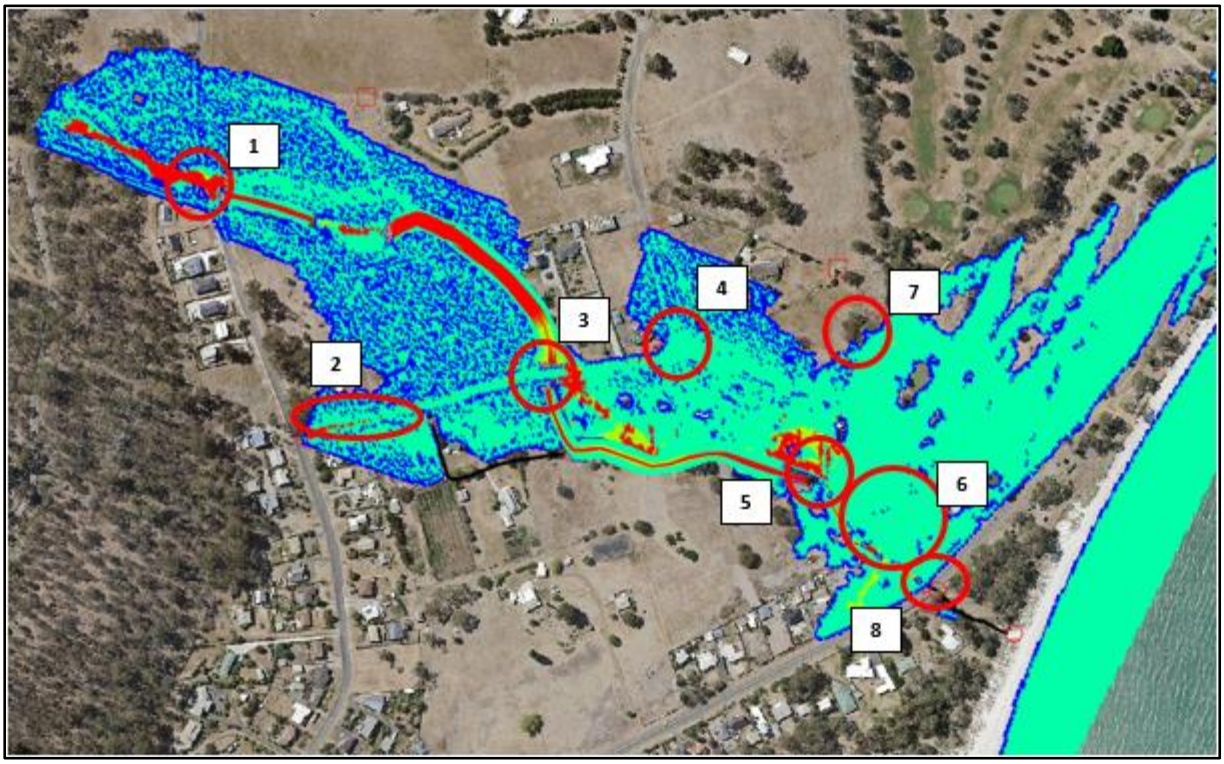
Holkham Court Stormwater Assessment

GLAMORGAN SPRING BAY COUNCIL 2019

Brighton Council Anna Wilson



Prepared for for Glamorgan Spring Bay Council

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Revision 3 *Final.*

Contents

1. Summary

The Holkham Court area is contained within a small valley with a minor watercourse running through the centre of the area. The area is zoned predominantly as low density residential which allows for increased development of the lower half of the catchment. The area has received significant rainfall events causing flooding issues including inundation of the lower areas and some impacts on properties and roads. Management of the flow path is critical for continued development of the area.

This report and associated modelling, considers the existing condition of the catchment, examines the catchment as if it is fully developed within the existing planning scheme limitations and considers possible solutions to the stormwater and drainage issues that arise. The modelling considers a 5% and 1% AEP (20yr and 100yr ARI) with a climate change increase factor of 30%.

Important considerations that have arisen from both observation and the modelling results include: that although the drainage line is predominantly dry, it does have the characteristics of a small watercourse rather than an urban drainage line. The practical application of this, is that in large events it will act as a small creek and the flow regime will not be dominated by rates of development in the lower catchment.

It is also important to note that the very lower portion of the catchment, including areas of the caravan park and golf course, have low elevations and it may be impossible to eliminate inundation in these areas. These areas may also be impacted by storm surge from the nearby bay however this is outside of the scope of this report.

Climate change impacts have been considered in the modelling, and all modelling has been run assuming a 30% increase in runoff. This is considered a starting point and further investigations indicate that climate change impacts may be greater than this. To manage the uncertainty and the possible impacts, it is advised that the flow route be maintained with enough area that the major overland flow path may be increased in future if required. The importance of identified overland flow paths and their management is critical to future proofing the stormwater network.

The modelling has found that maintaining the overland flow path, combined with recommended infrastructure works will allow the area to be developed without further impacting properties.

2. Overview

The northern area of Orford is located within a small catchment of an unnamed minor watercourse that runs from Rudds hill to an outfall behind Raspins Beach. The base of the catchment consists of residential developed areas, undeveloped areas, a caravan park and a highway. Many of these areas have received some inundation in recent, large rainfall events.

Development applications have been received for significant portions of the midsection of the catchment. These will increase the number of roads, amount of drainage infrastructure and the impervious percentages of the catchment, with possible effects on the downstream properties.

Glamorgan Spring Bay Council has requested Brighton Council undertake modelling of this catchment. The catchment has been modelled to establish the existing conditions, and then model possible future conditions to establish an appropriate pattern of development as well as an infrastructure plan. Climate change adaptation information for the area indicates a 30% increase in runoff. This increase has been applied to the model.

This report examines the existing conditions, identifies issues and areas of interest, models possible future scenarios and provides some insight into possible solutions. This report does not consider the effects of tidal influences and storm surges.

3. Scope and Objectives

The scope of this report is to model stormwater flows throughout the Rudds Hill – Raspins Beach catchment.

Establish a flow level for the 5% and 1% AEP (annual Exceedance Probability) events and identify overland flow paths.

Assess overland flow and infrastructure required to meet the Councils Climate Adaptation policy of a 30% increase in runoff.

Model the Holkam and Alma Court subdivisions and assess the stormwater consequences to overland flow and infrastructure upgrades.

Model the future low density residential zoning area, to assess the stormwater consequences on overland flow and infrastructure upgrades.

Recommend possible infrastructure upgrades for the minor and major flow paths.

4. Background

4.1 Catchment

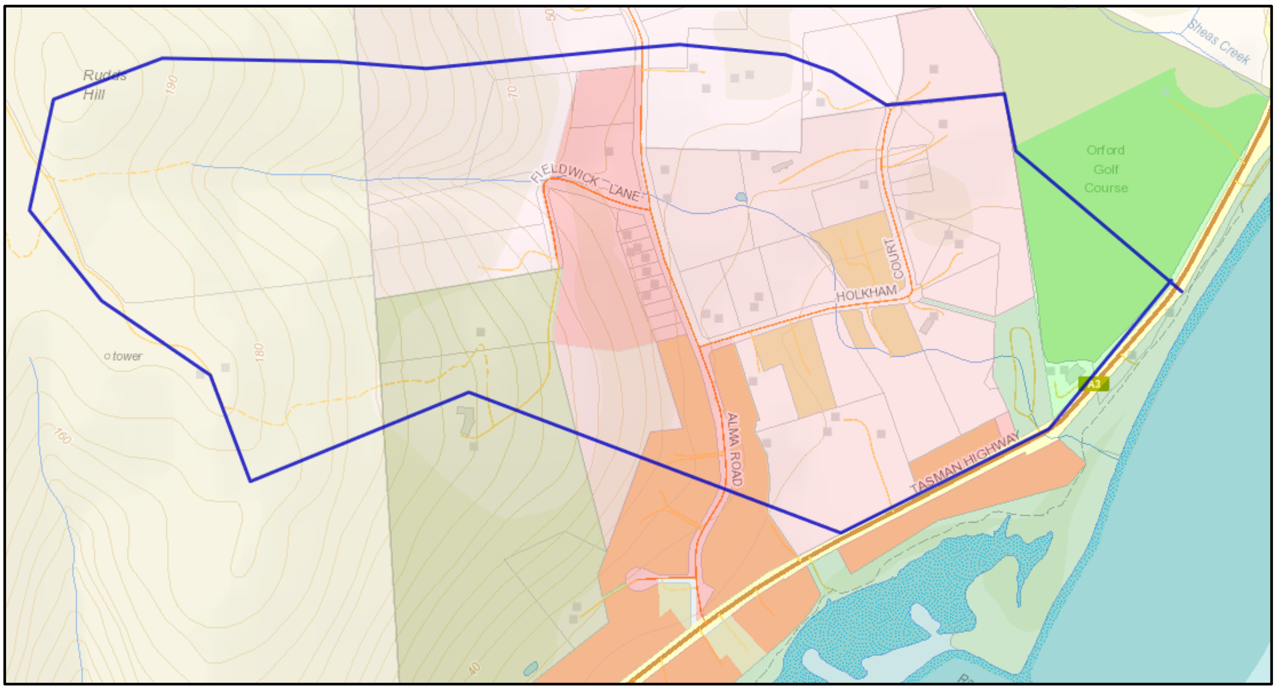


Figure 4.1 Catchment Boundary with zoning overlay and unnamed creek drainage line shown.

The total catchment is approximately 80 ha with a steep forested upper section transitioning into a lightly built up, medium grade residential area. The base of the catchment gradually flattens to the triple 450mm diameter outlet underneath the Tasman Highway, through the dune system to Raspins beach. The catchment includes a portion of the golf course to the north.

The catchment is dominated by the upper portion of the catchment to the west of Alma Road. This area makes up nearly half of the total catchment area and drains predominantly to the northernmost culvert under Alma Road. This section of the catchment dominates the flow regime. The catchment flow is limited at the downstream end by the Tasman Highway which severely limits outflow and provides a boundary to the lower edge of the catchment. The catchment boundary through the golf course has a very limited height change. In large events water spills northeast into the golf course catchment as the highway acts to dam the flow towards the coast.

Under the Glamorgan Spring Bay Interim Planning Scheme 2015 the upper portion of the catchment is divided between Rural Living, Environmental Living and a portion of General Residential zoning along Alma road. The lower half of the catchment is zoned Low Density Residential. The catchment is not fully developed to its capacity within the current zoning. The General Residential and Low Density Residential zonings have the capacity under the planning scheme for significant increases in dwellings and associated infrastructure.

A significant portion of the lower area is in a Coastal Inundation Hazard Area overlay. The flow path through the centre of the catchment is contained in a Water way and Coastal Protection Overlay.

The flow path through the catchment consists primarily of a managed open drain. Existing infrastructure is limited to culverts under Alma Road and Holkham court, and an open channel through the mid section of the catchment. This channel enters the caravan park lot where there are several small culverts through the channel to service small caravan park access roads.

The caravan park is in the lowest part of the catchment prior to the highway outlet and has little fall across the site.

The outfall past the highway is through the dune system to the ocean. There is very little grade through this outfall and it is affected by sand movement. Anecdotally this outfall often restricts stormwater outfall to the ocean.

The beach outfall will be affected by storm surges and high tides so has not been modelled in detail as part of this report.

4.2 History

The East Coast of Tasmania is characterised by low average annual rainfall and East Coast Low rainfall events. These events can bring extended heavy rainfall periods resulting in significant flooding and are variable in their frequency and intensity. Historically the catchment has experienced flooding effects from these events. Time between flooding event and their magnitude has been varied.

In late January 2016 there was a significant rainfall event that affected this area. The event is plotted in the graph below and clearly exceeded a 1% (ARI 100) event for all durations greater than 10 minutes. This event resulted in significant flooding in the catchment area and inundation in the caravan park and golf course.

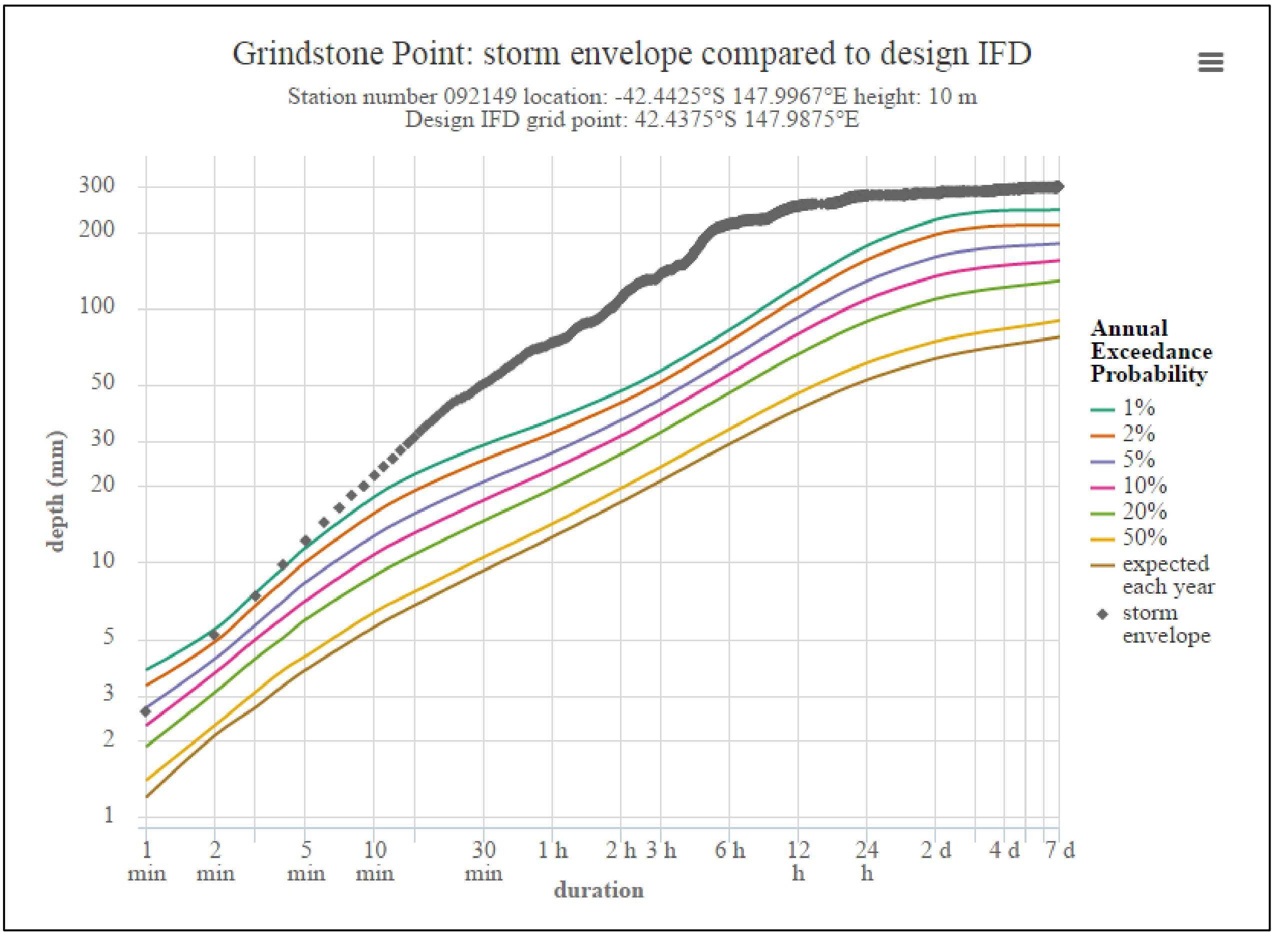


Figure.4.2 Intensity Frequency Duration (IFD) Chart with the January 2016 flood storm envelope plotted over the IFD's for Grindstone Point. Provided by the Bureau of Meteorology.

This event caused flooding in the area that has been documented in photographs. The event caused inundation of the caravan park, including flooding of the amenities block to at least 300mm depth and significant overflow over Holkham Court.

Figure 4.3 Inundation of the Caravan park.

4.3 Coastal Inundation

Large portions of the site have been identified under the *Glamorgan Spring Bay Interim Planning Scheme 2015* as Coastal Inundation Hazard area. Areas in this catchment that are subject to coastal inundation hazard are the same areas that will receive overland flooding during rainfall events and are likely to also be impacted by future storm surge. This includes portions of the caravan park and golf course. Recommendations to decrease flooding risk to these low-lying areas from rainfall events may increase the flooding risk from storm surge. This needs to be carefully considered in future decisions and possible mitigation strategies.

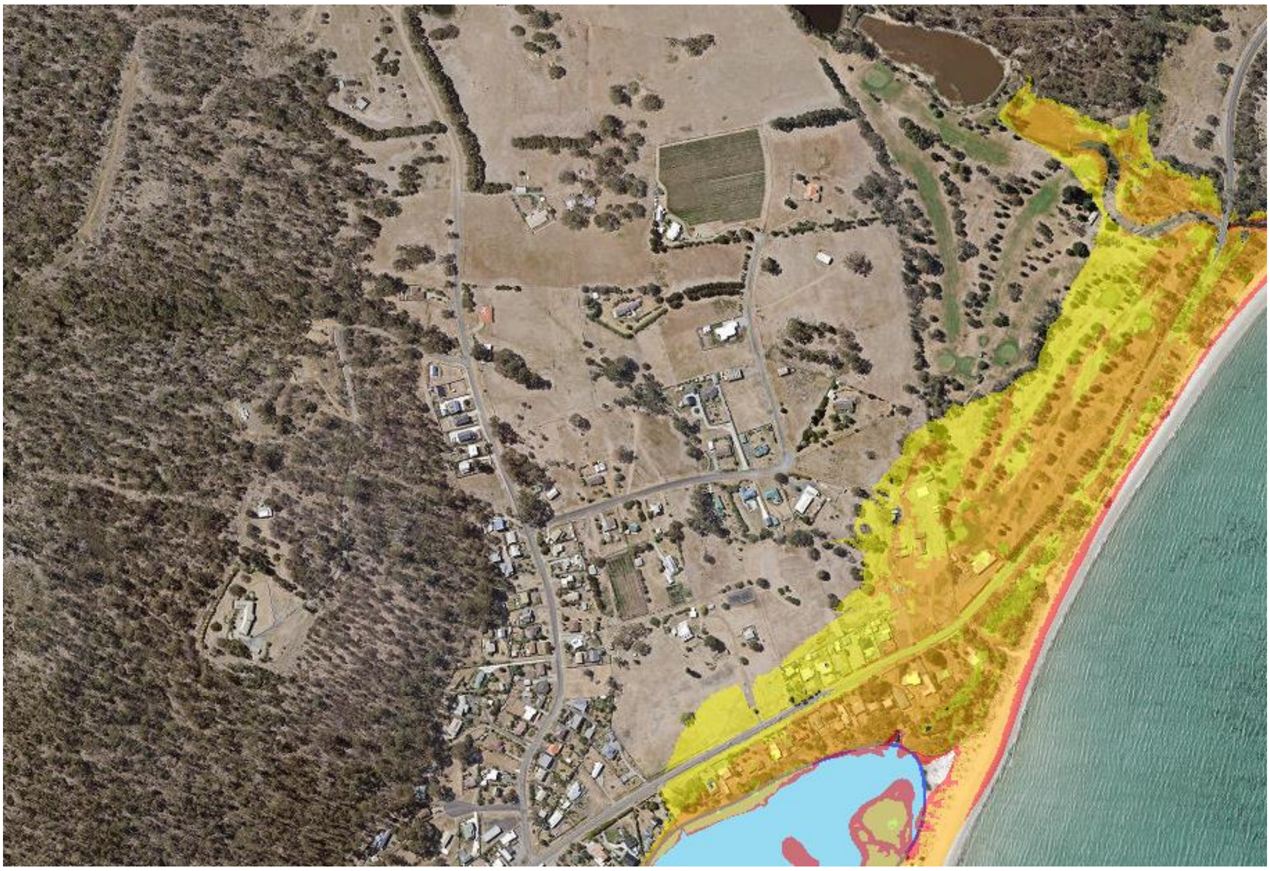


Figure 4.4 Coastal Inundation Hazard Bands LISTmap.

Coastal inundation bands; high (red), medium (orange) and low (yellow).

- High band is the area vulnerable to sea-level rise by 2050 from the mean high tide, rounded up to the nearest 100 mm.

- Medium band is the area vulnerable to a 1% AEP storm event in 2050 rounded up to the nearest 100mm plus 300 mm added for freeboard.

- Low band is the area vulnerable to a 1% AEP storm event in 2100 rounded up to the nearest 100mm, plus 300 mm added for freeboard. *M.J. Lacey, (2016) Coastal Inundation Mapping for Tasmania - Stage 4. Report to the Department of Premier and Cabinet by University of Tasmania.*

4.4 Climate Change

Climate change has been factored into the modelling by increasing the rainfall values by 30%. This value has been taken from the Glamorgan Spring Bay Council Corporate Adaptation Plan 2012 from the Runoff value (page 12). There are other considerations that are briefly discussed below.

Climate change modelling by the *Antarctic Climate and Ecosystems CRC from the Climate Futures for Tasmania project* indicates that for the east coast of Tasmania, rainfall will increase and "rainfall brought by rare extreme events will increase: a 200-year average recurrence interval (ARI) event increases by up to 110mm (90% increase). More common ARI events (ARI-10, ARI-50) increase by a similar proportion". It also indicates that "Proportional (%) increases in runoff are larger than the change in average rainfall, changes to runoff may exceed 30%". This means that by 2100 all significant events are likely to nearly double in size and what currently constitutes a significant event will occur more regularly.

Further investigations into the data showed that this increase is not linear and, as shown below, the 2069 increase may only be 11%. Discussion with current climate scientists indicate some uncertainty about the variation in increase over time. Due to this uncertainty this report does not include modelling for a 90% increase in storm values. Climate change has been incorporated into the model by increasing the rainfall values by 30% as per the recommended runoff values.

Table 7.3 Magnitudes of 24-hour duration ARI-200 (years) for 1961-1990 estimated from AWAP gridded observations (5th/95th CIs in brackets), with projected multi-GCM ensemble change for 2010-2039, 2040-2069 and 2070-2099, at eight representative locations across Tasmania. ARIs estimated using a generalized Pareto distribution. Multi-GCM ensemble ARIs estimated using the six downscaled-GCMs for the A2 emissions scenario. ARIs are expressed in mm. Delta ARI-200 values are expressed in millimetres and as a percentage change (in square brackets []), relative to the AWAP 1961-1990 baseline. Location of sites is shown in Appendix A

	ARI–200 (mm)	Delta ARI–200 (mm)		
Location	AWAP (1961–1990)	Multi–GCM ensemble (2010–2039)	Multi–GCM ensemble (2040–2069)	Multi–GCM ensemble (2070–2099)
Hobart	100 (76/128)	31 [31%]	40 [40%]	30 [30%]
Swansea	122 (91/162)	16 [13%]	14 [11%]	112 [92%]
St Helens	145 (107/210)	10 [7%]	40 [27%]	68 [47%]
Launceston	66 (51/85)	3 [4%]	34 [51%]	34 [52%]
Devonport	97 (76/131)	4 [4%]	23 [24%]	36 [37%]
Strahan	68 (65/73)	6 [9%]	8 [12%]	18 [26%]
Strathgordon	97 (93/105)	21 [21%]	30 [31%]	36 [37%]
Miena/Liawenee	98 (78/134)	50 [51%]	30 [30%]	5 [5%]

Figure 4.4 ACE CRC Climate futures for Tasmania, Technical Report 2010, Extreme Events Table 7.3.

Complicating this is the Australian Rainfall and Runoff Data Hub which holds data used for stormwater modelling in Australia has a different Climate Change factors of between 3.2% and 16.3% depending on the climate change model and year of consideration. This is based on a regional model that includes all of Tasmania so is unlikely to be as accurate as the ACE CRC modelling. These values may be used by engineers modelling stormwater within the Council area. Council must decide if this is acceptable. It is recommended that Council continue to use the 30% increase in runoff rates until data is available that is more accurate or up to date than the ACE CRC data.

In the future if it is clarified that the 90% increase occurs on a more linear trajectory than the current output suggests there are a number of options for Council to consider.

1. Council may increase its stormwater requirements for minor and major flow paths to be installed to cater for a 90% increase in flow rates.
2. Council may continue to use the current increase of 30% for its minor and major infrastructure until a set date based around the expected life of the infrastructure and cost benefit analysis.
3. Council may continue to use the current increase of 30% but accept that in the future the level of service provided to residents will be reduced i.e. the current level of service is to have a minor (mostly underground) network catering for a 5% AEP event (1 in 20 year ARI), this may, for instance, be reduced to a 10% AEP event (1 in 10 year ARI) and the major infrastructure may cater for a 2% AEP event (1 in 50 year ARI) instead of a 1% AEP.

Current recommendations are to:

1. Prioritise protecting the overland flow path. This will ensure that there is capacity to enlarge the overland drainage system as required. Having a robust major network also provides security for your minor network, it allows it to 'fail safely' and by doing so means that the impacts of increased flows on the minor network are less critical to amenity and safety.
2. Continue basing Council infrastructure on a 30% increase in runoff.
3. At minimum require developers to consider their major flow paths with a 30% increase.

5. Modelling Process.

The model has been based on a desktop analysis of the terrain, photography and on ground data provided by Glamorgan Spring Bay Council.

The area was modelled using procedures in line with Australian Rainfall and Runoff 2016 (ARR) using XP SWMM 2018.2.1 and 2018.2.2 modelling software.

A 1D/2D base model was set up using Lidar at 1m centres for the terrain model. The open channel was modelled with 1D channels and culverts linking to a 2D overland flow model. The developed catchments were modelled with 40% impervious for the low density residential and 60% impervious for the general residential areas.

Infiltration rates used for the catchment were adopted from ARR data hub recommendations. These rates are recommended for use unless they can be replaced by appropriate on-site infiltration data. Initial infiltration rates have a significant impact on initial flow rates, but much less impact on long term flow rates and areas of inundation. Antecedent rainfall places some rainfall on the catchment prior to the main rainfall event. Antecedent rainfall depths have been included in the modelling.

The base model was run as per the ARR 2016 procedures, with a suite of event times and storm ensembles to select the appropriate storms for catchment modelling. Storms selected for modelling were the 2hr storm number 7 for the 5% event and the 4.5 hr storm number 2 for the 1% event.

As per the adopted climate change scenario, there will be an increase in runoff of 30%. This is added to the model by increasing the rainfall multiplier by a factor of 1.3. The existing and climate change values for the chosen rainfall events are provided below.

The values in the below table have been used to assess the 5% and 1 % event with a 30% increase in rainfall during these events.

Name	**Initial Multiplier**	**Climate Change 30% value**
SST_5pct_2hr_7	35.1	45.63
SST_1pct_4_5hr_2	67.8	88.14

The climate change 30% multipliers were used for all standard models.

Models were run for the 1% (ARI 100) and 5% (ARI 20) scenarios as these are specified in the planning scheme for the minor and major stormwater systems.

6. Scenarios

The model was edited from the base model to test different scenarios that affect flow through the catchment. This allowed flooding impacts to be assessed and compared.

Scenario 1: **Culvert blockages** - Photographic evidence demonstrates that the HWY culverts may experience reduced flow due to sediment blockages. This was modelled with a 30% blockage to this culvert.

Scenario 2: **Outlet blockage** - Full outflow to the ocean is often impeded by dune movement. This has been modelled by raising the outfall to cause some impedance to the outflow.

Scenario 3: **Holkham subdivision** - Added Holkham subdivision area into the scenario. Added via new catchment with 40% impervious and free outfall at southern end of subdivision. Site coverage for structures in planning scheme is up to 25% plus added impervious areas for roads and driveways.

Scenario 4: **Alma subdivision** - Added Alma subdivision to the model as described above.

Scenario 5: **Full development under existing zoning** – Added 40% impervious for all catchments within the low-density residential zoning and general residential modelled at 60% impervious.

6.1 Scenario Analysis

Scenarios 1 and 2: **Highway Culvert Blockage and Outlet Blockage**

The highway culvert blockage had a significantly greater impact on the area of inundation upstream of the culvert than blocking the outlet. Culvert blockage was therefore considered highest risk and of significant likelihood and was selected for further modelling. This scenario may be impacted by tides and storm surge which is beyond the scope of this report.

Scenarios 3, 4 and 5: **Holkham Subdivision, Alma Subdivision and Full Low-Density Residential Models**

It quickly became apparent that assessing each subdivision alone was irrelevant as any future infrastructure upgrades will need to cater for full low-density residential development to future proof the upgrades. Further modelling therefore focussed on managing issues and sizing infrastructure for full low-density residential development. Interestingly, all the issues raised by increased development are already occurring due to inappropriate infrastructure and the nature of the catchment.

The other notable result was that due to the nature of the catchment, increases in impervious areas do not make a significant difference to the higher flow rates. This is due to two things, firstly the soil becomes saturated causing flow on pervious areas to act in the same manner as flow on impervious areas and secondly, the large upper portion of the catchment flow, which dominates the later stages of runoff events.

Points of interest:

The waterway running through the catchment is disrupted in several areas causing flow to be dispersed into properties unnecessarily. Maintaining the major flow path will be a priority for this area.

The lower portion of the catchment is in a depression that will become inundated under all flooding scenarios. If flow paths are increased to improve outfall into the ocean this may improve flood situations some of the time however, flood risk from storm surge and coincident flooding must be considered.

7. Results Assessment and Analysis

7.1 Summary of issues:

1. **Alma Road Culvert**. Flow from the creek line overflows Alma Road at this location.
2. **Holkham road entrance and first culvert**. The road geometry allows flow to cross the road and flow overland through private property into the secondary drain.
3. **Holkham Culvert**. Undersized for this location. Forces water onto the road. This then flows along the road east to the turning circle and flows over the road into private properties 24 and 30 and possibly 34 Holkham Court.
4. **Holkham Turning Circle**. Flows occur overland from the south side of this area. Low flow depths only however the water path has to flow overland for some distance through private property prior to re-entering the main channel. It then re-enters at the top of the caravan park where infrastructure is insufficient to manage this flow.
5. **Top Caravan Culvert** causes flows to back up and extend outwards. Addressing this issue will change the area of inundation.
6. **Caravan Park and Golf Club building area**. This area receives significant inundation affecting the caravan park and the golf club building.
7. **Holkham Court Subdivision**. This subdivision will create flow that does not flow into any currently defined flow paths.
8. **Highway Culvert.** The highway under the culvert is undersized and throttles flow. This is exacerbated by the culvert being periodically affected by sediment blockage.

Note issues 1 to 4 are independent of impacts from tidal variations and storm surge. Storm surge and tidal impacts do not form part of this model.

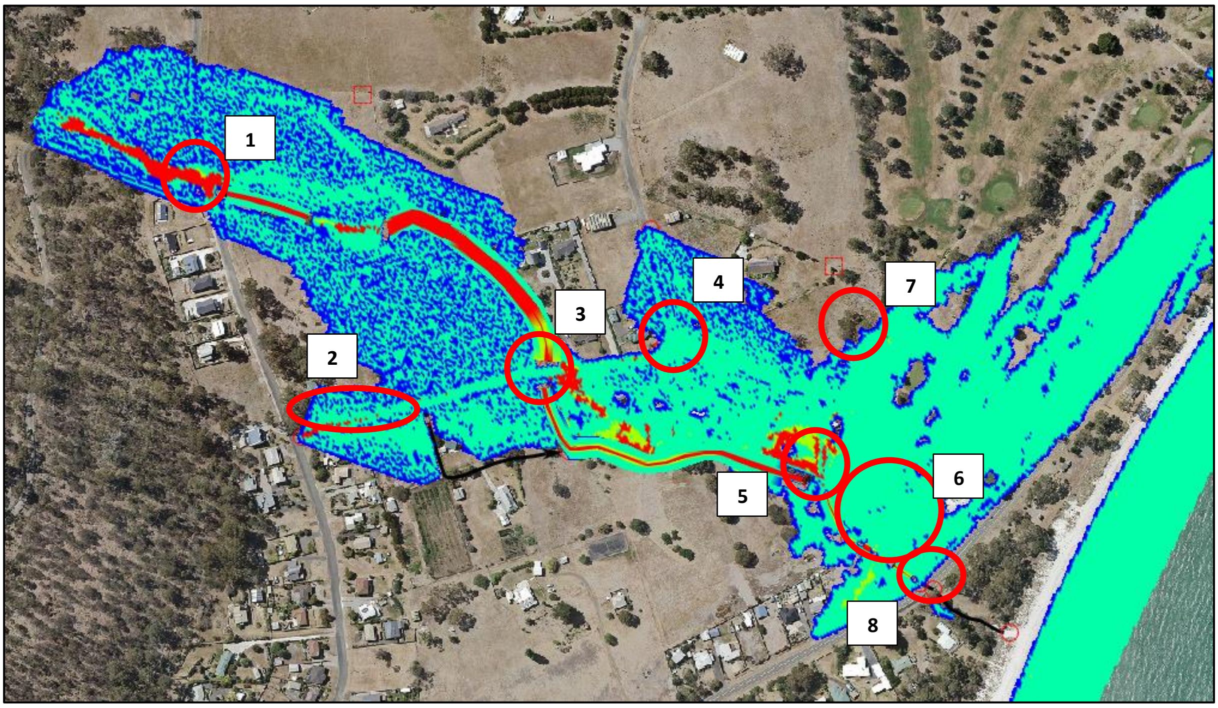


Figure 7.1 Low Density Residential model results. Showing areas of inundation and areas of particular concern. 1pct 4.5hr climate change model.

7.2 Results

Total Overland Flow Area

The previous map shows the entire area of inundation. Further maps will show areas with inundation deeper than 0.1m as a 10 cm water depth is of minimal concern to people or property.

5% AEP Results

Overland Flow of Depths Greater than 0.1m. 5% Result.

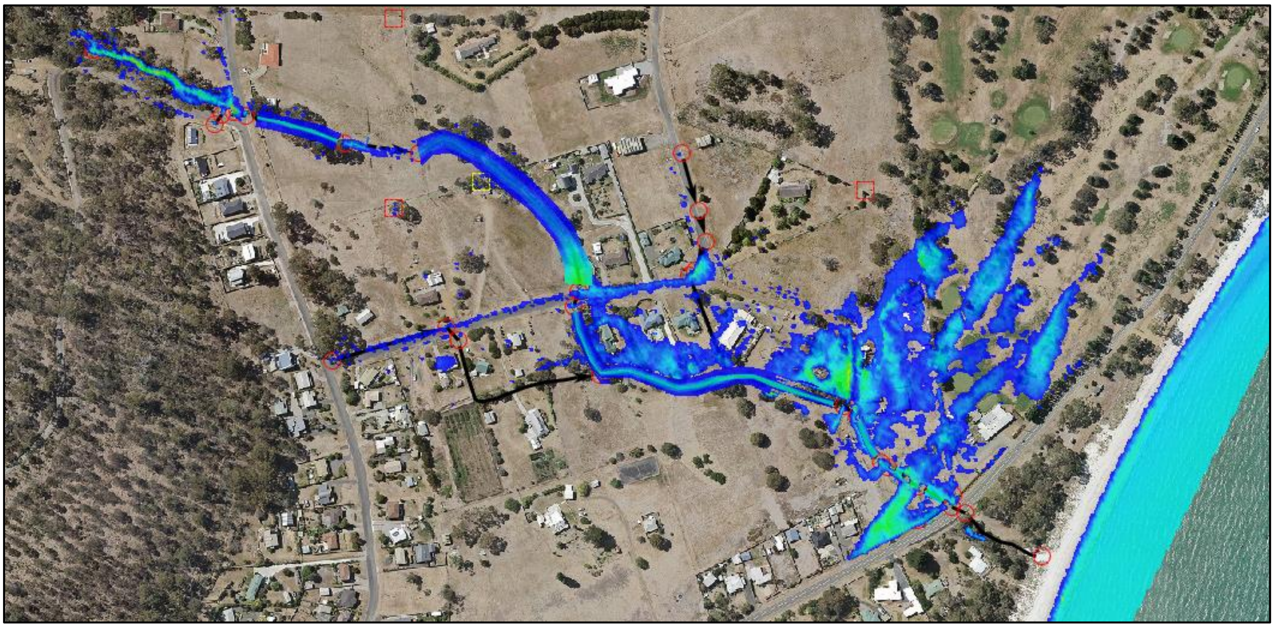


Figure 7.2 5% 2hr Climate Change Base model results. Max Water Depth. Map showing depths greater than 0.1m. 5pct_2hr climate change model.

Figure 7.3 2hr Climate Change Low Density Residential model results. Max Water Depth. Map showing depths greater than 0.1m. 5pct_2hr climate change model. This is the assumed future scenario to develop infrastructure for.

Overland Flow of Depths Greater than 0.1m. 5% Low Density Residential Result.

Comparing the above two images, it is clear the increase in residential area does not result in significant increases in the flooded zone for the 5% event given that what is shown is depths greater than 10cm of pooled water. Increasing the impervious area results in very slight increased peak flow rates in these events as shown by the graph below. The graph below is from the model that assumes some antecedent rainfall. This means it assumes there has been some rain preceding the main burst of the event. This is likely to be the case in real life and the antecedent volume from the Bureau of Meteorology has been used.

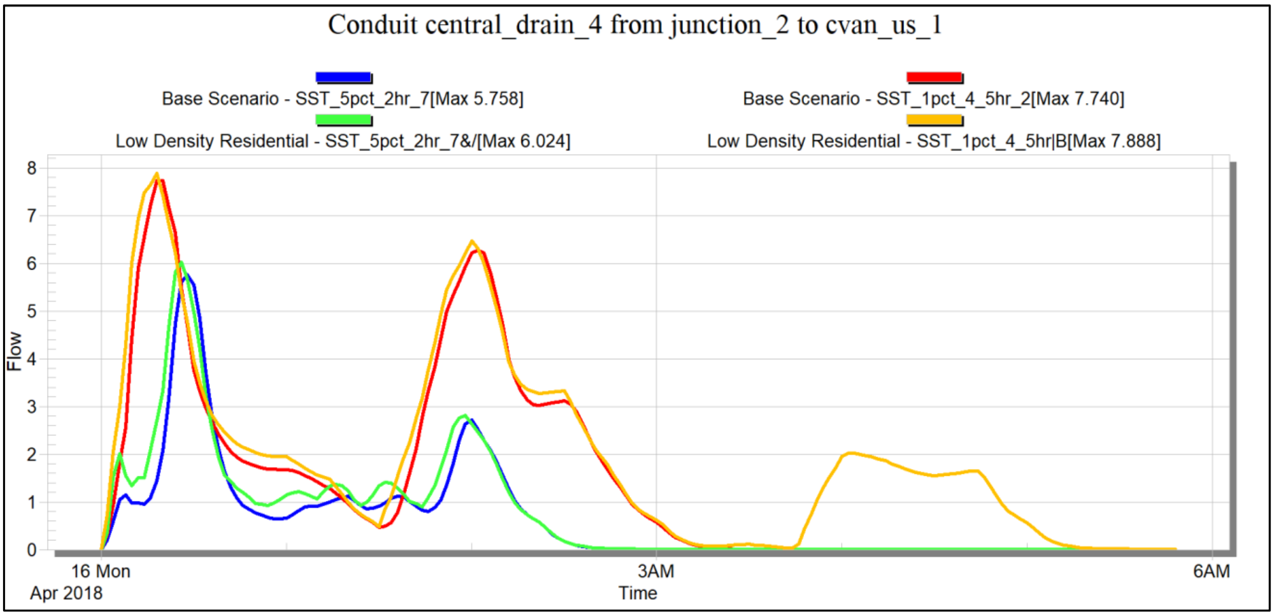


Figure 7.4 Graph of flow rates for Base model and Low Density Residential model for Central drain 4 section as shown above

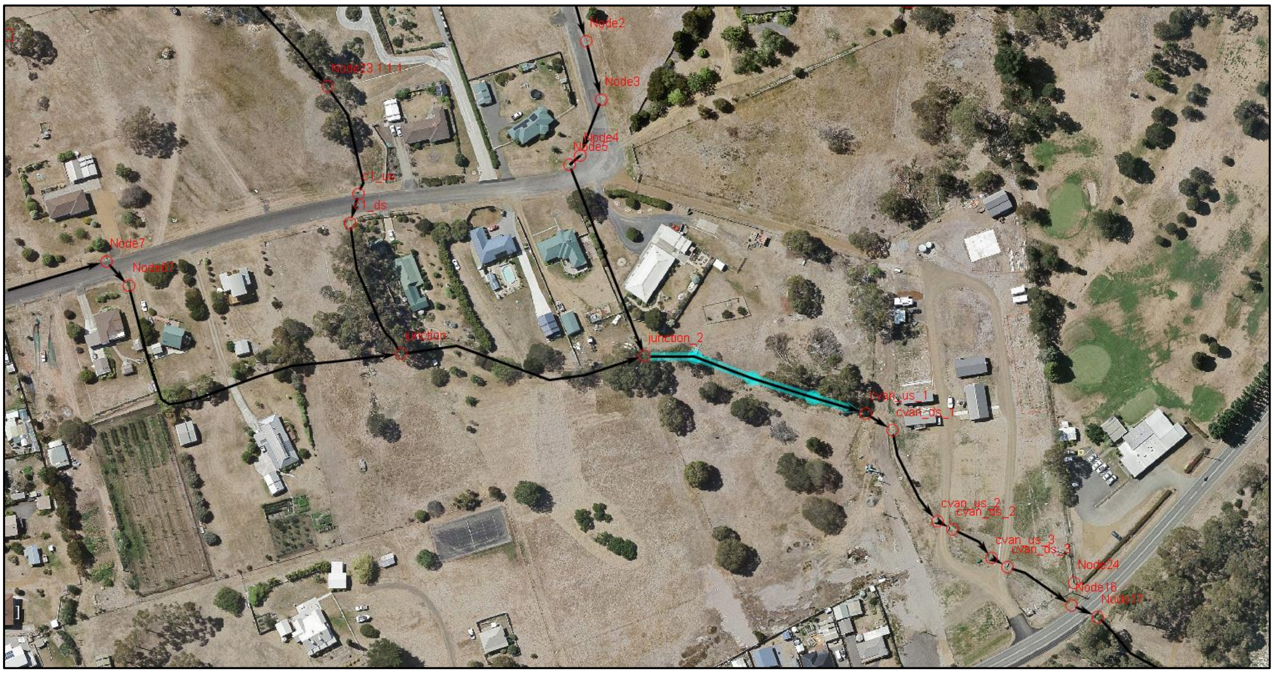


Figure 7.5 Central drain 4 section for above graph.

1% AEP Results

Overland Flow of Depths Greater than 0.1m. 1% Low Density Residential Result

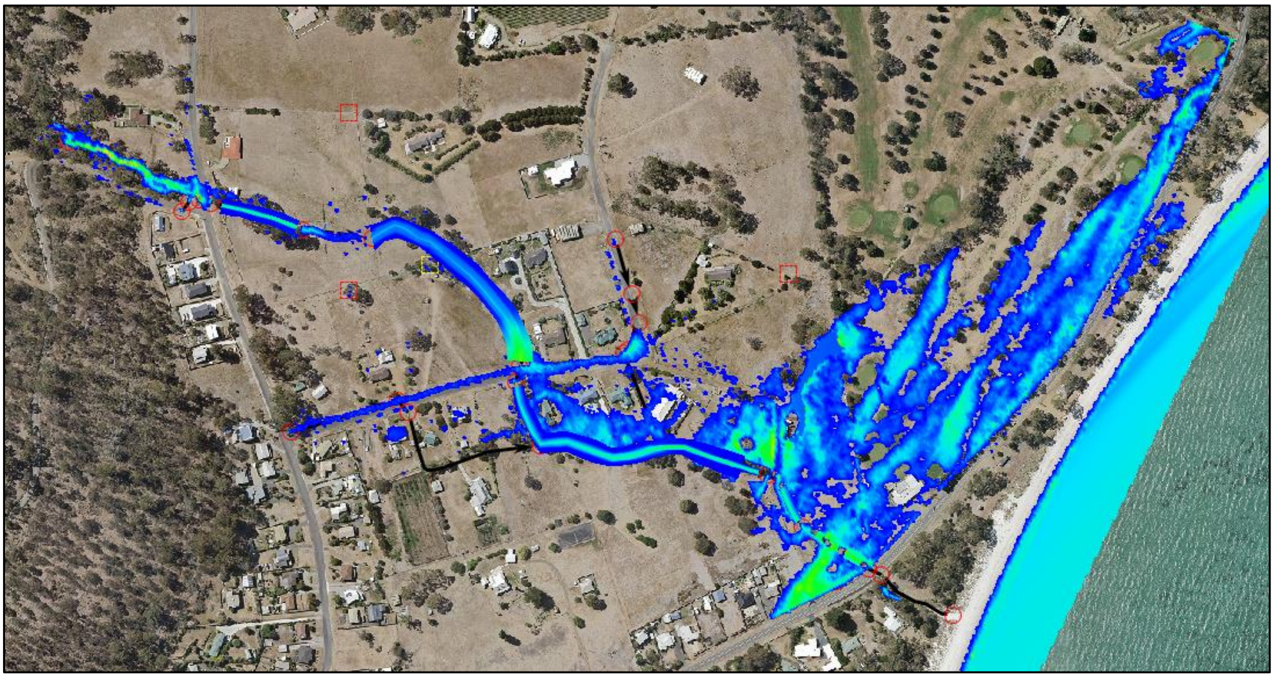


Figure 7.6 1pct 4.5hr Climate Change 30% Low Density Residential model results. Max Water Depth. Map showing depths greater than 0.1m.

Total Overland Flow Area. 1% Low Density Residential Result

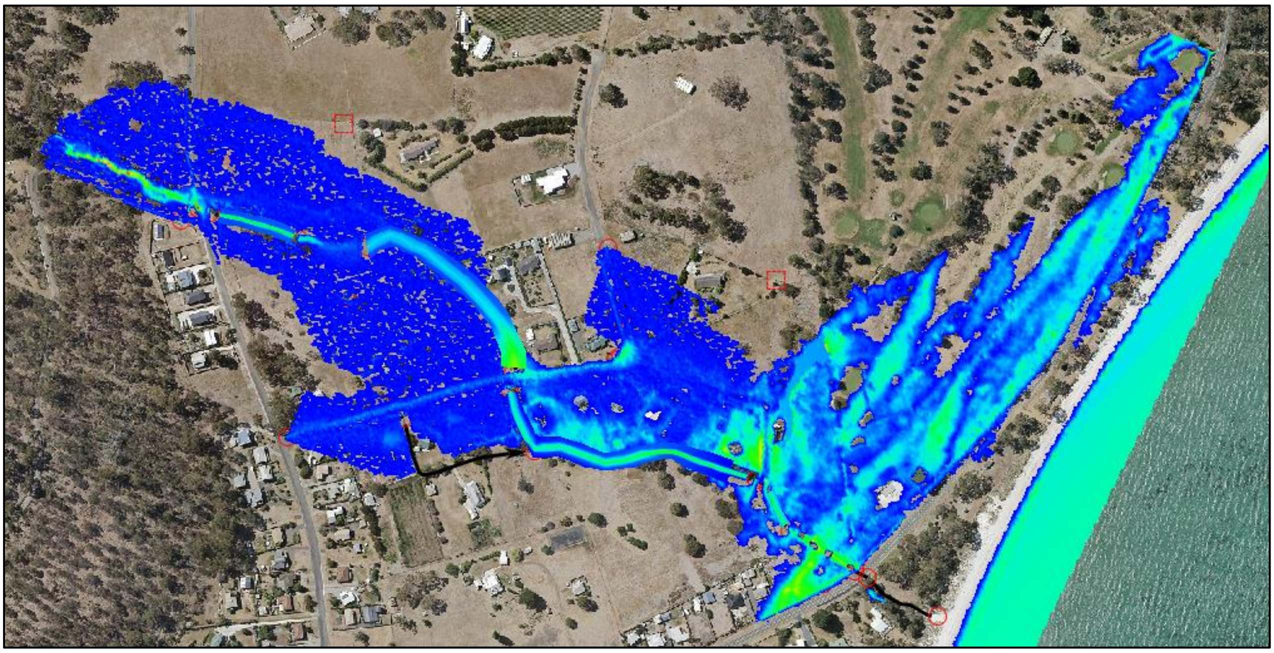


Figure 7.7 1pct 4.5hr Climate Change Low Density Residential model results. Max Water Depth. ***Map showing all depths for comparison.***

Note in the 1pct event the flood area extends throughout the golf course and overtops the highway.

7.3 Areas of Interest Results.

1. **Alma Road Culvert**

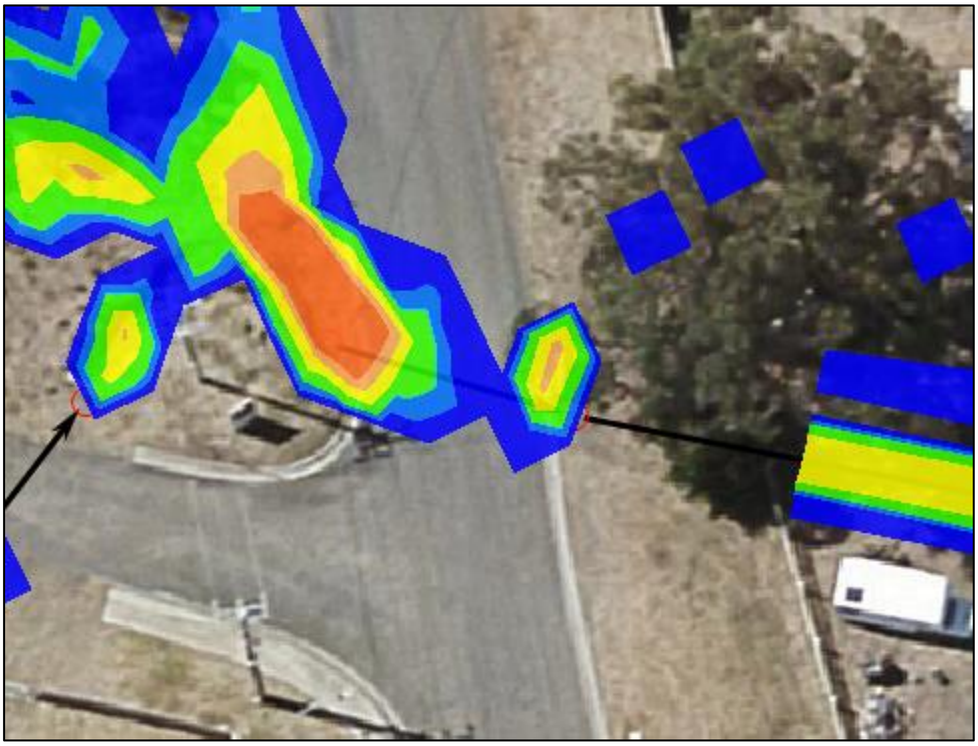


Figure 7.8 5% 2hr Climate Change Base model results. Flow greater than 0.1m overtopping Alma Road.

This demonstrates that some flows overtop Alma road in a 5% event.

2. **Holkham road entrance and first culvert**

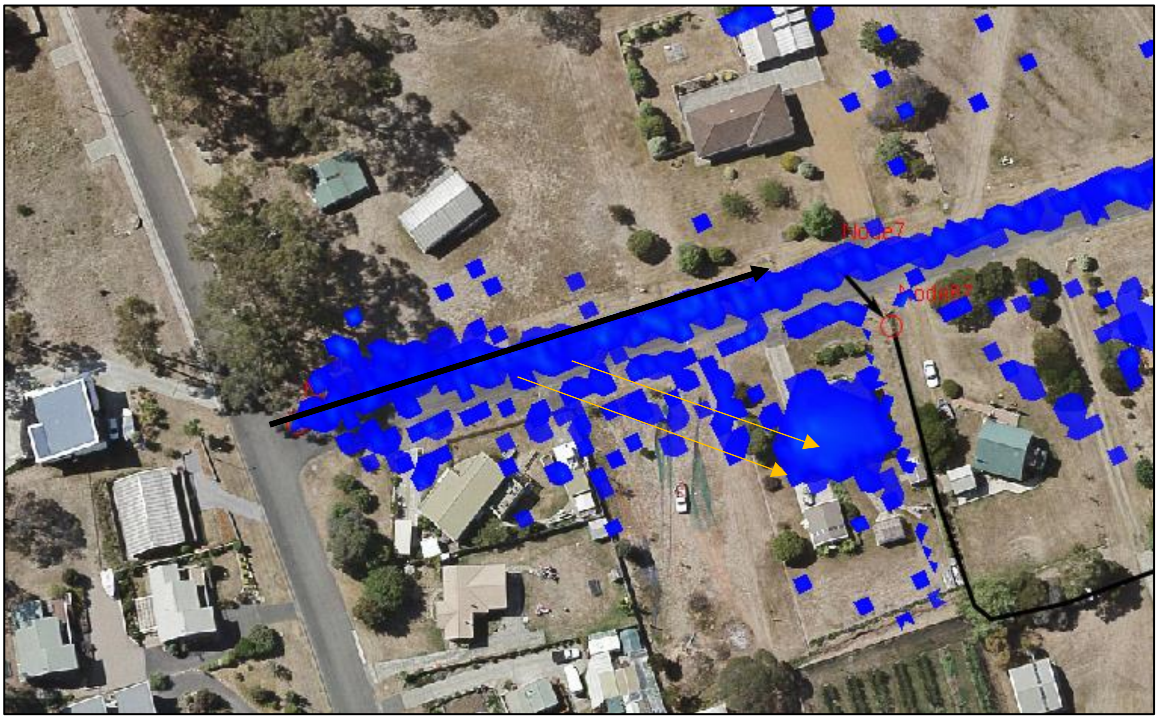


Figure 7.9 5% 2hr Climate Change Base model showing 5cm of water flow. This shows that water comes across Holkham Court and crosses private property to enter the small open drain.

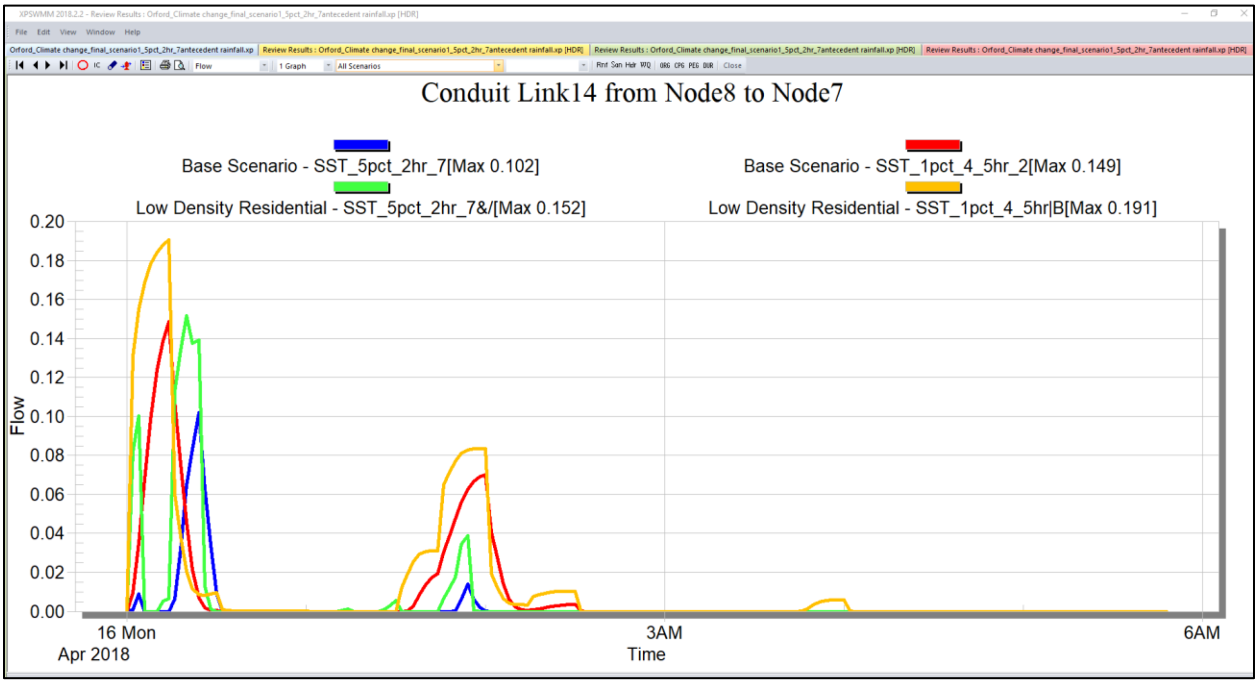
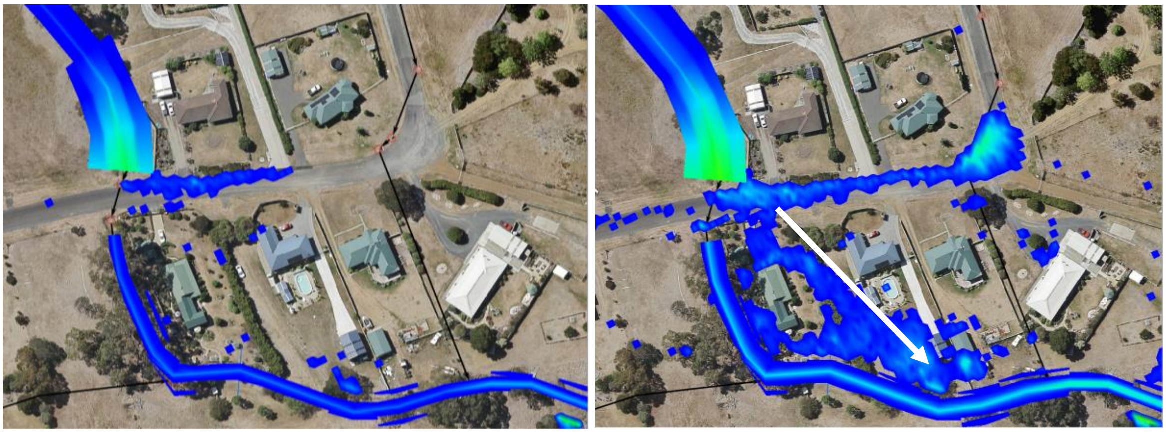


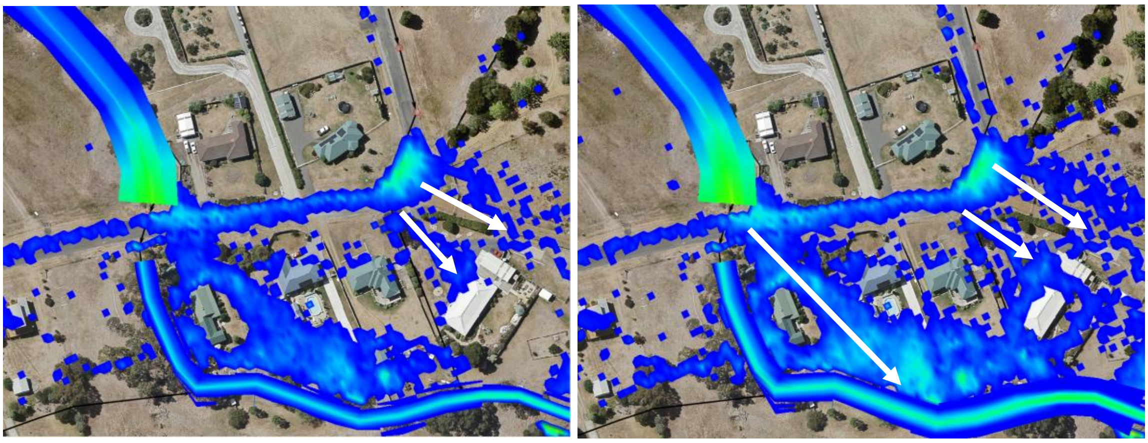
Figure 7.10 Flow rate in Link 14 for the 1% and 5% events. – Roadside drain in Fig 14 above.

These results indicate that flow escapes the drainage network at the entrance to Holkham Court and passes overland through private properties. Although flow depths are not large, these impacts are increased by increases in development as shown in Figure 0.15 which shows the increases in flow rates in the 5% and 1% events under the low-density residential scenario. The low-density results from both events show that the increase in development results in higher peak flows, peaking slightly earlier than in the base scenario.

3 & 4. Holkham Culvert and Holkham Turning Circle.



1. 8 minutes **2. 20 minutes**



2. 22 minutes **4. 28 minutes**

Figure 7.11 2hr Climate Change Low Density Residential model showing all water flow.

This series of images shows that the water that backs up at the Holkham Road culvert overtops onto the road and diverts east along Holkham Court where it flows out over a low point at the turning circle. The flow also overtops straight over Holkham Court and through private properties prior to re-entering the open drain.

5 & 6. Top Caravan Culvert

The culverts in the caravan park cause constrictions in the flow path. This causes the water to spread further into areas that may otherwise be unaffected.

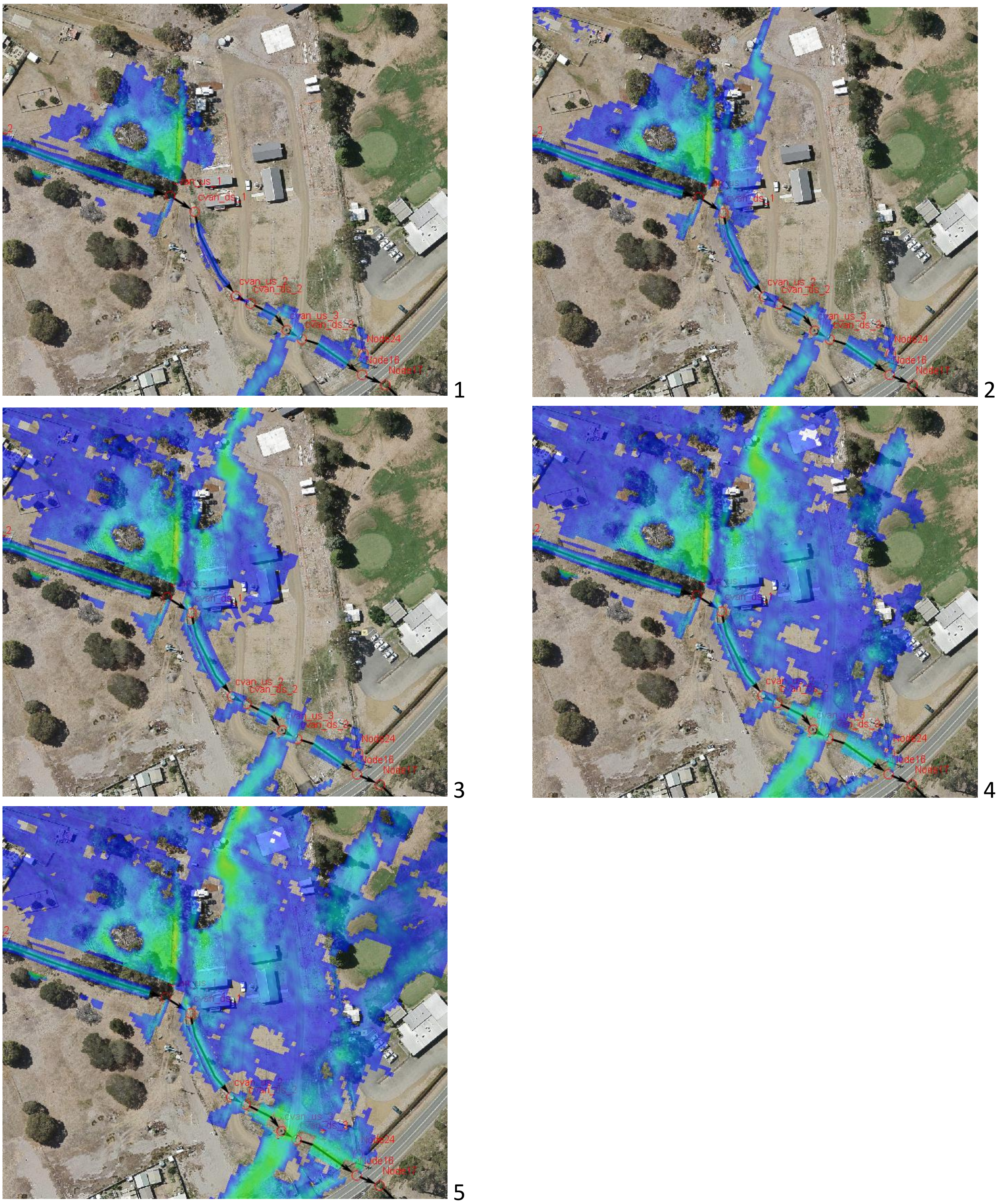


Figure 7.12 Series showing effects of restrictions caused by road and culverts in the caravan park.

7. Holkham Court Subdivision

This subdivision will divert water into the highlighted node.

Figure 7.13 Holkham Court Subdivision downstream node (node 75).

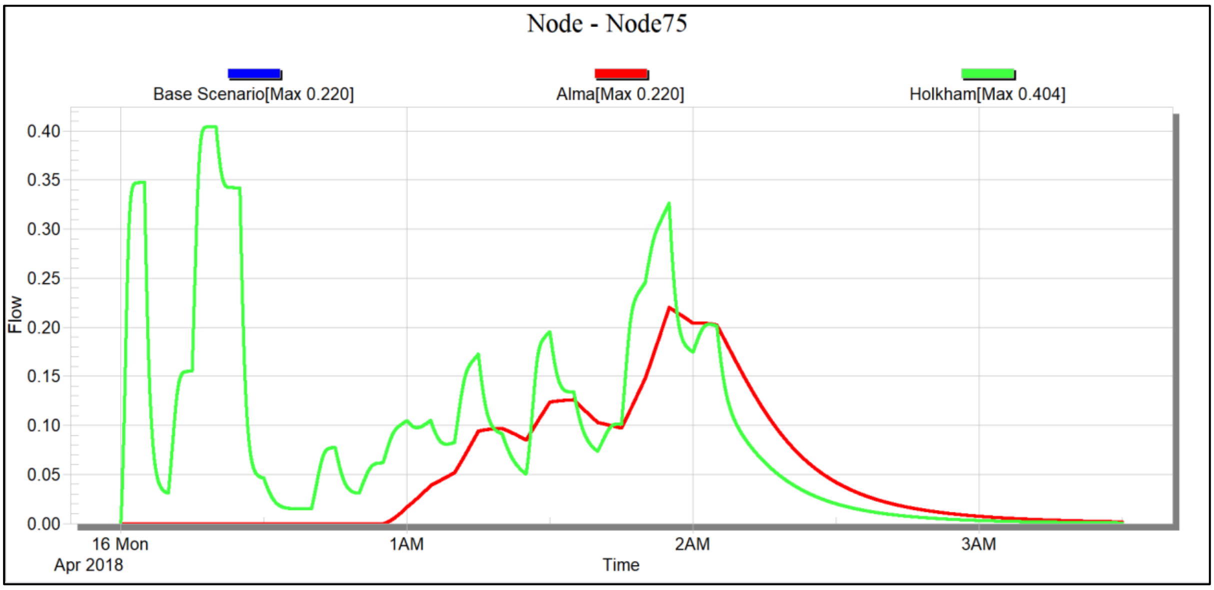


Figure 7.14 Runoff results from Holkham Court Subdivision catchment undeveloped vs developed.

This graph shows the extra outflow created from the south-east corner of the proposed Holkham subdivision. This results in a large amount of extra flow along this eastern boundary area but the overall impact on the peak flow rate within the caravan park area is unaffected as shown by the graph of the node highlighted in the caravan park below.

Figure 7.15 Holkham Court Subdivision downstream node (node cvan_us_1).

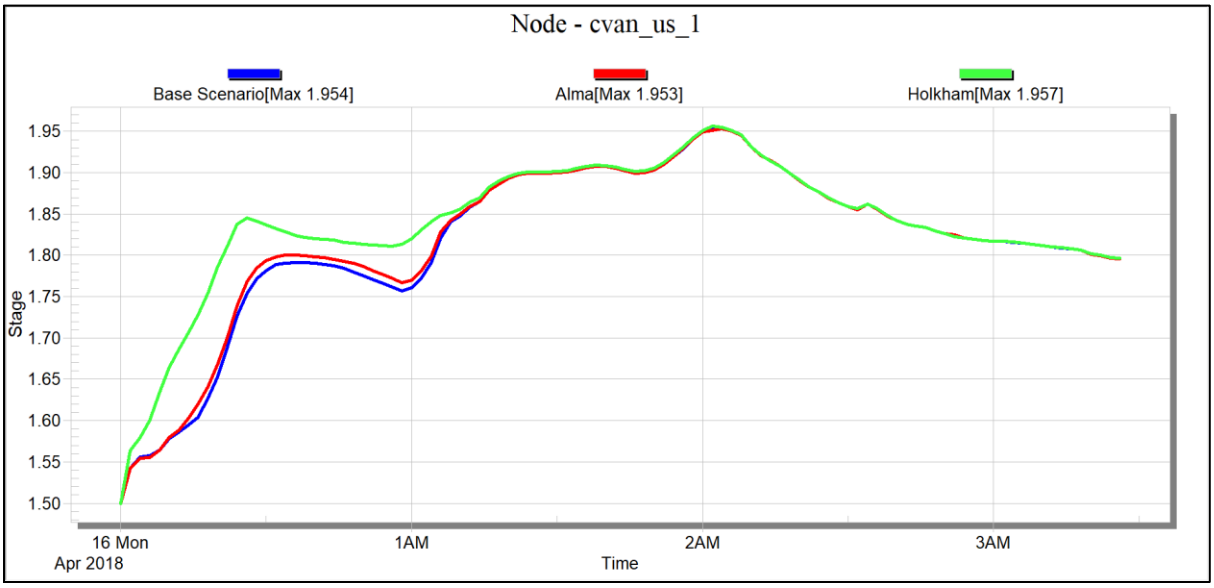


Figure 7.16 Hydraulic Results from the upstream culvert in the caravan park (node cvan_us_1).

The graph above shows the results from the top culvert in the caravan park. As shown, the Holkham development has some impact in the early stages of the event but the peak is unaffected by the extra impervious area.

8. Highway Culvert

The culvert under the highway causes large flow restrictions which impacts up into the catchment. These are exacerbated when the highway culvert is blocked by silt or other debris.
The below image shows the extent of overland flow greater than 10cm depth during the low density residential 5% event with the existing culvert. The final image shows the reduction in inundation area when the recommended mitigation measures have been installed.

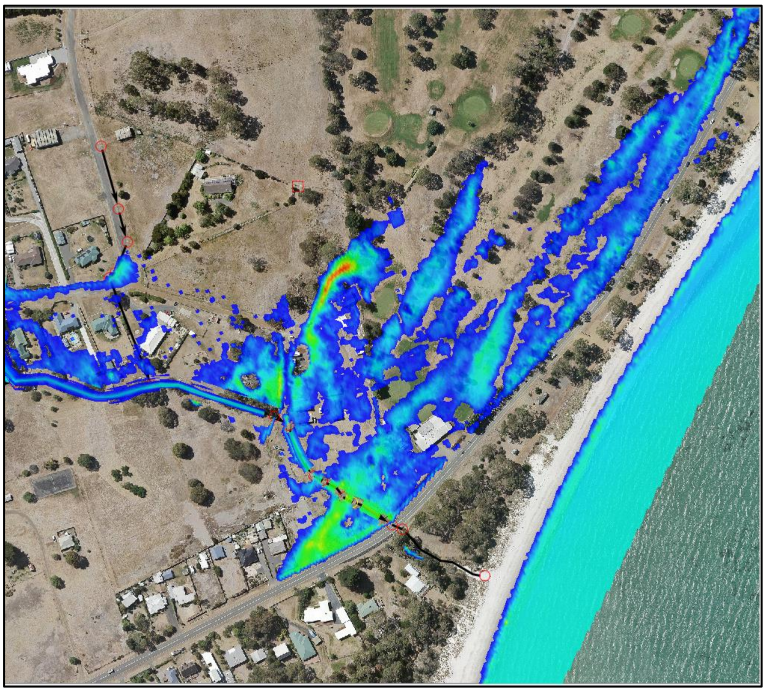


Figure 7.17 5% Low Density Residential inundation areas with existing HWY culvert

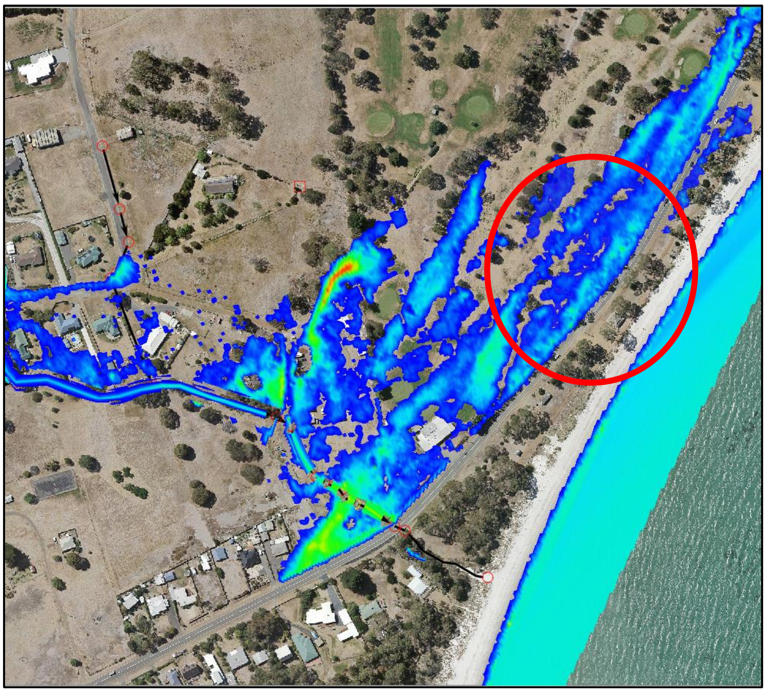


Figure 7.18 5% Low Density Residential inundation area with existing HWY culvert with 30% blockage.

Figure 7.19 5% Low Density Residential inundation area with enlarged HWY and Holkham culverts and a bypass channel around the western boundary of the caravan park.

8. Recommendations.

Figure 8.1 2hr Climate Change Low Density Residential model results. Max Water Depth. Map showing depths greater than 0.1m. 5pct_2hr climate change model.

Figure 8.2 2hr Climate Change Low Density Residential model results. Max Water Depth. Map showing depths greater than 0.1m. 5pct_2hr climate change model. Model including recommended upgrades and showing area of greatest reduction in overland flow.

There are a variety of short and long term works required in this catchment to reduce impacts of water flow on private property. These recommendations are general and specific design advice will be required for each job.

The following recommendations revolve around the key principles of increasing the highway culvert size, appropriately managing the central drainage line and installing kerb and channel along Holkham Court.

Minor works have been modelled to the 5pct 2hr low density residential climate change model and major works to the 1pct 4.5hr low density residential climate change model. On ground works should be designed to include climate change. The minor and major systems should be designed for the 30% increase in runoff from climate change however it will be prudent to protect the major drainage paths with appropriate public space or easements to allow for potential increases in climate change effects. This should also be considered when the major drainage path is incorporated into infrastructure such as roads.

Minor system works should aim to accommodate the 5% event and the major drainage system should, at this stage, be designed for a 1% event with a 30% increase for climate change.

Works that are interdependent and works that are achievable should be identified prior to undertaking any individual section of work in the lower catchment. If it is not possible to increase the highway culvert size this will impact upstream works. If this can be done expediently and combined with a diversion channel around the caravan park it will have a large effect on the amount of water that can be drained from the area.

The recommendations provided are based on modelling and lidar of the area. It is advisable to undertake specific surveys and design to ensure sizing and fall to accurately size infrastructure.

The above diagrams show that it is possible to minimise inundation on private property however there will be some areas, notably in the Southern end of the caravan park where some inundation shall still be expected.

9. Recommended Actions.

Recommended actions have been divided into specific actions that may be implemented as required and long-term general actions which will require further or ongoing planning.

Location	Recommendation	Possible Solution
1. **Alma Road Culvert (Link 7)**	**This culvert straddles the major drainage path. Consider whether a culvert is installed for the 1% event or if it is acceptable to allow flow over the road in events exceeding the 5% event.** **Increase the size of the Alma Road Culvert** to **5.1 cubic meters per second (cm/s)** capacity (Link 7) This will allow the low density residential 5% event to pass under Alma Road. Alma road should also have a slight redesign to allow the 1 % event to pass over Alma road and into the natural channel in a controlled manner. Alternately consider enlarging this culvert to cater for the 100 year event.	***A 1050mm dia pipe at 3.5% grade or similar for the 5% event.*** *The 1% event requires approximately 10 cm/s capacity so would require a twin 1050mm setup at this grade.*
2. **Holkham Road Central Culvert**	**This culvert straddles the major drainage path. Consider whether a culvert is installed for the 1% event or if it is acceptable to allow flow over the road in events exceeding the 5% event.** **Increase the size of the Central Holkham Road Culvert** to **5 cms** capacity. This will allow the low density residential 5% event to pass under Holkham Court. Holkham Court should also have a slight redesign to allow the 1 % event to pass over Alma road and into the natural channel in a controlled manner. This may be managed by appropriate design of kerb and channel.	***A 1050mm dia pipe at 3.5% grade or similar for the 5% event.*** *The 1% event requires approximately 10 cm/s capacity so would require a twin 1050mm setup at this grade.* **Modelling this area demonstrated that the design of the inlet area to the culvert is critical to preventing flow over the road. The existing ground levels and inlet arrangement is a factor in flow overtopping Holkham Court.**
3. **Holkham Court**	**Kerb and channel along Holkham Court**. Install kerb and channel along the length of Holkham court –	**Kerb and channel Holkham Court**

	particularly the east west section and the right angled bend. Ensure that the driveways are not low points. This will minimise water flows off Holkham Court and into private properties. Increasing the culvert as described above will also assist this situation as currently water that gets onto the road from the drain does not return directly to the main drain due to the easterly fall of the road. The existing 450 dia pipe from the right angled bend back to the main drainage line may require upgrading however this may not be required if the main drain is upgraded effectively.	**Modelled with 150mm kerb from the entrance to the culvert and 300mm kerb from the culvert around the northerly bend.**
4. Caravan Park	**The major flow path should be identified and adequately protected through this area with adequate space for a significant drainage path.** **Create an open channel bypass around the caravan park**. Capacity should be ideally **4.5cms** for a 5% event or **7.4 cms** for a 1% event. This will not prevent all the flows going through the park but will utilise the drain more efficiently causing less water to back up around the Caravan Park and Golf Course area. This should be done in conjunction with increasing the culvert size under the highway. **There is not grade available for a deep channel in this area so a wide and shallow channel is the likely outcome.** **This will allow flows to reach the highway culvert more efficiently without being throttled by the caravan park culverts. Otherwise maintain the existing flow path through the caravan park on the understanding that inundation is**	

	inevitable but does not cause great impact to property.	
5. Highway Culvert	**Increase the size of the Highway Culvert. This will have a significant effect on the volume of inundation in the lower catchment. The area most affected by this will be the caravan park and golf course, it will have minimal effects on other properties.** The design capacity of this culvert will be dependent on the design of the channel into the culvert. For a 1% event it will range between approximately 5 to 6 cms for a 1% event. Increasing the size of this culvert will allow flows to escape the caravan park area more efficiently. It will also provide some protection for blockages. This will also open the area up for increases in storm surge flows into the area which have not been considered as part of this report. A non-return valve may be considered at this location.	This has been modelled as a 1.75m wide and 0.85m high rectangular box culvert. **Increasing this culvert size is recommended in this report and will assist with solving inundation issues from rainfall events. However it is possible that it may have an effect on inundation of the area from storm surge events under sea level rise scenarios.**
6. Central Open Drain	**Increase the size of the open drain.** Increase the area of the open drain in locations where it is insufficient. Local knowledge will assist in providing this information. The model indicates that the area directly south of Holkham Court to is likely to require size increases. The open drains should be sized for a 1% event with capacity for **6.7 cms** capacity.	**Trapezoidal drain** **Approx Dimensions for 0.5% fall** **5m base** **1m depth** **1 in 2 sides**

10. Ongoing and Long-Term Actions

Long term actions will be considered as the area is further developed.

1. **Keep the Major flow path**
   A major flow route should be kept and protected through planning processes. The area designated for the overland flow path should include sufficient space to not limit future expansion of the flow path due to predicted climate change impacts. This can either be as part of a defined channel or may be contained in constructed roads if designed appropriately. Either way the Major flow route should always be designed for and protected as development increases. Development design in this area should also ensure that if the minor or major flow routes are exceeded water is not directed into private dwellings. Ensure that driveways or roads do not become low points for water entry. Due to the nature of the major flow path through this catchment it may help to consider it as a small creek rather than an urban overland flow path.

2. **Construct infrastructure with a 30% increase to account for climate change.**
   Council infrastructure should be designed and constructed to cater for an increase of 30% in runoff. Major infrastructure that will become Council assets should meet this requirement. Council should determine if a 30% increase will be required for minor infrastructure constructed by developers or if the ARR Data hub factors are sufficient.

3. **Design for inundation in low areas**
   The lowest areas in the catchment are geographically very low. This increases the chances of inundation from overland runoff and possibly storm surge events, particularly under the probable climate change scenario. Portions of the catchment on the inland side of the highway are between 1 and 1.5m above sea level. The Glamorgan Spring Bay Local Climate Profile states that "Accounting for all effects, the current 100-year event in Hobart is projected to be a 1.58 m in Spring Bay by 2090 under the high emissions scenario." This includes a 0.82m sea level rise and increases in the size of 100-year storm surge event on top of the base increase. Design and development in this area should be mindful of this and be designed to consider some inundation. The caravan park should be aware of this and manage the area accordingly and if any future development occurs here it should be designed accordingly with minimum floor heights and clear communication of the issues. The caravan park should also be prevented from placing blockages in the main flow path. The golf club may also find it advisable to do some small earth works to prevent water ingress into their building. Earthworks may reduce the inundation effects in other areas, if considered these must be designed with consideration for the effects on the flow regime through the area.

4. **Consider Detention or Retention options**
   Detention or retention options either above ground or underground may be considered to minimise the volume of flow reaching the lower catchment. Retention would be a better option lower in the catchment, particularly if the golf course can get involved with utilising any saved water. Any of these options need to be individually assessed and designed and should consider the effect on the whole catchment small and larger events.

11. Conclusion

Modelling has been undertaken to assess the Holkham Court catchment. The catchment is defined by an undeveloped, steep upper sub catchment and a lower sub catchment with increasing developmental pressures. It has an open drain through the centre of the catchment, large low-lying areas in the lower catchment and infrastructure of varying scope that crosses the drainage path.

There are a number of issues caused by flow paths through public property and inundation of the low lying areas. The catchment and these issues have been examined by the stormwater modelling and recommendations made in this report. Some of the issues can be managed by relatively small infrastructure projects and some may be moderated by larger projects as recommended in the report. Works are unlikely to completely prevent some inundation of very low-lying areas within the caravan park.

A discussion with State Growth should be initiated about the possibility of increasing the size of the highway culvert. The investigations into this option should consider storm surge effects. If this culvert is not increased in size the other recommended works will result in greater increases in inundation in the lower catchment in the caravan park area.

12. References

Heyward O, Graham K, Green G (2012) '*Glamorgan Spring Bay Council Corporate Adaptation Plan'* Southern Tasmanian Councils Authority, Tasmania

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