Our Ref: 59916196:BCP/bcp
Contact: Dr Brett C. Phillips

13th April 2018

The Development Manager
Mirvac Masterplanned Communities
Level 26, 60 Margaret Street
SYDNEY NSW 2000

Attention: Adam Perrott

Dear Arian,

UPDATE OF FLOOD IMPACT ASSESSMENT FOR MIRVAC DEVELOPMENT, NEWBRIDGE ROAD, MOOREBANK

Cardno has been requested to assess the flood impacts of the planned modification of the Georges Cove marina development (former Benedict's Sand and Gravel site) at Lot 7 DP 1065574, Newbridge Road, Moorebank. This assessment has been prepared to accompany a Planning Proposal to be submitted to Liverpool City Council.

1. BACKGROUND

1.1 Georges River Hydraulic Model Context

In 2012 Cardno prepared a detailed two-dimensional flood model of the Georges River floodplain in Moorebank within the Liverpool City Council Local Government Area (LGA). The model extended from upstream of the Newbridge Road crossing to downstream of the Western Highway crossing. The purpose of the model was to undertake a flood impact assessment of the proposed Georges Cove Marina development.

The establishment of the Georges River model for the Moorebank area is detailed in the report *Flood Impact Assessment for the Proposed Georges Cove Marina, Moorebank* (Cardno, dated 30 October 2014). This hydraulic model of the Georges River has been reviewed in detail by Liverpool City Council. The 20 year ARI and 100 year ARI events were established for the floodplain with the 36 hour duration event being critical for the floodplain based on flows extracted from the MIKE-11 models which were prepared as part of the 2004 *Georges River Flood Risk Management Study*.

1.2 Moorebank Cove

The Moorebank Cove site is a residential Mirvac development site lying on the portion of the elevated former Benedict's Sand and Gravel site at Newbridge Road, Moorebank. The site adjoins the Georges Cove site immediately to the south, with both sites being part of the same cadastral lot.

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The development of the site has been divided into a number of stages, with the following Development Applications previously submitted to Liverpool City Council:

- DA for Georges Cove site: A number of design iterations of the Georges Cove Marina site were prepared and submitted to Council, the first being prepared in October 2012. Cardno prepared a number of flood impact assessments for the Georges Cove site with impacts documented within a number of addendum reports, the last dated 3 August 2015.
- DA 1558/2006B – Site access bridge from Brickmakers Drive: A previous DA was submitted and approved by Liverpool Council for a 32 metre span bridge connecting Brickmakers Drive to the Moorebank Cove site and crossing over the access road to the Moorebank Recyclers site. The flood modelling of this bridge was incorporated in a Flood Impact Assessment Report dated 23 May 2014 (Cardno, 2014).
- DA 510/2016 for the initial works in the Moorebank Cove development site: The initial development of the Moorebank Cove site involved landform works on the elevated portions of the site, including a proposed retaining wall to be constructed along the western edge of the site. No flood impact assessments were prepared as part of the original DA, however in response to objections by neighbouring land owners during exhibition, a flood impact assessment was prepared for the retaining wall structure. The details of this assessment are summarised in the report dated 15 July 2016; *Flood Impact Assessment for Retaining Wall Construction, Moorebank Cove Development, Newbridge Road, Moore*bank (Cardno, 2016a)

DA 24/2017 is for the first residential development of the site as defined within the Plan of Works drawings prepared by JMD Development Consultants on behalf of Mirvac (drawings 14005E6-RevA, dated 15 June 2016). The following changes to the approved retaining wall works were proposed:

- Re-grading of the site to include local roads within the site. The majority of re-grading is proposed on the elevated portions of the site outside of the floodplain;
- Extension of the retaining wall on the western edge of the site from that proposed in DA 510/2016;
- Extension of the raised development platform to the south-west. This includes a temporary driveway connecting the two site at a grade of 1V: 6H.
- The north-eastern landscaped areas of the Georges Cove are to be raised to an elevation of 1.6m AHD to facilitate raingardens to service the Moorebank Cove development site.

The details of this assessment are summarised in the report dated 4 August 2016; *Flood Impact Assessment Stage 2 DA for Moorebank Cove Site, Newbridge Road, Moorebank* (Cardno, 2016b).

1.3 Planning Proposal

Cardno has been requested to assess the flood impacts of the planned modification of the Georges Cove marina development and the Moorebank Cove development in the following terms:

> Mirvac are currently in the process of preparing a planning proposal for the Marina.
>
> The preliminary model includes the finished ground surface of the entire site (Lot 7) including the marina, residential subdivision and B6 land. JMD have completed preliminary compensatory storage calculations based on this model compared to the base model. The base model was created following instructions from Mark Tooker (npc). Preliminary calculations show that the flood storage is balanced when the marina, B6 and residential subdivision are all combined.

Key points to note are:

- The whole site has been modelling including the B6 land to the north in order to achieve the target compensatory storage.
- The B6 land to the north will be developed into a commercial / residential complex. The model adopts an estimated floor level of below ground carpark which will be allowed to flood (refer **Attachment B**).

The residential/commercial portion of the marina is proposed to sit on piers. The area contains a "tanked" carpark starting a RL3.6 m (refer Attachment A – Drawings SK_001, SK_002, SK_008, SK_013, SK_014, SK_015 and SK_018).

2. ASSESSMENT SCENARIO

2.1 Benchmark Scenario

The benchmark scenario model used to inform this assessment of the Planning Proposal includes:

- The approved post-development scenario of the Georges Cove Marina site as modelled within the report dated 3 August 2015. The approved Georges Cove site included:
  - A large marina located in the middle of the site with an assumed an invert level of -3.5m AHD for the marina;
  - A series of wetlands with a finished level of 0.6m AHD, and vegetated areas with a finished level of 1.9 m AHD located along the eastern side of the site located within the 40m buffer zone of the Georges River;
  - A portion of landscaped area in the north-west corner of the site raised to 4.6 m AHD;
  - A proposed 6 storey building on the western side of the site with car parking on the ground floor at 6.3m AHD with a portion of the building suspended above a 1.65 m AHD finished ground level at the southern end; and
  - A car park located on the southern side of the site with a ground level of at 1.65 m AHD.
- As per advice from Liverpool City Council as part of the original flood study for Georges Cove Marina (30 October 2012) the future finished levels of the Flower Power site, to the east of the Moorebank Cove site has been modelled at 6.3 m AHD in the benchmark scenario.
- The approved access bridge design has been accounted for in the benchmark scenario as modelled within the assessment dated 23 May 2014. The latest access bridge design includes a bridge abutment to the west of the bridge and a 32 metre span that passes over the existing access road to the Moorebank Recyclers site.

While these conditions may not represent the site and its surrounds under its existing state, all of the above conditions reflect site conditions that are expected prior to the development and that have been assessed to have negligible impact on existing flood behaviour and previously approved by Liverpool City Council.

2.2 Post-development Scenario

The modelling of the Planning Proposal landform was based on a post-development design of the Moorebank Cove site received from JMD on behalf of Mirvac on 23 January 2018. The extent of the landform was guided by advice received from JMD on 23 January 2018.

The revised post-development Digital Elevation Model (DEM) is shown in **Figure 1**.

The major differences between the DEMs of benchmark conditions and the Planning Proposal are:

(i) The residential/commercial portion of the marina is proposed to sit on piers. The area contains a "tanked" carpark starting a RL3.6 m (refer Attachment A – Drawings SK_001, SK_002, SK_008, SK_013, SK_014, SK_015 and SK_018). The proposed ground level beneath the suspended car park is 1.65 m AHD creating a 1.95 m high void under the complete footprint of the car park (refer Drawing SK_002 in Attachment A). It is proposed that the car park be supported by 750 mm x 750 mm square columns at 7.5 m spacings. In comparison under benchmark conditions the southern half of this development was elevated above the 100 yr ARI flood level while the northern half of the development was located on fill; and

(ii) The B6 land to the north will be developed into a commercial / residential complex. The model adopts an estimated floor level of below ground carpark which will be allowed to flood in a 20 yr ARI event (refer **Attachment B**).

3. FLOOD IMPACT ASSESSMENT

The approach adopted to the representation of the key features of the development were as follows:

(i) The void beneath the elevated car park was represented in the 2D domain using the "layered flow method". Hydraulic losses were represented by a form loss which reflects the proposed dimensions and spacing of the columns;

(ii) The proposed boat storage facility located south of the elevated car park (refer "3" on Drawing SK_001 in Attachment A) was represented as a high roughness zone with a hydraulic roughness value of 0.08;

(iii) While the level of the B6 land in the northeastern corner has been lowered it has also been modelled with a high roughness (0.12) which represents the planned building development.

The hydraulic model was run for the 20 year and 100 year ARI events. The model results are summarised in the following sections.

3.1 Flood Behaviour

The estimated 20 yr ARI flood levels, depths and velocities under the Planning Proposal are plotted in **Figures 2, 3** and **4** respectively.

The estimated 100 yr ARI flood levels, depths and velocities under the Planning Proposal are plotted in **Figures 5, 6** and **7** respectively.

3.2 Water Level Impacts

The estimated flood level differences under the Planning are plotted in in **Figures 8** and **9** for the 20yr ARI and 100yr ARI respectively.

In both the 20 yr ARI and 100yr ARI flood it was assessed that the Planning Proposal has nil adverse impact on water levels (less than 0.01 m) at any location in the floodplain in comparison to the benchmark conditions. Therefore the Planning Proposal results in no water level impacts off-site.

3.3 Velocity Impacts

The estimated velocity differences under the Planning Proposal are plotted in in **Figures 10** and **11** for the 20yr ARI and 100yr ARI respectively.

In both the 20yr and 100yr ARI events the velocity impacts are modest west of the northern section of the elevated car park. This is because under benchmark conditions this area was filled and under the Planning Proposal this area is re-established as a flowpath (as existed prior to any development on the site). Notwithstanding these local changes in velocity the overall velocity remains much lower than 1 m/s and consequently does not pose a scour risk.

3.4 Flood Storage

The change in 100 yr ARI flood storage as a result of the works proposed under the Planning Proposal was also assessed. The 100 yr ARI flood storage under the Benchmark Scenario (refer Section 2.1) was estimated to be 499,200 m^3. The 100 yr ARI flood storage under the Post-development Scenario (refer Section 2.2) was estimated to be 521,800 m^3. This calculation accounted for the volume of floodwaters displaced by the proposed suspended car park and the columns which will support the car park.

It is concluded that the Planning Proposal would increase the 100 yr ARI flood storage by 22,600 m^3 in comparison with the previous approved land form and development.

4. FLOOD RISKS

The flood risks on the site have been defined through 1D/2D flood modelling as described above in previous reports as described above.

4.1 Flood Levels, Depths and Velocities

Flood modelling was undertaken for the 20 yr ARI and 100 yr ARI floods

The estimated 100 yr ARI flood level on the site is 5.52 m AHD.

A PMF level of 10.4 m AHD in the study area has been previously reported in the 1991 Georges River Flood Study. The AEP of the PMP for a catchment of the size of the Georges River catchment recommended by the 2016 edition of Australian Rainfall and Runoff is 0.0000005% AEP (2,000,000 yr ARI).

4.2 Pedestrian and Vehicular Stability in Floods

The latest edition of Australian Rainfall and Runoff released in 2016 provides guidance on both pedestrian and vehicle stability in floods.

4.2.1 Pedestrian Stability

As stated in ARR2016:

> *Cox et al., 2010 concluded that self-evacuation of the most vulnerable people in the community (typically small children, and the elderly) is limited to relatively placid flow conditions. Furthermore, a D.V as low as 0.4 m2s-1 would prove problematic for people in this category, i.e. the more vulnerable in the community.*

These hazard regimes for tolerable flow conditions (D.V) as related to the individual's physical characteristics (H.M) are presented in Figure 9.2.4 ……

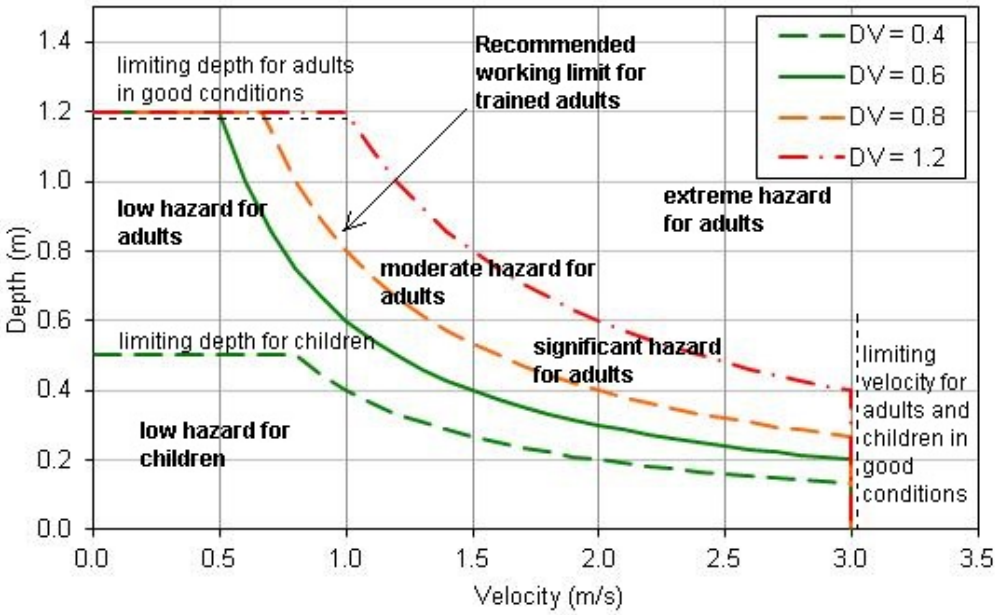


Figure 9.2.4. Safety Criteria for People in Variable Flow Conditions (After Cox et al, 2010)

4.2.2 Vehicle Stability

Determining safety criteria for vehicles requires an understanding of the physical characteristics of the vehicle along with the nature of the flow.

The measure of physical attributes for vehicle stability analysis is the vehicle classification as based on length (L, m), kerb weight (W, kg) and ground clearance (GC, m). Three vehicle classifications are suggested:

- *Small passenger: L < 4.3 m, W < 1250 kg, GC < 0.12 m*
- *Large passenger: L > 4.3 m, W > 1250 kg, GC > 0.12 m*
- *Large 4WD: L > 4.5 m, W > 2000 kg, GC > 0.22 m*

The measure of flow attributes for vehicle stability analysis is D.V m2s-1, determined as the product of flow depth (D, m) and flow velocity (V, ms-1).

Limiting conditions exist for each classification based on limited laboratory testing of characteristic vehicles. The upper tolerable velocity for moving water is defined based on the frictional limits, and is a constant 3.0 ms-1 for all vehicle classifications.

The upper tolerable depths within still water are defined by the floating limits:

- *Small passenger vehicles: 0.3 m*
- *Large passenger vehicles: 0.4 m*
- *Large 4WD vehicles: 0.5 m*

The upper tolerable depths within high velocity water (at 3.0 ms^{-1}) are defined by the frictional limits:

- *Small passenger vehicles: 0.1 m*
- *Large passenger vehicles: 0.15 m*
- *Large 4WD vehicles: 0.2 m*

… Stability criteria based on the best available information for stationary small passenger cars, large passenger cars and large 4WD vehicles in various flow situations are presented in Figure 9.2.6 …..

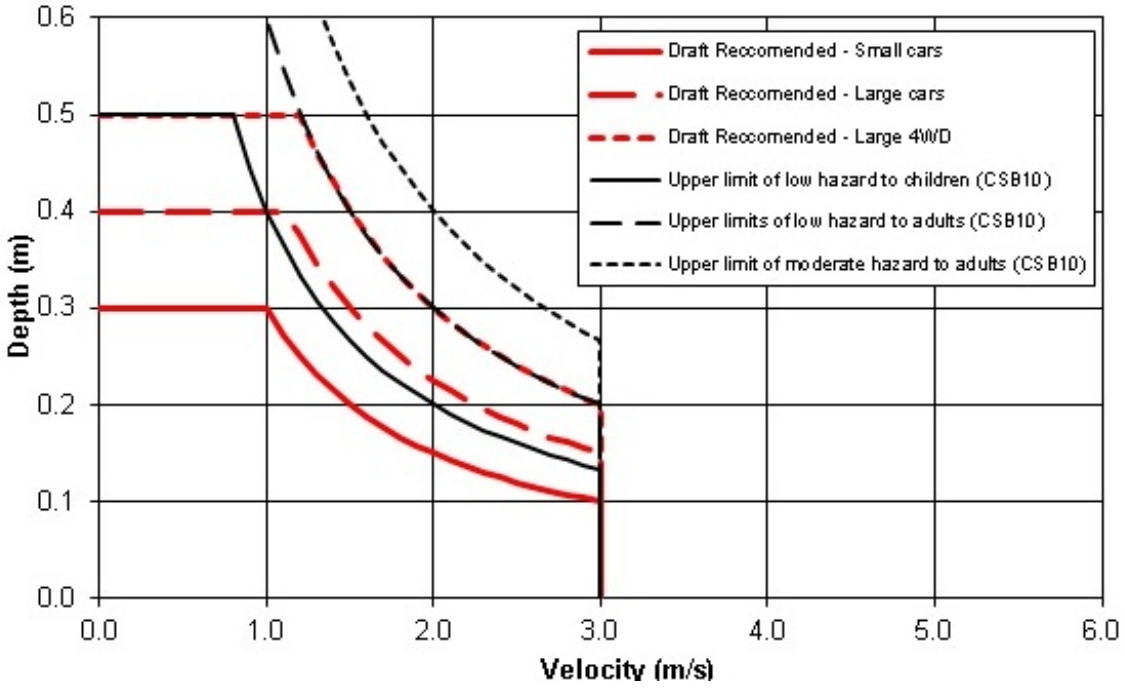


Figure 9.2.6. Interim Safety Criteria for Vehicles in Variable Flow Conditions (After Shand et al, 2011)

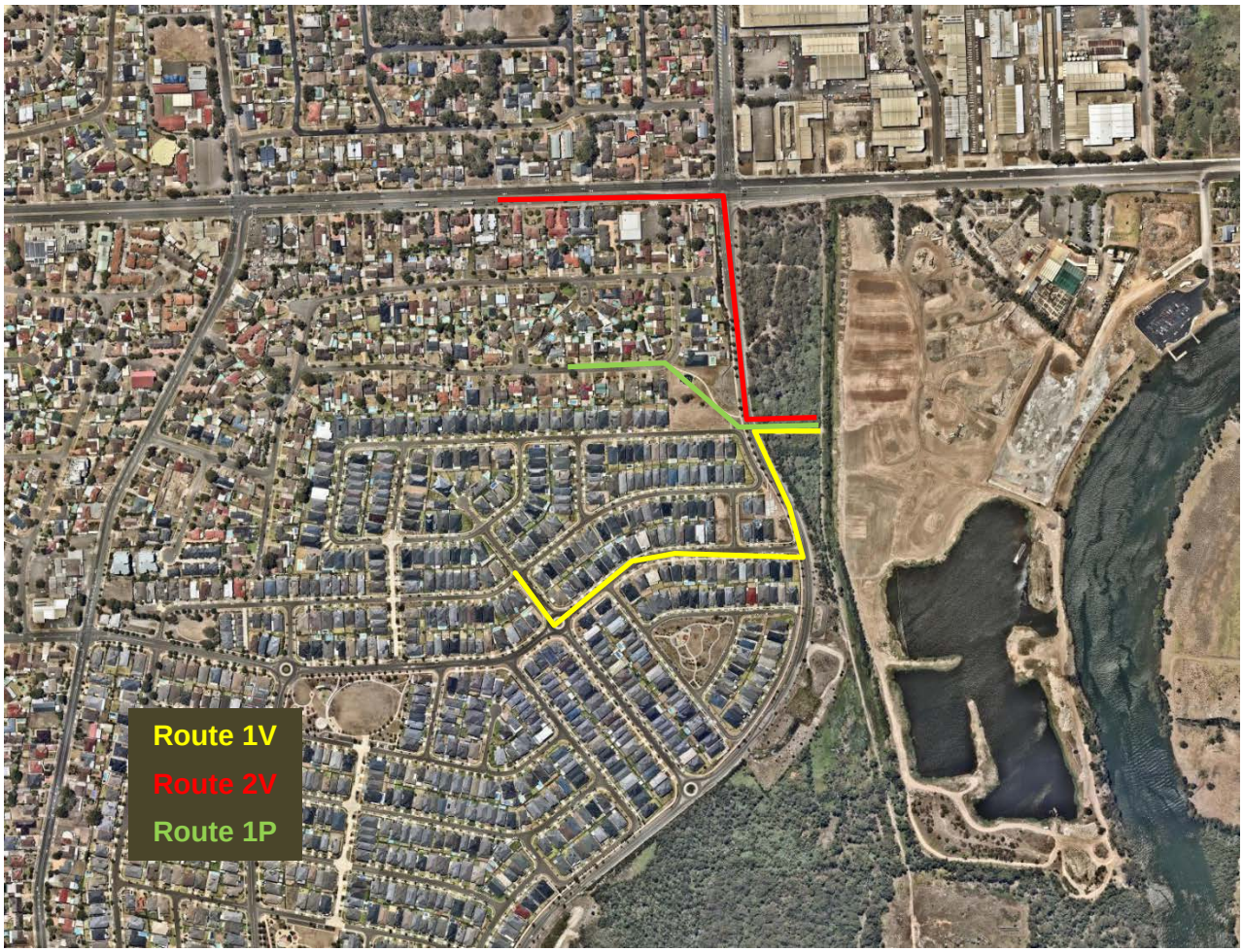
Shand et al (2011) concludes that the available datasets do not adequately account for the following factors and that more research is needed in these areas:

- *Friction coefficients for contemporary vehicle tyres in flood flows;*
- *Buoyancy changes in modern cars;*
- *The effect of vehicle orientation to flow direction (including vehicle movement);*
- *Information for additional categories including small and large commercial vehicles and emergency service vehicles*

4.3 Possible Evacuation Routes

A number of evacuation routes from the site are available across an already approved new bridge crossing. Two possible routes for vehicular evacuation and one possible pedestrian route to a level on the floodplain higher than the PMF are identified as follows.

Route 1V	Cross the new access bridge to Brickmakers Drive, turn left onto Brickmakers Drive, turn right onto Maddecks Ave then turn right on to Conlon Ave. The advantage of this route is that it is flood-free in a 100 yr ARI flood.
Route 2V	Cross the new access bridge to Brickmakers Drive, turn right onto Brickmakers Drive, turn left onto Newbridge Road. The advantage of this route is that it is shorter than Route 1V but the major disadvantage is that Brickmakers Drive north of the access bridge and a section of Newbridge Road experience low hazard flooding in a 1% AEP flood.
Route 1P	Persons would cross the new access bridge to Brickmakers Drive, then cross Brickmakers Drive to walk northwest across the local park to Eluora Cres and then walk west along Eulora Ave. The advantage of this route is that it is flood-free in a 100 yr ARI flood.



The times it would take to evacuate by vehicle or by foot from the site along these routes at different speeds are summarised in **Table 7**.

Table 7 Evacuation Times by Vehicle or by Foot

	Route 1V	Route 2V	Route 1P
Indicative Distance to reach 10.5 m AHD (m)	689	590	370
	Time to reach 10.5 m AHD (mins)		
Vehicle Speed (km/hr)			
10	4.1	3.5	
20	2.1	1.8	
30	1.4	1.2	
40	1.0	0.9	
50	0.8	0.7	
60	0.7	0.6	
Walking Speed (km/hr)			
2	20.7	17.7	11.1
4	10.3	8.9	5.6

It is concluded that:

(i) The advantage of Routes 1V and 1P are that they are flood-free in a 100 yr ARI flood;
(ii) The time to evacuate by vehicle is less than 4 minutes;
(iii) The time to evacuate by foot to higher ground is less than 12 minutes along Route 1P and would be shorter depending on the pace at which persons would walk;
(iv) 6.0 m AHD is the indicative level at which access to the site at the intersection of the new access bridge and Brickmakers Drive become unsafe for vehicles. This equates to a 250 yr ARI flood level.

4.4 Rate of Rise of Floodwaters and Flood Warning Times

To understand the likely warning times and associated response times during extreme flood events it is necessary to estimate the expected rate of rise of floodwaters. In the vicinity of the site the estimated rate of rise of floodwaters in a 1% AEP flood and in the PMF are around 0.45 m/hr and up to 1.45 m/hr respectively.

Features of the planned development include:

- Proposed ground floor levels for the Georges Cove Marina is 7.60 m AHD which provides 2,080 mm freeboard above the estimated 100 year ARI flood level. The Ground Floor level equates to a 5,000 yr ARI flood level;
- Proposed Level 1 floor levels of the apartments at Georges Cove Marina is 11.6 m AHD which is higher than the PMF level;
- Likewise the proposed floor levels of apartments on Levels 2 to 9 are all higher than the PMF level;
- A crest level of 6.3 m AHD on the driveway access to the single-storey car parking level at the Marina complex which provides 780 mm freeboard above the 100 year ARI level The driveway crest level equates to a 450 yr ARI flood level;

Incorporation of a 1.3 m flood barrier on the driveway crest to delay the ingress of floodwaters into the basement car park would provide the same level of protection as the Ground Floor.

The time for floodwaters to reach the following key levels in a 500 yr ARI flood, 1,000 yr ARI flood, 10,000 yr ARI flood and the PMF are given in **Tables 1 – 4** respectively. The key levels include:

- 2 m AHD which could be viewed as an indicator of the potential for significant flooding;
- 5.5 m AHD as an indicator of the 1% AEP flood level;
- 6.0 m AHD which is the indicative level at which access to the site at the intersection of the new access bridge and Brickmakers Drive become unsafe for vehicles;
- 6.3 m AHD which is the proposed crest level of the driveway to the single-storey car park in Georges Cove Marina; and
- 7.6 m AHD which is the proposed Ground Floor level for the Georges Cove Marina.

The results for the 500 yr ARI flood, 1,000 yr ARI flood and 10,000 yr ARI flood were obtained by scaling the 36 hour 1% AEP stage hydrograph extracted from the floodplain model at the centre of the Georges River opposite to entry to the Marina.

The results for the PMF were obtained by correlating the stage frequency curve at the Georges Cove Marina with the stage frequency curve at the Liverpool Weir, then determining the equivalent flow at the Liverpool Weir using the weir rating table published in the 1991 Georges River Flood Study (Figure 16) and then determining the various times from the 36 hour extreme flood hydrograph plotted in Figure 13 of the 1991 Georges River Flood Study.

Table 1 Time for Floodwaters to reach Key Levels in a 500 yr ARI Flood

Key Level (m AHD)	Time from Start of 36 hr Storm Burst (hrs)	Elapsed Time from 2 m AHD (hrs)	(mins)	Elapsed Time from 1% AEP FL (hrs)	(mins)	Duration Flood Level Exceeds (hrs)
2	15.50					
5.5	22.75	7.25	435			
6	24.50	9.00	540	1.75	105	6.25
6.3	26.25	10.75	645	3.50	210	2.00
7.6	28.00	12.50	750	5.25	315	0.00

Table 2 Time for Floodwaters to reach Key Levels in a 1,000 yr ARI Flood

Key Level (m AHD)	Time from Start of 36 hr Storm Burst (hrs)	Elapsed Time from 2 m AHD (hrs)	(mins)	Elapsed Time from 1% AEP FL (hrs)	(mins)	Duration Flood Level Exceeds (hrs)
2	15.00					
5.5	21.75	6.75	405			
6	23.00	8.00	480	1.25	75	9.50
6.3	24.00	9.00	540	2.25	135	7.25
7.6	28.00	13.00	780	6.25	375	0.00

Table 3 Time for Floodwaters to reach Key Levels in a 10,000 yr ARI Flood

Key Level (m AHD)	Time from Start of 36 hr Storm Burst (hrs)	Elapsed Time from 2 m AHD (hrs)	(mins)	Elapsed Time from 1% AEP FL (hrs)	(mins)	Duration Flood Level Exceeds (hrs)
2	14.00					
5.5	20.25	6.25	375			
6	21.00	7.00	420	0.75	45	14.50
6.3	21.50	7.50	450	1.25	75	13.25
7.6	24.50	10.50	630	4.25	255	6.25

Table 4 Time for Floodwaters to reach Key Levels in a PMF

Key Level (m AHD)	Time from Start of 36 hr Storm Burst (hrs)	Elapsed Time from 2 m AHD (hrs)	(mins)	Elapsed Time from 1% AEP FL (hrs)	(mins)	Duration Flood Level Exceeds (hrs)
2	4.00					
5.5	7.00	3.00	180			
6	7.33	3.33	200	0.33	20	30
6.3	7.50	3.50	210	0.50	30	29.2
7.6	8.50	4.50	270	1.50	90	26

While the warning times in a PMF are shorter than for major floods (500 yr ARI – 1,000 yr ARI) it is expected that the extreme weather required to generate a long duration PMP event across the Georges River catchment would be actively tracked by weather forecasters days ahead and that early warnings of extreme weather would be issued by the BoM.

It is concluded that in contrast to the short warning times available on other river system in metropolitan Sydney eg. Parramatta River, the warning times for major flooding in the Georges River are considerably longer and would give sufficient time for residents and visitors to evacuate if they did not want to shelter in place.

It is expected that any decision to shelter in place or to evacuate would be informed by the predicted severity of flooding, the likely duration of any closure of access via Brickmakers Drive and the access bridge and the likelihood that the single-storey car park and the ground floor of any buildings would be inundated.

The indicative depth of flooding in the single-storey car park at Georges Cover Marina was also estimated for the 500 yr ARI and 1,000 yr ARI flood for a single driveway entry which is 6 m, 8 m or 10 m wide. The indicative flood depths are summarised in **Table 5.**

Table 5 Indicative Maximum Depth (m) of Flooding in Car Park

ARI (yrs)	Driveway Width (m)		
	6	8	10
500	0.016	0.021	0.026
1,000	0.44	0.58	0.73

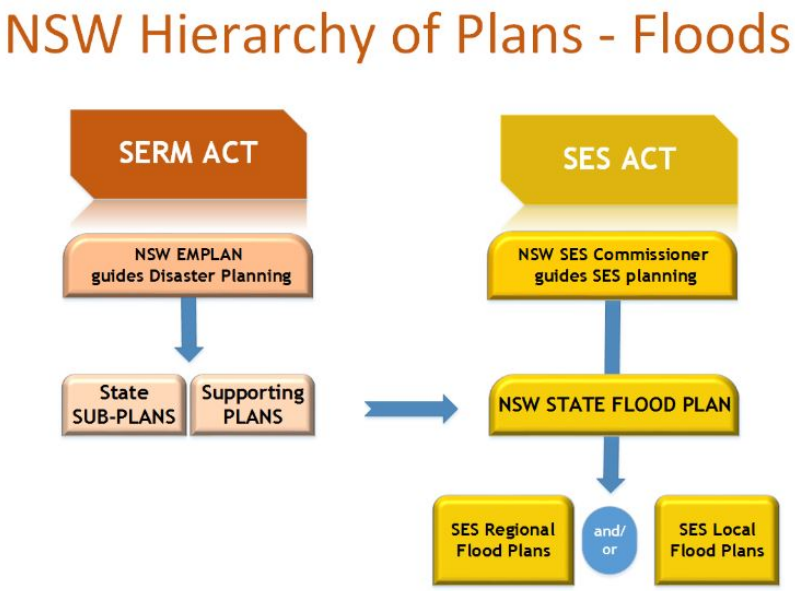
The time it would take to fill the single-storey car park during a PMF to a depth of 0.3 m, 0.9 m and 2.5 m for a single driveway entry which is 6 m, 8 m or 10 m wide was also estimated using a simple hydraulic model of flows down the ramp. The estimated times to flood the car park to various depths from the commencement of overtopping of the driveway crest are given in **Table 6**.

Table 6 Estimated Time (mins) to reach Various Depths in the Car Park in a PMF

	Driveway Width (m)		
	6	8	10
Reach 0.3 m depth	38	33	31
Reach 0.9 m depth	58	51	47
Reach 2.5 m depth	87	78	71

5 EMERGENCY PLANNING

The hierarchy of plans which guide the planning for floods in NSW is as follows:



5.1 2017 NSW State Flood Plan

The NSW State Flood Plan is a sub plan of the State Emergency Management Plan (EMPLAN). It has been prepared in accordance with the provisions of the State Emergency Service Act 1989 (NSW) and is authorised by the State Emergency Management Committee in accordance with the provisions of the State Emergency and Rescue Management Act 1989 (NSW).

The latest plan was provisionally endorsed by the State Emergency Management Committee at Meeting 107 held on 5 December 2017.

The purpose of this plan is to set out the arrangements for the emergency management of flooding in New South Wales

As described by the Plan:

The Plan sets out the emergency management aspects of prevention; preparation; response and initial recovery arrangements for flooding and the responsibilities of individuals, agencies and organisations with regards to these functions.

The Plan recognises the existence of the problem of coastal inundation and erosion caused by severe weather. The management system for dealing with episodes of coastal erosion is described in the New South Wales State Storm Plan.

The Plan recognises the existence of the threat posed by tsunami to NSW coastal communities. The arrangements for the emergency management of tsunami are contained within the State Tsunami Emergency Sub Plan.

This Plan is intended to be read in conjunction with:

(a) The New South Wales State Emergency Management Plan (EMPLAN), of which the State Flood Sub Plan is a sub-plan;
(b) The New South Wales State Storm Plan, which covers arrangements relating to severe storm events; and
(c) NSW Floodplain Development Manual.

Volume 3 of the State Flood Plan outlines Flood Planning Arrangements and the Gauge Warning network. The information for the Georges River given in Table 8 was extracted from Table 1 in Volume 3. It is noted that Gauge 66168 is located only around 1.5 km from the site.

5.2 2017 South West Metropolitan Regional Emergency Management Plan

The 2017 South West Metropolitan Regional Emergency Management Plan details arrangements for, prevention of, preparation for, response to and recovery from emergencies within the South West Region. It encompasses arrangements for:

- emergencies controlled by combat agencies ;
- emergencies controlled by combat agencies and supported by the Regional Emergency Operations Controller (REOCON) ;
- emergency operations for which there is no combat agency;
- circumstances where a combat agency has passed control to the REOCON; and,
- demobilisation and transition of control from response to recovery.

As described by the Plan:

The objectives of this plan are to:

- *support Local Emergency Management Plans (EMPLANs) and augment them when required;*
- *identify trigger points for regional level activation, escalation and demobilisation;*
- *define participating organisation and Functional Area roles and responsibilities in preparation for , response to and recovery from emergencies;*
- *set out the control, co-ordination, support and liaison arrangements at the Regional level;*

Table 8 The Provision and Requirements for Flood warning in the Georges River Catchment

Bureau number	AWRC number	Forecast location	Station owner	Gauge type	Flood classification (m)			Flood Warnings provided by the Bureau	Target warning lead time		70% of peak forecasts within	Local Flood Advices Provided by NSW SES
					Minor	Moderate	Major		Time (hours)	Trigger height (m)		
566054	213400	Liverpool *	NSW Office of Environment and Heritage – Manly Hydraulics Laboratory	Automatic	2.0	3.0	4.5	Quantitative	6 hrs	>2.0 m	+/- 0.3 m	
									12 hrs	>4.0 m		
66168	213405	Milperra *	NSW Office of Environment and Heritage – Manly Hydraulics Laboratory	Automatic	2.0	3.3	4.2	Quantitative	6 hrs	>2.0 m	+/- 0.3 m	
									12 hrs	>4.0 m		
566011	213410D	Picnic Point Downstream	NSW Office of Environment and Heritage – Manly Hydraulics Laboratory	Automatic	2.0	n/a	n/a	Quantitative	6 hrs	>2.0m	+/- 0.3 m	

^ = Small catchments described in 5.6.
*= key location for downstream predictions, critical for the provision of a quantitative flood forecasting service to downstream sites marked with +.
+= key locations for prediction which are based on a telemetered gauge proxy
All levels are in metres to local gauge datum unless indicated otherwise.
u/s refers to upstream levels acting as a trigger for forecasts at given location.

- *detail activation and alerting arrangements for involved agencies at the Regional level;*
- *detail arrangements for the acquisition and co-ordination of resources at the Regional level;*
- *maintain a governance over the Local Emergency Management Committees within its area of responsibility; and*
- *provide/facilitate emergency management training at a local and regional level*

The plan describes the arrangements at Regional level to prevent, prepare for, respond to and recover from emergencies and also provides policy direction for the preparation of Sub Plans and Supporting Plans. Further:

- *This plan relies on effective implementation of the Governance framework for Emergency Management;*
- *Arrangements detailed in this plan are based on the assumption that the resources upon which the plan relies are available when required; and*
- *The effectiveness of arrangements detailed in this plan are dependent upon all involved agencies preparing, testing and maintaining appropriate internal instructions, and/or standing operating procedures.*

This plan is to be read in conjunction with the arrangements stipulated in the NSW State-EMPLAN

5.3 2015 Liverpool City Flood Emergency Sub Plan

The 2015 Liverpool City Flood Emergency Sub Plan is a sub plan of the Liverpool City Local Emergency Management Plan (EMPLAN). The plan covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the Liverpool Local Government Area (LGA). It covers operations for all levels of flooding within the council area.

As described by the Plan:

The area covered by the plan is the Liverpool City LGA. …..

The council area is in the NSW SES Sydney Southern Region and for emergency management purposes is part of the South West Metropolitan Emergency Management Region.

The Council area faces a number of flood threats including those from:

(a) The Georges River and its tributaries including the Cabramatta, Harris, Deadmans and William's Creeks.
(b) South Creek and its tributaries including the Badgery's, Rileys and Kemp's Creeks.
(c) The Upper Nepean River …….

RESPONSIBILITIES

***NSW SES Liverpool Local Controller**. The NSW SES Liverpool Local Controller is responsible for dealing with floods as detailed in the State Flood Plan, and will;*

Preparedness

(a) Maintain a Local Headquarters at 67 Pearce Street, Liverpool in accordance with the NSW SES Controllers' Guide and the NSW SES Operations Manual.

(b) *Ensure that NSW SES members are trained to undertake operations in accordance with current policy as laid down in the NSW SES Controllers' Guide and the NSW SES Operations Manual.*

(c) *Coordinate the development and operation of a flood warning service for the community.*

(d) *Participate in floodplain risk management initiatives organised by the Liverpool City Council.*

(e) *Coordinate a community engagement and capacity building program regarding local flood issues and associated risks to assist communities in building resilience to floods.*

(f) *Identify and monitor people and/or communities at risk of flooding.*

(g) *Ensure that the currency of this plan is maintained.*

Response

(h) *Appoint an appropriate Incident Controller to undertake response roles. The Incident Controller will;*

- *Control flood and storm response operations. This includes;*
  - *Directing the activities of the NSW SES units operating within the council area.*
  - *Coordinating the activities of supporting agencies and organisations and ensuring that liaison is established with them.*
  - *Contribute to preparation of Region IAP.*
- *Coordinate the provision of an information service in relation to;*
  - F*lood heights and flood behaviour.*
  - *Road conditions and closures.*
  - *Advice on methods of limiting property damage.*
  - *Confirmation of evacuation warnings and evacuation orders.*
- *Direct the conduct of flood rescue operations.*
- *Direct the evacuation of people and/or communities.*
- *Coordinate immediate welfare support for evacuated people.*
- *Coordinate the provision of emergency food and medical supplies to isolated people and/or communities.*
- *Coordinate operations to assist the community to protect property. This may include;*
  - *Arranging resources for sandbagging operations.*
  - *Lifting or moving household furniture.*
  - *Lifting or moving commercial stock and equipment.*
- *Where possible, arrange for support (for example, accommodation and meals) for emergency service organisation members and volunteers assisting them.*
- *If NSW SES resources are available, assist with emergency fodder supply operations conducted by Agriculture and Animal Services.*
- *If NSW SES resources are available, assist the NSW Police Force, RMS and Council with road closure and traffic control operations.*
- *Exercise financial delegations relating to the use of emergency orders as laid down in the NSW SES Controllers' Guide.*
- *Coordinate the collection of flood information for development of intelligence.*

- *Submit Situation Reports to the NSW SES Sydney Southern Region Headquarters and agencies assisting within the council area. These should contain information on;*
  - *Road conditions and closures.*
  - *Current flood behaviour.*
  - *Current operational activities.*
  - *Likely future flood behaviour.*
  - *Likely future operational activities.*
  - *Probable resource needs.*
- *Keep the Local Emergency Operations Controller advised of the flood situation and the operational response.*
- *Issue the 'All Clear' when flood operations have been completed.*

Recovery

(i) Ensure that appropriate After Action Reviews are held after floods.

(j) Provide appropriate representation to the recovery committee for the duration of the response phase of an event and as agreed during the recovery phase.

….

Australian Government Bureau of Meteorology (The Bureau)

(a) Provide Flood Watches for the Georges River and Hawkesbury-Nepean Basins.

(b) Provide Flood Warnings, incorporating height-time predictions, for Liverpool Weir (AWRC No. 213400), Milperra (AWRC No. 213405), Camden Bridge (AWRC No. 212900), and Wallacia Bridge (AWRC No. 212202) gauges.

(c) Provide severe weather warnings when flash flooding is likely to occur.

6. FLOOD EMERGENCY RESPONSE

It is expected that Building Owners and Managers (in accordance with existing OH&S requirements, the Building Code of Australia and relevant City of Liverpool regulations) are to have a building Emergency Management Plan which complies with the provisions of AS 3745.

It is expected that the building Emergency Management Plan will contain a Flood Emergency Response Plan. It is also expected that all wardens trained under the building emergency plan are to be aware of the flood risks, routes to/from the site and how to liaise with the any building occupants on the site.

It is expected that the building Emergency Management Plan will contain details on how the information regarding any evacuation will be disseminated from the Chief Warden to occupants of the Marina.

6.1 Flood Warning

As outlined above that the Bureau of Meteorology provides:

- Flood Watches for the Georges River;
- Flood Warnings, incorporating height-time predictions, for Liverpool Weir (AWRC No. 213400), and Milperra (AWRC No. 213405),

It is noted that the Milperra Gauge is located only around 1.5 km from the site.

While the warning times in a PMF are shorter than for major floods (500 yr ARI – 1,000 yr ARI) it is expected that the extreme weather required to generate a long duration PMP event across the Georges River catchment would be actively tracked by weather forecasters days ahead and that early warnings of extreme weather would be issued by the BoM.

It is concluded that in contrast to the short warning times available on other river system in metropolitan Sydney eg. Parramatta River, the warning times for major flooding in the Georges River are considerably longer and would give sufficient time for residents and visitors to evacuate if they did not want to shelter in place. It is noted that the BoM target warning lead time for flooding higher than 4.0 m on the gauge (3.045 m AHD) is 12 hours.

6.2 Flood Evacuation

In flood events up to the 100 yr ARI flood a flood-free vehicular evacuation route and a separate flood-free pedestrian evacuation route is available to residents, visitors and workers on the site.

6.0 m AHD is the indicative level at which access to the site at the intersection of the new access bridge and Brickmakers Drive become unsafe for vehicles. This equates to a 250 yr ARI flood level.

It is expected that any decision to shelter in place or to evacuate would be informed by the predicted severity of flooding, the likely duration of any closure of access via Brickmakers Drive and the access bridge and the likelihood that the single-storey car park and the ground floor of any buildings would be inundated.

6.3 Draft Flood Emergency Response Plan

Flood Threat

Features of the planned Georges Cove Marina development include:

- Proposed ground floor levels for the Georges Cove Marina is 7.60 m AHD which provides 2,080 mm freeboard above the estimated 100 year ARI flood level. The Ground Floor level equates to a 5,000 yr ARI flood level;
- Proposed Level 1 floor levels of the apartments at Georges Cove Marina is 11.6 m AHD which is higher than the PMF level;
- Likewise the proposed floor levels of apartments on Levels 2 to 9 are all higher than the PMF level;
- A crest level of 6.3 m AHD on the driveway access to the single-storey car parking level at the Marina complex which provides 780 mm freeboard above the 100 year ARI level The driveway crest level equates to a 450 yr ARI flood level;

Incorporation of a 1.3 m flood barrier on the driveway crest to delay the ingress of floodwaters into the basement car park would provide the same level of protection as the Ground Floor.

The time for floodwaters to reach the following key levels in a 500 yr ARI flood, 1,000 yr ARI flood, 10,000 yr ARI flood and the PMF are given in **Tables 1 – 4** respectively. The key levels include:

- 2 m AHD which could be viewed as an indicator of the potential for significant flooding;
- 5.5 m AHD as an indicator of the 1% AEP flood level;
- 6.0 m AHD which is the indicative level at which access to the site at the intersection of the new access bridge and Brickmakers Drive become unsafe for vehicles;
- 6.3 m AHD which is the proposed crest level of the driveway to the single-storey car park in Georges Cove Marina; and
- 7.6 m AHD which is the proposed Ground Floor level for the Georges Cove Marina.

The indicative depth of flooding in the single-storey car park at Georges Cover Marina was also estimated for the 500 yr ARI and 1,000 yr ARI flood for a single driveway entry which is 6 m, 8 m or 10 m wide. The indicative flood depths in a 500 yr ARI flood vary from 0.016 - 0.026 m while the flood depths in a 1,000 yr ARI flood vary from 0.44 - 0.74 m**.**

The time it would take to fill the single-storey car park during a PMF to a depth of 0.3 m, 0.9 m and 2.5 m for a single driveway entry which is 6 m, 8 m or 10 m wide was also assessed. Depending on the driveway width, the estimated times to flood the car park to 0.3 m are 31 - 38 mins and to 0.9 m are 47-51 mins from the commencement of overtopping of the driveway crest.

Responsibilities

While in a flood emergency the NSW State Emergency Service (SES) has responsibilities including to:

- Direct the evacuation of persons and/or communities at risk of flood inundation.
- Issue evacuation warnings for individual communities that describe possible local effects, suggested actions and evacuation arrangements.

it is expected that the building on-site manager or other designated person(s) will be responsible for implementing the actions defined in the Flood Emergency Response Plan and should not rely on the SES for any evacuation warnings. These actions would include liaising with the SES, monitoring any BoM flood warnings, maintaining regular communication with residents, visitors and workers and initiating actions as documented in the Plan.

Preparedness

Visitors and residents shall be advised of the potential flood threat in their locality, and recommended management and evacuation procedures in case of a major flood event. They will comply with all lawful directions.

It is recommended that a practice evacuation drill or meeting is organised by management for residents and workers annually.

Warning

While in a flood event, the SES will prepare, authorise and distribute evacuation warnings it is expected that the short warning times mean that in the case of extreme floods that there would be insufficient time to evacuate any residents and/or visitors from the site and that instead residents and/or visitors would need to shelter in place. The building on-site manager or other designated person(s) will be responsible for implementing the actions defined in the Flood Emergency Detailed Response Plan and should not rely on the SES for any evacuation warnings.

Response

It is expected that any decision to shelter in place or to evacuate would be informed by the predicted severity of flooding, the likely duration of any closure of access via Brickmakers Drive and the access bridge and the likelihood that the single-storey car park and the ground floor of any buildings would be inundated.

In extreme floods residents and any visitors on the Ground Floor who decide to remain on site could retreat to Levels 1 - 9 in floods greater than a 5,000 yr ARI as all these levels are above the PMF level.

Recovery

The building on-site manager or other designated person(s) will issue an 'all clear' message when the immediate danger to life and property has passed.

7. OEH AND NSW SES ISSUES OF CONCERN

7.1 OEH Issues of Concern

OEH issues of concern are detailed in a letter dated 24 May 2017. A number of these issues are discussed as follows.

> *OEH is concerned that although the Georges Cove site ground levels have been raised to RL 6.3m AHD which is above the 100 year flood level of 5.6m AHD, the adjacent land falls away to RL 2.5m with the adjacent Newbridge Road flooded at levels 1.5 m to 3.0 m AHD. The proposed evacuation routes are inundated in frequent flood events such as the 5% AEP flood, which results in the site becoming isolated and preventing evacuation. OEH's concerns are also supported by Figures 4 and 7 of the Flood Impact Assessment Stage 2 prepared for DA24/2017 for the Moorebank Cove Site (Cardno, July 2016). Figures 4 and 7 provide a general overview on the scale of isolation and depict the depth of floodwaters surrounding the Georges Cove and Moorebank Cove proposed residential sites in the 5% and 1% AEP respectively.*

As discussed in Section 4.3, a number of evacuation routes from the site are available across an already approved new bridge crossing. Two possible routes for vehicular evacuation and one possible pedestrian route to a level on the floodplain higher than the PMF are identified as follows.

Route 1V	Cross the new access bridge to Brickmakers Drive, turn left onto Brickmakers Drive, turn right onto Maddecks Ave then turn right on to Conlon Ave. The advantage of this route is that it is flood-free in a 100 yr ARI flood.
Route 2V	Cross the new access bridge to Brickmakers Drive, turn right onto Brickmakers Drive, turn left onto Newbridge Road. The advantage of this route is that it is shorter than Route 1V but the major disadvantage is that Brickmakers Drive north of the access bridge and a section of Newbridge Road experience low hazard flooding in a 1% AEP flood.
Route 1P	Persons would cross the new access bridge to Brickmakers Drive, then cross Brickmakers Drive to walk northwest across the local park to Eluora Cres and then walk west along Eulora Ave. The advantage of this route is that it is flood-free in a 100 yr ARI flood.

In flood events up to the 100 yr ARI flood a flood-free vehicular evacuation route and a separate flood-free pedestrian evacuation route is available to residents, visitors and workers on the site.

6.0 m AHD is the indicative level at which access to the site at the intersection of the new access bridge and Brickmakers Drive become unsafe for vehicles. This equates to a 250 yr ARI flood level.

> *OEH has general concerns regarding the proposed use of shelter in place i.e. using access to floor levels above the PMF level. Shelter in place is not acceptable in the case of a mainstream flooding environment, characterised by deep flooding for extended period of time. The Australian Emergency Management Handbook 7 highlights that 'there is no safe duration of isolation' (Emergency Management Australia, 2013). Residents sheltering in place during a flood may be without basic services, need assistance with critical supplies, and need evacuation due to medical conditions and requirements. The isolation and proposed shelter in place situation in this site can cause significant risk to life for potential occupiers and for emergency personnel.*

In Section 4.4, the time for floodwaters to reach the following key levels in a 500 yr ARI flood, 1,000 yr ARI flood, 10,000 yr ARI flood and the PMF are given in **Tables 1 – 4** respectively. The key levels include:

- 2 m AHD which could be viewed as an indicator of the potential for significant flooding;
- 5.5 m AHD as an indicator of the 1% AEP flood level;
- 6.0 m AHD which is the indicative level at which access to the site at the intersection of the new access bridge and Brickmakers Drive become unsafe for vehicles;
- 6.3 m AHD which is the proposed crest level of the driveway to the single-storey car park in Georges Cove Marina; and
- 7.6 m AHD which is the proposed Ground Floor level for the Georges Cove Marina.

As outlined in Section 5.3, the Bureau of Meteorology provides:

- Flood Watches for the Georges River;
- Flood Warnings, incorporating height-time predictions, for Liverpool Weir (AWRC No. 213400), and Milperra (AWRC No. 213405),

It is noted that the Milperra Gauge is located only around 1.5 km from the site.

While the warning times in a PMF are shorter than for major floods (500 yr ARI – 1,000 yr ARI) it is expected that the extreme weather required to generate a long duration PMP event across the Georges River catchment would be actively tracked by weather forecasters days ahead and that early warnings of extreme weather would be issued by the BoM.

It is concluded that in contrast to the short warning times available on other river system in metropolitan Sydney eg. Parramatta River, the warning times for major flooding in the Georges River are considerably longer and would give sufficient time for residents and visitors to evacuate if they did not want to shelter in place. It is noted that the BoM target warning lead time for flooding higher than 4.0 m on the gauge (3.045 m AHD) is 12 hours

It is expected that any decision to shelter in place or to evacuate would be informed by the predicted severity of flooding, the likely duration of any closure of access via Brickmakers Drive and the access bridge in floods greater than a 250 yr ARI flood and the likelihood that the single-storey car park and the ground floor of any buildings would be inundated.

7.2 NSW SES Issues of Concern

NSW SES issues of concern are detailed in a letter dated 2 November 2017. A number of these issues are discussed as follows.

> *The site of the proposal is also in an area that is subject to flash flooding. Flash flooding is characterised by short warning time (an area that generally has less than 6 hours between rain falling and flooding) with often high hazard floodwater impacting a community that is built within proximity to the watercourses. During such flood events, roads that are used to convey flow or cross watercourses are potentially hazardous.*

In Section 4.4 the time for floodwaters to reach the following key levels in a 500 yr ARI flood, 1,000 yr ARI flood, 10,000 yr ARI flood and the PMF are given in **Tables 1 – 4** respectively. The key levels include:

- 2 m AHD which could be viewed as an indicator of the potential for significant flooding;
- 5.5 m AHD as an indicator of the 1% AEP flood level;
- 6.0 m AHD which is the indicative level at which access to the site at the intersection of the new access bridge and Brickmakers Drive become unsafe for vehicles;
- 6.3 m AHD which is the proposed crest level of the driveway to the single-storey car park in Georges Cove Marina; and
- 7.6 m AHD which is the proposed Ground Floor level for the Georges Cove Marina.

As outlined in Section 5.3 the Bureau of Meteorology provides:

- Flood Watches for the Georges River;
- Flood Warnings, incorporating height-time predictions, for Liverpool Weir (AWRC No. 213400), and Milperra (AWRC No. 213405),

It is noted that the Milperra Gauge is located only around 1.5 km from the site.

It is unclear how this flooding regime would be classified as “flash” flooding.

> *Although the planning proposal states that ‘all residents would have internal access to floor levels above the PMF level’ and therefore the ability to ‘shelter in place’ if they cannot evacuate (Appendix D, p 1), there are additional hazards and risks in people being surrounded by high hazard floodwater. These include the potential for people to attempt to evacuate when it unsafe to do so or taking risks by crossing flooded roads in order to access their place of residence.*

As discussed in Section 4.3 a number of evacuation routes from the site are available across an already approved new bridge crossing. Two possible routes for vehicular evacuation and one possible pedestrian route to a level on the floodplain higher than the PMF are identified.

In flood events up to the 100 yr ARI flood a flood-free vehicular evacuation route and a separate flood-free pedestrian evacuation route is available to residents, visitors and workers on the site. 6.0 m AHD is the indicative level at which access to the site at the intersection of the new access bridge and Brickmakers Drive become unsafe for vehicles. This equates to a 250 yr ARI flood level.

In contrast to the short warning times available on other river system in metropolitan Sydney eg. Parramatta River, the warning times for major flooding in the Georges River are considerably longer and would give sufficient time for residents and visitors to evacuate if they did not want to shelter in place. It is noted that the BoM target warning lead time for flooding higher than 4.0 m on the gauge (3.045 m AHD) is 12 hours.

It is expected that any decision to shelter in place or to evacuate would be informed by the predicted severity of flooding, the likely duration of any closure of access via Brickmakers Drive and the access bridge in floods greater than a 250 yr ARI flood and the likelihood that the single-storey car park and the ground floor of any buildings would be inundated.

> *On an additional but related note, this application reflect the facts in Mercury Resources Pty Ltd v Parramatta City Council [2016] NSWLEC 1094. Mercury Resources proposed the development of a high rise building that was only accessible through high hazard floodwater. Mercury Resources proposed shelter in place as an appropriate strategy during a flood for safety of the future occupants (at [26]). Council refused to grant consent to the application. The Land and Environment Court Commissioner Sue Morris dismissed the applicant's appeal against Council's refusal to grant consent. She held that as the access to the site is through high hazard floodwater, and that the development would result in additional people being put at risk during a flood, it was an unacceptable flood risk and 'not compatible with the flood hazard of the land, (as it) may result in unsustainable social and economic costs to the community as a consequence* of flooding' (at [112]).

The property which was the subject of *NSWLEC 1094* was 32 Tramway Avenue, Parramatta. Council refused to grant consent because the only access to the property was via Arthur Street which is subject to high hazard flooding for a period of time in a 100 yr ARI flood ie. Council's concern was access to/from the property in events up to the 100 yr ARI flood. Council approved a development of three apartment towers on 2-8 River Road West which is closer to the Parramatta River and only 180 m from 32 Tramway Ave on the basis that flood free access was available to a corner of the development in a 100 yr ARI flood. This approved development also relies on shelter-in-place in events greater than a 100 yr ARI flood up to the PMF which is around 4.2 m higher than the 100 yr ARI flood level. The same level of high hazard is experienced on both properties in the PMF. It is concluded that the level of hazard in the PMF would not have been of concern to Council given its approval of residential apartment development (with a greater number of residents) on the nearby property.

> *The planning proposal states '(a)ll residents would have carparking flood protected to a level of RL 6.3m which is 200mm above the flood planning level.' (Appendix D, p 1). The proposal states there will be parking for 851 vehicles, made up of 201 parking spaces for residents and 650 for employees, customers and other visitors (p 1).*
>
> *Although the crest level of the basement parking is proposed to be 200mm above the flood planning level, the basement will be flooded above this level. There is a height difference of 3.9m between the crest level and the PMF (Appendix D, p 1).*
>
> *Above the crest level there is likely to be damage to property and risk to life of occupants who may become trapped in a basement carpark during a large enough flood. A recent paper by Collier et al. (2017) provides a thorough analysis of the risks to people and property associated with basement carparks when considering flooding up to the PMF. This is attached for consideration (Annexure 4). The analysis of the planning proposal should take into account these risks to future occupants.*

In Section 4.4, the indicative depth of flooding in the single-storey car park at Georges Cover Marina is also estimated for the 500 yr ARI and 1,000 yr ARI flood for a single driveway entry which is 6 m, 8 m or 10 m wide. The indicative flood depths in a 500 yr ARI flood vary from 0.016 - 0.026 m while the flood depths in a 1,000 yr ARI flood vary from 0.44 - 0.74 m.

The time it would take to fill the single-storey car park during a PMF to a depth of 0.3 m, 0.9 m and 2.5 m for a single driveway entry which is 6 m, 8 m or 10 m wide was also assessed. Depending on the driveway width, the estimated times to flood the car park to 0.3 m are 31 - 38 mins and to 0.9 m are 47-51 mins from the commencement of overtopping of the driveway crest.

It is considered that flooding of the proposed car park is not as rapid as may occur elsewhere and that there is sufficient time available for any residents, visitors or workers to evacuate to a level higher than the PMF once overtopping of the driveway commences in a PMF. It is noted that in the available time to evacuate the car park (30-45 mins) that the ground floor would not be already inundated by rising PMF floodwaters.

8. CONCLUSIONS

In conclusion the hydraulic modelling of the Planning Proposal shows the following:

- In both the 20 yr ARI and 100yr ARI flood it was assessed that the Planning Proposal has nil adverse impact on water levels (less than 0.01 m) at any location in the floodplain in comparison to the benchmark conditions; and
- While in the 20yr and 100yr ARI events there are modest velocity impacts west of the northern section of the elevated car park this is because under benchmark conditions this area was filled and under the Planning Proposal this area is re-established as a flowpath (as existed prior to any development on the site). Notwithstanding these local changes in velocity the overall velocity remains much lower than 1 m/s and consequently does not pose a scour risk.

The following additional issues have been considered beyond the previous flood impact assessments.

8.1 Flood Storage

The change in 100 yr ARI flood storage as a result of the works proposed under the Planning Proposal was also assessed. The 100 yr ARI flood storage under the Benchmark Scenario (refer Section 2.1) was estimated to be 499,200 m^3. The 100 yr ARI flood storage under the Post-development Scenario (refer Section 2.2) was estimated to be 521,800 m^3. This calculation accounted for the volume of floodwaters displaced by the proposed suspended car park and the columns which will support the car park.

It is concluded that the Planning Proposal would increase the 100 yr ARI flood storage by 22,600 m^3 in comparison with the previous approved land form and development.
Possible Evacuation Routes

8.2 Possible Evacuation Routes

A number of evacuation routes from the site are available across an already approved new bridge crossing. Two possible routes for vehicular evacuation and one possible pedestrian route to a level on the floodplain higher than the PMF are identified. The times it would take to evacuate by vehicle or by foot from the site along these routes at different speeds was assessed. It is concluded that:

(v) The advantage of Routes 1V and 1P are that they are flood-free in a 100 yr ARI flood;
(vi) The time to evacuate by vehicle is less than 4 minutes;
(vii) The time to evacuate by foot to higher ground is less than 12 minutes along Route 1P and would be shorter depending on the pace at which persons would walk;
(viii) 6.0 m AHD is the indicative level at which access to the site at the intersection of the new access bridge and Brickmakers Drive become unsafe for vehicles. This equates to a 250 yr ARI flood level.

8.3 Rate of Rise of Floodwaters and Flood Warning Times

Features of the planned development include:

- Proposed ground floor levels for the Georges Cove Marina is 7.60 m AHD which provides 2,080 mm freeboard above the estimated 100 year ARI flood level. The Ground Floor level equates to a 5,000 yr ARI flood level;
- Proposed Level 1 floor levels of the apartments at Georges Cove Marina is 11.6 m AHD which is higher than the PMF level;
- Likewise the proposed floor levels of apartments on Levels 2 to 9 are all higher than the PMF level;
- A crest level of 6.3 m AHD on the driveway access to the single-storey car parking level at the Marina complex which provides 780 mm freeboard above the 100 year ARI level The driveway crest level equates to a 450 yr ARI flood level;

The time for floodwaters to reach the following key levels in a 500 yr ARI flood, 1,000 yr ARI flood, 10,000 yr ARI flood and the PMF are given in **Tables 1 – 4** respectively. The key levels include:

- 2 m AHD which could be viewed as an indicator of the potential for significant flooding;
- 5.5 m AHD as an indicator of the 1% AEP flood level;
- 6.0 m AHD which is the indicative level at which access to the site at the intersection of the new access bridge and Brickmakers Drive become unsafe for vehicles;
- 6.3 m AHD which is the proposed crest level of the driveway to the single-storey car park in Georges Cove Marina; and
- 7.6 m AHD which is the proposed Ground Floor level for the Georges Cove Marina.

As outlined in Section 5.3 the Bureau of Meteorology provides:

- Flood Watches for the Georges River;
- Flood Warnings, incorporating height-time predictions, for Liverpool Weir (AWRC No. 213400), and Milperra (AWRC No. 213405),

It is noted that the Milperra Gauge is located only around 1.5 km from the site.

While the warning times in a PMF are shorter than for major floods (500 yr ARI – 1,000 yr ARI) it is expected that the extreme weather required to generate a long duration PMP event across the Georges River catchment would be actively tracked by weather forecasters days ahead and that early warnings of extreme weather would be issued by the BoM.

It is concluded that in contrast to the short warning times available on other river system in metropolitan Sydney eg. Parramatta River, the warning times for major flooding in the Georges River are considerably longer and would give sufficient time for residents and visitors to evacuate if they did not want to shelter in place. It is noted that the target warning lead time for flooding higher than 4.0 m on the gauge (3.045 m AHD) is 12 hours

It is expected that any decision to shelter in place or to evacuate would be informed by the predicted severity of flooding, the likely duration of any closure of access via Brickmakers Drive and the access bridge and the likelihood that the single-storey car park and the ground floor of any buildings would be inundated.

8.4 Flooding of the Car Park

In Section 4.4, the indicative depth of flooding in the single-storey car park at Georges Cover Marina is also estimated for the 500 yr ARI and 1,000 yr ARI flood for a single driveway entry which is 6 m, 8 m or 10 m wide. The indicative flood depths in a 500 yr ARI flood vary from 0.016 - 0.026 m while the flood depths in a 1,000 yr ARI flood vary from 0.44 - 0.74 m**.**

The time it would take to fill the single-storey car park during a PMF to a depth of 0.3 m, 0.9 m and 2.5 m for a single driveway entry which is 6 m, 8 m or 10 m wide was also assessed. Depending on the driveway width, the estimated times to flood the car park to 0.3 m are 31 - 38 mins and to 0.9 m are 47-51 mins from the commencement of overtopping of the driveway crest. It is considered that flooding of the proposed car park is not as rapid as may occur elsewhere and that there is sufficient time available for any residents, visitors or workers to evacuate to a level higher than the PMF once overtopping of the driveway commences in a PMF. It is noted that in the available time to evacuate the car park (30-45 mins) that the ground floor would not be already inundated by rising PMF floodwaters.

8.5 Emergency Planning

The hierarchy of plans which guide the planning for floods in NSW and in the Liverpool LGA are overviewed. These include the

- 2017 NSW State Flood Plan
- 2017 South West Metropolitan Regional Emergency Management Plan
- 2015 Liverpool City Flood Emergency Sub Plan

Flood Emergency Response

It is expected that the building Emergency Management Plan will contain a Flood Emergency Response Plan. It is also expected that all wardens trained under the building emergency plan are to be aware of the flood risks, routes to/from the site and how to liaise with the any building occupants on the site.

Flood Warning

It is concluded that in contrast to the short warning times available on other river system in metropolitan Sydney eg. Parramatta River, the warning times for major flooding in the Georges River are considerably longer and would give sufficient time for residents and visitors to evacuate if they did not want to shelter in place. It is noted that the BoM target warning lead time for flooding higher than 4.0 m on the gauge (3.045 m AHD) is 12 hours.

Flood Evacuation

In flood events up to the 100 yr ARI flood a flood-free vehicular evacuation route and a separate flood-free pedestrian evacuation route is available to residents, visitors and workers on the site.

6.0 m AHD is the indicative level at which access to the site at the intersection of the new access bridge and Brickmakers Drive become unsafe for vehicles. This equates to a 250 yr ARI flood level.

It is expected that any decision to shelter in place or to evacuate would be informed by the predicted severity of flooding, the likely duration of any closure of access via Brickmakers Drive and the access bridge and the likelihood that the single-storey car park and the ground floor of any buildings would be inundated.

A Draft Flood Emergency Response Plan is also outlined.

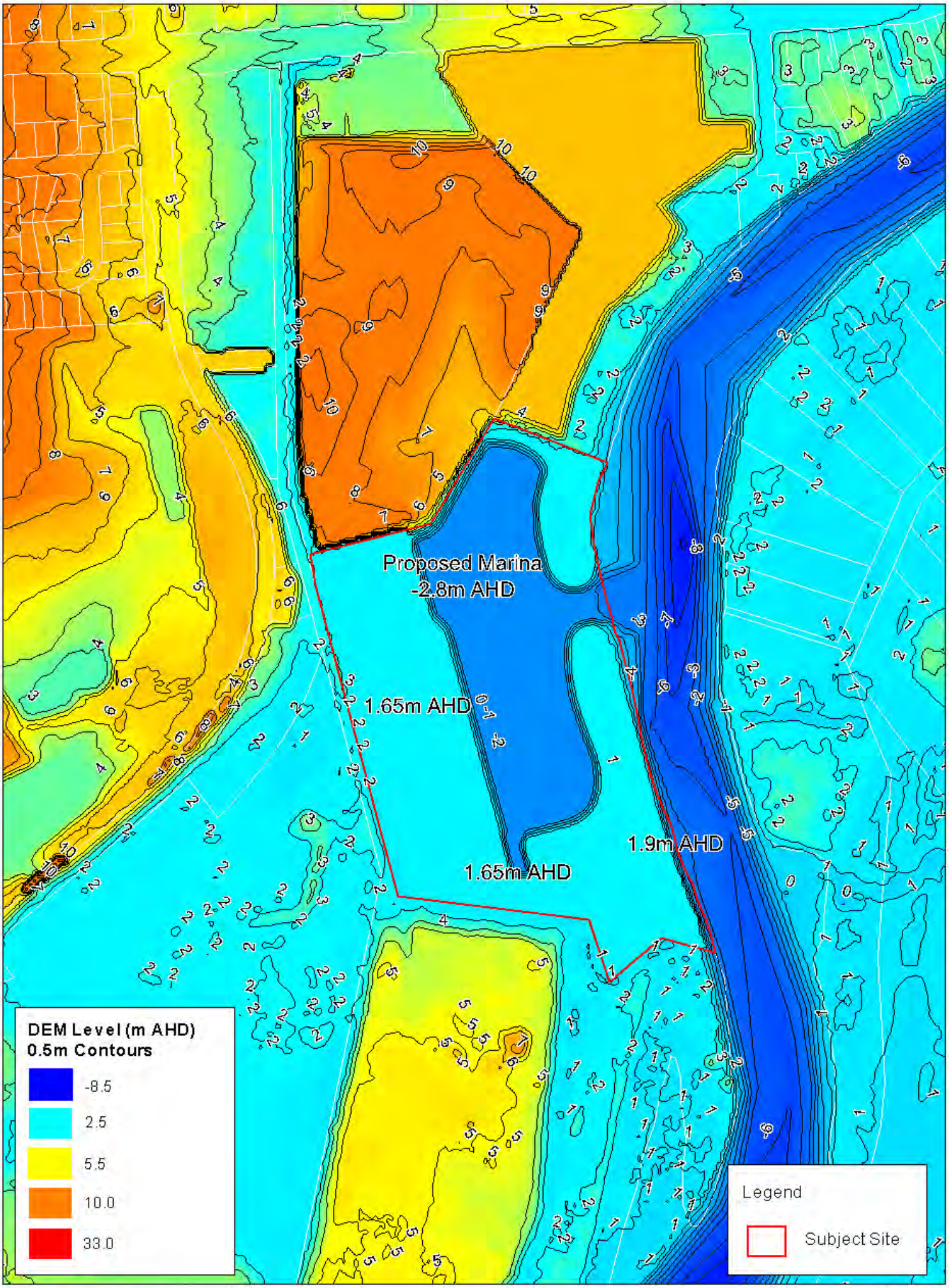
8.6 OEH and NSW SES Issues of Concern

OEH issues of concern are detailed in a letter dated 24 May 2017. NSW SES issues of concern are detailed in a letter dated 2 November 2017. A number of these issues are discussed as follows.
A number of these issues are discussed and responses are provided.

Should you have any questions regarding this assessment please do not hesitate to contact me on 9496 7700.

Yours faithfully

……
Dr Brett C. Phillips
Director, Water Engineering
for **Cardno**

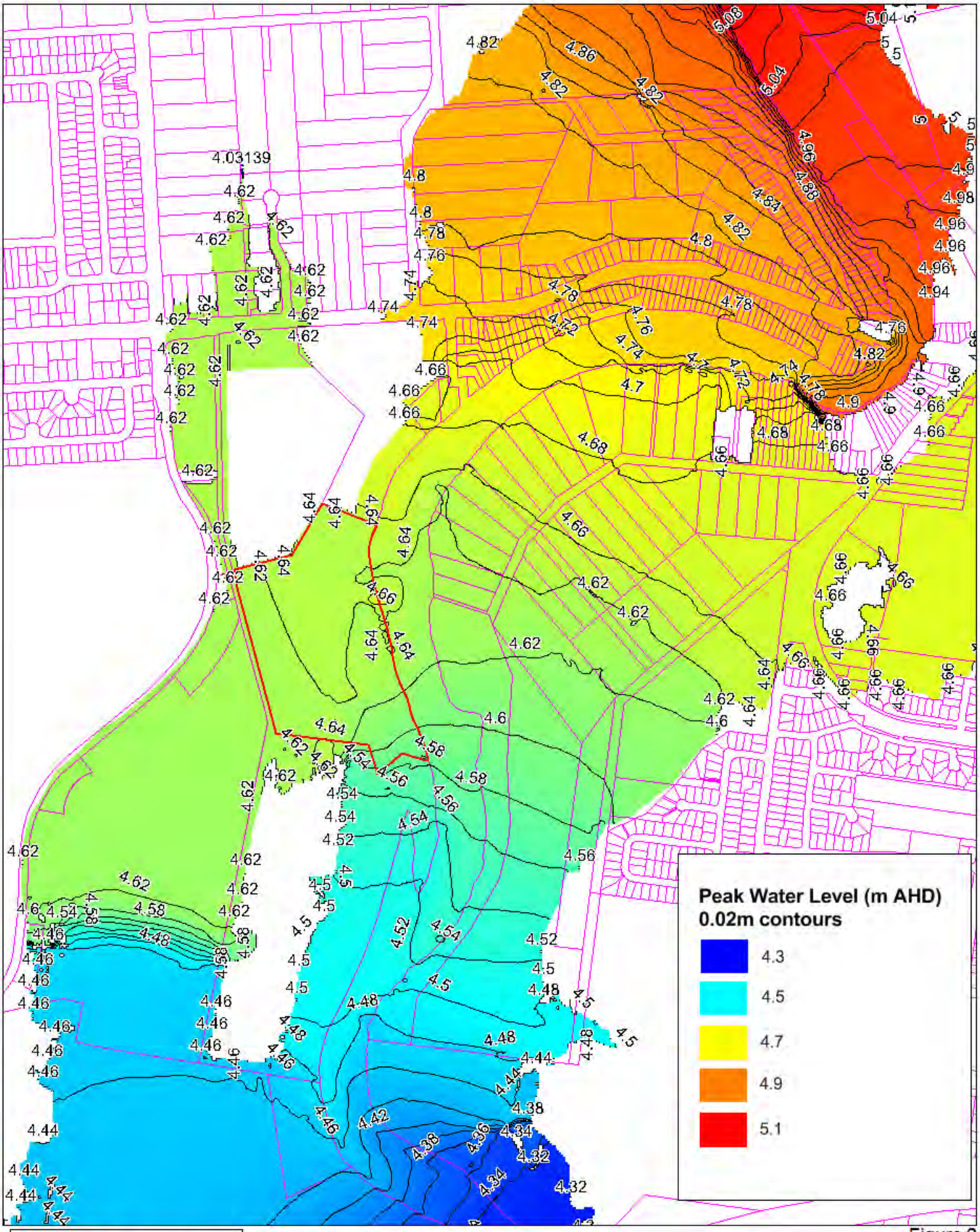


Cardno

NA49913037
January 2018

Georges Cove
Flood Impact Assessment

Figure 1
DEM
Post-Development Design (Jan18)

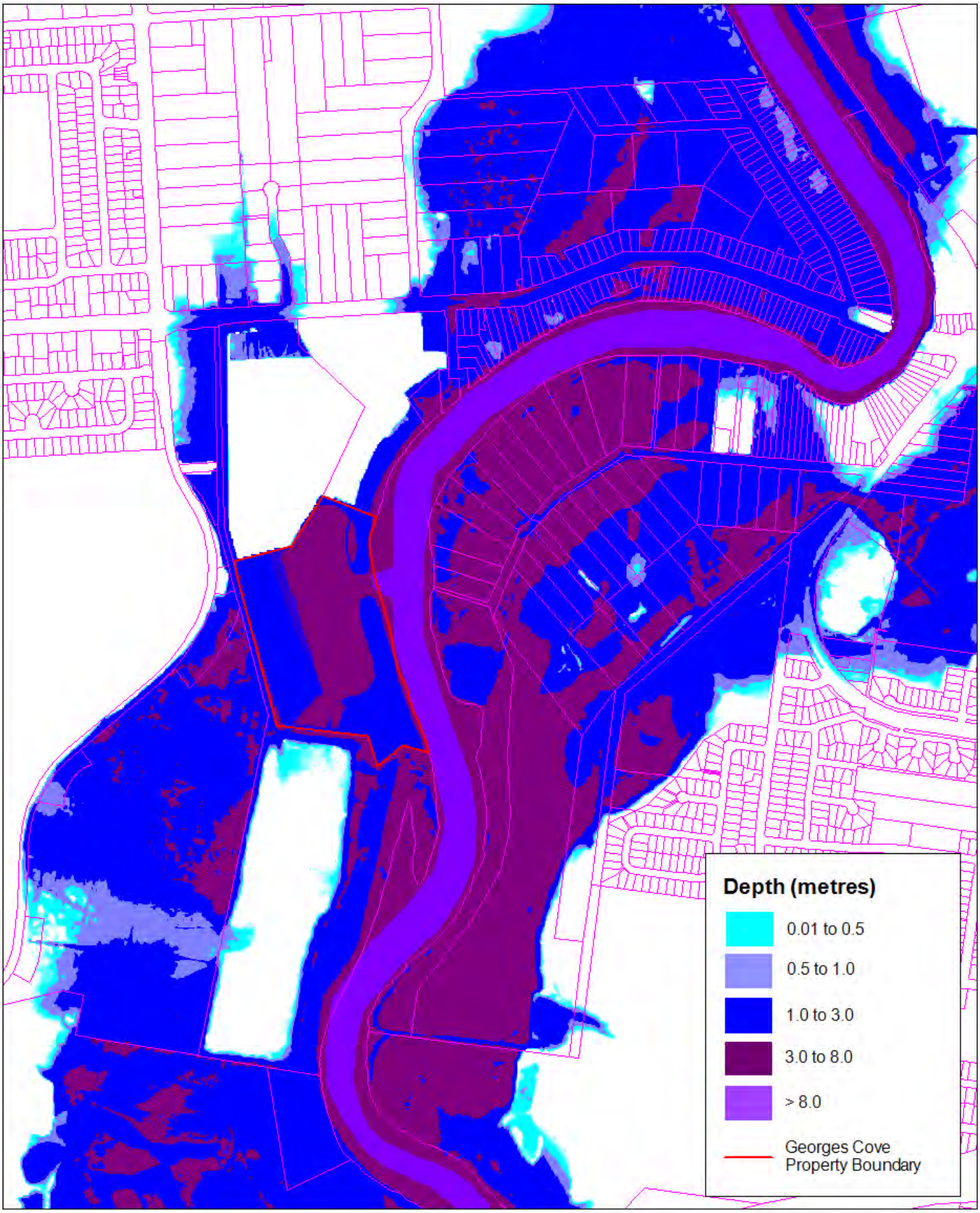


Cardno

NA49913037
January 2018

Georges Cove
Flood Impact Assessment

Figure 2
20 year ARI
Peak Water Level
Design (Jan18)

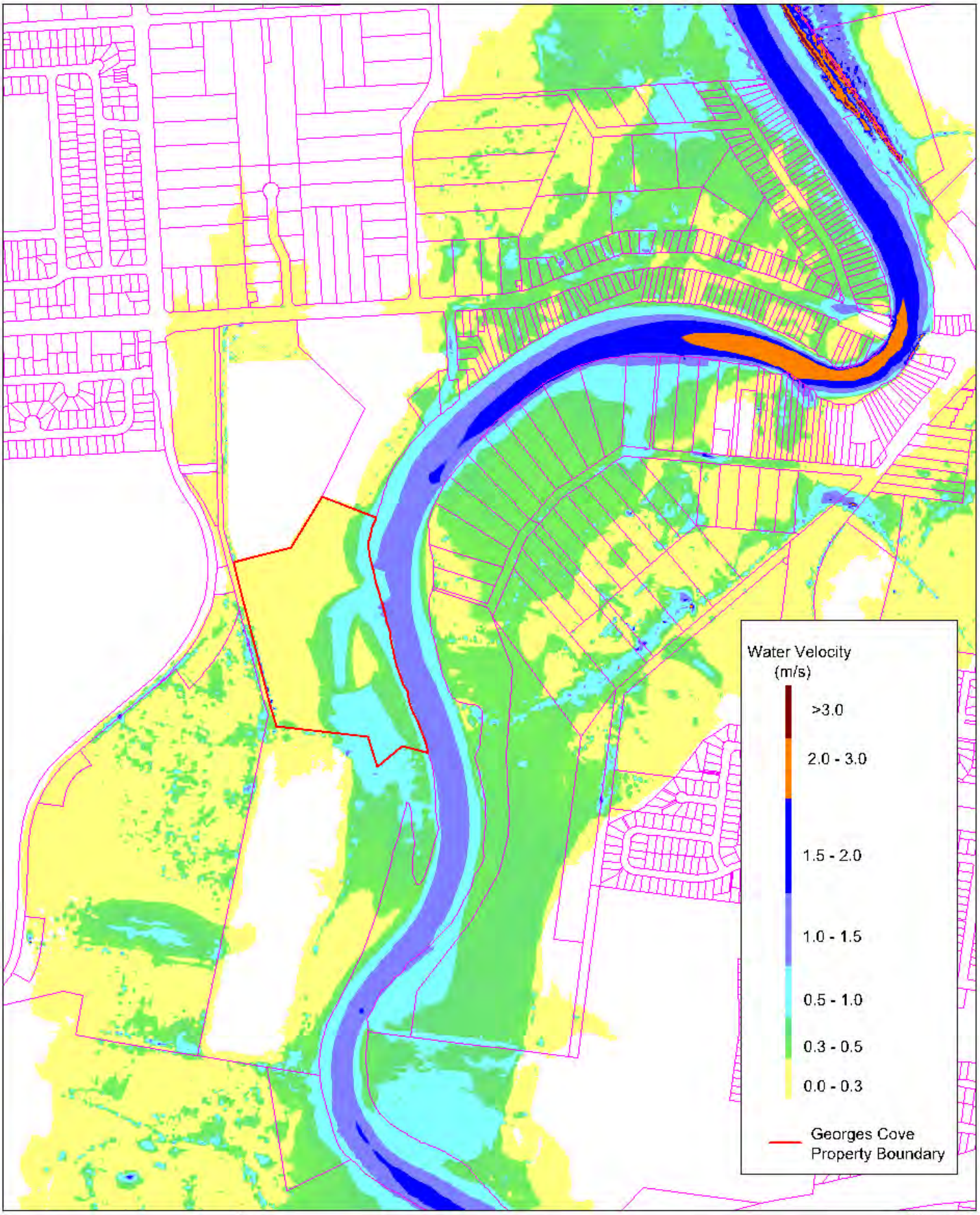


Cardno

NA49913037
January 2018

Georges Cove
Flood Impact Assessment

Figure 3
20 year ARI
Peak Depth
Design (Jan18)

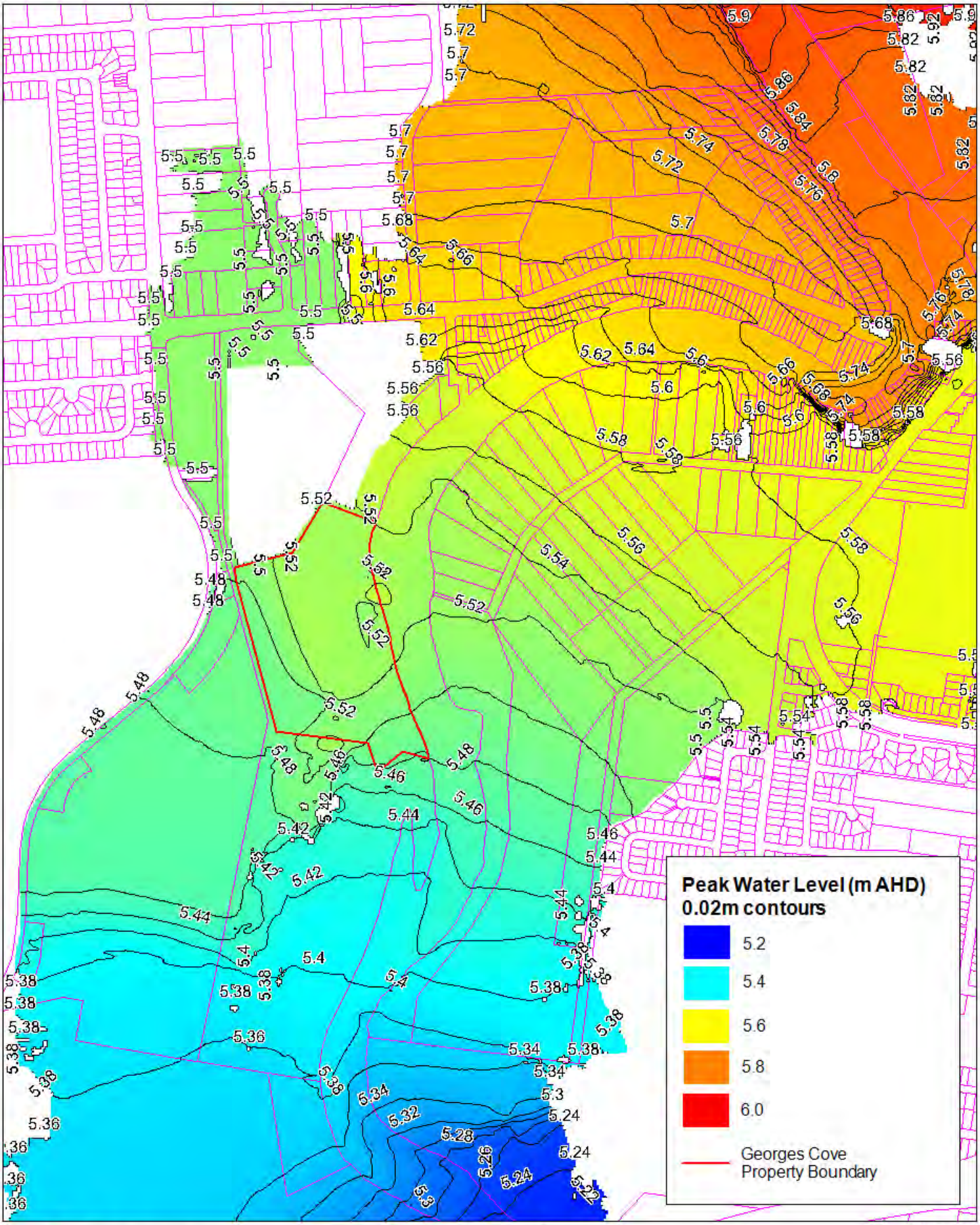


Cardno

NA49913037
January 2018

Georges Cove
Flood Impact Assessment

Figure 4
20 year ARI
Peak Velocity
Design (Jan18)

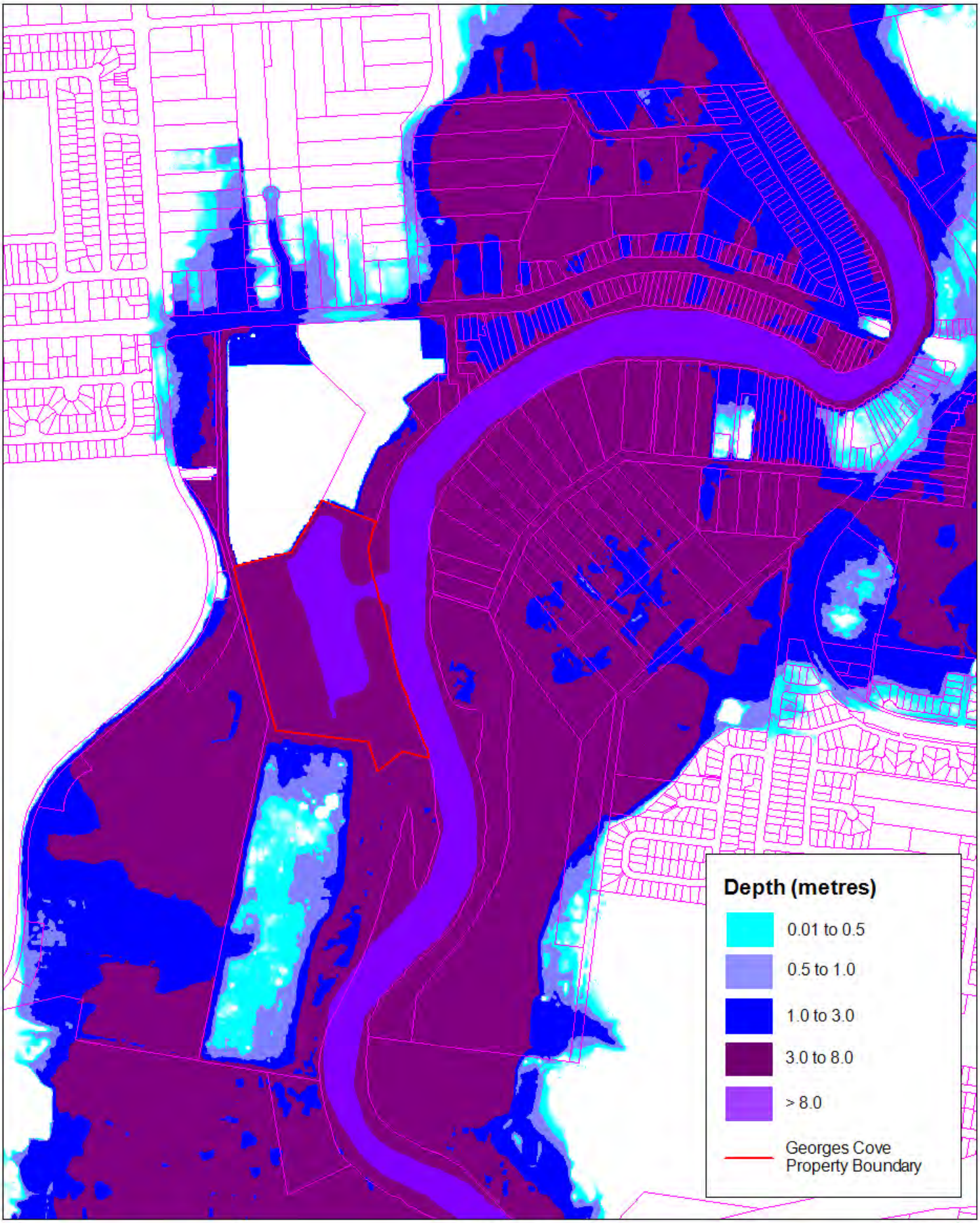


Cardno

NA49913037
January 2018

Georges Cove
Flood Impact Assessment

Figure 5
100 year ARI
Peak Water Level
Design (Jan18)

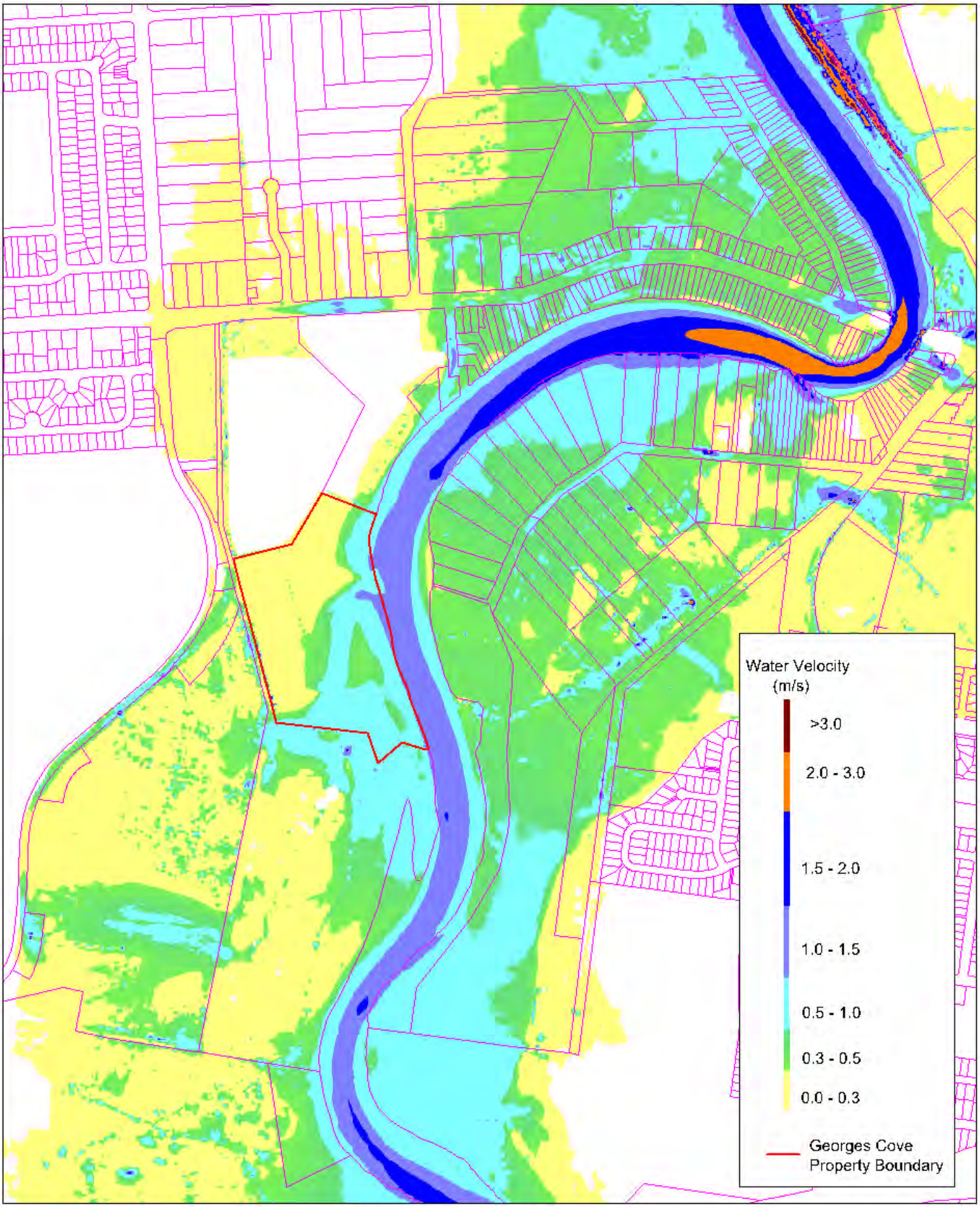


Cardno

NA49913037
January 2018

Georges Cove
Flood Impact Assessment

Figure 6
100 year ARI
Peak Depth
Design (Jan18)

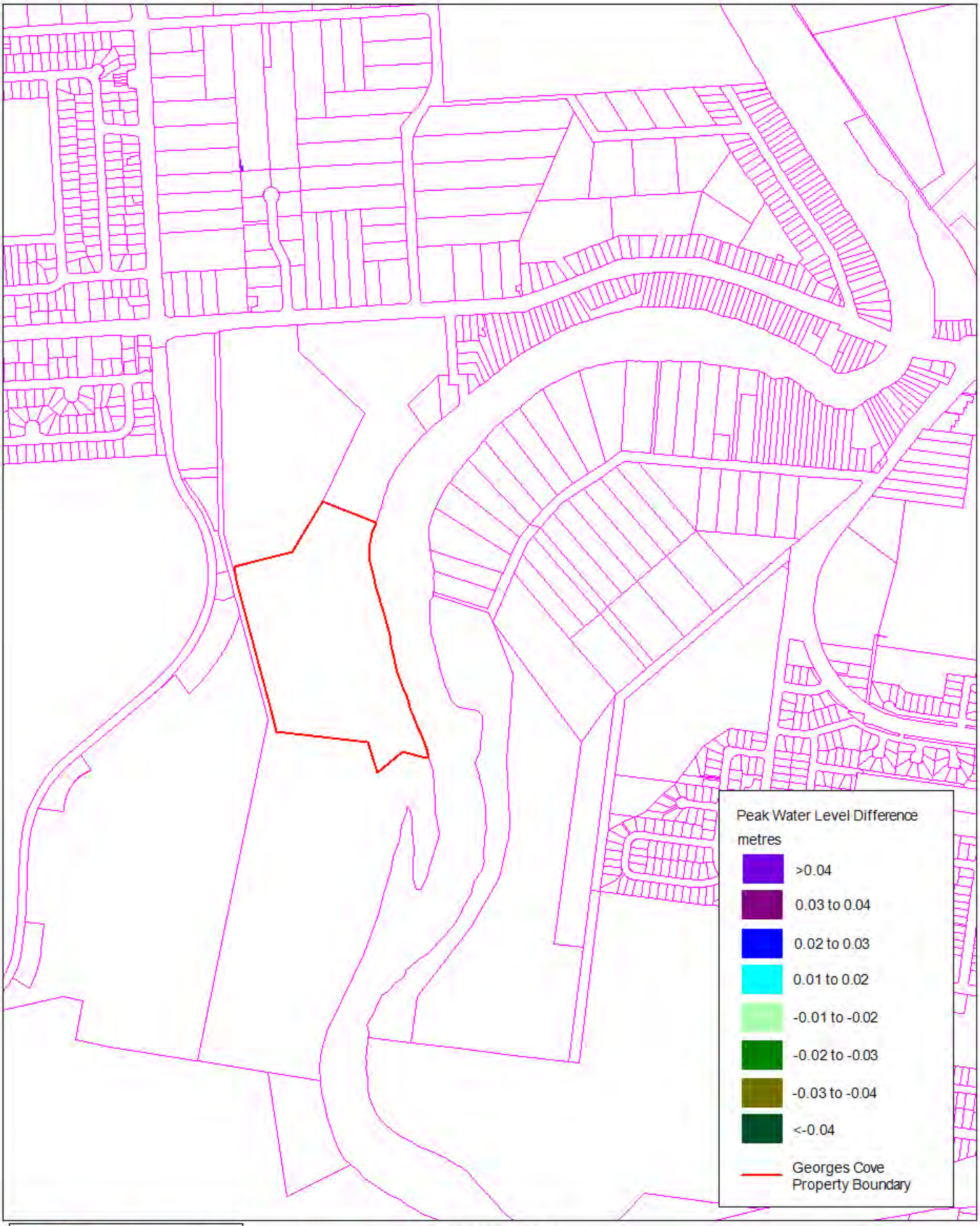


Cardno

Georges Cove
Flood Impact Assessment

Figure 7
100 year ARI
Peak Velocity
Design (Jan18)

NA49913037
January 2018

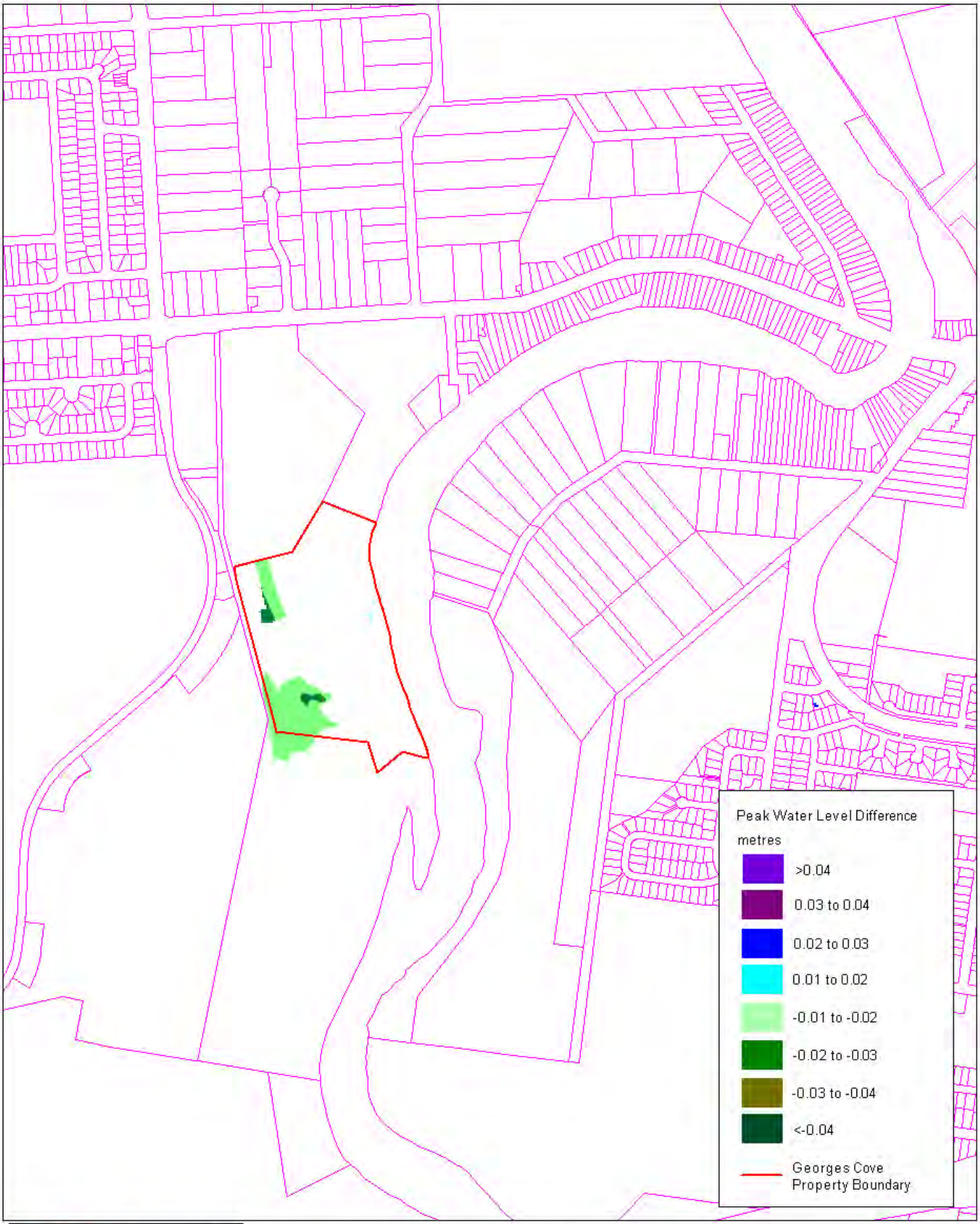


Cardno

Georges Cove
Flood Impact Assessment

Figure
20 year ARI
Peak Water Level Difference
Design (Jan18) Less Approved Design

NA49913037
January 2018

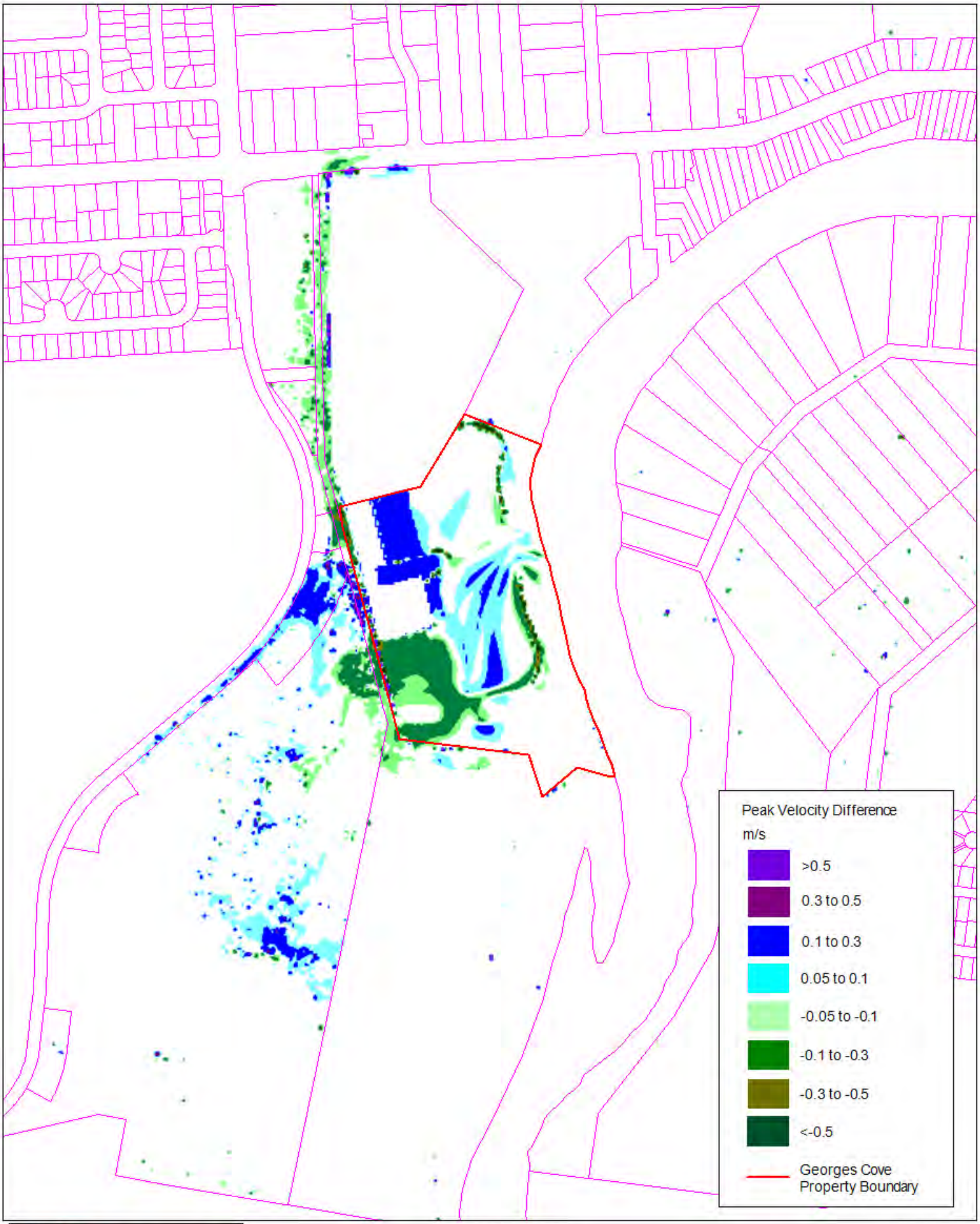


Cardno

Georges Cove
Flood Impact Assessment

Figure
100 year ARI
Peak Water Level Difference
Design (Jan18) Less Approved Design

NA49913037
January 2018

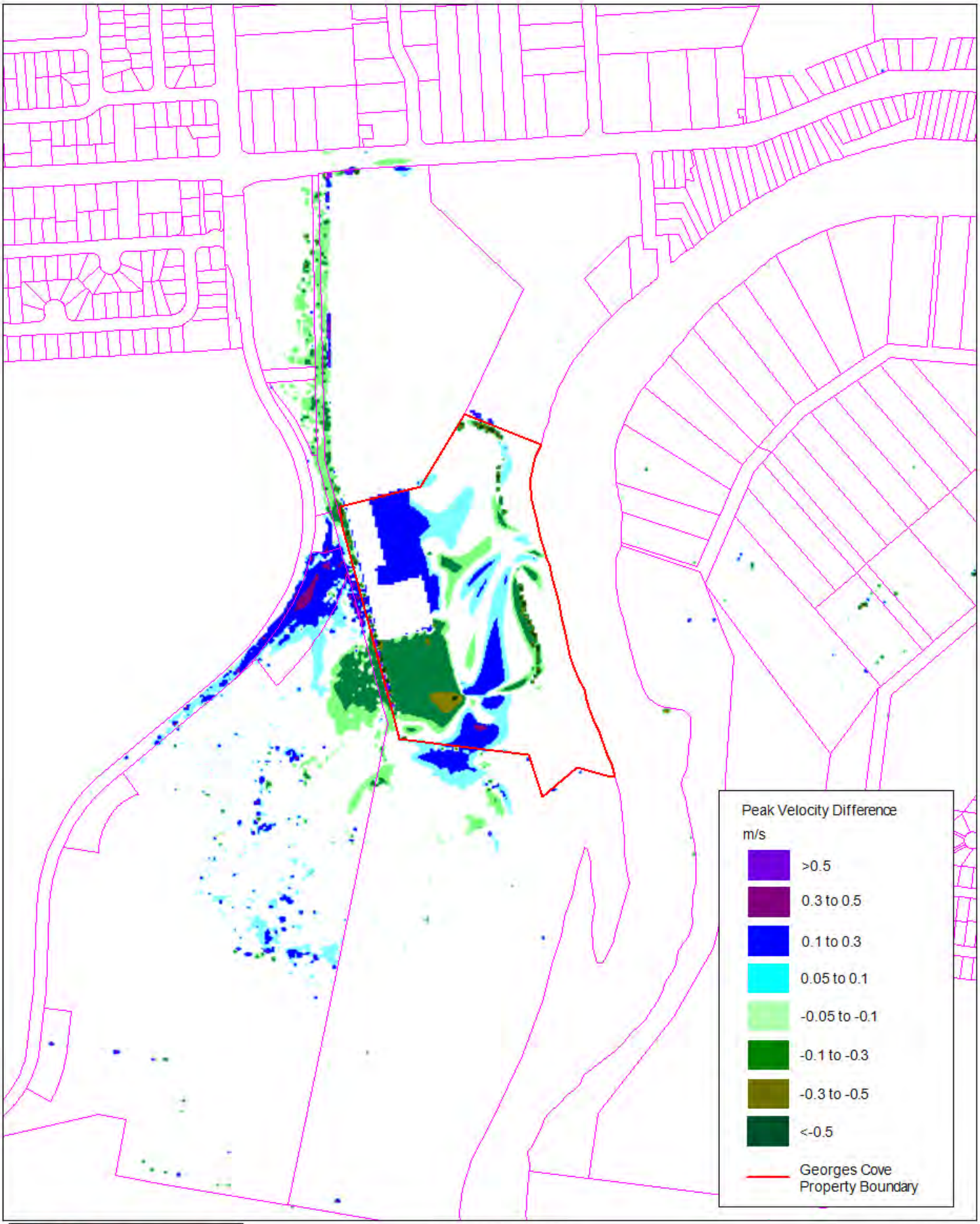


Cardno

Georges Cove
Flood Impact Assessment

Figure
20 year ARI
Peak Velocity Difference
Design (Jan18) Less Approved Design

NA49913037
January 2018



Cardno

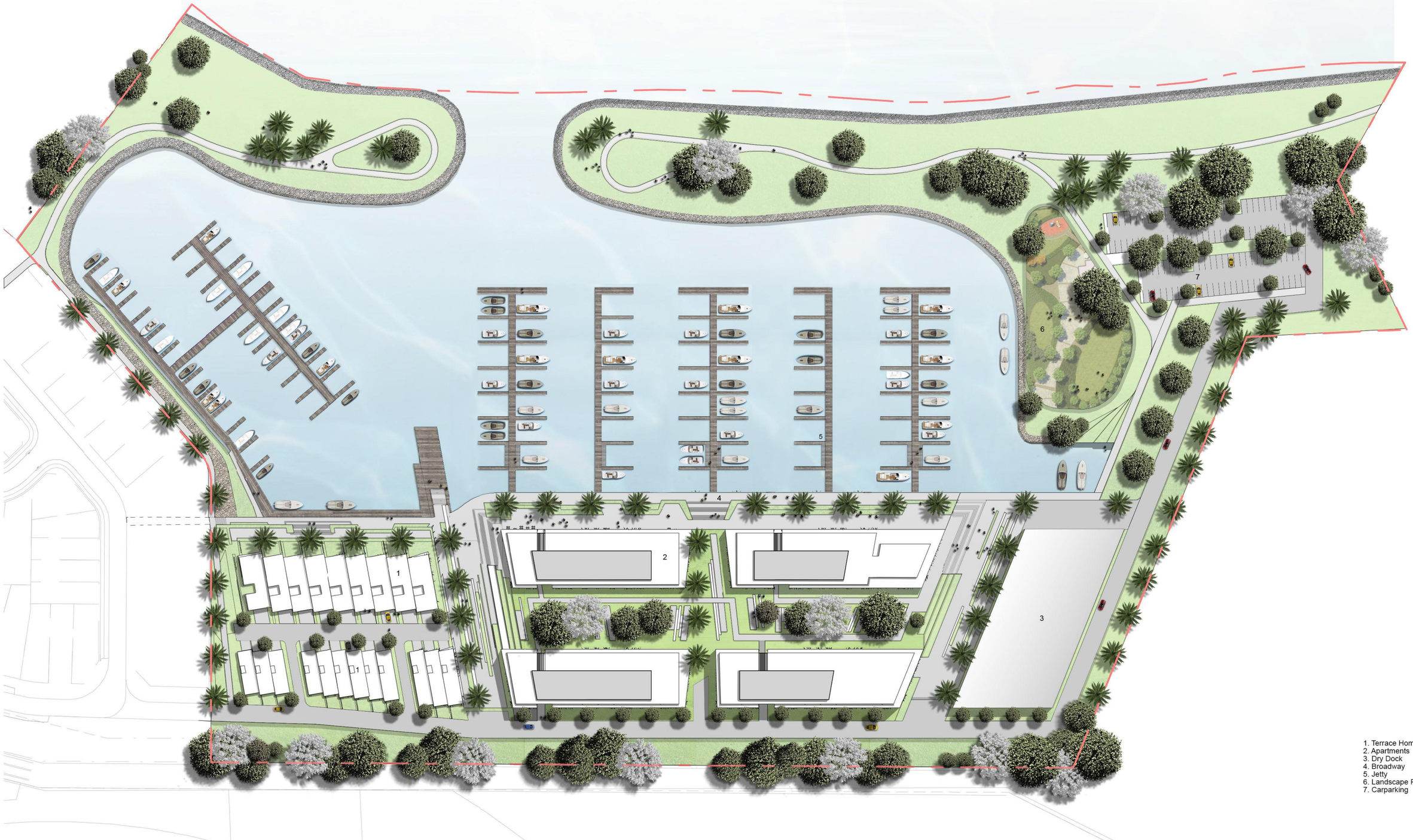
Georges Cove
Flood Impact Assessment

Figure
100 year ARI
Peak Velocity Difference
Design (Jan18) Less Approved Design

NA49913037
January 2018

CONTENTS

MIRVAC
DESIGN



1. Terrace Homes
2. Apartments
3. Dry Dock
4. Broadway
5. Jetty
6. Landscape Park
7. Carparking

Georges Cove Marina

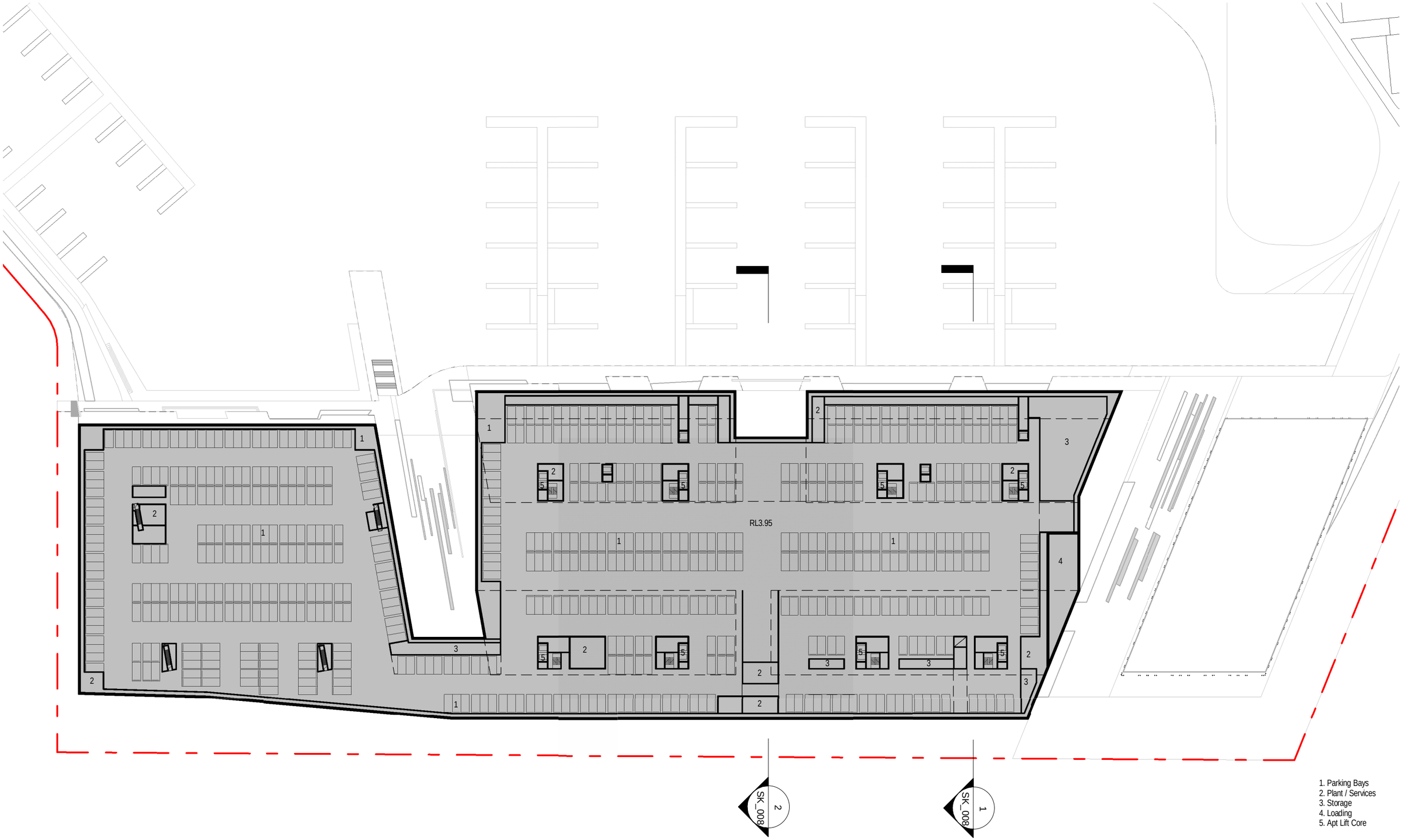
0 18.75 37.5 75

Scale 1 : 1500

SITE PLAN

SK_001

MIRVAC
DESIGN



1. Parking Bays
2. Plant / Services
3. Storage
4. Loading
5. Apt Lift Core

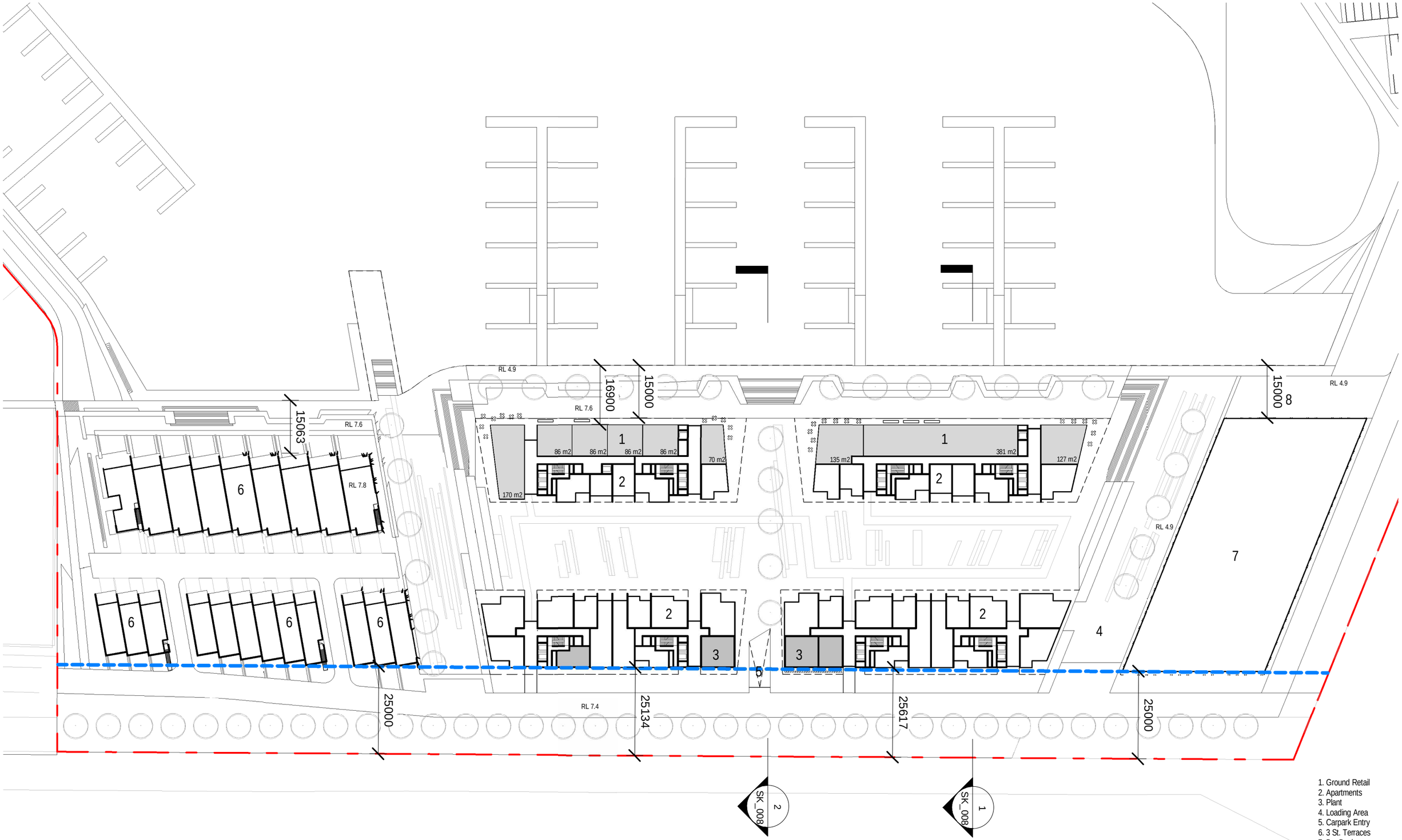
Georges Cove Marina

0 12.5 25 50
Scale 1 : 1000

BASEMENT

SK_002 E

MIRVAC
DESIGN



1. Ground Retail
2. Apartments
3. Plant
4. Loading Area
5. Carpark Entry
6. 3 St. Terraces
7. Dry Dock
8. Dry Dock Loading

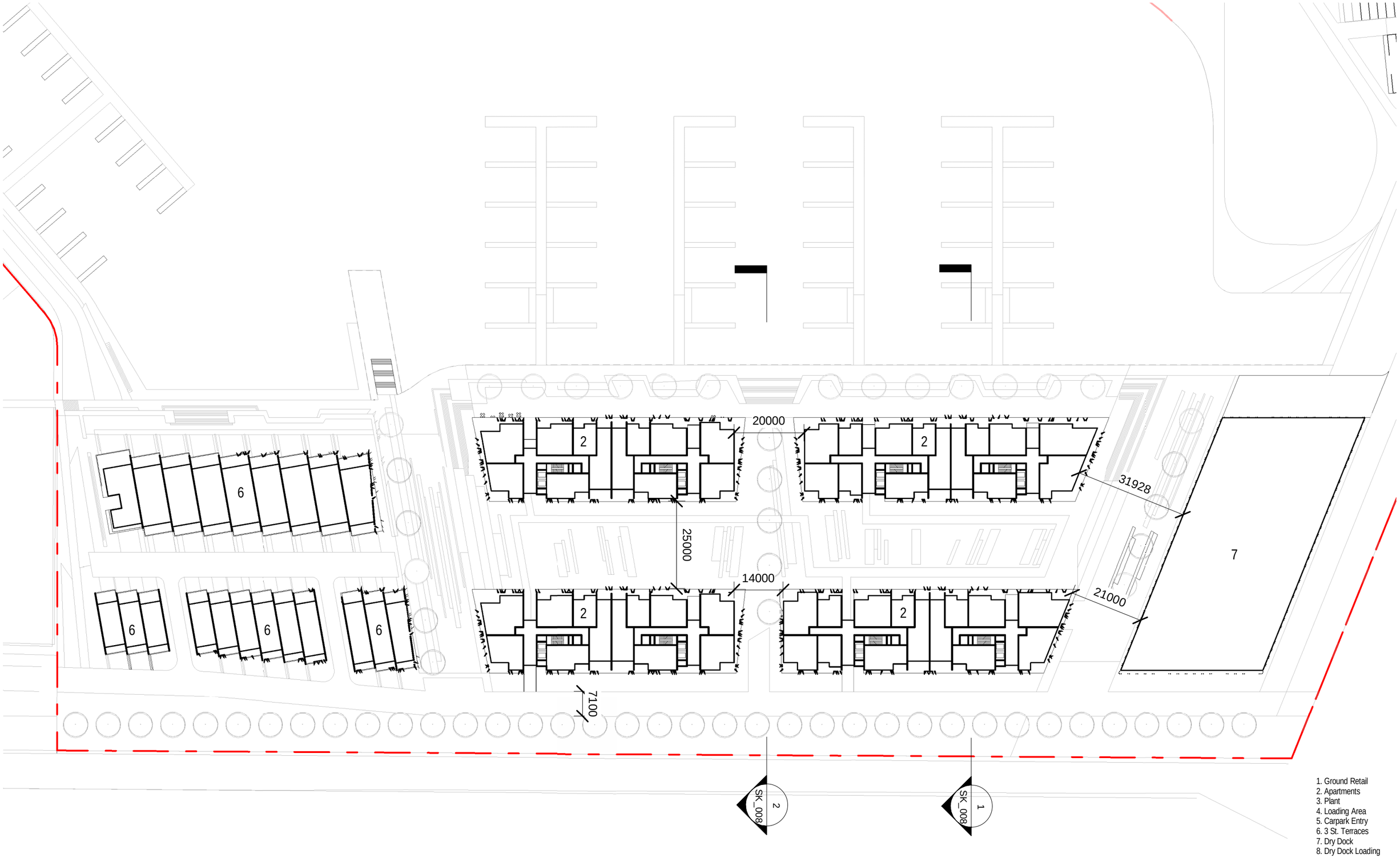
Georges Cove Marina

0 6.25 12.5 25
Scale 1 : 500

LEVEL 1

SK_003 E

MIRVAC
DESIGN



1. Ground Retail
2. Apartments
3. Plant
4. Loading Area
5. Carpark Entry
6. 3 St. Terraces
7. Dry Dock
8. Dry Dock Loading

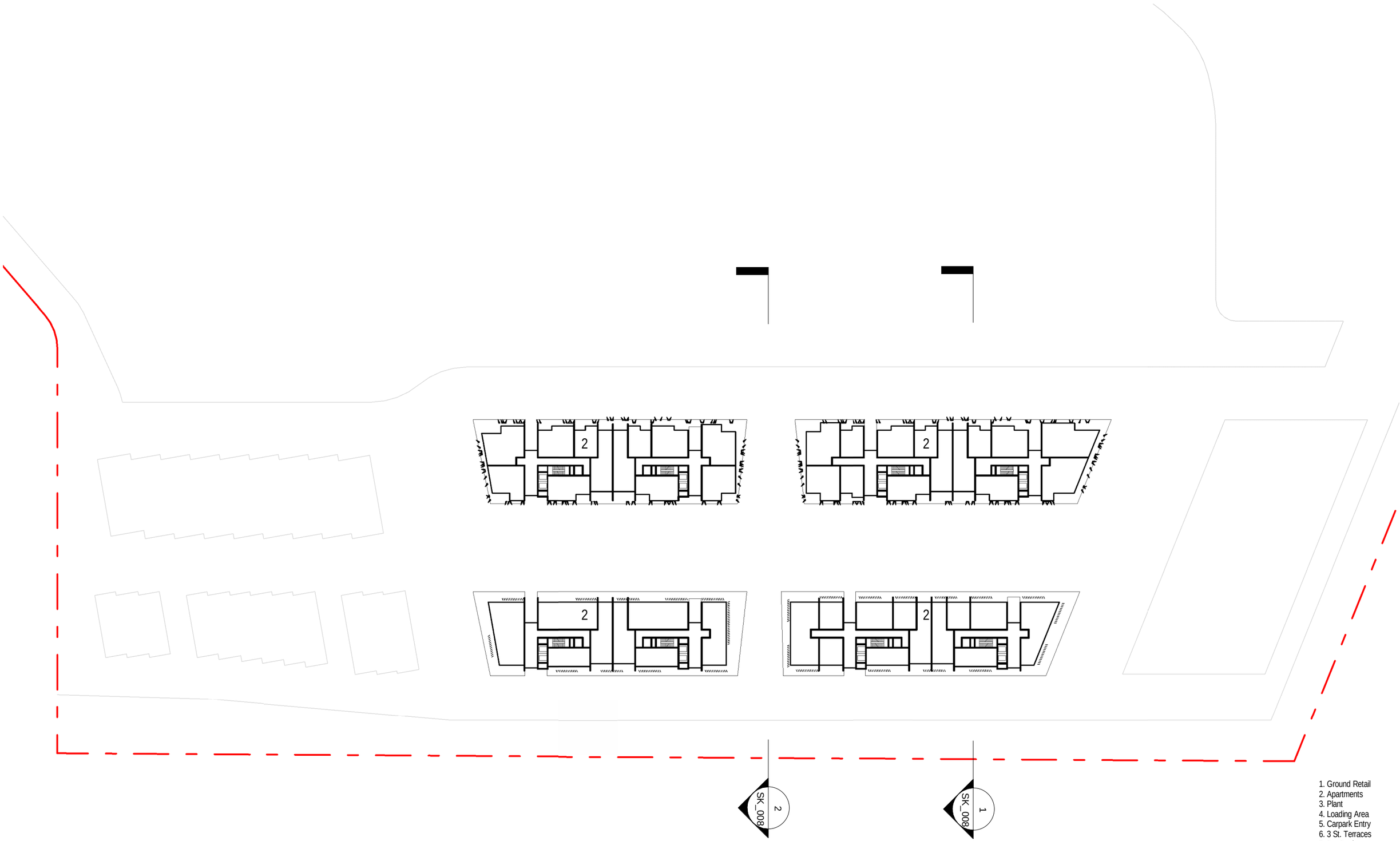
Georges Cove Marina

0 6.25 12.5 25
Scale 1 : 500

LEVEL 2-6 (excl. Terraces)

SK_004 E

MIRVAC
DESIGN



1. Ground Retail
2. Apartments
3. Plant
4. Loading Area
5. Carpark Entry
6. 3 St. Terraces
7. Dry Dock
8. Dry Dock Loading

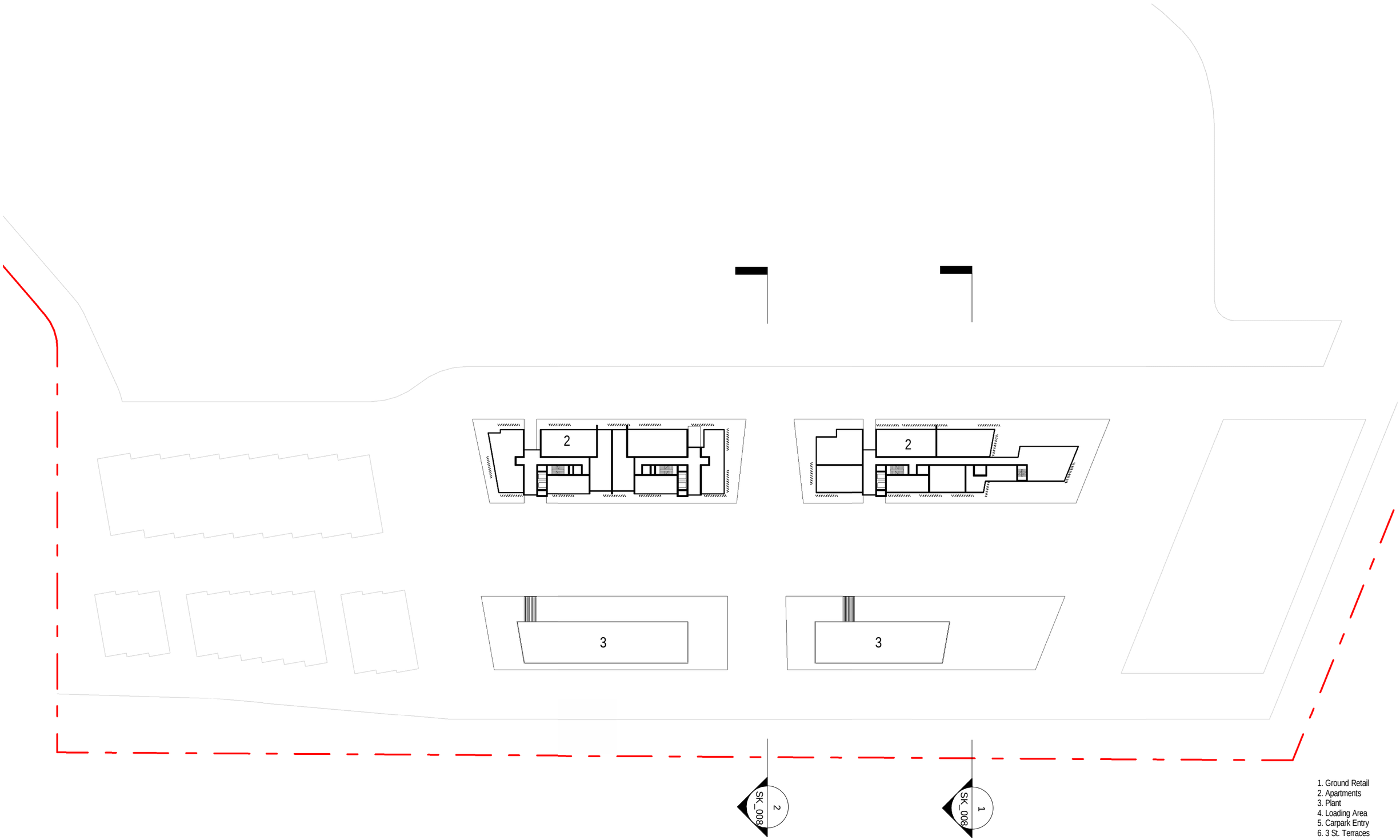
Georges Cove Marina

0 6.25 12.5 25
Scale 1 : 500

LEVEL 7

SK_005 E

MIRVAC
DESIGN



1. Ground Retail
2. Apartments
3. Plant
4. Loading Area
5. Carpark Entry
6. 3 St. Terraces
7. Dry Dock
8. Dry Dock Loading

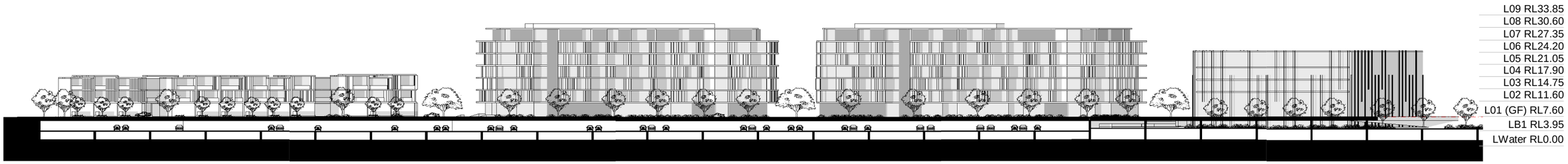
Georges Cove Marina

0 6.25 12.5 25
Scale 1 : 500

LEVEL 8

SK_006 E

MIRVAC
DESIGN



Georges Cove Marina

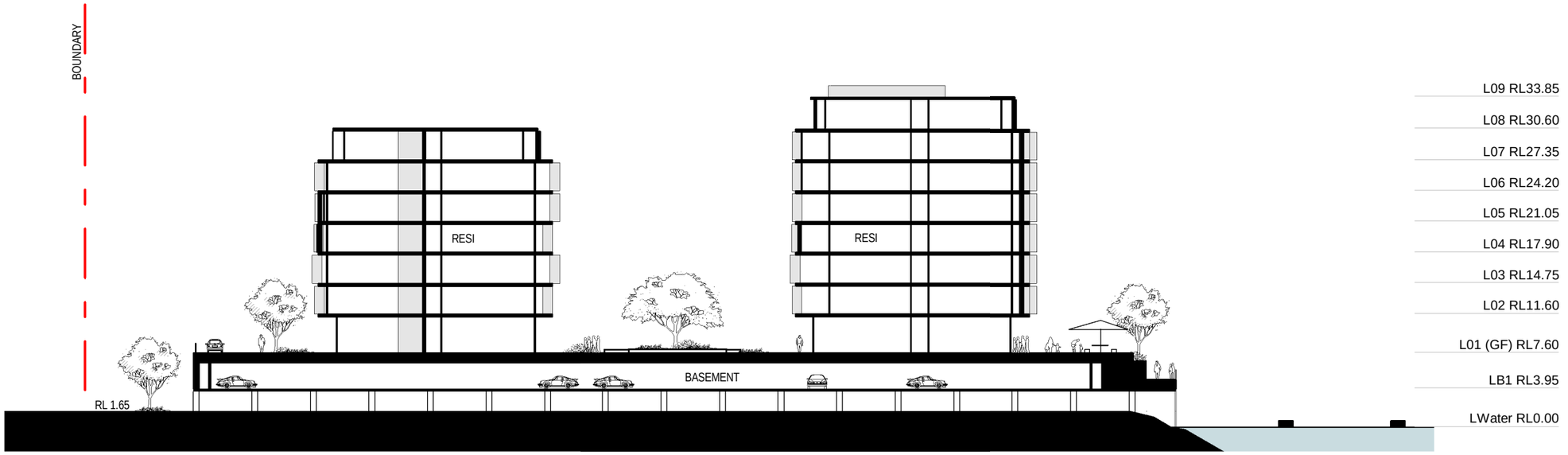
0 12.5 25 50

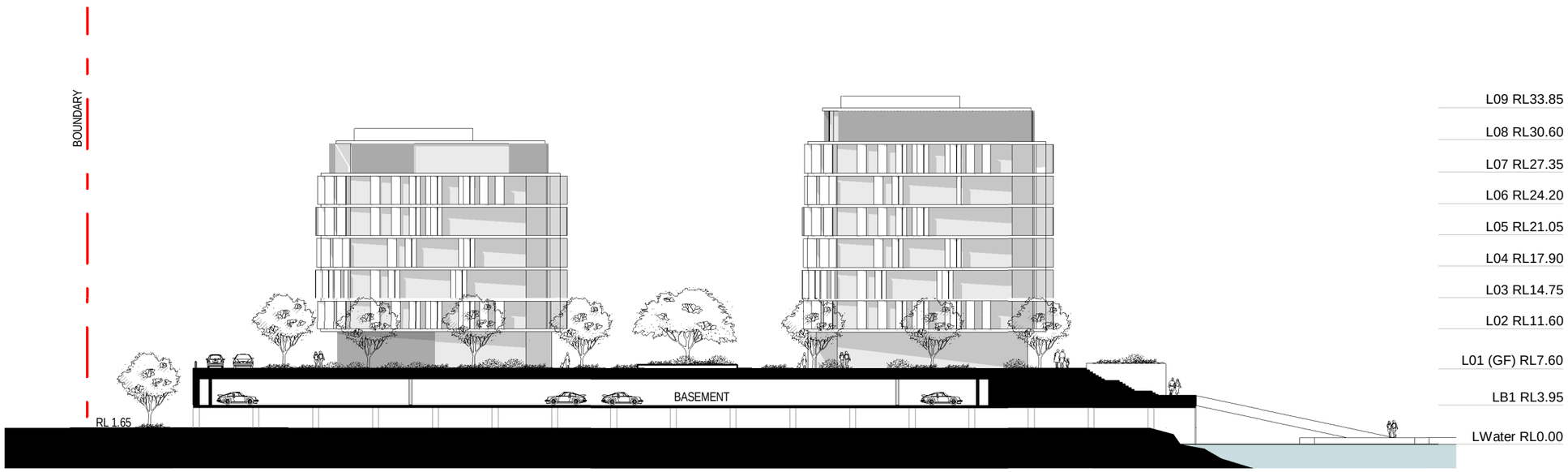
Scale 1 : 1000

ELEVATIONS

SK_007 E

MIRVAC
DESIGN





Georges Cove Marina

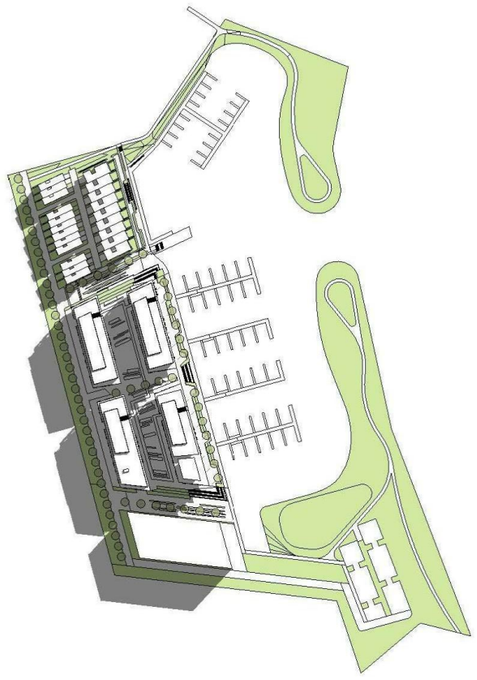
0 6.25 12.5 25

Scale 1 : 500

SECTIONS

SK_008 E

MIRVAC
DESIGN



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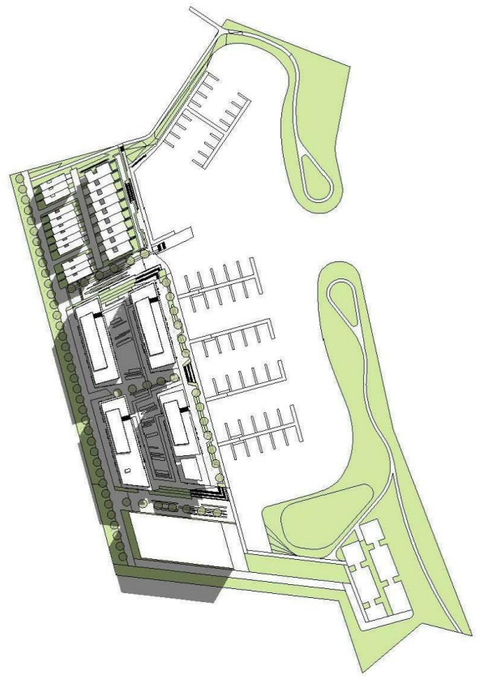

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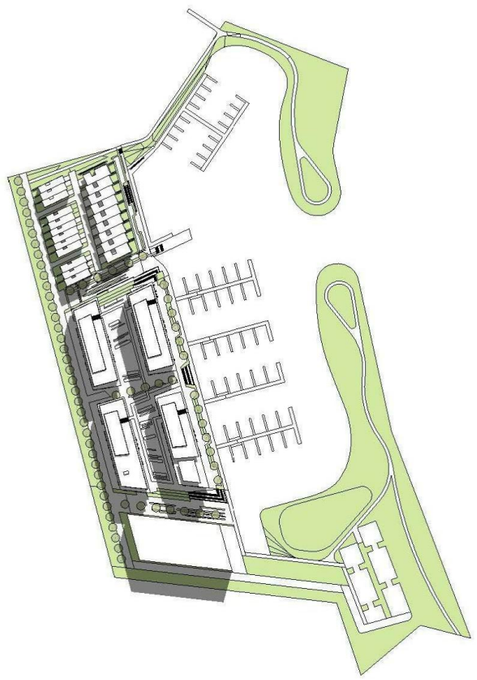

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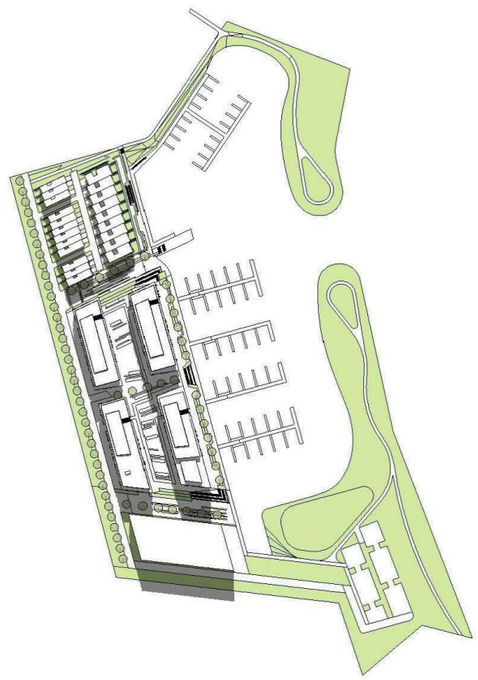


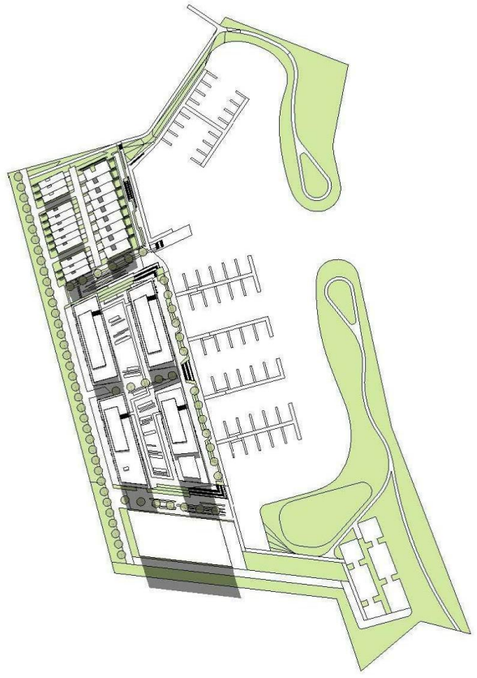
12pm - 21st June

Georges Cove Marina

SHADOW DIAGRAMS

SK_009 E

MIRVAC
DESIGN



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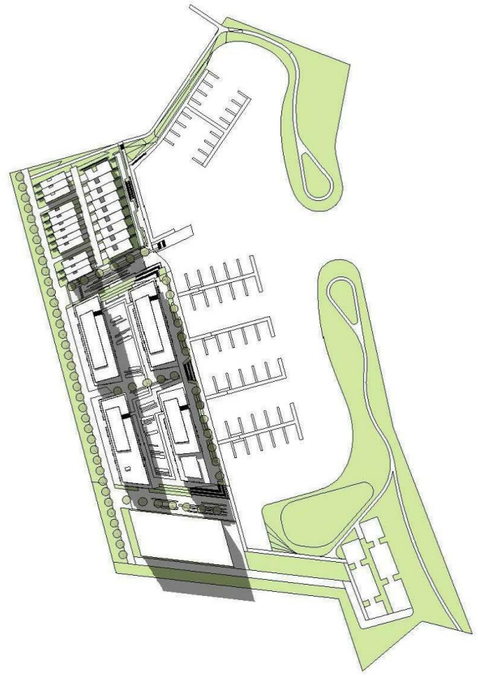

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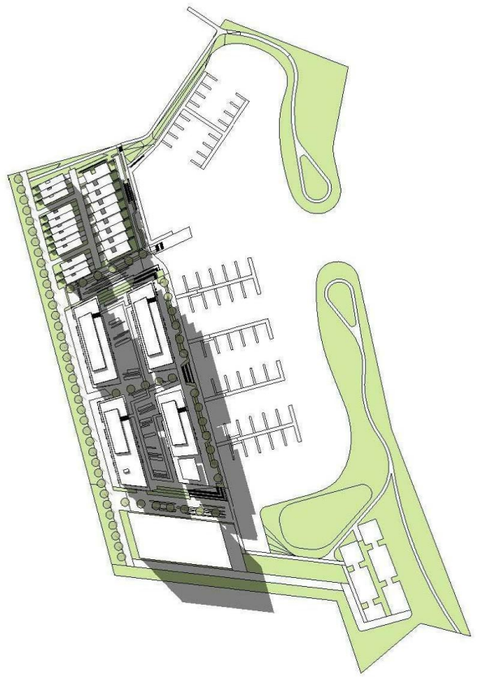


3pm - 21st June

Georges Cove Marina

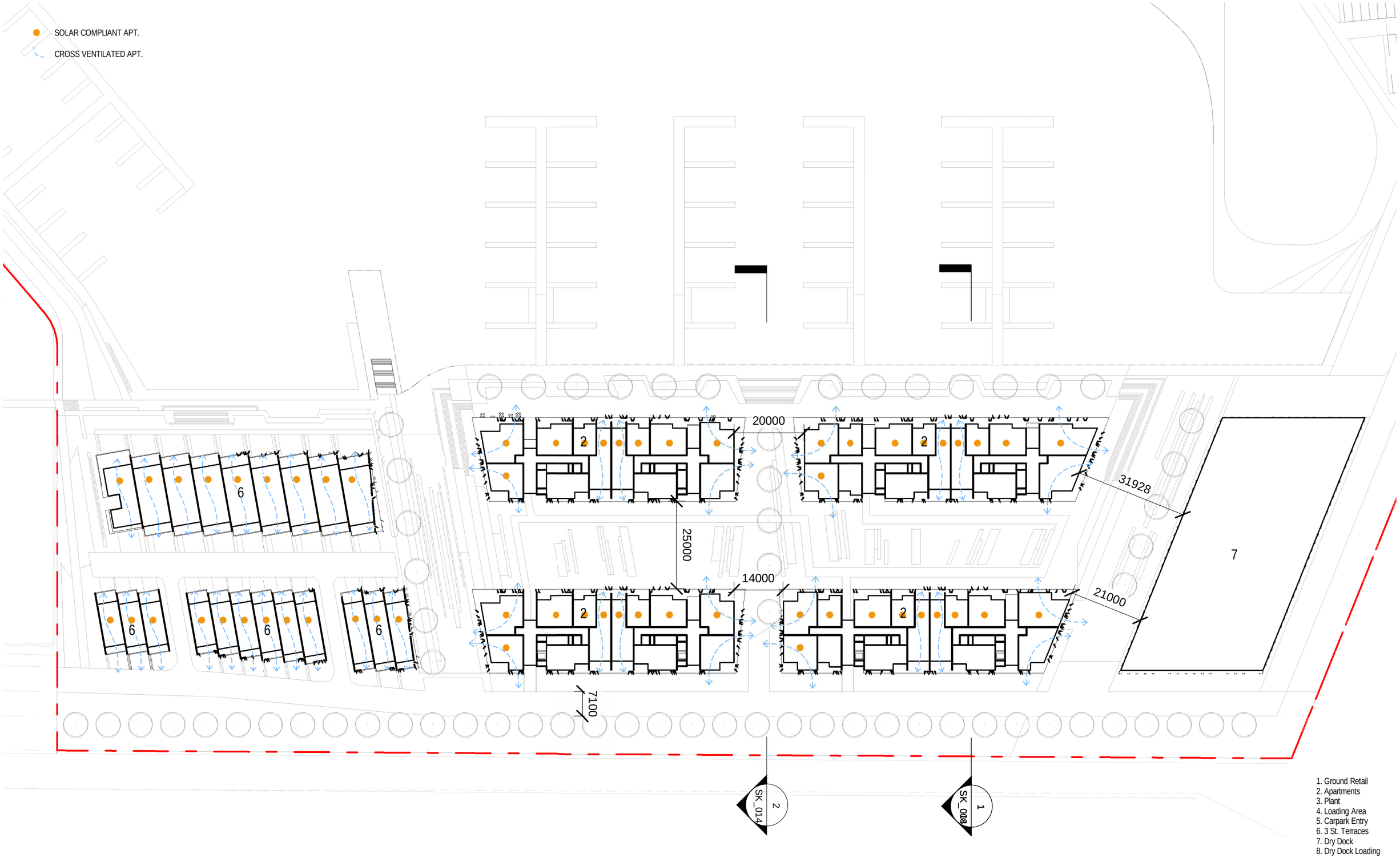
SHADOW DIAGRAMS

SK_010 E

MIRVAC
DESIGN

SOLAR COMPLIANT APT.

CROSS VENTILATED APT.



1. Ground Retail
2. Apartments
3. Plant
4. Loading Area
5. Carpark Entry
6. 3 St. Terraces
7. Dry Dock
8. Dry Dock Loading

Georges Cove Marina

0 12.5 25 50

Scale 1 : 1000

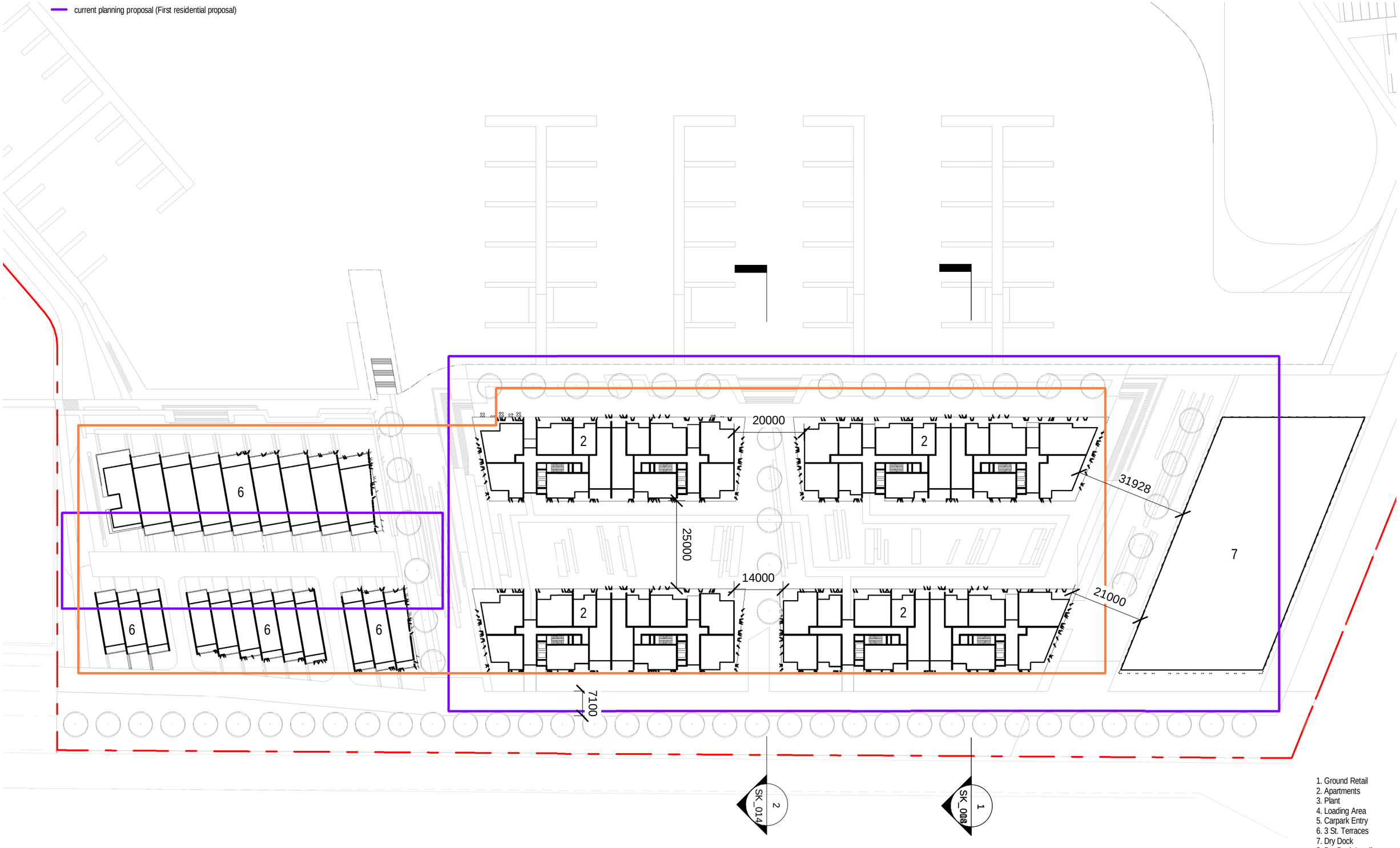
COMPLIANCE - L2-6 (typical)

SK_011 E

MIRVAC
DESIGN

DA-781/2015

current planning proposal (First residential proposal)



1. Ground Retail
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5. Carpark Entry
6. 3 St. Terraces
7. Dry Dock
8. Dry Dock Loading

Georges Cove Marina

0 12.5 25 50

Scale 1 : 1000

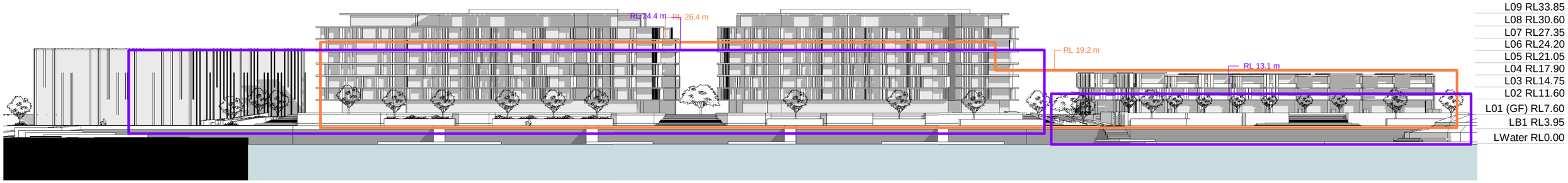
COMPLIANCE - L2-6 (typical)

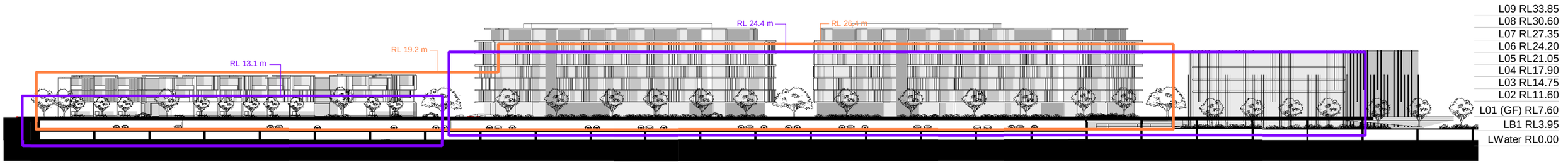
SK_012 E

MIRVAC
DESIGN

DA-781/2015

current planning proposal (First residential proposal)





Georges Cove Marina

0 12.5 25 50

Scale 1 : 1000

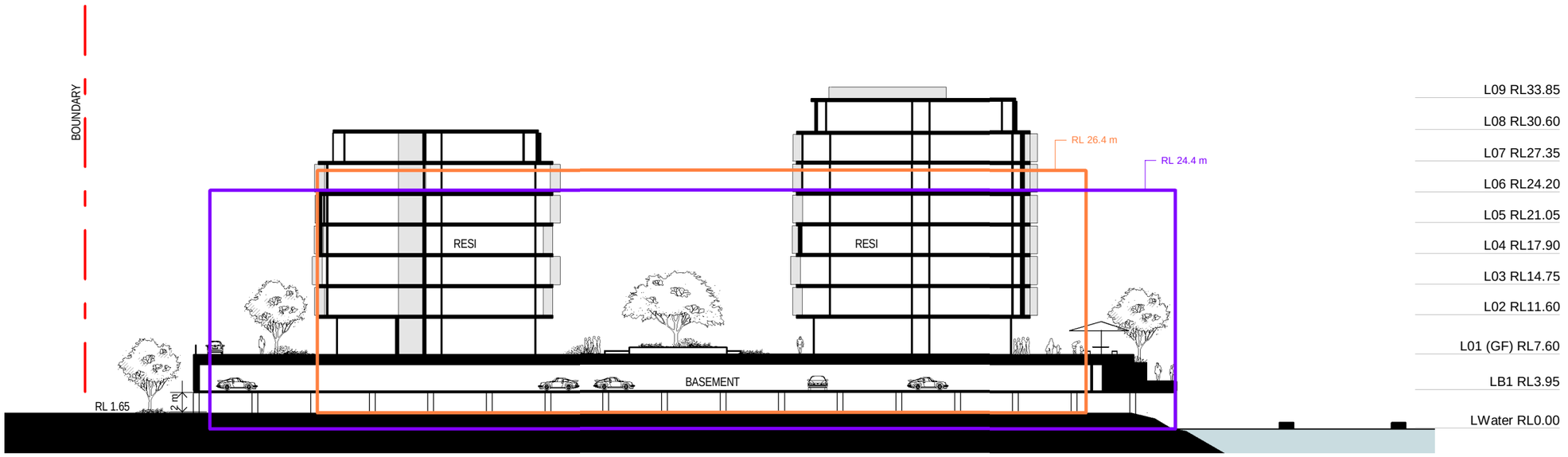
COMPLIANCE - ELEVATION

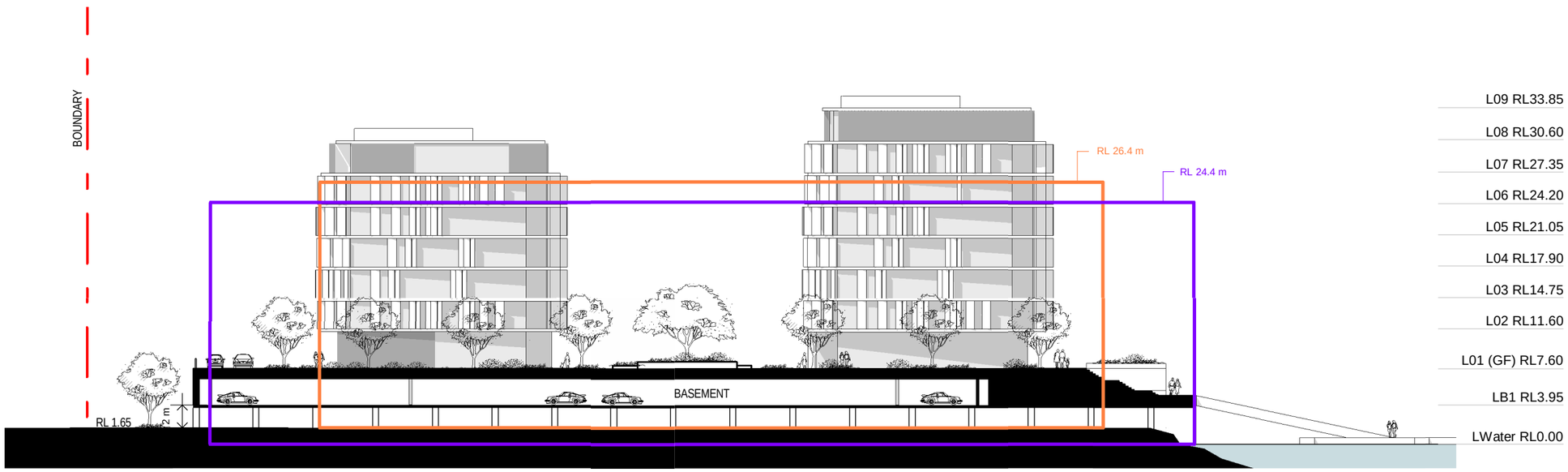
SK_013 E

MIRVAC DESIGN

DA-781/2015

current planning proposal (First residential proposal)





Georges Cove Marina

0 6.25 12.5 25

Scale 1 : 500

COMPLIANCE - SECTION

SK_014 E

MIRVAC
DESIGN

Georges Cove Marina

PERSPECTIVE

SK_015 E

MIRVAC
DESIGN

Georges Cove Marina

PERSPECTIVE

SK_016 E

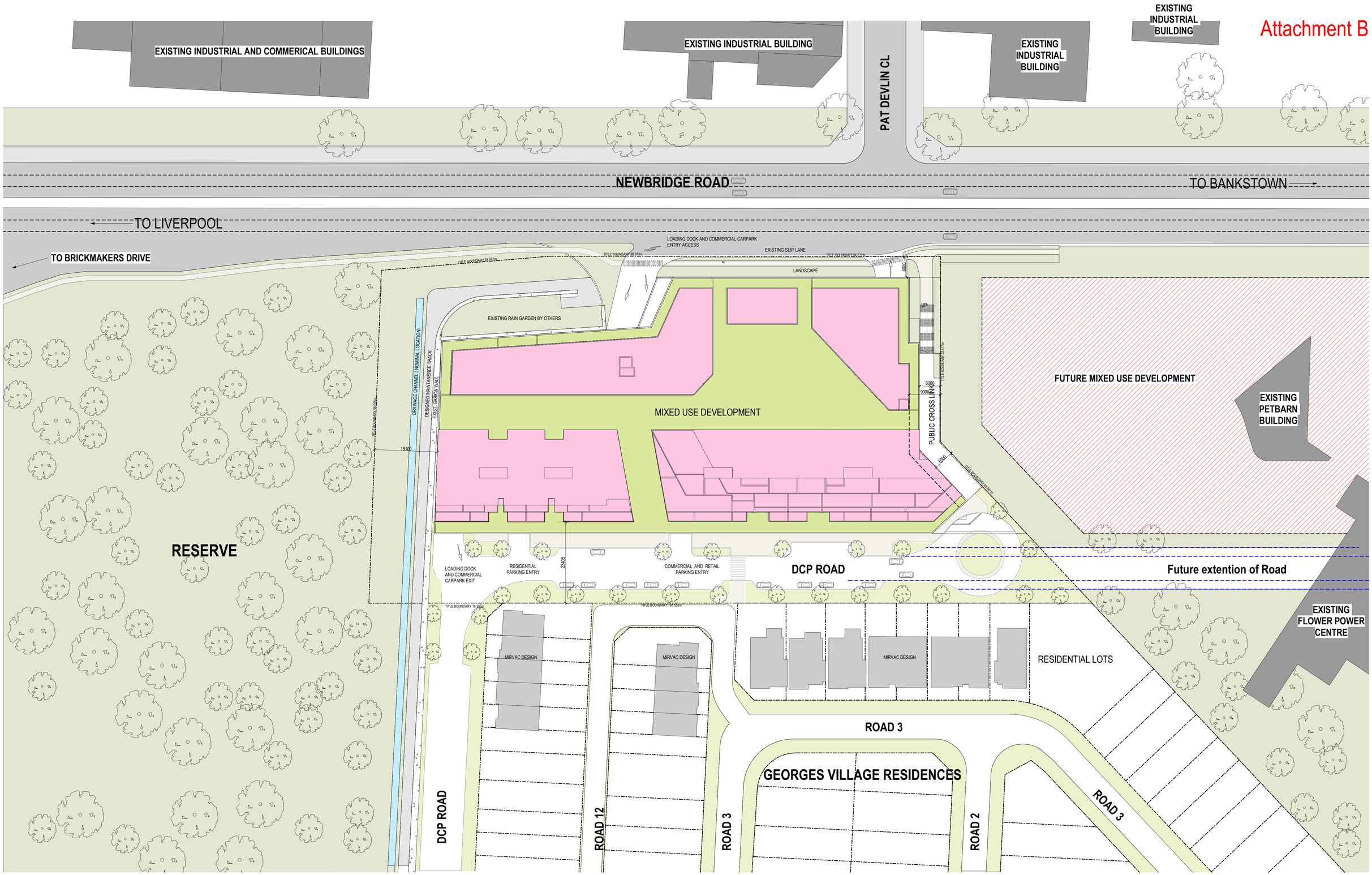
MIRVAC
DESIGN

Georges Cove Marina

PERSPECTIVE

SK_017 E

Attachment B



PRELIMINARY

Revisions

P2	28.06.17	FOR INFORMATION	JM
P3	17.07.17	FOR PLANNER REVIEW	JM
P4	19.07.17	FOR PLANNER REVIEW	AK
P5	02.08.17	FOR TRAFFIC ENGINEER	AK
P6	22.08.17	FOR CONSULTANTS	JM

22/08/2017 8:14:10 PM

Project: **GEORGES COVE VILLAGE**
146 Newbridge Rd
MOOREBANK, NSW

Drawing: **SITE PLAN**

Project No: **214205**

Date: **11/05/2017**

Author: **JM**

Scale: @ A1 **1 : 500**

Drawing No.: **SK00.003 P6**

rothelowman

Brisbane, Melbourne, Sydney
www.rothelowman.com.au