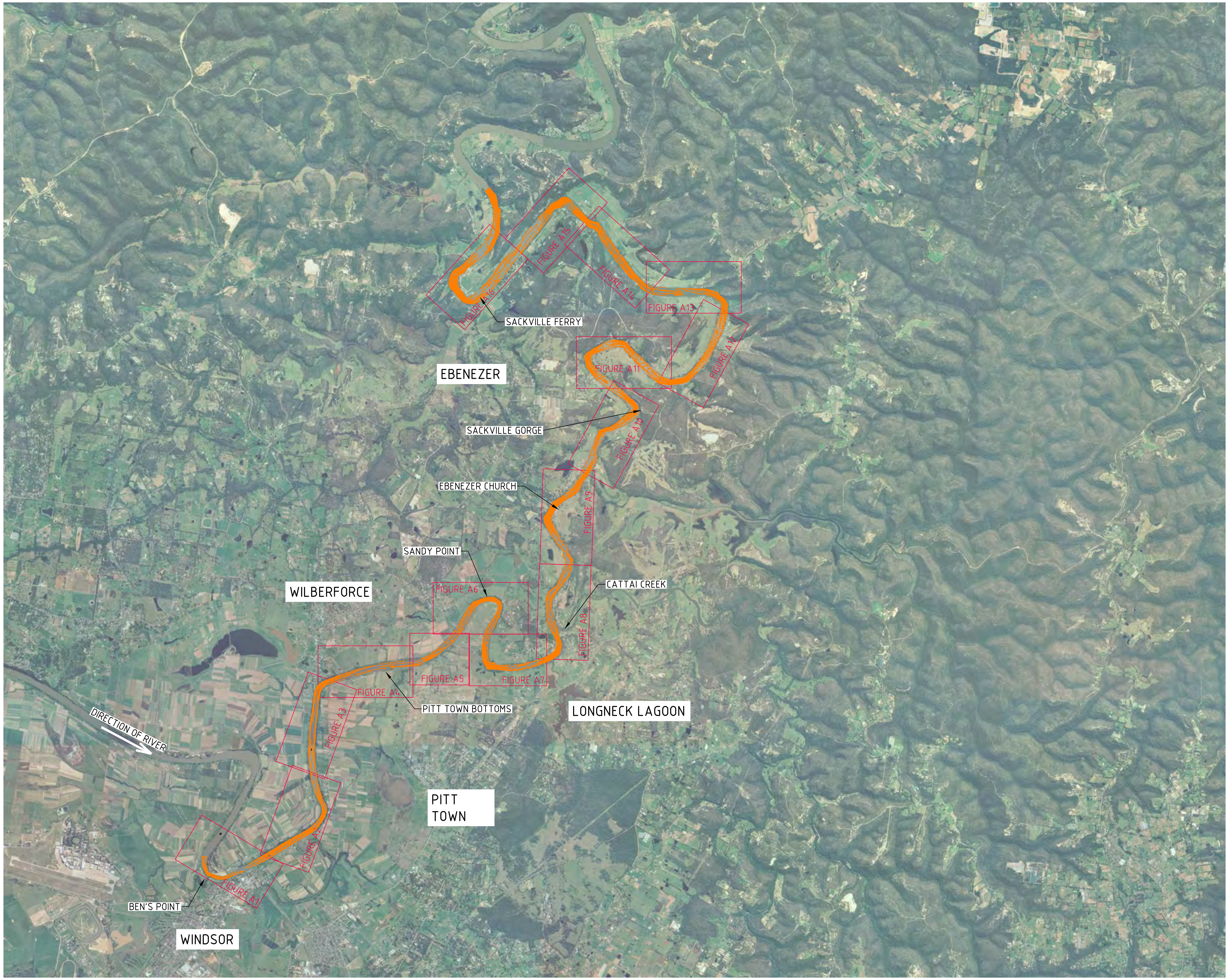

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OneWay to zero harm

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NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA
INDEX SHEET

FIGURE A

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CONTOURS SHOWN AT 1m INTERVALS

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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA
PRIORITY AREA: BEN'S POINT

FIGURE A1

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-2011 CONTOURS.DWG
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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA

FIGURE A2

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LEGEND

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CONTOURS SHOWN AT 1m INTERVALS

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ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA

FIGURE A3

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-2011 CONTOURS.DWG
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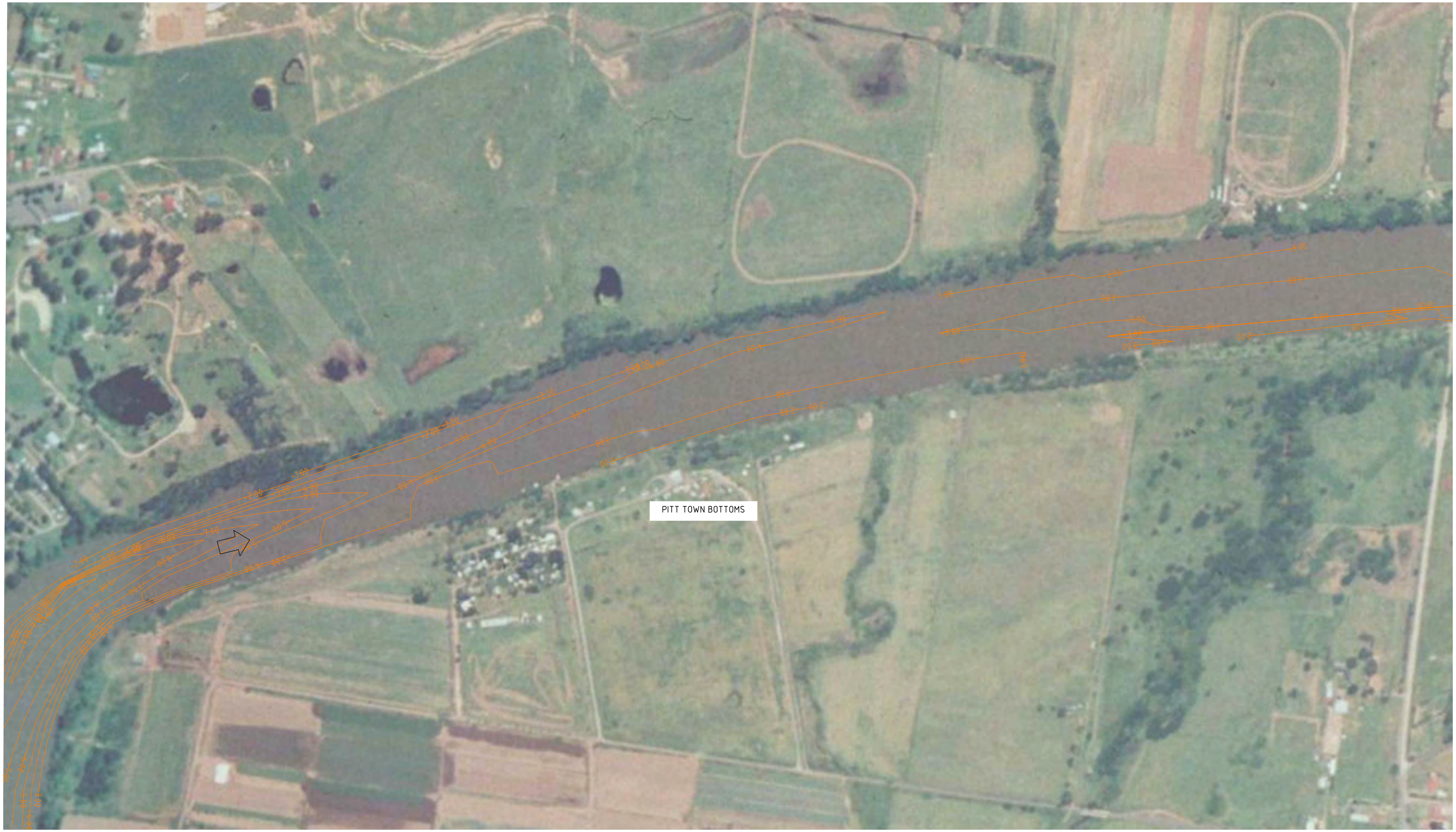

LEGEND

RIVER BED LEVEL CONTOUR (mAHD)
CONTOURS SHOWN AT 1m INTERVALS

PLAN
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OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA
PRIORITY AREA: PITT TOWN BOTTOMS

FIGURE A4

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-2011 CONTOURS.DWG
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CONTOURS SHOWN AT 1m INTERVALS

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1:2500 (A1) 1:5000 (A3)

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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA

FIGURE A5

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-2011 CONTOURS.DWG
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CONTOURS SHOWN AT 1m INTERVALS

PLAN
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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA
PRIORITY AREA: SANDY POINT

FIGURE A6

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-2011 CONTOURS.DWG
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PLAN

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LEGEND

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CONTOURS SHOWN AT 1m INTERVALS

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1:2500 (A1) 1:5000 (A3)

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HAWKESBURY RIVER DREDGING BUSINESS CASE

CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA

FIGURE A7

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-2011 CONTOURS.DWG

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CONTOURS SHOWN AT 1m INTERVALS

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1:2500 (A1) 1:5000 (A3)

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to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA
PRIORITY AREA: CATTAI CREEK

FIGURE A8

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-2011 CONTOURS.DWG
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CONTOURS SHOWN AT 1m INTERVALS

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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA
PRIORITY AREA: EBENEZER CHURCH

FIGURE A9

PLOT DATE & TIME: 31/7/2015 6:58:59 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-2011 CONTOURS.DWG
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HAWKESBURY RIVER DREDGING

AREAS WHERE DREDGING IS REQUIRED TO ACHIEVE A 3m FUNCTIONAL WATER DEPTH BELOW MEAN LOW WATER SPRING TIDE LEVEL

LEGEND

-2.00 RIVER BED LEVEL CONTOUR (mAHD)
CONTOURS SHOWN AT 1m INTERVALS

PLAN
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ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
A	31.07.15	ISSUED FOR CLIENT REVIEW	EN

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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA
PRIORITY AREA: SACKVILLE GORGE

FIGURE A10

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-2011 CONTOURS.DWG
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CONTOURS SHOWN AT 1m INTERVALS

PLAN
SCALE 1 : 2500

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1:2500 (A1) 1:5000 (A3)

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OneWay to zero harm

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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA

FIGURE A11

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LEGEND

-2.00 RIVER BED LEVEL CONTOUR (mAHD)
CONTOURS SHOWN AT 1m INTERVALS

PLAN
SCALE 1 : 2500

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1:2500 (A1) 1:5000 (A3)

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OneWay to zero harm

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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA

FIGURE A12

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-2011 CONTOURS.DWG
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CONTOURS SHOWN AT 1m INTERVALS

PLAN
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WorleyParsons
resources & energy

OneWay to zero harm

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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA

FIGURE A13

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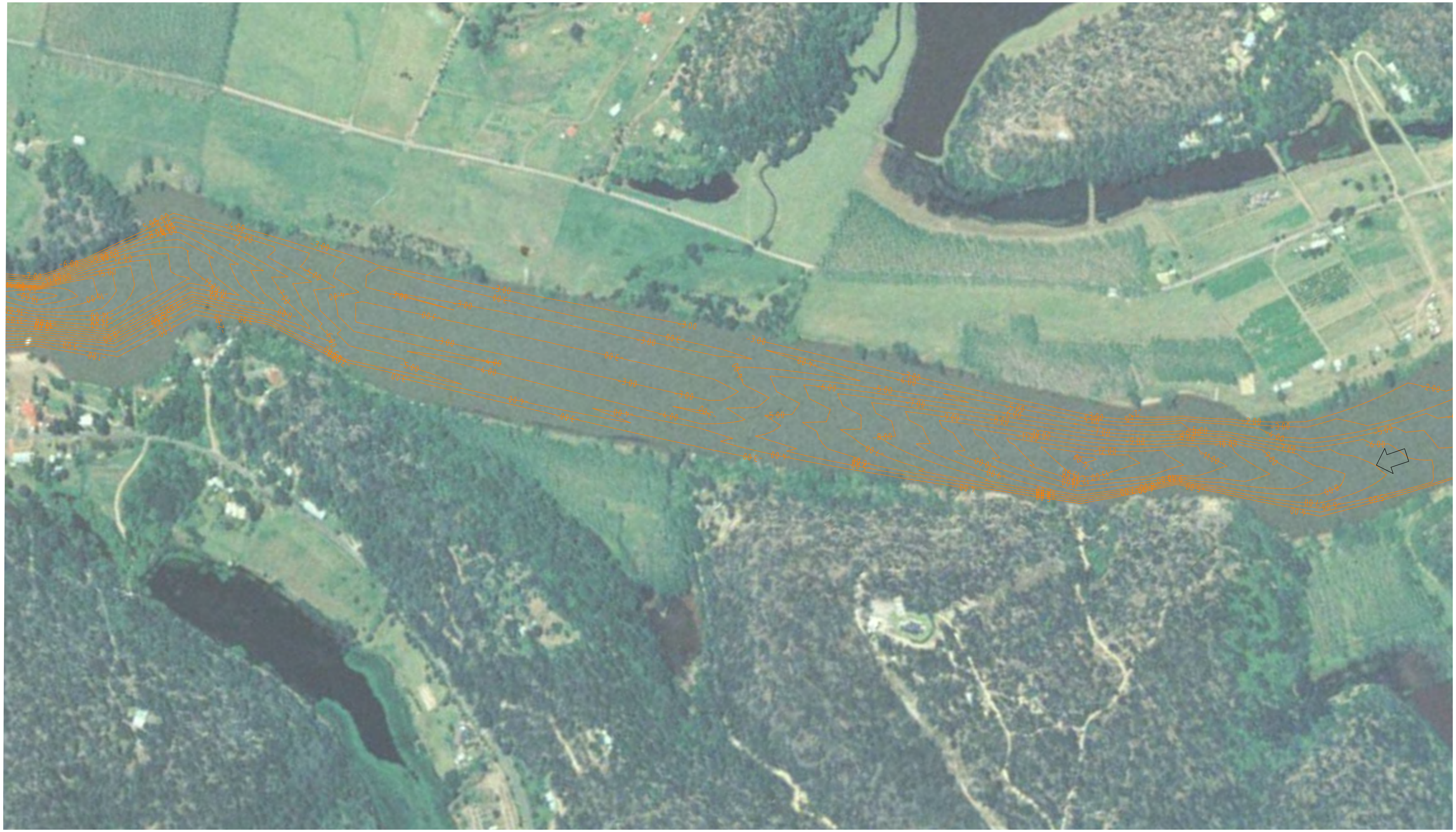

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CONTOURS SHOWN AT 1m INTERVALS

PLAN
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1:2500 (A1) 1:5000 (A3)

WorleyParsons
resources & energy

OneWay
to zero harm

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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA

FIGURE A14

PLOT DATE & TIME: 31/7/2015 6:59:10 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-2011 CONTOURS.DWG
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LEGEND

-2.00 RIVER BED LEVEL CONTOUR (mAHD)
CONTOURS SHOWN AT 1m INTERVALS

PLAN
SCALE 1 : 2500

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1:2500 (A1) 1:5000 (A3)

WorleyParsons
resources & energy

OneWay
to zero harm

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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA

FIGURE A15

PLOT DATE & TIME: 31/7/2015 6:59:13 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-2011 CONTOURS.DWG
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LEGEND

RIVER BED LEVEL CONTOUR (mAHD)
CONTOURS SHOWN AT 1m INTERVALS

PLAN
SCALE 1 : 2500

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1:2500 (A1) 1:5000 (A3)

WorleyParsons
resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
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HAWKESBURY RIVER DREDGING BUSINESS CASE
CURRENT RIVER BED LEVELS - 2011 HYDROSURVEY DATA
PRIORITY AREA: SACKVILLE FERRY

FIGURE A16

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-2011 CONTOURS.DWG
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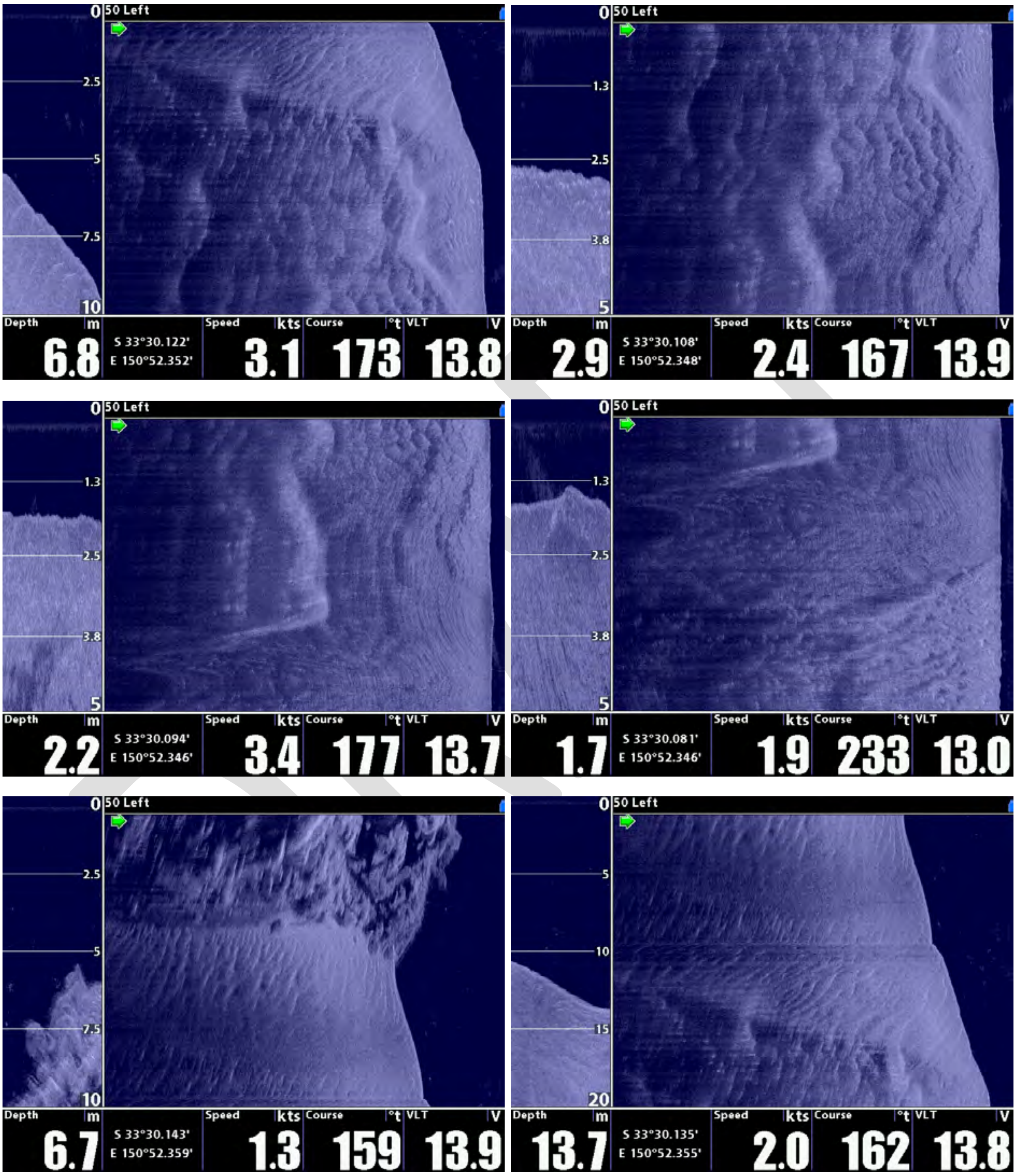
Appendix B

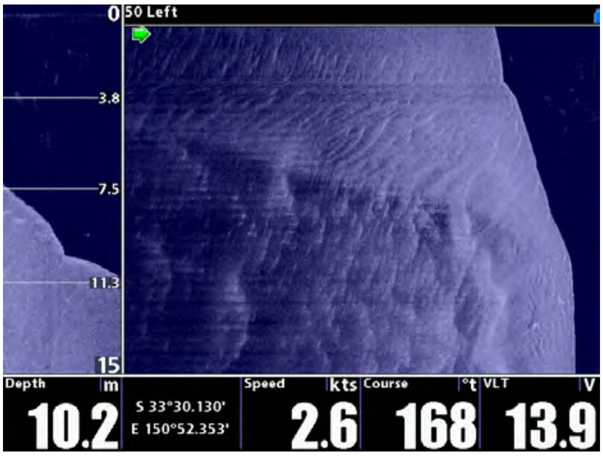
RMS 2012 River Soundings

WorleyParsons

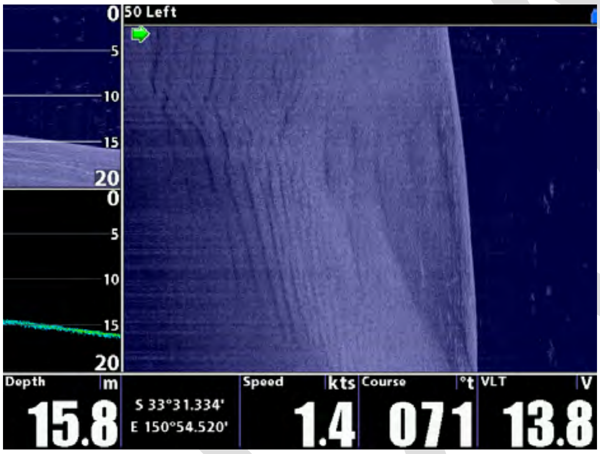
resources & energy

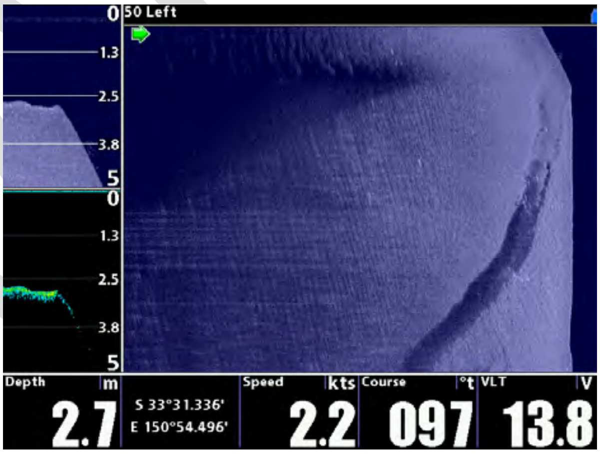
Sackville Ferry

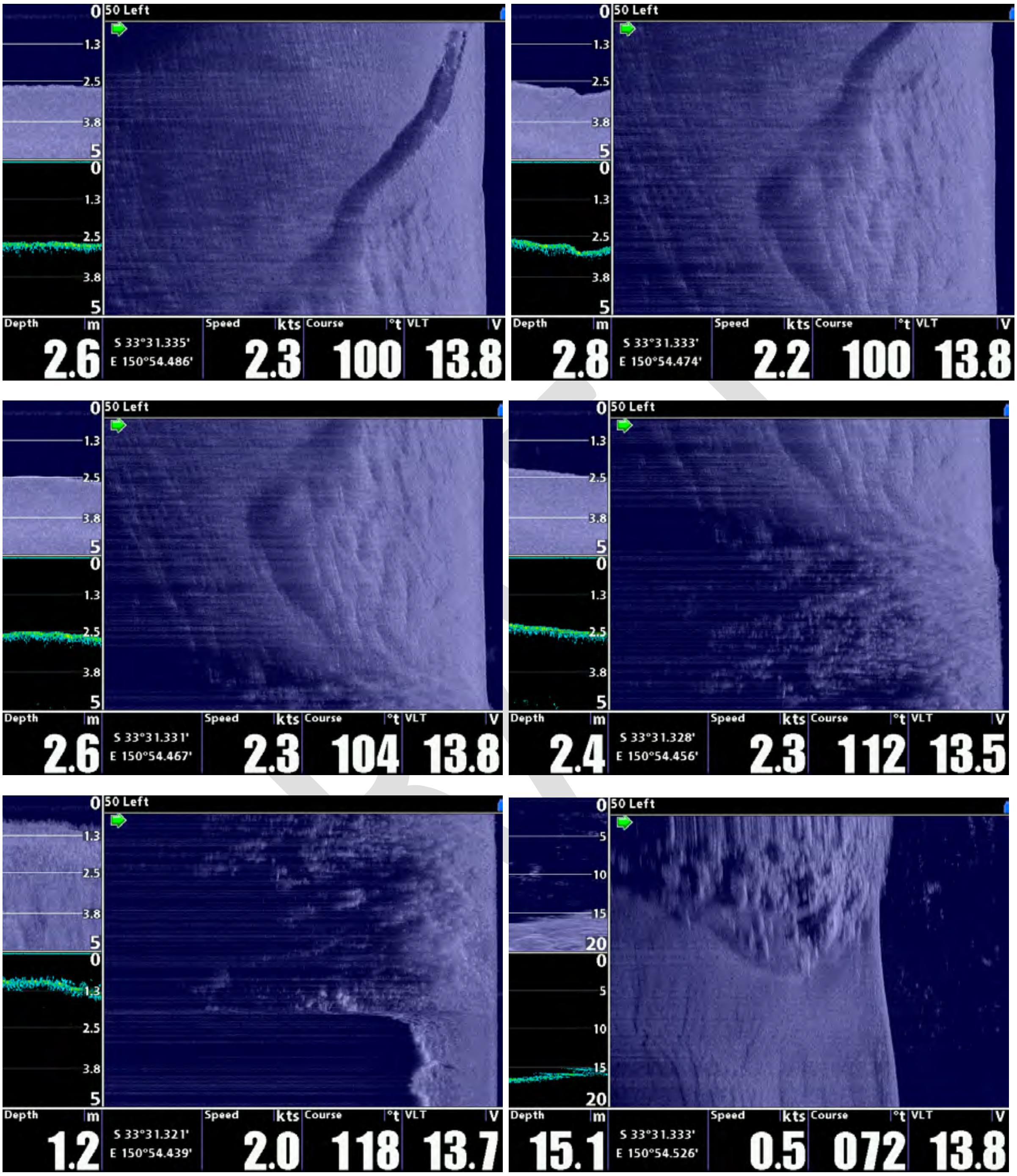




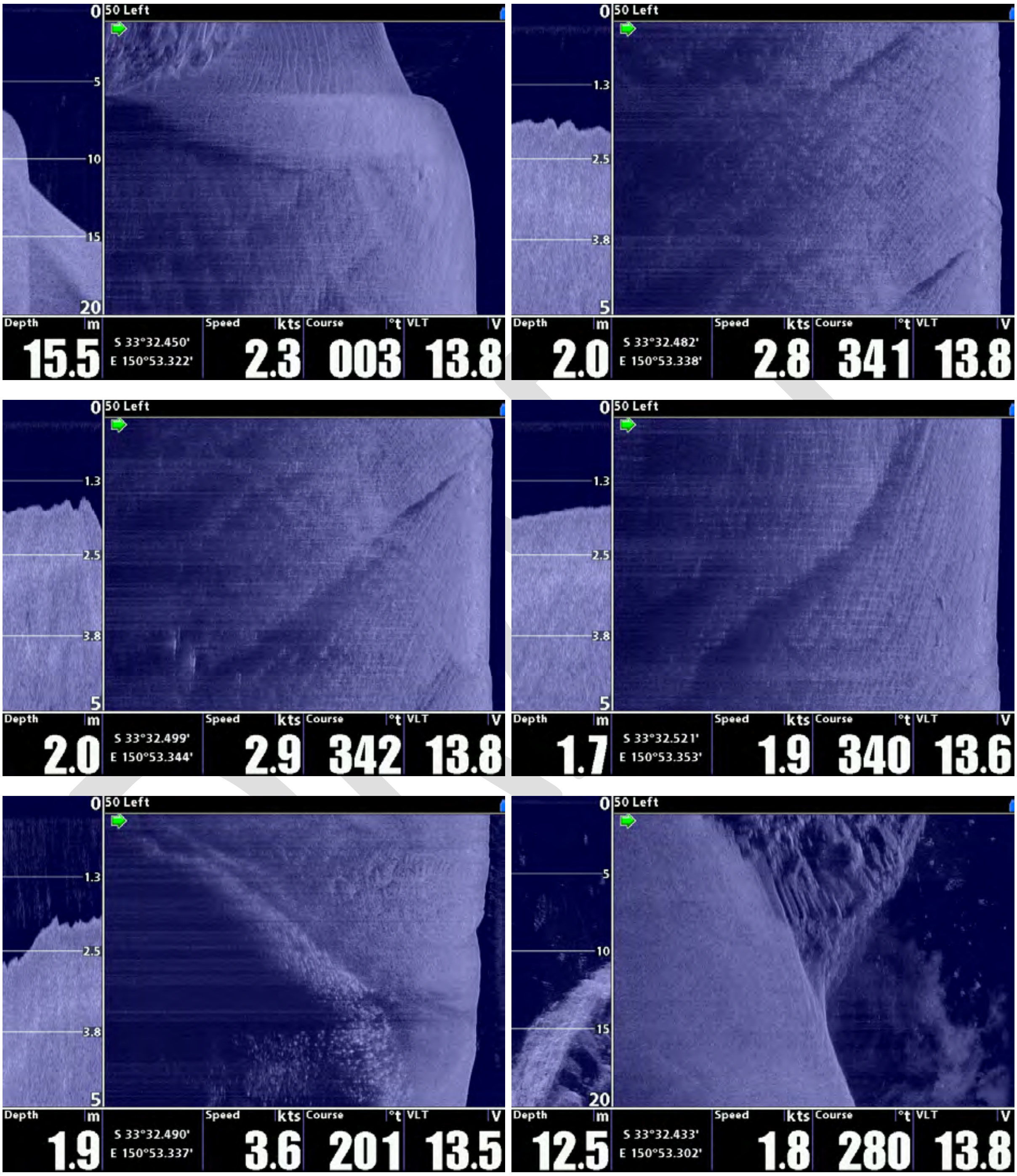
Sackville Gorge

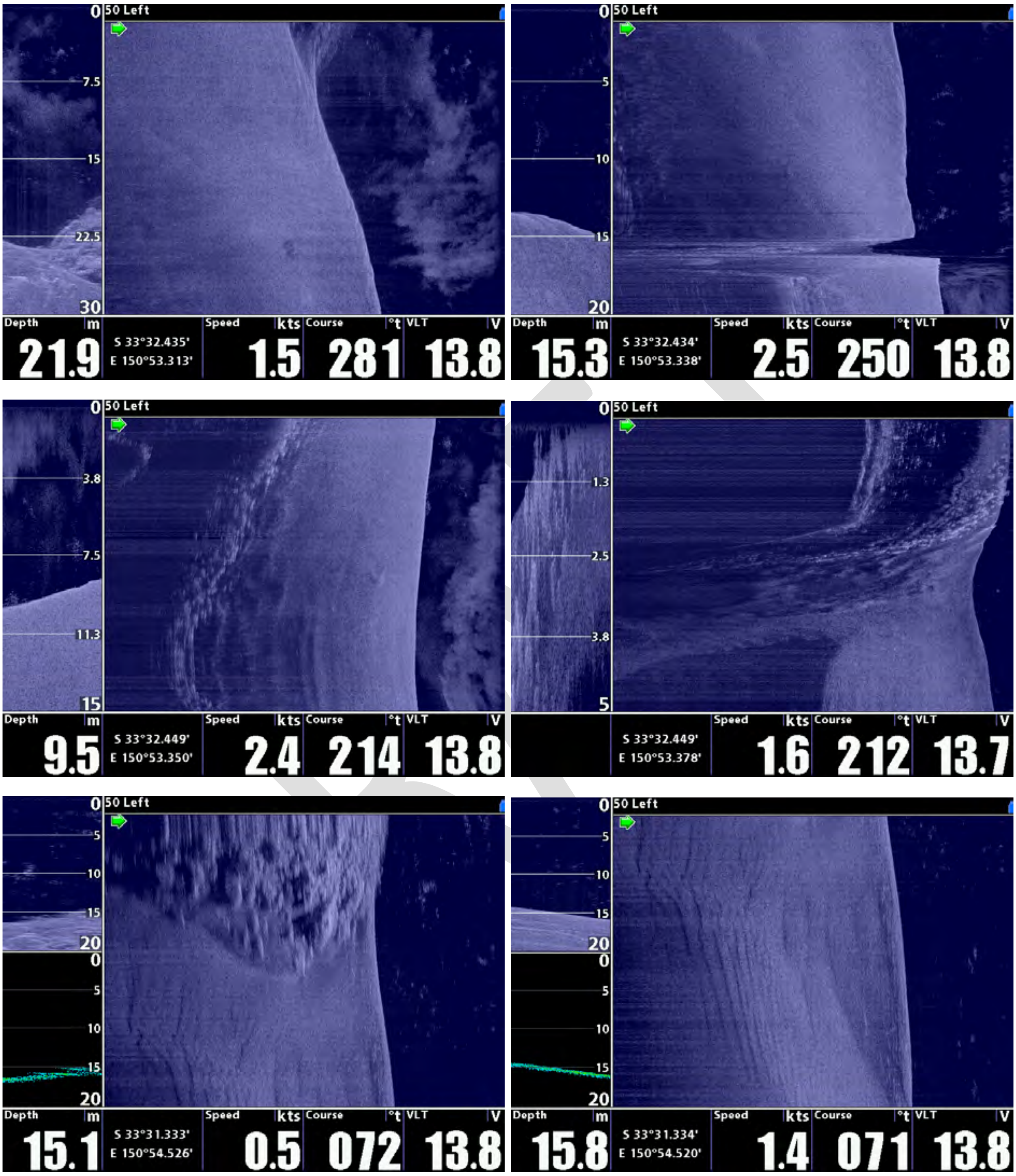


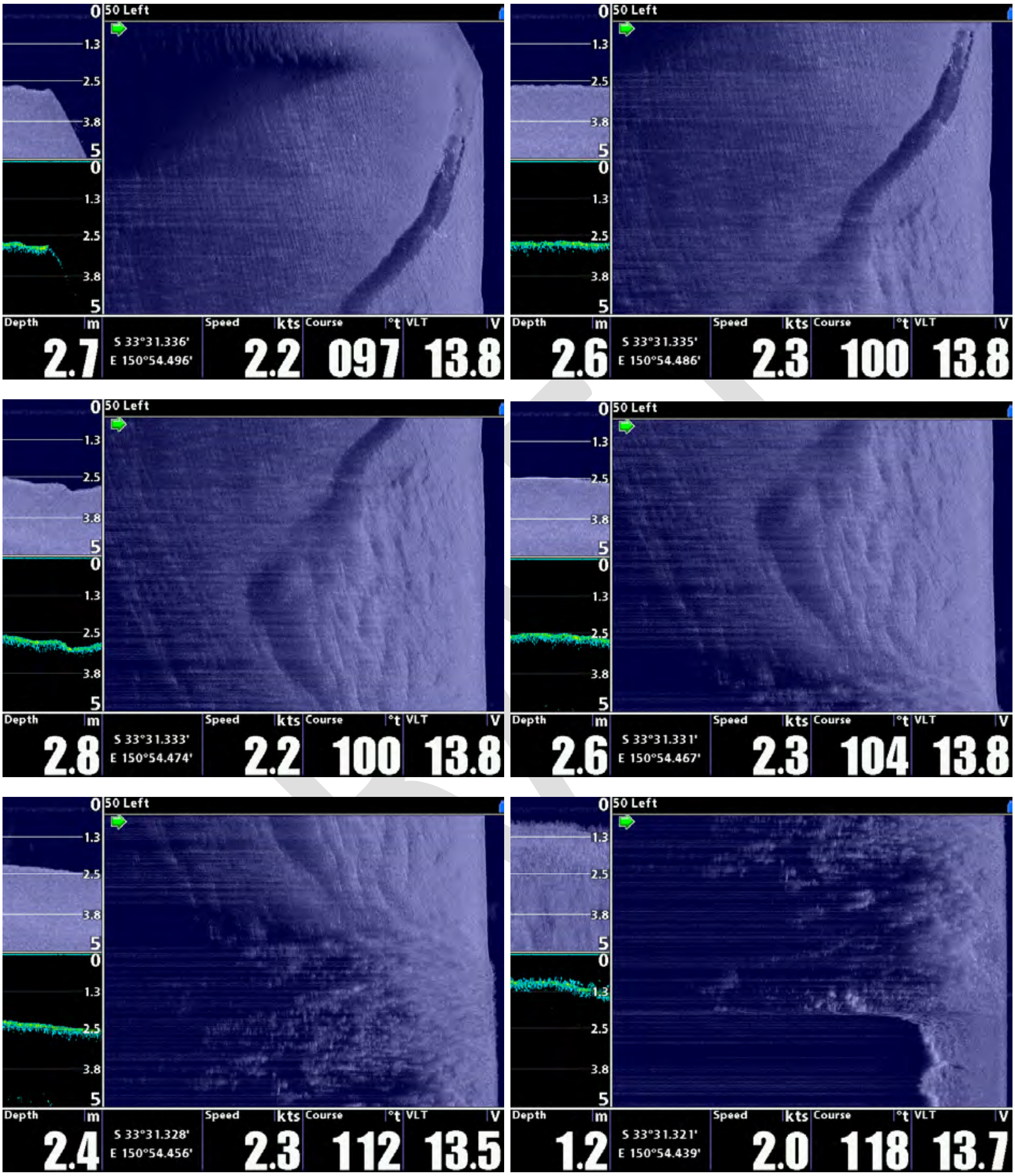


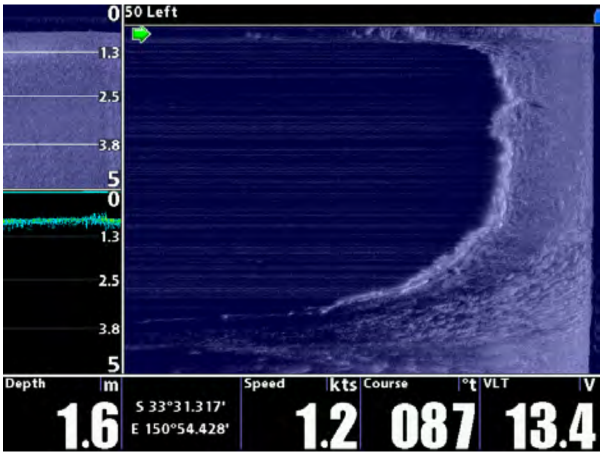

50 Left
Depth m 2.6
S 33°31.335'
E 150°54.486'
Speed kts 2.3
Course °t 100
VLT V 13.8
50 Left
Depth m 2.8
S 33°31.333'
E 150°54.474'
Speed kts 2.2
Course °t 100
VLT V 13.8
50 Left
Depth m 2.6
S 33°31.331'
E 150°54.467'
Speed kts 2.3
Course °t 104
VLT V 13.8
50 Left
Depth m 2.4
S 33°31.328'
E 150°54.456'
Speed kts 2.3
Course °t 112
VLT V 13.5
50 Left
Depth m 1.2
S 33°31.321'
E 150°54.439'
Speed kts 2.0
Course °t 118
VLT V 13.7
50 Left
Depth m 15.1
S 33°31.333'
E 150°54.526'
Speed kts 0.5
Course °t 072
VLT V 13.8

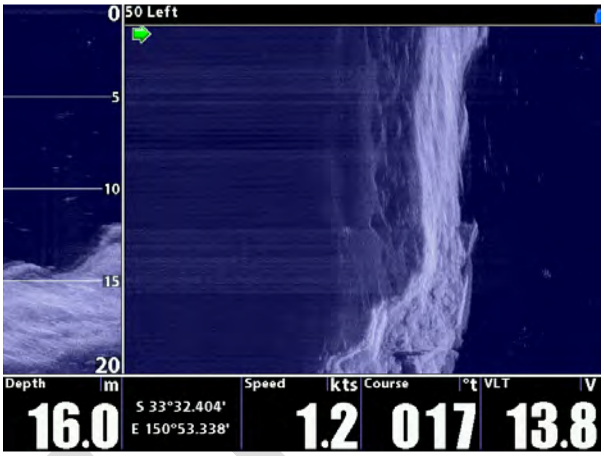
Ebenezer Church



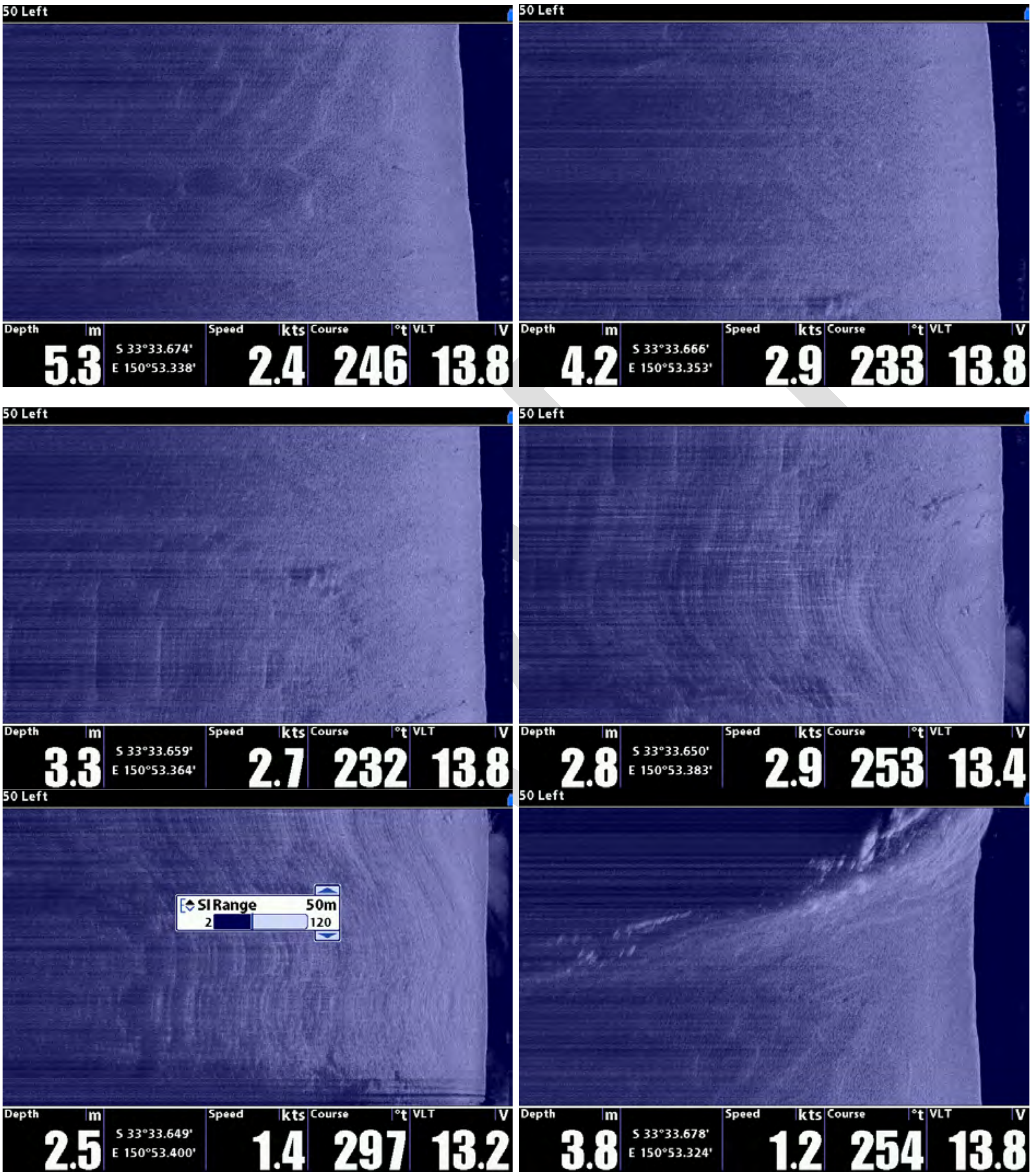

50 Left
Depth m 21.9
S 33°32.435'
E 150°53.313'
Speed kts 1.5
Course °t 281
VLT V 13.8
50 Left
Depth m 15.3
S 33°32.434'
E 150°53.338'
Speed kts 2.5
Course °t 250
VLT V 13.8
50 Left
Depth m 9.5
S 33°32.449'
E 150°53.350'
Speed kts 2.4
Course °t 214
VLT V 13.8
50 Left
S 33°32.449'
E 150°53.378'
Speed kts 1.6
Course °t 212
VLT V 13.7
50 Left
Depth m 15.1
S 33°31.333'
E 150°54.526'
Speed kts 0.5
Course °t 072
VLT V 13.8
50 Left
Depth m 15.8
S 33°31.334'
E 150°54.520'
Speed kts 1.4
Course °t 071
VLT V 13.8


50 Left
Depth m 2.7
S 33°31.336'
E 150°54.496'
Speed kts 2.2
Course °t 097
VLT V 13.8
50 Left
Depth m 2.6
S 33°31.335'
E 150°54.486'
Speed kts 2.3
Course °t 100
VLT V 13.8
50 Left
Depth m 2.8
S 33°31.333'
E 150°54.474'
Speed kts 2.2
Course °t 100
VLT V 13.8
50 Left
Depth m 2.6
S 33°31.331'
E 150°54.467'
Speed kts 2.3
Course °t 104
VLT V 13.8
50 Left
Depth m 2.4
S 33°31.328'
E 150°54.456'
Speed kts 2.3
Course °t 112
VLT V 13.5
50 Left
Depth m 1.2
S 33°31.321'
E 150°54.439'
Speed kts 2.0
Course °t 118
VLT V 13.7

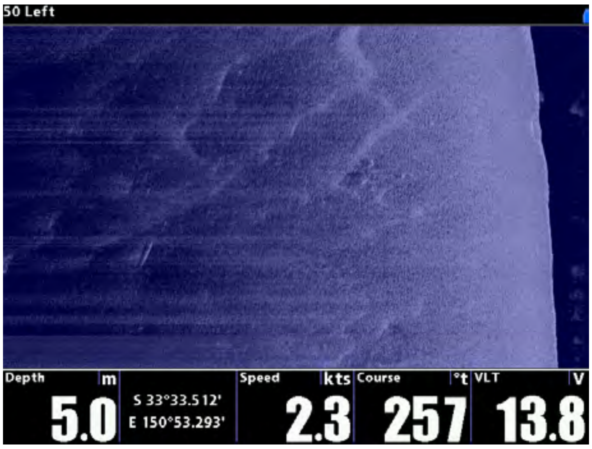

50 Left
Depth m
1.6
S 33°31.317'
E 150°54.428'
Speed kts
1.2
Course °t
087
VLT V
13.4

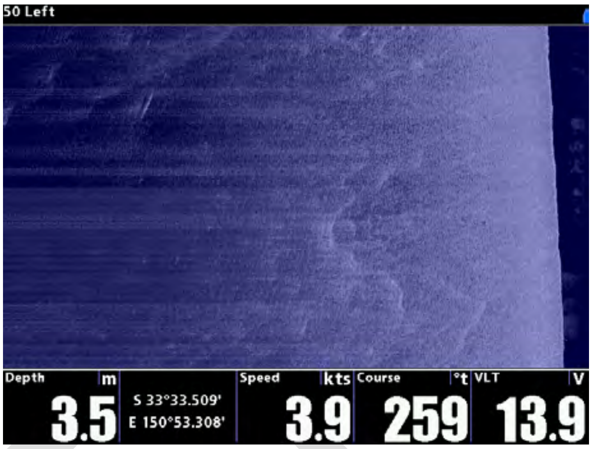

50 Left
Depth m
16.0
S 33°32.404'
E 150°53.338'
Speed kts
1.2
Course °t
017
VLT V
13.8

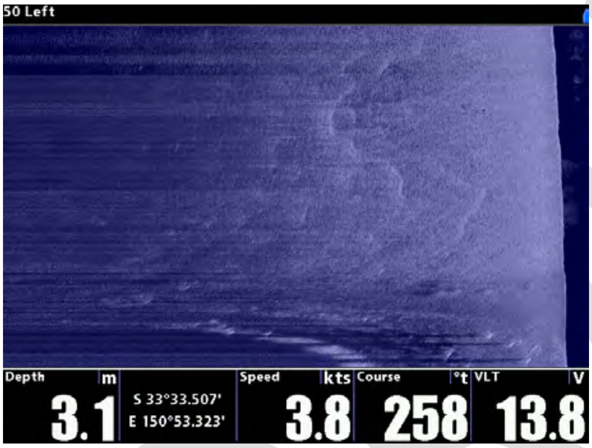
Cattai Creek 1

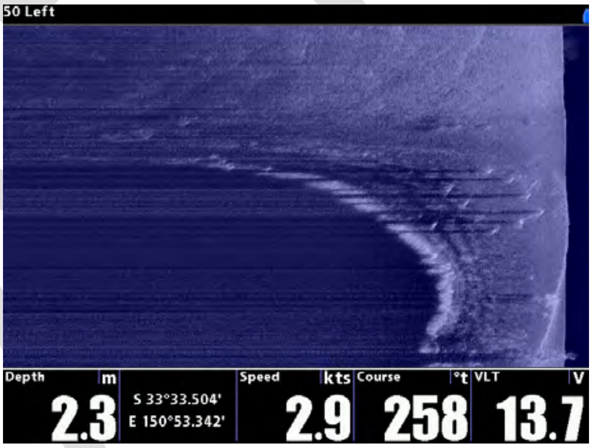


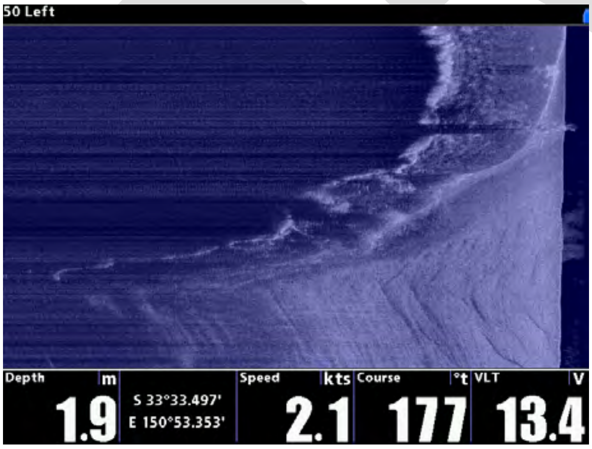
Cattai Creek 2

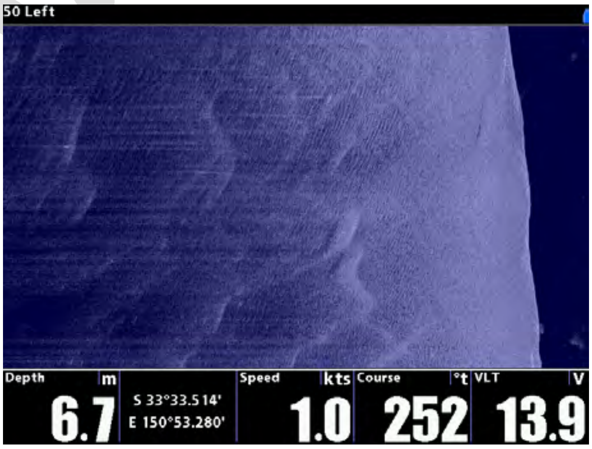




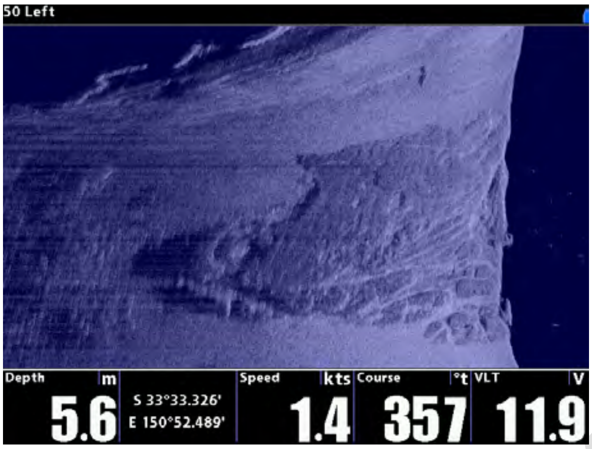


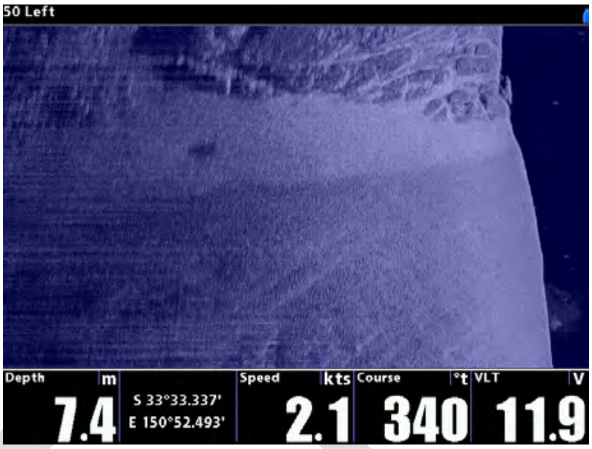


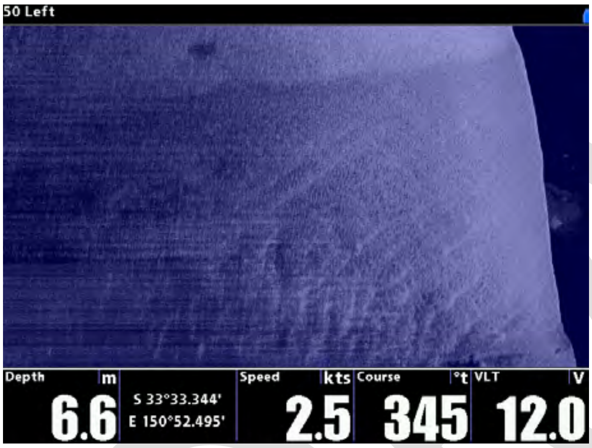


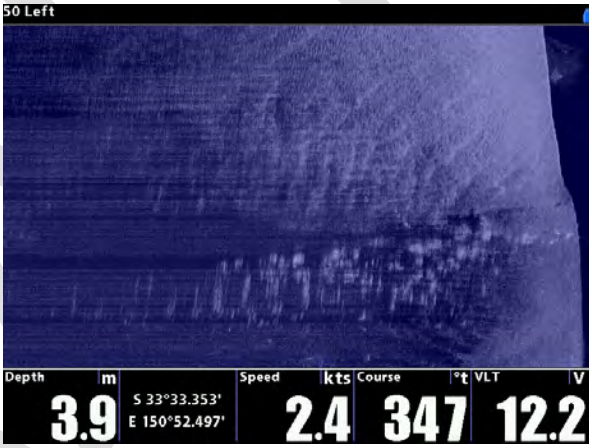


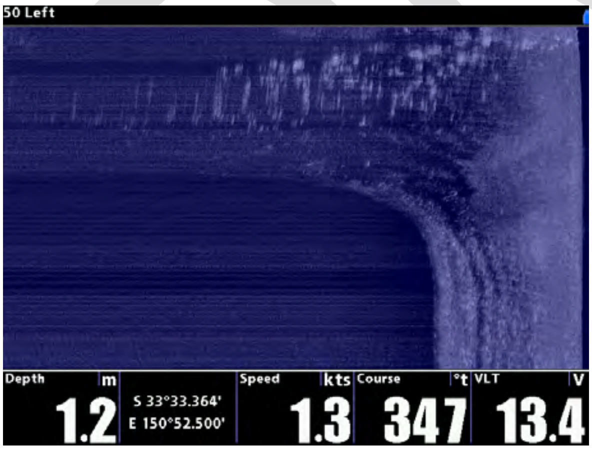
Sandy Point

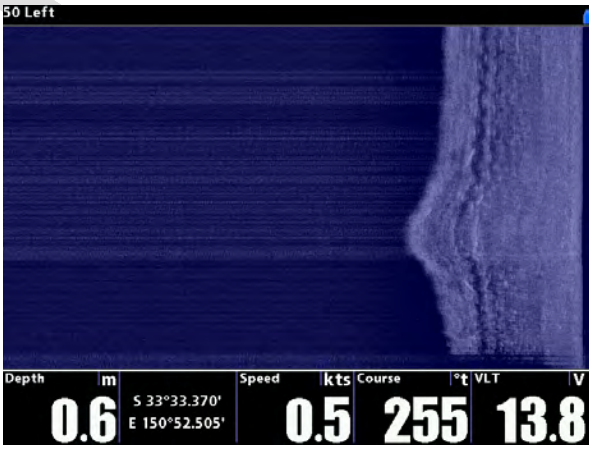

50 Left
Depth m
5.6
S 33°33.326'
E 150°52.489'
Speed kts
1.4
Course °t
357
VLT V
11.9

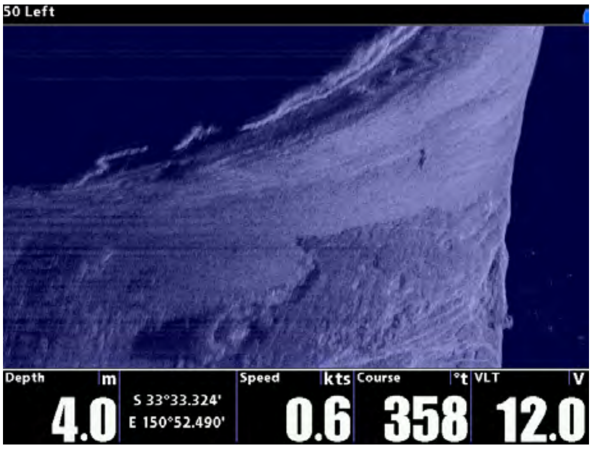

50 Left
Depth m
7.4
S 33°33.337'
E 150°52.493'
Speed kts
2.1
Course °t
340
VLT V
11.9


50 Left
Depth m
6.6
S 33°33.344'
E 150°52.495'
Speed kts
2.5
Course °t
345
VLT V
12.0

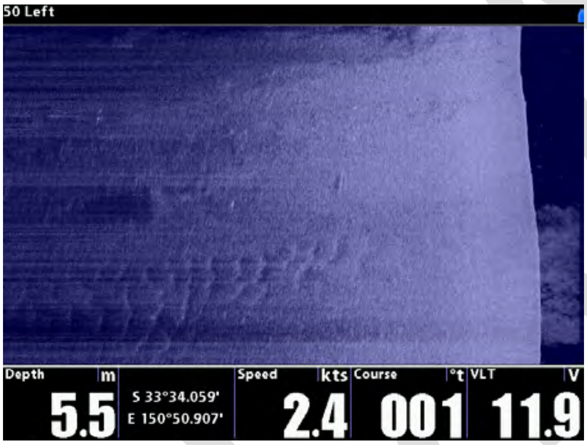

50 Left
Depth m
3.9
S 33°33.353'
E 150°52.497'
Speed kts
2.4
Course °t
347
VLT V
12.2

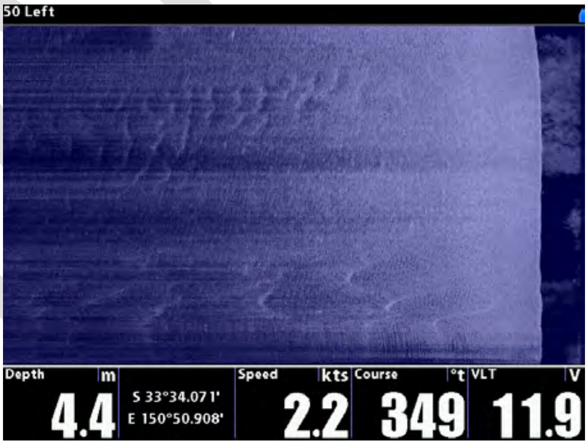

50 Left
Depth m
1.2
S 33°33.364'
E 150°52.500'
Speed kts
1.3
Course °t
347
VLT V
13.4

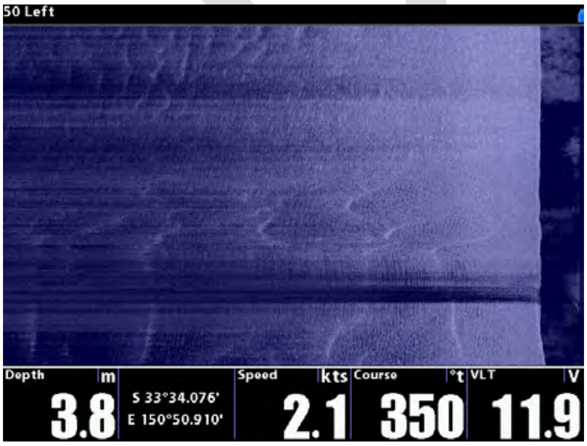

50 Left
Depth m
0.6
S 33°33.370'
E 150°52.505'
Speed kts
0.5
Course °t
255
VLT V
13.8

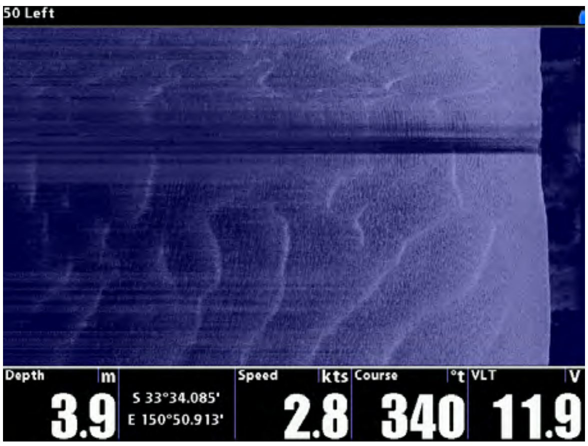


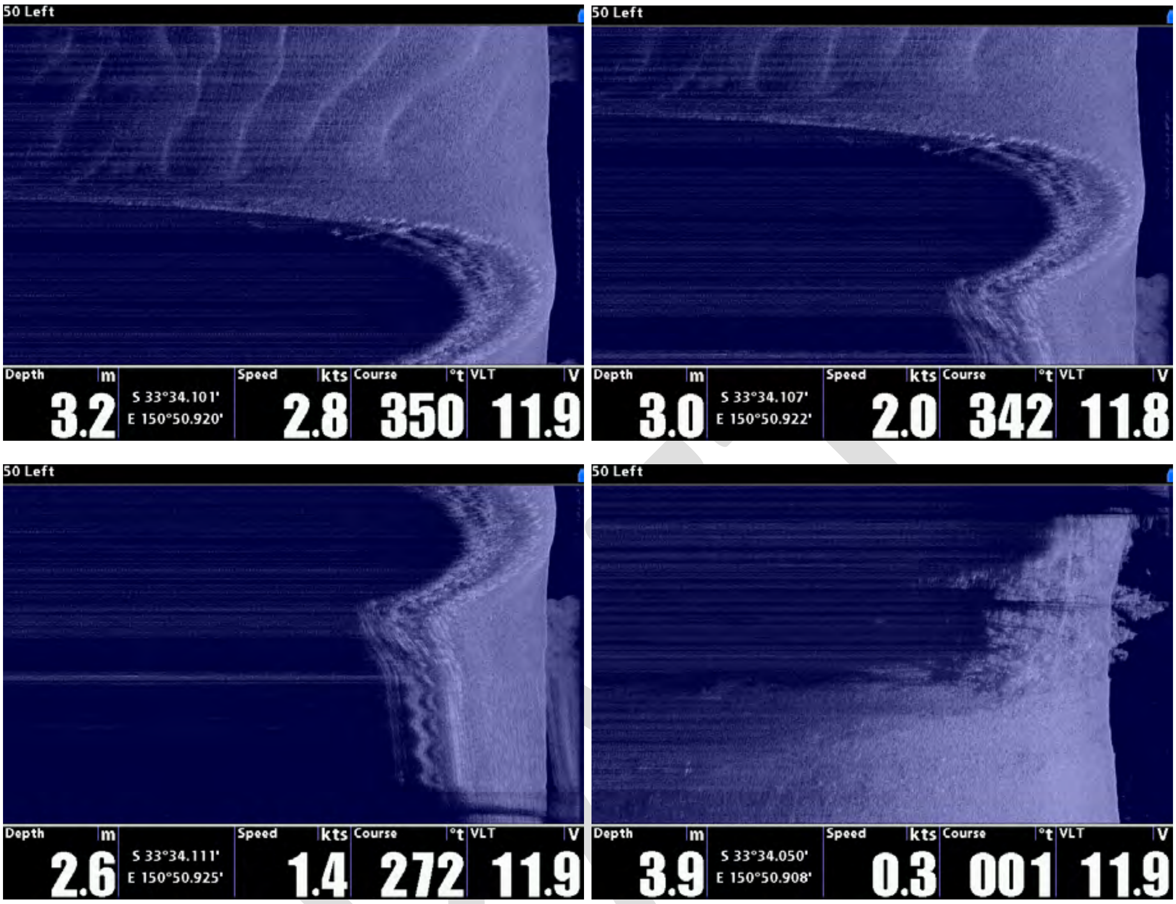
Pitt Town Bottoms



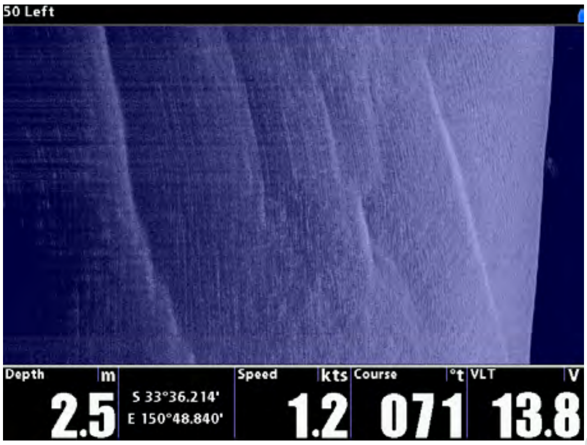


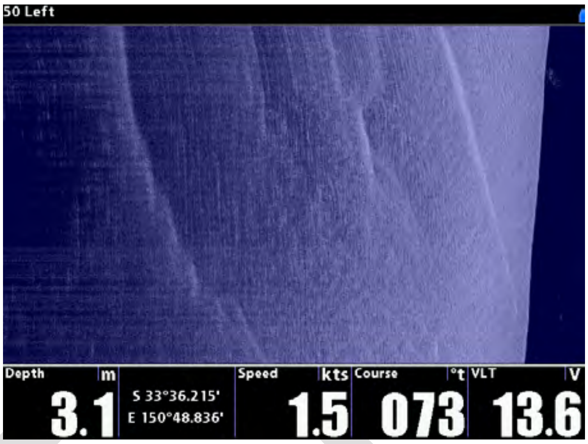


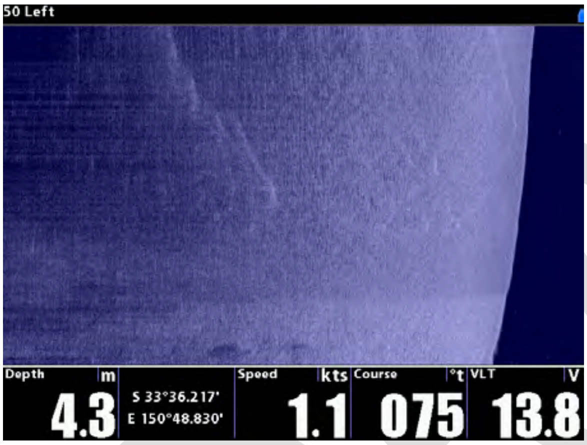


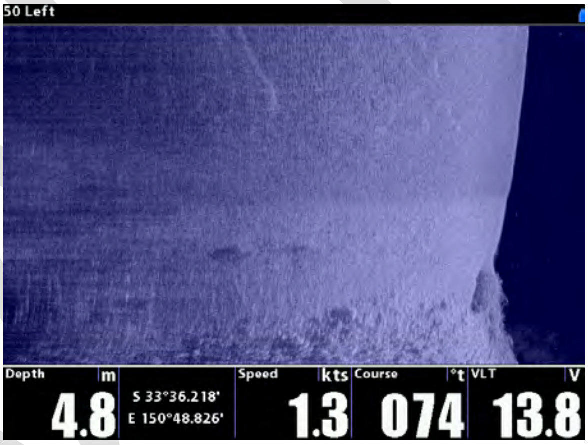

50 Left
Depth m
3.2
S 33°34.101'
E 150°50.920'
Speed kts
2.8
Course °t
350
VLT V
11.9
50 Left
Depth m
3.0
S 33°34.107'
E 150°50.922'
Speed kts
2.0
Course °t
342
VLT V
11.8
50 Left
Depth m
2.6
S 33°34.111'
E 150°50.925'
Speed kts
1.4
Course °t
272
VLT V
11.9
50 Left
Depth m
3.9
S 33°34.050'
E 150°50.908'
Speed kts
0.3
Course °t
001
VLT V
11.9

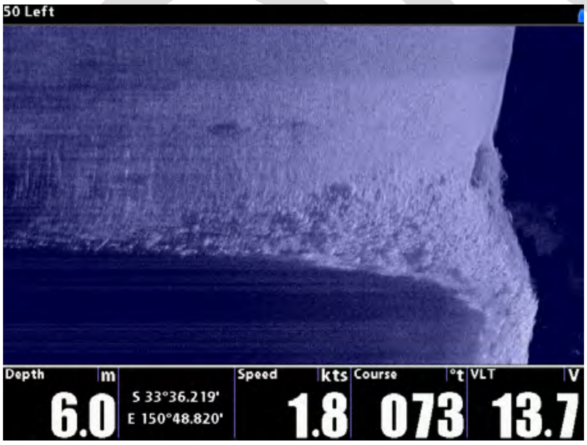
Ben's Point

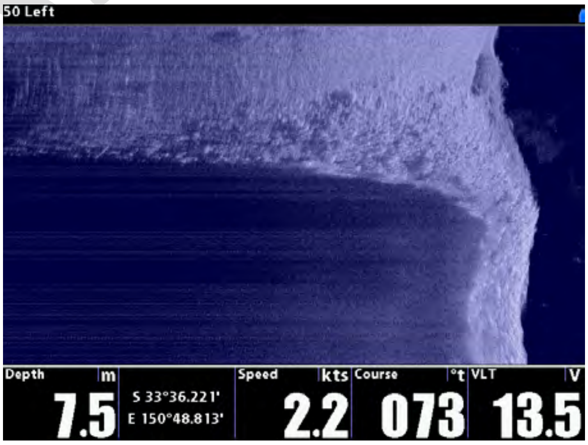

50 Left
Depth m 2.5
S 33°36.214'
E 150°48.840'
Speed kts 1.2
Course °t 071
VLT V 13.8

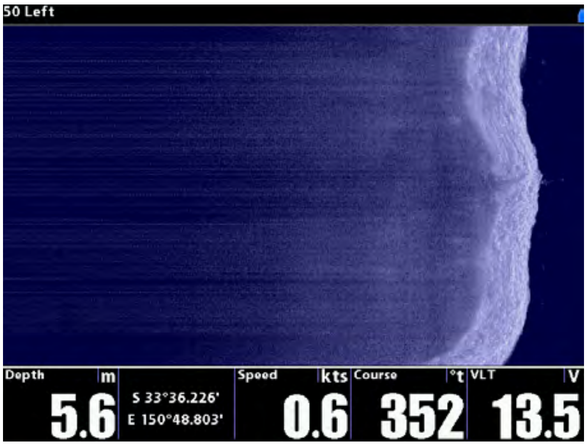

50 Left
Depth m 3.1
S 33°36.215'
E 150°48.836'
Speed kts 1.5
Course °t 073
VLT V 13.6

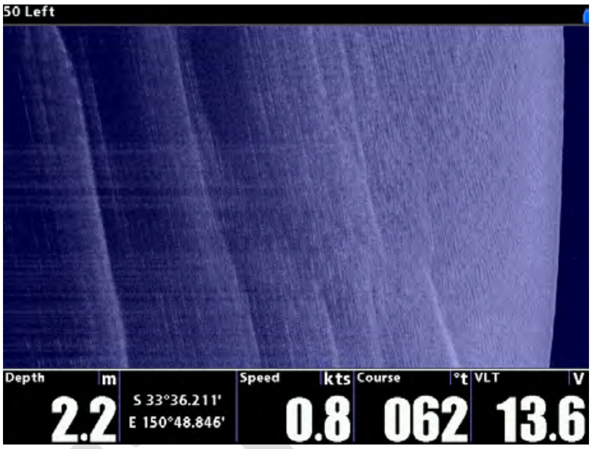

50 Left
Depth m 4.3
S 33°36.217'
E 150°48.830'
Speed kts 1.1
Course °t 075
VLT V 13.8


50 Left
Depth m 4.8
S 33°36.218'
E 150°48.826'
Speed kts 1.3
Course °t 074
VLT V 13.8


50 Left
Depth m 6.0
S 33°36.219'
E 150°48.820'
Speed kts 1.8
Course °t 073
VLT V 13.7


50 Left
Depth m 7.5
S 33°36.221'
E 150°48.813'
Speed kts 2.2
Course °t 073
VLT V 13.5


50 Left
Depth m
5.6
S 33°36.226'
E 150°48.803'
Speed kts
0.6
Course °t
352
VLT V
13.5

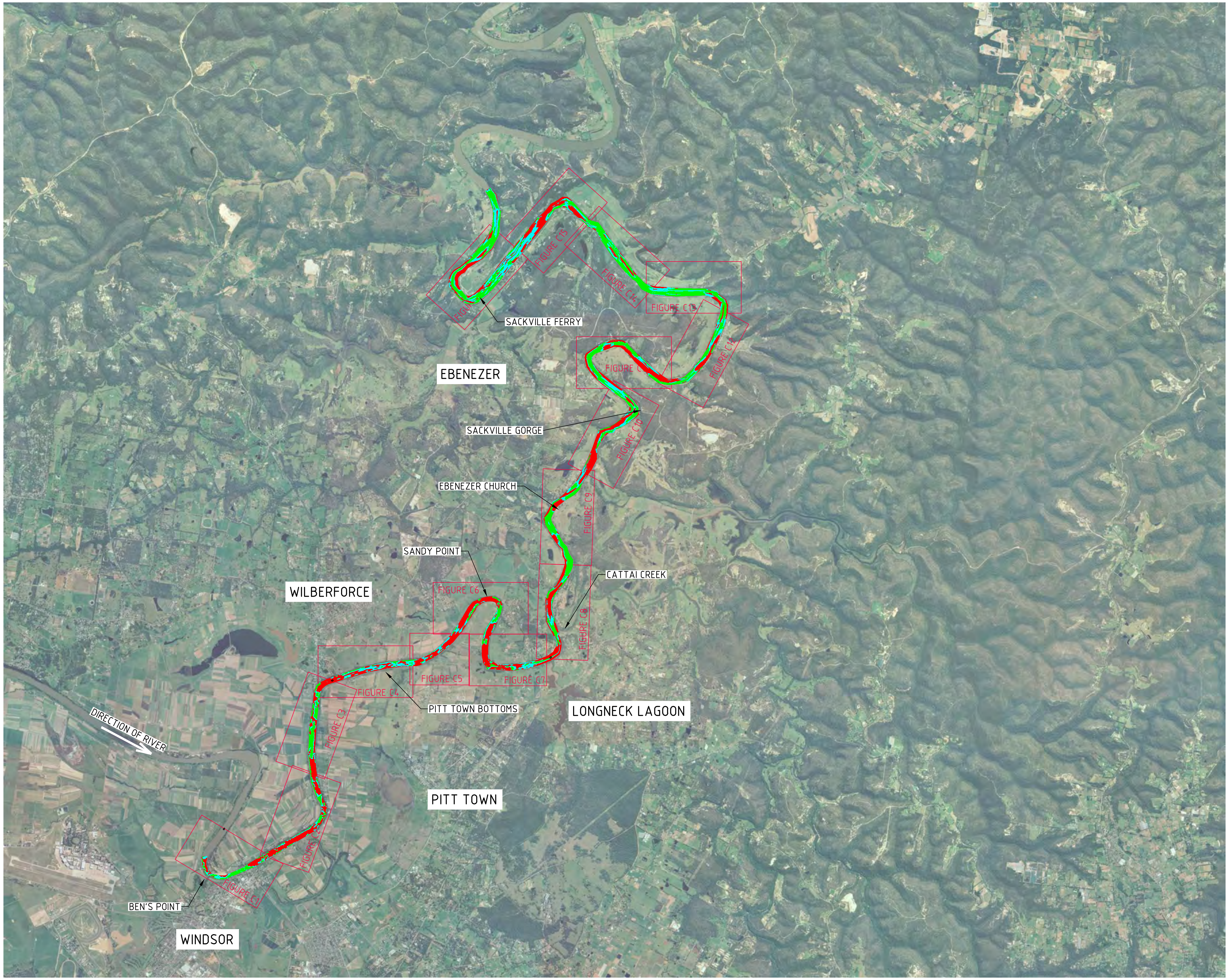

50 Left
Depth m
2.2
S 33°36.211'
E 150°48.846'
Speed kts
0.8
Course °t
062
VLT V
13.6

Appendix C

River Bed Change Difference Mapping

WorleyParsons

resources & energy



PLAN
SCALE 1 : 40000

HAWKESBURY RIVER DIFFERENCE MAPPING	
AREA OF SCOUR (< - 0.25m)	red
AREA OF NEGLIGIBLE CHANGE-0.25m TO +0.25m	cyan
AREA OF DEPOSITION (> +0.25m)	green

CHANGE FROM 1978-88 OR 1987-80 SURVEY TO 2011 SURVEY

NOTES

1. FROM BEN'S POINT TO NEAR LONGNECK LAGOON 2011 SURVEY DATA IS COMPARED WITH 1987-88 SURVEY DATA. FROM NEAR LONGNECK LAGOON TO SACKVILLE FERRY 2011 SURVEY DATA IS COMPARED WITH 1978-80 SURVEY DATA

800 0 800 1600 2400 3200 4000m
1:40000 (A1) 1:80000 (A3)

WorleyParsons
resources & energy

OneWay to zero harm

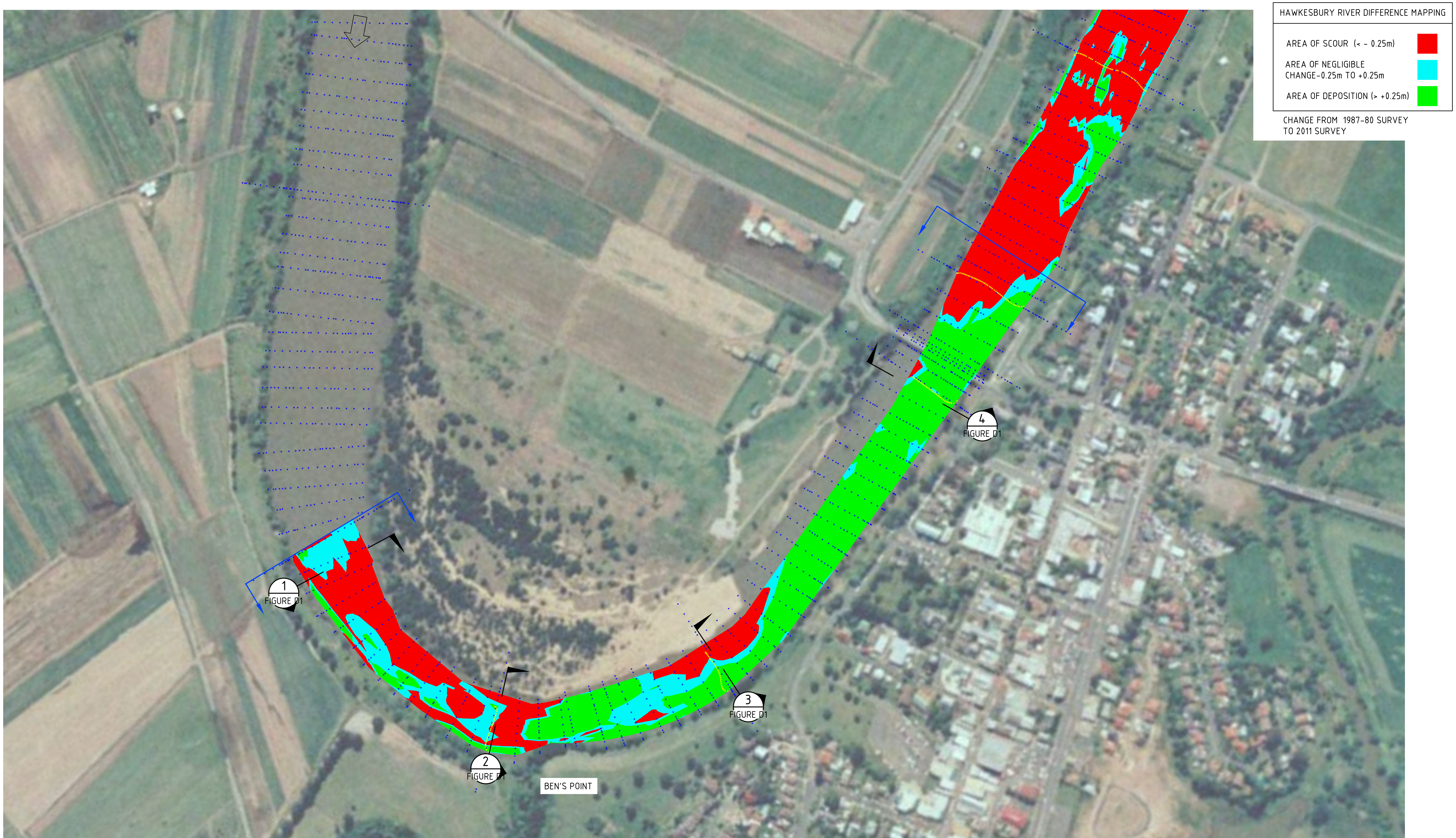
ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

N
NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE
INDEX SHEET

FIGURE C

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG
USER NAME: enosh.newar
CTB FILE: Worley-Full.ctb Plotter:None
PLOT DATE & TIME: 31/7/2015 6:55:46 PM
SAVE DATE & TIME: 31/7/2015 6:52:55 PM



LEGEND

2011 SURVEY DATA POINTS

1987 SURVEY DATA POINTS

PRIORITY AREAS

SECTION MARKER 1 FIGURE D1

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons resources & energy

OneWay to zero harm

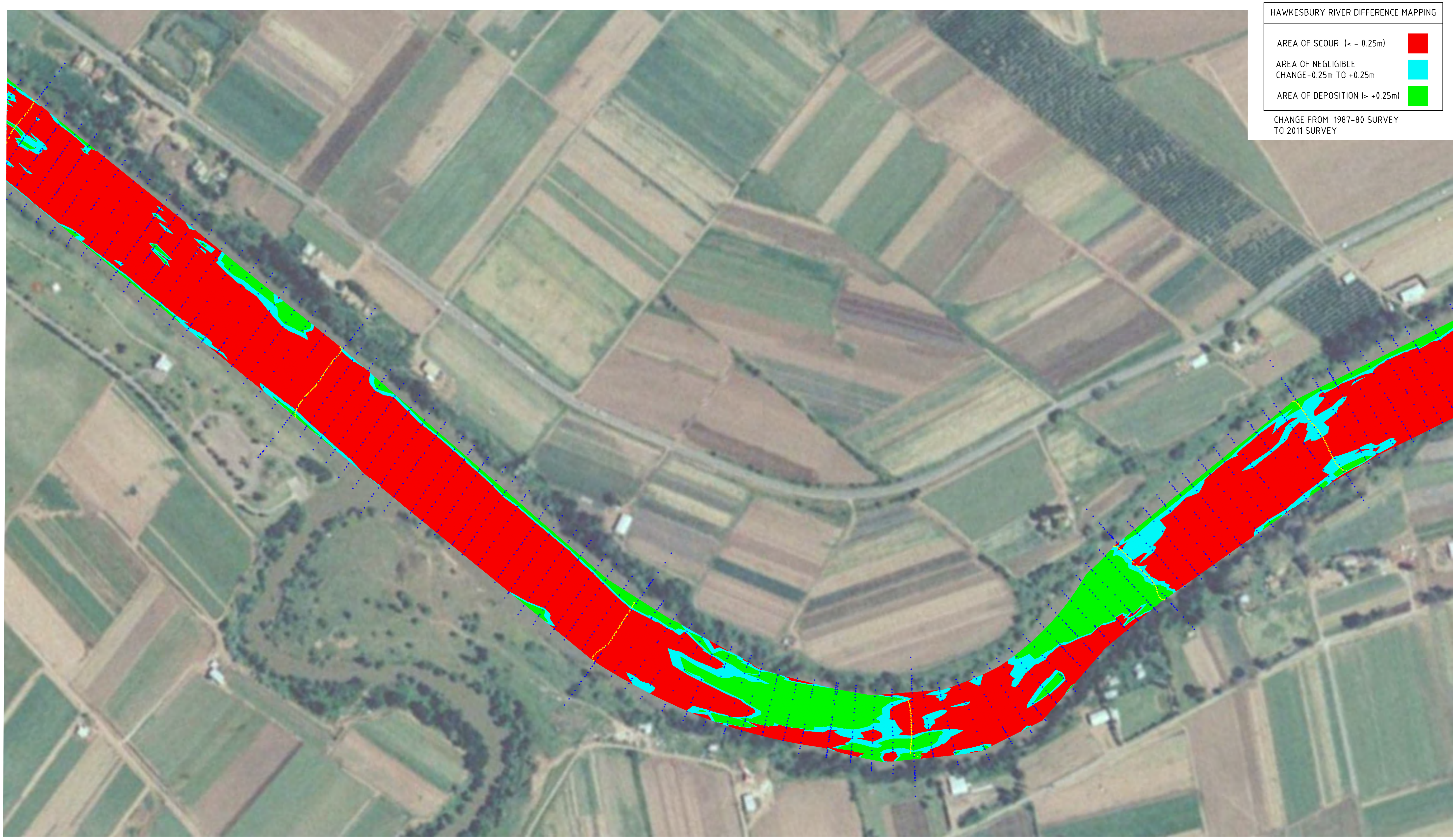
ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE
PRIORITY AREA: BEN'S POINT

FIGURE C1

PLOT DATE & TIME: 31/7/2015 6:55:55 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG
SAVE DATE & TIME: 31/7/2015 6:52:55 PM CTB FILE: Worley-Full.ctb Plotter:None



LEGEND

2011 SURVEY DATA POINTS

1987 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons
resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE

FIGURE C2

PLOT DATE & TIME: 31/7/2015 6:56:02 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG
SAVE DATE & TIME: 31/7/2015 6:52:55 PM CTB FILE: Worley-Full.ctb Plotter:None

LEGEND

2011 SURVEY DATA POINTS

1987 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE

COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE

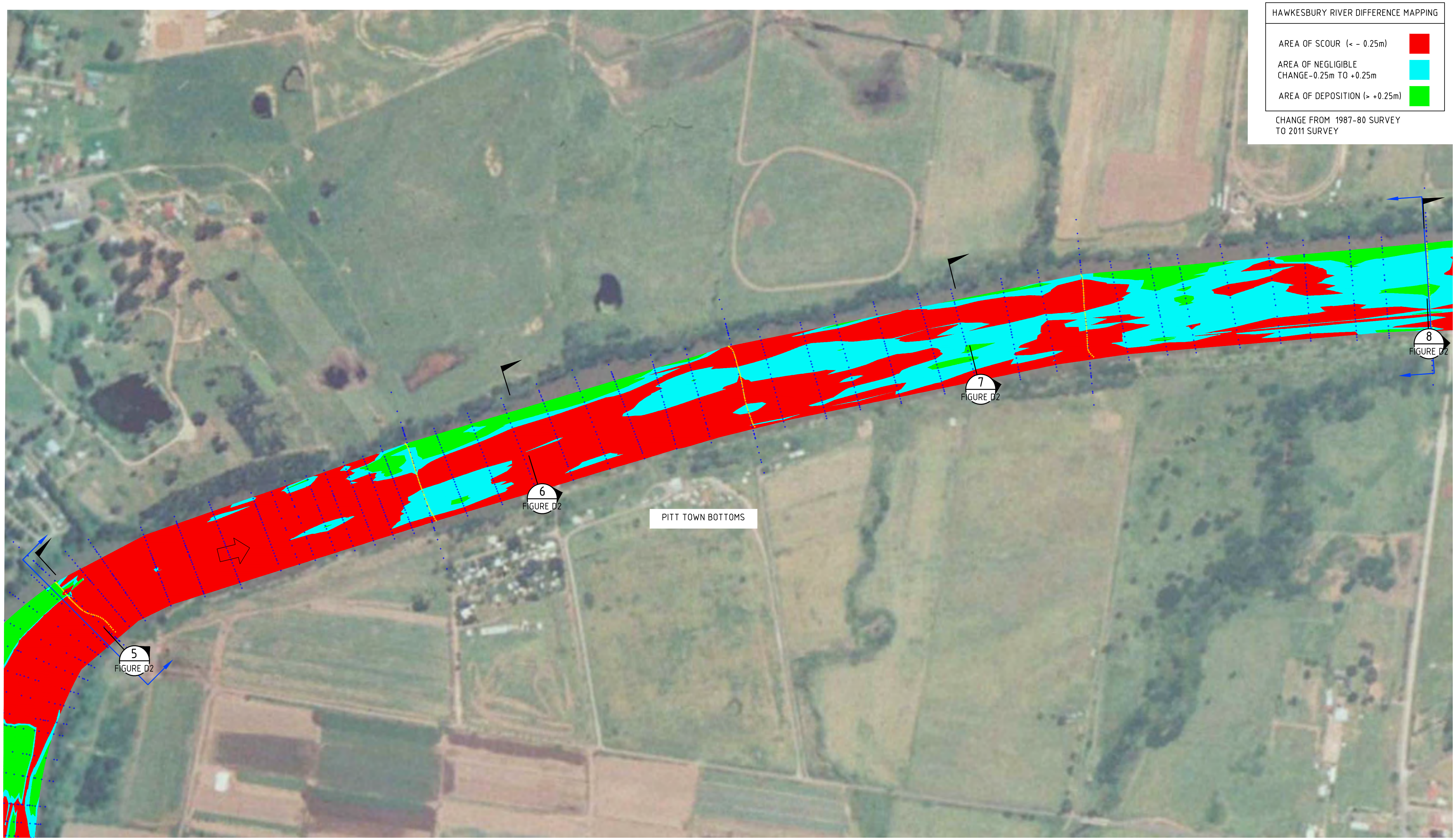
FIGURE C3

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG

USER NAME: enosh.newar CTB FILE: Worley-Full.ctb Plotter:None

PLOT DATE & TIME: 31/7/2015 6:56:09 PM

SAVE DATE & TIME: 31/7/2015 6:52:55 PM



LEGEND

2011 SURVEY DATA POINTS

1987 SURVEY DATA POINTS

PRIORITY AREAS

1 FIGURE D2 SECTION MARKER

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE

COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE

PRIORITY AREA: PITT TOWN BOTTOMS

FIGURE C4

HAWKESBURY RIVER DIFFERENCE MAPPING
AREA OF SCOUR (< - 0.25m)
AREA OF NEGLIGIBLE CHANGE-0.25m TO +0.25m
AREA OF DEPOSITION (> +0.25m)

CHANGE FROM 1987-80 SURVEY TO 2011 SURVEY

LEGEND

2011 SURVEY DATA POINTS

1987 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons

resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

N

NORTH

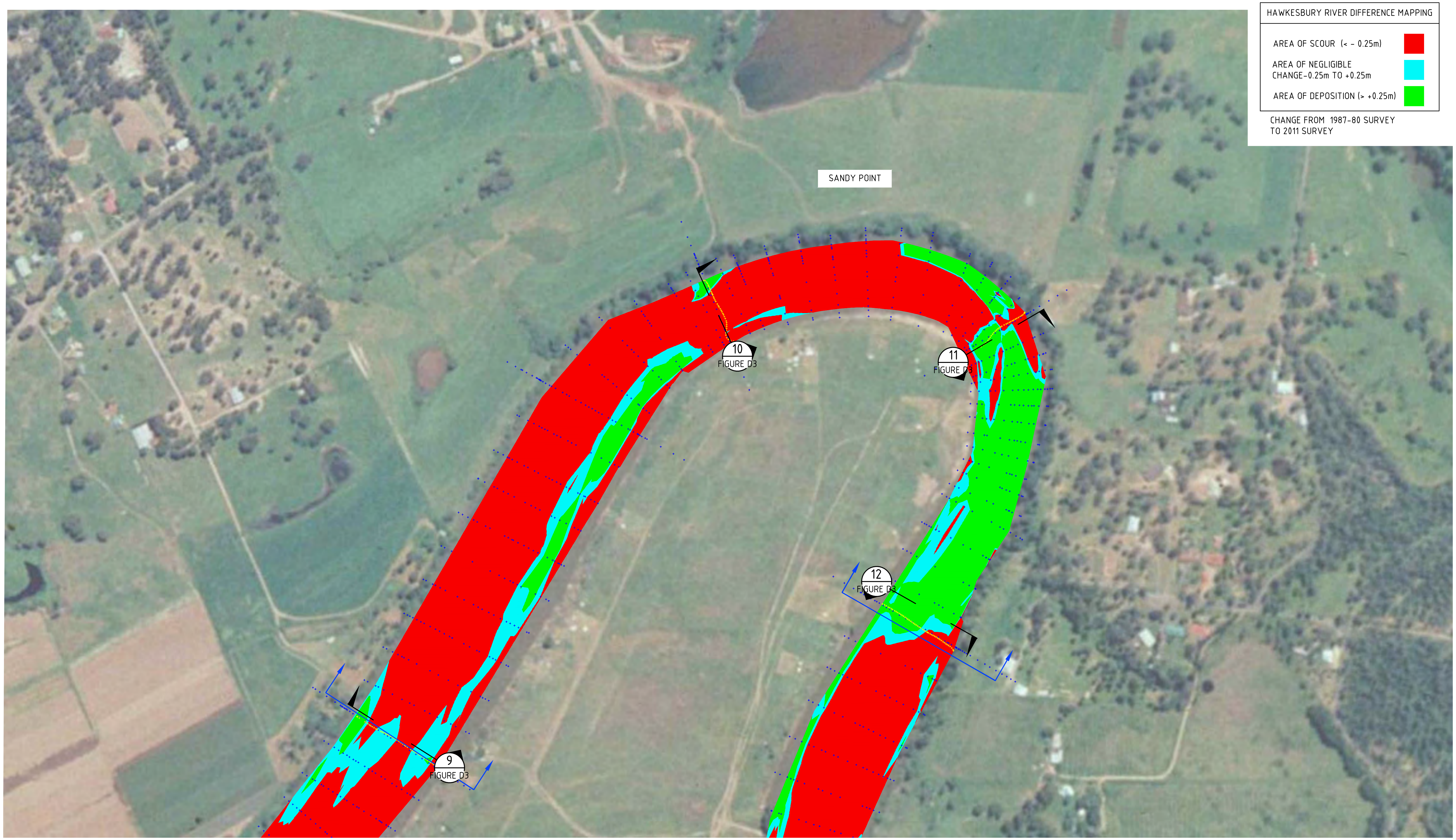
HAWKESBURY RIVER DREDGING BUSINESS CASE

COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE

FIGURE C5

PLOT DATE & TIME: 31/7/2015 6:56:20 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG

SAVE DATE & TIME: 31/7/2015 6:52:55 PM CTB FILE: Worley-Full.ctb Plotter:None



LEGEND

2011 SURVEY DATA POINTS

1987 SURVEY DATA POINTS

PRIORITY AREAS

1 FIGURE D3 SECTION MARKER

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons resources & energy

OneWay to zero harm

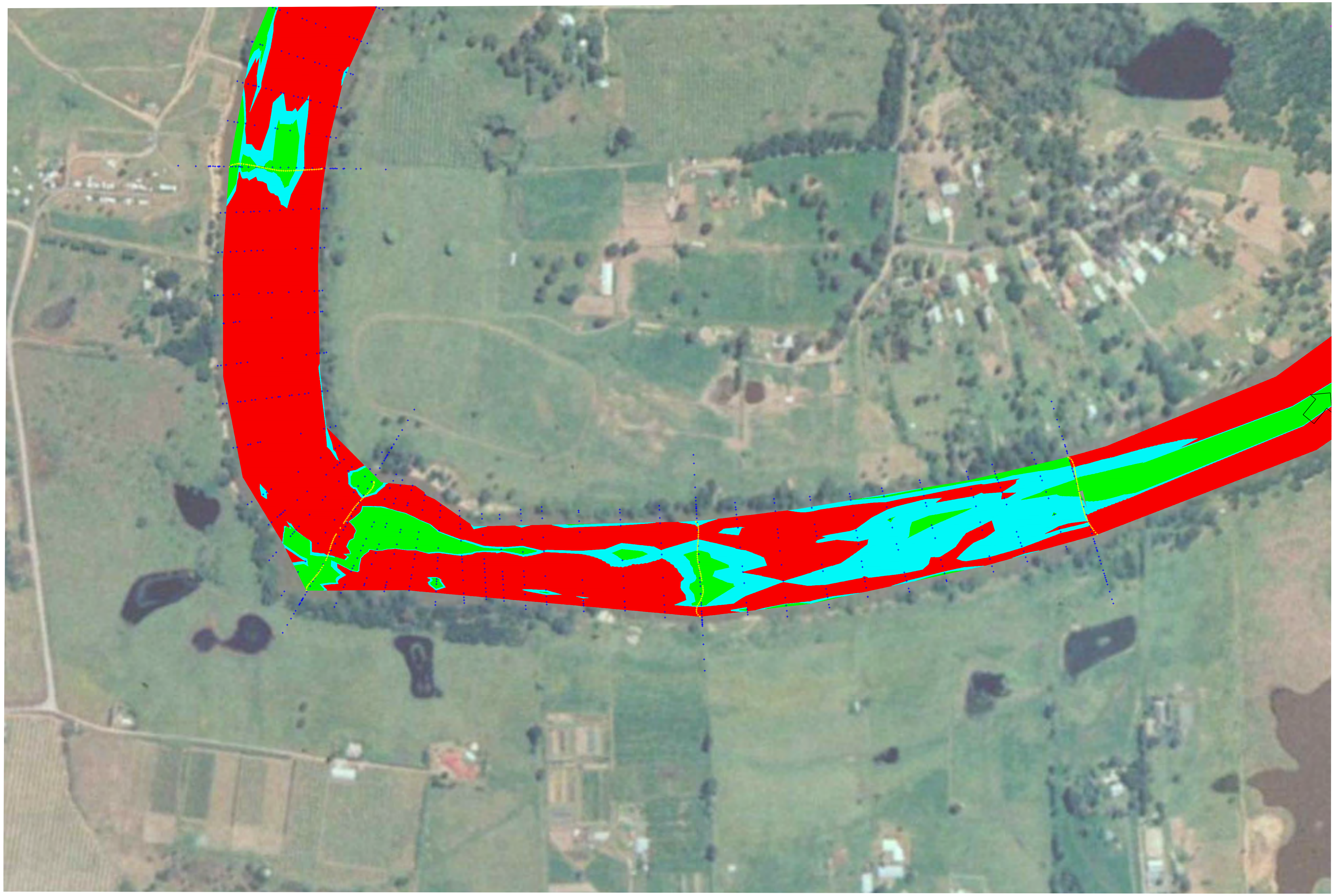
ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

N NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE
PRIORITY AREA: SANDY POINT

FIGURE C6

PLOT DATE & TIME: 31/7/2015 6:56:26 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG
SAVE DATE & TIME: 31/7/2015 6:52:55 PM CTB FILE: Worley-Full.ctb Plotter:None



HAWKESBURY RIVER DIFFERENCE MAPPING

AREA OF SCOUR (< - 0.25m)

AREA OF NEGLIGIBLE CHANGE-0.25m TO +0.25m

AREA OF DEPOSITION (> +0.25m)

CHANGE FROM 1978-88 OR 1987-80 SURVEY TO 2011 SURVEY

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

LEGEND

2011 SURVEY DATA POINTS

1987 SURVEY DATA POINTS

PRIORITY AREAS

WorleyParsons

resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE

COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE

FIGURE C7

PLOT DATE & TIME: 31/7/2015 6:56:32 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG

SAVE DATE & TIME: 31/7/2015 6:52:55 PM CTB FILE: Worley-Full.ctb Plotter:None

LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

SECTION MARKER (1 FIGURE D4)

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons resources & energy

OneWay to zero harm

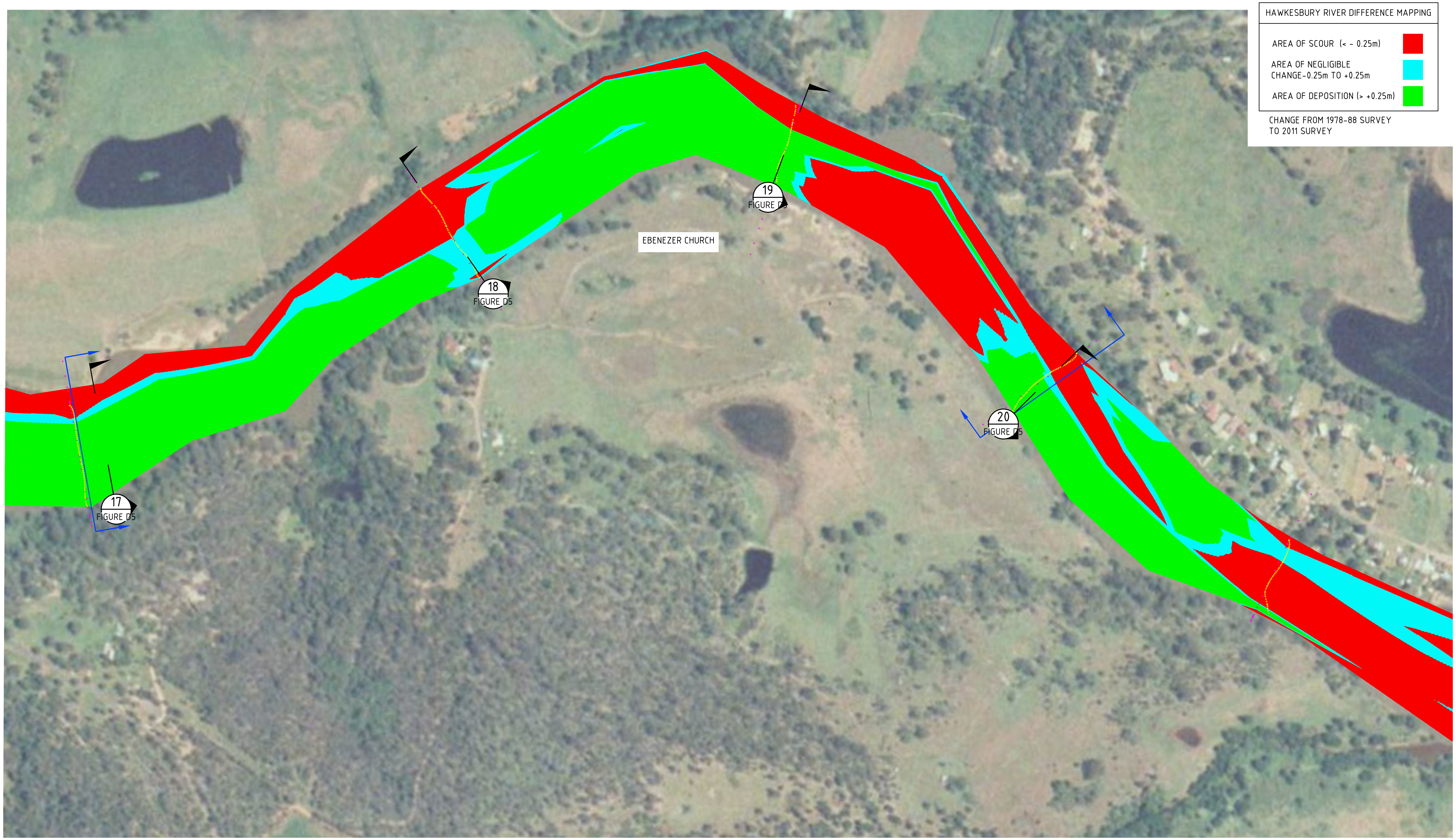
ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE
PRIORITY AREA: CATTAI CREEK

FIGURE C8

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG
USER NAME: enosh.newar CTB FILE: Worley-Full.ctb Plotter:None
PLOT DATE & TIME: 31/7/2015 6:56:38 PM SAVE DATE & TIME: 31/7/2015 6:52:55 PM



LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

1 FIGURE D5 SECTION MARKER

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

WorleyParsons resources & energy

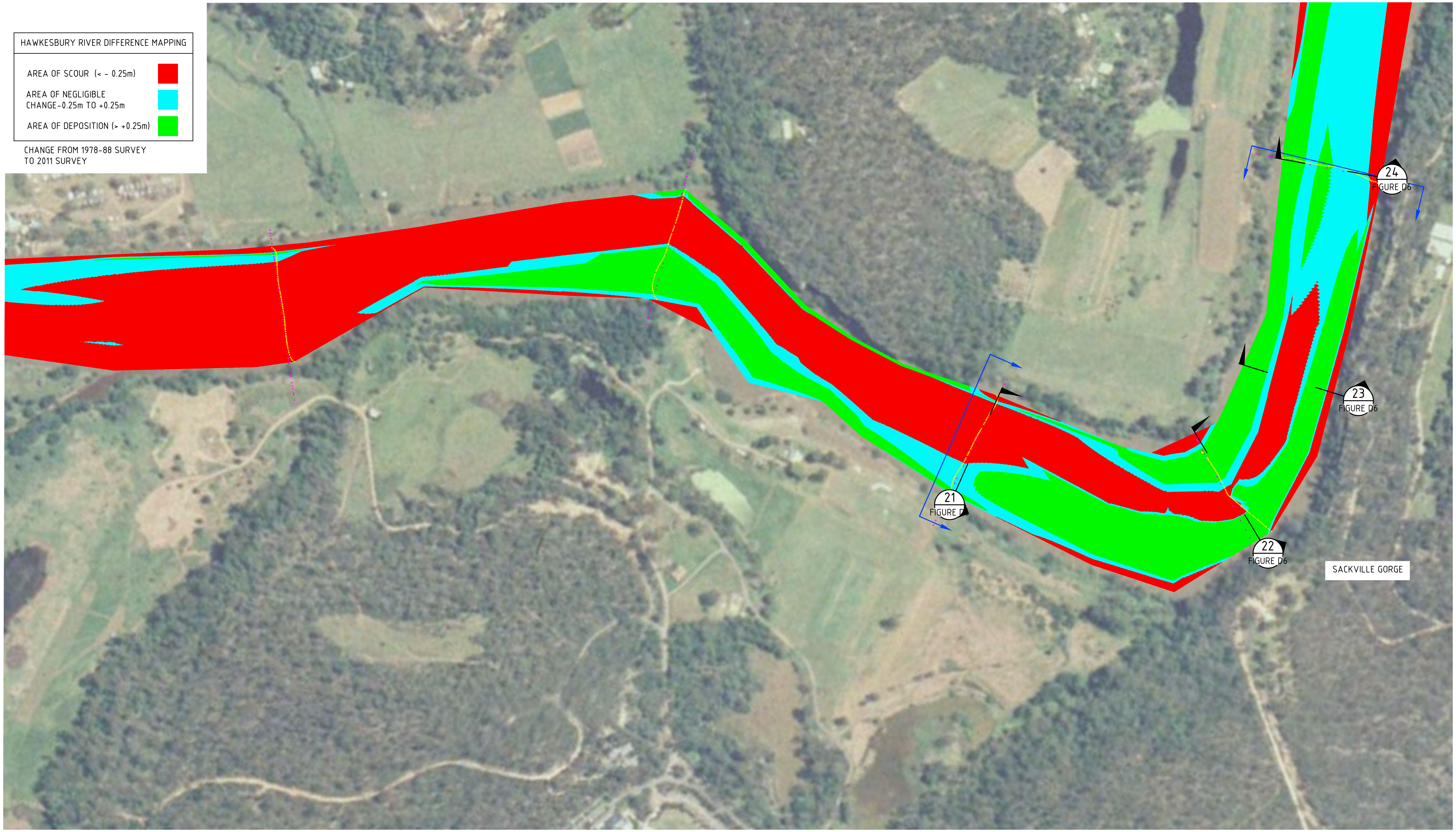
OneWay to zero harm

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE
PRIORITY AREA: EBENEZER CHURCH

FIGURE C9

PLOT DATE & TIME: 31/7/2015 6:56:44 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG
SAVE DATE & TIME: 31/7/2015 6:52:55 PM CTB FILE: Worley-Full.ctb Plotter:None



LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

1 FIGURE D6 SECTION MARKER

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE
PRIORITY AREA: SACKVILLE GORGE

FIGURE C10

LOCATION W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG
USER NAME: enosh.newar
CTB FILE: Worley-Full.ctb Plotter:None
PLOT DATE & TIME: 31/7/2015 6:56:51 PM
SAVE DATE & TIME: 31/7/2015 6:52:55 PM

LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

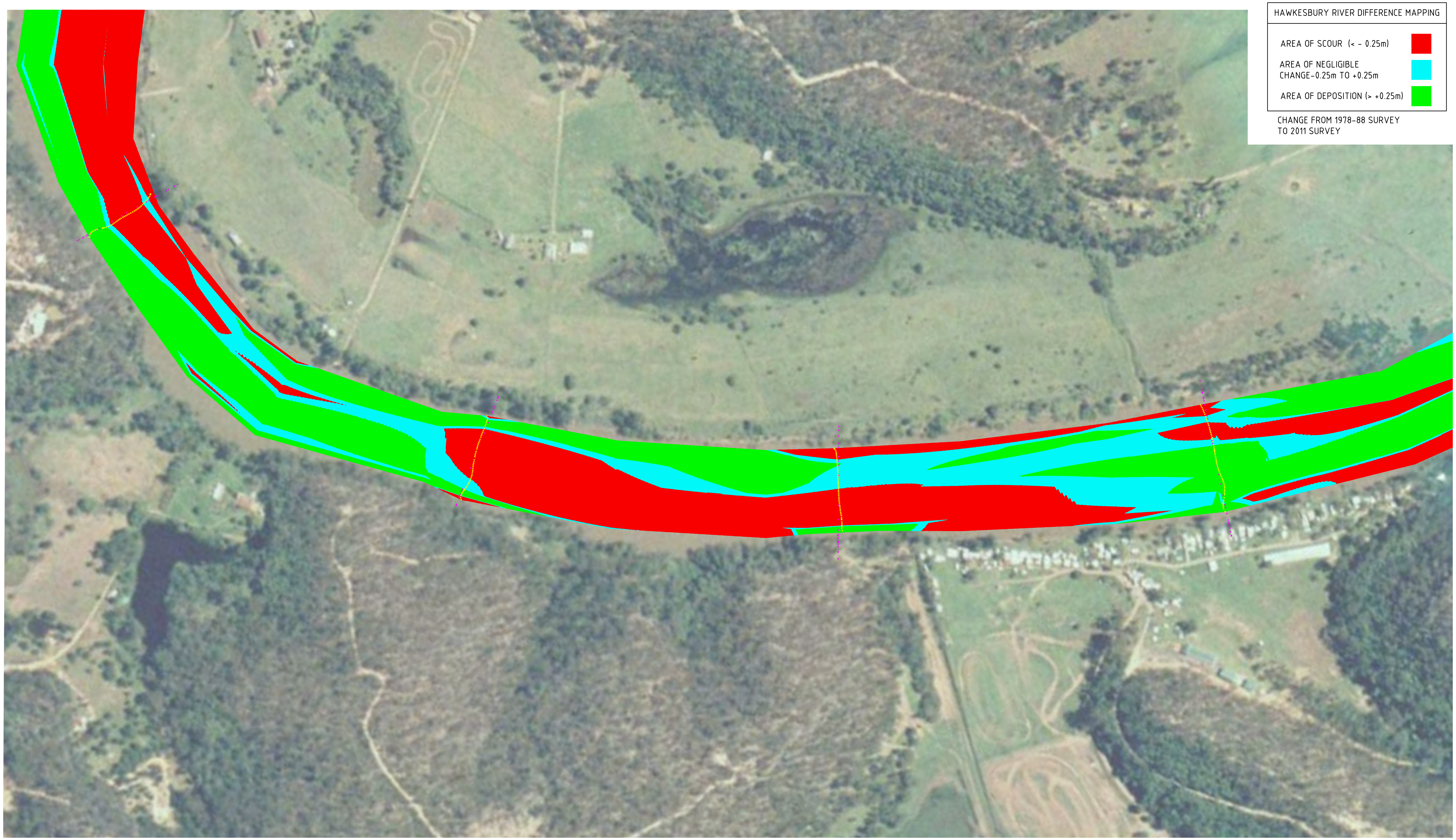
NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE

COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE

FIGURE C11

PLOT DATE & TIME: 31/7/2015 6:56:56 PM
SAVE DATE & TIME: 31/7/2015 6:52:55 PM
USER NAME: enosh.newar
CTB FILE: Worley-Full.ctb Plotter:None
LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG



LEGEND

2011 SURVEY DATA POINTS

1987 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons

resources & energy

OneWay
to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE

COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE

FIGURE C12

PLOT DATE & TIME: 31/7/2015 6:57:03 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG

SAVE DATE & TIME: 31/7/2015 6:52:55 PM CTB FILE: Worley-Full.ctb Plotter:None

LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons

resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

N

NORTH

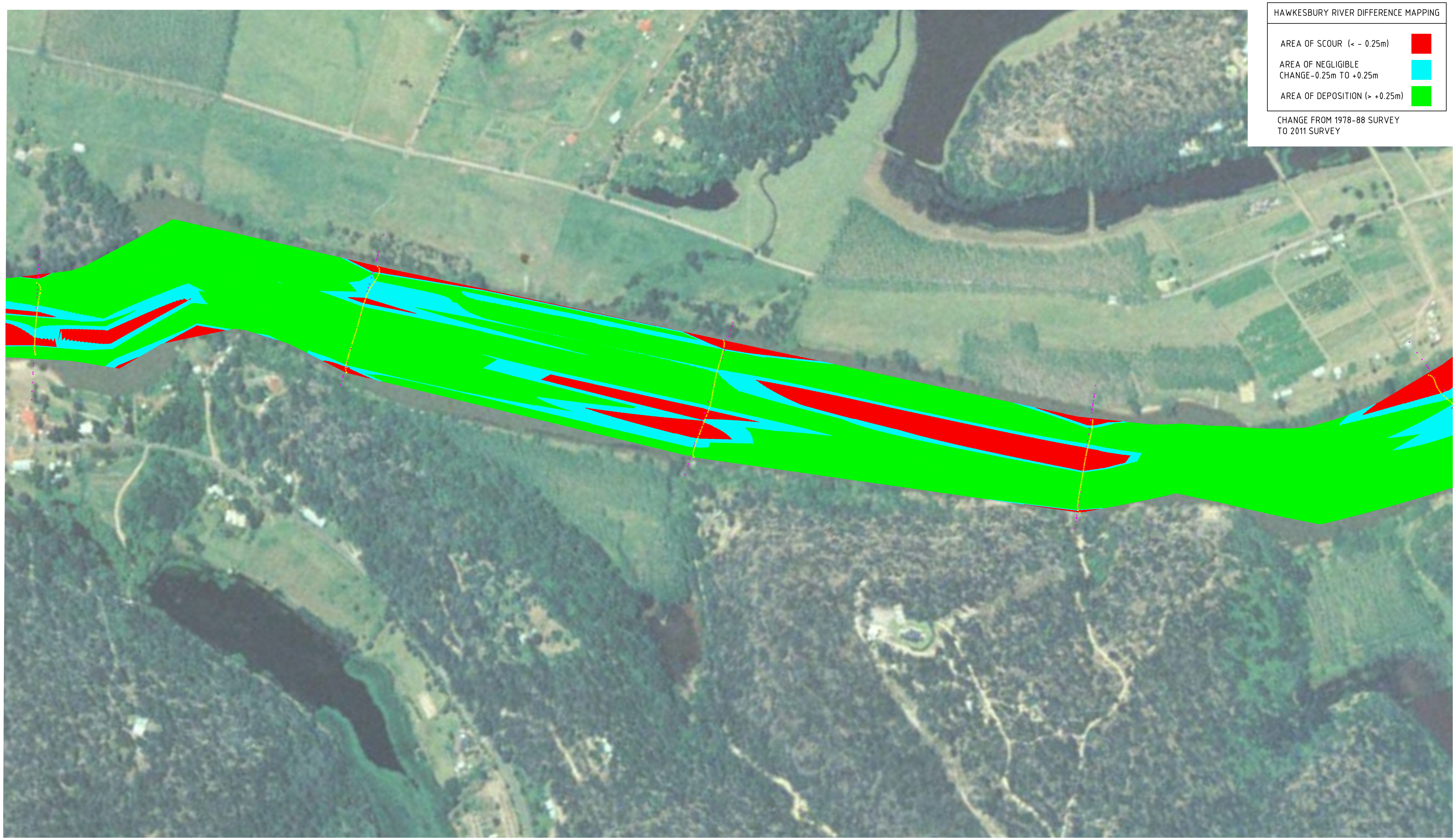
HAWKESBURY RIVER DREDGING BUSINESS CASE

COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE

FIGURE C13

PLOT DATE & TIME: 31/7/2015 6:57:09 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG

SAVE DATE & TIME: 31/7/2015 6:52:55 PM CTB FILE: Worley-Full.ctb Plotter:None



LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons

resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

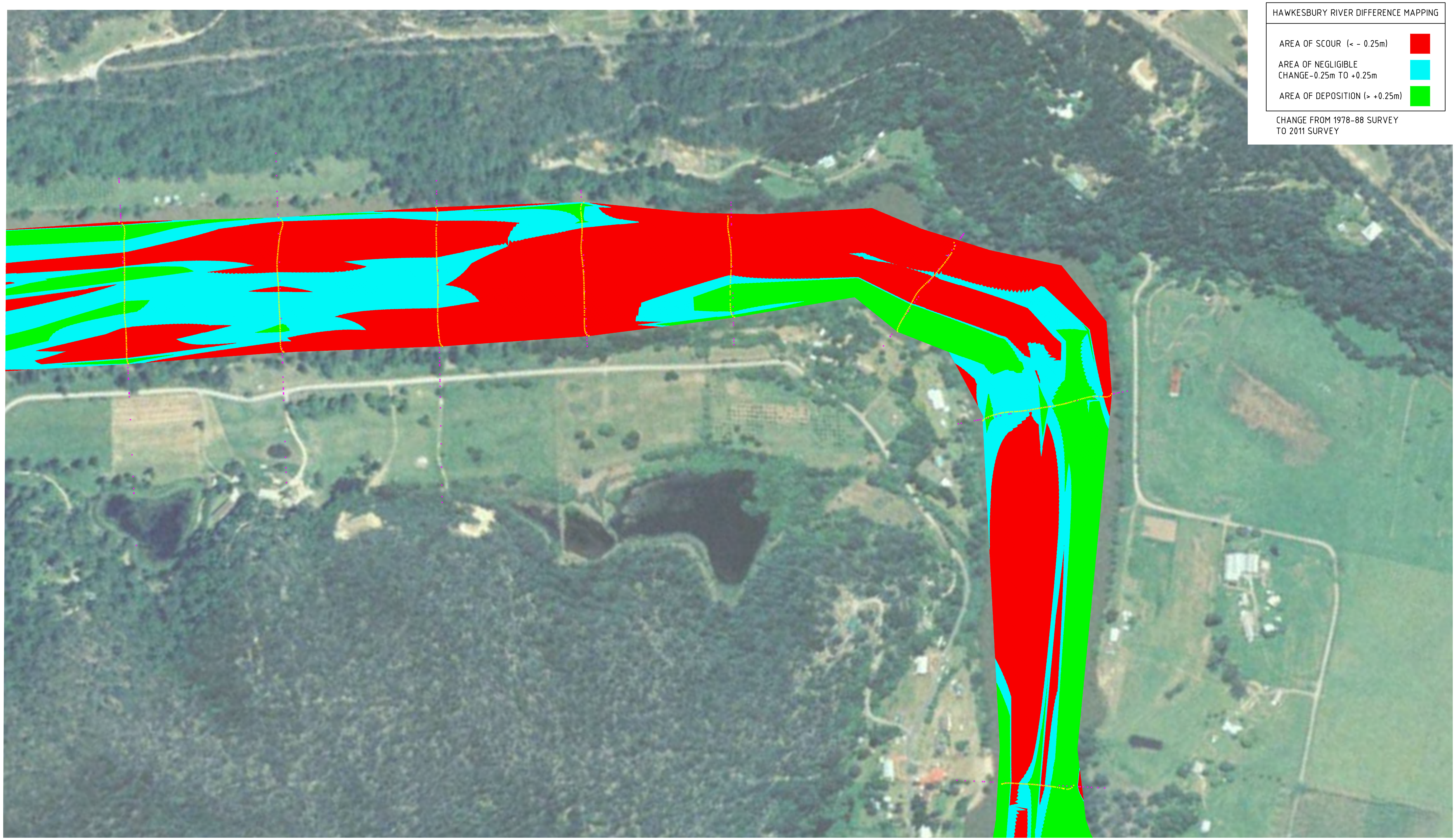
HAWKESBURY RIVER DREDGING BUSINESS CASE

COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE

FIGURE C14

PLOT DATE & TIME: 31/7/2015 6:57:17 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG

SAVE DATE & TIME: 31/7/2015 6:52:55 PM CTB FILE: Worley-Full.ctb Plotter:None



LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

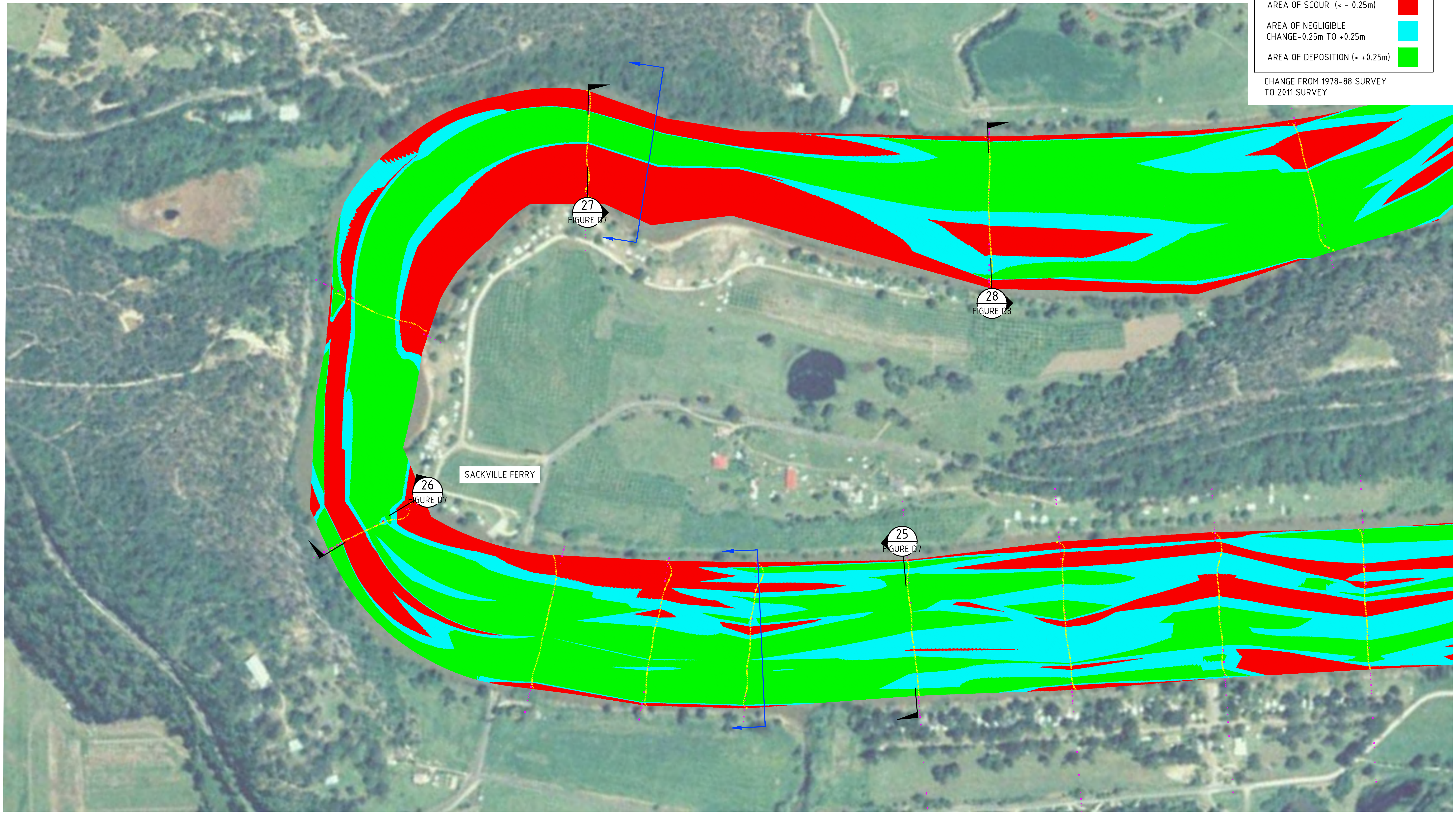
HAWKESBURY RIVER DREDGING BUSINESS CASE

COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE

FIGURE C15

PLOT DATE & TIME: 31/7/2015 7:11:34 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG

SAVE DATE & TIME: 31/7/2015 7:09:59 PM CTB FILE: Worley-Full.ctb Plotter:None



HAWKESBURY RIVER DIFFERENCE MAPPING

AREA OF SCOUR (< - 0.25m)

AREA OF NEGLIGIBLE CHANGE -0.25m TO +0.25m

AREA OF DEPOSITION (> +0.25m)

CHANGE FROM 1978-88 SURVEY TO 2011 SURVEY

LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

1
FIGURE D7
SECTION MARKER

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons
resources & energy

OneWay
to zero harm

B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN
ISSUE	DATE	ISSUE DESCRIPTION	DRAWN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
COMPARISON OF HYDROSURVEY - RIVER BED LEVEL CHANGE
PRIORITY AREA: SACKVILLE FERRY

FIGURE C16

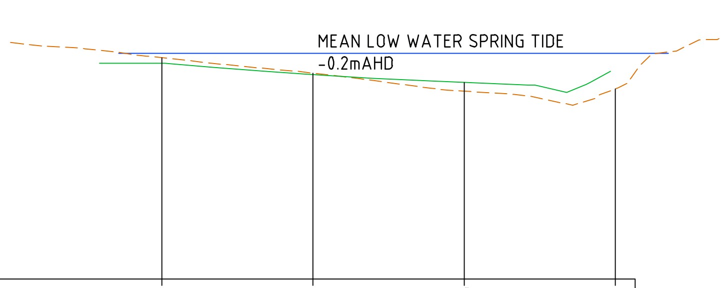
LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DIFFERENCE.DWG
CTB FILE: Worley-Full.ctb Plotter:None
USER NAME: enosh.newar
PLOT DATE & TIME: 31/7/2015 6:57:34 PM
SAVE DATE & TIME: 31/7/2015 6:52:55 PM

Appendix D

Hydrosurvey Comparison

WorleyParsons

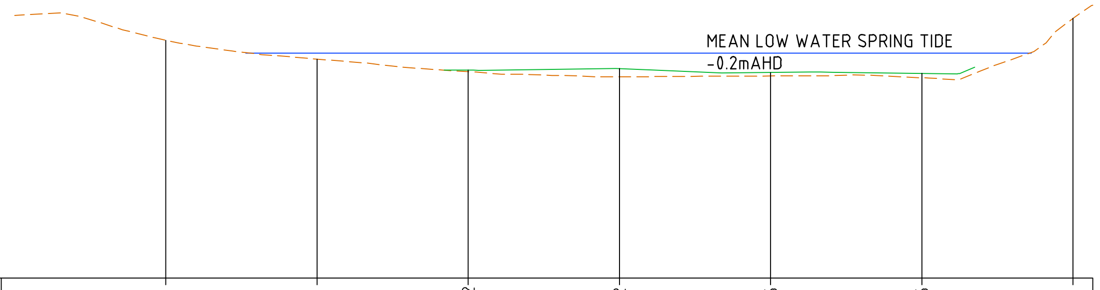
resources & energy



DATUM RL -30.0

2011 SURVEY	-1.53	-3.02	-4.06	
1987 SURVEY	-0.80	-2.83	-5.22	-4.91
CHAINAGE	20.00	40.00	60.00	80.00

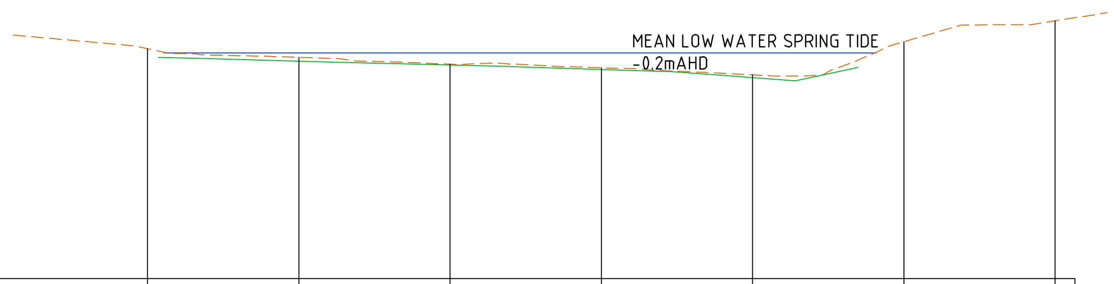
SECTION 3
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



DATUM RL -30.0

2011 SURVEY			-2.42	-2.22	-2.75	-2.85	
1987 SURVEY	1.53	-0.97	-2.64	-3.30	-3.20	-3.44	4.43
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00

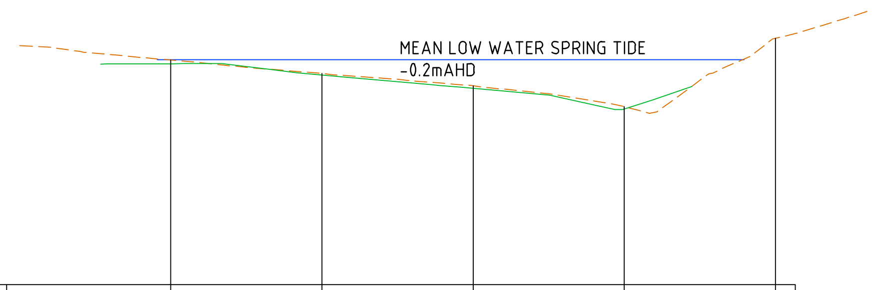
SECTION 4
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



DATUM RL -30.0

2011 SURVEY			-1.29	-1.79	-2.38	-3.47		
1987 SURVEY		0.37	-0.78	-1.68	-2.15	-3.08	1.29	4.04
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00

SECTION 1
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



DATUM RL -30.0

2011 SURVEY	-0.73	-2.22	-4.00	-6.73	
1987 SURVEY	-0.23	-2.03	-3.65	-6.42	2.64
CHAINAGE	20.00	40.00	60.00	80.00	100.00

SECTION 2
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500

10 0 10 20 30 40 50m
1:500 (A1) 1:1000 (A3)

WorleyParsons
resources & energy

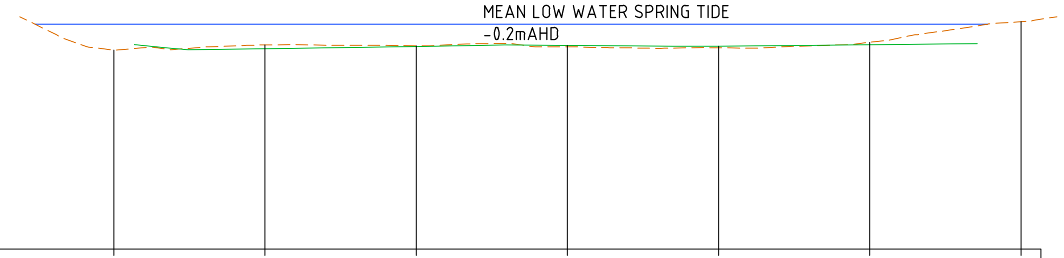
OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

HAWKESBURY RIVER DREDGING BUSINESS CASE
RIVER CROSS-SECTIONS. 2011 AND 1987 HYDROSURVEY
PRIORITY AREA : BEN'S POINT

FIGURE D1

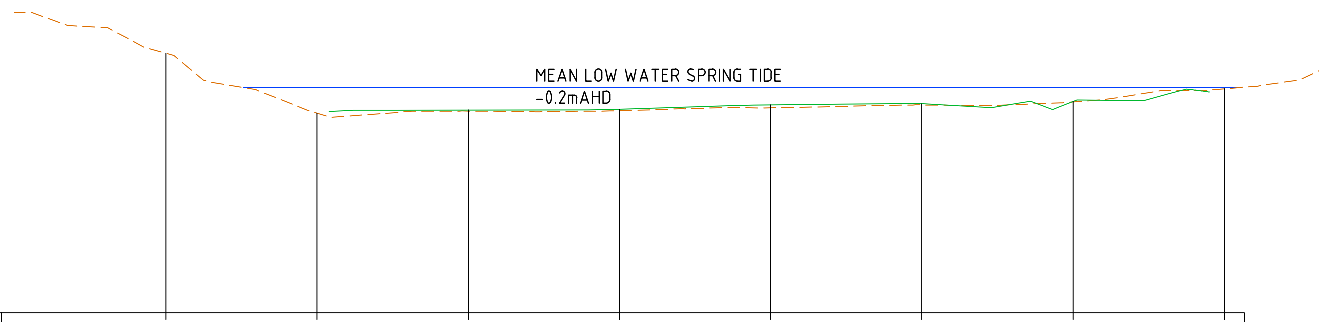
LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-SECTIONS.DWG
USER NAME: enosh.newar
CTB FILE: Worley-Full.ctb Plotter:None
PLOT DATE & TIME: 31/7/2015 6:58:29 PM
SAVE DATE & TIME: 31/7/2015 6:52:20 PM



DATUM RL -30.0

2011 SURVEY		-3.47	-3.19	-3.03	-3.12	-2.96	
1987 SURVEY	-3.64	-2.98	-3.09	-3.23	-3.35	-2.62	0.12
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00

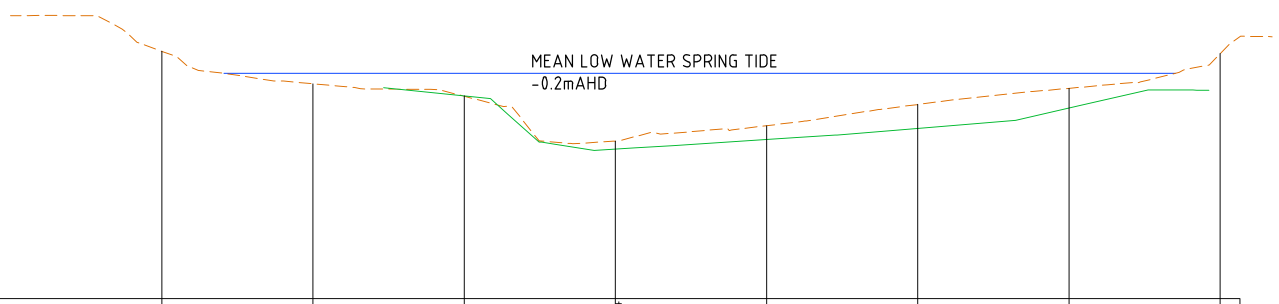
SECTION 7
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



DATUM RL -30.0

2011 SURVEY			-3.15	-3.08	-2.48	-2.32	-2.05	
1987 SURVEY	4.34	-3.58	-3.30	-3.24	-2.88	-2.49	-2.09	-0.36
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00

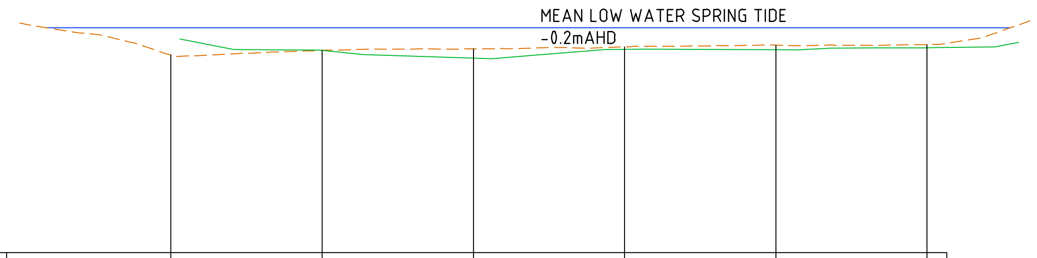
SECTION 8
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



DATUM RL -30.0

2011 SURVEY			-3.17	-10.24	-8.95	-7.49	-4.78	
1987 SURVEY	2.71	-1.58	-3.23	-9.18	-7.12	-4.32	-2.18	2.42
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00

SECTION 5
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



DATUM RL -30.0

2011 SURVEY		-3.21	-4.22	-3.05	-3.09	-2.85
1987 SURVEY	-3.80	-3.19	-3.00	-2.73	-2.51	-2.42
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00

SECTION 6
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-SECTIONS.DWG
USER NAME: enosh.newar
CTB FILE: Worley-Full.ctb Plotter:None
PLOT DATE & TIME: 31/7/2015 6:58:30 PM
SAVE DATE & TIME: 31/7/2015 6:52:20 PM

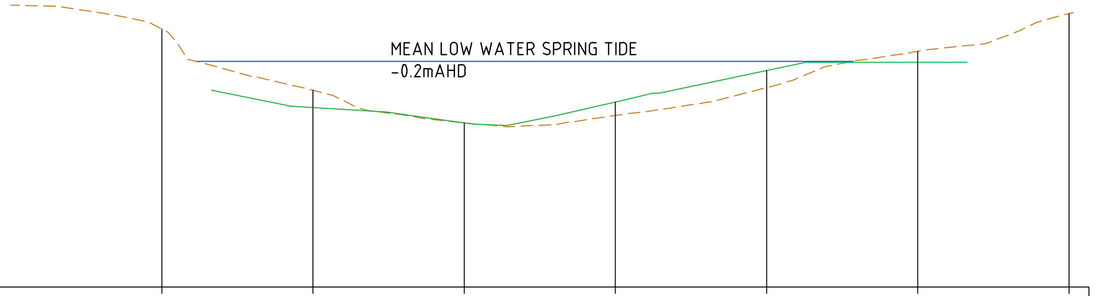
WorleyParsons
resources & energy

OneWay
to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

HAWKESBURY RIVER DREDGING BUSINESS CASE
RIVER CROSS-SECTIONS. 2011 AND 1987 HYDROSURVEY
PRIORITY AREA : PITT TOWN BOTTOMS

FIGURE D2

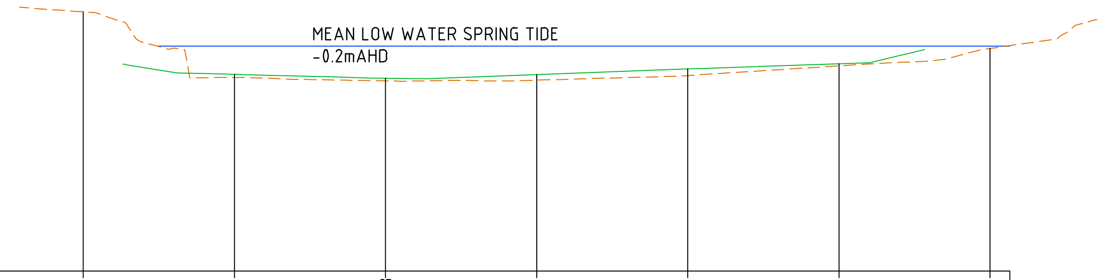


DATUM RL -30.0

2011 SURVEY		-6.33	-8.35	-5.59	-1.45	-0.35	
1987 SURVEY	4.05	-4.03	-8.34	-7.36	-3.68	1.11	6.07
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00

SECTION 11

SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500

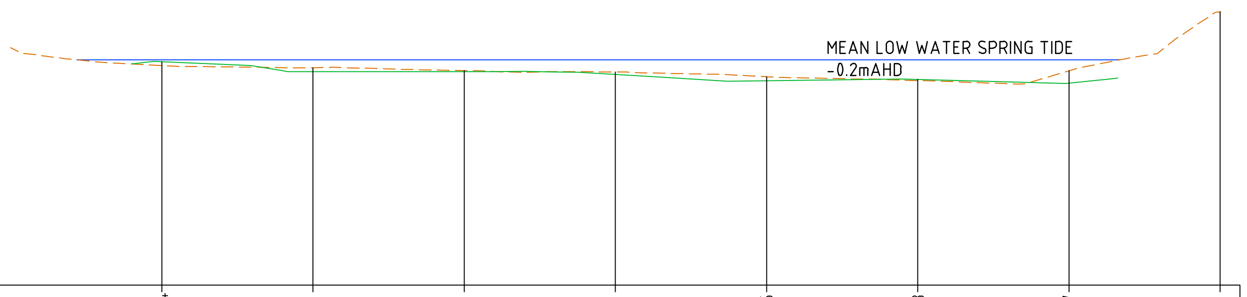


DATUM RL -30.0

2011 SURVEY		-3.93	-4.43	-3.97	-3.21	-2.51	
1987 SURVEY	4.37	-4.32	-4.79	-4.69	-4.08	-2.80	-0.48
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00

SECTION 12

SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500

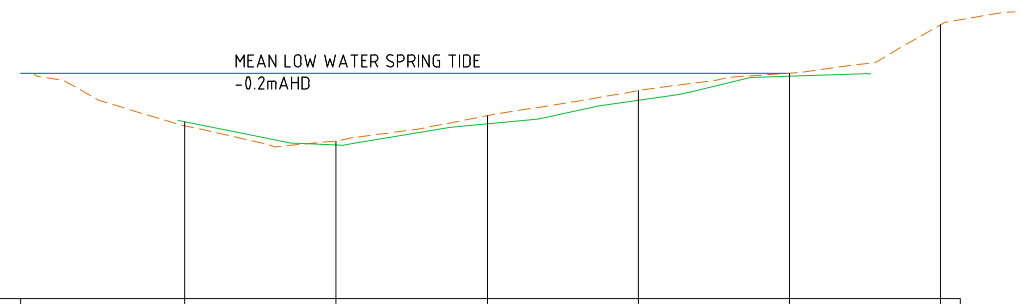


DATUM RL -30.0

2011 SURVEY	-0.44	-1.76	-1.74	-2.14	-2.95	-2.78	-3.27	
1987 SURVEY	-0.96	-1.24	-1.62	-1.81	-2.42	-2.94	-1.65	6.14
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00

SECTION 9

SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



DATUM RL -30.0

2011 SURVEY	-6.62	-9.67	-6.89	-3.75	-0.58	
1987 SURVEY	-7.15	-9.15	-5.82	-2.49	-0.19	6.22
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00

SECTION 10

SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500

10 0 10 20 30 40 50m
1:500 (A1) 1:1000 (A3)

WorleyParsons
resources & energy

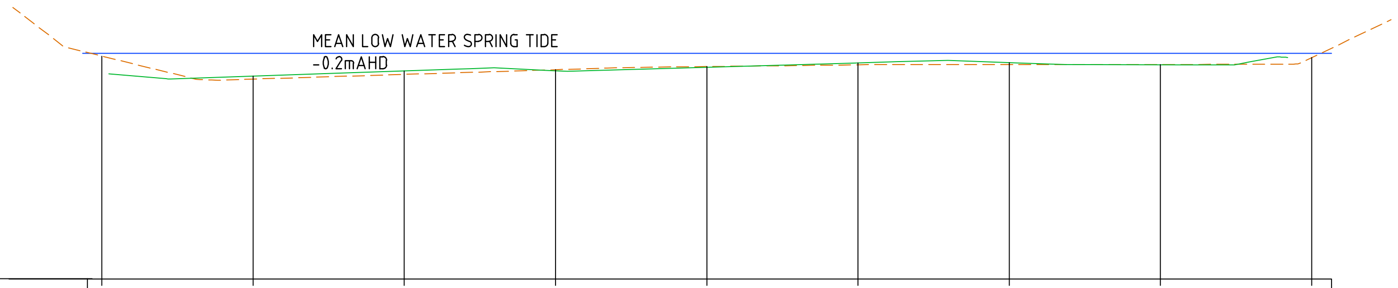
OneWay
to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

HAWKESBURY RIVER DREDGING BUSINESS CASE
RIVER CROSS-SECTIONS. 2011 AND 1987 HYDROSURVEY
PRIORITY AREA : SANDY POINT

FIGURE D3

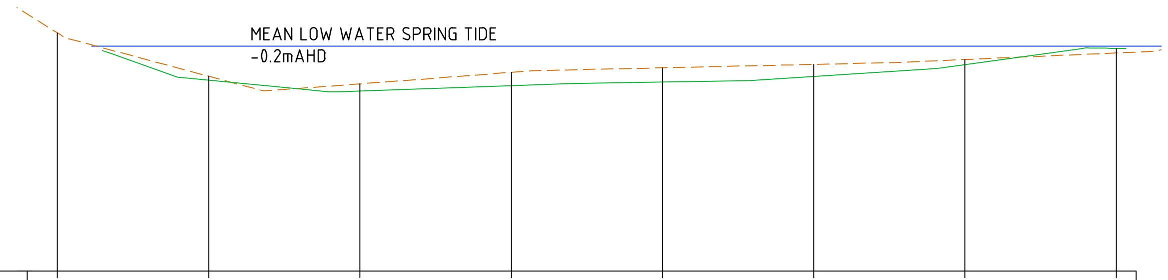
LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-SECTIONS.DWG
USER NAME: enosh.newar
CTB FILE: Worley-Full.ctb Plotter:None
PLOT DATE & TIME: 31/7/2015 6:58:30 PM
SAVE DATE & TIME: 31/7/2015 6:52:20 PM



2011 SURVEY		-3.21	-2.53	-2.53	-2.07	-1.49	-1.45	-1.74	
1978 SURVEY	-0.58	-3.62	-3.00	-2.38	-1.96	-1.74	-1.70	-1.70	-0.78
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00

SECTION 15

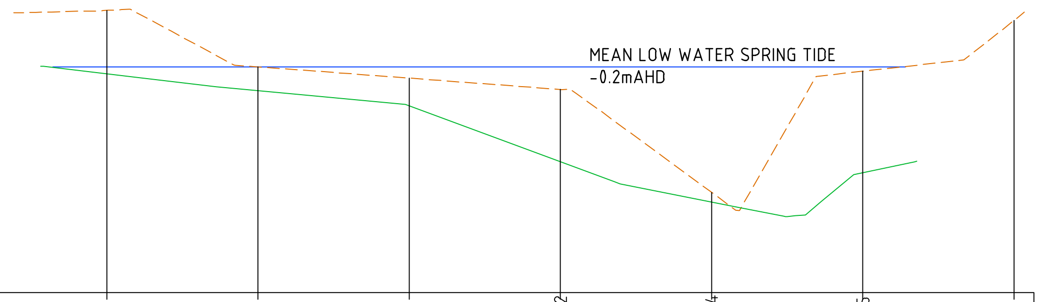
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



2011 SURVEY		-4.69	-6.12	-5.42	-4.93	-4.19	-2.65	-0.47
1978 SURVEY	1.57	-4.17	-5.18	-3.66	-3.05	-2.60	-1.95	-1.08
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00

SECTION 16

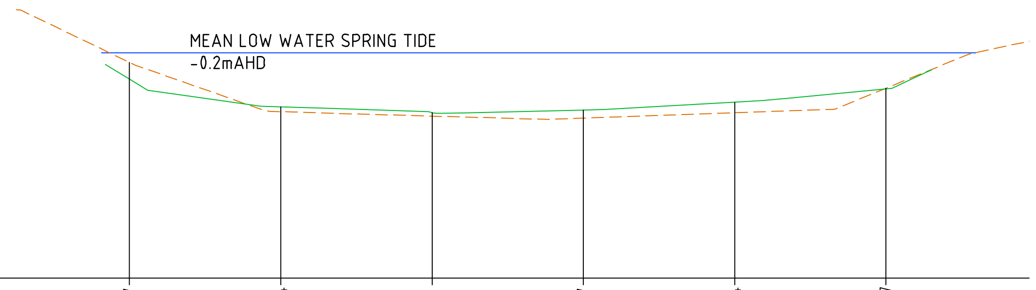
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



2011 SURVEY	-1.11	-3.33	-5.33	-12.72	-18.04	-14.15	
1978 SURVEY	7.27	-0.21	-1.67	-3.17	-16.77	-0.77	5.94
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00

SECTION 13

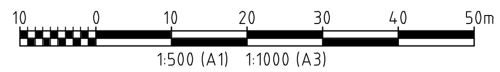
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



2011 SURVEY	-3.67	-7.34	-8.12	-7.77	-6.74	-4.97
1978 SURVEY	-1.46	-7.97	-8.57	-8.84	-8.13	-4.88
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00

SECTION 14

SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



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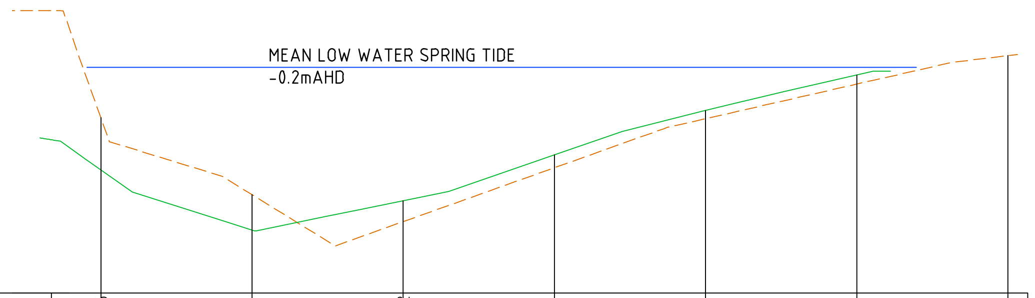
ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

HAWKESBURY RIVER DREDGING BUSINESS CASE
RIVER CROSS-SECTIONS. 2011 AND 1978 HYDROSURVEY
PRIORITY AREA : CATTAI CREEK

FIGURE D4

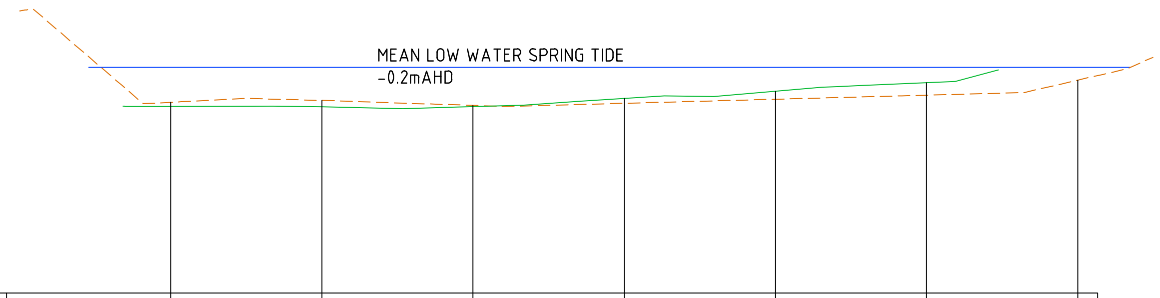


DATUM RL -30.0

2011 SURVEY	-13.76	-21.71	-17.82	-11.79	-5.92	-1.24	
1978 SURVEY	-6.88	-17.04	-20.59	-13.48	-7.00	-2.43	1.33
CHAINAGE	40.00	60.00	80.00	100.00	120.00	140.00	160.00

SECTION 19

SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500

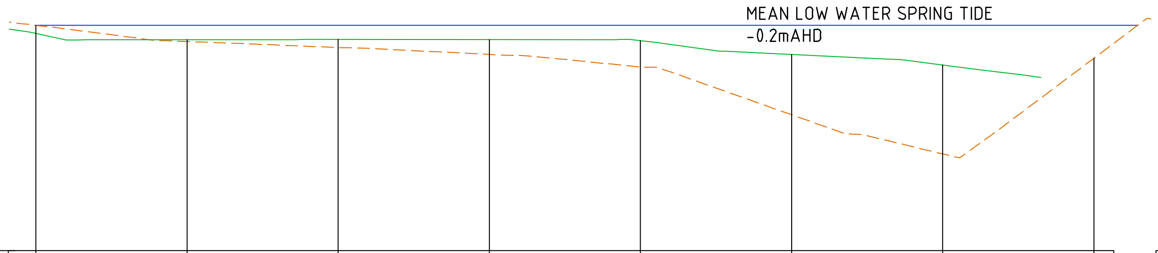


DATUM RL -30.0

2011 SURVEY	-5.33	-5.37	-5.36	-4.29	-3.34	-2.21	
1978 SURVEY	-4.79	-4.55	-5.21	-4.92	-4.39	-3.86	-1.88
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00

SECTION 20

SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500

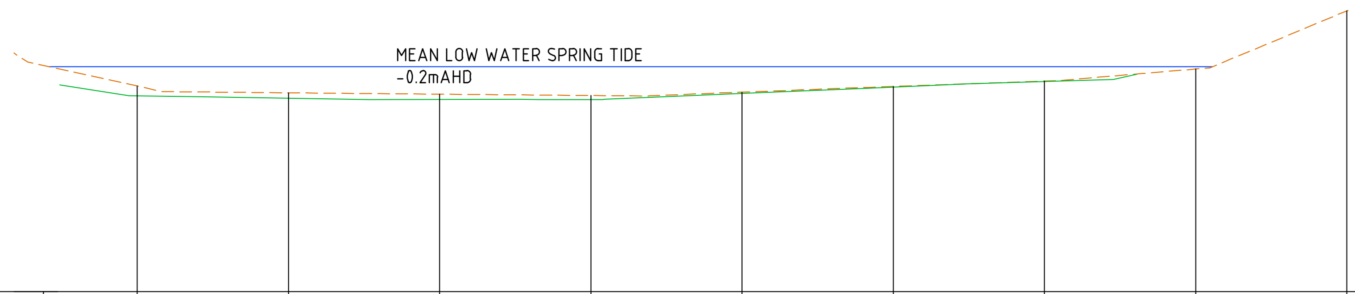


DATUM RL -30.0

2011 SURVEY	-1.28	-2.10	-2.05	-2.09	-2.23	-4.04	-5.45	
1978 SURVEY	-0.20	-2.34	-3.13	-4.05	-5.70	-12.03	-17.20	-4.55
CHAINAGE	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00

SECTION 17

SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500

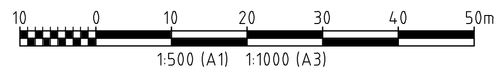


DATUM RL -30.0

2011 SURVEY	-4.08	-4.37	-4.54	-4.55	-3.75	-2.91	-2.16		
1978 SURVEY	-2.76	-3.66	-3.84	-4.01	-3.57	-2.81	-2.10	-0.50	7.20
CHAINAGE	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00

SECTION 18

SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



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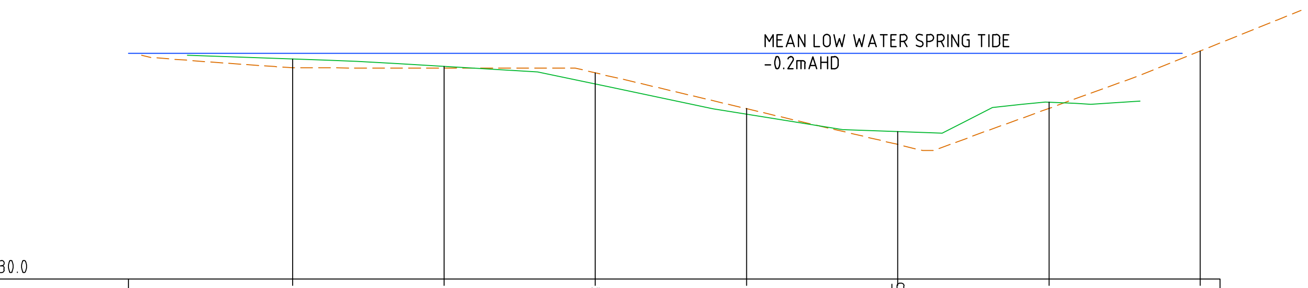
ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

HAWKESBURY RIVER DREDGING BUSINESS CASE
RIVER CROSS-SECTIONS. 2011 AND 1978 HYDROSURVEY
PRIORITY AREA : EBENEZER CHURCH

FIGURE D5

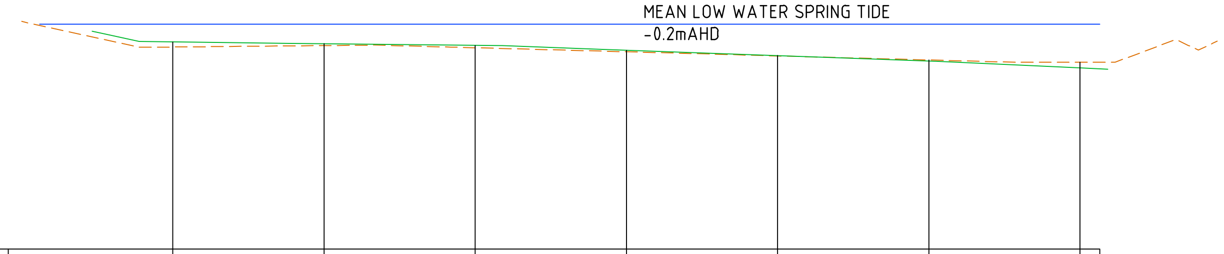
LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-SECTIONS.DWG
USER NAME: enosh.newar
CTB FILE: Worley-Full.ctb Plotter:None
PLOT DATE & TIME: 31/7/2015 6:58:32 PM
SAVE DATE & TIME: 31/7/2015 6:52:20 PM



DATUM RL -30.0

2011 SURVEY	-0.96	-1.95	-4.28	-8.26	-10.55	-6.66	
1978 SURVEY	-2.14	-2.15	-2.79	-7.52	-12.26	-7.48	0.09
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00

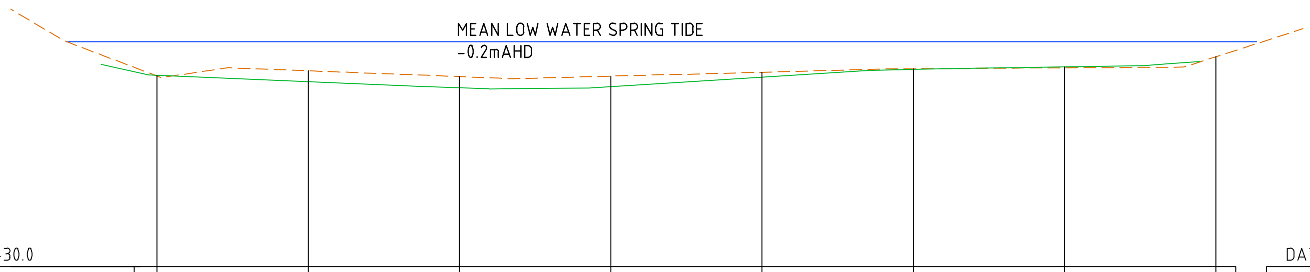
SECTION 23
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



DATUM RL -30.0

2011 SURVEY	-2.54	-2.77	-3.00	-3.63	-4.34	-5.07	-5.98
1978 SURVEY	-3.21	-3.02	-3.31	-3.84	-4.38	-4.92	-5.23
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00

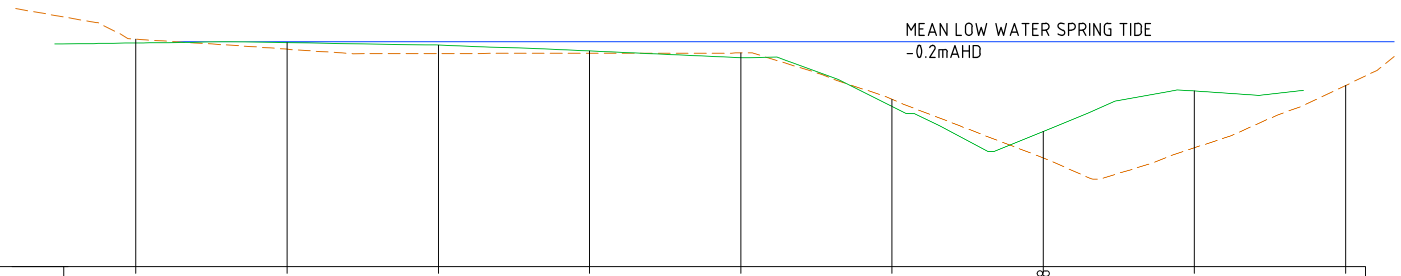
SECTION 24
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



DATUM RL -30.0

2011 SURVEY	-4.65	-5.49	-6.29	-6.14	-4.90	-3.87	-3.53	
1978 SURVEY	-4.73	-4.05	-4.81	-4.76	-4.24	-3.78	-3.65	-2.20
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00

SECTION 21
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



DATUM RL -30.0

2011 SURVEY	-0.36	-0.32	-0.65	-1.43	-2.30	-8.77	-12.08	-6.73	
1978 SURVEY	0.15	-1.19	-1.75	-1.72	-1.69	-7.82	-15.59	-14.25	-5.99
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00

SECTION 22
SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500

10 0 10 20 30 40 50m
1:500 (A1) 1:1000 (A3)

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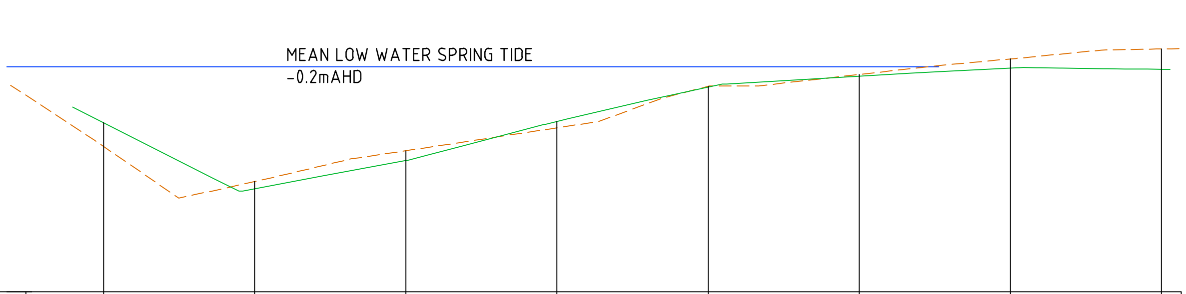
to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

HAWKESBURY RIVER DREDGING BUSINESS CASE
RIVER CROSS-SECTIONS. 2011 AND 1978 HYDROSURVEY
PRIORITY AREA : SACKVILLE GORGE

FIGURE D6

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-SECTIONS.DWG
USER NAME: enosh.newar
CTB FILE: Worley-Full.ctb Plotter:None
PLOT DATE & TIME: 31/7/2015 6:58:33 PM
SAVE DATE & TIME: 31/7/2015 6:52:20 PM

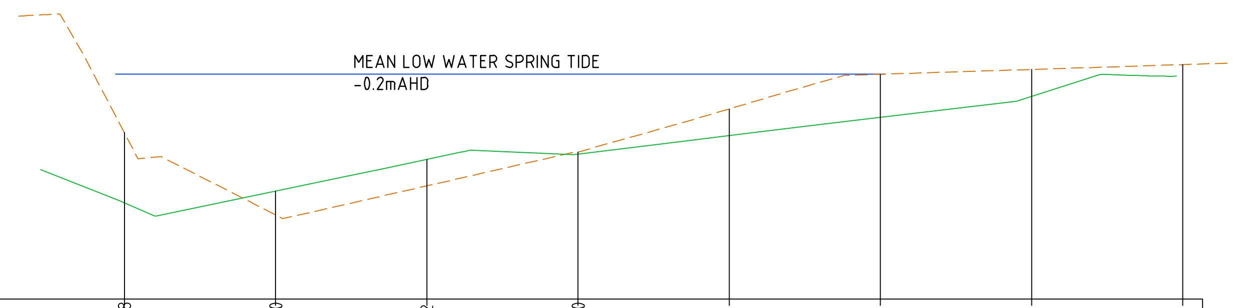


DATUM RL -30.0

2011 SURVEY	-7.62	-16.37	-12.62	-7.46	-2.92	-1.45	-0.37	-0.54
1978 SURVEY	-10.75	-15.42	-11.33	-8.30	-2.80	-1.23	0.83	2.15
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00

SECTION 26

SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500

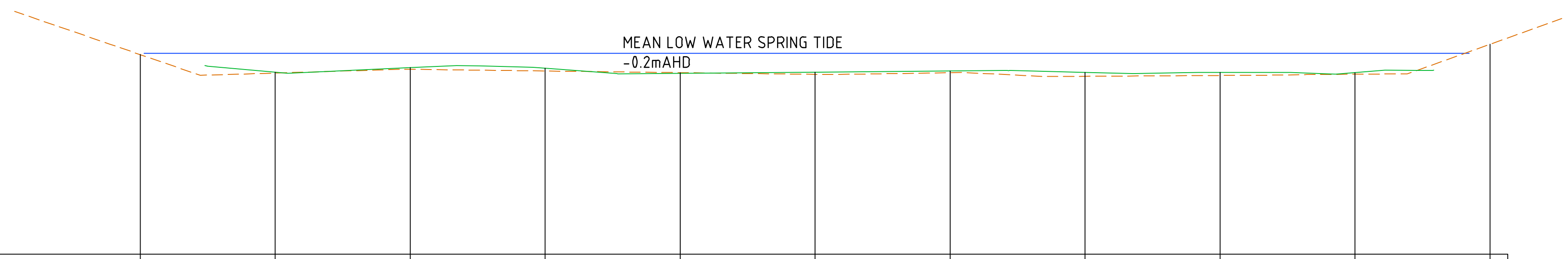


DATUM RL -30.0

2011 SURVEY	-17.28	-15.70	-11.52	-10.80	-8.36	-5.95	-3.16	
1978 SURVEY	-7.98	-18.87	-15.02	-10.55	-4.83	-0.24	0.40	1.04
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00

SECTION 27

SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500



DATUM RL -30.0

2011 SURVEY		-3.00	-2.32	-2.40	-3.15	-2.98	-2.81	-3.03	-3.02	-3.05	
1978 SURVEY	-0.38	-3.13	-2.57	-2.82	-3.07	-3.32	-3.08	-3.60	-3.48	-3.29	1.15
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00

SECTION 25

SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500

10 0 10 20 30 40 50m
1:500 (A1) 1:1000 (A3)

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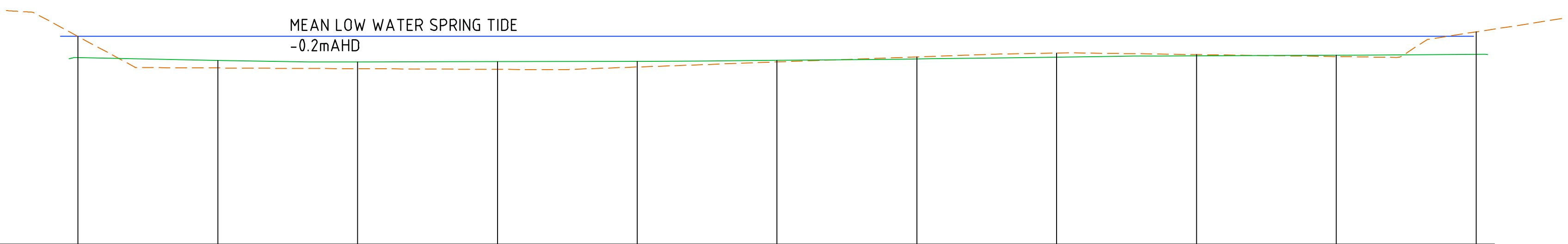
OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

HAWKESBURY RIVER DREDGING BUSINESS CASE
RIVER CROSS-SECTIONS. 2011 AND 1978 HYDROSURVEY
PRIORITY AREA : SACKVILLE FERRY

FIGURE D7

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-SECTIONS.DWG
USER NAME: enosh.newar CTB FILE: Worley-Full.ctb Plotter:None
PLOT DATE & TIME: 31/7/2015 6:58:33 PM
SAVE DATE & TIME: 31/7/2015 6:52:20 PM



DATUM RL -30.0

2011 SURVEY	-3.23	-3.63	-3.85	-3.81	-3.79	-3.63	-3.44	-3.18	-3.00	-2.90	-2.78
1978 SURVEY	-0.21	-4.73	-4.83	-4.93	-4.59	-3.87	-3.15	-2.59	-2.81	-3.09	0.45
CHAINAGE	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00

SECTION 28

SCALE HORIZONTAL 1:500
SCALE VERTICAL 1:500

10 0 10 20 30 40 50m
1:500 (A1) 1:1000 (A3)

WorleyParsons
resources & energy

OneWay
to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

HAWKESBURY RIVER DREDGING BUSINESS CASE
RIVER CROSS-SECTIONS. 2011 AND 1978 HYDROSURVEY
PRIORITY AREA : SACKVILLE FERRY

FIGURE D8

PLOT DATE & TIME: 31/7/2015 6:58:34 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-SECTIONS.DWG
SAVE DATE & TIME: 31/7/2015 6:52:20 PM CTB FILE: Worley-Full.ctb Plotter:None

Appendix E

Dredge Volume Ananlysis

WorleyParsons

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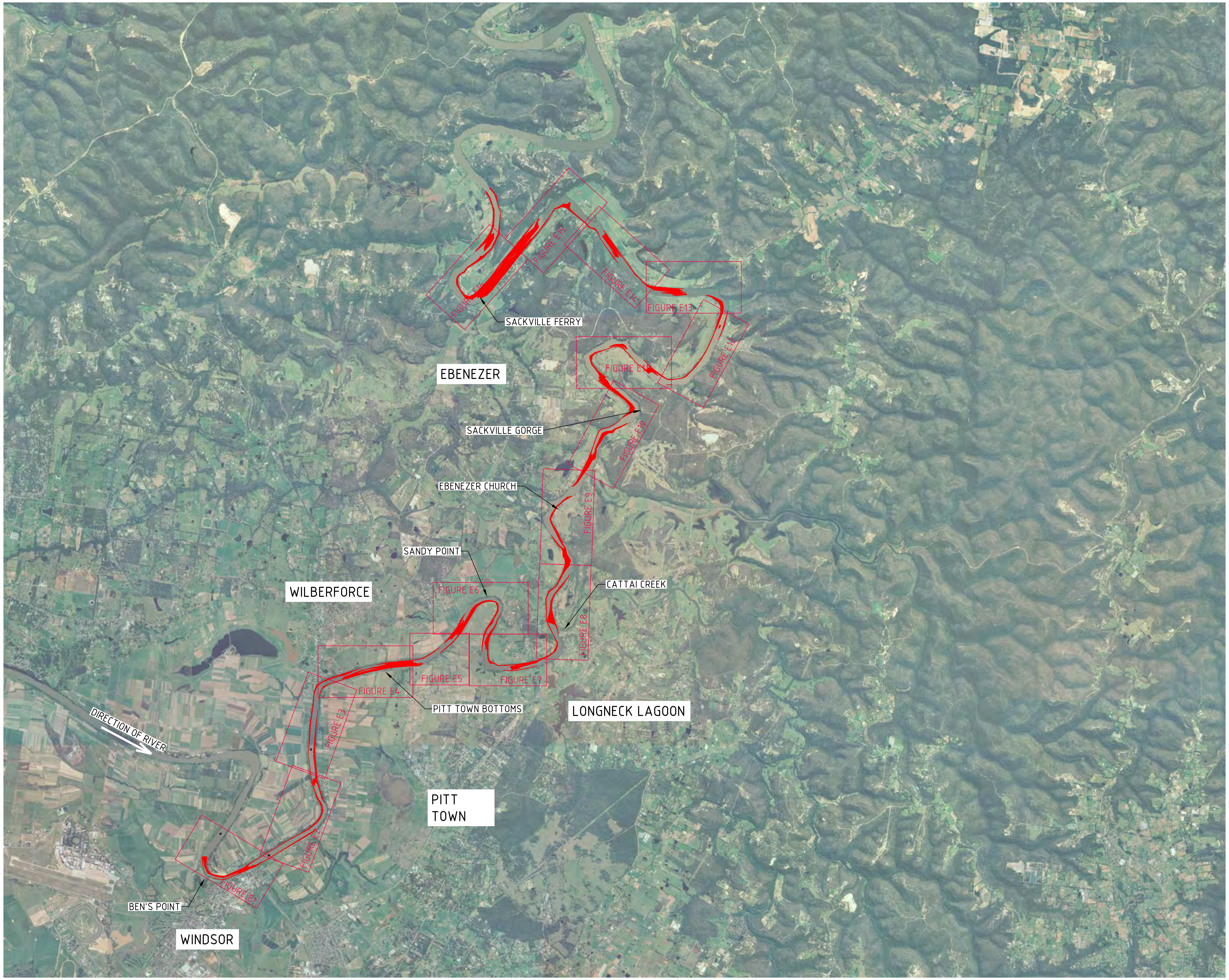

HAWKESBURY RIVER DREDGING
AREAS WHERE DREDGING IS REQUIRED TO ACHIEVE A 3m FUNCTIONAL WATER DEPTH BELOW MEAN LOW WATER SPRING TIDE LEVEL

NOTES

1. FROM BEN'S POINT TO NEAR LONGNECK LAGOON 2011 SURVEY DATA IS COMPARED WITH 1987-88 SURVEY DATA. FROM NEAR LONGNECK LAGOON TO SACKVILLE FERRY 2011 SURVEY DATA IS COMPARED WITH 1978-80 SURVEY DATA

3. DREDGE IS REQUIRED TO CREATE A MINIMUM FUNCTIONAL WATER DEPTH OF 3M BELOW MEAN LOW WATER SPRING TIDE LEVEL

4. MEAN LOW WATER SPRING (MLWS) LEVEL FOR THE STUDY AREA VARIES BETWEEN -0.123M AHD AND -0.284M AHD WITH A +-0.05M ACCURACY. MLWS HAS BEEN ASSUMED AS -0.2M FOR THE EXTENT OF THE STUDY AREA.

800 0 800 1600 2400 3200 4000m

1:40000 (A1) 1:80000 (A3)

PLAN

SCALE 1 : 40000

WorleyParsons
resources & energy

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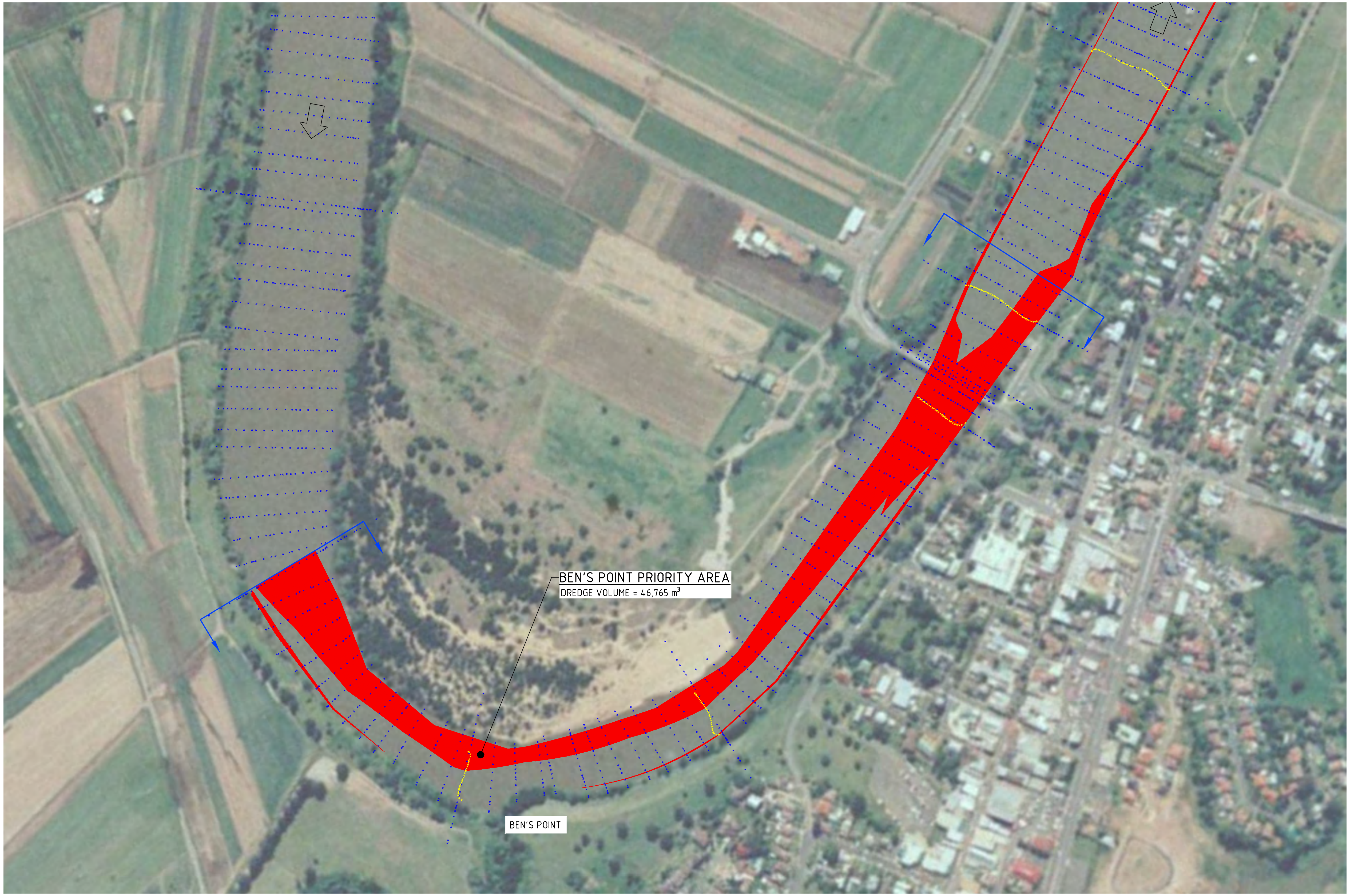
ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
DREDGE VOLUME ANALYSIS
INDEX SHEET

FIGURE E

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING.DWG
USER NAME: enosh.newar
CTB FILE: Worley-Full.ctb Plotter:None
PLOT DATE & TIME: 31/7/2015 6:57:45 PM
SAVE DATE & TIME: 31/7/2015 6:44:23 PM



HAWKESBURY RIVER DREDGING

AREAS WHERE DREDGING IS REQUIRED TO ACHIEVE A 3m FUNCTIONAL WATER DEPTH BELOW MEAN LOW WATER SPRING TIDE LEVEL

LEGEND

2011 SURVEY DATA POINTS

1987 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

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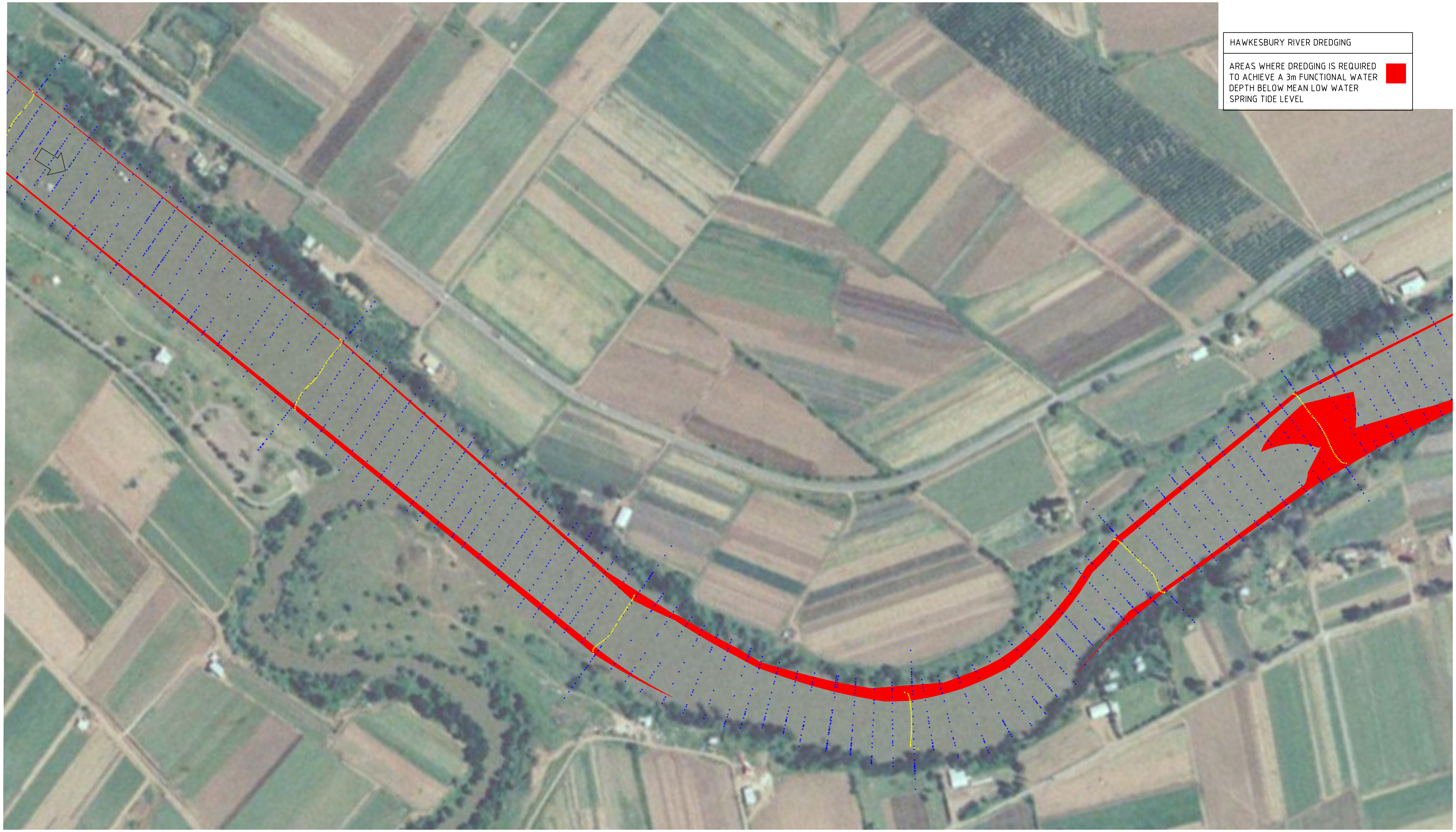
ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
DREDGE VOLUME ANALYSIS
PRIORITY AREA: BEN'S POINT

FIGURE E1

PLOT DATE & TIME: 31/7/2015 6:57:48 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING .DWG
SAVE DATE & TIME: 31/7/2015 6:44:23 PM CTB FILE: Worley-Full.ctb Plotter:None



LEGEND

2011 SURVEY DATA POINTS

1987 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons

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OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE

DREDGE VOLUME ANALYSIS

FIGURE E2

PLOT DATE & TIME: 31/7/2015 6:57:51 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING.DWG

SAVE DATE & TIME: 31/7/2015 6:44:23 PM CTB FILE: Worley-Full.ctb Plotter:None

LEGEND

2011 SURVEY DATA POINTS

1987 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons

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OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

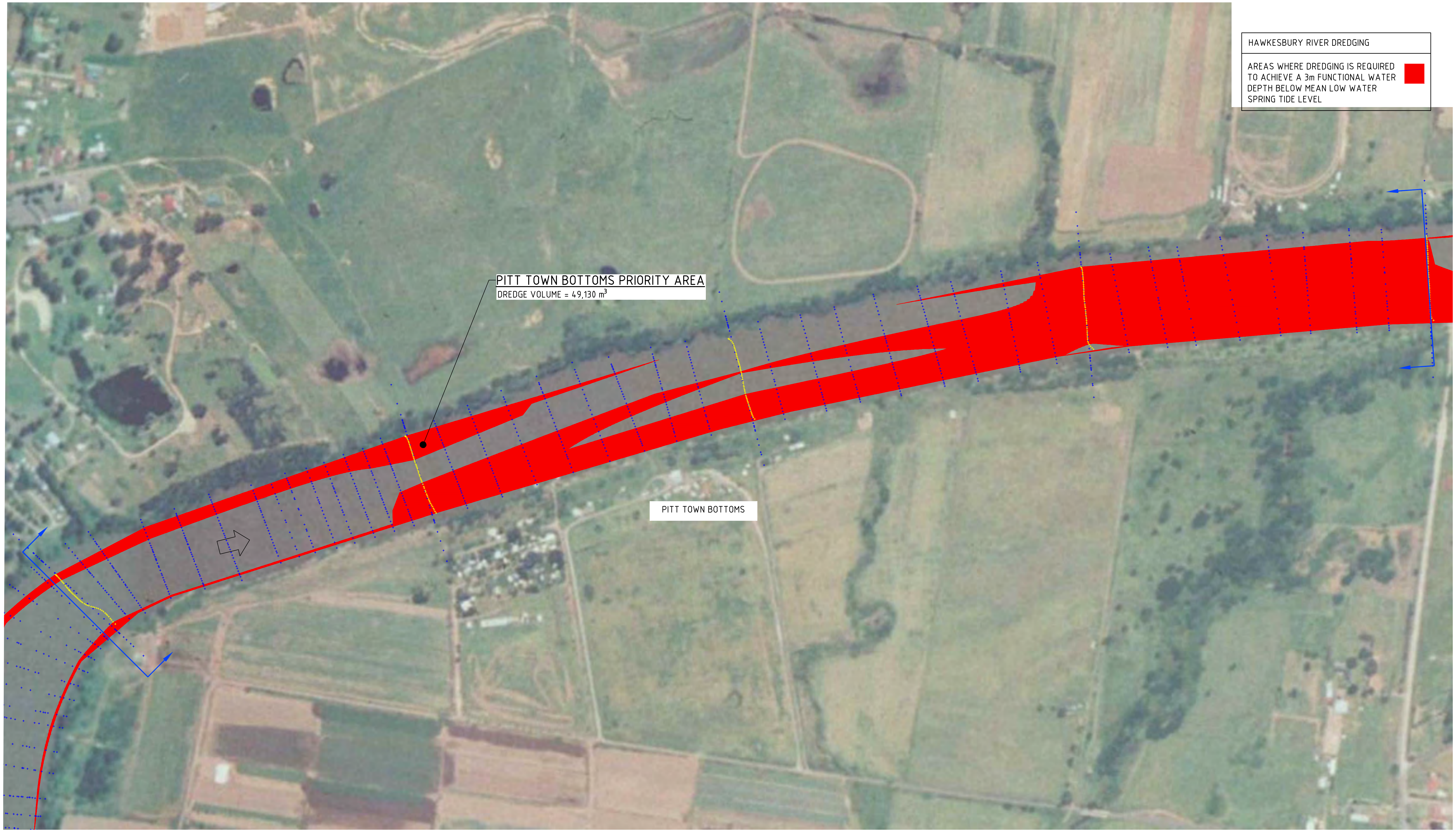
HAWKESBURY RIVER DREDGING BUSINESS CASE

DREDGE VOLUME ANALYSIS

FIGURE E3

PLOT DATE & TIME: 31/7/2015 6:57:54 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING.DWG

SAVE DATE & TIME: 31/7/2015 6:44:23 PM CTB FILE: Worley-Full.ctb Plotter:None



LEGEND

2011 SURVEY DATA POINTS

1987 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

N NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
DREDGE VOLUME ANALYSIS
PRIORITY AREA: PITT TOWN BOTTOMS

FIGURE E4

LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING.DWG
USER NAME: enosh.newar CTB FILE: Worley-Full.ctb Plotter:None
PLOT DATE & TIME: 31/7/2015 6:57:56 PM SAVE DATE & TIME: 31/7/2015 6:44:23 PM

HAWKESBURY RIVER DREDGING	
AREAS WHERE DREDGING IS REQUIRED TO ACHIEVE A 3m FUNCTIONAL WATER DEPTH BELOW MEAN LOW WATER SPRING TIDE LEVEL	

LEGEND

- 2011 SURVEY DATA POINTS
- 1987 SURVEY DATA POINTS
- PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons
resources & energy

OneWay to zero harm

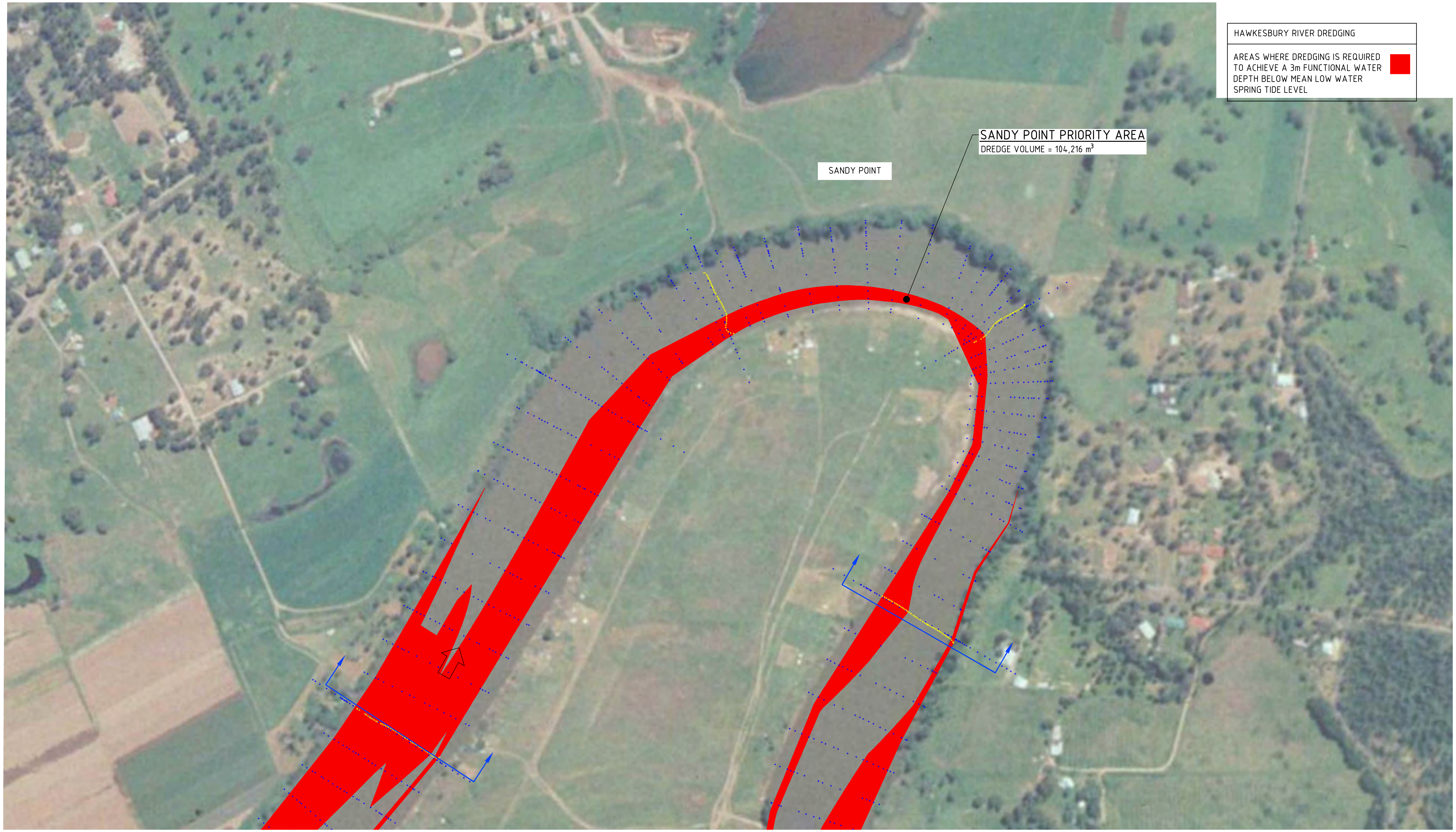
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN
ISSUE	DATE	ISSUE DESCRIPTION	DRAWN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
DREDGE VOLUME ANALYSIS

FIGURE E5

PLOT DATE & TIME: 31/7/2015 6:57:57 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING .DWG
SAVE DATE & TIME: 31/7/2015 6:44:23 PM CTB FILE: Worley-Full.ctb Plotter:None



LEGEND

2011 SURVEY DATA POINTS

1987 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons
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OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

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HAWKESBURY RIVER DREDGING BUSINESS CASE
DREDGE VOLUME ANALYSIS
PRIORITY AREA: SANDY POINT

FIGURE E6

PLOT DATE & TIME: 31/7/2015 6:57:59 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING.DWG
SAVE DATE & TIME: 31/7/2015 6:44:23 PM CTB FILE: Worley-Full.ctb Plotter:None

LEGEND

2011 SURVEY DATA POINTS

1987 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons

resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

N

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE

DREDGE VOLUME ANALYSIS

FIGURE E7

PLOT DATE & TIME: 31/7/2015 6:58:01 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING .DWG

SAVE DATE & TIME: 31/7/2015 6:44:23 PM CTB FILE: Worley-Full.ctb Plotter:None

LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE

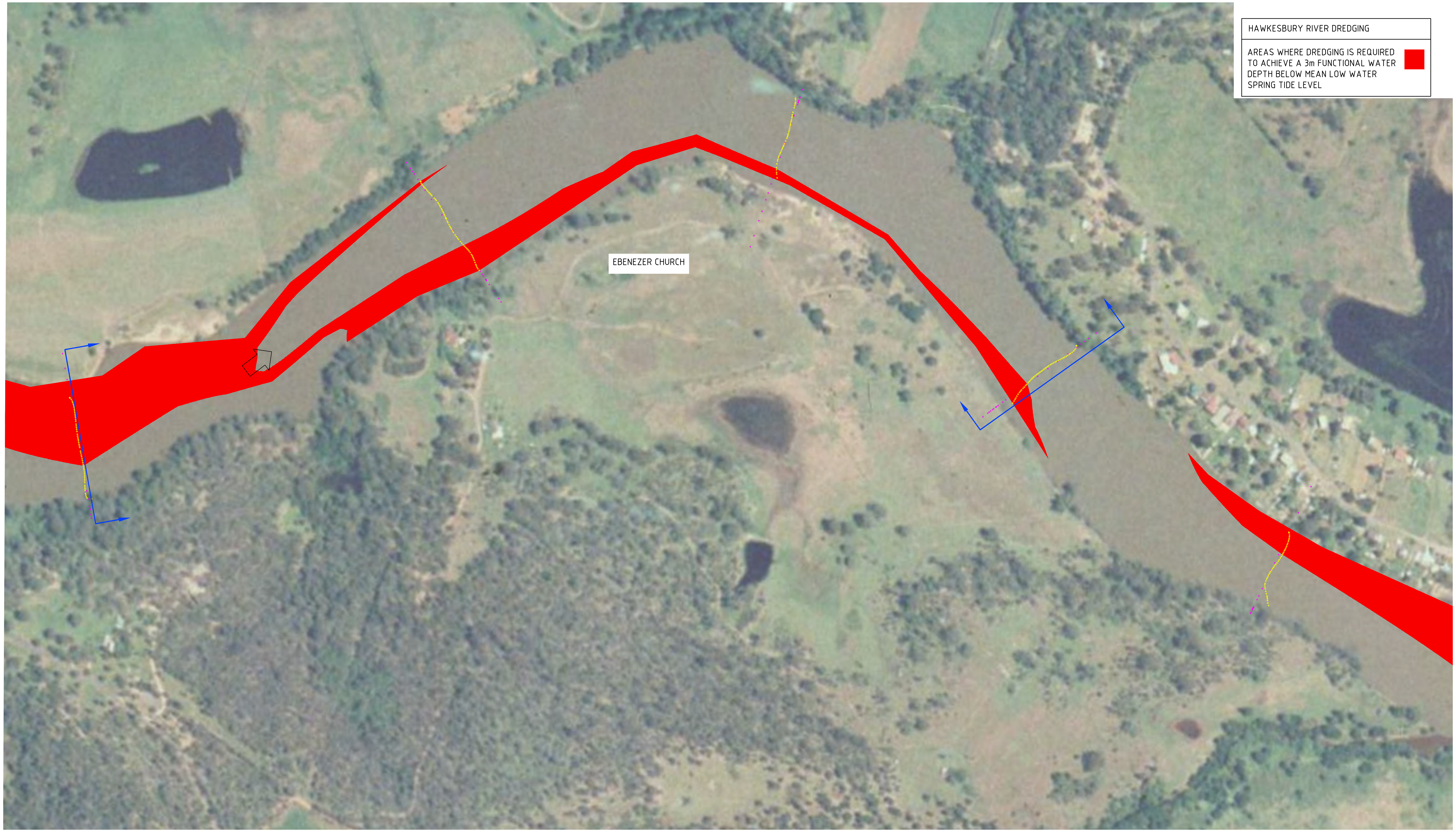
DREDGE VOLUME ANALYSIS

PRIORITY AREA: CATTAI CREEK

FIGURE E8

PLOT DATE & TIME: 31/7/2015 6:58:03 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING.DWG

SAVE DATE & TIME: 31/7/2015 6:44:23 PM CTB FILE: Worley-Full.ctb Plotter:None



LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons
resources & energy

OneWay to zero harm

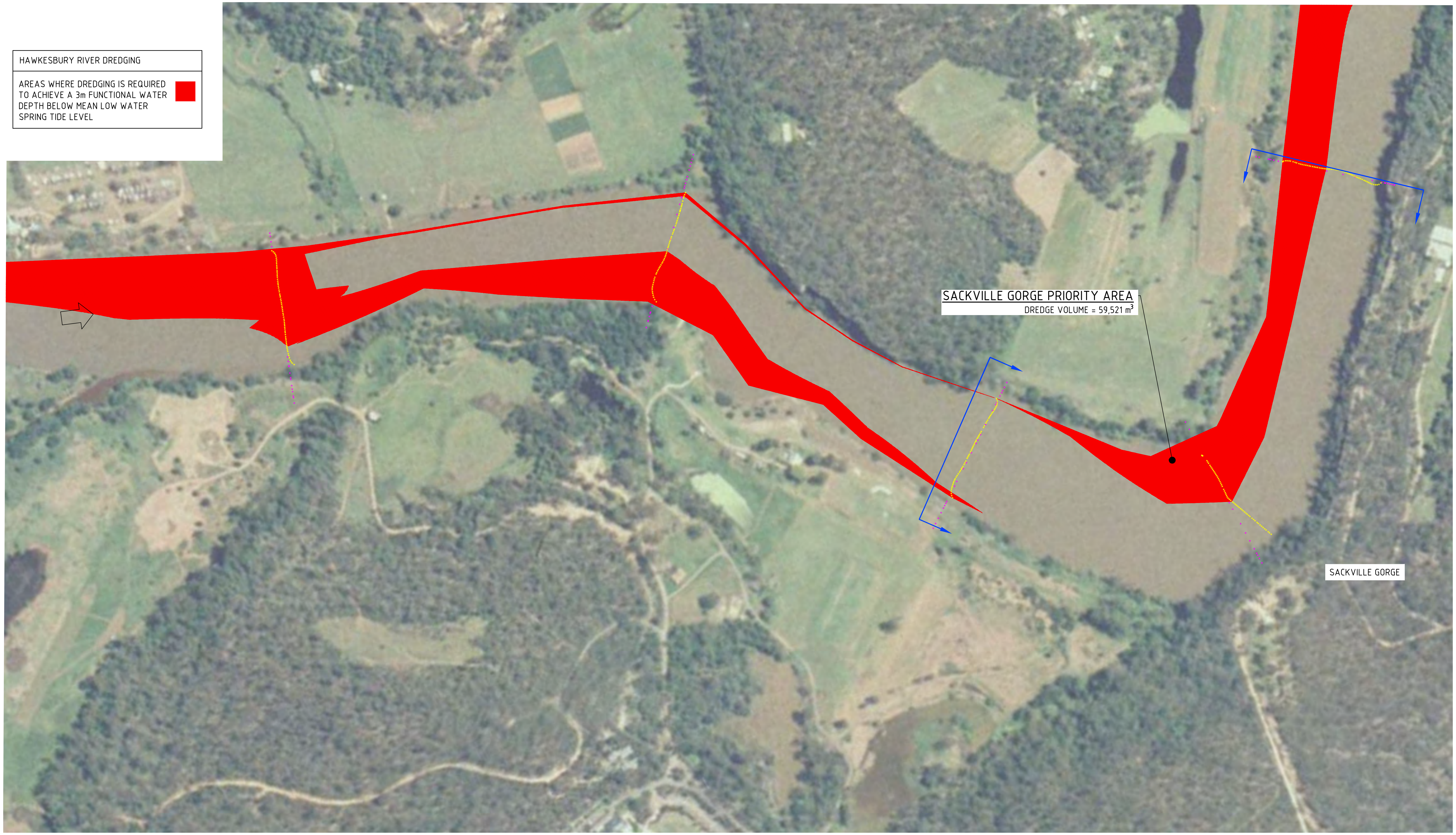
ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
DREDGE VOLUME ANALYSIS
PRIORITY AREA: EBENEZER CHURCH

FIGURE E9

PLOT DATE & TIME: 31/7/2015 6:58:06 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING.DWG
SAVE DATE & TIME: 31/7/2015 6:44:23 PM CTB FILE: Worley-Full.ctb Plotter:None



LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE

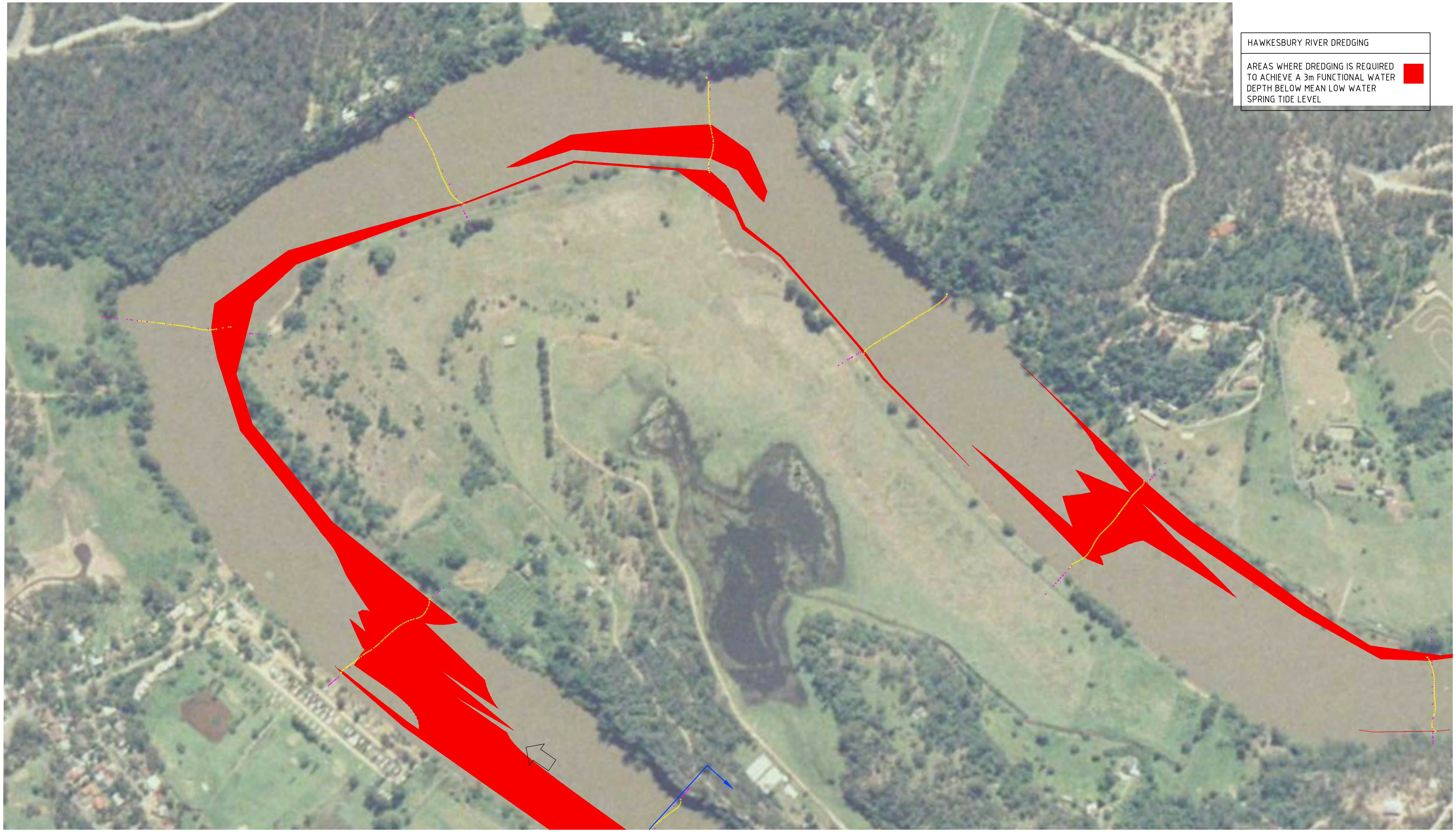
DREDGE VOLUME ANALYSIS

PRIORITY AREA: SACKVILLE GORGE

FIGURE E10

PLOT DATE & TIME: 31/7/2015 6:58:09 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING.DWG

SAVE DATE & TIME: 31/7/2015 6:44:23 PM CTB FILE: Worley-Full.ctb Plotter:None



LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons

resources & energy

OneWay to zero harm

B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN
ISSUE	DATE	ISSUE DESCRIPTION	DRAWN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE

DREDGE VOLUME ANALYSIS

FIGURE E11

PLOT DATE & TIME: 31/7/2015 6:58:11 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING.DWG

SAVE DATE & TIME: 31/7/2015 6:44:23 PM CTB FILE: Worley-Full.ctb Plotter:None

LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

PLAN
SCALE 1 : 2500

50 0 50 100 150 200 250m
1:2500 (A1) 1:5000 (A3)

WorleyParsons
resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
DREDGE VOLUME ANALYSIS

FIGURE E12

PLOT DATE & TIME: 31/7/2015 6:58:14 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING .DWG
SAVE DATE & TIME: 31/7/2015 6:44:23 PM CTB FILE: Worley-Full.ctb Plotter:None

LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE

DREDGE VOLUME ANALYSIS

FIGURE E13

PLOT DATE & TIME: 31/7/2015 6:58:16 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING.DWG

SAVE DATE & TIME: 31/7/2015 6:44:23 PM CTB FILE: Worley-Full.ctb Plotter:None

LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons

resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE

DREDGE VOLUME ANALYSIS

FIGURE E14

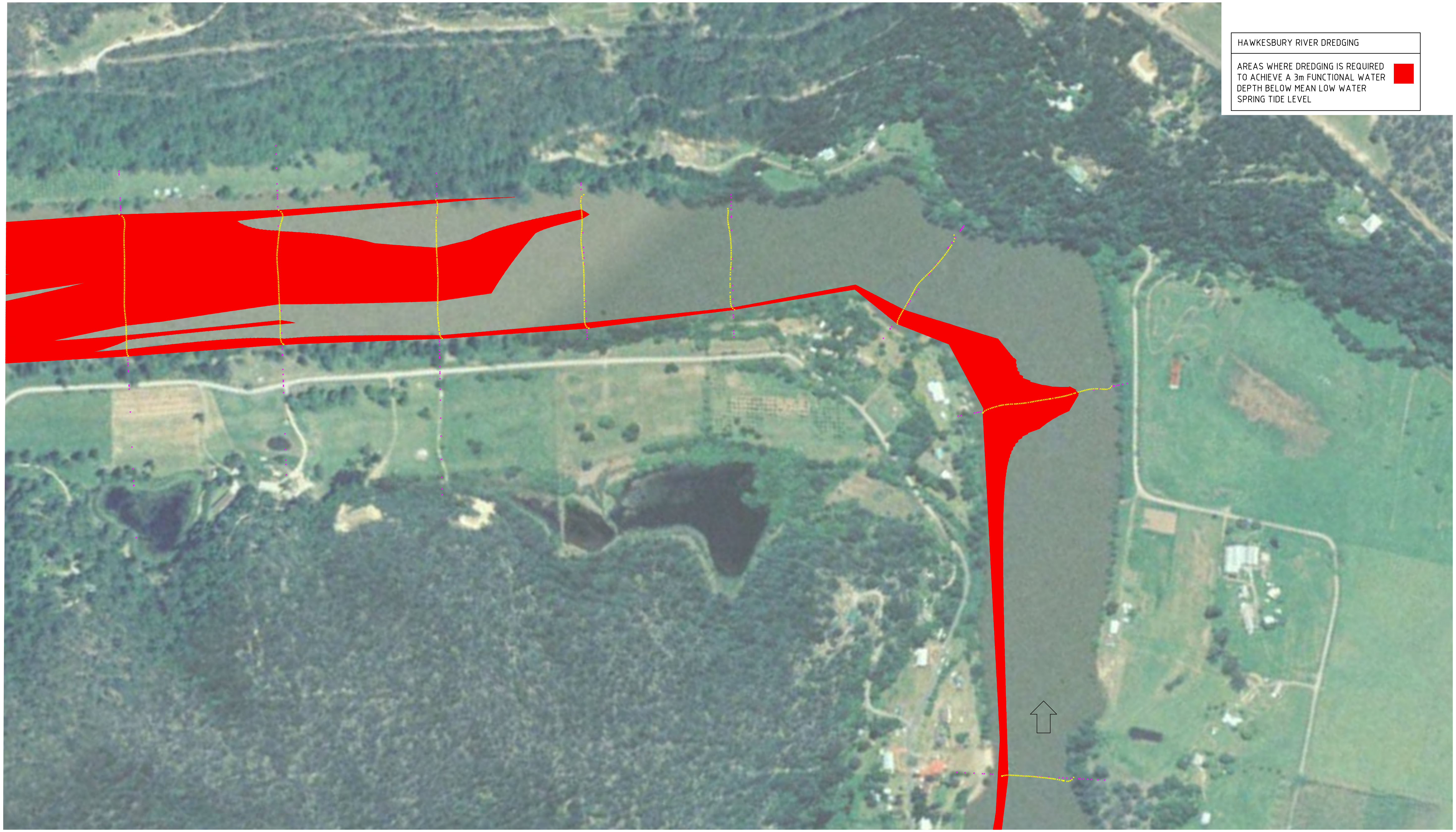
LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING.DWG

USER NAME: enosh.newar

CTB FILE: Worley-Full.ctb Plotter:None

PLOT DATE & TIME: 31/7/2015 6:58:20 PM

SAVE DATE & TIME: 31/7/2015 6:44:23 PM



HAWKESBURY RIVER DREDGING
AREAS WHERE DREDGING IS REQUIRED TO ACHIEVE A 3m FUNCTIONAL WATER DEPTH BELOW MEAN LOW WATER SPRING TIDE LEVEL

LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons

resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE

DREDGE VOLUME ANALYSIS

FIGURE E15

PLOT DATE & TIME: 31/7/2015 6:58:23 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING .DWG

SAVE DATE & TIME: 31/7/2015 6:44:23 PM CTB FILE: Worley-Full.ctb Plotter:None

LEGEND

2011 SURVEY DATA POINTS

1978 SURVEY DATA POINTS

PRIORITY AREAS

PLAN

SCALE 1 : 2500

50 0 50 100 150 200 250m

1:2500 (A1) 1:5000 (A3)

WorleyParsons
resources & energy

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	31.07.15	RE ISSUED FOR CLIENT REVIEW	EN
A	01.06.15	ISSUED FOR CLIENT REVIEW	EN

NORTH

HAWKESBURY RIVER DREDGING BUSINESS CASE
DREDGE VOLUME ANALYSIS
PRIORITY AREA: SACKVILLE FERRY

FIGURE E16

PLOT DATE & TIME: 31/7/2015 6:58:26 PM USER NAME: enosh.newar LOCATION: W:_INFRASTRUCTURE\PROJECTS\301015\03616 - HAWKESBURY RIVER DREDGING BUSINESS CASE\12.0 DRAWINGS\SKETCHES\301015-03616-FIGURES-DREDGING .DWG
SAVE DATE & TIME: 31/7/2015 6:44:23 PM CTB FILE: Worley-Full.ctb Plotter:None

Appendix F

Costing Estimates

WorleyParsons

resources & energy

Cost Estimate for Dredge of Total Study Area

WorleyParsons
resources & energy

Rev	Description	Orig	Review	WorleyParsons Approval	Date
0	Issued for Information	LB	WJH		25/05/2015
		L Baxter	Reviewer	Approver	

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 authority approval fees.

Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 30, 2012

Item	Description	Quantity		Rate	Unit		Cost
1	Preliminaries						
	- Site Establishment	1		2	%	$	468,000
	- Deploy water quality monitoring systems	1	$	200,000	No.	$	200,000
	- Mobilise large THSD dredger	1	$	700,000	No.	$	700,000
	- Mobilise barges	1	$	500,000	No.	$	500,000
2	Dredging						
	- Dredging of river and disposal	830668	$	4.95	cu. m	$	4,111,807
	- Transport and handling of dredge material	830668	$	2.00	cu. m	$	1,661,336
	- Supervision	26	$	50,000	$/wk	$	1,300,000
	- Water quality monitoring	26	$	10,000	$/wk	$	260,000
3	Processing of Dredge Material						
	- Washing cost (incl materials handling)	830668	$	10.00	cu. m	$	8,306,680
4	Management of Dredge Spoil						
	- Site clearing to establish dredge stockpile areas	199360	$	0.48	sq. m	$	95,693
	- Stockpiling of dredge material (assume 90% of total dredged)	747601	$	2.80	cu. m	$	2,093,283
	- Disposal of waste (assumed 10%)	83067	$	50	cu. m	$	4,153,340
5	Site Disestablishment						
	- Site disestablishment	1		2	%	$	468,000
					SUB-TOTAL (SYDNEY)	$	24,318,138.91
					plus CPI	$	25,300,591.73
	Additional						
	- Design	1		5	%	$	1,265,000
	- Environmental and construction management	1		5	%	$	1,265,000
	- Survey	1		5	%	$	1,265,000
					TOTAL COST	$	29,100,000
					TOTAL (plus 40% contingency)	$	40,740,000
5	Commercial Sale of Processed Dredge Material						
	- Sale of sand to Sydney construction market	747601	$	25.00	cu. m	$	18,690,030
					TOTAL REVENUE	$	18,690,030
					COST - NET TOTAL	$	22,049,970

Cost Estimate for Dredge of Bens Point

WorleyParsons
resources & energy

Rev	Description	Orig	Review	WorleyParsons Approval	Date
0	Issued for Information	LB	WJH		25/05/2015
		L Baxter	Reviewer	Approver	

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 authority approval fees.

Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 30, 2012

Item	Description	Quantity	Rate	Unit	Cost
1	Preliminaries				
	- Site Establishment	1	2	%	$ 53,000
	- Deploy water quality monitoring systems	1	$ 50,000	No.	$ 50,000
	- Mobilise large THSD dredger	1	$ 700,000	No.	$ 700,000
	- Mobilise barges	1	$ 500,000	No.	$ 500,000
2	Dredging				
	- Dredging of river and disposal	46765	$ 4.95	cu. m	$ 231,487
	- Transport and handling of dredge material	46765	$ 2.00	cu. m	$ 93,530
	- Supervision	4	$ 50,000	$/wk	$ 200,000
	- Water quality monitoring	4	$ 10,000	$/wk	$ 40,000
3	Processing of Dredge Material				
	- Washing cost (incl materials handling)	46765	$ 10.00	cu. m	$ 467,650
4	Management of Dredge Spoil				
	- Site clearing to establish dredge stockpile areas	11224	$ 0.48	sq. m	$ 5,387
	- Stockpiling of dredge material (assume 90% of total dredged)	42089	$ 2.80	cu. m	$ 117,848
	- Disposal of waste (assumed 10%)	4677	$ 50	cu. m	$ 233,825
5	Site Disestablishment				
	- Site disestablishment	1	2	%	$ 53,000
				SUB-TOTAL (SYDNEY)	$ 2,745,726.88
				plus CPI	$ 2,856,654.24
	Additional				
	- Design	1	10	%	$ 286,000
	- Environmental and construction management	1	10	%	$ 286,000
	- Survey	1	10	%	$ 286,000
				TOTAL COST	$ 3,710,000
				TOTAL (plus 40% contingency)	$ 5,194,000
5	Commercial Sale of Processed Dredge Material				
	- Sale of sand to Sydney construction market	42089	$ 25.00	cu. m	$ 1,052,213
				TOTAL REVENUE	$ 1,052,213
				COST - NET TOTAL	$ 4,141,788

Cost Estimate for Dredge of Pitt Town Bottoms

WorleyParsons
resources & energy

Rev	Description	Orig	Review	WorleyParsons Approval	Date
0	Issued for Information	LB	WJH		25/05/2015
		L Baxter	Reviewer	Approver	

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 authority approval fees.

Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 30, 2012

Item	Description	Quantity	Rate	Unit	Cost
1	Preliminaries				
	- Site Establishment	1	2	%	$ 54,000
	- Deploy water quality monitoring systems	1	$ 50,000	No.	$ 50,000
	- Mobilise large THSD dredger	1	$ 700,000	No.	$ 700,000
	- Mobilise barges	1	$ 500,000	No.	$ 500,000
2	Dredging				
	- Dredging of river and disposal	49130	$ 4.95	cu. m	$ 243,194
	- Transport and handling of dredge material	49130	$ 2.00	cu. m	$ 98,260
	- Supervision	4	$ 50,000	$/wk	$ 200,000
	- Water quality monitoring	4	$ 10,000	$/wk	$ 40,000
3	Processing of Dredge Material				
	- Washing cost (incl materials handling)	49130	$ 10.00	cu. m	$ 491,300
4	Management of Dredge Spoil				
	- Site clearing to establish dredge stockpile areas	11791	$ 0.48	sq. m	$ 5,660
	- Stockpiling of dredge material (assume 90% of total dredged)	44217	$ 2.80	cu. m	$ 123,808
	- Disposal of waste (assumed 10%)	4913	$ 50	cu. m	$ 245,650
5	Site Disestablishment				
	- Site disestablishment	1	2	%	$ 54,000
				SUB-TOTAL (SYDNEY)	$ 2,805,870.88
				plus CPI	$ 2,919,228.06
	Additional				
	- Design	1	10	%	$ 292,000
	- Environmental and construction management	1	10	%	$ 292,000
	- Survey	1	10	%	$ 292,000
				TOTAL COST	$ 3,800,000
				TOTAL (plus 40% contingency)	$ 5,320,000
5	Commercial Sale of Processed Dredge Material				
	- Sale of sand to Sydney construction market	44217	$ 25.00	cu. m	$ 1,105,425
				TOTAL REVENUE	$ 1,105,425
				COST - NET TOTAL	$ 4,214,575

Cost Estimate for Dredge of Sandy Point (including reach into meander)					WorleyParsons resources & energy
Rev	**Description**	**Orig**	**Review**	**Worley-Parsons Approval**	**Date**
0	Issued for Information	LB L Baxter	WJH Reviewer	Approver	25/05/2015

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 authority approval fees.

Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 30, 2012

Item	Description	Quantity		Rate	Unit		Cost
1	Preliminaries						
	- Site Establishment	1		2	%	$	81,000
	- Deploy water quality monitoring systems	1	$	50,000	No.	$	50,000
	- Mobilise large THSD dredger	1	$	700,000	No.	$	700,000
	- Mobilise barges	1	$	500,000	No.	$	500,000
2	Dredging						
	- Dredging of river and disposal	104216	$	4.95	cu. m	$	515,869
	- Transport and handling of dredge material	104216	$	2.00	cu. m	$	208,432
	- Supervision	4	$	50,000	$/wk	$	200,000
	- Water quality monitoring	4	$	10,000	$/wk	$	40,000
3	Processing of Dredge Material						
	- Washing cost (incl materials handling)	104216	$	10.00	cu. m	$	1,042,160
4	Management of Dredge Spoil						
	- Site clearing to establish dredge stockpile areas	25012	$	0.48	sq. m	$	12,006
	- Stockpiling of dredge material (assume 90% of total dredged)	93794	$	2.80	cu. m	$	262,624
	- Disposal of waste (assumed 10%)	10422	$	50	cu. m	$	521,080
5	Site Disestablishment						
	- Site disestablishment	1		2	%	$	81,000
					SUB-TOTAL (SYDNEY)	$	4,214,171.20
					plus CPI	$	4,384,423.72
	Additional						
	- Design	1		10	%	$	438,000
	- Environmental and construction management	1		10	%	$	438,000
	- Survey	1		10	%	$	438,000
					TOTAL COST	$	5,700,000
					TOTAL (plus 40% contingency)	$	7,980,000
5	Commercial Sale of Processed Dredge Material						
	- Sale of sand to Sydney construction market	93794	$	25.00	cu. m	$	2,344,860
					TOTAL REVENUE	$	2,344,860
					COST - NET TOTAL	$	5,635,140

Cost Estimate for Dredge of Sandy Point (priority area only)

WorleyParsons
resources & energy

Rev	Description	Orig	Review	WorleyParsons Approval	Date
0	Issued for Information	LB	WJH		25/05/2015
		L Baxter	Reviewer	Approver	

Disclaimer
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Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 30, 2012

Item	Description	Quantity	Rate	Unit	Cost
1	Preliminaries				
	- Site Establishment	1	2	%	$ 46,000
	- Deploy water quality monitoring systems	1	$ 50,000	No.	$ 50,000
	- Mobilise large THSD dredger	1	$ 700,000	No.	$ 700,000
	- Mobilise barges	1	$ 500,000	No.	$ 500,000
2	Dredging				
	- Dredging of river and disposal	32673	$ 4.95	cu. m	$ 161,731
	- Transport and handling of dredge material	32673	$ 2.00	cu. m	$ 65,346
	- Supervision	4	$ 50,000	$/wk	$ 200,000
	- Water quality monitoring	4	$ 10,000	$/wk	$ 40,000
3	Processing of Dredge Material				
	- Washing cost (incl materials handling)	32673	$ 10.00	cu. m	$ 326,730
4	Management of Dredge Spoil				
	- Site clearing to establish dredge stockpile areas	7842	$ 0.48	sq. m	$ 3,764
	- Stockpiling of dredge material (assume 90% of total dredged)	29406	$ 2.80	cu. m	$ 82,336
	- Disposal of waste (assumed 10%)	3267	$ 50	cu. m	$ 163,365
5	Site Disestablishment				
	- Site disestablishment	1	2	%	$ 46,000
				SUB-TOTAL (SYDNEY)	$ 2,385,272.24
				plus CPI	$ 2,481,637.24
	Additional				
	- Design	1	10	%	$ 248,000
	- Environmental and construction management	1	10	%	$ 248,000
	- Survey	1	10	%	$ 248,000
				TOTAL COST	$ 3,230,000
				TOTAL (plus 40% contingency)	$ 4,522,000
5	Commercial Sale of Processed Dredge Material				
	- Sale of sand to Sydney construction market	29406	$ 25.00	cu. m	$ 735,143
				TOTAL REVENUE	$ 735,143
				COST - NET TOTAL	$ 3,786,858

Cost Estimate for Dredge of Cattai Creek

WorleyParsons
resources & energy

Rev	Description	Orig	Review	WorleyParsons Approval	Date
0	Issued for Information	LB	WJH		25/05/2015
		L Baxter	Reviewer	Approver	

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Item	Description	Quantity	Rate	Unit		Cost
1	Preliminaries					
	- Site Establishment	1	2	%	$	50,000
	- Deploy water quality monitoring systems	1	$ 50,000	No.	$	50,000
	- Mobilise large THSD dredger	1	$ 700,000	No.	$	700,000
	- Mobilise barges	1	$ 500,000	No.	$	500,000
2	Dredging					
	- Dredging of river and disposal	40095	$ 4.95	cu. m	$	198,470
	- Transport and handling of dredge material	40095	$ 2.00	cu. m	$	80,190
	- Supervision	4	$ 50,000	$/wk	$	200,000
	- Water quality monitoring	4	$ 10,000	$/wk	$	40,000
3	Processing of Dredge Material					
	- Washing cost (incl materials handling)	40095	$ 10.00	cu. m	$	400,950
4	Management of Dredge Spoil					
	- Site clearing to establish dredge stockpile areas	9623	$ 0.48	sq. m	$	4,619
	- Stockpiling of dredge material (assume 90% of total dredged)	36086	$ 2.80	cu. m	$	101,039
	- Disposal of waste (assumed 10%)	4010	$ 50	cu. m	$	200,475
5	Site Disestablishment					
	- Site disestablishment	1	2	%	$	50,000
				SUB-TOTAL (SYDNEY)	$	2,575,743.59
				plus CPI	$	2,679,803.64
	Additional					
	- Design	1	10	%	$	268,000
	- Environmental and construction management	1	10	%	$	268,000
	- Survey	1	10	%	$	268,000
				TOTAL COST	$	3,480,000
				TOTAL (plus 40% contingency)	$	4,872,000
5	Commercial Sale of Processed Dredge Material					
	- Sale of sand to Sydney construction market	36086	$ 25.00	cu. m	$	902,138
				TOTAL REVENUE	$	902,138
				COST - NET TOTAL	$	3,969,863

Cost Estimate for Dredge of Cattai Creek and area downstream

WorleyParsons
resources & energy

Rev	Description	Orig	Review	WorleyParsons Approval	Date
0	Issued for Information	LB	WJH		25/05/2015
		L Baxter	Reviewer	Approver	

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Item	Description	Quantity		Rate	Unit		Cost
1	Preliminaries						
	- Site Establishment	1		2	%	$	73,000
	- Deploy water quality monitoring systems	1	$	50,000	No.	$	50,000
	- Mobilise large THSD dredger	1	$	700,000	No.	$	700,000
	- Mobilise barges	1	$	500,000	No.	$	500,000
2	Dredging						
	- Dredging of river and disposal	86948	$	4.95	cu. m	$	430,393
	- Transport and handling of dredge material	86948	$	2.00	cu. m	$	173,896
	- Supervision	4	$	50,000	$/wk	$	200,000
	- Water quality monitoring	4	$	10,000	$/wk	$	40,000
3	Processing of Dredge Material						
	- Washing cost (incl materials handling)	86948	$	10.00	cu. m	$	869,480
4	Management of Dredge Spoil						
	- Site clearing to establish dredge stockpile areas	20868	$	0.48	sq. m	$	10,016
	- Stockpiling of dredge material (assume 90% of total dredged)	78253	$	2.80	cu. m	$	219,109
	- Disposal of waste (assumed 10%)	8695	$	50	cu. m	$	434,740
5	Site Disestablishment						
	- Site disestablishment	1		2	%	$	73,000
					SUB-TOTAL (SYDNEY)	$	3,773,633.97
					plus CPI	$	3,926,088.78
	Additional						
	- Design	1		10	%	$	393,000
	- Environmental and construction management	1		10	%	$	393,000
	- Survey	1		10	%	$	393,000
					TOTAL COST	$	5,110,000
					TOTAL (plus 40% contingency)	$	7,154,000
5	Commercial Sale of Processed Dredge Material						
	- Sale of sand to Sydney construction market	78253	$	25.00	cu. m	$	1,956,330
					TOTAL REVENUE	$	1,956,330
					COST - NET TOTAL	$	5,197,670

Cost Estimate for Dredge of downstream of Ebnezer Church

WorleyParsons
resources & energy

Rev	Description	Orig	Review	WorleyParsons Approval	Date
0	Issued for Information	LB L Baxter	WJH Reviewer	Approver	25/05/2015

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Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 30, 2012

Item	Description	Quantity		Rate	Unit		Cost
1	Preliminaries						
	- Site Establishment	1		2	%	$	54,000
	- Deploy water quality monitoring systems	1	$	50,000	No.	$	50,000
	- Mobilise large THSD dredger	1	$	700,000	No.	$	700,000
	- Mobilise barges	1	$	500,000	No.	$	500,000
2	Dredging						
	- Dredging of river and disposal	48458	$	4.95	cu. m	$	239,867
	- Transport and handling of dredge material	48458	$	2.00	cu. m	$	96,916
	- Supervision	4	$	50,000	$/wk	$	200,000
	- Water quality monitoring	4	$	10,000	$/wk	$	40,000
3	Processing of Dredge Material						
	- Washing cost (incl materials handling)	48458	$	10.00	cu. m	$	484,580
4	Management of Dredge Spoil						
	- Site clearing to establish dredge stockpile areas	11630	$	0.48	sq. m	$	5,582
	- Stockpiling of dredge material (assume 90% of total dredged)	43612	$	2.80	cu. m	$	122,114
	- Disposal of waste (assumed 10%)	4846	$	50	cu. m	$	242,290
5	Site Disestablishment						
	- Site disestablishment	1		2	%	$	54,000
					SUB-TOTAL (SYDNEY)	$	2,789,349.62
					plus CPI	$	2,902,039.35
	Additional						
	- Design	1		10	%	$	290,000
	- Environmental and construction management	1		10	%	$	290,000
	- Survey	1		10	%	$	290,000
					TOTAL COST	$	3,770,000
					TOTAL (plus 40% contingency)	$	5,278,000
5	Commercial Sale of Processed Dredge Material						
	- Sale of sand to Sydney construction market	43612	$	25.00	cu. m	$	1,090,305
					TOTAL REVENUE	$	1,090,305
					COST - NET TOTAL	$	4,187,695

Cost Estimate for Dredge of Sackville Gorge

WorleyParsons
resources & energy

Rev	Description	Orig	Review	WorleyParsons Approval	Date
0	Issued for Information	LB	WJH		25/05/2015
		L Baxter	Reviewer	Approver	

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Item	Description	Quantity		Rate	Unit		Cost
1	Preliminaries						
	- Site Establishment	1		2	%	$	59,000
	- Deploy water quality monitoring systems	1	$	50,000	No.	$	50,000
	- Mobilise large THSD dredger	1	$	700,000	No.	$	700,000
	- Mobilise barges	1	$	500,000	No.	$	500,000
2	Dredging						
	- Dredging of river and disposal	59521	$	4.95	cu. m	$	294,629
	- Transport and handling of dredge material	59521	$	2.00	cu. m	$	119,042
	- Supervision	4	$	50,000	$/wk	$	200,000
	- Water quality monitoring	4	$	10,000	$/wk	$	40,000
3	Processing of Dredge Material						
	- Washing cost (incl materials handling)	59521	$	10.00	cu. m	$	595,210
4	Management of Dredge Spoil						
	- Site clearing to establish dredge stockpile areas	14285	$	0.48	sq. m	$	6,857
	- Stockpiling of dredge material (assume 90% of total dredged)	53569	$	2.80	cu. m	$	149,993
	- Disposal of waste (assumed 10%)	5952	$	50	cu. m	$	297,605
5	Site Disestablishment						
	- Site disestablishment	1		2	%	$	59,000
					SUB-TOTAL (SYDNEY)	$	3,071,335.69
					plus CPI	$	3,195,417.65
	Additional						
	- Design	1		10	%	$	320,000
	- Environmental and construction management	1		10	%	$	320,000
	- Survey	1		10	%	$	320,000
					TOTAL COST	$	4,160,000
					TOTAL (plus 40% contingency)	$	5,824,000
5	Commercial Sale of Processed Dredge Material						
	- Sale of sand to Sydney construction market	53569	$	25.00	cu. m	$	1,339,223
					TOTAL REVENUE	$	1,339,223
					COST - NET TOTAL	$	4,484,778

Cost Estimate for Dredge of Sackville Ferry

WorleyParsons
resources & energy

Rev	Description	Orig	Review	WorleyParsons Approval	Date
0	Issued for Information	LB	WJH		25/05/2015
		L Baxter	Reviewer	Approver	

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Item	Description	Quantity		Rate	Unit		Cost
1	Preliminaries						
	- Site Establishment	1		2	%	$	115,000
	- Deploy water quality monitoring systems	1	$	50,000	No.	$	50,000
	- Mobilise large THSD dredger	1	$	700,000	No.	$	700,000
	- Mobilise barges	1	$	500,000	No.	$	500,000
2	Dredging						
	- Dredging of river and disposal	173853	$	4.95	cu. m	$	860,572
	- Transport and handling of dredge material	173853	$	2.00	cu. m	$	347,706
	- Supervision	4	$	50,000	$/wk	$	200,000
	- Water quality monitoring	4	$	10,000	$/wk	$	40,000
3	Processing of Dredge Material						
	- Washing cost (incl materials handling)	173853	$	10.00	cu. m	$	1,738,530
4	Management of Dredge Spoil						
	- Site clearing to establish dredge stockpile areas	41725	$	0.48	sq. m	$	20,028
	- Stockpiling of dredge material (assume 90% of total dredged)	156468	$	2.80	cu. m	$	438,110
	- Disposal of waste (assumed 10%)	17385	$	50	cu. m	$	869,265
5	Site Disestablishment						
	- Site disestablishment	1		2	%	$	115,000
					SUB-TOTAL (SYDNEY)	$	5,994,210.78
					plus CPI	$	6,236,376.89
	Additional						
	- Design	1		10	%	$	624,000
	- Environmental and construction management	1		10	%	$	624,000
	- Survey	1		10	%	$	624,000
					TOTAL COST	$	8,110,000
					TOTAL (plus 40% contingency)	$	11,354,000
5	Commercial Sale of Processed Dredge Material						
	- Sale of sand to Sydney construction market	156468	$	25.00	cu. m	$	3,911,693
					TOTAL REVENUE	$	3,911,693
					COST - NET TOTAL	$	7,442,308