# St Marys *Freight Hub*—

## Flood Impact Assessment

FOR / Flooding Engineering Services

CLIENT / Pacific National

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# CONTENTS


**1 INTRODUCTION 1**

1.1 Purpose of Report 1

1.2 Terminology 1

1.3 Available Flood Data 1

1.3.1 Advice from Penrith City Council 1

1.3.2 Existing Flood Models 2

1.4 Australian Rainfall and Runoff 2016 2

**2 SITE SUMMARY 3**

2.1 Existing Site Summary 3

2.1.1 Access 4

2.1.2 Watercourses 4

2.1.3 Existing Sediment Basin 4

2.1.4 Existing Site Drainage 5

2.1.5 Upstream and Adjoining Site Drainage 5

2.2 Proposed Development 6

**3 FLOOD MODELLING UPDATE 8**

3.1 Sources of Flooding 8

3.2 Flood Model Updates 8

3.3 Flood Modelling Assumptions 10

**4 EXISTING FLOOD BEHAVIOUR 11**

4.1 Flood Behaviour 11

4.2 Flood Levels 11

4.3 Flood Hazard 12

4.4 Hydraulic Categories 12

4.5 Existing Hydraulic Structures 12

**5 POST-DEVELOPMENT FLOOD RISK ASSESSMENT 14**

5.1 Proposed Development 14

5.1.1 Site Runoff 14

5.1.2 Managing Flows from Upstream Catchments 14

5.2 Mitigation Measures 14
5.3 Flood Impact Assessment 15
5.4 Floodway and High Hazard Flows 16
5.5 Flood Levels and Pad Levels 16
5.6 Evacuation Planning / Flood Emergency Management 17
5.6.1 Flood Warning 18
5.6.2 Shelter-in-Place Recommendation 18
5.7 Climate Change 18
**7 CONCLUSIONS AND RECOMMENDATIONS 20**
7.1 Conclusions 20

**Appendices**

Appendix A Penrith City Council Flood Advice
Appendix B Flood Mapping – Pre-Development Scenario
Appendix C Flood Mapping – Post-Development Scenario

# 1 INTRODUCTION

## 1.1 Purpose of Report

BG&E Pty Limited (BG&E) has been engaged by Pacific National to prepare a flood risk assessment for the proposed freight hub facility at St Marys.

This Flood Study and Flood Impact Assessment has been prepared to support the Development Application of the proposed freight hub facility at St Marys.

The aim of this report is to:

- Describe the updates made to Penrith City Council's flood model of Little Creek to make fit-for-purpose for the assessment of the proposed development;
- Understand flood risks to the existing site and identify potential flood risks to the future development;
- Identify key development constraints in regard to flooding;
- Establish any flood mitigation measures required to minimise flood impacts to the development itself and the surrounding area; and
- Consider potential flood management and evacuation options for the site.

**This report has been prepared for Development Application only.**

The proposed development is subject to the Planning Secretary's Environmental Assessment Requirements (SEARS), application number 7308.

## 1.2 Terminology

The frequency of a flood event is expressed in terms of its Annual Exceedance Probability (AEP); the probability of an event being equalled or exceeded within a year. Smaller magnitude events are described by Exceedances per Year (EY); the average number of times a year in which the event is likely to be equalled or exceeded. Previously flood probabilities have been described by the Average Recurrence Interval (ARI); that is the average time period between occurrences equalling or exceeding a given value. Some documents, such as Development Control Plans and Guidelines still refer to the ARI terminology.

For example, a 1% AEP event has a 1% chance (i.e. a 1 in 100 chance) of being equalled or exceeded in any one year and is equivalent to a 100 year Average Recurrence Interval (ARI) event. In the same way, a 5% AEP event is the equivalent of a 20 year ARI event.

## 1.3 Available Flood Data

### 1.3.1 Advice from Penrith City Council

Advice from Penrith City Council is included as Appendix A and is based on the *Little Creek Catchment Overland Flow Flood Study* (WMAwater for PCC, 2017). This advice concludes:

- The site is affected by the 1% AEP mainstream flood from Little Creek.

- Penrith Development Control Plan 2014 Section C3.5 Flood Planning applies to any development of the site.
- Flood depths in excess of 150 mm affect the site.
- Council may require a detailed assessment of overland flows affecting the property.
- Development will be designed to ameliorate flood risk.

### 1.3.2 Existing Flood Models

Little Creek passes through the site from east to west and joins with South Creek to the west of the site (refer Figure 2-1). Both creeks have been subject to flood modelling commissioned by Penrith City Council for Flood Studies undertaken through the NSW Government's Floodplain Management Program. The following studies have been adopted by Council for the purpose of flood planning:

- Little Creek was modelled using TUFLOW software as part of the *Little Creek Catchment Overland Flow Flood Study* (WMAwater, 2017); and
- South Creek has been modelled using RMA-2 software as part of the *South Creek Flood Study* (WorleyParsons, 2015).

Council provided digital copies of the two flood models and a full set of modelling results in Geographic Information System (GIS) format. Little Creek flood modelling considered events from the 0.5 EY event (2 year ARI) to the PMF event. The smallest magnitude event considered for South Creek was the 5% AEP event (20 year ARI) and the largest event assessed was the PMF.

Flooding from Little Creek is the dominant flood mechanism for the area of land to the east of the existing disused railway line for the majority of flood events with the exception of events of larger magnitude than the 0.2% AEP flood event. In this regard, Council's flooding engineer (Ratnam Thilliyar, pers.comm., 27 July 2018) has advised that it is acceptable to use only the Little Creek flood model in the assessment of Development Application.

## 1.4 Australian Rainfall and Runoff 2016

The flood modelling adopted by Council used Australian Rainfall and Runoff 1987 (ARR1987) methods. As the existing models have been adopted by Council, BG&E has not updated the model hydrology to ARR2016 methods.

# 2 SITE SUMMARY

## 2.1 Existing Site Summary

The site is known as Lot 2 in DP 876781 with a frontage to Forrester Road, St Marys, NSW owned by Pacific National. It is located within a largely industrial area of St Marys, 8 km east of Penrith, NSW. The site is bounded by Forrester Road and industrial development to the east, the Great Western Railway Line to the south, and Little Creek to the North.

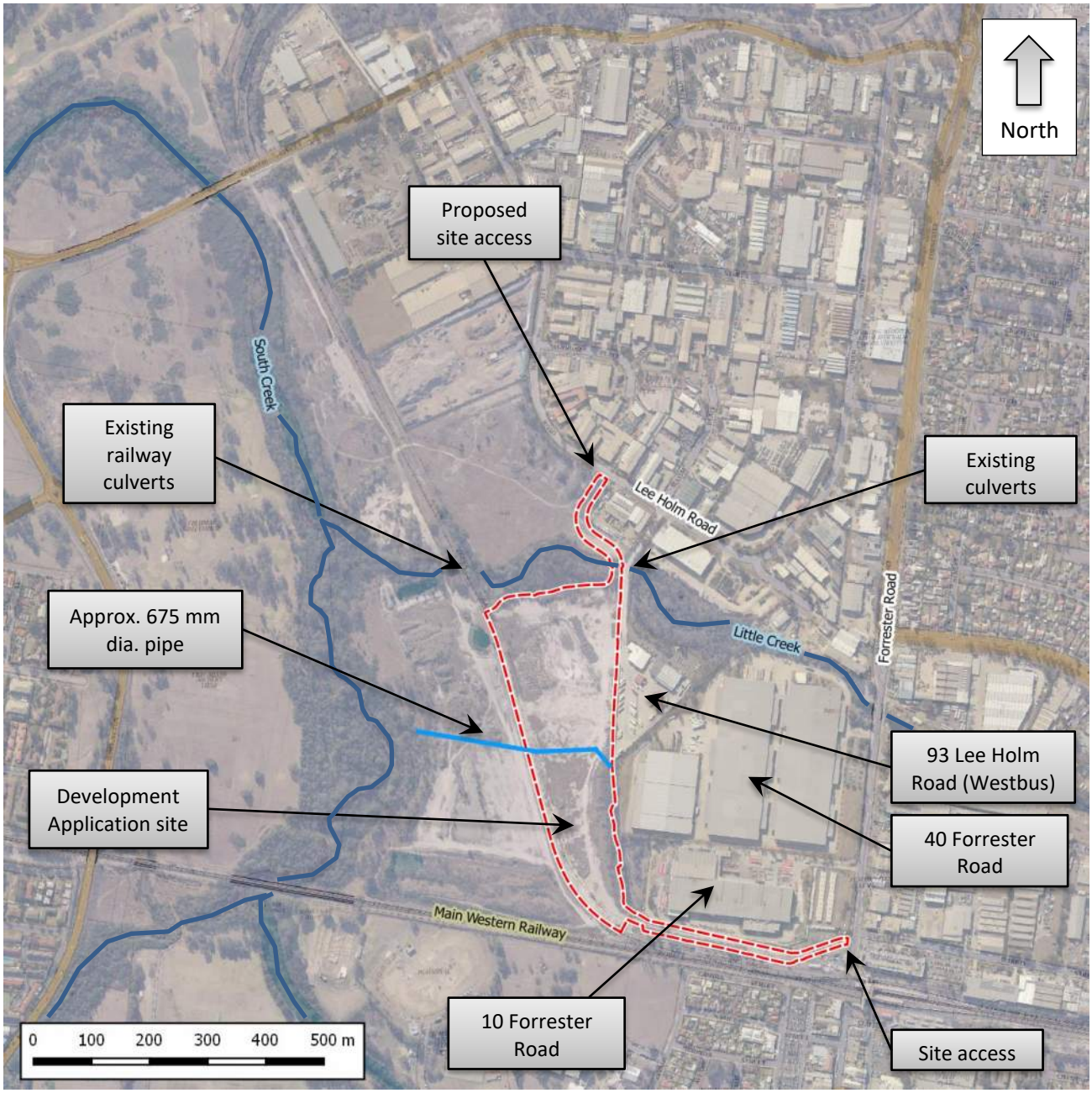


**Figure 2-1 – Site Location and Features**

### 2.1.1 Access

As shown in Figure 2-1, existing access to the site is from Forrester Road near the intersection with Harris Street. An existing access track runs along the western site boundary (outside site boundary) from Lee Holm Road to no. 93 Lee Holm Road (triangular property south of Little Creek). It is culverted where it crosses Little Creek.

The Main Western Railway runs parallel to the southern site boundary, and an existing siding turns into the site and runs towards the north. The site is currently undeveloped vacant industrial land, although the natural terrain has been modified through movement and stockpiling of material and aggregate.

### 2.1.2 Watercourses

South Creek is located about 200m west of the rail sidings. South Creek flows from south to north and is part of the wider Hawkesbury-Nepean catchment.

Little Creek, a tributary of South Creek, flows through the site from east to west draining a catchment area of about 4.5 $km^2$.

An access road to 93 Lee Holm Road is located parallel to the eastern boundary of the site (outside of the development application boundary) and crosses the creek at an existing 2.4 m x 1.8 m RCBC (reinforced concrete box culvert)[1].

Little Creek continues through the future St Marys' freight hub site through 2.5 m x 1.8 m culvert[1] beneath the sidings and towards South Creek.

**Culvert at site access road (upstream side)**

**Culvert at rail lines (upstream side)**

*(Obtained from Hydrographic & Cadastral Survey Pty via Penrith City Council)*

**Figure 2-2 – Photos of Little Creek culverts**

### 2.1.3 Existing Sediment Basin

An existing sedimentation basin is located on the south side of Little Creek (refer Figure 2-3). The majority of the site drains to this basin prior to discharging to the creek. In low flows, site runoff is directed to the basin via two existing 300 mm diameter culverts and cut off drains.

The *Little Creek Catchment Overland Flow Flood Study* (WMAwater, June 2016) does not make reference to this basin and it is therefore assumed that is not been designed to be used primarily for flood detention purposes.

[1] Culvert dimensions reported are extracted from inputs to Penrith City Council's Little Creek flood model and should be confirmed through survey for detailed design.

*(Obtained from Hydrographic & Cadastral Survey Pty via Penrith City Council)*

**Figure 2-3 – Photos of "Sedimention Basin" within the site**

### 2.1.4 Existing Site Drainage

The existing site is 100% pervious and falls in a northerly direction at approximately 1% towards Little Creek.

A narrow drainage channel runs along the southern side of the access road from Forrester Road. An approximately 300mm diameter culvert was identified during site visit. This culvert conveys flows under the existing access road to a vegetated channel running along the sites eastern boundary.

This vegetated depression along the eastern area of the site is evident in the site survey with a more than 3 m high bund separating this area from the rest of the site. This feature appears to be a swale, following the alignment of a drainage easement. Title searches show the easement being for the benefit of drainage from the railway corridor.

Current survey does not pick up any culverts draining from this area. However during the site visit it was identified that this swale drains to an existing pit in a lowpoint on the sites eastern boundary near the boundary between 40-88 Forester Road and 93 Lee Holm Road. An approximately 675 mm diameter pipe from this pit is assumed to follow the alignment of the easement in a westerly direction towards South Creek. Flow that cannot be conveyed by this pipe spills from the lowpoint and flows overland towards Little Creek.

Further survey will confirm existing pipe sizes and pit locations at detailed design stage.

### 2.1.5 Upstream and Adjoining Site Drainage

There are significant upstream local drainage catchments to the site. Confirmation of these and the exact discharge locations are required during detailed design.

Approximately 2.1 ha of rail corridor are believed to flow through the site, discharging via an existing headwall adjacent to the south eastern corner of the site and flowing overland toward the existing access road from Forrester Road.

Penrith City Council provided drainage drawings for Lot 221 DP1025100 (40 Forrester Road) and Lot 220 DP1172926 (10 Forrester Road). Drainage plans for Lot 100 DP1136503 for (93 Lee Holm Road) were provided to BG&E by the site owner.

The following assumptions were made from the provided plans for this purpose of the flood modelling. Further details, and copies of the drainage plans obtained for the adjoining sites can be found in the Stormwater Management Report (B18028_RPT_003_RevC).

**Lot 100 DP1136503 for (93 Lee Holm Road)**

Drainage plans for the Westbus Site located at 93 Lee Holm Road show all runoff for storm events up to and including the 1% AEP will discharge toward Little Creek to the north and will not enter the St Marys freight hub site.

**Lot 221 DP1025100 (40 Forrester Road)**

The drainage plan provided by Penrith City Council for 40 Forrester Road also included the area of 10 Forrester Road. The plan does not correspond with the current development on Number 10, however the three warehouses on Number 40 appear to represent those on the existing site.

The following assumptions have been made based on the drainage layout and review of LiDAR data:

- The intention of the drainage layout on 40 Forrester Road is to discharge stormwater collected in the piped drainage system towards Little Creek to the north.
- For warehouses 1 and 2 (central and eastern), overland flows would also flow to Little Creek to the north.
- LiDAR and aerial imagery also show a low lying vegetated area between the Westbus site at 93 Lee Holm Road and the property at 40 Forrester Road. This area appears to drain toward the development site.
- Stormwater runoff that exceeds the pipes network from around warehouse 3 would discharge to a low lying area between 93 Lee Holm Road and 40 Forrester Road and subsequently drain towards the proposed development site.
- It is assumed that the site piped drainage was designed in accordance with Penrith City Council's Stormwater Drainage Policy ES002 which requires internal and piped drainage systems to be designed for the 5% AEP event with an overland flow path provided to the 1% AEP event.

Further survey and confirmation of these assumptions are required during detailed design.

**Lot 220 DP1172926 (10 Forrester Road)**

Plans were not available for the current site layout. Based on LiDAR and Council's Little Creek flood model, it is believed the property at 10 Forrester Road discharges to the development site near to the existing drainage easement and swale.

## 2.2 Proposed Development

The proposed freight hub development is located on the portion of the site to the east of the existing sidings and south of Little Creek. A sketch is shown as Figure 2-4. Earthworks will be undertaken to grade the site towards Little Creek.

A new access from Lee Holm Road is proposed. As the access crosses Little Creek, a new culvert is proposed immediately downstream of the existing culvert at the access to 93 Lee Holm Road (the WestBus site).

The access point from Forrester Road will be maintained for vehicular access, and the alignment of the existing rail sidings will be maintained.

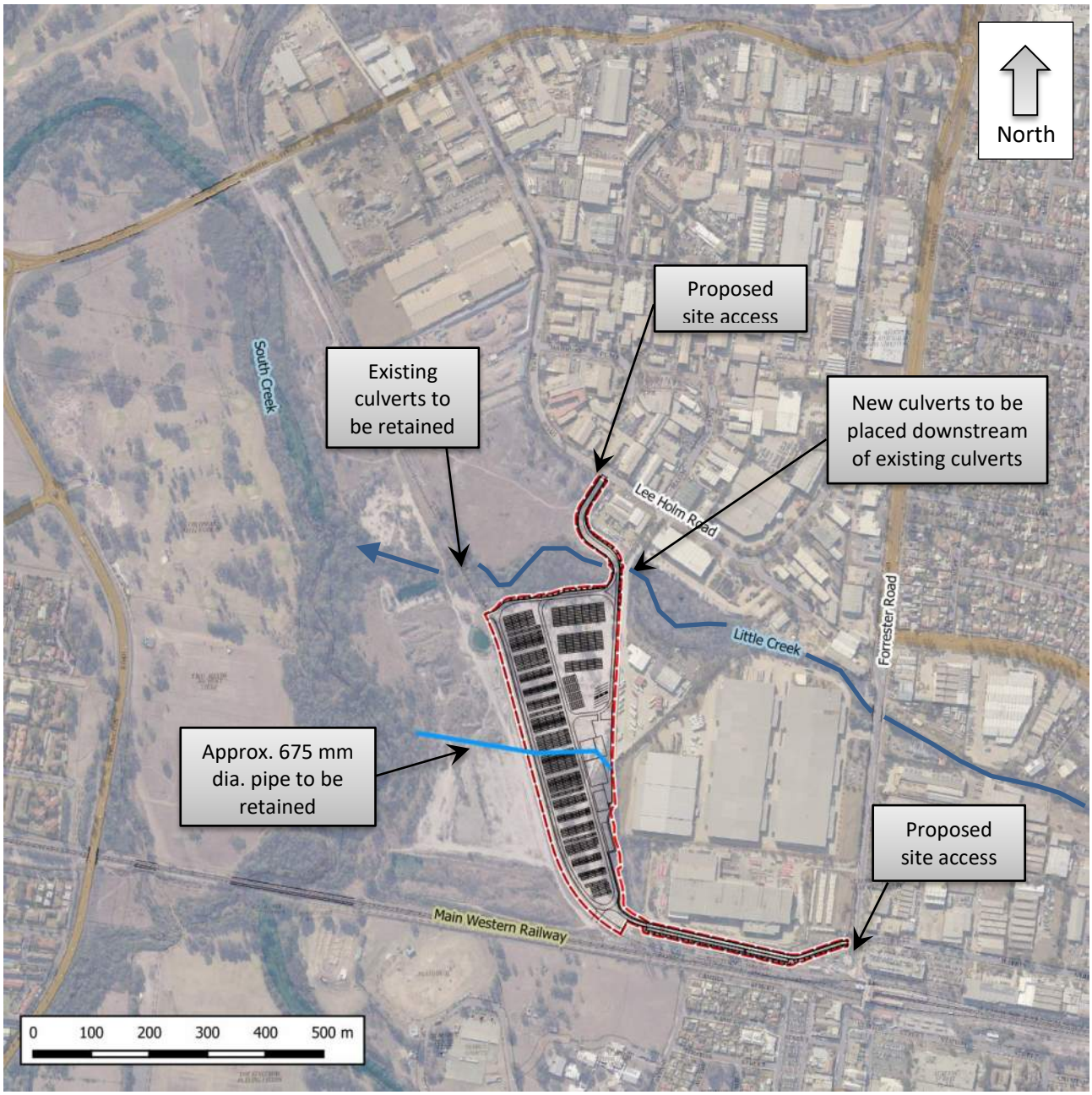


**Figure 2-4 – Proposed Development Layout**

# 3 FLOOD MODELLING UPDATE

## 3.1 Sources of Flooding

Based on Council's flood advice and flood models, the site is shown to be flood affected by flooding from three sources:

- Mainstream flooding from Little Creek;
- Mainstream flooding from South Creek; and
- Local overland flows from local catchment runoff.

Flooding from Little Creek is the dominant flood mechanism for the area of land to the east of the existing disused railway line for the majority of flood events with the exception of events of larger magnitude than the 0.2% AEP flood event. In this regard, Council's flooding engineer (Ratnam Thilliyar, pers.comm., 27 July 2018) has advised that it is acceptable to use only the Little Creek flood model in the assessment of the proposed development.

The South Creek model shows potential for some overtopping of the sidings with floodwaters spilling into the portion of the site north of Little Creek. However, although this is land owned by Pacific National, there are no development proposals within this area as part of this development application submission.

## 3.2 Flood Model Updates

Council's Little Creek flood model was used as the base model for assessment of the St Marys freight hub development. Key features of the model are summarised in Table 3-1, and further detail on the model can be found in the *Little Creek Overland Flow Flood Study* report.

**Table 3-1 – Key Features of PCC's Little Creek Flood Model**

| Feature / Parameter | Value / Comment |
|---|---|
| 2d Grid Size | 1.5 m |
| Simulated run time | 4 hours |
| Inflows / Hydrology | DRAINS model |
| Critical Storm Duration | 120 minutes |
| Base Digital Terrain Model | 2011 LiDAR data, plus cross section survey of Little Creek undertaken specifically for the Flood Study. |
| 1d elements | • Pit and pie network<br>• Little Creek crossings |
| Blockage factors | • 25% structure blockage for 0.5 EY to 10% AEP events<br>• 50% structure blockage for 5% AEP event to 0.5% AEP event<br>• 75% structure blockage for 0.2% AEP event and PMF event<br>• No blockage assumed on pit and pipe network |

| Feature / Parameter | Value / Comment |
|---|---|
| Pits and pipes | Based on PCC's GIS database and survey undertaken specifically for the Flood Study. |
| Tailwater Levels | • Constant tailwater level assumed (ie not time varying)<br>• 22.6 mAHD adopted for 5% AEP events and greater – *Little Creek Overland Flow Flood Study* Report references this as the 5% AEP flood level on South Creek<br>• 20 mAHD adopted for 10% AEP event and smaller magnitude floods |

A number of refinements were made to the flood model in order to better represent flooding conditions in and around the development site and to allow for assessment of hydraulic impacts. These are described in Table 3-2.

Assumptions made in the development of the model for Council's adopted Little Creek Catchment Overland Flow Flood Study, e.g. blockages, catchment hydrology, hydraulic structure sizes, have not been reviewed unless described in Table 3-2.

**Table 3-2 – Updates to PCC's Little Creek Flood Model**

| Revision | Comment |
|---|---|
| Reduced model extent. | The model extent was reduced to reduce model runtimes. Boundary conditions were generated from results of the full extent Little Creek flood model. Testing prior to additional model updates showed that the truncated model matched the flood level results of the full extent model. |
| Revised site surface levels. | Site survey data has been used to update the model DEM.<br>Top level of rail sidings added as a break line to better represent level of flood overtopping. |
| Added major existing drainage features within the site. | The 675 mm dimeter pipe identified on site is not included in Council's flood model and has been added. Invert levels have been assumed from site measurements. This will be updated at detailed design phase when detailed survey is available. |
| Revised inflows locations for local catchments draining towards the site. | Inflow locations for 93 Lee Holm Road, 40 Forrester Road and 10 Forrester Road have been updated to represent expected drainage behaviour on these sites as per the discussion in section 2.1.5. |
| Local catchment inflows within the development application boundary. | Council's flood model included 10 local catchment inflows within the proposed development site which create the effect of flooding across the site when mapped. However in reality depths are shallow (typically less than 200 mm) and will be managed through the site stormwater design. Therefore, it was assumed that all overland flows on the site will be to Little Creek through the site drainage system. |

## 3.3 Flood Modelling Assumptions

- The hydrology adopted in the flood modelling is as per Penrith City Council's adopted flood model. No amendments have been made to input hydrographs other than modifying the inflow locations at the adjoining properties as described above.
- The water levels in South Creek (the tailwater conditions) have been assumed as per Council's flood model. There is potential for the timing of flooding on South Creek to differ from Little Creek depending on storm temporal and spatial patterns, and therefore flooding may not occur exactly as mapped in this study.
- This assessment focusses on flooding from Little Creek as it is the dominant source of flooding for the majority of ARI events. Flooding from South Creek could also occur as the rail lines are overtopped in events greater than the 0.2% AEP event (refer Section 4).
- The accuracy of flood levels is dependent on the accuracy of the data used to build the model. LiDAR is typically only accurate to +/- 0.15 m and in some areas (especially vegetated channels) can be several hundred mm.
- The model is based on the ground level data and hydraulic structure dimensions as per PCC's Little Creek Flood Study model, with the exception of the updated site topographic survey.
- **The *Little Creek Catchment Overland Flow Flood Study* flood model has been adopted for use by PCC for the purpose of flood planning and assessment. The Flood Study will have been through the rigorous review and processes of the NSW Floodplain Management Program. Therefore use of PCC's *Little Creek Catchment Overland Flow Flood* model provides consistency between this study and council flood planning information.**

# 4 EXISTING FLOOD BEHAVIOUR

## 4.1 Flood Behaviour

Flood extents for the 5% AEP, 1% AEP and PMF events for Little Creek are shown in Appendix B. The extent of flooding does not scale significantly between the 5% AEP and 1% AEP event.

Flood modelling shows that in the 5% AEP event flows are expected to exceed the existing channel capacity and spill into the site. Some localised flooding on Lee Holm Road to the north of the site is also expected in this event. Much of the proposed development area is not affected by flooding until the PMF event.

Flood flows are expected to overtop the existing road access to the Westbus site in events smaller than the 5% AEP event. Flows overtopping the road spill back into the Little Creek channel but also overland and into the existing basin downstream.

## 4.2 Flood Levels

In the 5% AEP event, predicted peak flood levels are 23.55 mAHD immediately upstream of the railway culverts to 24.3 mAHD in the Little Creek Channel at the upstream boundary of the site (refer Figure B 1). A portion of the rail siding is shown as being overtopped. This is due to limited capacity of the rail culverts, high water levels in Little Creek and additional flows draining towards the creek from catchments to the north.

Flood levels for the 1% AEP flood are shown in Figure B 2. Based on Council's flood modelling, the maximum 1% AEP flood level applicable to the site is 24.6 mAHD occurring at the site access of Lee Holm Road. This is a result of local runoff in the roadway area. In the creek itself, 1% AEP levels vary from 23.6 mAHD at the railway culverts and up to 24.3 mAHD immediately downstream of the culverts at the western boundary. Flood levels overtopping the access road are 24.9 mAHD (refer Table 4-1).

Higher flood levels are expected for a PMF flood event from South Creek than for a PMF event on Little Creek. The PMF level across the site is 26.8 mAHD from a PMF event occurring on the South Creek catchment (refer Table 4-1). Flood levels for a PMF event on Little Creek (5% AEP tailwater on South Creek) are shown in Figure B 3.

Peak flood levels for Little Creek within the development site are presented in Table 4-1. This higher level is caused by over topping of the access to the Westbus site. In events greater than the 0.2% AEP event, South Creek becomes the dominant source of flooding.

**Table 4-1 – Peak Flood Levels (mAHD)**

| | 0.2 EY | 5% AEP | 1% AEP | 0.5% AEP | 0.2% AEP | PMF |
|---|---|---|---|---|---|---|
| Little Creek flood model | 23.35 – 24.75 | 23.55 – 24.8 | 23.6 – 24.9 | 23.65 – 24.9 | 23.7 – 24.95 | 23.9 – 25.25 (Little Creek) |
| South Creek flood model | Not assessed | 22.7 | 23.2 | 23.4 | 23.7 | 26.8 |

*Peak flood levels for South Creek are not mapped as part of this report (refer section 1.3.2). The have been extracted from the South Creek Flood Study, WorleyParsons for Penrith City Council, 2015. Note this table shows peak flood levels for Little Creek only. Peak flood levels for local overland flow through the site and peak flood levels on Lee Holm Road at the proposed site access are not shown here and can be extracted from the mapping in Appendix B and Appendix C.*

## 4.3 Flood Hazard

The predicted flood hazard for the 5% AEP, 1% AEP and PMF events is shown in Figure B 10, Figure B 11 and Figure B 12. The main channel of Little Creek is considered as high flood hazard. This is likely due to a combination of high velocities and significant depths. Flood depths of more than 1m in the area immediately south of the channel also result in high flood hazard although the velocities through this area are low. The overland flow path through the site is typically low hazard with depths of typically less than 100 mm in a 1% AEP event (refer Figure B 5).

Although the roads used to access the site such as Lee Holm Road are inundated, flood hazard on the surrounding roads in a 1% AEP event is considered low as a result of shallow depth flooding from overland local runoff.

In a PMF event, flood hazard on the roads in the vicinity of the site can be high. In particular Lee Holm Road between Anne Street and Warrior Place. Where Forrester Road crosses Little Creek, high hazard flows occur as the road is overtopped. Within the site itself, flood flows from Little Creek cause high hazard flooding in the vicinity of the creek corridor. Shallow overland flood from local catchments draining towards the creek causes low flood hazard flooding within the development application area.

## 4.4 Hydraulic Categories

Hydraulic categories have been defined as per the adopted PCC *Little Creek Catchment Overland Flow Flood Study* and are based on methods developed by Howells *et al* 2003. Hydraulic categories for the 1% AEP event on Little Creek, under pre-development conditions, are shown in Figure B 13.

The floodway associated with Little Creek is a maximum of 25 m wide through the development site. The existing basin and waterway corridor are identified as flood storage areas. The shallow overland flow path through the site is considered as flood fringe.

There are some small isolated patches of floodway as well as an area running parallel with the siding. Based on the definition of floodway in the Floodplain Development Manual these areas can be discounted from being considered as floodways as they are not aligned with obvious natural channels or flow paths.

## 4.5 Existing Hydraulic Structures

The Little Creek flood model results identify that the capacity of the existing culvert beneath the adjacent access from Lee Holm Road is exceeded in a 0.5 EY event[2] (2 year ARI) and that overtopping of the access road to the WestBus site occurs in as little as the 0.2 EY event (5 year ARI). Flows through the culvert and over the roadway are shown in Table 4-2. The flow in the culverts is shown to be reduced between the 0.2 EY event and 5% AEP event, and the 1% AEP event and PMF, due to blockage assumptions in the flood model (refer Table 3-1). It is likely that during a flood event the single barrel culverts would experience some blockage and capacity would further reduce as the magnitude of the flood increases.

[2] Flood mapping has not been provided for the 0.5EY event (equivalent of the 2 year ARI event) as it is not required by the project SEARS.

**Table 4-2 – Flow at upstream culverts – pre development**

| | 0.2 EY | 5% AEP | 1% AEP | PMF |
|---|---|---|---|---|
| Flow through culverts | 9.7 | 7.1 | 7.1 | 3.6 |
| Flow over roadway | 8.7 | 17.7 | 25.1 | 98 |

Flows through the railway culvert and over the railway are shown in Table 4-3. Similarly to the upstream culverts, flows through the culvert are reduced in larger flood events due to the greater risk of blockage.

**Table 4-3 – Flow at railway culverts – pre development**

| | 0.2 EY | 5% AEP | 1% AEP | PMF |
|---|---|---|---|---|
| Flow through culverts | 12.1 | 7.0 | 7.2 | 3.6 |
| Flow over railway | 2.6 | 12.7 | 25.9 | 120 |

# 5 POST-DEVELOPMENT FLOOD RISK ASSESSMENT

## 5.1 Proposed Development

The development design was developed through an iterative process to minimise flood impacts and work within the various development constraints. Development proposals fill a portion of the site in order to level the site for the proposed development.

The Stormwater Management Report (B18028-RPT-003 BG&E) describes the internal site drainage for runoff from the proposed site. It is proposed to separate site runoff from the flows making their way through the site from upstream catchments.

The proposed development earthworks, trunk drainage modifications, new trunk drainage and culverts beneath the access road from Lee Holm Road were incorporated into the flood model and run for the range of flood events to assess potential impacts to existing flood behaviour. Mapping is included in Appendix C and discussed in the following sections.

### 5.1.1 Site Runoff

To manage site runoff, it is proposed to provide a pit and pipe network within the proposed roads and hardstand areas to collect and convey runoff from the minor storm events away from roads and hardstand areas as well as proposed structures. This network is proposed to discharge to Little Creek to the north of the proposed hardstand area.

Runoff from the proposed buildings will be collected by gutters and discharged to proposed rainwater collection tanks. These tanks will overflow to the stormwater network outlined above.

In the major storm event the hardstand areas will direct flows in a northerly direction toward Little Creek. The piped network draining the trapped lowpoint in the Forrest Road access road has been designed to cater for the major event. In the event of failure of this system a backup inlet to the proposed trunk drainage line through the site (outlined below) has been provided 0.1 m above the sag point.

The flood modelling has assumed all site runoff will be directed to the watercourse, and therefore the drainage network designed to cater for site runoff only has not been included in the TUFLOW model.

### 5.1.2 Managing Flows from Upstream Catchments

A trunk drainage line is proposed to convey runoff from the upstream catchments through the site. The trunk drainage system will start in the south-east corner of the site, picking up flows discharging from the upstream rail corridor catchment and discharge to Little Creek on the downstream side of the proposed access road to Lee Holm Road. The existing 675 mm diameter pipe is proposed to be retained and connected to this trunk main, with post development flows through this existing pipe to closely match pre development flows.

The trunk drainage has been included in the flood model to allow for the assessment of transfer of upstream flows.

## 5.2 Mitigation Measures

In order to minimise the effect of the development proposal on flood behaviour, the following measures are to be incorporated into the site design:

- The existing 675 mm pipe is to be retained to convey flows from the rail corridor;
- A trunk drainage system will convey additional flows from upstream catchments, including the rail corridor, and 10 and 40 Forrester Road and discharge to Little Creek;
- Cross drainage will be incorporated into the access road design from Lee Holm Road, to discharge flows from a trapped low point on the northern side of the access road towards the creek;
- Where the proposed access from Lee Holm Road crosses Little Creek, the level of the road will be at or lower than the existing access to the Westbus site; and
- The proposed culvert at the site access will be sized to ensure no adverse impacts to upstream flood levels.

## 5.3 Flood Impact Assessment

PCC DCP 2014 requires that "Flood levels are not increased by more than 0.1m by the proposed filling" (Part C3.5,C.14.a,i).

Flood impacts for the 5% AEP, 1% AEP and PMF event are presented in Figure C 16, Figure C 17 and Figure C 20 respectively. Flood impacts are also shown for the 0.5% AEP and 0.2% AEP events which have been used as proxies for climate change assessment as per the requirement of the SEARS (refer Figure C 18 and Figure C 19).

The mapping shows, that for the full range of events assessed there are no significant increases in flood level outside of the land owned by Pacific National, with the exception of a minor increase in the PMF event near the site access from Lee Holm Road. Given the already medium to high hazard flooding in this area, the minor increase in flood levels does not affect flood hazard.

The DCP also requires that "The development will not increase the flood hazard or risk to other properties". A comparison of the hazard mapping for pre and post development, shows there is no change to flood hazard in the vicinity of the site for all design events assessed.

There is a minor increase in velocities where Little Creek spills over the access to the Westbus site and the proposed access. This is likely due to the change in surface levels within the site allowing flow to move more quickly towards the channel and basin. However, the increase does not result in a change in the flood hazard which is already considered as high at this location during the PMF, and Medium Hazard in the 100 year ARI event.

Downstream of the site, there is no significant change in velocities as the railway line culverts and embankment act as a control to flows.

Flows at the upstream culverts and railway culverts under developed conditions are shown in Table 5-1 and Table 5-2. Comparison of Table 4-3 and Table 5-2 (flow at railway culverts) shows there is no significant increase in flows downstream of the development site as a result of the proposed development.

**Table 5-1 – Flow at upstream culverts – post development**

| | 0.2 EY | 5% AEP | 1% AEP | PMF |
|---|---|---|---|---|
| Flow through culverts | 10.6 | 7.1 | 7.1 | 3.2 |
| Flow over roadway | 6.9 | 16.7 | 23.9 | 98 |

**Table 5-2 – Flow at railway culverts – post development**

| | 0.2 EY | 5% AEP | 1% AEP | PMF |
|---|---|---|---|---|
| Flow through culverts | 12.1 | 7.0 | 7.2 | 3.6 |
| Flow over railway | 2.9 | 12.7 | 26.1 | 120 |

## 5.4 Floodway and High Hazard Flows

Council will consider development on land subject to the flood planning provisions of the LEP but will not grant consent to new development in floodways or in high hazard areas.

The development layout has been designed to avoid areas of high hazard flows and floodways. The Little Creek floodway though the site has been maintained (refer Figure B 13 and Figure C 15).

High hazard flows may occur at the access from Lee Holm Road as the road is overtopped by Little Creek. However, raising the road to prevent overtopping would cause impacts upstream and is therefore not feasible. Alternative access is available to Forrester Road, and a site management plan will be developed to ensure that the Lee Holm Road access is closed during overtopping.

## 5.5 Flood Levels and Pad Levels

The proposed development grades up from about 23.9 mAHD at the northern end (earthwork adjacent to the existing basin) to about 30.5 mAHD in the south (refer Figure 5-1).

These levels are above the 1% AEP flood level from Little Creek, and are not expected to be inundated until the Little Creek PMF event (refer mapping in Appendix B and C). In the Little Creek PMF event, flood depths are expected to be shallow (less than 100 mm as shown in Figure C 8) and can be managed through the site.

The peak flood level for a PMF event on South Creek is 26.8 mAHD (refer Table 4-1). Flooding is therefore expect to a maximum of 2.9 mAHD at the northern portion of the site. The PMF flood extent is expected to inundate approximately half of the site as shown in Figure 5-1. Buildings are located on this higher areas of the site, and are typically above the PMF flood level.

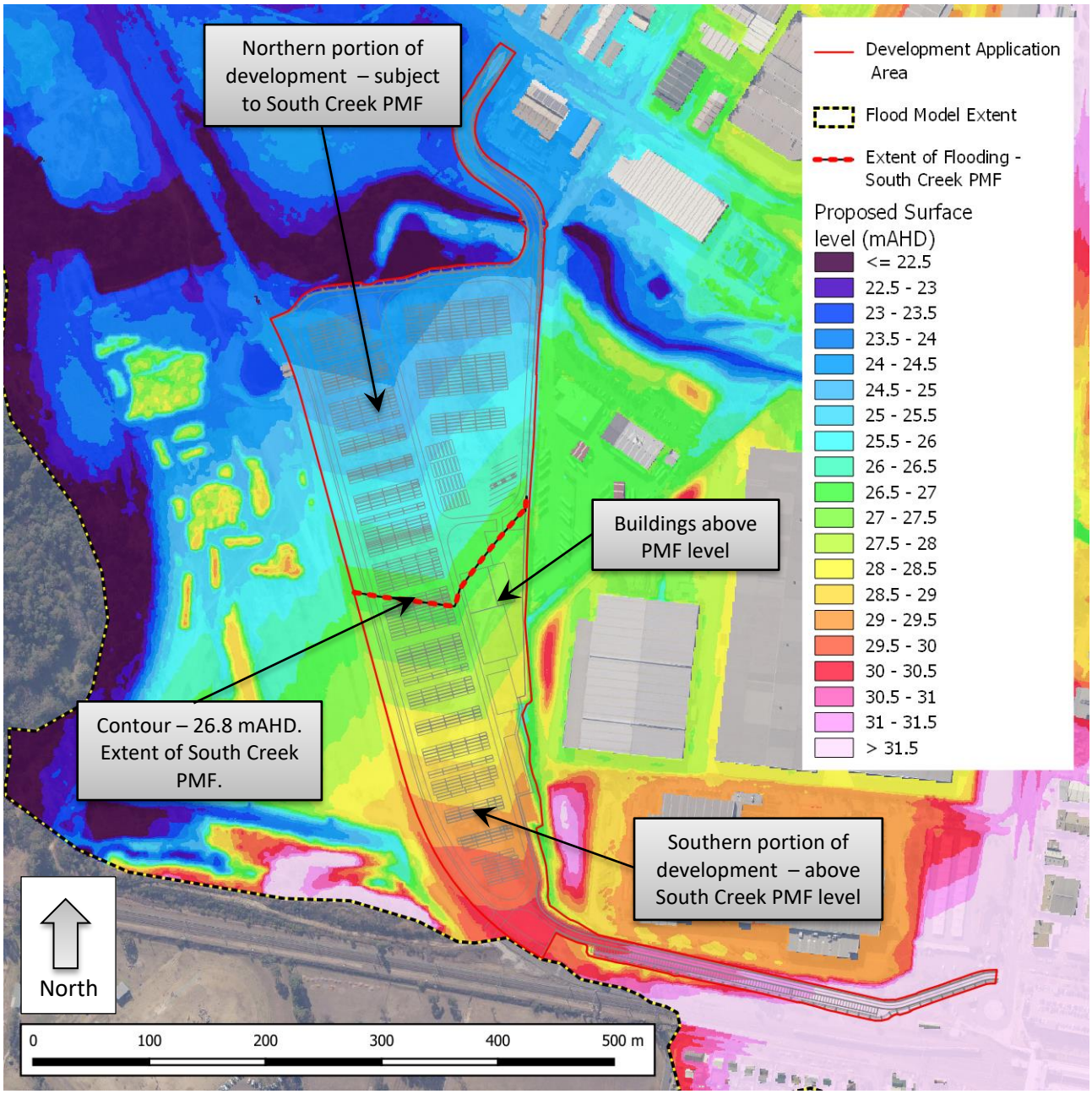


**Figure 5-1 – Proposed Site Surface Levels and South Creek PMF level contour**

## 5.6 Evacuation Planning / Flood Emergency Management

For flooding from Little Creek, a shelter-in-place evacuation may be suitable for the site due to the inundation of the surrounding roads and the short duration flooding expected from Little Creek (2 hour critical storm duration). Although the PMF from South Creek would inundate the lower portion of the site, sufficient area above the South Creek PMF level remains above the flood extent.

The area above the PMF level (for both watercourses) can be used for shelter-in-place until flooding on surrounding roads has subsided and there is safe egress from the property via Forrester Road. Furthermore, building are located on the higher area of the site (refer Figure 5-1) and can provide a location for shelter-in-place during a PMF event.

The South Creek critical storm duration is 36 hours however, flooding on the roadways in the Little Creek sub catchment is likely to have subsided within only a few hours due to the urban flash flooding natures of these overland flows.

As the existing Little Creek culvert at the access from Lee Holm Road is expected to be exceeded in small magnitude events (flood modelling shows culvert capacity is exceeded in a 0.5 EY event). Therefore access to Lee Holm Road will not be available once the culvert capacity is exceeded and the access road is overtopped.

Although there is flooding predicted on the roadways connecting to the site access, flooding in these areas is shown to be low hazard in the 1% AEP event, with the exception of the Forrester Road crossing of Little Creek. The crossing is subject to medium to high hazard flow as Little Creek exceeds the capacity of the crossing and overtops the road. Therefore although access from the site will be available to Forester Road, there is potential that the road will be cut by flood waters. No alternate routes are available as the local roads are constrained by the creek and railway line.

The critical storm duration is 2 hours for flooding from Little Creek and in the local catchments (established from Council's Little Creek Flood Study). As such, flooding of the surrounding roadways (overland flows) is expected to be short duration even when flooding from South Creek may be of a longer duration.

### 5.6.1 Flood Warning

For South Creek, river gauges are located at Mulgoa Road and Great Western Highway. These gauges are maintained by Bureau of Metrology (BoM). Live level data is available for both gauges online: http://www.bom.gov.au/cgi-bin/wrap_fwo.pl?IDN60143.html.

No river level gauges are available for Little Creek. However BoM Weather Watches and Weather Warnings will advise of potential flash-flooding.

### 5.6.2 Shelter-in-Place Recommendation

A shelter-in-place evacuation strategy is recommended to minimise risk and hazard to occupants of the site.

- There is sufficient land available above both the South Creek and Little Creek predicted PMF levels;
- Buildings are located on higher areas of the site and typically above the PMF level;
- Buildings can provide shelter to occupants of the site during flooding of the creeks and local roads.
- Although the PMF duration for South Creek is about 36 hours, the PMF duration for Little Creek is only 2 hours. Therefore flooding on local roads is not expected to be long duration (about 2 hours) and the period of time for which site access is considered unsafe is short (< 2 hours).
- Therefore, shelter-in-place is likely to be no more than 2 hours for access to Forrester Road based on the critical flood event duration.
- Site manager will be responsible for receiving flood warnings for South Creek as well as weather watches and weather warnings for the local area.

It is recommended that a formal flood evacuation and management plan be prepared as part of future design stages.

## 5.7 Climate Change

The 0.5% AEP and 0.2% AEP events have been assessed as proxies for assessing sensitivity to an increase in rainfall due to climate change as per the requirement of the SEARS. Predicted peak flood levels under the

post-development scenario area shown in Figure C 3 and Figure C 4. Within the Little Creek corridor, flood levels increase by 30 mm between the 1% AEP and 0.5% AEP events, and by 100mm between the 1% AEP and 0.2% AEP events.

Mapping shows that with the exception of the access to Lee Holm Road, the 0.5 % AEP and 0.2% AEP events on Little Creek are not expected to inundate the proposed development.

Mapping shows that peak flood levels in Little Creek are expected to be less than 23.9 mAHD in the 0.2% AEP event. The maximum flood level is about 24.9 mAHD as the upstream culverts are overtopped. Development levels are above these levels and therefore not shown to be flood affected, with the exception of the access road from Lee Holm Road which is inundated in small events.

# 7 CONCLUSIONS AND RECOMMENDATIONS

## 7.1 Conclusions

- Flood modelling has only been carried out using the Little Creek flood model (based on advice from Penrith City Council). Flooding from South Creek has not been modelled but has been considered based on flood levels reported in the South Creek Flood Study.
- The *Little Creek Overland Flow Flood Study* flood model has been obtained from Penrith City Council. As this model is adopted by Council for flood planning purposes, no changes have been made to the model parameters and assumptions, including blockage assumption and catchment hydrology.
- Based on Council's flood modelling, the dominant flood mechanism for flooding is flows from Little Creek (up to the 0.2% AEP event). For events of larger magnitude, backwater flooding from South Creek becomes the dominant flood mechanism.
- The proposed development complies with PCC DCP criteria that flood levels (outside of the development application area) are not increased by more than 0.1m by the proposed filling.
- The proposed development is not considered to expose any resident to unacceptable levels of risk or property to unreasonable damage and will not increase flood hazard or risk to other properties.
- A trunk drainage system will convey additional flows from upstream catchments, including the rail corridor, and 10 and 40 Forrester Road and discharge to Little Creek.
- Cross drainage will be incorporated into the access road design from Lee Holm Road, to discharge flows from a trapped low point on the northern side of the access road towards the creek.
- Where the proposed access from Lee Holm Road crosses Little Creek, the level of the road will be at or lower than the existing access to the Westbus site and the proposed culvert at the site access will be sized to ensure no adverse impacts to upstream flood levels.
- The site is not expected to be significantly at risk from a PMF event on Little Creek, however a PMF event on South Creek would inundate approximately half of the development area.
- During a PMF event from South Creek or Little Creek a shelter-in-place strategy will mitigate risk to occupants of the site. Proposed buildings are located above the predicted South Creek and Little Creek PMF levels and provide a location for shelter.
- It is recommend that a formal evacuation management plan be prepared at later stages of the design.

**This Flood Impact Assessment has shown that any increase in flood levels occurring as a result of the proposed development is within the criteria of the PCC DCP and contained within land owned by Pacific National. Flood modelling has been undertaken using PCC's adopted flood model for Little Creek catchment.**

Appendix A

# Penrith City Council Flood Advice

PENRITH

Our reference: ECM 8299143
Contact: Ratnam Thilliyar
Telephone: 4732 7988

30 July 2018

BG & E
Level 2, 8 Windmill Street
SYDNEY NSW 2000

Attention: Ms Laura Baxter

Dear Ms Baxter

**Flood Level Enquiry**
**Lot 2 DP 876781 – Lot 2 Forrester Road St Marys**

Please find enclosed Flood Level information for the above property.

Should you require any further information please do not hesitate to contact me on 4732 7988.

Yours sincerely

Ratnam Thilliyar
**Engineering Stormwater Supervisor**

Penrith City Council
PO Box 60, Penrith
NSW 2751 Australia
T 4732 7777
F 4732 7958
penrithcity.nsw.gov.au

PENRITH

# Flood Information
# Lot 2 DP 876781 - Lot 2 Forrester Road St Marys

## Date of issue: 30 July 2018

The 1%AEP local overland flow flood levels affecting the above property are as indicated in red colour on the attached on the map.

In addition, this locality has also been investigated in regard to flooding from mainstream and the property has been identified as being affected by the 1%AEP mainstream flood.

Property less than 0.5m above the 1% AEP flood level is subject to Penrith Development Control Plan 2014 Section C3.5 Flood Planning. The Penrith Development Control Plan 2014 is available from Council's website www.penrithcity.nsw.gov.au.

**Definitions**

**AEP** – *Annual Exceedance Probability* – the chance of a flood of this size occurring in any one year.

**AHD** – *Australian Height Datum* – A standard level datum used throughout Australia, approximately equivalent to mean sea level.

**Notes:**

1. The contours shown above in yellow numbering are at 0.5m intervals and are based on Aerial Laser Scanning (ALS) Survey undertaken in 2002. The contour levels are approximate and for general information only. Accurate ground levels should be obtained by a Registered Surveyor.
2. The flood level is based on current information available to Council at the date of issue. The flood level may change in the future if new information becomes available. The 1% AEP flood is the flood adopted by Council for planning controls. Rarer and more extreme flood events will have a greater effect on the property.
3. Council's studies are reflected in flood mapping for the City which show properties potentially affected by overland flows in excess of 150mm.
4. This property is shown on Council's flood mapping as potentially so affected.
5. Council imposes flood related development controls where, in its opinion, such controls are justified. Such controls may or may not be imposed with respect to this property in the event of an application for development consent.
6. If a development proposal is submitted with respect to this property, Council will consider the possibility of flood or overland flow in the context of the application. Council may impose a requirement that the applicant for development consent carry out a detailed assessment of the possible overland water flows affecting the property (a flood study) and/or may impose other controls on any development designed to ameliorate flood risk.
7. You are strongly advised if you propose to carry out development upon the property, that you retain the assistance of an experienced flooding engineer and have carried out a detailed investigation.
8. Council accepts no liability for the accuracy of the flood levels (or any other data) contained in this certificate, having regard to the information disclosed in Notes "1" to "4". As such you should carry out and rely upon your own investigations.

Ratnam Thilliyar
**Engineering Stormwater Supervisor**

Penrith City Council
PO Box 60, Penrith
NSW 2751 Australia
T 4732 7777
F 4732 7958
penrithcity.nsw.gov.au


## Lot 2 DP 876781 - Lot 2 Forrester Road St Marys

**Legend**

| | |
|---|---|
| | Extent of 1% AEP local catchment overland flow path. Generally depths less than 150mm is not shown. |

Penrith City Council
PO Box 60, Penrith
NSW 2751 Australia
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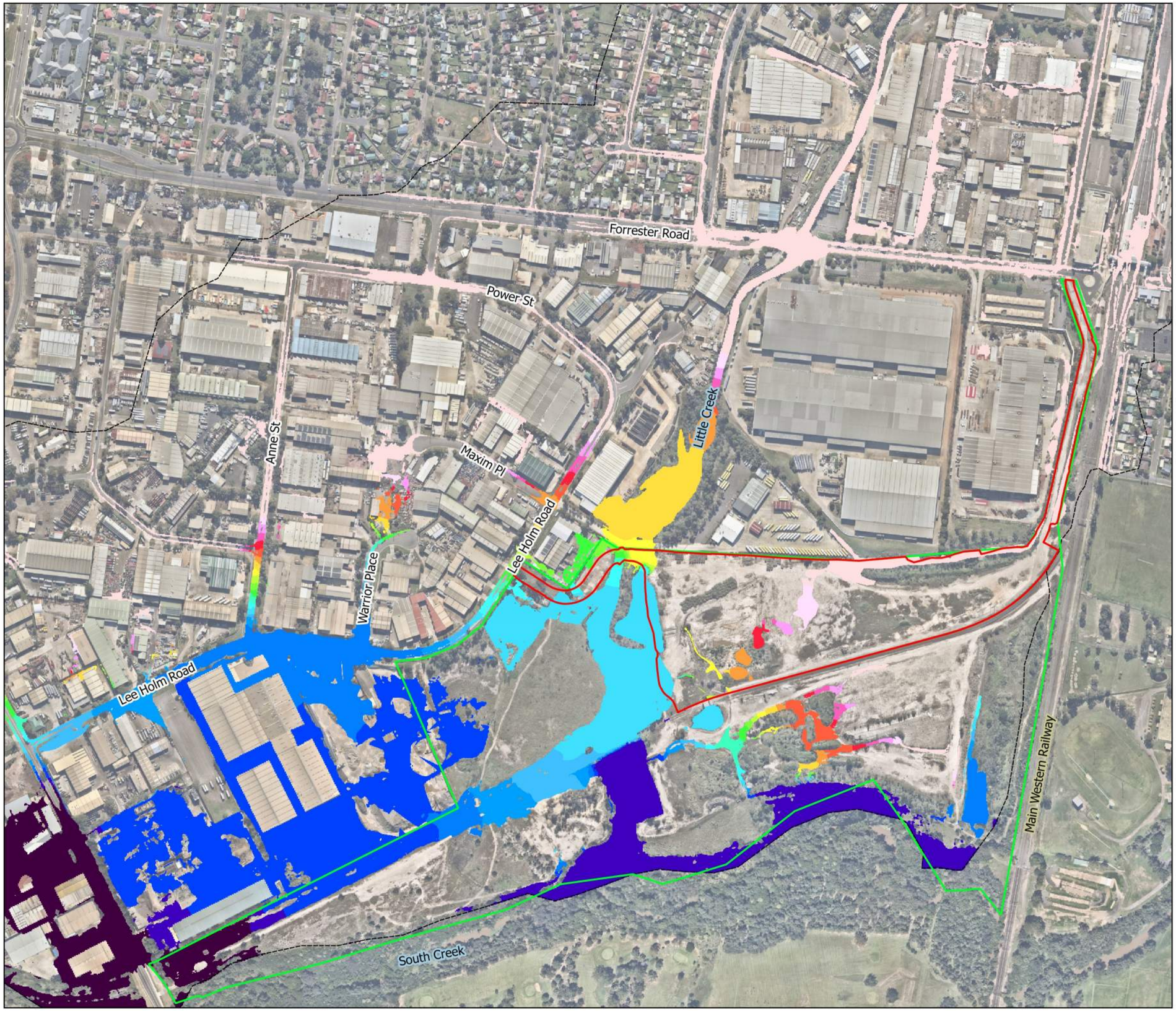
penrithcity.nsw.gov.au

Appendix B

# Flood Mapping – Pre-Development Scenario

Figure B 1 Existing Flood Levels – 5% AEP event
Figure B 2 Existing Flood Levels – 1% AEP event
Figure B 3 Existing Flood Levels – PMF event
Figure B 4 Existing Flood Depths– 5% AEP event
Figure B 5 Existing Flood Depths– 1% AEP event
Figure B 6 Existing Flood Depths – PMF event
Figure B 7 Existing Flood Velocities – 5% AEP event
Figure B 8 Existing Flood Velocities – 1% AEP event
Figure B 9 Existing Flood Velocities – PMF event
Figure B 10 Existing Flood Hazard – 5% AEP event
Figure B 11 Existing Flood Hazard – 1% AEP event
Figure B 12 Existing Flood Hazard – PMF event
Figure B 13 Existing Flood Hydraulic Categories – 1% AEP event




## Legend

- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Flood Level (mAHD)

- <= 22.5
- 22.5 - 22.7
- 22.7 - 22.9
- 22.9 - 23.1
- 23.1 - 23.3
- 23.3 - 23.5
- 23.5 - 23.7
- 23.7 - 23.9
- 23.9 - 24.1
- 24.1 - 24.3
- 24.3 - 24.5
- 24.5 - 24.7
- 24.7 - 24.9
- 24.9 - 25.1
- 25.1 - 25.3
- 25.3 - 25.5
- 25.5 - 25.7
- 25.7 - 25.9
- 25.9 - 26.1
- 26.1 - 26.3
- > 26.3

0 100 200 300 400 m

SCALE 1:5.500

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APPROVED: LB

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PROJECT: B18028
CLIENT: PACIFIC NATIONAL

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Figure B1 -
Existing Flood Levels
5% AEP event

DATUM GDA 1994 MGA Zone 56


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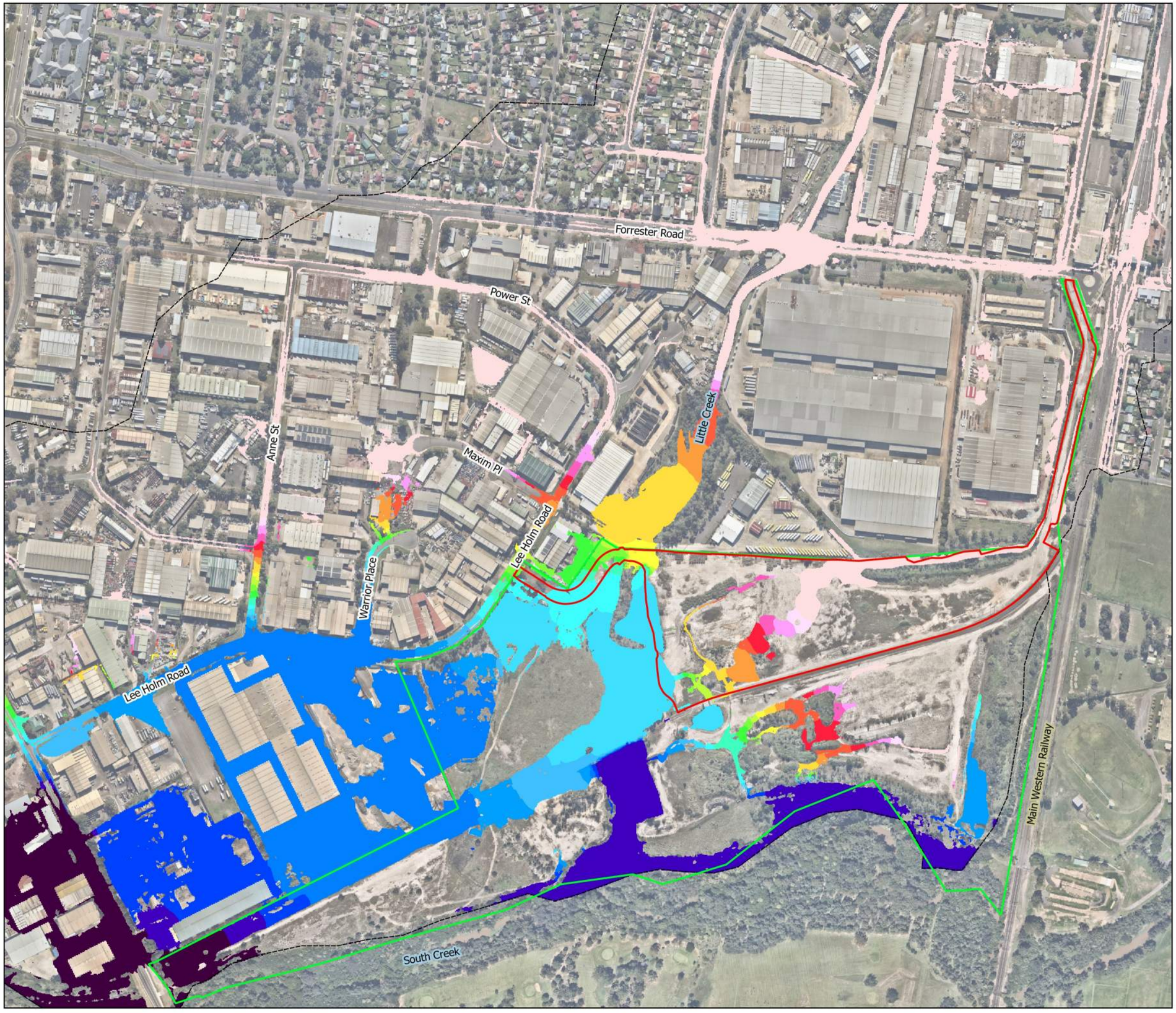
*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*




## Legend

- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Flood Level (mAHD)

- <= 22.5
- 22.5 - 22.7
- 22.7 - 22.9
- 22.9 - 23.1
- 23.1 - 23.3
- 23.3 - 23.5
- 23.5 - 23.7
- 23.7 - 23.9
- 23.9 - 24.1
- 24.1 - 24.3
- 24.3 - 24.5
- 24.5 - 24.7
- 24.7 - 24.9
- 24.9 - 25.1
- 25.1 - 25.3
- 25.3 - 25.5
- 25.5 - 25.7
- 25.7 - 25.9
- 25.9 - 26.1
- 26.1 - 26.3
- > 26.3

0 100 200 300 400 m

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DATE: 5/3/2019
PROJECT: B18028
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Figure B2 -
Existing Flood Levels
1% AEP event

DATUM GDA 1994 MGA Zone 56


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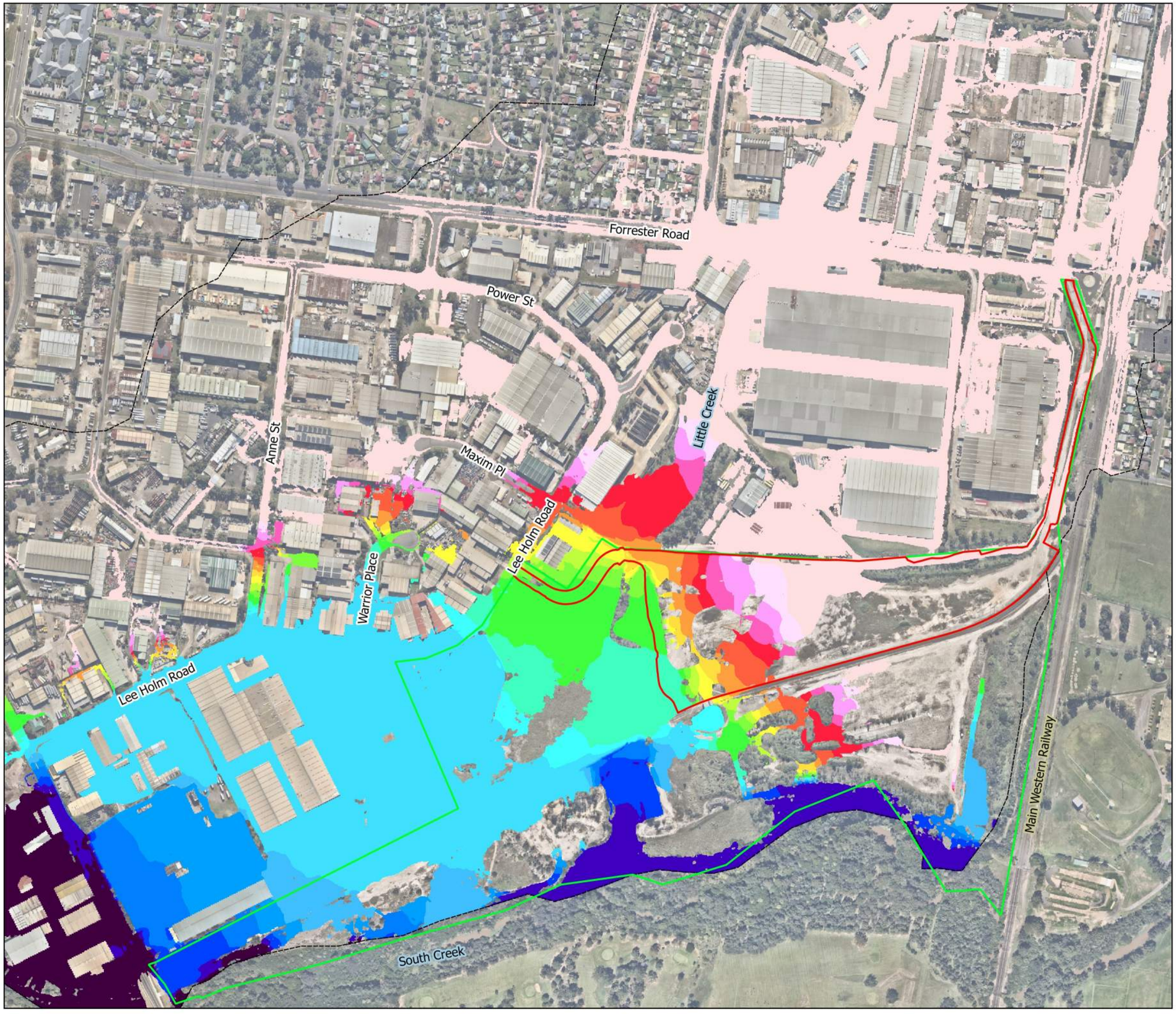
*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*




## Legend

- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Flood Level (mAHD)

- <= 22.5
- 22.5 - 22.7
- 22.7 - 22.9
- 22.9 - 23.1
- 23.1 - 23.3
- 23.3 - 23.5
- 23.5 - 23.7
- 23.7 - 23.9
- 23.9 - 24.1
- 24.1 - 24.3
- 24.3 - 24.5
- 24.5 - 24.7
- 24.7 - 24.9
- 24.9 - 25.1
- 25.1 - 25.3
- 25.3 - 25.5
- 25.5 - 25.7
- 25.7 - 25.9
- 25.9 - 26.1
- 26.1 - 26.3
- > 26.3

0 100 200 300 400 m

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Figure B3 -
Existing Flood Levels
PMF event

DATUM GDA 1994 MGA Zone 56



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*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*


## Legend

- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Depths (m)

- <= 0.05 - Not Shown
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1
- > 1

0 100 200 300 400 m

SCALE 1:5.500

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Figure B4 -
Existing Flood Depths
5% AEP event

DATUM GDA 1994 MGA Zone 56


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*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*


## Legend

- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Depths (m)

- <= 0.05 - Not Shown
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1
- > 1

0 100 200 300 400 m

SCALE 1:5.500

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Figure B5 -
Existing Flood Depths
1% AEP event

DATUM GDA 1994 MGA Zone 56


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*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*


## Legend

- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Depths (m)

- <= 0.05 - Not Shown
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1
- > 1

0 100 200 300 400 m

SCALE 1:5.500

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Figure B6 -
Existing Flood Depths
PMF event

DATUM GDA 1994 MGA Zone 56



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*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*


## Legend

- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Velocity (m/s)

- <= 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

0 100 200 300 400 m

SCALE 1:5.500

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PROJECT: B18028
CLIENT: PACIFIC NATIONAL

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Figure B7 -
Existing Flood Velocities
5% AEP event

DATUM GDA 1994 MGA Zone 56



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*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*


## Legend

- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Velocity (m/s)

- <= 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

0 100 200 300 400 m

SCALE 1:5.500

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APPROVED: LB

DATE: 5/3/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure B8 -
Existing Flood Velocities
1% AEP event

DATUM GDA 1994 MGA Zone 56



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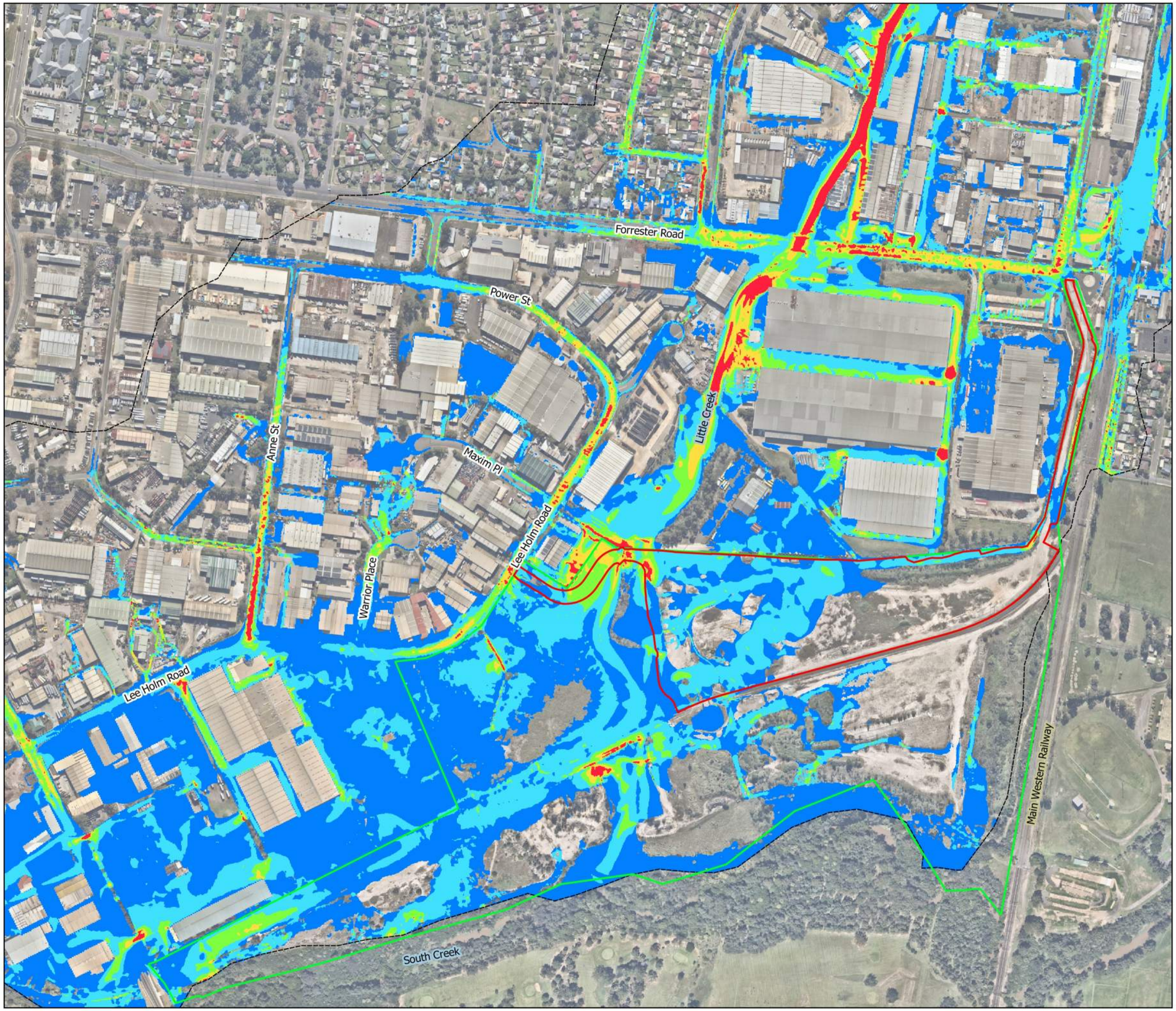
*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*




## Legend

- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Velocity (m/s)

- <= 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

0 100 200 300 400 m

SCALE 1:5.500

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DATE: 5/3/2019
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CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure B9 -
Existing Flood Velocities
PMF event

DATUM GDA 1994 MGA Zone 56


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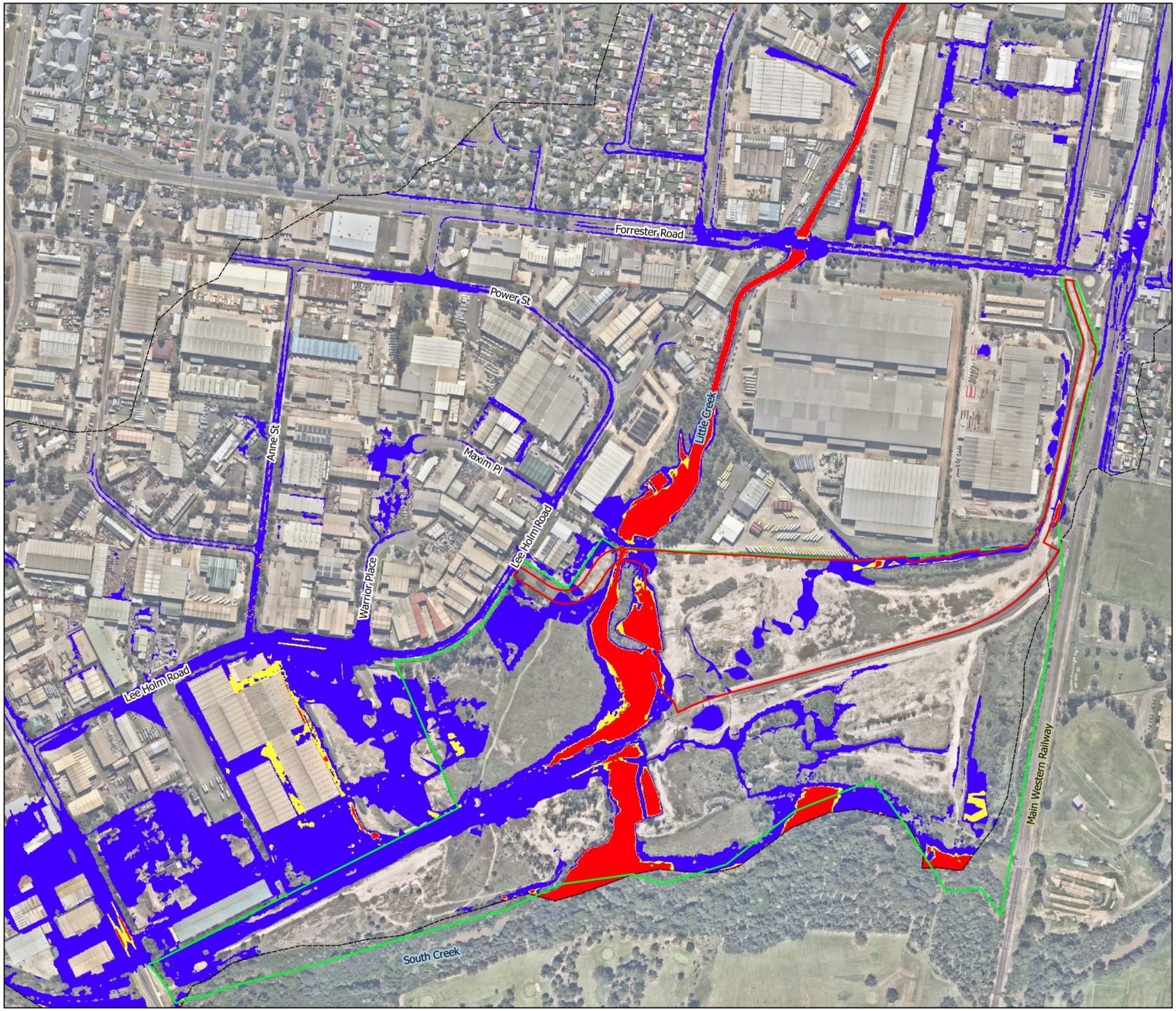
*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*




## Legend

- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Flood Hazard

- Low
- Medium
- High

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 5/3/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure B10 -
Existing Flood Hazard
5% AEP event

DATUM GDA 1994 MGA Zone 56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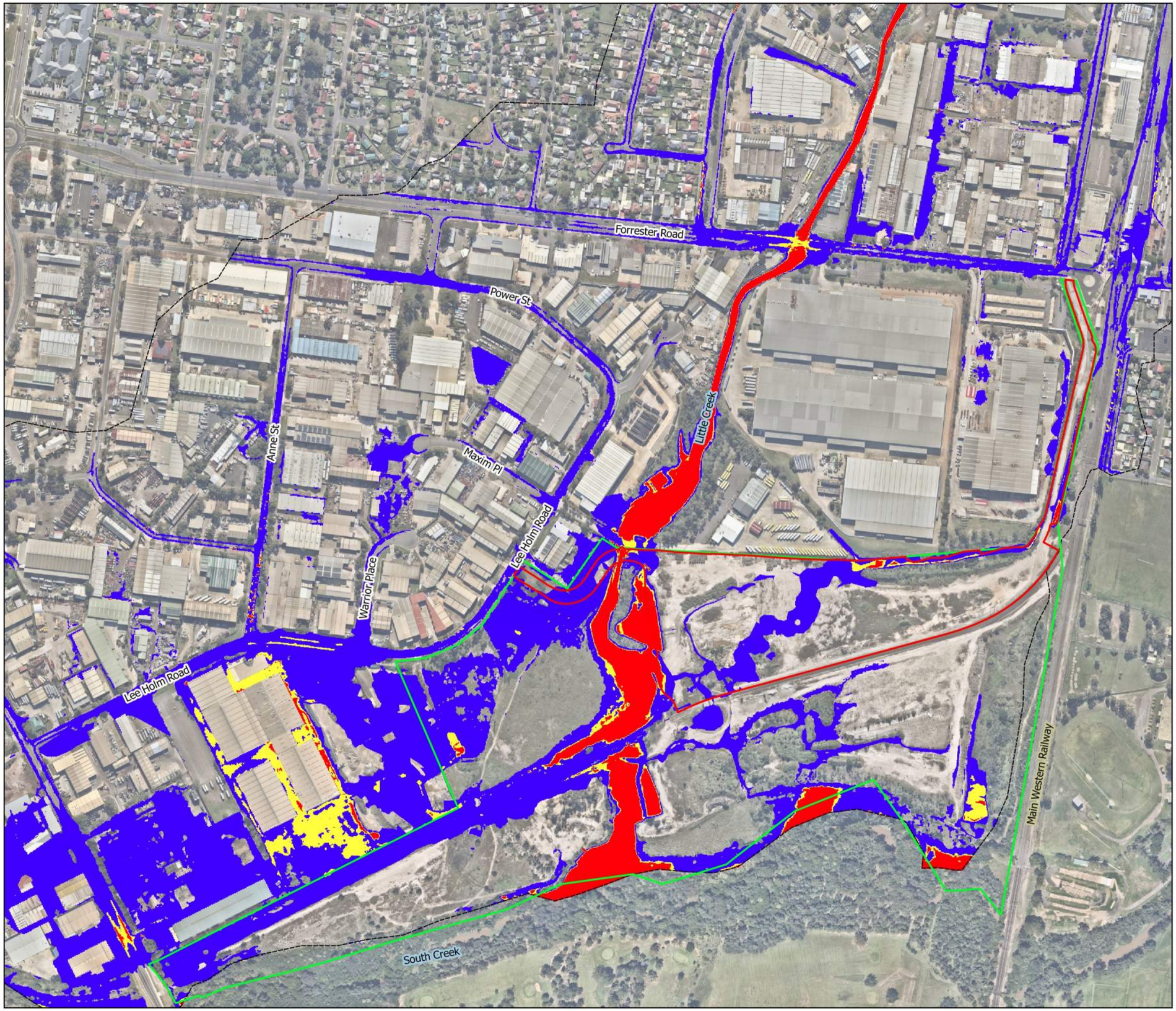
*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*




## Legend

- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Flood Hazard

- Low
- Medium
- High

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 5/3/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

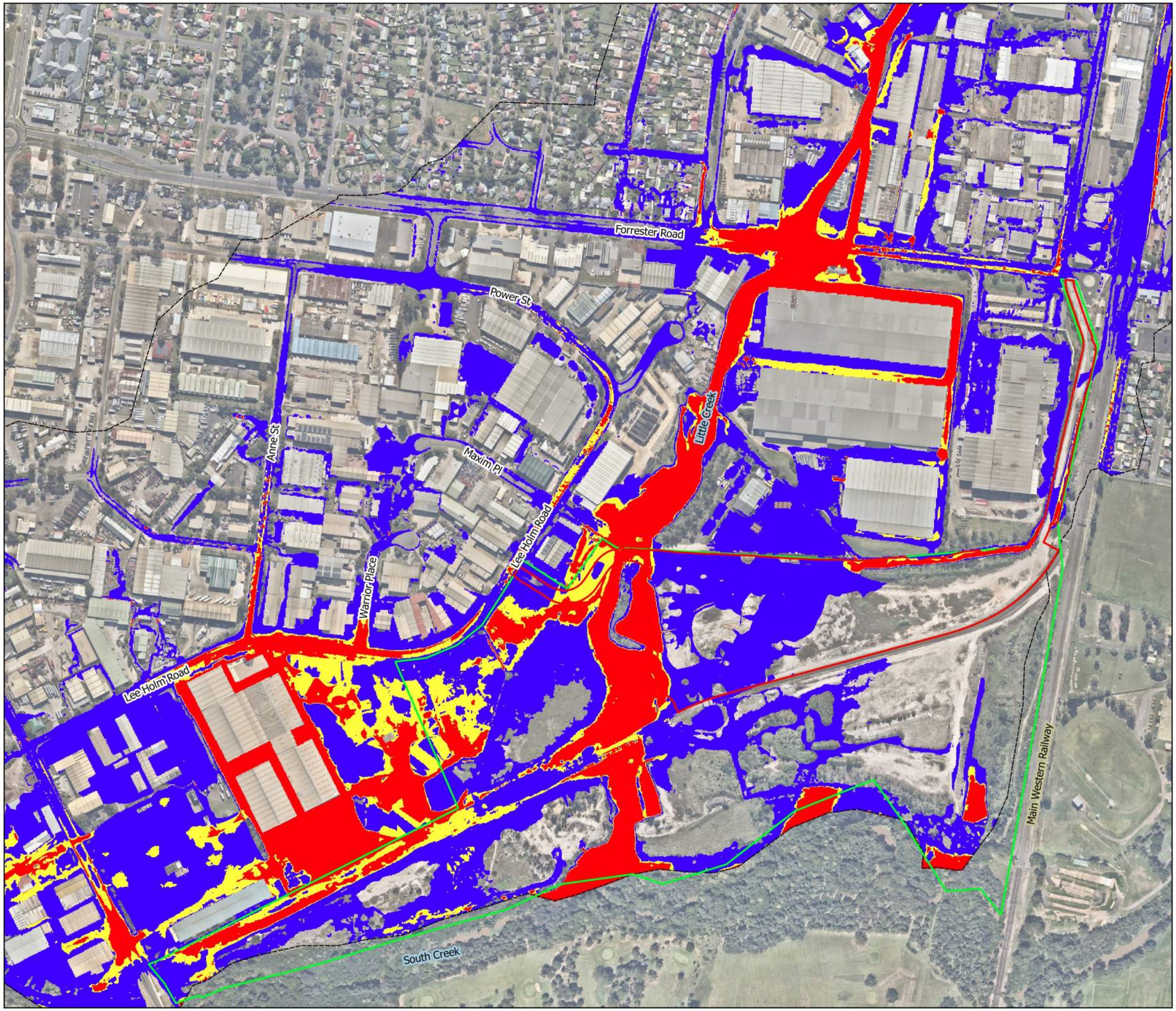
Figure B11 -
Existing Flood Hazard
1% AEP event

DATUM GDA 1994 MGA Zone 56



*P:\BGE\BNE\B18028\220 Calcs\TUFLOW_Qgis\Figures_EX200_DS204_DA_Submission_RevA.qgs*

*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*




## Legend

- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Flood Hazard

- Low
- Medium
- High

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 5/3/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure B12 -
Existing Flood Hazard
PMF event

DATUM GDA 1994 MGA Zone 56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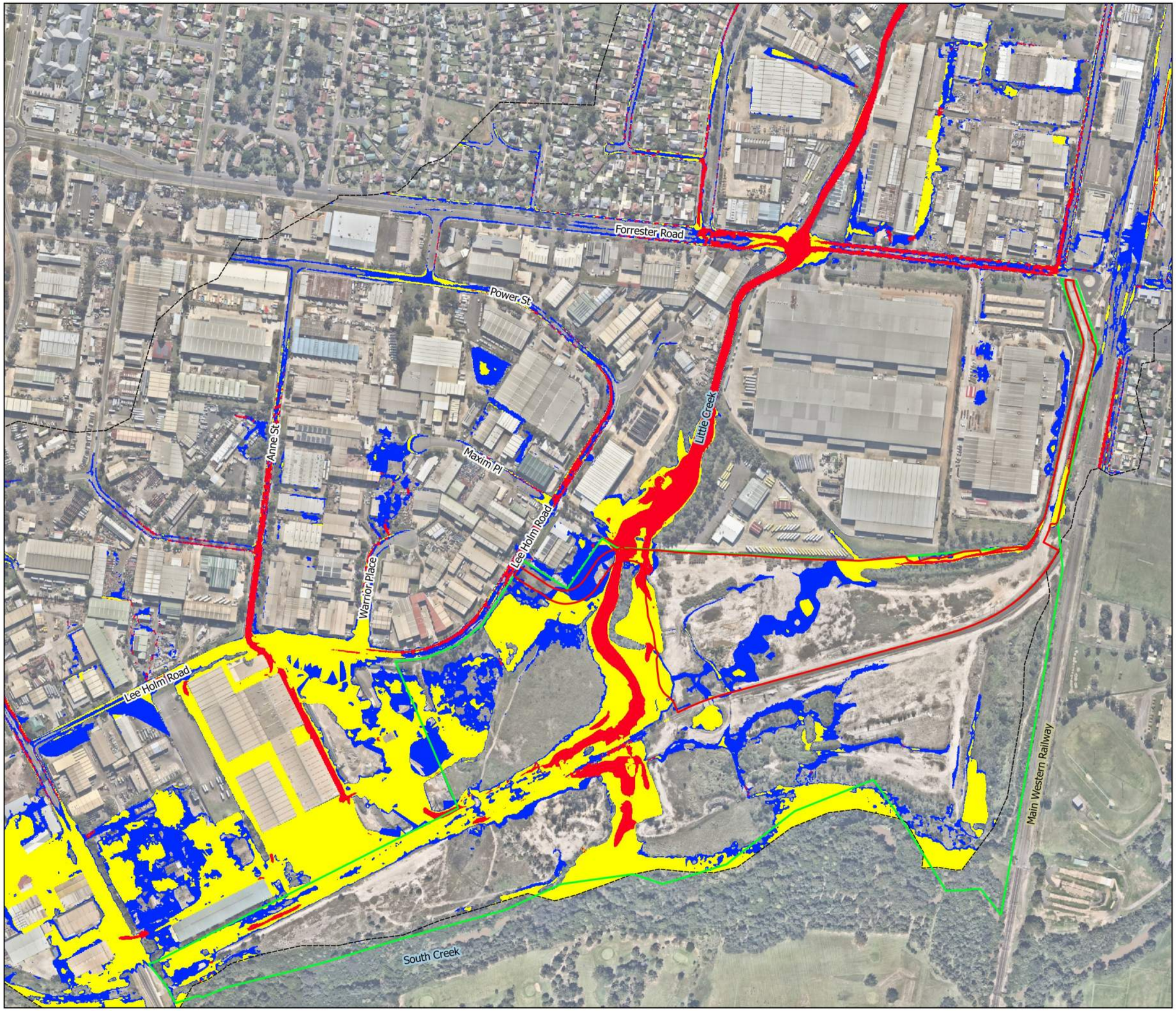
*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*




## Legend

- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

N

DATE: 5/3/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure B13 -
Existing Flood Hydraulic Categories
1% AEP event

DATUM GDA 1994 MGA Zone 56



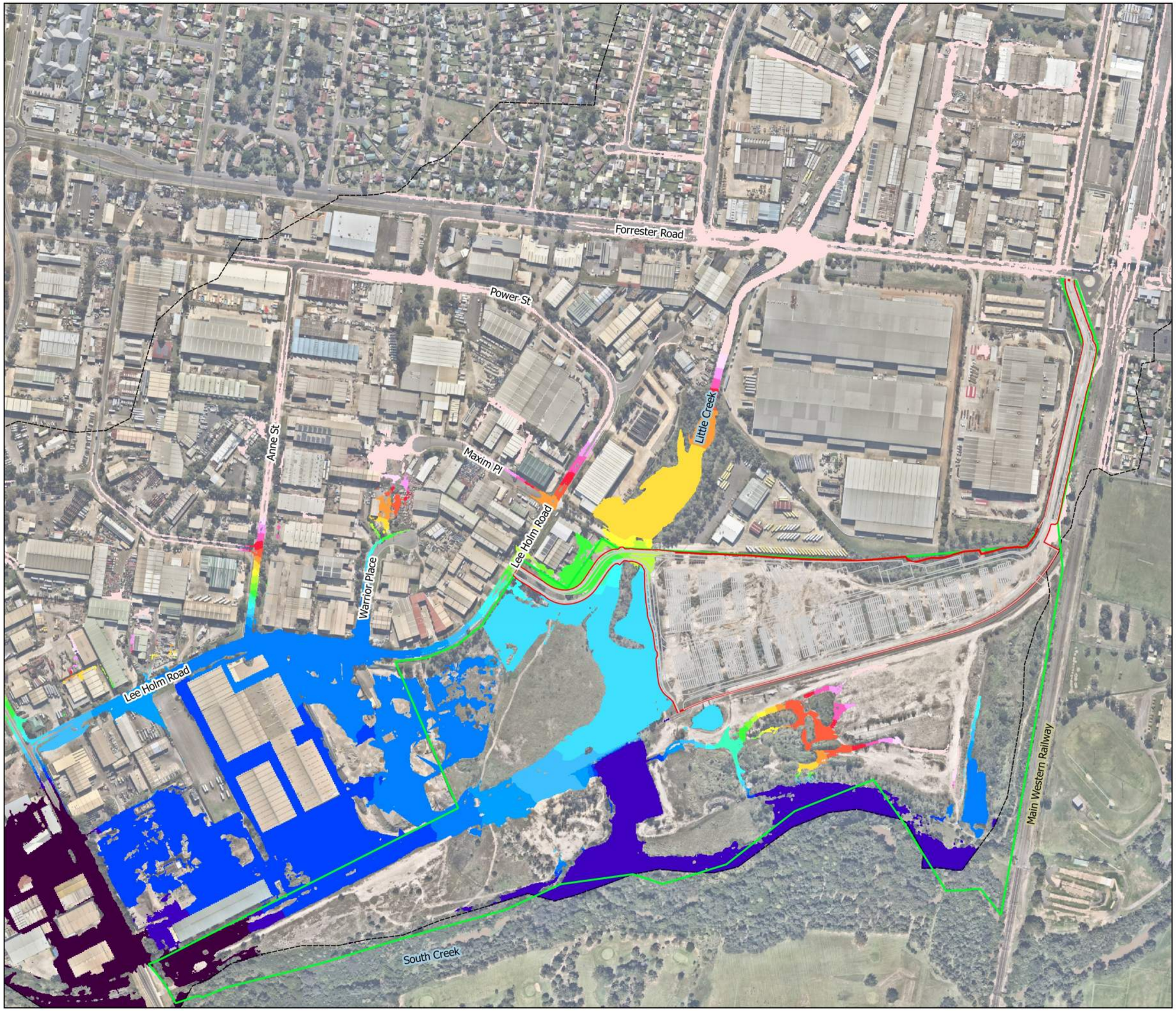
*P:\BGE\BNE\B18028\220 Calcs\TUFLOW_Qgis\Figures_EX200_DS204_DA_Submission_RevA.qgs*

*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*

Appendix C

# Flood Mapping – Post-Development Scenario

Figure C 1 Post Development Flood Levels – 5% AEP event
Figure C 2 Post-Development Flood Levels – 1% AEP event
Figure C 3 Post-Development Flood Levels – 0.5% AEP event
Figure C 4 Post-Development Flood Levels – 0.2% AEP event
Figure C 5 Post-Development Flood Levels – PMF event
Figure C 6 Post Development Flood Depths – 5% AEP event
Figure C 7 Post-Development Flood Depths – 1% AEP event
Figure C 8 Post-Development Flood Depths – PMF event
Figure C 9 Post Development Flood Velocities – 5% AEP event
Figure C 10 Post-Development Flood Velocities – 1% AEP event
Figure C 11 Post-Development Flood Velocities – PMF event
Figure C 12 Post-Development Flood Hazard – 5% AEP event
Figure C 13 Post-Development Flood Hazard – 1% AEP event
Figure C 14 Post-Development Flood Hazard – PMF event
Figure C 15 Post-Development Flood Hydraulic Categories – 1% AEP event
Figure C 16 Post-Development Flood Level Impact – 5% AEP event
Figure C 17 Post-Development Flood Level Impact – 1% AEP event
Figure C 18 Post-Development Flood Level Impact – 0.5% AEP event
Figure C 19 Post-Development Flood Level Impact – 0.2% AEP event
Figure C 20 Post-Development Flood Level Impact – PMF event




## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Flood Level (mAHD)

- <= 22.5
- 22.5 - 22.7
- 22.7 - 22.9
- 22.9 - 23.1
- 23.1 - 23.3
- 23.3 - 23.5
- 23.5 - 23.7
- 23.7 - 23.9
- 23.9 - 24.1
- 24.1 - 24.3
- 24.3 - 24.5
- 24.5 - 24.7
- 24.7 - 24.9
- 24.9 - 25.1
- 25.1 - 25.3
- 25.3 - 25.5
- 25.5 - 25.7
- 25.7 - 25.9
- 25.9 - 26.1
- 26.1 - 26.3
- > 26.3

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure C1 -
Post-Development Flood Levels
5% AEP event

DATUM GDA 1994 MGA Zone 56



P:\BGE\BNE\B18028\220 Calcs\TUFLOW_Qgis\Figures_EX200_DS204_DA_Submission_RevB.qgs

*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*


## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Flood Level (mAHD)

- <= 22.5
- 22.5 - 22.7
- 22.7 - 22.9
- 22.9 - 23.1
- 23.1 - 23.3
- 23.3 - 23.5
- 23.5 - 23.7
- 23.7 - 23.9
- 23.9 - 24.1
- 24.1 - 24.3
- 24.3 - 24.5
- 24.5 - 24.7
- 24.7 - 24.9
- 24.9 - 25.1
- 25.1 - 25.3
- 25.3 - 25.5
- 25.5 - 25.7
- 25.7 - 25.9
- 25.9 - 26.1
- 26.1 - 26.3
- > 26.3

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
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DATE: 16/4/2019
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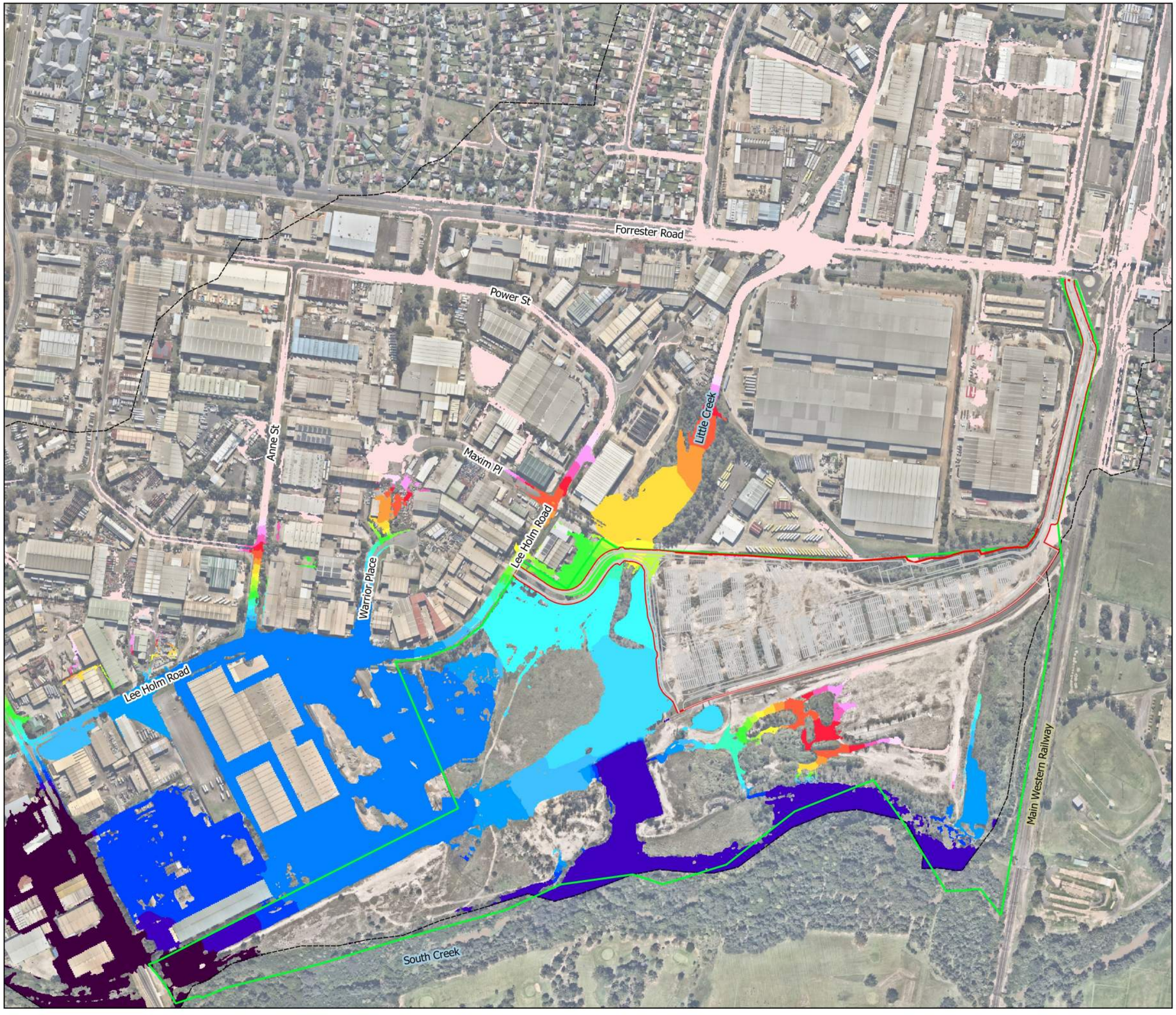
ST MARYS INTERMODAL

Figure C2 -
Post-Development Flood Levels
1% AEP event

DATUM GDA 1994 MGA Zone 56


P:\BGE\BNE\B18028\220 Calcs\TUFLOW_Qgis\Figures_EX200_DS204_DA_Submission_RevB.qgs

*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*




## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Flood Level (mAHD)

- <= 22.5
- 22.5 - 22.7
- 22.7 - 22.9
- 22.9 - 23.1
- 23.1 - 23.3
- 23.3 - 23.5
- 23.5 - 23.7
- 23.7 - 23.9
- 23.9 - 24.1
- 24.1 - 24.3
- 24.3 - 24.5
- 24.5 - 24.7
- 24.7 - 24.9
- 24.9 - 25.1
- 25.1 - 25.3
- 25.3 - 25.5
- 25.5 - 25.7
- 25.7 - 25.9
- 25.9 - 26.1
- 26.1 - 26.3
- > 26.3

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
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APPROVED: LB

DATE: 16/4/2019
PROJECT: B18028
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ST MARYS INTERMODAL

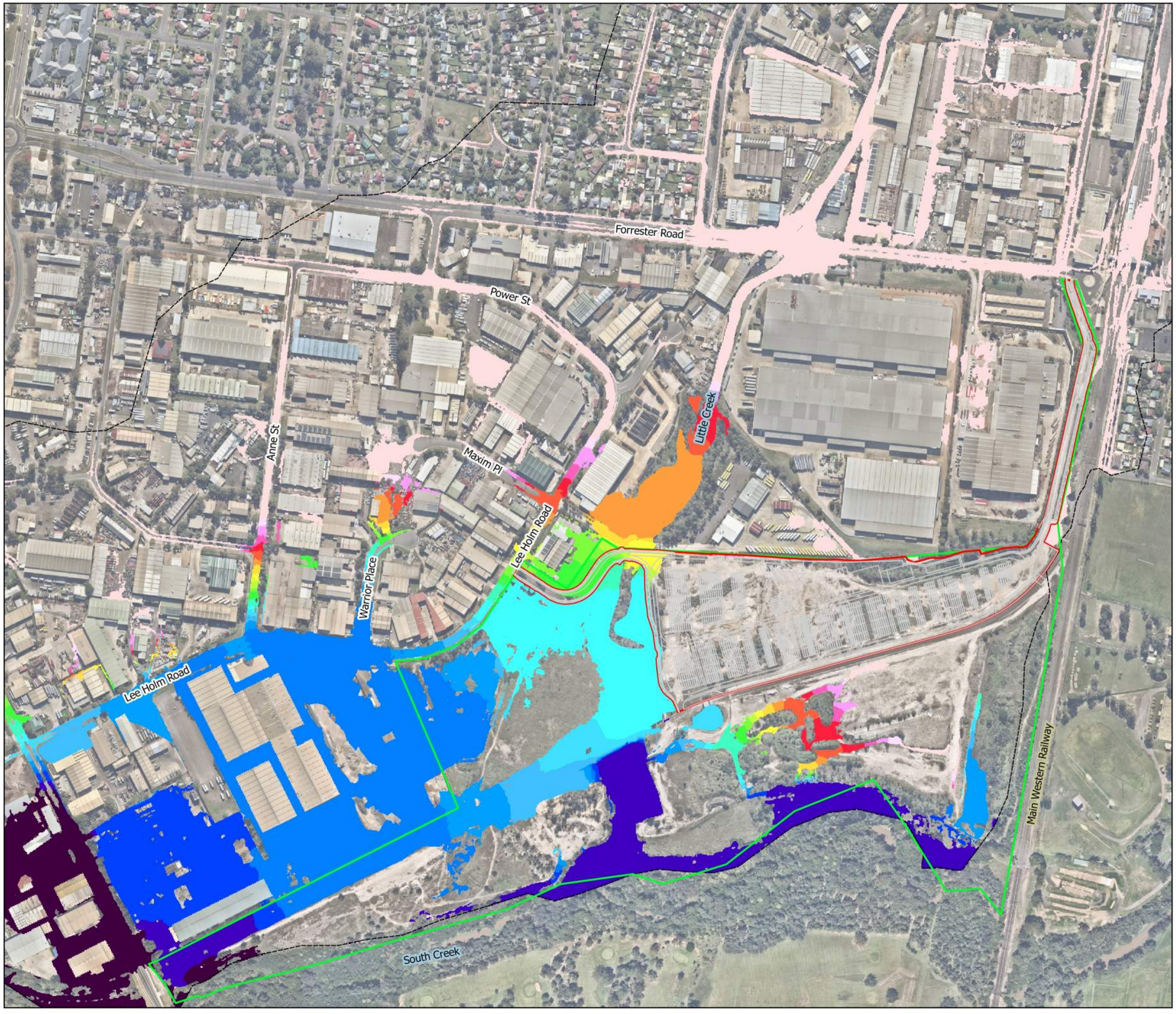
Figure C3 -
Post-Development Flood Levels
0.5% AEP event

DATUM GDA 1994 MGA Zone 56



*P:\BGE\BNE\B18028\220 Calcs\TUFLOW_Qgis\Figures_EX200_DS204_DA_Submission_RevB.qgs*

*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*




## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Flood Level (mAHD)

- <= 22.5
- 22.5 - 22.7
- 22.7 - 22.9
- 22.9 - 23.1
- 23.1 - 23.3
- 23.3 - 23.5
- 23.5 - 23.7
- 23.7 - 23.9
- 23.9 - 24.1
- 24.1 - 24.3
- 24.3 - 24.5
- 24.5 - 24.7
- 24.7 - 24.9
- 24.9 - 25.1
- 25.1 - 25.3
- 25.3 - 25.5
- 25.5 - 25.7
- 25.7 - 25.9
- 25.9 - 26.1
- 26.1 - 26.3
- > 26.3

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

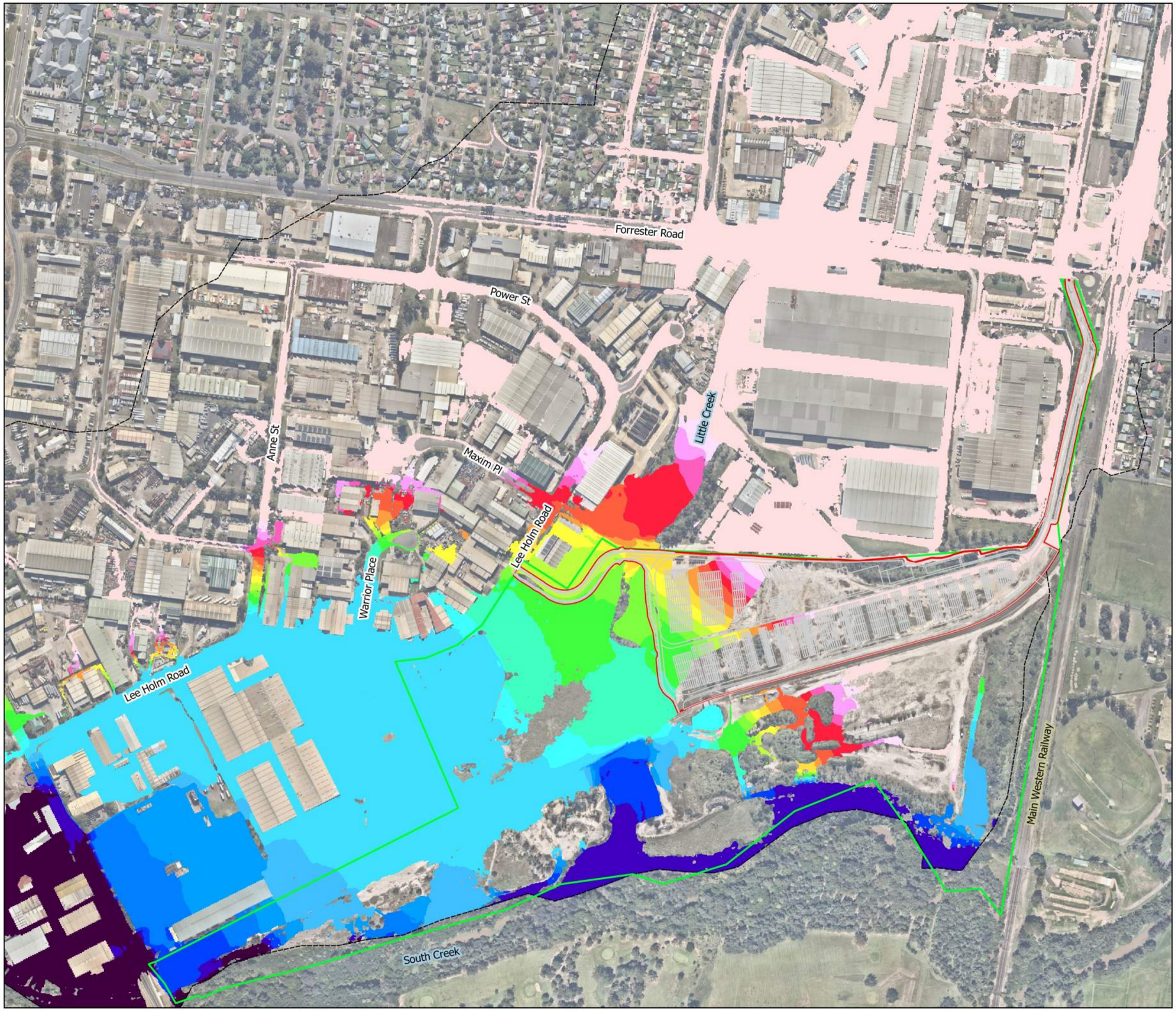
ST MARYS INTERMODAL

Figure C4 -
Post-Development Flood Levels
0.2% AEP event

DATUM GDA 1994 MGA Zone 56


P:\BGE\BNE\B18028\220 Calcs\TUFLOW_Qgis\Figures_EX200_DS204_DA_Submission_RevB.qgs

*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*




## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Flood Level (mAHD)

- <= 22.5
- 22.5 - 22.7
- 22.7 - 22.9
- 22.9 - 23.1
- 23.1 - 23.3
- 23.3 - 23.5
- 23.5 - 23.7
- 23.7 - 23.9
- 23.9 - 24.1
- 24.1 - 24.3
- 24.3 - 24.5
- 24.5 - 24.7
- 24.7 - 24.9
- 24.9 - 25.1
- 25.1 - 25.3
- 25.3 - 25.5
- 25.5 - 25.7
- 25.7 - 25.9
- 25.9 - 26.1
- 26.1 - 26.3
- > 26.3

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure C5 -
Post-Development Flood Levels
PMF event

DATUM GDA 1994 MGA Zone 56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*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*


## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Depths (m)

- <= 0.05 - Not Shown
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1
- > 1

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

N

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure C6 -
Post-Development Flood Depths
5% AEP event

DATUM GDA 1994 MGA Zone 56


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*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*


## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Depths (m)

- <= 0.05 - Not Shown
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1
- > 1

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure C7 -
Post-Development Flood Depths
1% AEP event

DATUM GDA 1994 MGA Zone 56


P:\BGE\BNE\B18028\220 Calcs\TUFLOW_Qgis\Figures_EX200_DS204_DA_Submission_RevB.qgs

*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*


## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Depths (m)

- <= 0.05 - Not Shown
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1
- > 1

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure C8 -
Post-Development Flood Depths
PMF event

DATUM GDA 1994 MGA Zone 56



*P:\BGE\BNE\B18028\220 Calcs\TUFLOW_Qgis\Figures_EX200_DS204_DA_Submission_RevB.qgs*

*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*


## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Velocity (m/s)

- <= 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

N

ST MARYS INTERMODAL

Figure C9 -
Post-Development Flood Velocities
5% AEP event

DATUM GDA 1994 MGA Zone 56


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*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*


## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Velocity (m/s)

- <= 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

N

ST MARYS INTERMODAL

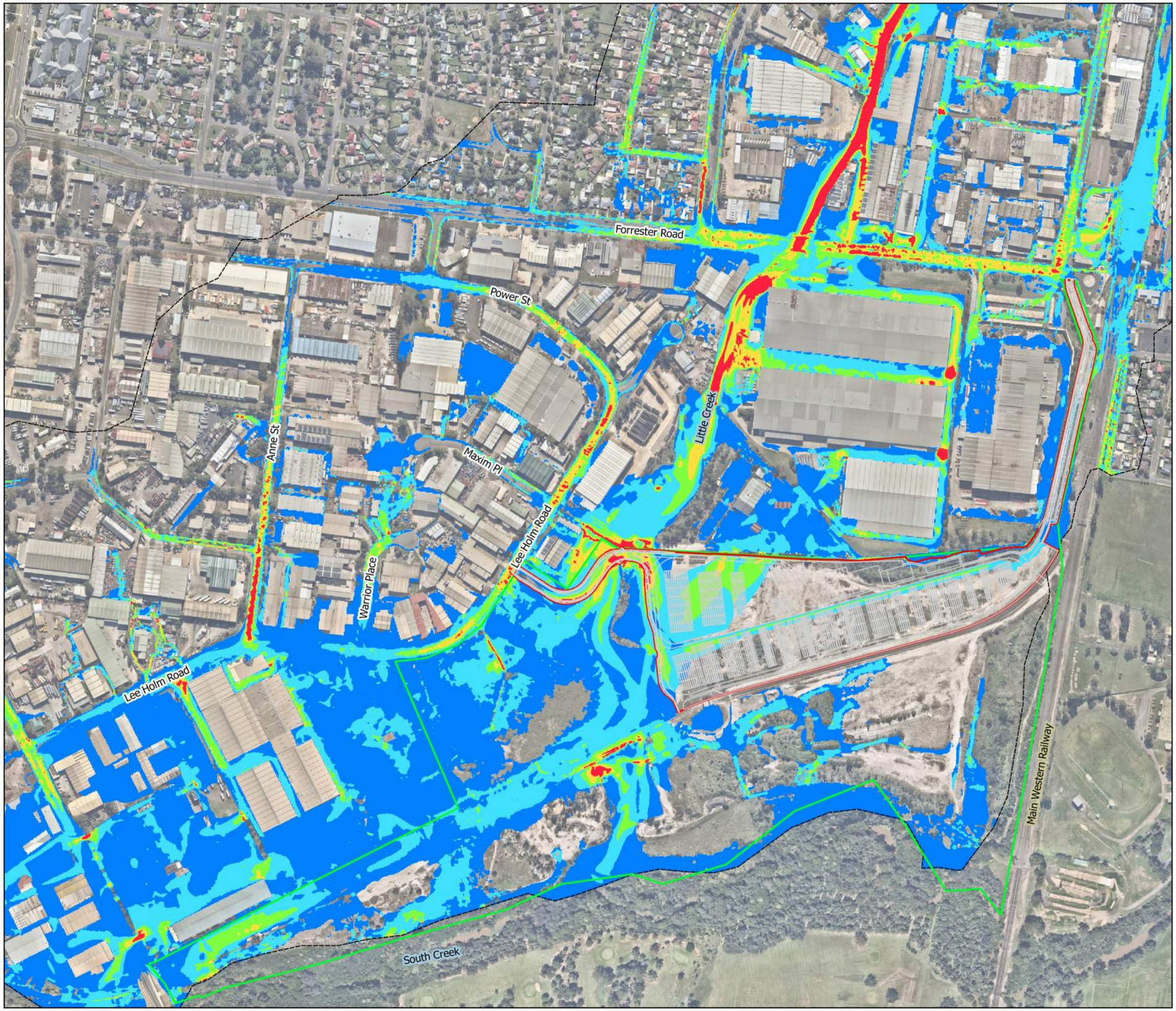
Figure C10 -
Post-Development Flood Velocities
1% AEP event

DATUM GDA 1994 MGA Zone 56



*P:\BGE\BNE\B18028\220 Calcs\TUFLOW_Qgis\Figures_EX200_DS204_DA_Submission_RevB.qgs*

*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*




## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Velocity (m/s)

- <= 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

N

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure C11 -
Post-Development Flood Velocities
PMF event

DATUM GDA 1994 MGA Zone 56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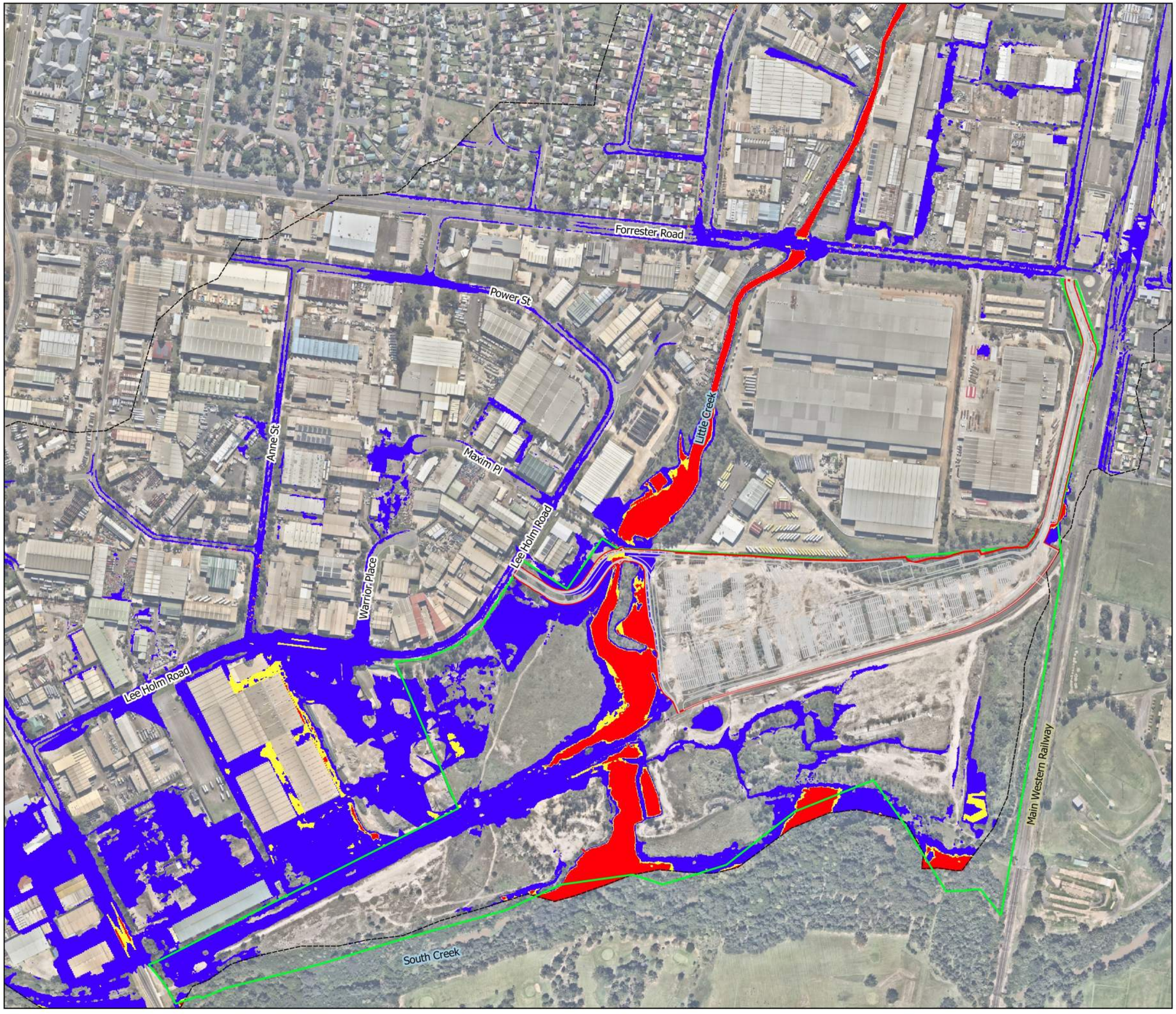
*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*




## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Flood Hazard

- Low
- Medium
- High

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

N

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure C12 -
Post-Development Flood Hazard
5% AEP event

DATUM GDA 1994 MGA Zone 56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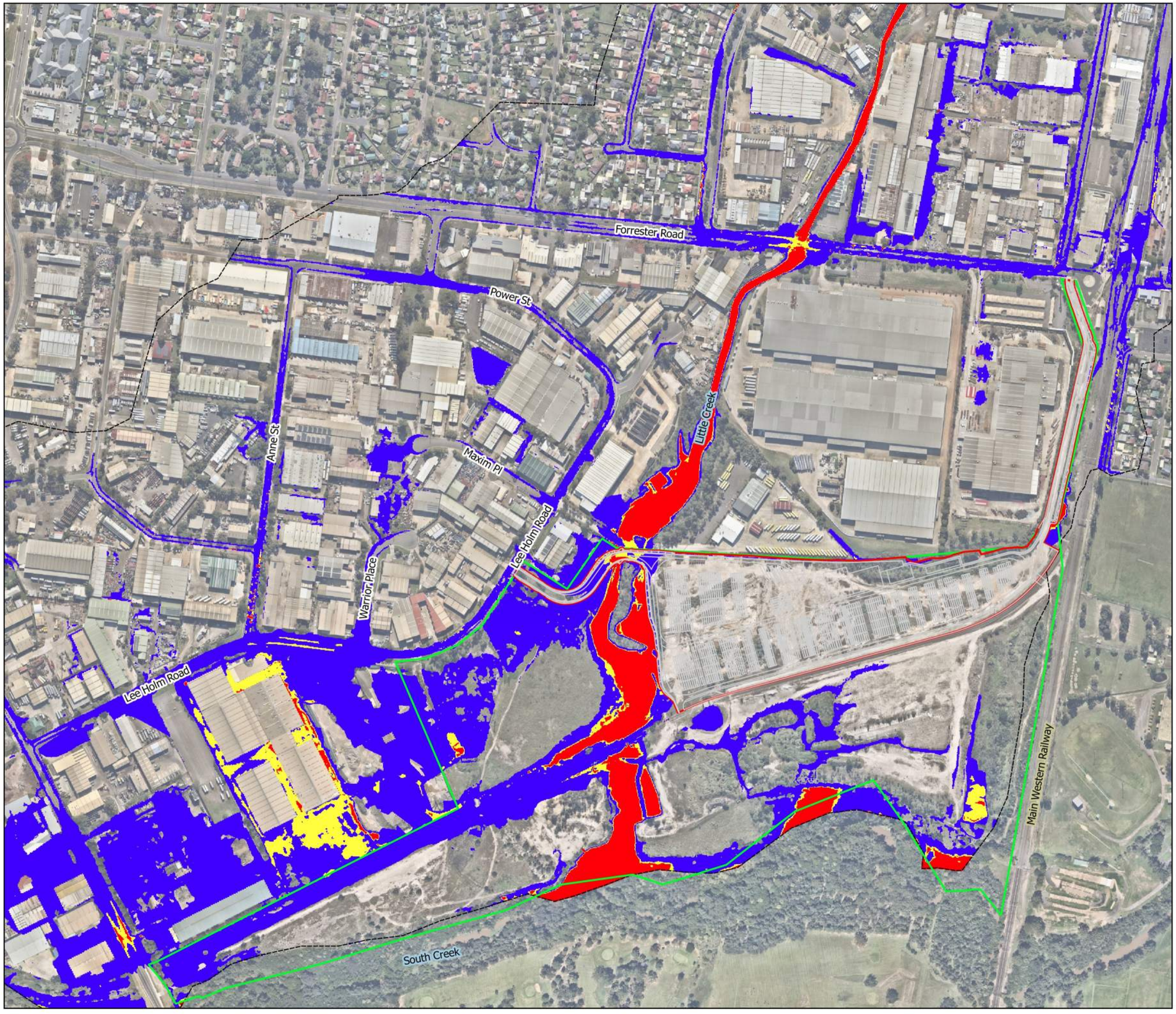
*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*




## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Flood Hazard

- Low
- Medium
- High

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

N

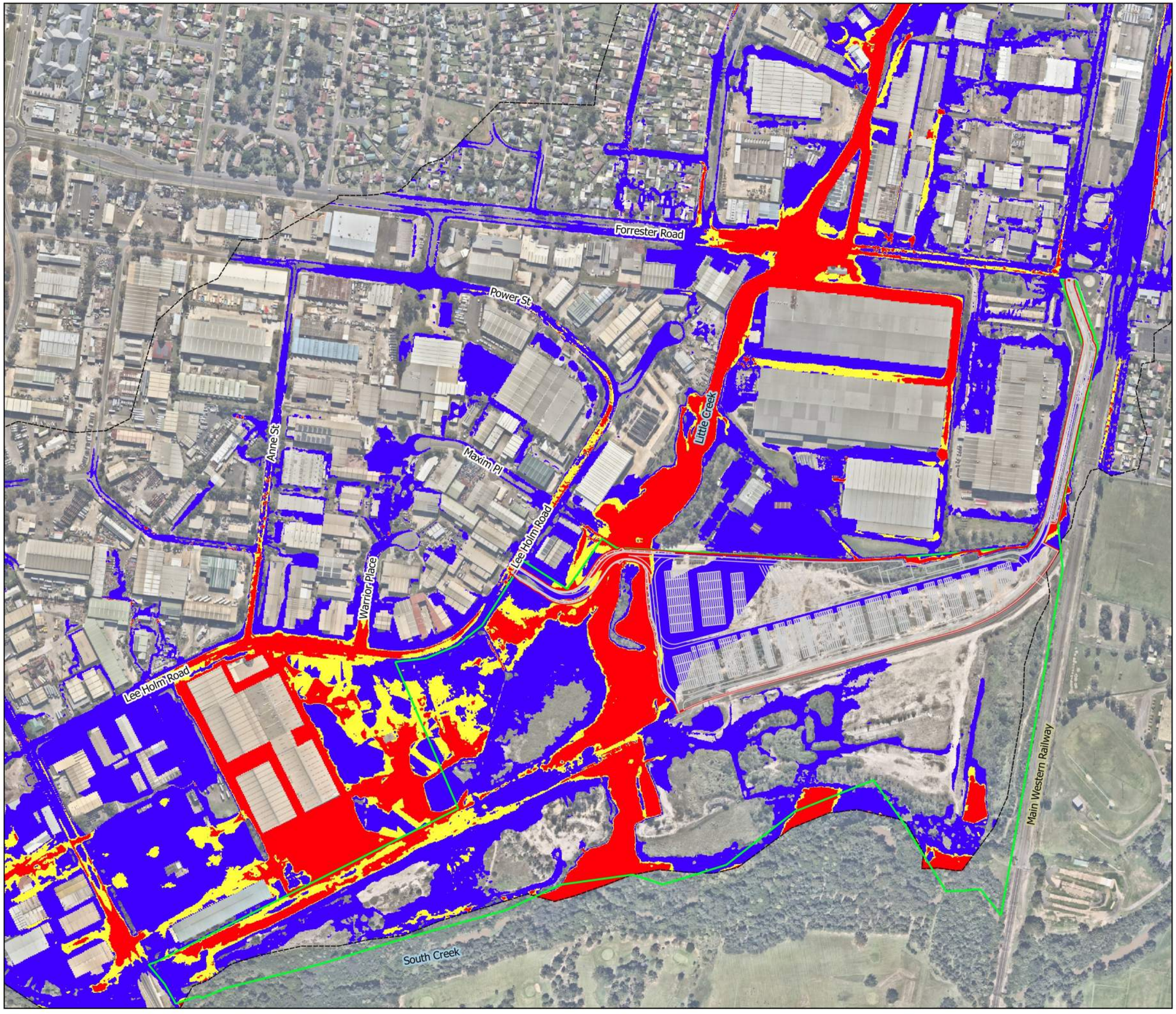
ST MARYS INTERMODAL

Figure C13 -
Post-Development Flood Hazard
1% AEP event

DATUM GDA 1994 MGA Zone 56


P:\BGE\BNE\B18028\220 Calcs\TUFLOW_Qgis\Figures_EX200_DS204_DA_Submission_RevB.qgs

*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*




## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Flood Hazard

- Low
- Medium
- High

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

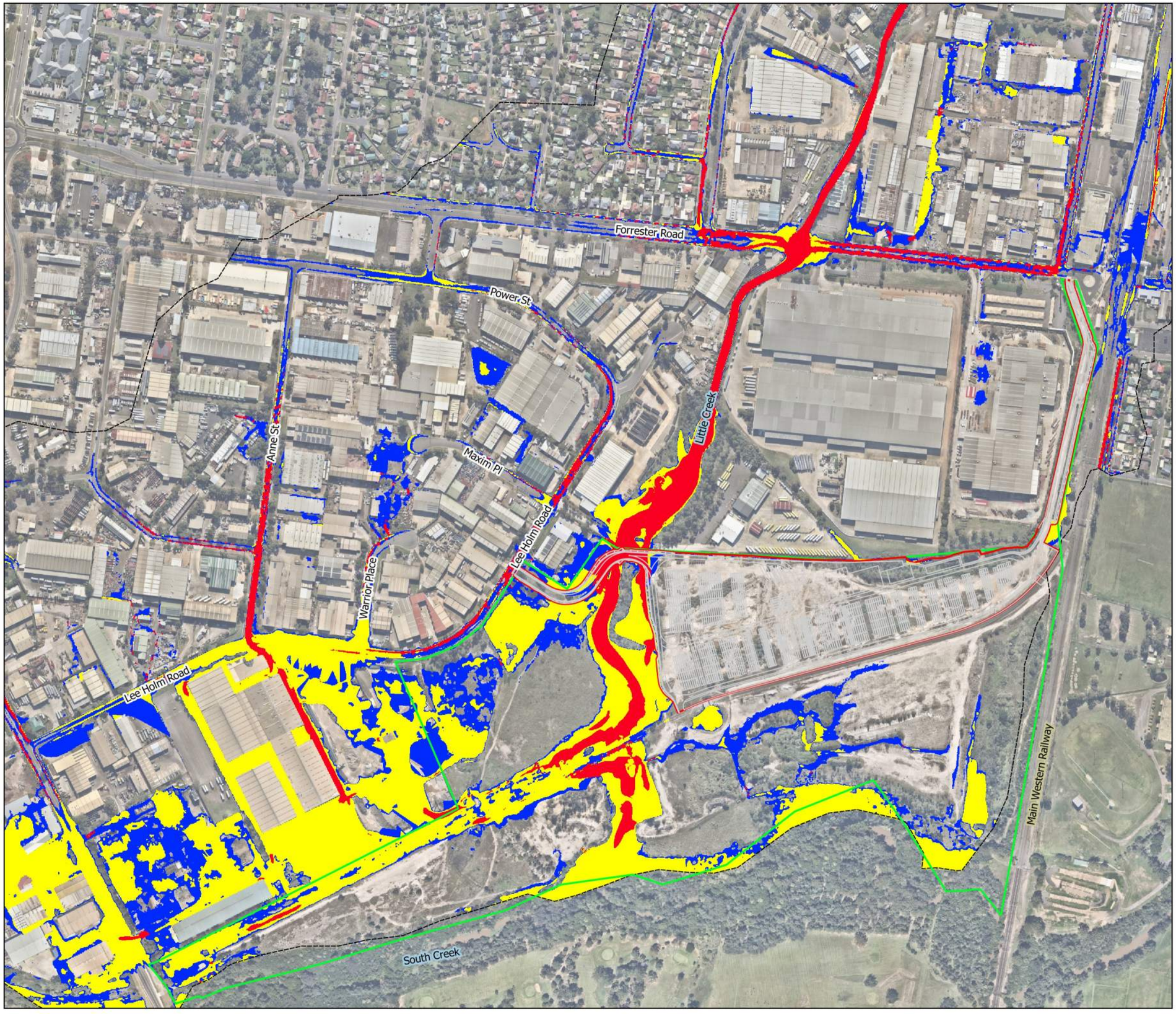
ST MARYS INTERMODAL

Figure C14 -
Post-Development Flood Hazard
PMF event

DATUM GDA 1994 MGA Zone 56


P:\BGE\BNE\B18028\220 Calcs\TUFLOW_Qgis\Figures_EX200_DS204_DA_Submission_RevB.qgs

*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*




## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure C15 -
Post-Development Flood Hydraulic Categories
1% AEP event

DATUM GDA 1994 MGA Zone 56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*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*


## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Post-Development Less Existing Water Level Difference (m)

- <= -0.35
- -0.35 - -0.3
- -0.3 - -0.25
- -0.25 - -0.2
- -0.2 - -0.15
- -0.15 - -0.1
- No Significant Impact (+/- 0.1)
- 0.1 - 0.15
- 0.15 - 0.2
- 0.2 - 0.25
- 0.25 - 0.3
- 0.3 - 0.35
- > 0.35
- Was Wet - Now Dry
- Was Dry - Now Wet

PCC DCP 2014, C3 Water Management Control 3.5.c.14.a.i requires that "Flood levels are not increased by more than 0.1m by the proposed filling".

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
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ST MARYS INTERMODAL

Figure C16 -
Post-Development Flood Level Impact
5% AEP event

DATUM GDA 1994 MGA Zone 56


P:\BGE\BNE\B18028\220 Calcs\TUFLOW_Qgis\Figures_EX200_DS204_DA_Submission_RevB.qgs

*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*


## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Post-Development Less Existing Water Level Difference (m)

- <= -0.35
- -0.35 - -0.3
- -0.3 - -0.25
- -0.25 - -0.2
- -0.2 - -0.15
- -0.15 - -0.1
- No Significant Impact (+/- 0.1)
- 0.1 - 0.15
- 0.15 - 0.2
- 0.2 - 0.25
- 0.25 - 0.3
- 0.3 - 0.35
- > 0.35
- Was Wet - Now Dry
- Was Dry - Now Wet

PCC DCP 2014, C3 Water Management Control 3.5.c.14.a.i requires that "Flood levels are not increased by more than 0.1m by the proposed filling".

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure C17 -
Post-Development Flood Level Impact
1% AEP event

DATUM GDA 1994 MGA Zone 56


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*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*


## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Post-Development Less Existing Water Level Difference (m)

- <= -0.35
- -0.35 - -0.3
- -0.3 - -0.25
- -0.25 - -0.2
- -0.2 - -0.15
- -0.15 - -0.1
- No Significant Impact (+/- 0.1)
- 0.1 - 0.15
- 0.15 - 0.2
- 0.2 - 0.25
- 0.25 - 0.3
- 0.3 - 0.35
- > 0.35
- Was Wet - Now Dry
- Was Dry - Now Wet

PCC DCP 2014, C3 Water Management Control 3.5.c.14.a.i requires that "Flood levels are not increased by more than 0.1m by the proposed filling".

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure C18 -
Post-Development Flood Level Impact
0.5% AEP event

DATUM GDA 1994 MGA Zone 56


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*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*


## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Post-Development Less Existing Water Level Difference (m)

- <= -0.35
- -0.35 - -0.3
- -0.3 - -0.25
- -0.25 - -0.2
- -0.2 - -0.15
- -0.15 - -0.1
- No Significant Impact (+/- 0.1)
- 0.1 - 0.15
- 0.15 - 0.2
- 0.2 - 0.25
- 0.25 - 0.3
- 0.3 - 0.35
- > 0.35
- Was Wet - Now Dry
- Was Dry - Now Wet

PCC DCP 2014, C3 Water Management Control 3.5.c.14.a.i requires that "Flood levels are not increased by more than 0.1m by the proposed filling".

0 100 200 300 400 m

SCALE 1:5.500

DRAWN: BO
REVIEWED: LB
APPROVED: LB

DATE: 16/4/2019
PROJECT: B18028
CLIENT: PACIFIC NATIONAL

ST MARYS INTERMODAL

Figure C19 -
Post-Development Flood Level Impact
0.2% AEP event

DATUM GDA 1994 MGA Zone 56


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*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Background map sourced from LPI - Six Maps.*


## Legend

- Development Layout
- Development Application Area
- Pacific National Land
- Little Creek flood model extent

Post-Development Less Existing Water Level Difference (m)

- <= -0.35
- -0.35 - -0.3
- -0.3 - -0.25
- -0.25 - -0.2
- -0.2 - -0.15
- -0.15 - -0.1
- No Significant Impact (+/- 0.1)
- 0.1 - 0.15
- 0.15 - 0.2
- 0.2 - 0.25
- 0.25 - 0.3
- 0.3 - 0.35
- > 0.35
- Was Wet - Now Dry
- Was Dry - Now Wet

PCC DCP 2014, C3 Water Management Control 3.5.c.14.a.i requires that "Flood levels are not increased by more than 0.1m by the proposed filling".

0 100 200 300 400 m

SCALE 1:5.500

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APPROVED: LB

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ST MARYS INTERMODAL

Figure C20 -
Post-Development Flood Level Impact
PMF event

DATUM GDA 1994 MGA Zone 56


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*Depths less than 50 mm removed from flood extents. Flood modelling results for Little Creek catchment shown only. Flooding from South Creek is not shown. Backaround map sourced from LPI - Six Maps.*