HERVEY BAY CITY COUNCIL
FLOOD RISK REDUCTION STUDY
OVERALL STUDY CONSOLIDAQTION REPORT

Appendix D – Sawmill Creek Catchment Flood Risk Reduction Study

WorleyParsons

resources & energy

Incorporating JWP & Patterson Britton

EcoNomics

HERVEY BAY CITY COUNCIL

Sawmill Road Catchment

Flood Risk Reduction Study

060479-001

6 March 2008

Environmental and Water Resources
Level 3, 80 Albert Street
Brisbane QLD 4000
Australia
Telephone: +61 7 3221 7444
Facsimile: +61 7 3221 7791
www.worleyparsons.com
ABN: 61 001 279 812

WorleyParsons

resources & energy

EcoNomics

Incorporating JWP & Patterson Britton

HERVEY BAY CITY COUNCIL
SAWMILL ROAD CATCHMENT
FLOOD RISK REDUCTION STUDY

PROJECT 060479-001 - SAWMILL ROAD CATCHMENT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for internal review	A Thompson	E Reid	N/A	26Feb08	N/A	
0	Issued for client	A. Thompson	E. Reid	N/A	6-Mar-08	N/A	

CONTENTS

Appendices

APPENDIX 1– PEAK WATER SURFACE LEVELS: EXISTING SCENARIO

APPENDIX 2– PEAK WATER SURFACE LEVELS: MITIGATED SCENARIO

APPENDIX 3– PRELIMINARY COSTING

HERVEY BAY CITY COUNCIL
SAWMILL ROAD CATCHMENT
FLOOD RISK REDUCTION STUDY

EXECUTIVE SUMMARY

WorleyParsons was commissioned by Hervey Bay City Council (HBCC) to undertake a Flood Risk Reduction Study for the Sawmill Road Catchment. The purpose of the analysis is to document existing flooding characteristics within the catchment, classify the flooding risks and assess potential mitigation options for reducing flood risk in order to meet HBCC design standards.

An XP-STORM model, encompassing both hydrologic and hydraulic analyses and previously developed by HBCC, was supplied to WorleyParsons for the purposes of this project. This model was reviewed by WorleyParsons and deemed suitable for the identification of flood risks throughout the catchment. Following this verification, the model was run simulating the 2, 10, 20, 50 and 100 year Average Recurrence Interval (ARI) design events in order to determine the

The hydraulic model results were mapped and following information is available digitally and as hard copy for all design events:

1. Flood inundation extents

2. Peak flood depths and water surface levels.

The risk assessment showed that the majority of existing flooding issues are classified low risk. However, this study has identified one (1) area in the catchment where the flooding risk (from road overtopping) requires mitigation works. Flood mitigation works for this location, Meadow Drive, have been assessed and are predicted to reduce flood levels and provide a reduction of risk to within an acceptable range with respect to QUDM guidelines. It is recommended that the implementation of these mitigation works be undertaken to reduce road overtopping of Meadow Drive.

The flood extents developed show that there are sections of the study area where property inundation occurs, however above floor flooding can not be determined due to the absence of floor level information. It is recommended that floor level survey data be obtained and an additional analysis be undertaken to determine the full impact of this inundation. Furthermore, in areas where flooding is found to be above property floor levels, additional local drainage studies or an update of the existing Sawmill Road model should be undertaken to enable the assessment of options to reduce flooding in these areas.

1. INTRODUCTION

WorleyParsons (incorporating JWP) was commissioned by Hervey Bay City Council (HBCC) to undertake a Flood Risk Reduction Study for the Sawmill Road Catchment area. The purpose of the study includes: -

- Documenting the existing flooding and drainage characteristics throughout the catchment for a range of design flood events;
- Undertaking a broad flood risk assessment for the catchments based upon the existing flooding characteristics. This includes the identification of areas of risk within the catchment; and
- Broadly identifying the various options for managing and reducing existing flood risks in the catchment. These options will form the basis on which future flood risk reduction strategies will then be developed for the catchment.

It is the intent of this study to form the basis on which existing flooding problems in the catchment are characterised. This includes the assessment of flood risks for the purposes of providing the base information on which future flood risk reduction activities can be investigated and undertaken for the catchment.

The scope of works undertaken for this study includes:

- Review of the supplied XP-STORM model to determine its suitability for use in this flood risk reduction study.
- Consolidation of GIS data into a detailed catchment plan to facilitate site inspections and as a record of site photographs;
- The identification of existing drainage patterns including both piped systems (trunk drainage) and major overland flows via a detailed site inspections;
- Revision of hydrology within the supplied XP-STORM model(developed by HBCC) to include the analysis of the 10, 20 and 50 year ARI events based on existing conditions with the previously analysed 2 and 100 year ARI events;
- Hydraulic simulation for the 2, 10, 20, 50 and 100 year ARI events under existing conditions;

- Preparation of flood inundation maps for the 2, 10, 20, 50 and 100 year ARI events for the existing flooding scenario across the catchment area to define existing case flooding;
- Quantification of existing flood risk throughout the area on a broad scale basis taking into account property inundation and road immunity;
- Analysis of mitigation options determined during a meeting between WorleyParsons (WP) and HBCC project staff;
- Model iterations including mitigation options determined in liaison with HBCC;
- Preparation of flood inundation maps for the 2, 10, 20, 50 and 100 year ARI events for the mitigated flooding scenario;
- Preparation of cost estimates for the mitigation works and associated culvert upgrades as appropriate. The cost estimates will represent preliminary estimates for planning purposes and will be appropriate in the context of a broad flood risk assessment study; and
- Preparation of a consolidated flood risk report outlining the methodology used and outcomes achieved. The flood risk report will also outline the outcomes from the flood risk assessment and identification works undertaken.

The review of the supplied XP-STORM model undertaken by WorleyParsons revealed that although the model was coarse in structure, it appeared to be appropriate and representative of the drainage in the area and is considered appropriate within the context of the flood risk studies. The following sections of this report aim to fully document the analysis works undertaken as part of this investigation of the Sawmill Road Catchment.

2. CATCHMENT DESCRIPTION AND SUPPLIED DATA

2.1 Study Area

The Sawmill Road catchment consists predominantly of residential and rural land use and is located approximately 12 kilometres from centre of the city of Hervey Bay. The natural drainage flow paths present in the catchments are a combination of natural waterways, highly modified engineered open channels and formalised sub-surface stormwater drainage systems. The total area of the Sawmill Road Catchment is approximately 420 hectares.

2.2 Study Data

The works undertaken as part of this study have been prepared based upon a compilation of data sources as provided by Hervey Bay City Council for the purposes of the project. Although WP were provided with the existing hydraulic model (developed in 2003 by HBCC), additional data was supplied to assist the investigation which is outlined and discussed separately below.

2.2.1 Topography Data

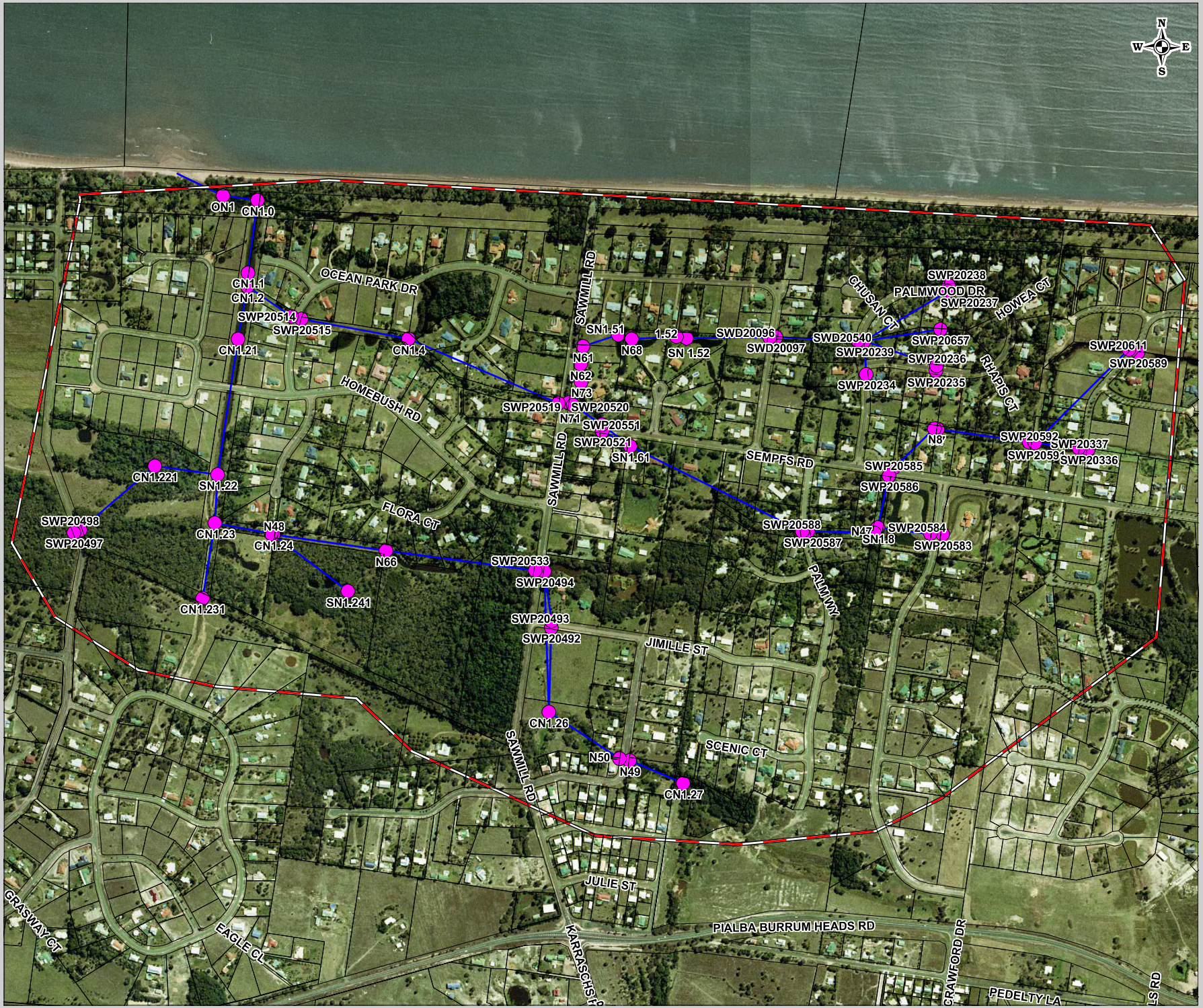
Topographical data for the study area was supplied as raw aerial laser survey (ALS) data in 2007. This raw data was used to prepare a Digital Terrain Model (DTM) to facilitate data extraction for the various modelling tasks undertaken as part of this study. As the DTM was prepared using the contour information supplied and not from raw data, limitations in the degree of detail afforded by the DTM should be noted.

2.2.2 Model Data

The flood risk assessment of the Sawmill Road catchment is based on an existing XP-STORM hydraulic model originally developed by Council for flood impact purposes. This model represented the existing waterway conditions at the time of the original model development and as such did not prescriptively include the various catchment changes which have since occurred since the model was developed in 2003. Figure 1 illustrates the location of the model with regard to the overall Sawmill Road Catchment study area.

2.2.3 Site Inspection

As part of the works for this study, WorleyParsons have undertaken a site inspection of the catchment. The site inspection was documented by way of site notes and photographs. Together, this information assisted in the definition of the catchment and existing drainage patterns, flow regimes and Council's existing models as well as benefiting in reviewing appropriate roughness parameters and verification of existing hydraulic structures.



HERVEY BAY CITY COUNCIL

Legend

- Study Area
- XP-STORM Node (Reporting Locations)
- XP-STORM Link

Scale: 1:7,500

SAWMILL ROAD CATCHMENT FLOOD RISK REDUCTION STUDY

FIGURE 1
SAWMILL ROAD CATCHMENT MODEL LAYOUT

WorleyParsons
resources & energy

OneWay
to zero harm

WorleyParsons Services Pty. Ltd.
ABN 61 001 279 812
PO Box 81, Albert Street QLD 4002, Australia
Ph. +61 7 3221 7444 Fax. +61 7 3221 7791

3. HYDRAULIC MODELLING

The original hydraulic modelling of the Sawmill Road Catchment was undertaken by HBCC through the preparation of an XP-STORM model. This model was previously developed by Council to establish a basis for determining the existing flood characteristics across the catchment and identify potential flooding problems. This model was supplied to WorleyParsons by HBCC along with supporting information in the form of project reports and strategic planning documents.

3.1 Hydraulic Modelling Analysis

The hydraulic XP-STORM model for the Sawmill Road catchment area was analysed for the 2, 10, 20, 50 and 100 year ARI design events for the 120 minute storm duration. A review of the supplied documentation revealed that the critical storm duration for the Sawmill Road catchment was 120 minutes and this duration was adopted for the purposes of this study. The results of the hydraulic analysis are discussed separately below.

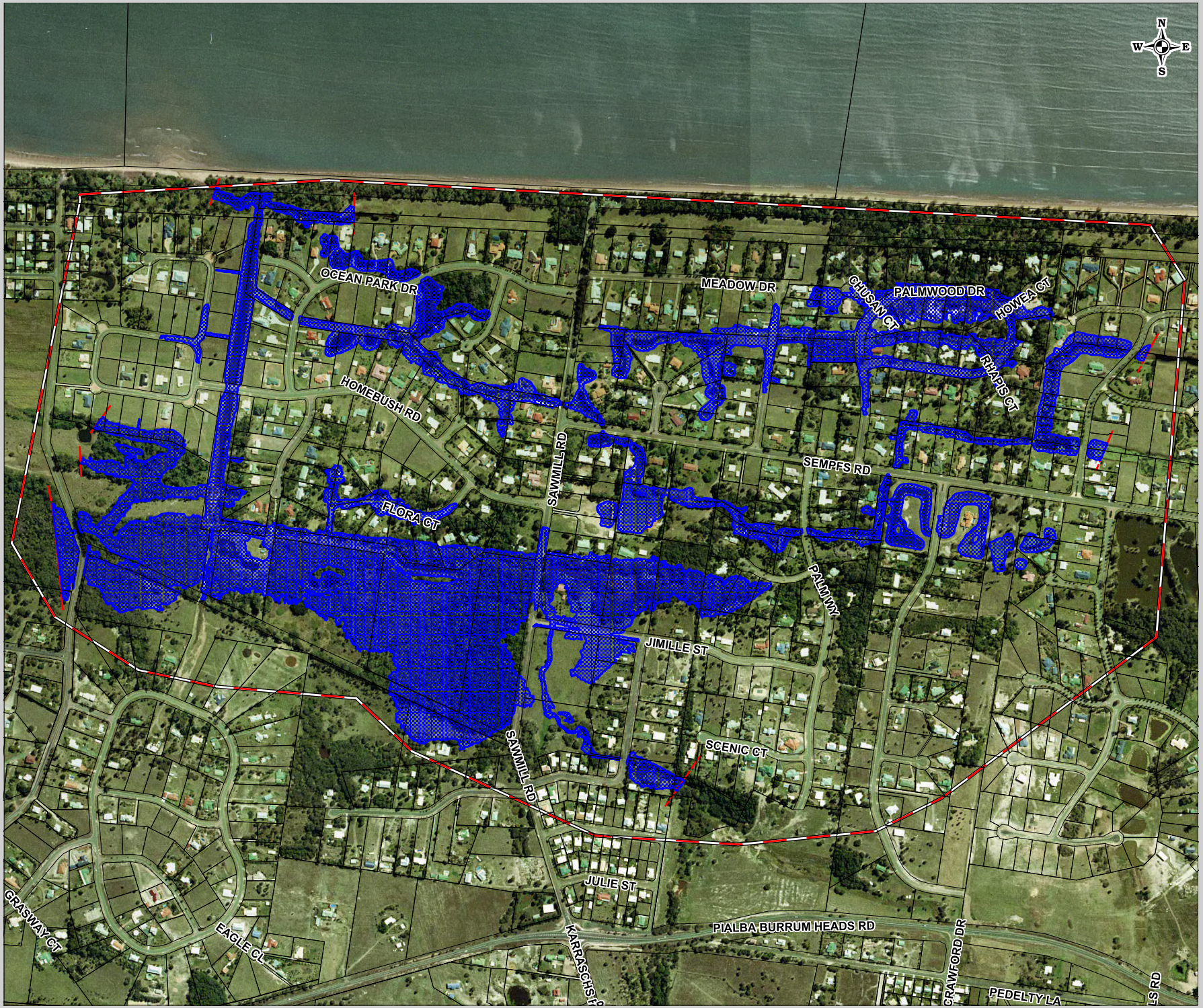
4. DISCUSSION OF EXISTING RESULTS

4.1 Flood Level and Depth Summaries

All calculated water surface levels and flood depths for the Sawmill road Catchment existing scenario XP-STORM model are summarised in Appendix 1. The results are presented based on flood level and discharge reporting locations and these are summarised in detail in tabular formats. The locations of the reporting points are illustrated in Figure 1.

4.2 GIS Flood Maps

Flood extent maps have been prepared as part of this study to assist in illustrating areas of concern with regards to flooding and flood risk. The plans are presented to demonstrate the anticipated extent of flooding for the 2, 10, 20, 50 and 100 year ARI events over the study area for the existing case. The extents have been prepared using the DTM and results from the hydraulic model. This has been developing a 3-dimensional (3D) flood surface using the model results within the GIS and the subsequent draping of this surface over the DTM in order to prepare a 3D flood depth surface. The 3D flood depth surface has then been contoured in a manner such that only positive flood depths greater than or equal to zero are displayed which by default defines the extent of flood inundation for each event under question. Figures 2 through 6 highlight the extent of inundation under existing conditions for the Sawmill Road Catchment.



HERVEY BAY CITY COUNCIL

Legend

- Study Area
- Q100 Existing Flood Extent
- Limit of Mapping

Scale: 1:7,500

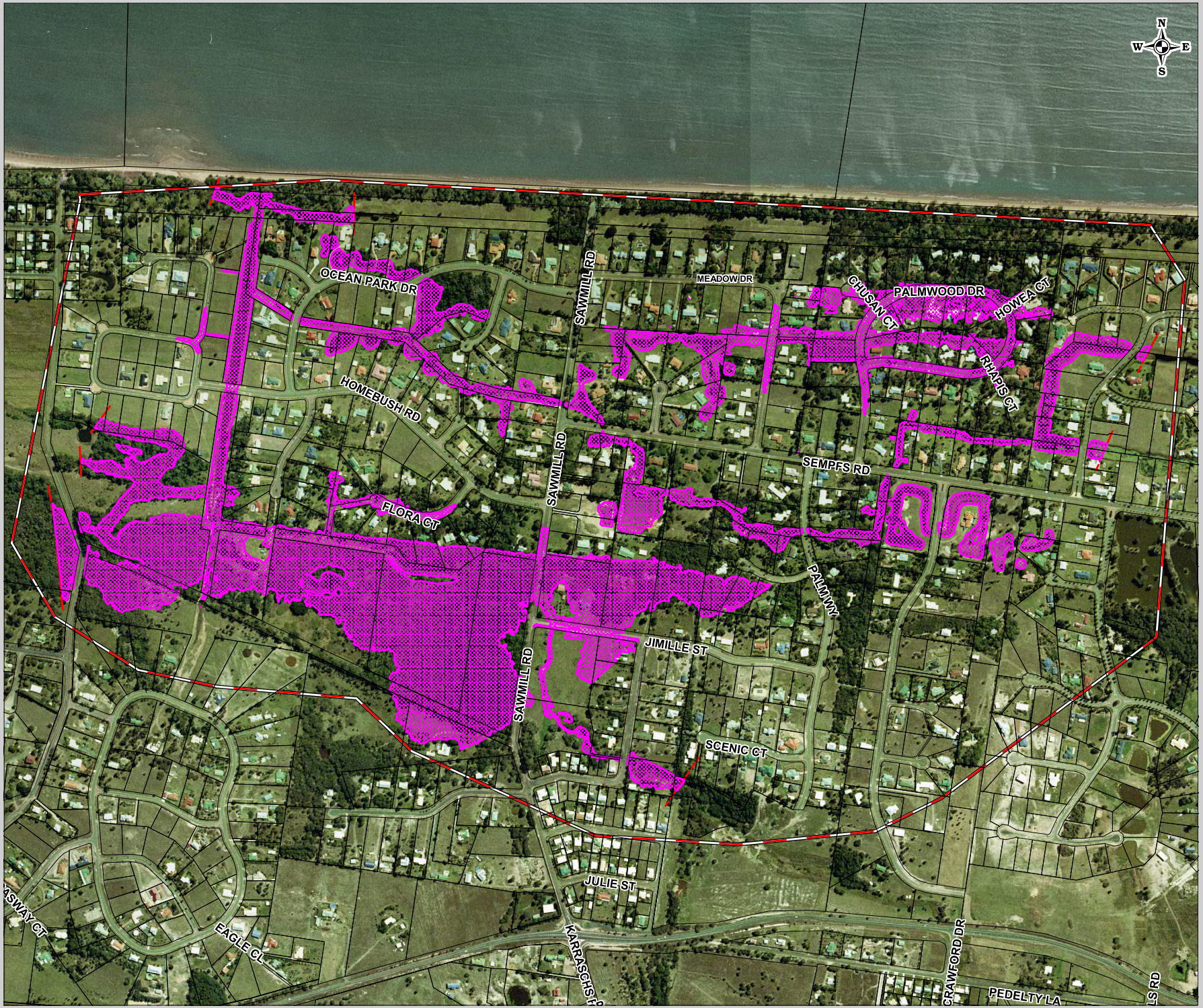
SAWMILL ROAD CATCHMENT FLOOD RISK REDUCTION STUDY

FIGURE 2
EXISTING Q100 FLOOD EXTENT

WorleyParsons
resources & energy

OneWay
to zero harm

WorleyParsons Services Pty. Ltd.
ABN 61 001 279 812
PO Box 81, Albert Street QLD 4002, Australia
Ph. +61 7 3221 7444 Fax. +61 7 3221 7791



HERVEY BAY CITY COUNCIL

Legend

- Study Area
- Q50 Existing Flood Extent
- Limit of Mapping

Scale: 1:7,500

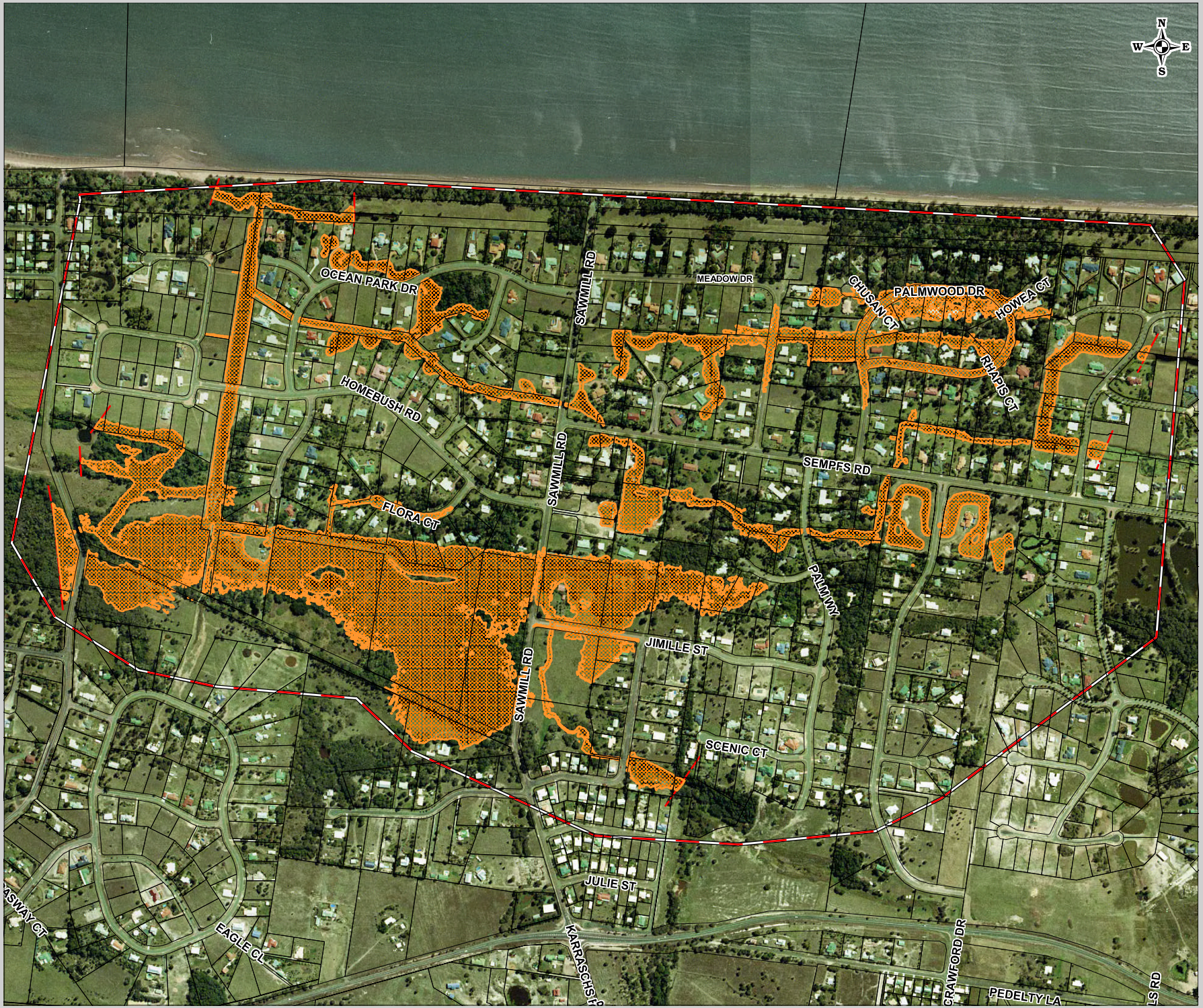
SAWMILL ROAD CATCHMENT FLOOD RISK REDUCTION STUDY

FIGURE 3 EXISTING Q50 FLOOD EXTENT

WorleyParsons
resources & energy

OneWay
to zero harm

WorleyParsons Services Pty. Ltd.
ABN 61 001 279 812
PO Box 81, Albert Street QLD 4002, Australia
Ph. +61 7 3221 7444 Fax. +61 7 3221 7791



HERVEY BAY CITY COUNCIL

Legend

- Study Area
- Q20 Existing Flood Extent
- Limit of Mapping

Scale: 1:7,500

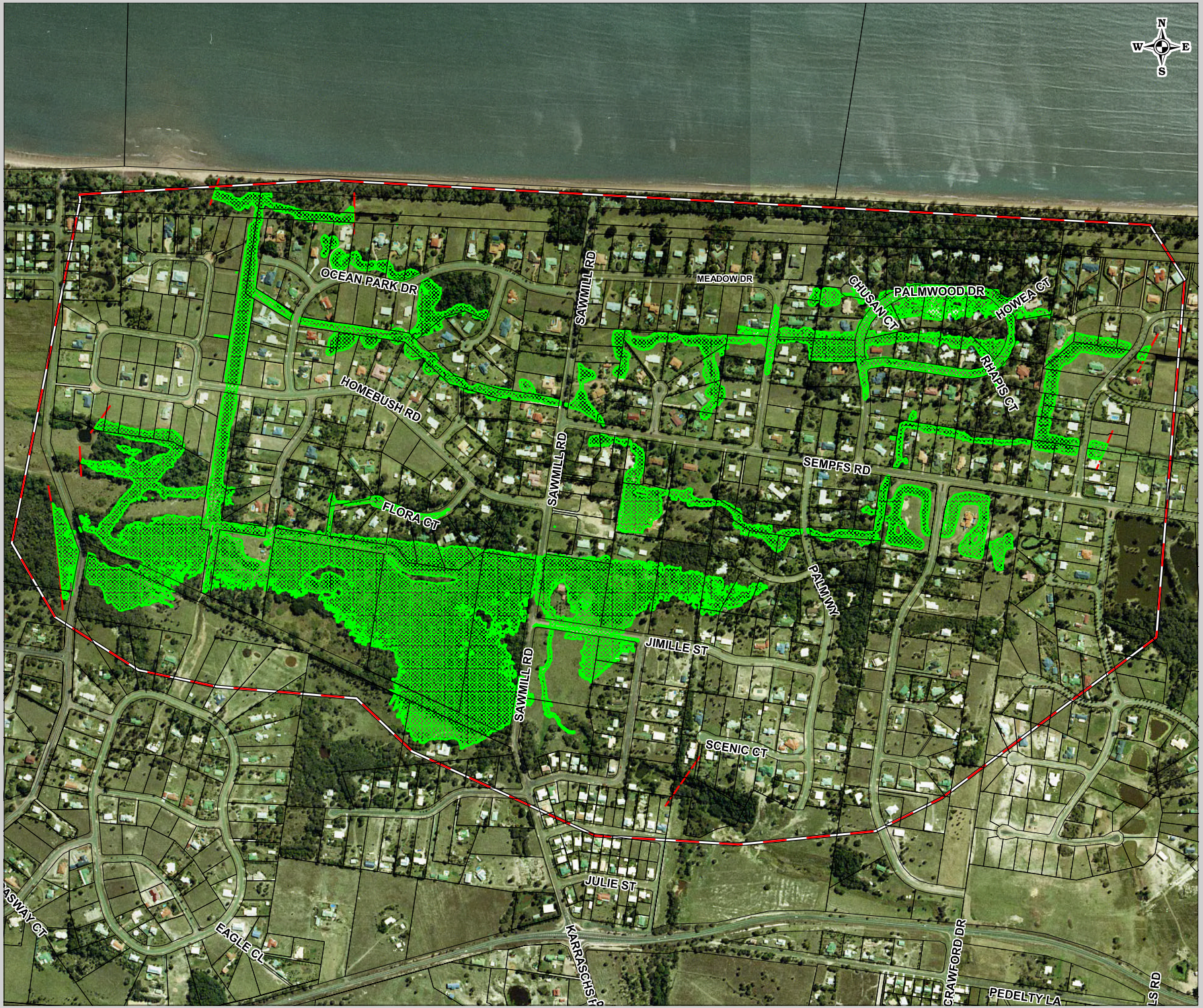
SAWMILL ROAD CATCHMENT FLOOD RISK REDUCTION STUDY

FIGURE 4
EXISTING Q20 FLOOD EXTENT

WorleyParsons
resources & energy

OneWay
to zero harm

WorleyParsons Services Pty. Ltd.
ABN 61 001 279 812
PO Box 81, Albert Street QLD 4002, Australia
Ph. +61 7 3221 7444 Fax. +61 7 3221 7791



HERVEY BAY CITY COUNCIL

Legend

- Study Area
- Q10 Existing Flood Extent
- Limit of Mapping

Scale: 1:7,500

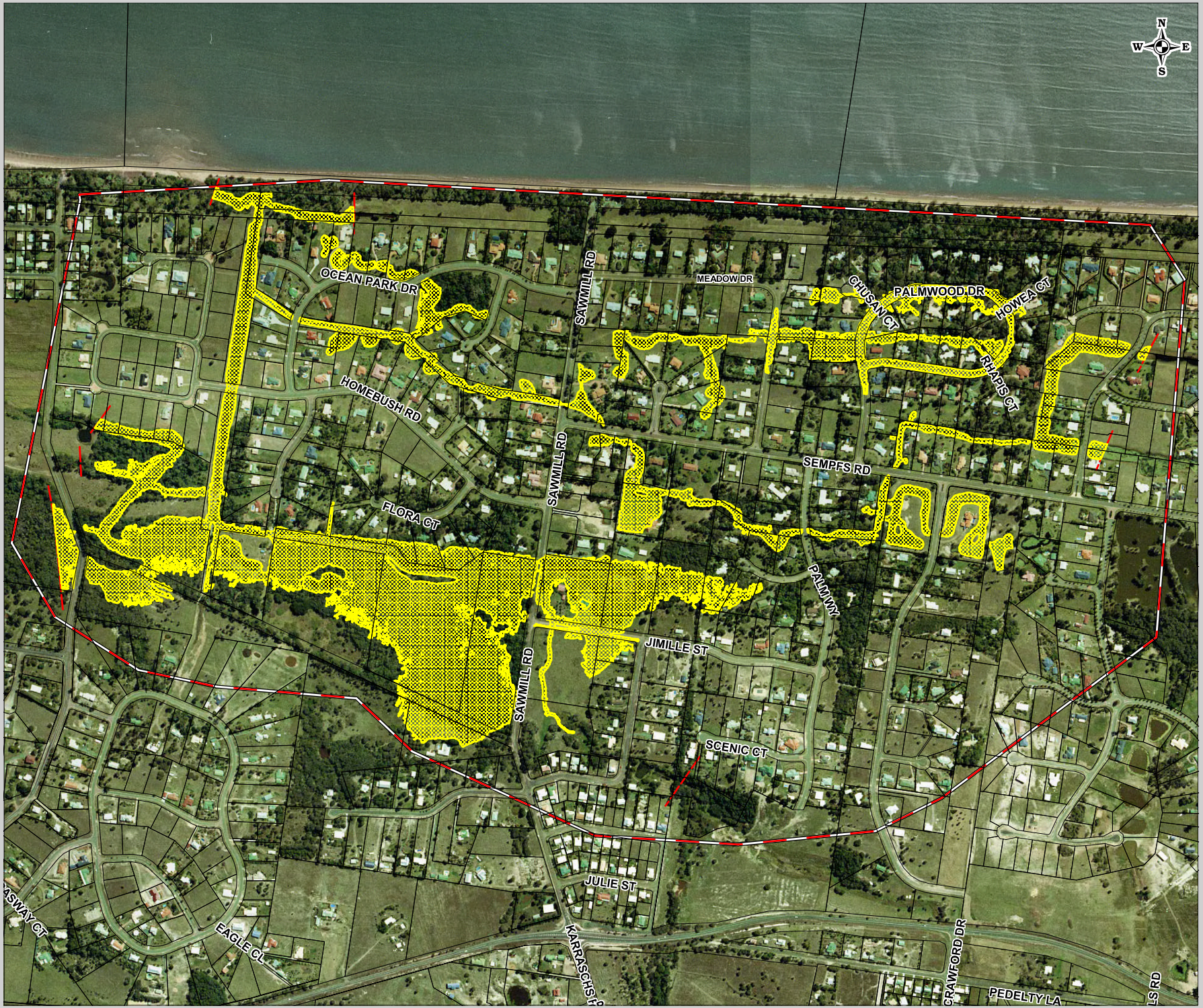
SAWMILL ROAD CATCHMENT FLOOD RISK REDUCTION STUDY

FIGURE 5 EXISTING Q10 FLOOD EXTENT

WorleyParsons
resources & energy

OneWay
to zero harm

WorleyParsons Services Pty. Ltd.
ABN 61 001 279 812
PO Box 81, Albert Street QLD 4002, Australia
Ph. +61 7 3221 7444 Fax. +61 7 3221 7791



HERVEY BAY CITY COUNCIL

Legend

- Study Area
- Q2 Existing Flood Extent
- Limit of Mapping

Scale: 1:7,500

SAWMILL ROAD CATCHMENT FLOOD RISK REDUCTION STUDY

FIGURE 6 EXISTING Q2 FLOOD EXTENT

WorleyParsons
resources & energy

OneWay
to zero harm

WorleyParsons Services Pty. Ltd.
ABN 61 001 279 812
PO Box 81, Albert Street QLD 4002, Australia
Ph. +61 7 3221 7444 Fax. +61 7 3221 7791

5. EXISTING SCENARIO RISK IDENTIFICATION

5.1 Risk Identification Methodology

In liaison with HBCC a procedure for the evaluation and prioritisation of risks was developed. Risks are evaluated and prioritised using two methodologies, Queensland Urban Drainage Manual (QUDM) and the risk ranking matrix. Identification of overtopping and hazard at road crossings was defined using the QUDM design criteria for roads as shown in Table 5-1 below.

Table 5-1 QUDM design criteria for roads

Criteria	Limit
For Vehicle and Pedestrian Safety	0.6m^2/s (0.4 m^2/s if the area is known to have high pedestrian usage or has safety issues)
Maximum depth of flow on any Road	300mm

Prioritisation and risk for the identified crossings was evaluated using the risk ranking matrix. The risk ranking matrix considers the likelihood and consequence of the risk occurring and defines a risk ranking for each risk. Table 5-2 and 5-3 provides the classification of likelihood and consequence respectively. Table 5-4 shows the resulting risk ranking derived from the relationship of likelihood and consequence.

Table 5-2 Likelihood parameters

Almost certain	A 99.5% chance of a hazard being exceeded in a 50 year period – a 1 in 10 year event
Likely	Probability of exceedance is greater than 50% in a 50 year period, but less than 99.5% - a 1 in 50 year event
Possible	Probability of exceedance is greater than 20% in a 50 year period, but less than 50% - a 1 in 100 - 200year event
Unlikely	Probability of exceedance is greater than 5% in a 50 year period. but less than 20% - a 1 in 500 year event
Rare	Probability of exceedance is less than 5% in a 50 year period - a 1 in 500 year event

Table 5-3 Consequence parameters (based on 2000 AU$)

Insignificant	Natural hazards are experienced and cause some stress on community lifelines. Community agencies cope with some effort and total community financial loss is less than $1.0m
Minor	No disaster is officially declared and effects lead to temporary failure of lifelines other than energy supply for up to 24 hours. Total community financial loss is less than $10m
Moderate	Disruption lasts for more than 5 days including energy disruption. Recovery takes 14 – 21 days. Vulnerable elements are severely affected and all major agencies are involved. Hospitalisation of victims occurs and total community financial loss is less than $50m. State of emergency is declared during the event.
Major	All lifelines affected. Energy is disrupted for up to 14 days. Recovery takes 4 – 6 weeks. At least one death is suffered and temporary evacuation of area is required. State of Disaster is declared and total community loss is up to $200m.
Catastrophic	Effects are severe and all lifelines are affected. No energy for up to 8 weeks and recovery takes 6 – 24 months. At least 10 deaths suffered and significant evacuation required. Total community financial loss in hundreds of millions.

Table 5-4 Risk Ranking

Return period	Consequence Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
10	Almost certain	H	H	E	E	E
50	Likely	M	H	H	E	E
100/200	Possible	L	M	H	E	E
500	Unlikely	L	L	M	H	E
1000	Rare	L	L	M	H	H

Where: E = extreme risk H = high risk M = moderate risk L = low risk

In addition to infrastructure lifelines, risk parameters for people, buildings, economic loss and loss of the natural environment are proposed as shown in Table 5-5.

Table 5-5 Risk Parameters for People, Buildings, Economic Loss and Natural Environment

Risk element	Extreme (unacceptable) risk
People	Vulnerability to natural hazards is generally measured by the risk to life and property from known hazards. An area may be prone to a known hazard, but if there is no possible risk to life or property, the vulnerability is low. Where life and property are at risk, the magnitude and likelihood of the hazard combine to create a measure of vulnerability. **Unacceptable risks are death, serious injury and major health hazard.**
Buildings	The built environment is at risk from a number of known hazards in Hervey Bay. Various regulations have been developed locally (e.g. Local Laws) and at a wider scale (e.g. the Building Code of Australia) to minimise the risk of damage to the built environment. All of these regulations are based on an acceptable level of risk which has been determined either by Council or a wider community of interest (e.g., 1:100 flood immunity). Inevitably there will be extreme events which go beyond the acceptable level of immunity and the only possible way to immunise against these events is avoidance. **Unacceptable risks are collapse or damage to buildings requiring demolition.**
Economic loss	In all disaster events there is bound to be some form of economic loss. The Federal Government under the Natural Disaster Relief Arrangements provides funding to victims of disaster events. This funding is generally short term and designed to minimise immediate suffering and loss. Businesses need to make their own assessment of potential economic loss through a natural disaster event and make plans accordingly. These would range from building construction, to choice of location to insurance. **Unacceptable risks are loss of livelihood for more than 10% of the working community.**
Natural environment	The natural environment is at risk from a number of known hazards in Hervey Bay. **Unacceptable risks are loss of ecological systems, major habitats or conservation areas. Significant disruption to natural drainage systems.**
Risk escalation Risk escalation is likely to happen when initial risk minimisation programs or event response mechanisms do not achieve their intended purpose. The risks outlined in this document may have follow-on or secondary effects (e.g. an earthquake may lead to a dam break, which may lead to flooding, which may lead to injury or isolation). **Unacceptable risks arise from the failure of initial risk minimisation and response mechanisms.**	
Risk frequency Risks to physical infrastructure are usually incorporated in design parameters (e.g. bridges are designed to withstand certain loads; drains are designed to accommodate mathematically derived flood levels). These are generally based on industry standards of acceptable levels of risk. These standards have until recently had very little legislative basis. The recent adoption of *State Planning 1/03 - Mitigating the adverse impacts of Flood, Bushfire and Landslide* introduces risk frequency levels (e.g., 1:100 years) which are required to be accommodated in planning and design documents (e.g. planning schemes and infrastructure codes). **Unacceptable risks are events which occur within the design capacity of infrastructure or industry accepted measures.**	
Legal and social justice implications Risk management is applied by Council across all parts of its jurisdiction in an equal manner and includes all persons. Council is required to make decisions on an annual basis about prioritising its expenditure on various competing items. Expenditure on risk minimisation is incorporated in most capital works projects by way of an in-built design standard. **Unacceptable risks are deliberate inequality of expenditure against any one group, or any one part of the city.**	

Political implications

Council's decisions are subject to scrutiny and influence from various elements and sectors of the community. It is Council's role to make informed and un-biased decisions. **Unacceptable risks are decisions made which reflect unlawful political bias.**

Specific flood risks were identified through use of the above risk matrix and examination of modelling results as discussed previously in Section 4. The risk matrix was used in conjunction with a detailed assessment that was undertaken for each of the roads contained in the models to determine less obvious flooding risks such as minor overtopping and property inundation and to determine any risk (velocity x depth) issues. A risk ranking for each specific flooding risk was then determined and a description of flooding and risk ranking is presented separately below.

Risk elements were further defined by flood hazard and road overtopping. The following sections provide existing case flooding information for key areas across the catchment. These areas include road overtopping and areas of inundation. Road overtopping has been assessed in accordance with QUDM (1992).

5.2 Existing Flood Risk Assessment

The inundation plans show that although flooding is widespread throughout the low-lying Sawmill Road catchment, it is predominantly contained in designated areas such as wetland, lagoon and swamp areas. However there are regions of the study area that affected by flooding and these have been identified and discussed with Council with regards to impact and mitigation. The critical locations identified during the existing modelling task have been highlighted on Figure 7 and are outlined in tabular form in Table 5.6 below.

Table 5-6 Critical Areas of Flood Inundation

Location ID and Name	Q2 Depth (m,AHD)	Q10 Depth (m,AHD)	Q20 Depth (m,AHD)	Q50 Depth (m,AHD)	Q100 Depth (m,AHD)
1. Flora Court	N/A	0.06	0.13	0.16	0.27
2. Private Property	0.05	0.07	0.08	0.11	0.12
3. Private Property	0.03	0.07	0.08	0.09	0.12

Location ID and Name	Q2 Depth (m,AHD)	Q10 Depth (m,AHD)	Q20 Depth (m,AHD)	Q50 Depth (m,AHD)	Q100 Depth (m,AHD)
4. Private Property	0.16	0.21	0.25	0.30	0.47
5. Private Property	0.05	0.11	0.15	0.22	0.28
6. Palmwood Drive	N/A	N/A	N/A	N/A	N/A
7. Meadow Drive	0.21	0.27	0.29	0.31	0.33
8. Sawmill Road	N/A	N/A	0.02	0.06	0.14

The area outlined as ID 6 (Palmwood Drive) is shown in Table 5-6 as the modelling and flood inundation extents indicate that there is widespread road and property flooding. However the impact of this inundation is not known as there is no available survey information for property floor levels. WorleyParsons recommends that floor levels survey data be obtained to determine the true extent of flooding throughout this area. If required, an additional local drainage investigation should be carried out to fully understand the flooding behaviour in this portion of the study area. Table 5-7 shows the water surface level at each property in this risk area for comparison to future floor level survey data.

Table 5-7 Water Surface Level Elevations – Palmwood Drive Properties

Property Description	100 Year ARI Water Surface Level (m,AHD)
Lot 34 RP224701	3.86
Lot 35 RP224701	3.86
Lot 36 RP224701	3.86
Lot 37 RP224701	3.84
Lot 38 RP224701	3.72
Lot 39 RP224698	3.71
Lot 40 RP224698	3.75
Lot 41 RP224698	3.85
Lot 42 RP224698	3.85
Lot 43 RP224700	3.79
Lot 33 RP224700	3.79

The modelling results suggest that flooding is prevalent at ID 1 (Flora Court) however this is due to backwater from the channel at the rear of the properties on Flora Court. This has been highlighted by the mapping procedures and is likely to occur however this section of the catchment has not been included prescriptively in the model layout. As no XP-STORM nodes or links are representative of this area, no velocity data can be analysed.

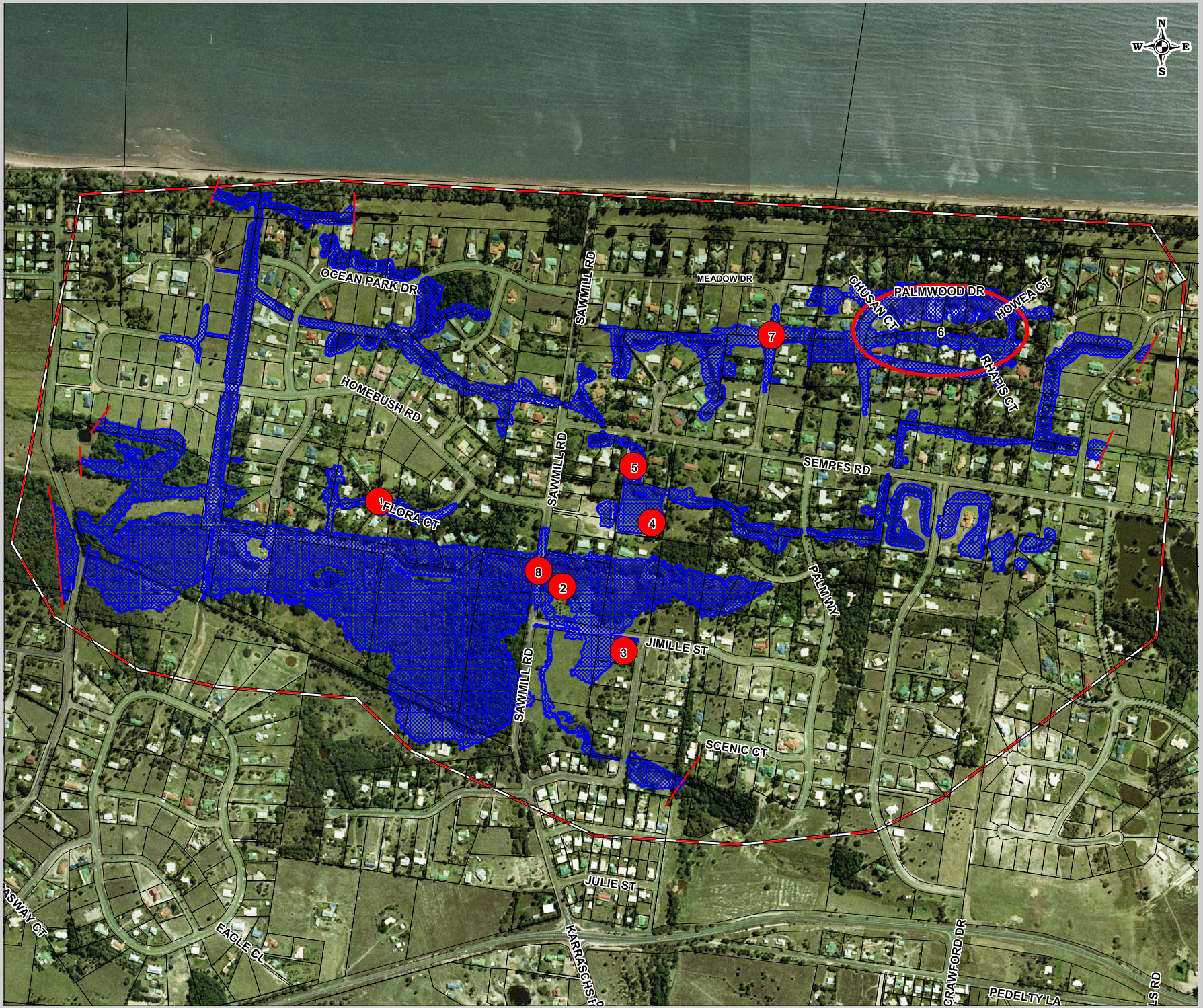
The results also suggest that there is flooding across Sawmill Road at ID 8 however limitations in the supplied model indicate that obtaining velocity information was not possible. However, the depths obtained from the GIS mapping show that flooding across Sawmill Road is in the form of sheet flow and is not deep enough to result in a hazard to residents and/or property and falls within QUDM guidelines.

The extent of flooding at Meadow Drive was assessed to define the risk ranking and is outlined in Table 5-8 below:

Table 5-8 Depth – Velocity Risk Assessment

Location ID and Name	Depth – Velocity Ratio				
	Q2 vxd	Q10 vxd	Q20 vxd	Q50 vxd	Q100 vxd
7. Meadow Drive	0.06	0.04	0.04	0.05	0.07

Table 5-8 outlines the risk analysis for the previously highlighted areas of the Sawmill Road Catchment using the risk assessment methodology outlined above.



HERVEY BAY CITY COUNCIL

Legend

- Study Area
- Flooding Hot Spots
- Q100 Existing Flood Extent
- Limit of Mapping

Scale: 1:7,500

SAWMILL ROAD CATCHMENT FLOOD RISK REDUCTION STUDY

FIGURE 7
EXISTING FLOOD RISK ASSESMENT LOCATIONS

WorleyParsons
resources & energy

OneWay
to zero harm

WorleyParsons Services Pty. Ltd.
ABN 61 001 279 812
PO Box 81, Albert Street QLD 4002, Australia
Ph. +61 7 3221 7444 Fax. +61 7 3221 7791

Table 5-9 - Flood Risk Analysis

Location ID and Name	Risk Element	Acceptable standard	Currently meets desired risk standard	Likelihood	Consequence	Risk Ranking	Upgrade recommended
1. Flora Court	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	**Low**	×
	People - ease of egress	DV Product <0.6 D<300mm	✓	Unlikely	Insignificant	**Low**	×
	Buildings	Q100 immunity	✓	Unlikely	Minor	**Low**	×
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	**Low**	×
	Natural environment	N/A	✓	Unlikely	Insignificant	**Low**	×
2. Private Property	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	**Low**	×

Location ID and Name	Risk Element	Acceptable standard	Currently meets desired risk standard	Likelihood	Consequence	Risk Ranking	Upgrade recommended
	People - ease of egress	DV Product <0.6 D<300mm	✓	Unlikely	Insignificant	Low	×
	Buildings	Q100 immunity	×	Possible	Minor	Moderate	×
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	Low	×
	Natural environment	N/A	✓	Unlikely	Insignificant	Low	×
3. Private Property	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	Low	×
	People - ease of egress	DV Product <0.6 D<300mm	✓	Unlikely	Insignificant	Low	×
	Buildings	Q100 immunity	×	Possible	Minor	Moderate	×

Location ID and Name	Risk Element	Acceptable standard	Currently meets desired risk standard	Likelihood	Consequence	Risk Ranking	Upgrade recommended
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	Low	×
	Natural environment	N/A	✓	Unlikely	Insignificant	Low	×
4. Private Property	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	Low	×
	People - ease of egress	DV Product <0.6 D<300mm	✓	Unlikely	Insignificant	Low	×
	Buildings	Q100 immunity	×	Possible	Minor	Moderate	×
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	Low	×
	Natural environment	N/A	✓	Unlikely	Insignificant	Low	×

Location ID and Name	Risk Element	Acceptable standard	Currently meets desired risk standard	Likelihood	Consequence	Risk Ranking	Upgrade recommended
5. Private Property	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	Low	×
	People - ease of egress	DV Product <0.6 D<300mm	✓	Unlikely	Insignificant	Low	×
	Buildings	Q100 immunity	×	Possible	Minor	Moderate	×
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	Low	×
	Natural environment	N/A	✓	Unlikely	Insignificant	Low	×
	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	Low	×

Location ID and Name	Risk Element	Acceptable standard	Currently meets desired risk standard	Likelihood	Consequence	Risk Ranking	Upgrade recommended
7. Meadow Drive	People - ease of egress	DV Product <0.6 D<300mm	×	Likely	Moderate	**High**	✓
	Buildings	Q100 immunity	✓	Unlikely	Insignificant	**Low**	×
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	**Low**	×
	Natural environment	N/A	✓	Unlikely	Insignificant	**Low**	×
8. Sawmill Road	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	**Low**	×
	People - ease of egress	DV Product <0.6 D<300mm	✓	Likely	Insignificant	**Low**	×
	Buildings	Q100 immunity	✓	Unlikely	Insignificant	**Low**	×

Location ID and Name	Risk Element	Acceptable standard	Currently meets desired risk standard	Likelihood	Consequence	Risk Ranking	Upgrade recommended
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	**Low**	×
	Natural environment	N/A	✓	Unlikely	Insignificant	**Low**	×

As highlighted previously in this report, property inundation is present at locations 2, 3, 4 and 5. This information is based on ALS data in GIS mapping. Floor level data was not available in these areas to determine if the above property inundation occurs. It is recommended that floor level survey be carried out to determine the impact of inundation on these properties. As such, no mitigation works have been assessed at these locations in this study. Mitigation measures have only been proposed for the Meadows Road culvert.

6. FLOODING MITIGATION OPTIONS

6.1 Risk Treatment Options

Treatment of flooding risks as identified in Section 5 of this report has been investigated and are summarised below. Specifically, flooding areas that were identified as high risk were mitigated by means of drainage augmentation with the aim of an overall reduction of the flooding risk. Where flow depths were identified as failing to meet Council design guidelines and QUDM design requirements, mitigation options are suggested in this section.

Mitigation options have only been considered where necessary and to provide a beneficial outcome in terms of reducing flooding and flood risks. At this point, limited consideration has been given to the likely cost implications associated with these options. A brief description and costing of the mitigation option is provided below. Detailed design of the mitigation works is not included and is outside the scope of works of this study. As summarised in Section 5, mitigation works have only been undertaken for ID 7 (Meadow Drive).

6.1.1 Meadow Drive Culvert Upgrade (ID 7)

To meet QUDM and Councils design requirements Meadow Drive should be trafficable (i.e., flood depth less than 300mm and V x D product < 0.6m²/s) in a 50 year ARI event. The following mitigation options were carried out in order to achieve trafficability during a 50 year ARI event.

1. Adding an identical pipe to the existing 450mm reinforced concrete pipe which traverses underneath Meadow Drive creating a twin 450mm culvert;
2. Removing the existing pipe and replacing it with No. 1 2.4 x 0.6m reinforced concrete box culvert (RCBC); and
3. Removing the existing pipe and replacing it with No. 2 2.4 x 0.6m reinforced concrete box culvert (RCBC).

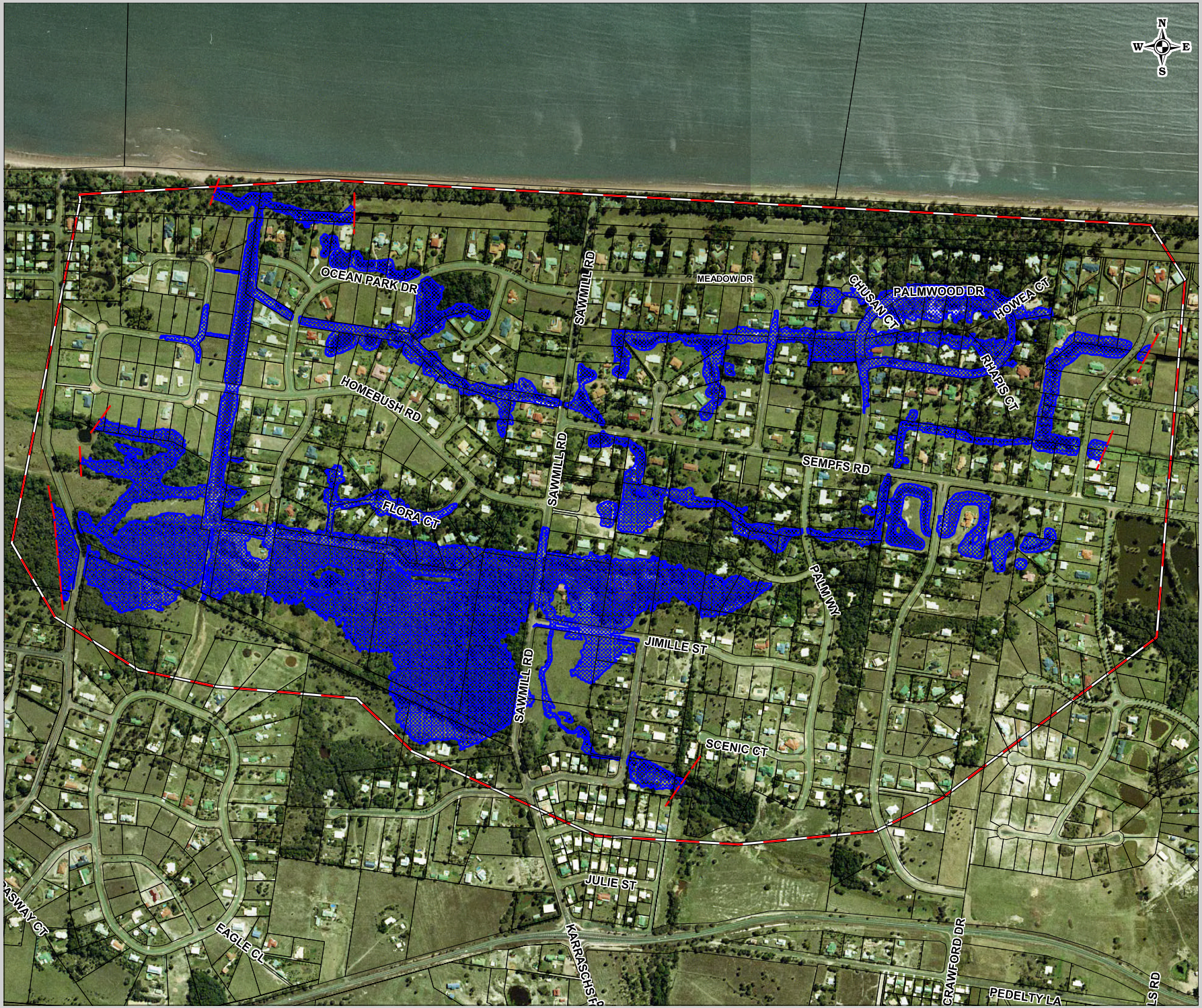
Modelling of Option 1 results in only a minor decrease in peak flood levels for the 50 year ARI design event and the road is still inundated by over 300mm. The replacement of the concrete pipe with a box culvert in Option 2 results in a general lowering of flood levels to 180mm which complies with QUDM guidelines. With regards to Option 3, the modelling results suggest that flood levels are dropped to 140mm over Meadow Drive during a 50 year ARI design event.

6.2 Risk Treatment Summary

This Flood Risk Reduction study has identified that much of the flooding throughout the Sawmill Road catchment is largely flooding of open space with sections of property inundation. However, without detailed floor level survey, the extent and impact of flooding on private property is unknown. As such, these areas have not been included in the mitigation option assessment.

This study has identified one (1) area in the catchment where the flooding risk (from road overtopping) is considered a high risk. Mitigation options have been assessed to make the road trafficable and to lower the risk at these locations. A review of the mitigation results indicates that the implementation of Option 2 results in a general lowering of flood levels and is also the most cost effective of the two (2) options that both comply with QUDM guidelines.

Water surface levels for the proposed mitigation works are presented at the reporting locations in Appendix 2. Figures 8 through 12 highlight the extent of flooding under the mitigated scenario.



HERVEY BAY CITY COUNCIL

Legend

- Study Area
- Q100 Mitigated Flood Extent
- Limit of Mapping

Scale: 1:7,500

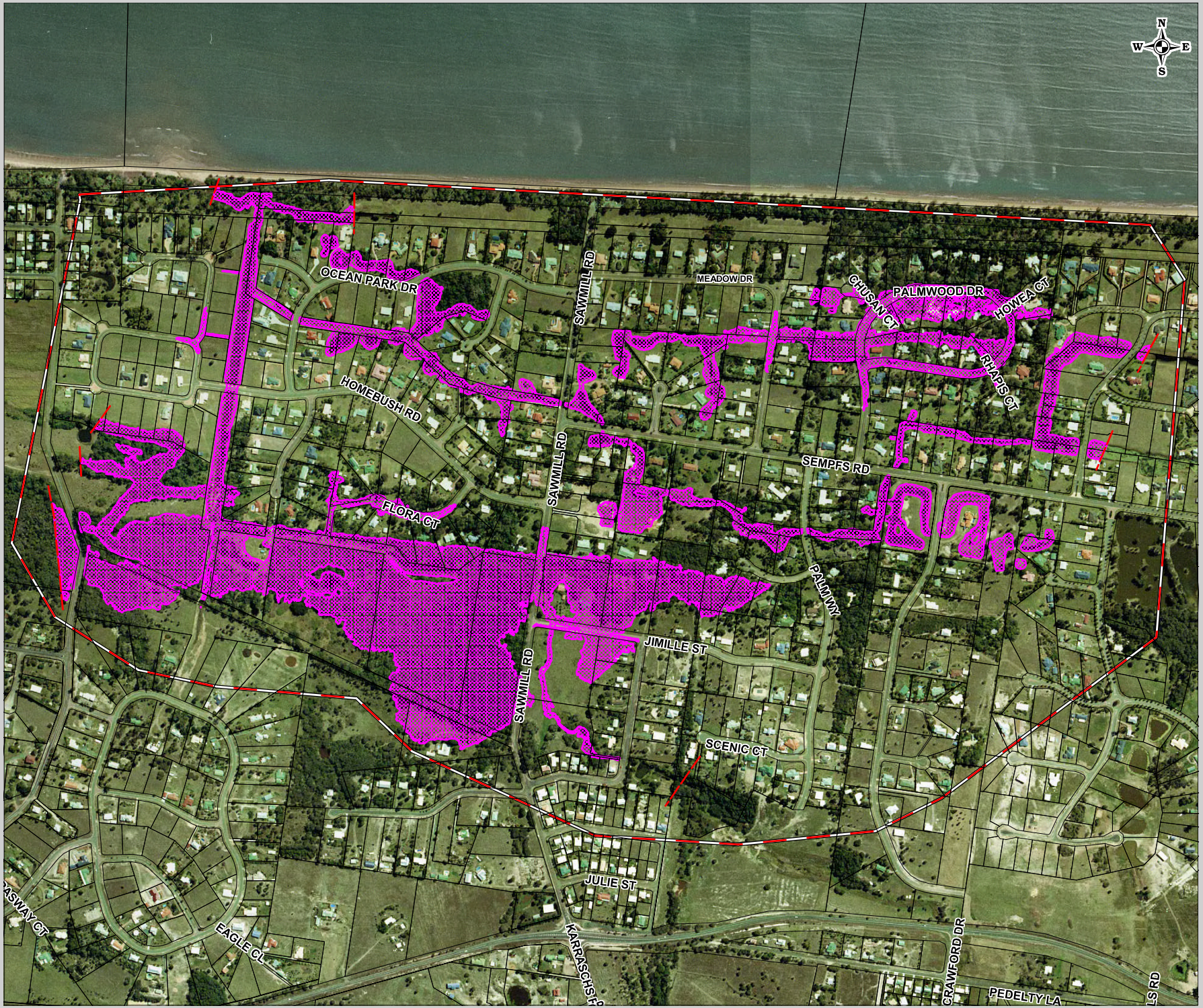
SAWMILL ROAD CATCHMENT FLOOD RISK REDUCTION STUDY

FIGURE 8
Q100 MITIGATED FLOOD EXTENT

WorleyParsons
resources & energy

OneWay
to zero harm

WorleyParsons Services Pty. Ltd.
ABN 61 001 279 812
PO Box 81, Albert Street QLD 4002, Australia
Ph. +61 7 3221 7444 Fax. +61 7 3221 7791



HERVEY BAY CITY COUNCIL

Legend

- Study Area
- Q50 Mitigated Flood Extent
- Limit of Mapping

Scale: 1:7,500

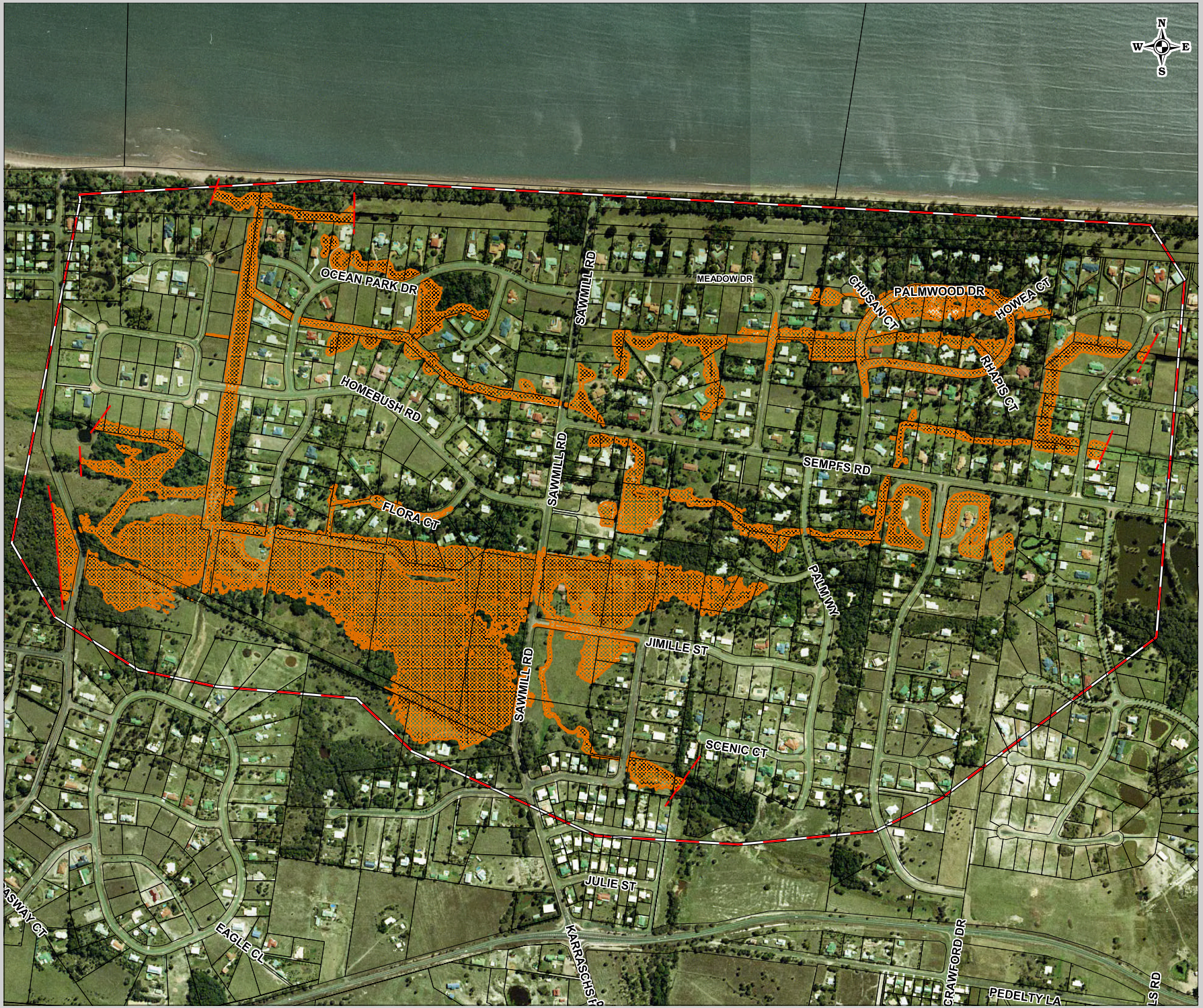
SAWMILL ROAD CATCHMENT FLOOD RISK REDUCTION STUDY

FIGURE 9
Q50 MITIGATED FLOOD EXTENT

WorleyParsons
resources & energy

OneWay
to zero harm

WorleyParsons Services Pty. Ltd.
ABN 61 001 279 812
PO Box 81, Albert Street QLD 4002, Australia
Ph. +61 7 3221 7444 Fax. +61 7 3221 7791



HERVEY BAY CITY COUNCIL

Legend

- Study Area
- Q20 Mitigated Flood Extent
- Limit of Mapping

Scale: 1:7,500

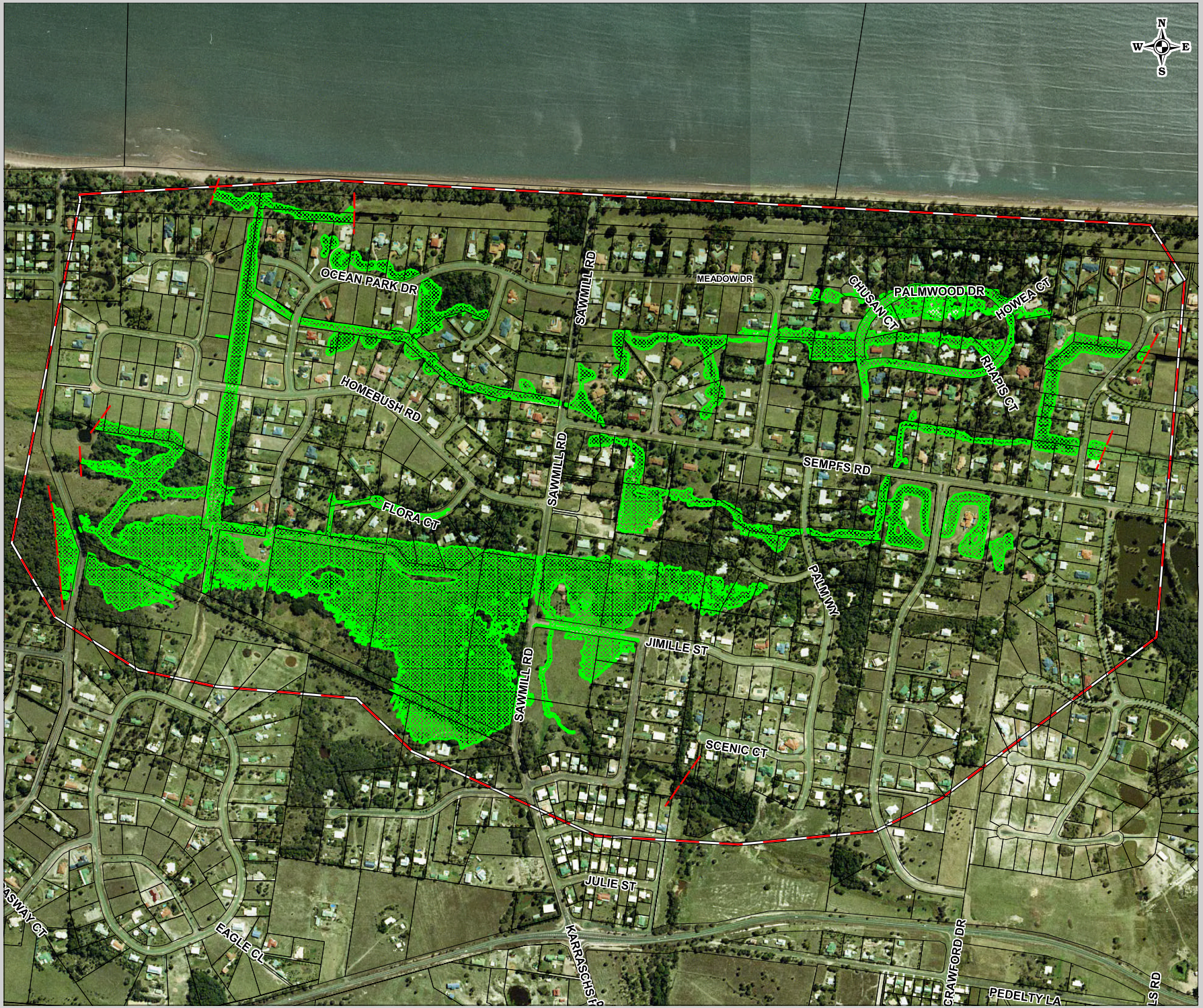
SAWMILL ROAD CATCHMENT FLOOD RISK REDUCTION STUDY

FIGURE 10
Q20 MITIGATED FLOOD EXTENT

WorleyParsons
resources & energy

OneWay
to zero harm

WorleyParsons Services Pty. Ltd.
ABN 61 001 279 812
PO Box 81, Albert Street QLD 4002, Australia
Ph. +61 7 3221 7444 Fax. +61 7 3221 7791



HERVEY BAY CITY COUNCIL

Legend

- Study Area
- Q10 Mitigated Flood Extent
- Limit of Mapping

Scale: 1:7,500

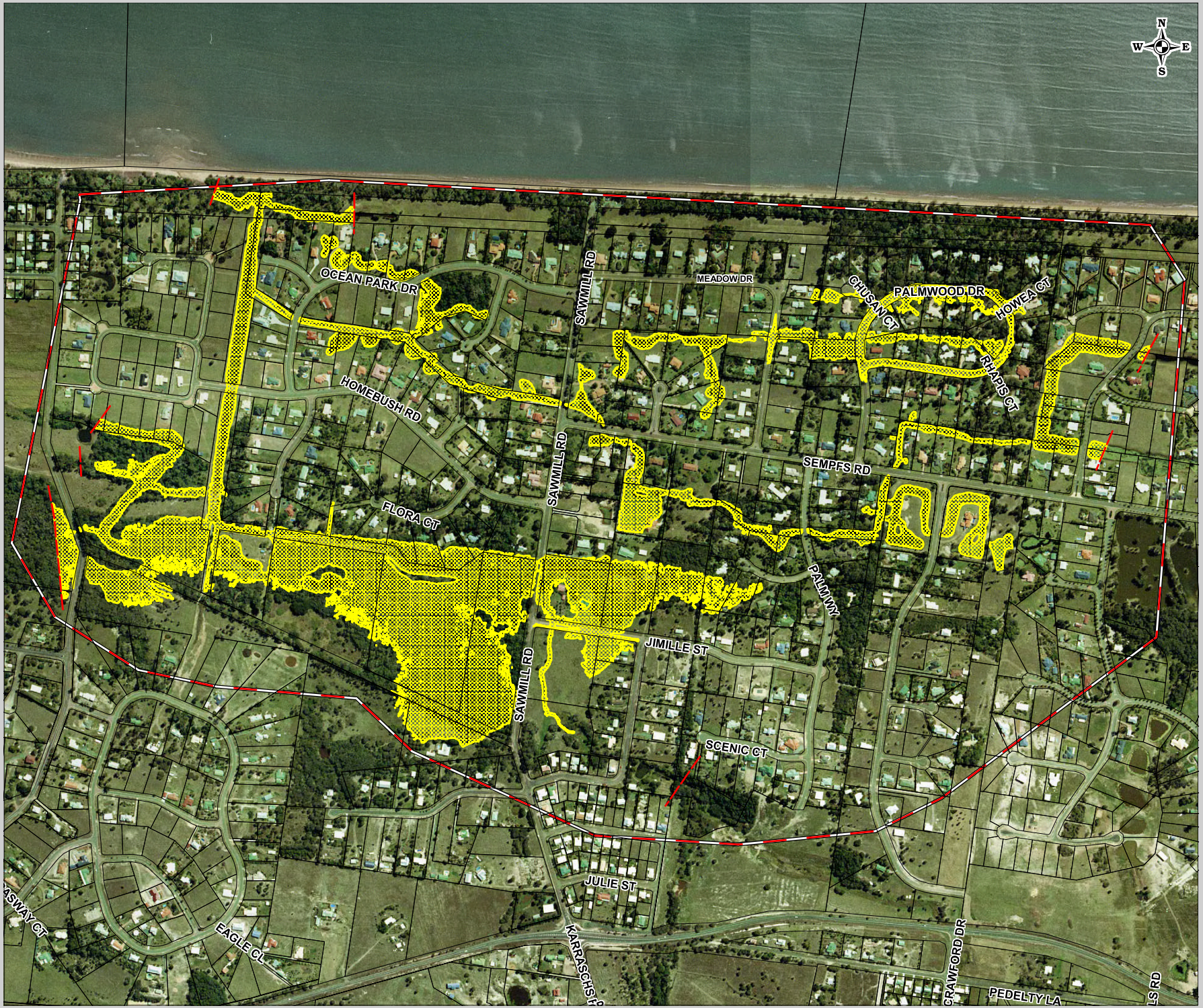
SAWMILL ROAD CATCHMENT FLOOD RISK REDUCTION STUDY

FIGURE 11
Q10 MITIGATED FLOOD EXTENT

WorleyParsons
resources & energy

OneWay
to zero harm

WorleyParsons Services Pty. Ltd.
ABN 61 001 279 812
PO Box 81, Albert Street QLD 4002, Australia
Ph. +61 7 3221 7444 Fax. +61 7 3221 7791



HERVEY BAY CITY COUNCIL

Legend

- Study Area
- Q2 Mitigated Flood Extent
- Limit of Mapping

Scale: 1:7,500

SAWMILL ROAD CATCHMENT FLOOD RISK REDUCTION STUDY

FIGURE 12
Q2 MITIGATED FLOOD EXTENT

WorleyParsons
resources & energy

OneWay
to zero harm

WorleyParsons Services Pty. Ltd.
ABN 61 001 279 812
PO Box 81, Albert Street QLD 4002, Australia
Ph. +61 7 3221 7444 Fax. +61 7 3221 7791

7. COST ESTIMATE

A cost estimate was undertaken for the proposed mitigation works. This cost estimate is preliminary only. Conceptual or detailed design has not been undertaken. The cost for the implementation of mitigation measures at Meadow Drive (ID 7) is estimated to be $ 90,000. A detailed breakdown of the costs is presented in Appendix 3.

8. CONCLUSIONS

This study has assessed the existing flood behaviour and classified associated risks within the Sawmill Road catchment. Specifically, the works completed have included:

- The assessment and identification of existing drainage capacities, flow paths and flood information for the 2, 10, 20, 50 and 100 year ARI design flood events
- Preparation of detailed flood data outputs to fully document the outcomes from the analysis works including flood summary data and flood extent plans;
- Assessment of flood risk and the preparation of flood risk summaries;
- Identification of flood mitigation options for the catchment;
- Hydraulic assessment of the agreed drainage augmentation options for the catchment including the preparation of detailed outputs to fully document the outcomes from the mitigation works;
- Identification of a preferred flood mitigation option for the catchment which has be shown to provide a beneficial outcome for the study in terms of reducing flood inundation of roads and consequently flood risk;
- Preparation of preliminary cost estimates for the preferred mitigation works;
- Preparation of summary tables, models, flood extents, and GIS mapping to formally document the outcomes of the study.

It should be noted that the supplied Sawmill Road Catchment XP-STORM model was originally developed by HBCC and was not based on the same DTM used in this Flood Risk Reduction study. Although the model was reviewed as part of this project, there are some slight variations with regards to ground levels included in the model and those found in the DTM. As such, the flood inundation mapping undertaken should be viewed as an indication of flooding throughout the catchment. As mentioned previously in this report, the study has identified numerous flooding risks with regards to property inundation. However, without detailed floor level survey data, this inundation can only be summarised as a perceived risk.

9. RECOMMENDATIONS

WorleyParsons recommends that Council utilises the outcomes from this Flood Risk Reduction Study for the Sawmill Road catchment in the management of existing and future development within the catchment in terms of reducing flood risk to an acceptable and manageable standard. It is also recommended that further works be investigated to proceed with the detailed design of the preferred mitigation works and the procurement of property floor levels in areas outlined in this study as being inundated.

One (1) location has been identified as a risk area requiring mitigation works. Flood mitigation works for this location, Meadow Drive, have been assessed and are predicted to reduce flood levels and provide a reduction of risk to within an acceptable range with respect to QUDM guidelines

WorleyParsons recommends that further flood analysis works be instigated for Sawmill Road catchment to accurately determine the full impacts of flooding on residential properties, road infrastructure and commercial sectors but more importantly for the purposes of focusing on risk treatment measures. In areas where flooding is found to be above property floor levels, additional local drainage studies or an update of the existing Sawmill Road model should be undertaken to enable the assessment of options to reduce flooding in these areas.

10. REFERENCES

1. The Queensland Urban Drainage Manual (QUDM)
2. Drainage Strategy Review Sawmill Road Catchment - Dundowran West (HBCC, 2003)
3. Review of Dundowran West Stormwater Drainage Strategy (HBCC, 2004)

11. QUALIFICATION

1. In preparing the report and estimate of costs WorleyParsons has exercised the degree of skill and care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering design principles.

2. WorleyParsons has used all reasonable endeavours to inform itself of the parameters and requirements of the project and has taken all reasonable steps to ensure that the report and costs estimate is as accurate and comprehensive as possible given the information upon which it is based.

3. It is not intended that this report and costs estimate represent a final assessment of the feasibility of the project.

4. WorleyParsons reserves the right to review and amend all calculations, cost estimates and/or opinions included or referred to in the report if:

   (a) additional sources of information not presently available (for whatever reason) are provided or become known to WorleyParsons; or

   (b) WorleyParsons considers it prudent to revise the estimate in light of any information which becomes known to it after the date of submission.

5. The report and cost estimate are preliminary only and restricted in that certain information is obtained from external sources and has not been independently verified.

6. WorleyParsons does not give any warranty nor accept any liability in relation to the completeness or accuracy of the report and cost estimate.

7. If any warranty would be implied whether by law, custom or otherwise, that warranty is to the full extent permitted by law excluded.

8. All limitations of liability shall apply for the benefit of the employees, agents and representatives of WorleyParsons to the same extent that they apply for the benefit of WorleyParsons.

9. This report and cost estimate is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this report and cost estimate.

10. If any claim or demand is made by any person against WorleyParsons on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the report and cost estimate or information therein, WorleyParsons will rely upon this provision as a defence to any such claim or demand.

Appendix 1– Peak Water Surface Levels: Existing Scenario

SAWMILL ROAD CATCHMENT - Existing XP-STORM Results

XP-STORM Node	X	Y	Q100 WSL (m,AHD)	Q50 WSL (m,AHD)	Q20 WSL (m,AHD)	Q10 WSL (m,AHD)	Q2 WSL (m,AHD)	Q100 Depth (mm)	Q50 Depth (mm)	Q20 Depth (mm)	Q10 Depth (mm)	Q2 Depth (mm)
1.52	7205035.04	474843.97	3.25	3.18	3.09	3.03	2.92	800	730	640	580	470
CN1.0	7205320.03	473970.31	2.43	2.42	2.41	2.41	2.41	1430	1420	1410	1410	1410
CN1.1	7205168.12	473950.6	2.92	2.82	2.71	2.63	2.53	1620	1520	1410	1330	1230
CN1.2	7205140.2	473949.03	2.98	2.87	2.75	2.67	2.56	1630	1520	1410	1320	1210
CN1.21	7205030.17	473929.25	3.22	3.05	2.91	2.81	2.63	1660	1490	1350	1250	1070
CN1.221	7204765.5	473755.79	3.11	3.06	3.01	2.96	2.85	940	890	840	790	680
CN1.23	7204646.43	473881.17	3.55	3.44	3.33	3.23	3.03	1250	1140	1030	930	730
CN1.231	7204489.59	473855.8	3.66	3.62	3.61	3.57	3.50	460	420	410	370	300
CN1.24	7204622.61	474003.31	3.73	3.67	3.61	3.55	3.42	1230	1160	1100	1040	910
CN1.26	7204252.27	474577.65	7.81	7.77	7.75	7.71	7.55	1560	1520	1500	1460	1300
CN1.27	7204103.95	474857.9	15.93	15.86	15.84	15.78	15.62	930	860	840	780	620
CN1.4	7205030.99	474285.04	3.04	2.93	2.82	2.75	2.64	860	750	640	570	460
N47	7204625.71	475256.31	3.32	3.23	3.14	3.09	3.00	900	810	720	670	580
N48	7204624.2	473998.88	3.65	3.54	3.43	3.34	3.14	1230	1120	1010	920	720
N49	7204151.47	474745.86	14.90	14.86	14.84	14.81	14.71	2510	2480	2460	2420	2330
N50	7204155.39	474725.15	13.07	13.03	13.01	12.98	12.89	790	750	730	700	610
N61	7205014.62	474649.08	3.14	3.07	2.99	2.94	2.83	760	690	610	560	440
N62	7204977.48	474643.88	3.12	3.04	2.96	2.90	2.79	750	680	590	540	420
N66	7204589.09	474238.05	3.96	3.89	3.82	3.75	3.59	1080	1010	940	880	720
N68	7205029.84	474750.38	3.25	3.18	3.09	3.03	2.92	850	780	690	630	520
N7	7204842.34	475388.63	3.29	3.21	3.12	3.06	2.95	630	540	460	400	290
N71	7204897.23	474619.21	3.07	2.97	2.87	2.80	2.67	790	690	590	530	390
N73	7204940.93	474644.97	3.12	3.04	2.96	2.90	2.79	820	740	660	600	490
N8	7204843.57	475381.92	3.31	3.22	3.13	3.08	2.98	660	570	490	430	330
ON1	7205329.07	473898.05	2.40	2.40	2.40	2.40	2.40	1650	1650	1650	1650	1650
SN 1.52	7205032.18	474864.51	3.25	3.18	3.09	3.03	2.92	1300	1220	1130	1080	970
SN1.22	7204747.81	473887.1	3.40	3.24	3.11	2.99	2.77	1230	1070	940	820	600
SN1.241	7204504.64	474158.84	3.74	3.67	3.61	3.55	3.42	1440	1370	1310	1250	1120
SN1.51	7205038.79	474722.47	3.25	3.18	3.09	3.03	2.92	750	680	590	530	420
SN1.61	7204806.74	474747.45	3.29	3.19	3.10	3.05	2.97	1490	1390	1300	1250	1170
SN1.8	7204636.85	475263.46	3.32	3.23	3.14	3.09	3.00	890	800	710	660	570
SWD20096	7205033.51	475038.27	3.68	3.66	3.65	3.62	3.57	340	320	310	280	230
SWD20097	7205033.75	475051.62	3.68	3.66	3.65	3.62	3.57	1620	1600	1580	1560	1500
SWD20540	7205026.73	475222.15	3.69	3.66	3.63	3.61	3.53	690	660	630	610	530
SWP20234	7204956.57	475239.19	3.69	3.66	3.63	3.61	3.53	1450	1430	1390	1370	1290
SWP20235	7204964	475384.52	3.69	3.66	3.63	3.61	3.53	560	540	500	480	400
SWP20236	7204974.02	475386.29	3.69	3.66	3.63	3.61	3.53	580	550	520	500	420
SWP20237	7205130.16	475409.27	3.69	3.66	3.63	3.61	3.53	610	580	550	530	450
SWP20238	7205141.72	475411.53	3.69	3.66	3.63	3.61	3.53	600	570	540	520	440
SWP20239	7205026.33	475235.28	3.86	3.80	3.72	3.68	3.59	420	360	280	240	150
SWP20336	7204800.53	475702.93	3.29	3.20	3.12	3.06	2.95	1140	1050	970	920	800
SWP20337	7204803.38	475682.41	3.29	3.20	3.12	3.06	2.95	1140	1050	970	910	800
SWP20492	7204428.44	474582.67	4.68	4.68	4.68	4.68	4.67	750	760	760	760	750
SWP20493	7204442.24	474583.7	4.65	4.65	4.65	4.66	4.65	1010	1010	1020	1020	1010
SWP20494	7204545.7	474568.27	4.26	4.21	4.18	4.16	4.12	960	910	880	860	820
SWP20497	7204626.17	473587.33	3.59	3.58	3.57	3.56	3.53	950	940	930	920	890
SWP20498	7204631.92	473600.8	3.11	3.06	3.01	2.96	2.86	590	540	490	440	340
SWP20514	7205076.98	474041	2.98	2.88	2.76	2.67	2.57	780	680	560	470	370
SWP20515	7205072.05	474061.65	3.02	2.90	2.78	2.73	2.62	810	690	570	520	410
SWP20519	7204896.33	474597.73	3.07	2.96	2.87	2.80	2.67	880	780	680	620	490
SWP20520	7204892.21	474628.48	3.11	3.01	2.91	2.85	2.71	630	530	430	370	240
SWP20521	7204837.85	474688.96	3.29	3.19	3.09	3.03	2.89	650	550	460	400	260
SWP20533	7204547.34	474549.21	4.24	4.19	4.14	4.09	3.94	1030	980	930	880	730
SWP20551	7204851.99	474688.21	3.12	3.02	2.92	2.87	2.73	600	500	410	350	210
SWP20583	7204622.94	475398.58	3.72	3.70	3.68	3.60	3.38	870	850	830	750	530
SWP20584	7204624.2	475373.63	3.33	3.24	3.15	3.09	3.01	730	640	550	490	410
SWP20585	7204761.42	475296.73	3.31	3.22	3.14	3.08	2.98	670	580	500	440	340
SWP20586	7204744.76	475286.8	3.32	3.23	3.14	3.09	3.00	680	590	500	450	360
SWP20587	7204629.46	475118.26	3.31	3.21	3.12	3.07	2.98	660	560	470	420	330
SWP20588	7204628.55	475105.93	3.30	3.20	3.11	3.06	2.98	690	590	510	450	380
SWP20589	7205002.37	475806.14	3.29	3.20	3.12	3.06	2.95	1080	1000	920	860	750
SWP20591	7204813.78	475591.06	3.29	3.20	3.12	3.06	2.95	1150	1060	980	920	810
SWP20592	7204815.44	475578.94	3.29	3.21	3.12	3.06	2.95	700	610	530	470	350
SWP20611	7205008.32	475787.54	3.29	3.20	3.12	3.06	2.95	1110	1030	950	890	770
SWP20657	7205050.42	475394.34	3.86	3.80	3.72	3.68	3.57	1510	1450	1380	1340	1220

Appendix 2– Peak Water Surface Levels: Mitigated Scenario

SAWMILL ROAD CATCHMENT - Mitigated XP-STORM Results

XP-STORM Node	X	Y	Q100 WSL (m,AHD)	Q50 WSL (m,AHD)	Q20 WSL (m,AHD)	Q10 WSL (m,AHD)	Q2 WSL (m,AHD)	Q100 Depth (mm)	Q50 Depth (mm)	Q20 Depth (mm)	Q10 Depth (mm)	Q2 Depth (mm)
1.52	7205035.04	474843.97	3.10	3.05	3.00	2.97	2.89	650	600	550	520	440
CN1.0	7205320.03	473970.31	2.43	2.42	2.41	2.41	2.41	1430	1420	1410	1410	1410
CN1.1	7205168.12	473950.6	2.92	2.82	2.71	2.63	2.53	1620	1520	1410	1330	1230
CN1.2	7205140.2	473949.03	2.98	2.87	2.76	2.67	2.56	1630	1520	1410	1320	1210
CN1.21	7205030.17	473929.25	3.22	3.05	2.92	2.81	2.63	1660	1490	1350	1250	1070
CN1.221	7204765.5	473755.79	3.11	3.06	3.01	2.96	2.85	940	890	840	790	680
CN1.23	7204646.43	473881.17	3.55	3.44	3.33	3.23	3.03	1250	1140	1030	930	730
CN1.231	7204489.59	473855.8	3.66	3.62	3.61	3.57	3.50	460	420	410	370	300
CN1.24	7204622.61	474003.31	3.73	3.67	3.61	3.55	3.42	1230	1160	1100	1040	910
CN1.26	7204252.27	474577.65	7.81	7.77	7.75	7.71	7.55	1560	1520	1500	1460	1300
CN1.27	7204103.95	474857.9	15.93	15.86	15.84	15.78	15.62	930	860	840	780	620
CN1.4	7205030.99	474285.04	3.04	2.92	2.82	2.75	2.64	860	740	640	570	460
N47	7204625.71	475256.31	3.32	3.23	3.14	3.09	3.00	900	810	720	670	580
N48	7204624.2	473998.88	3.65	3.54	3.43	3.34	3.14	1230	1120	1010	920	720
N49	7204151.47	474745.86	14.90	14.86	14.84	14.81	14.71	2510	2480	2460	2420	2330
N50	7204155.39	474725.15	13.07	13.03	13.01	12.98	12.89	790	750	730	700	610
N61	7205014.62	474649.08	3.08	3.02	2.96	2.91	2.83	700	640	570	530	440
N62	7204977.48	474643.88	3.08	3.01	2.93	2.88	2.79	710	640	570	520	420
N66	7204589.09	474238.05	3.96	3.89	3.82	3.75	3.59	1080	1010	950	880	720
N68	7205029.84	474750.38	3.10	3.05	3.00	2.97	2.89	700	650	600	570	490
N7	7204842.34	475388.63	3.29	3.21	3.12	3.07	2.95	630	550	460	400	290
N71	7204897.23	474619.21	3.06	2.96	2.87	2.80	2.67	780	680	590	520	390
N73	7204940.93	474644.97	3.08	3.01	2.93	2.88	2.79	780	710	630	580	490
N8	7204843.57	475381.92	3.31	3.22	3.14	3.08	2.98	660	570	490	430	330
ON1	7205329.07	473898.05	2.40	2.40	2.40	2.40	2.40	1650	1650	1650	1650	1650
SN 1.52	7205032.18	474864.51	3.10	3.05	3.00	2.97	2.89	1150	1100	1050	1020	940
SN1.22	7204747.81	473887.1	3.40	3.24	3.12	2.99	2.77	1230	1070	950	820	600
SN1.241	7204504.64	474158.84	3.74	3.67	3.61	3.55	3.42	1440	1370	1310	1250	1120
SN1.51	7205038.79	474722.47	3.10	3.05	3.00	2.97	2.89	600	550	500	470	390
SN1.61	7204806.74	474747.45	3.29	3.19	3.10	3.05	2.97	1490	1390	1300	1250	1170
SN1.8	7204636.85	475263.46	3.32	3.23	3.14	3.09	3.00	890	800	710	660	570
SWD20096	7205033.51	475038.27	3.56	3.53	3.52	3.50	3.47	220	190	180	160	130
SWD20097	7205033.75	475051.62	3.56	3.53	3.51	3.49	3.47	1490	1460	1450	1430	1400
SWD20540	7205026.73	475222.15	3.62	3.59	3.56	3.55	3.49	620	590	560	550	490
SWP20234	7204956.57	475239.19	3.62	3.59	3.56	3.55	3.49	1380	1360	1330	1310	1250
SWP20235	7204964	475384.52	3.62	3.59	3.56	3.55	3.49	490	470	440	420	370
SWP20236	7204974.02	475386.29	3.62	3.59	3.56	3.55	3.49	510	480	450	440	380
SWP20237	7205130.16	475409.27	3.62	3.59	3.56	3.55	3.49	540	510	480	470	410
SWP20238	7205141.72	475411.53	3.62	3.59	3.56	3.55	3.49	530	500	470	460	400
SWP20239	7205026.33	475235.28	3.85	3.79	3.71	3.68	3.56	410	350	270	240	120
SWP20336	7204800.53	475702.93	3.29	3.20	3.12	3.07	2.95	1140	1060	980	920	800
SWP20337	7204803.38	475682.41	3.29	3.20	3.12	3.07	2.95	1140	1050	970	920	800
SWP20492	7204428.44	474582.67	4.68	4.68	4.68	4.68	4.67	750	760	760	760	750
SWP20493	7204442.24	474583.7	4.65	4.65	4.65	4.66	4.65	1010	1020	1020	1020	1010
SWP20494	7204545.7	474568.27	4.26	4.21	4.18	4.16	4.12	960	910	880	860	820
SWP20497	7204626.17	473587.33	3.59	3.58	3.57	3.56	3.53	950	940	930	920	890
SWP20498	7204631.92	473600.8	3.11	3.06	3.01	2.96	2.85	590	540	490	440	340
SWP20514	7205076.98	474041	2.98	2.88	2.76	2.67	2.57	780	680	560	470	370
SWP20515	7205072.05	474061.65	3.02	2.90	2.78	2.73	2.62	810	690	570	520	410
SWP20519	7204896.33	474597.73	3.06	2.96	2.87	2.80	2.67	880	780	680	620	490
SWP20520	7204892.21	474628.48	3.10	3.00	2.91	2.85	2.71	630	530	430	370	240
SWP20521	7204837.85	474688.96	3.29	3.19	3.09	3.03	2.89	650	550	460	400	260
SWP20533	7204547.34	474549.21	4.24	4.19	4.14	4.09	3.94	1030	980	930	880	730
SWP20551	7204851.99	474688.21	3.11	3.01	2.92	2.87	2.73	590	500	410	350	210
SWP20583	7204622.94	475398.58	3.72	3.70	3.68	3.60	3.38	870	860	830	750	530
SWP20584	7204624.2	475373.63	3.33	3.24	3.15	3.10	3.01	730	640	550	500	410
SWP20585	7204761.42	475296.73	3.31	3.22	3.14	3.08	2.98	670	580	500	440	340
SWP20586	7204744.76	475286.8	3.32	3.23	3.14	3.09	3.00	680	590	510	450	360
SWP20587	7204629.46	475118.26	3.31	3.21	3.13	3.07	2.98	660	560	470	420	330
SWP20588	7204628.55	475105.93	3.29	3.20	3.11	3.06	2.98	690	590	510	460	370
SWP20589	7205002.37	475806.14	3.29	3.20	3.12	3.07	2.95	1080	1000	920	860	740
SWP20591	7204813.78	475591.06	3.29	3.20	3.12	3.07	2.95	1150	1060	980	930	810
SWP20592	7204815.44	475578.94	3.29	3.21	3.12	3.07	2.95	700	610	530	470	350
SWP20611	7205008.32	475787.54	3.29	3.20	3.12	3.07	2.95	1110	1030	950	890	770
SWP20657	7205050.42	475394.34	3.85	3.79	3.71	3.68	3.53	1510	1440	1370	1340	1190

Appendix 3– Preliminary Costing

Sawmill Road Flood Risk Reduction Study - Meadow Drive Upgrade

Preliminary Cost Estimate				
Description	Unit	Rate	Quantity	Cost
Project Establishment				**$4,000.00**
Site Establishment	Item	$1,000.00	1	$1,000.00
Provision for Traffic	Item	$500.00	1	$500.00
Soil Testing for Road Pavement Design	Item	$2,500.00	1	$2,500.00
Site Preparation				**$3,000.00**
Clearing & Grubbing	Item	$1,500.00	1	$1,500.00
Stockpile Topsoil on Site for Later Reinstatement	Item	$1,500.00	1	$1,500.00
Earthworks				**$9,680.00**
Excavation Through Road and Stockpile	m^3	$40.00	117	$4,680.00
Allowance for Disposal of Material Off-Site	Item	$5,000.00	1	$5,000.00
Pavements / Surfacing				**$3,170.00**
Grade, Compact and Form Road	m^3	$25.00	80	$2,000.00
2 Coat bitumen surfacing	m^2	$18.00	65	$1,170.00
Culvert Installation				**$22,500.00**
Supply No 1. 2.4m x 0.6m RCBC	Item	$20,000.00	1	$20,000.00
Installation	Item	$2,500.00	1	$2,500.00
Landscaping				**$6,500.00**
Seeding & Hydromulch	Item	$1,500.00	1	$1,500.00
Allowance for Re-vegetation	Item	$2,500.00	1	$2,500.00
Maintenance of Vegetation Works (during establishment period)	Item	$2,500.00	1	$2,500.00
Miscelaneous				**$12,500.00**
Provision for Sediment & Erosion Control During Construction	Item	$2,500	1	$2,500.00
Allowance for Survey Setout of Works	Item	$5,000	1	$5,000.00
Survey and As Constructed Plans	Item	$5,000	1	$5,000.00
Sub-Total				**$61,350.00**
Project Management and Design at 15%				$9,202.50
Contingencies at 30%				$18,405.00
Total for Works (Excl. GST)				**$88,957.50**