



Inverleigh Flood Mitigation Assessment

Phase 1, 2 & 3 Feasibility
Report and Identification
of Drainage Strategy

June 2024

Loetis Pty Ltd
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Over a period of time, a number of private properties in the north of Inverleigh in the Common Road area have been impacted by flooding, particularly along Faulkner Road, King Road and Argyle Court. Following earlier reports undertaken by Water Technology, Golden Plains Shire Council (Council) has engaged Loetis to undertake an assessment of the mitigation options proposed in the earlier reports.

Following the earlier works Golden Plains Shire Council has advised that 3 options are preferable, these being Option 1, 2 & or 2a from the earlier Water Technology Report, following initial phase works, Option 3a was also added to the assessment. These options are:

- Option 1 – Lowering of the intersection of Argyle Court and Faulkner Road to drain toward King Road.
- Option 2 – Increase the basin size at Gregory Drive by combining the basin footprints into one.
- Option 2a – This involves the re-direction of high-flows from the basin toward Common Road directly west out falling via the existing gully and easements.
- Option 3a - Argyle Park Court to Common Road Outfall Pipe

Option 1

Option 1 was found to provide a viable strategy to alleviate flood impacts on a number of properties, particularly in the King Estate, however based on the modelling undertaken to date, Option 1 needs to be undertaken in conjunction with 'other' works to achieve the desired mitigation for the majority of effected properties.

A key element of Option 1 is that no acquisition of easements or reserves is required to facilitate the works, nor is there requirement to remove vegetation, with minimal and potentially nil impact on native vegetation. However, it is considered that significant impact on access to residents will result during construction.

Despite the design preventing flows overtopping Faulkner Road, still requires additional local swale drain works in the vicinity of 14, 16 & 22 King Road to alleviate localised residual flooding around these dwellings.

Option 1 also resulted in increased flood levels and extents within private properties downstream.

Option 2

The Option 2 investigation found that that there is some limited ability to make minor 'tweaks' to the existing basin outlet structures to make their operation more efficient.

Without undertaking acquisition of significant additional easement or reserve area, it is not considered feasible to provide a significant increase in the volume of the existing basins. Additionally, the earlier Water Technology report has shown that this work has minimal positive impact unless taken in combination with other works options.

This Option was not taken forward into the phase 2 & 3 works.

Option 2a

The investigation into Option 2a found that the delivery of the proposed western outfall (big basin) would result in significant impacts on existing vegetation and would require acquisition of significant additional easements. Therefore, it is not considered feasible to provide a significant outfall along the proposed Option 2a alignment.

During the Option 2a investigation, an alternate Option 2b alignment was identified with the outfall being piped along Argyle Park Court and Savage Drive which was identified as having significant merits on the basis that no easement / reserve acquisition is required and the impacts on native vegetation are assessed to be comparatively low.

Because this alternative alignment discharges directly into a waterway the impacts of increased flow depths and extents are anticipated to be comparatively relatively minor and restricted to already encumbered areas and well clear of any dwellings and public access locations (roads and paths).

This Option was not taken forward into the phase 2 & 3 works.

Option 3a

The investigation found that Option 3a does have a significant advantage comparative to Option 1, in that rather than re-directing flows into a location where there will be downstream impacts on private property in the form of increased flood depths and extents, it essentially diverts the water to the location of the receiving waterway, where the impacts are anticipated to be comparatively relatively minor and restricted to already encumbered areas and well clear of any dwellings and public access locations (roads and paths). It is considered that this outcome has significant value to Council, the community and all landholders and should be given strong weight when assessing alternate options.

Option 3a is also considered to have a less disruptive impact on residents during construction, with road access being able to be maintained during construction (1 way contraflow) and short duration closures during driveway crossings.

However, Option 3a was found to be more expensive than option 1, and despite the design preventing flows overtopping Faulkner Road, still requires additional local swale drain works in the vicinity of 14, 16 & 22 King Road to alleviate localised residual flooding around these dwellings.

Option 3a also resulted in increased flood levels and extents within private properties downstream however these impacts are limited to existing drainage easements.

Recommendations

Accordingly, Option 1 is considered to provide a superior outcome on all assessed elements except for the impacts on the downstream landholdings. To further assess this impact, the legal implications of the increased flood extents and depths on private property and the net public impact and benefits of the proposed alternate arrangements should be considered further. It is considered to be beyond the scope of this report to consider these two issues.



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1.1 Introduction & Background

Over a period of time, a number of private properties in the north of Inverleigh in the Common Road area have been impacted by flooding, particularly along Faulkner Road, King Road and Argyle Court. Golden Plains Shire Council (Council) has previously engaged Water Technology to undertake a detailed flood and drainage investigation for the area, with reports issued in 2021 and an updated report in 2023 following a significant rainfall event in November 2022.

The purpose of these investigations was to provide detailed flood mapping of the project area and subsequently identify potential mitigation options to reduce flood risk within the area. A number of potential mitigation options were identified and assessed in the two reports. Golden Plains Shire Council has engaged Loetis to undertake a more detailed assessment of the preferred options including functional design and costing of proposed mitigation works in the Common Road, Inverleigh estates.

The Water Technology investigations found that capacity of the drainage network within the project area was limited due to several factors including limited system capacity, lack of maintenance and flat grades. The capacity of the existing network has been regularly exceeded, resulting in inundation of private properties, including in some instances above the floor level of the dwellings.

Options to mitigate the flood impacts via changes to the existing network are limited by the topography and existing residential layout within the catchment. Previous minor works and maintenance of the existing network have been partially effective but have limited further potential to reduce flooding risks. In their report, Water Technology have identified four mitigation options which are shown to reduce flooding risks, and when combined, the identified works have the potential to reduce the risk of stormwater entering private property. The four mitigating options are presented in the below Figure.

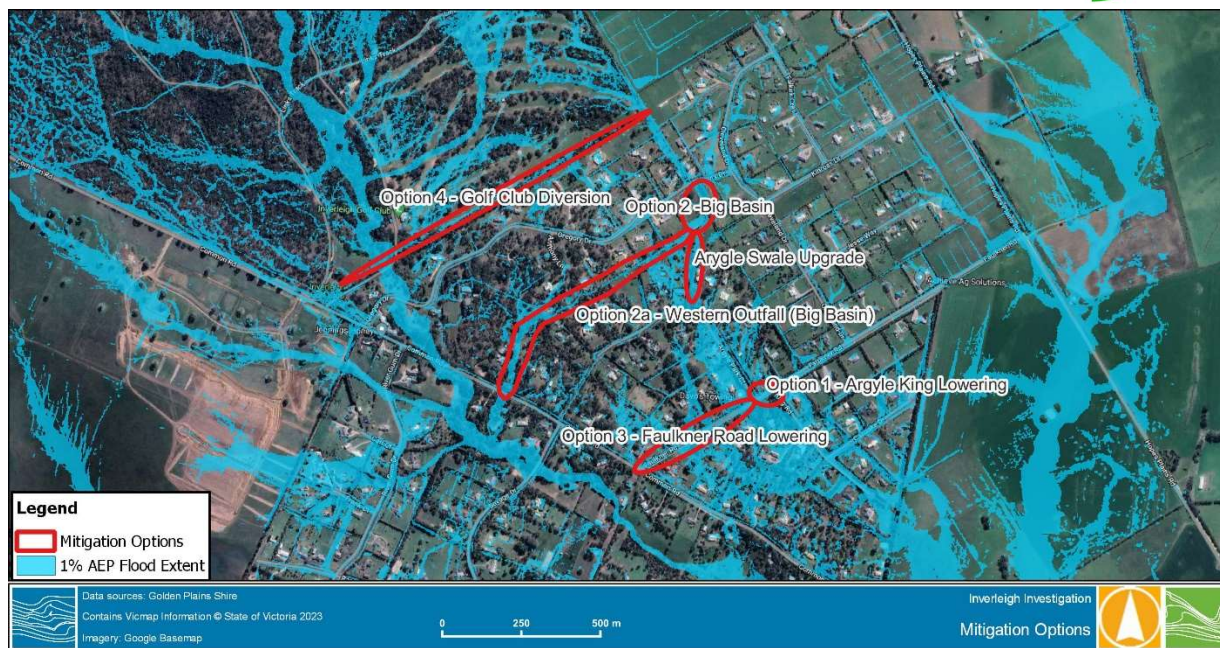


Figure 1 – Identified Mitigation Options

1.2 Scope of Report

Following the earlier works Golden Plains Shire Council has advised that 3 options are preferable, these being Option 1, 2 & or 2a. **These options were the primary initial focus of this assessment and were addressed in the version V02. Following the completion of the phase 1 works and consultation with Council officers and local residents, an additional option was added into the assessment as part of the phase 2 and phase 3 works. This report includes feasibility summary of the additional option and reports on final drainage strategy recommendations.**

It is noted that the terminology between phases and parts in this report is alternately used, following on from the terminology of the initial brief. For clarity part 1 / 2 / 3 is interchangeable with phase 1 / 2 / 3.

This assessment report will investigate these options to work through a feasibility assessment which will ultimately inform a preferred Drainage Strategy to administer flood mitigation improvements for the precinct.

Key project objectives are defined as:

- Identify constraints and feasibility of the proposed works.
- Provide a bill of quantities and costing of proposed works and additional required works.
- Provide a staging plan of proposed drainage works.
- Develop functional plans for preferred scheme.

It is strongly recommended that this report be read in conjunction with the report 'Inverleigh Investigation – Manna Gum Estate, V02 , Issued 27/04/2023 prepared by Water Technology.

This current assessment is broken into three separate phases.

- **Stage 1 - Feasibility and identification of Drainage Strategy**

- Review of the area and previous assessments
- Assessment of the constraints and opportunities
- Identification of the strategy and required inputs and process to go forward.
- Preliminary cost estimates for the option
- Provide recommendation on the option.

Following Council review and direction on the preferred strategy

- **Stage 2 – Functional design of Drainage Strategy (part 1)**

- Functional Design of preferred strategy(s)
- Flood Modelling of functional design(s) to validate the flood outcomes

Following Council review and direction on the preferred strategy

- **Stage 3 – Functional design of Drainage Strategy (part 2)**

- Updated reporting covering the Functional Designs of the preferred strategy(s)
- Detailed cost estimates and bill of quantities reflecting the functional design plans

The version Rev 03 report is issued at the completion of stage 3 of the scope outlined above, the revision 02 was issued at the completion of stage 1 of the report.

1.3 Locality

The subject area is located in the north of Inverleigh and is generally centred along a shallow natural depression in the topography running from north to south and generally through Gregory Drive, Argyle Park Court, Faulkner Road and King Road. The area is zoned Low Density Residential and is not subject to any 'drainage related' planning overlays.



Figure 2 - Site Location and Existing Context (Image courtesy Google Maps)

1.4 Site Description

The subject area is predominantly cleared low density residential area with varying tree cover. Lot sizes typically range from 0.5 – 2.0Ha.

A detailed description of the area, the existing drainage network and the identified existing key drainage issues can be found in section 2 of the Water Technology Report.



Figure 3 - Site Area Plan & Contours

1.5 Received Information

In preparation of this assessment, Loetis has received the following information as part of the brief.

- Inverleigh Investigation – Manna Gum Estate, V02, Issued 27/04/2023 prepared by Water Technology Water Technology
- Inverleigh Drainage Assessment – Common Road, 8 November 2021, Water Technology
- Approved and preliminary design plans for Barrabool Views Estate, Mannagum Estate & King Estate
- LiDAR surface information
- BYDA information on existing services from Telstra, Powercor and Barwon Water
- Site inspection and verbal advice from Council officers.
- Aerial and other imagery from commercial and Government sources

1.6 Options Investigated

Following the earlier Water Technology report, Golden Plains Shire Council advised that 3 of the proposed mitigation options were identified as preferable to investigate and assess further. These options form the basis of this report.

These options are:

- Option 1 – Lowering of the intersection of Argyle Court and Faulkner Road to drain toward King Road.
- Option 2 – Increase the basin size at Gregory Drive by combining the basin footprints into one.
- Option 2a – This involves the re-direction of high-flows from the basin toward Common Road directly west out falling via the existing gully and easements. Note to achieve grade from the basin, the height of the basin from option 2 was raised by 250 mm.

Following the works undertaken in phase 1 of the report, an additional option being labelled as Option 3a was added to the options being assessed.

- Option 3a – This involves the re-direction of high-flows from the intersection of King Road / Faulkner Road west along Faulkner Road toward Common Road via an underground pipeline, along with raising of the footpath along Faulkner Road to prevent overtopping by storm flows in large events.

2 MITIGATION OPTION 1 – LOWERING INTERSECTION OF ARGYLE PARK / FAULKNER & KING

The Mitigation Option 1 “Lowering Argyle Intersections” is outlined in detail in section 6.3 of the Water Technology report. In summary, this option looks to lower the intersection of Argyle Park Court and Faulkner Road to direct the overland flows to King Road and reduce and or prevent flows from overtopping Faulkner Road and continuing southwards through private property.

2.1 Existing Conditions

The proposed area of works is located in a LDRZ zone and has a design and development overlay – Schedule 5 (DD05) and is within designated bushfire prone areas.

There are no identified heritage or drainage overlays on the vicinity.

Argyle Park Court, Faulkner Road and King Road all have formations typical of low-density residential areas, with a raised roadway with wide swale drains on both sides of the road that convey the drainage. There are several culverts of limited capacity conveying flows from the upstream swales to the downstream swales. There is a footpath along the south side of Faulkner Road and the east side of King Road.

There are existing established trees on the corner of Argyle Park Court and Faulkner Roads, with limited existing vegetation within the remaining road reserves in the vicinity. There are also established trees within the private property directly adjoining the road reserves.

There is existing overhead electrical lines in Faulkner Road and existing underground electrical, water and telecommunications assets in all three road reserves.

Figure 4 below shows the existing area with approximate service locations shown, and figures 5 and 6 show photos of the existing conditions.

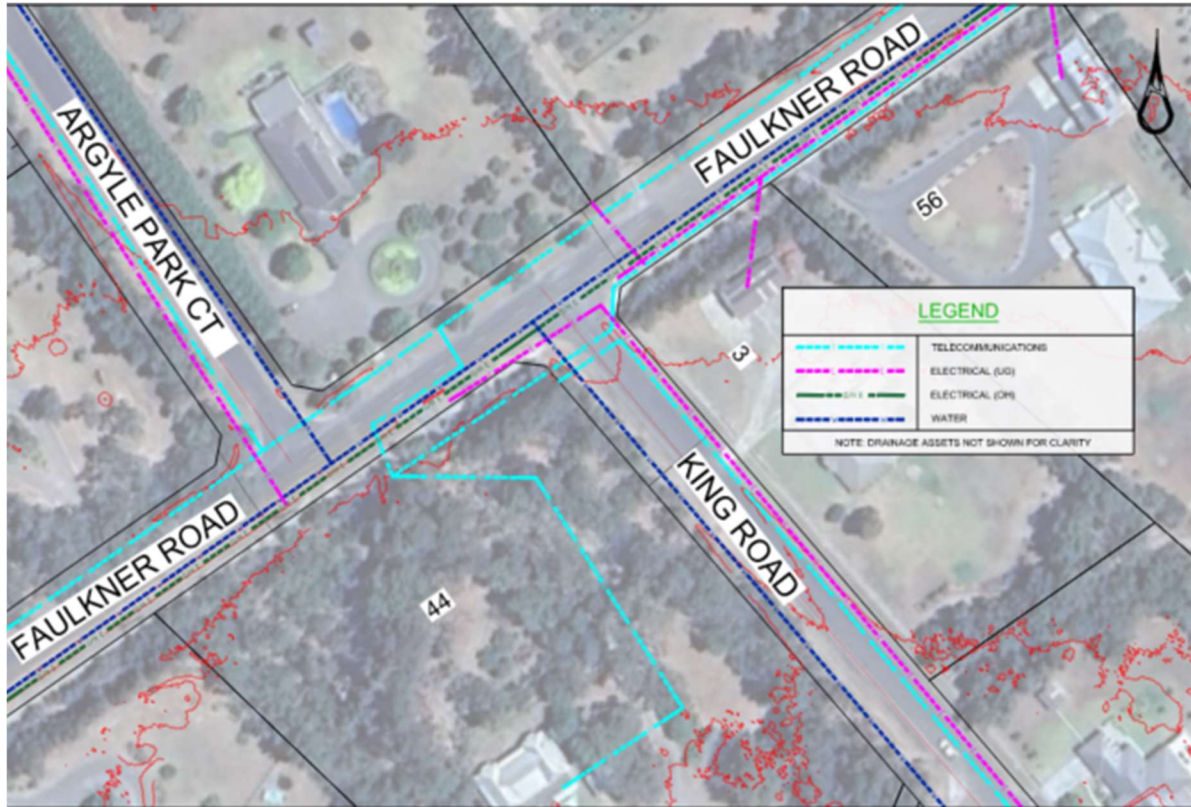


Figure 4 - Site Location and Existing Services



Figure 5 – Photo of looking northwest up Argyle Park Court



Figure 6 – Photo of looking northeast along Faulkner Road

2.2 Proposed Works Detail

As outlined in the Water Technology report, it is proposed to lower the level of the existing roadway at the intersections of Argyle Park Court and Faulkner Road and Faulkner Road and King Road, to direct the overland stormwater flows from Argyle Park Court into King Road.

The surface modelled in the Water Technology report utilises a lowering of approximately 300mm at the intersection of Argyle Park Court and King Road, increasing to a lowering of 700mm at the intersection of Faulkner and King Roads. These lowered sections then transition back to the existing road surfaces on each of the roads. The extent of these transitions would be driven by not only the hydraulic requirements, but also the road design standards, safety and ride comfort for road users. In the case of Faulkner Road to the northeast (towards Cleveland Drive) due to the depth of lowering and incoming road grades, it is considered that this transition will need to be reasonably significant.

The sketch plan in figure 7 below shows the approximate extents of the proposed road lowering.

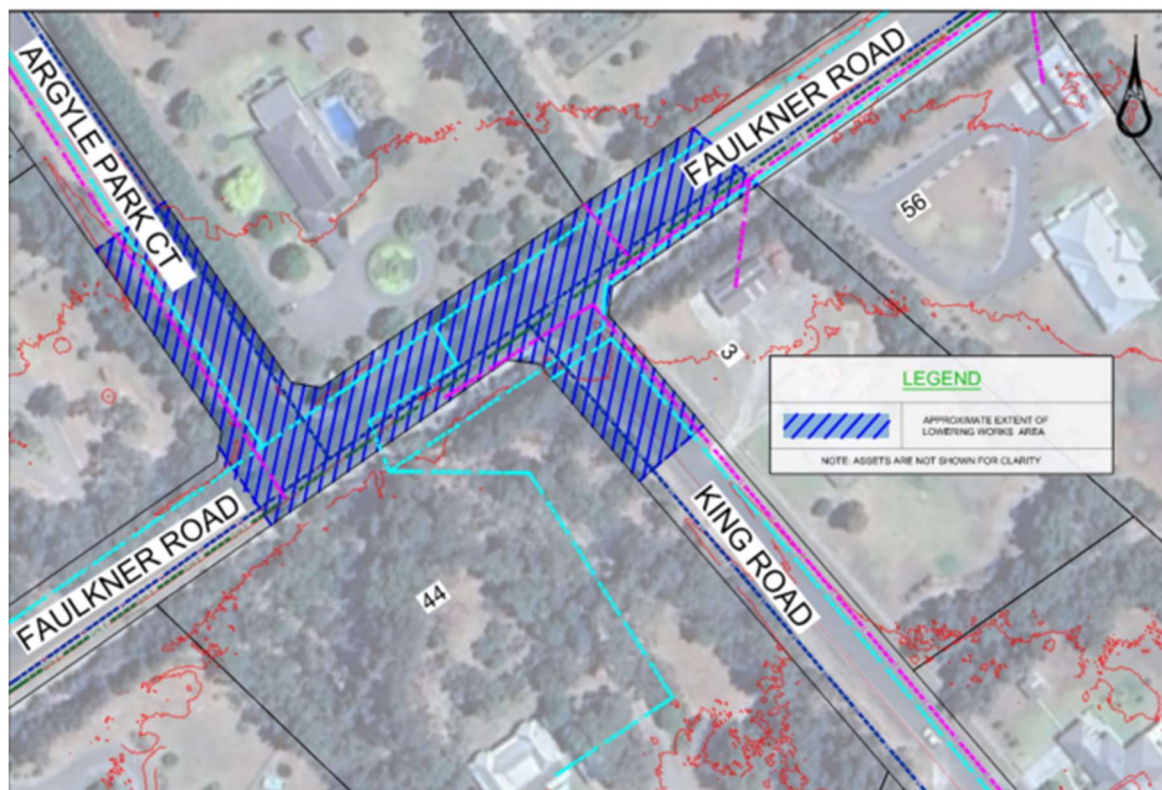


Figure 7 – Sketch Plan of Proposed Option 1 Road Lowering extents

It is considered that any conveyance upgrades to the Argyle Park Court / Faulkner Road / King Road intersection area would be undertaken in conjunction with upgrades to the capacity of Argyle Park Court between 40 Argyle Park Court and the Faulkner Road intersection to minimise or prevent breakout of flows to the south as is happening in the current conditions. These works are anticipated to include enlargement to the swale and driveway culvert capacities and some localised formalisation of the low side property boundary levels.

Similarly, as outlined in the Water Technology report, works will need to be undertaken in King Road to increase the roadway capacity and the driveway crossover capacities to limit the impacts outside the road reserve.

2.3 Identified Opportunities & Constraints

Through this investigation, it has been identified that there are a number of constraints and opportunities around the proposed intersection lowering works.

Constraints

- There are a number of existing underground services in the road reserve will be impacted by the proposed lowering.
 - Based on the conceptual surface, it is considered that the electrical, communications and water services at the intersection of Faulkner Road and King Road will almost certainly need to be lowered / relocated.
 - The underground electrical, communications and water services located at the intersection of Argyle Park Court and Faulkner may require lowering, however given the reduction in surface levels is relatively minor, if the existing services are of sufficient depth, it may be possible to retain them without alteration.

- It is assessed that the current network of crossroad culverts in the vicinity of the two intersections will be impacted, however it is considered that there is likely to be some rationalisation of their alignments and sizes in the detail design phase of this project should it proceed.
- A significant area of road pavement will either need to be partially or fully removed and replaced, the total area affected is assessed to be in the order of 2,000m².
- The driveways to 44 and 45 Faulkner road and to a lesser extent 56 Faulkner and 3 King Road will likely have some impact requiring as a minimum partial reconstruction.
- Access during construction to the immediately adjacent properties as well as all properties in Argyle Park Court and King Road will need to be considered and provided for, with no alternate routes available for these properties.

Given the depth of cut required, total excavation including for pavement boxing in the vicinity of the Faulkner Road and King Road intersection is anticipated to exceed 1.0m in total depth. This will take some time to construct and will have periods where it is difficult to stage the works such that safe access can easily be maintained. It is considered that this access requirement will require construction practices that impact efficiencies and the cost of the works.

If possible, avoidance of construction during the winter and spring months will assist in avoiding delays due to wet weather periods.

- It is unclear if a hazard assessment on the overland flows through the Faulkner / King / Argyle intersection was undertaken as part of the earlier investigation. This should be assessed to consider if additional hazard due to the overland flows is being introduced due to the proposed works, and if so the extent and location of this hazard.
- It is noted that the Water Technology modelling indicates that this proposed mitigation option will result in increased flood levels along a significant section of the downstream flow path and within several properties. From a technical perspective, this is the effective result of water being diverted from one location to another. However, we strongly recommend that the legal implications of these increased flood levels and extents within private property particularly where it is not within a drainage easement should be appropriately assessed by a qualified person.

The below image 8 shows the extent of the increased flow extents from figure 6-3 in the Water Technology report.



Figure 6-3 Option 1 – 1% AEP Flood Level Difference

Figure 8 – Flood level difference (afflux) due to Option 1 (Image courtesy of Water Technology)

Opportunities

- It is considered that there may be an opportunity to investigate the effects of a slight raising of the road pavement in Faulkner Road immediately to the southwest of the Argyle Park Court intersection to achieve the same design outcome but reduce the extent of road lowering required, noting that some lowering will still be required. This may need to be accompanied by localised increased levels along the adjacent section of footpath on the southeast side of Faulkner Road to prevent breakout of flows.
- As part of the proposed works, it is suggested that further consideration and discussion be given in the functional stage to the redirection of flows and whether a ‘split’ strategy whereby low flows (not exceeding downstream system capacity) that maximise the total volume are directed down the existing Faulkner / Common Road route be maintained to minimise impacts in King Road and the properties downstream of King Road.

Should this option 1 be considered further, it is recommended the following additional assessments should be made,

- Flora and Fauna assessment be made to ascertain potential impacts, particularly on the large tree at the front of 37 Faulkner Road.
- Feature survey of the area and particularly key information including location and ‘depthing’ of the existing services.
- Legal advice on liabilities and risks to Council from the effects of increased flood depth and extent on impacted private properties.

2.4 Preliminary Costing of Proposed Drainage Strategy

The estimated construction and related cost for Option 1 is \$1,464,039 (excl. GST)

Included in this cost are allowances for upgrades within Argyle Park Court upstream and King Road downstream.

Please refer to figure 21 for additional detail.

2.5 Areas of Suggested Discussion / Investigation / Alternative Solutions

It is noted that in the earlier modelling undertaken by Water Technology, no assessment appears to have been documented of a scenario that effectively assesses Option 1, but in conjunction with works in Argyle Park Court along the frontage of number 19 and 29 Argyle Park Court to assess the impact of reducing or preventing breakout of flows from the road reserve into the lots.

Subject to discussion, the works in Argyle Park Court should also assess impacts on restricting or limiting the flow entering the open drain along the rear of properties 11-37 Faulkner Road to limit the flows entering this drain to the drains capacity and reduce or prevent the breakouts currently occurring in this drain.

It is assessed that such works are likely to reduce impacts on a number of properties west of Argyle Park Court, but with increased flows and impacts if unmitigated at the intersection of Argyle Park Court / Faulkner Road / King Road area.

It is suggested that this option be considered and modelled in conjunction with the options outlined above.

Also considered during this assessment were two alternative solutions to the Option 1 proposal. It is recommended that these undergo further discussion in conjunction with Council and the Water Technology team. These include.

2.5.1 Potential 'Option 1a – Piped Conveyance of Flows From Argyle Park Court to King Road

We have assessed at a preliminary level an alternative option to convey the flows via underground culverts. We have nominally named this option as Option 1a 'piped conveyance of flows from Argyle Park Court to King Road'.

- Based on the Water Technology report, it is assumed that the peak additional flow to be diverted towards King Road is approximately 1.9m³/s.
- It is assessed that box culverts could be constructed to pick up the flows from King Road and then direct them to King Road where they daylight in the roadside swale drains. Preliminary assessments suggest that these could be laid at a grade of 0.7%.
- Due to the shallow cover, it is assessed that these would likely have a maximum height of 300mm. High level hydraulic assessment suggests that box culverts in the order of 3 x 900 x 300mm box culverts would be required to convey this flow. Detailed assessment and design of the inlet structures would be vital to ensure flows are directed into the culverts.
- High level cost estimate of this option estimates the total cost of these works is in the order of \$860,000 (exc. GST)
- The below sketch plan shows an approximate arrangement for this concept. Detailed hydraulic assessment would be required to validate these assumed layouts and sizes.

Based on the financial result and the impact of construction disruption basis, this option is considered to compare favourably with Option 1 to nominally achieve a similar outcome, however consideration also needs to be given to the ongoing maintenance of the structures and also the risk

of blockage in large events comparative to the ‘overland’ approach for option 1, these factors both favour Option 1.

Additionally, it is considered that Option 1a is likely to be comparatively less effective in events larger than the 1%AEP design event (e.g. November 2022) than Option 1, noting however, that detailed hydraulic analysis should be undertaken to confirm this assumption.

As noted later in the report, it is also queried whether a ‘light Option 1a’ may be a feasible option in conjunction with other works. It is envisaged that a light Option 1a would have a piped culvert system similar to Option 1a, however it would be sized to convey a lower flow than the nominal 1.9m³ flow outlined above. It may also be undertaken in conjunction with some swale and or culvert works to convey flows from the northeast from Faulkner Road into King Road.



Figure 9 –Concept sketch of Option 1a piped conveyance of flows from Argyle Park Court to King Road

Should this option 1a be considered further, it is recommended the following additional assessments should be made,

- Flood modelling of the proposed concept to ascertain resultant flood level afflux and verification of the proposed concept.
- Feature survey of the area and particularly key information including location and ‘depthing’ of the existing services.

- Legal advice on liabilities and risks to Council from the effects of increased flood depth and extent on impacted private properties.

2.5.2 Potential 'Option 3a' – Piped Conveyance of Flows along Faulkner Road

While preparing the phase 1 report, Loetis also assessed at a preliminary level an option of capturing flows in the vicinity of Argyle Park Court and Faulkner Road intersection and conveying the flows via underground pipe along Faulkner Road and discharging directly into the large waterway running northwest to southeast parallel with Common Road, nominally at the rear of the 119 / 135 Common Road properties.

Subsequently this option was assessed further in phase 2 of this report and a more detailed assessment of this option is provided in section 5.

2.6 Option 1 Phase 1 Summary

It is considered that Option 1 provides a viable strategy to alleviate flood impacts on a number of properties, particularly in the King Estate, however based on the modelling undertaken to date, Option 1 needs to be undertaken in conjunction with 'other' works to achieve the desired mitigation for the majority of effected properties.

A key element of Option 1 is that no acquisition of easements or reserves is required to facilitate the works, nor is there requirement to remove vegetation, with minimal and potentially nil impact on native vegetation. However, it is considered that significant impact on access to residents will result during construction.

It is strongly recommended that the legal implications of these increased flood levels and extents within private property particularly where it is not within a drainage easement downstream of the proposed works should be appropriately assessed by a qualified person.

It is recommended that Option 1a and 1b be assessed further and tested against Option 1 via preliminary flood modelling.

3 MITIGATION OPTION 2 – BIG BASIN

The Mitigation Option 2 “Big Basin” is outlined in detail in section 6.4 of the Water Technology report. In summary, this option looks to increase the combined volume of the Gregory Basins being the existing ‘Manna Gum Estate Stage 2’ basin located at 120 Gregory Drive and the Barrabool Views Estate Stage 2 Basin located at 130 Gregory Drive. It was conceptually proposed in the Water Technology report that this is done by combining the two basins into one single enlarged basin.

3.1 Existing Conditions

Both existing basins are located in the LDRZ zone and have a design and development overlay – Schedule 5 (DD05) and Development Plan Overlay – Schedule 9 (DPO9) and are within designated bushfire prone areas.

Number 120 Gregory Drive also has an environmental significance overlay (ESO4), it is understood that this overlay relates to protection of Clover Glycine (*Glycine latrobeana*), however that the area of protection is remote from the specific 120 Gregory Drive property and relates to a separate part of the ‘parent’ property.

There are no identified heritage or drainage overlays on the properties.

These basins have the following nominal design information.

	120 Gregory Drive Basin	130 Gregory Drive Basin
(Design) Volume	760m ³	1,245m ³
Top Water Level (TWL)	RL 84.81	RL 85.85
Invert / Outlet level	RL 84.15	RL 84.65

It is noted that the combined design volumes of ~2,000m³ is significantly less than the 3,400m³ for the existing basins estimated from the Water Technology report (refer to table 5-1). It is assumed that the Water Technology volumes are based off measured Lidar surface volumes, however it is unclear on the reason for this discrepancy. However, we would consider the following reasons may explain this difference.

- Differences between design and as constructed surfaces.
- Allowance for volume of storage in the ‘upstream’ reaches (open drains) that are nominally outside the basin footprint, but provide storage volume.
- Differences in assumed outlet levels for the various weir operations.

Both basins are controlled currently by ‘slot weir’ style outlet control structures and both basins are located within private property, but within easements in favour of Council. Collectively these easements have a footprint area of approximately 5,450m² and within this, the basin footprints are approximately 3,700m², i.e. the basins take up approximately 2/3 of the easement area with the remainder being made up of the batters, embankments and inlet / outlet structures.

Both basins are excavated below their outlet level to provide a permanent water body. These water bodies were designed to provide aesthetic and environmental (habitat) outcomes, and whilst

functioning as such in a limited capacity, were not specifically designed to provide water quality outcomes.

It is noted that the 'maximum' Top Water Level (TWL) in the 130 Gregory Drive basin is effectively controlled by the levels in Gregory Drive adjacent to the basin, with the table drains at this location being inundated when the basin is at TWL.

The maximum TWL for the 120 Gregory Drive Basin is limited by two key design constraints, these being the floor level of the dwelling located at 120 Gregory Drive and also the levels of the incoming drainage line from the southeast, generally along the rear of 110 Gregory Drive and the adjacent properties.

The invert or outlet levels for both basins are controlled by the levels of the downstream drainage network. For the 120 Gregory Drive basin, this is the level of the open drain located in an easement running along the eastern boundary of 40 Argyle Park Court. This drain commences at an RL of approximately 84.10.

The invert level of the 130 Gregory Drive Basin is located at RL84.65 and is also nominally controlled by the downstream open drain, noting that there is some 500mm of height difference that theoretically could be utilised if the outlet structure was to be lowered.

Both basins have design batters of 1:6.

Both basins have varying levels of vegetation surrounding them, this vegetation is a mix of planted and naturally regenerated vegetation that has self-sown since the basins were constructed some 10 years ago.

Figures 10, 11 and 12 below shows the two existing basins and photos of their current state.

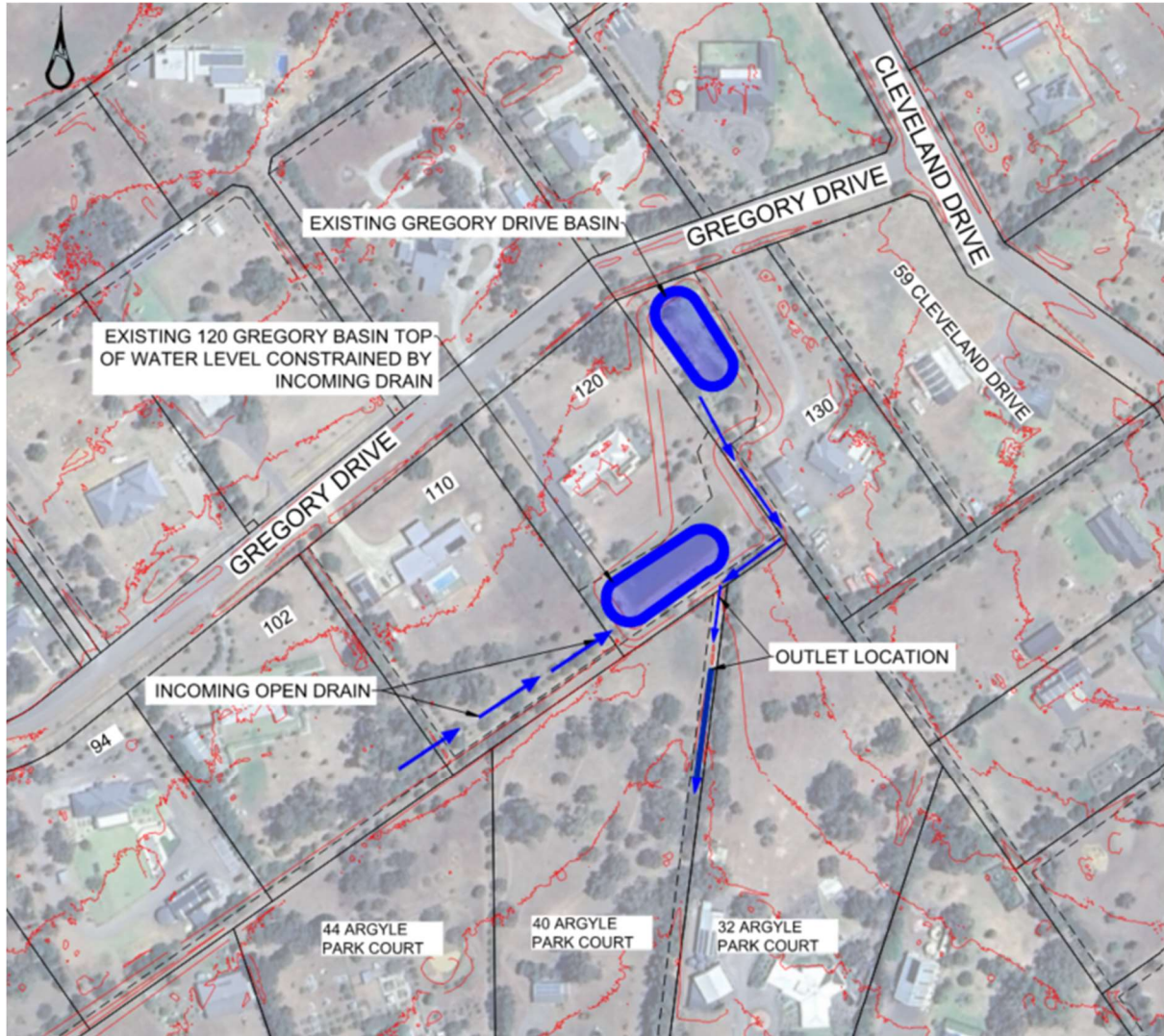


Figure 10 - Site Location and Existing Context



Figure 11 – Photo of 110 Gregory Basin looking southwest



Figure 12 – Photo of 130 Gregory Basin outlet looking northwards

3.2 Proposed Works Detail

As outlined in the Water Technology report, it is proposed to increase the combined volume of the two Gregory basins by combining them into a single basin.

It is understood from the Water Technology report that the concept would be to increase the footprint size of the combined basin to approximately 6,000m² (Table 6-1) with an updated storage volume nominally of 5,300m³ (section 6.4)

It is unclear of the adopted invert and TWL levels adopted in the Water Technology options.

The below sketch plan detailed in figure 13, depicts the nominal footprint of the proposed amended basin as modelled in the Water Technology report.

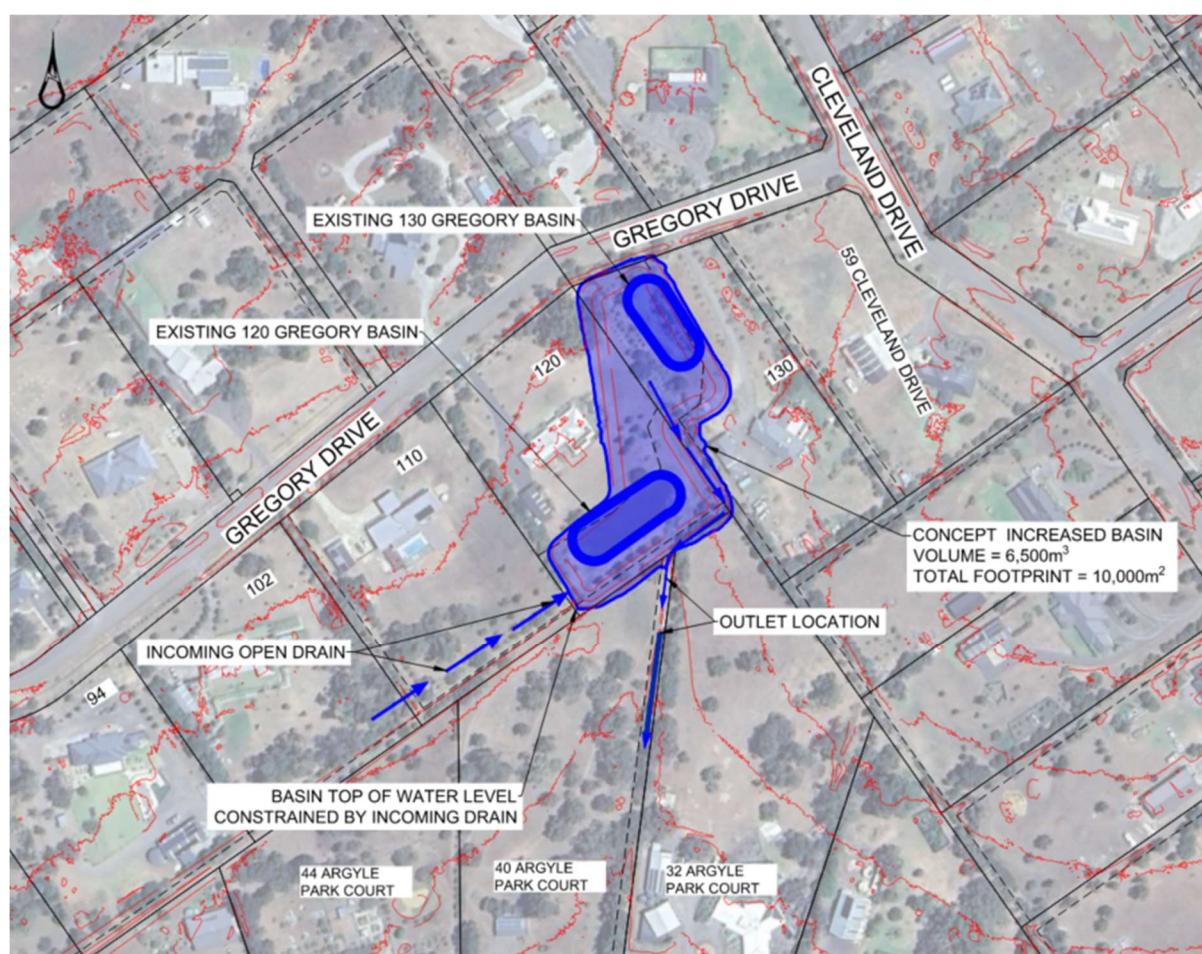


Figure 13 - Site Location and Existing Context

3.3 Identified Opportunities & Constraints

Through this investigation, it has been identified that there are several constraints that govern the ability to increase the size of the Gregory basins.

Constraints

- The existing surface levels along the incoming drain to the rear of 102 & 110 Gregory Drive limit the lifting the TWL of the 120 Gregory basin. Theoretically, these surface levels could be lifted however, it is considered that this would require additional width of the easement to achieve this, and the impacted works area would by necessity extend over several properties.
- The requirement to provide sufficient freeboard (300mm) to the floor levels of the dwelling at 120 Gregory Drive prevent significant increase in the TWL of the 120 Gregory basin.
- If the two basins are combined, then it is considered that the 130 Gregory Drive Basin TWL will need to be lowered to match the adopted (revised) TWL of the 120 Gregory Basin. Assuming some nominal increase of say 300mm to the 120 Gregory Basin, this would result in a revised TWL for 130 Gregory basin of RL 85.11. This is roughly 750mm lower than the current TWL of the 130 Gregory basin. This would significantly reduce the volume of detention storage in the 130 Gregory Drive basin, high level calculations estimate this to be in the order of a 900m³ reduction in volume comparative to the existing state.
- Assuming that the adopted TWL is in the order of RL85.11 and the invert is in the order of RL 84.15, then to achieve a volume of 6,000m³, a basin footprint of approximately 6,500m² would be required.
- Based on a 2/3 ratio of basin footprint to easement area, this would require an easement area in the order of 10,000m² which is significantly above the current easement area of 5,450m². This would require the acquisition of a significant additional easement area, it is considered outside the scope of the Loetis investigation to ascertain the financial, legal and community impacts of meeting this requirement.
- Access to the 120 Gregory Road basin is severely constrained with the existing house and sheds preventing access except through/over the area that appears to contain the wastewater treatment and effluent field. It is anticipated that as a minimum, some level of rectification to these assets would be required to facilitate access to this basin. Access to the 130 Gregory basin has minimal restrictions, although it is considered that it would likely need to be facilitated via parts of 130 Gregory Drive outside of the easement.
- Allowance has been made in the cost estimates to bore / pipe jack a lower outfall pipe along the easement of 40 Argyle Park Drive so as to provide a lower invert level to the proposed basins. It is noted that this alignment is heavily vegetated and given the shallow downstream levels this concept is considered likely to be difficult to implement in its entirety in the functional design.
- The concept shape that has been utilised in the earlier modelling is noted to as best as possible work with the existing basin and easement shapes. Whilst the shape is necessitated to minimise impacts on the two properties, it is noted that this irregular shape results in an inefficient volume from the given footprint.

Opportunities

- The earlier concept designs have assumed that the enlargement of the basin would generally be restricted to the existing basin footprints and or expansions of those footprints within numbers 120 & 130 Gregory Drive.

As outlined above, this approach has significant constraints limiting the effectiveness of the proposal. As an alternate solution, consideration could be given to an alternate basin location located further downstream of the existing basins, potentially enlarging the existing basin at 120 Gregory Drive, or acting independently of it. Nominally this would be located in the property(s) in the vicinity of 32 – 40 Argyle Park Court.

Land / easement acquisition is considered the primary obstacle to this approach, however the impact on vegetation and other assets looks minimal in comparison to the Gregory Drive properties and the location within the property would be remote from the existing home and other structures unlike in the Gregory Drive properties. The landform also more readily facilitates a more optimal basin depth to volume ratio for the basin.

Should this option be considered further, it is recommended the following assessments should be made,

- Flora and Fauna assessment be made to ascertain potential impacts.
- Survey of the key information in the area including FFL of 120 Gregory Drive, surface levels along the rear of 102 & 110 Gregory Drive, and the existing basin information.

3.4 Preliminary Costing of Proposed Drainage Strategy

The estimated construction and related cost for Option 2 is \$1,230,000 (excl. GST).

Excluded from this cost is any costs associated with acquisition of additional easements or reserves to facilitate the works.

Please refer to Figure 21 for additional detail.

3.5 Areas of Suggested Discussion / Investigation / Alternative Solutions

Some identified areas for further discussion in conjunction with Council and the Water Technology team include.

- Consideration of construction of basins in series (130 Gregory Basin discharging directly into 120 Gregory Basin with revised outlet structures. This would enable minor increase in 120 Gregory basin in the order of 200m³ in storage with minimal works and site impact.
- Consideration of adopting steeper batters to increase storage, noting that this will need to be assessed on a safety basis and impact on landholders.
- Further consideration could be given to an option to lower the invert levels of the basins in their current configurations. This would enable utilisation of the current wet base volumes, possibly enlarged with some additional earthworks.
 - However, it is noted that the volume achieved from this approach is not anticipated to be significant, with a volume of 500 – 1,000m³ considered likely to be achievable with minor earthworks only.
 - This would require the lowering of the outlet invert, nominally via installing a 'lower' flow pipe through the easement in 40 Argyle Park Court. The outlet arrangements would then operate in a 'staged' approach, it is considered that this would need to be assessed through detailed hydraulic modelling to understand the implications.
 - Due to existing vegetation, it is assessed that this pipe would need to be bored. The length of the bore would be in the order of 270m, indicative costs for this pipeline construction would be considered to be in the order of \$200,000 , excluding works at the basin end.



Based on the volume of storage obtained for the construction cost, it is considered that all of these approaches are unlikely to provide significant downstream impact and are unlikely to be an economically feasible option.

3.6 Option 2 Phase 1 – Big Basin Summary

Based on the above assessment, it is considered that there is some limited ability to make minor 'tweaks' to the existing basin outlet structures to make their operation more efficient.

However, without undertaking acquisition of significant additional easement or reserve area, it is not considered feasible to provide a significant increase in the volume of the existing basins.

Additionally, the earlier Water Technology report has shown that this work has minimal positive impact unless taken in combination with other works options.

4 MITIGATION OPTION 2a – WESTERN OUTFALL (BIG BASIN)

The Mitigation Option 2a “Western Outfall Big Basin” is outlined in detail in section 6.5 of the Water Technology report. In summary, this option looks to provide a diversion of flows from the Gregory Basin(s) to the southwest.

In the scenario modelled by Water Technology, this option is undertaken in conjunction with the Option 2 ‘Big Basin’ scenario where significant additional storage is created in the combined volume of the Gregory Basins.

The outfall alignment traverses a number of properties as shown in figure 14 below.

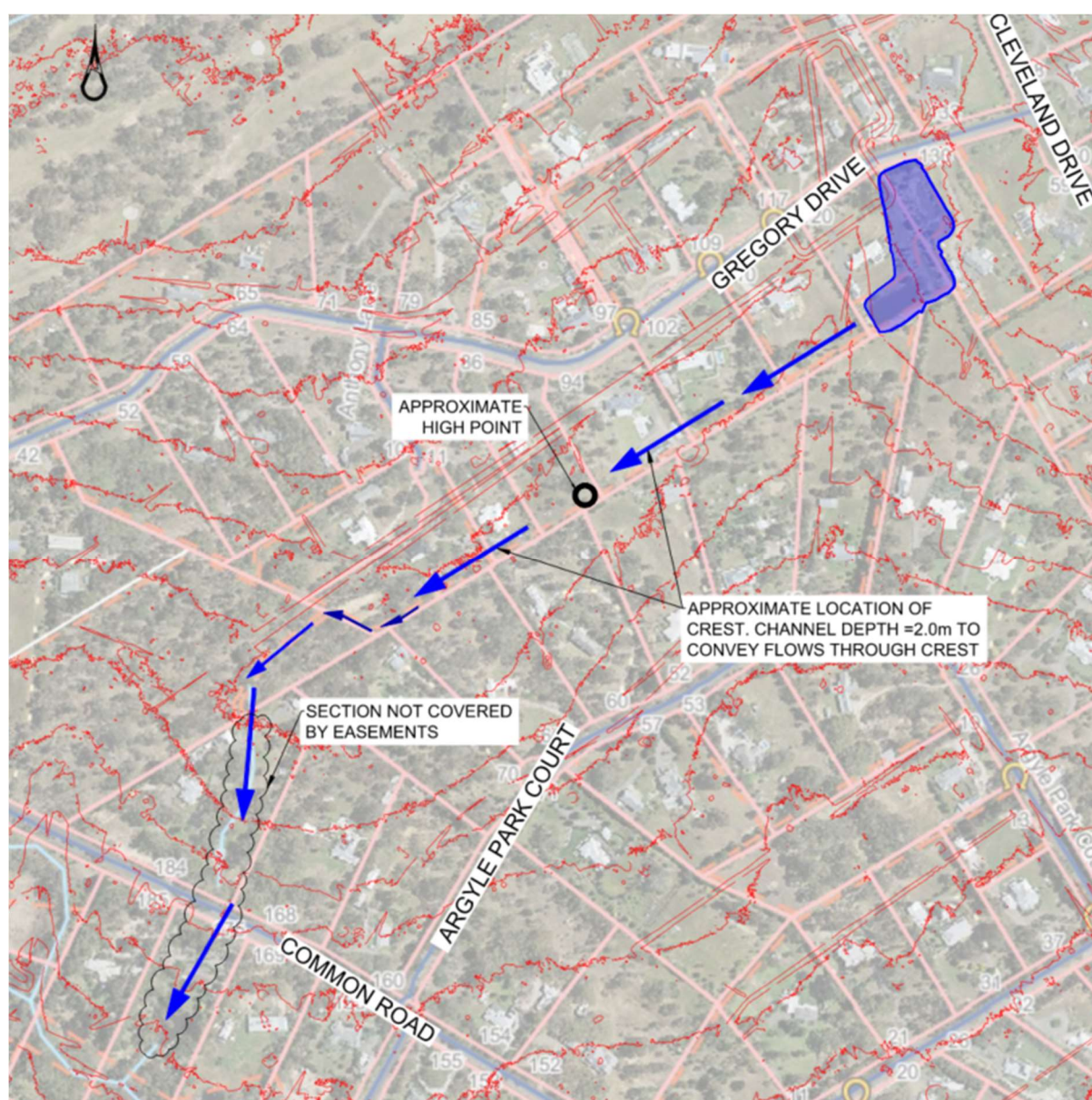


Figure 14 – Alignment of Option 2a Proposed Western Outfall (Big Basin)

4.1 Existing Conditions

The proposed outfall alignment is located within the LDRZ zone and part of the alignment traverses through land that has a design and development overlay – Schedule 5 (DD05) and Development Plan Overlay – Schedule 9 (DPO9). All of the alignment is within designated bushfire prone areas.

Numbers 86-120 Gregory Drive, 11 & 14 Anthony Lane and 42 Gregory Drive also have an environmental significance overlay (ESO4), it is understood that this overlay relates to protection of Clover Glycine (*Glycine latrobeana*) remnant vegetation area. The map 1 within the ESO4 identifies the portion of 42 Gregory Drive as being the identified area of Clover Glycine within the overlay. An extract from ESO4 is shown below in figure 15.

There is also a restriction on title on 42 Gregory Drive denoting ‘no vegetation shall be cleared...unless approved by the relevant authority.’

General area of site covered by Clover Glycine



[Zoom and rotate image](#)

Figure 15 – Extract from ESO4 – Extent of Clover Glycine Protection Area (Image courtesy of planning.vic.gov.au)

There are no identified heritage or drainage overlays on the properties.

There is an identified ‘mapped’ waterway that traverses from the southern boundary of 42 Gregory Drive southwards through 184 Common Road, this waterway terminates slightly before the Common Road boundary of 184 Common Road. This waterway recommences in the central portion of 175

Common Road before terminating in the large waterway running northwest to southeast through 175 Common Road.

As detailed in Figure 15 above, there are drainage easements in favour of Council within the properties 86-120 Gregory Drive, 11 & 14 Anthony Lane and 42 Gregory Drive. Generally, these are 5m wide and located along the rear (south) boundary of the lots, however there are deviations in 14 Anthony Lane and 42 Gregory Drive, it is understood that these deviations were to avoid impact on existing indigenous trees at the time of the drain and easement establishment during the subdivision development.

There are no existing easements within 184 and 175 Common Road along the flow path, noting that the legal status of the waterway and the effects of its truncated extents are unclear. There is a large easement that encompasses a defined waterway that runs from the northeast to southwest within 175 Common Road. This waterway drains a larger catchment of some 1,100Ha and is considered the receiving waterway for this mitigation option.

Access to the properties for this investigation was limited however generally speaking,

- There are constructed swales running within the easements within 86-120 Gregory Drive, 11 and 14 Anthony Lane. There is a high point in this swale network within the rear of 11 Anthony Lane, with the swale to the northwest of this falling to the 120 Gregory Drive basin, and the swales to the southeast of this falling out to the southeast. These swales have significant sections of planted or naturally regenerated vegetation within or immediately adjacent to them. They also run adjacent to (and potentially within) the tree protection zones of remnant vegetation that predates the development of the estate.
- Within 42 Gregory Drive, it is understood that there is minimal or no constructed nor natural definition to the waterway, and the area is heavily covered by vegetation.
- The existing waterway within 184 Common Road has some natural definition and formation to it and is largely well-maintained lawn with a canopy of larger trees above.
- Historically 175 Common Road has not had any formal drainage alignment through the property, however following the November 2022 flood event in which the dwelling was affected with above floor flooding, the owner has constructed a combination berm and swale to divert flows westwards around the dwelling. It is unclear of the extent, effectiveness and of any potential adverse effects on the property and neighbouring properties that these works may have had. The property has established landscaping and canopy trees within the drainage alignment.

The below Figure 16 shows the alignment of the open drain within 110 Gregory Drive. The below Figure 17 shows the alignment of the 'waterway' within 184 Common Rd.



Figure 16 – Image of easement and open drain within 110 Gregory Drive

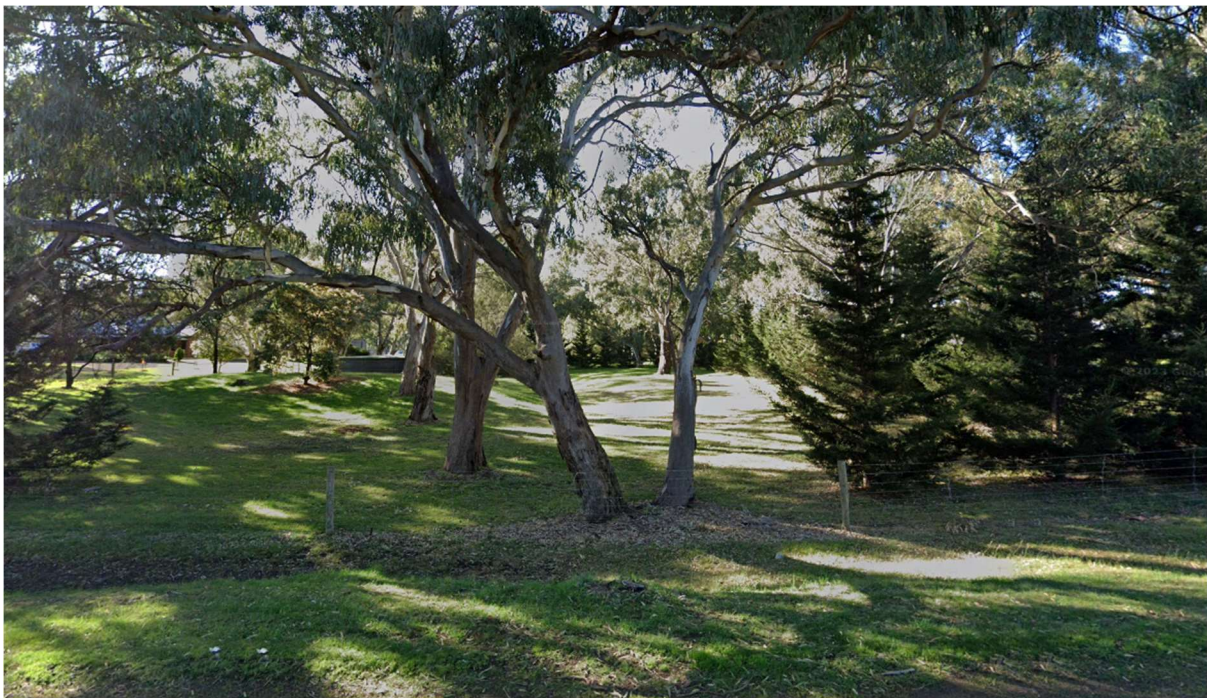


Figure 17 – Image of waterway within 184 Common Road (Image courtesy of Google Maps)

4.2 Proposed Works Detail

As outlined in the Water Technology report, it is proposed to divert high flows from the Gregory basins along the western outfall. It is understood that in the modelling undertaken, this would be undertaken in conjunction with a 250mm lifting of the TWL of the Gregory basin(s) and an increase in their volume in line with Option 2.

It is unclear of the exact required flow for this proposed option in the Water Technology report, however we have assumed from section 6.5, dot point 2 that it is 1.3m³/sec.

The alignment of the proposed western outfall is detailed in Figure 15 above.

4.3 Identified Opportunities & Constraints

Through this investigation, it has been identified that there are a number of constraints that govern the ability to deliver an outfall drain along the proposed alignment.

Constraints

- As noted above, there is an existing high point in the drainage alignment located in 86 Gregory Drive, which is approximately 300m southwest of the Gregory basin(s). It is understood that this level is approximately RL 85.2 which would put the surface approximately 150mm above the raised TWL of the Gregory basins.
 - If the open drain were to be graded away from the basin at the Council minimum grade of 1:300, then the drain at this location would need to be more than 1.2m deep, not including any allowance at the basin end to enable sufficient hydraulic capacity.
 - Assuming side batter slopes of 1:5, then if allowance is made to convey a flow of 1.3m³/s, then a drain to the depth of 1.7m and with a top width of 17m would be required to convey the flow through the high point, which is significantly in excess of the existing easement width of 5m.
 - Site feature survey would be required to be undertaken to confirm these exact levels and resultant widths.
- As noted earlier there is a significant amount of vegetation located along the proposed drain alignment. Whilst much of this is planted and or naturally regenerated, it is considered that any drainage works would have a medium to high level of impact on extensive areas of remnant and protected vegetation. This would trigger a planning permit application process and require referral to DEECA, at best it is considered that this process would be lengthy and financially costly.
 - There is also the section of the proposed alignment that traverses the area with the environmental significance overly to protect the Clover Glycine.
 - It is suggested that if this alignment is to be considered further, suitable inspection by a combination of experienced engineer and ecologist be undertaken to ascertain this impact further.
 - The aerial photo from September 2006 in Figure 2-1 of the Water Technology report clearly shows the significant extent of existing vegetation from over 17 years ago along the alignment.
- As noted previously, whilst there is existing easement in favour of Council along much of the proposed route, there are sections without current legal right to undertake works and or convey additional water, and the extent of works is likely to need to extend beyond the existing easement width. It is considered that the proposed works would require the acquisition of additional easement area, it is considered

outside the scope of the Loetis investigation to ascertain these financial, legal and community impacts of meeting this requirement.

- It is considered that to undertake construction within the easements, access will be required through multiple private properties which would require agreement to be reached with each individual landowner.
- Currently the main incoming drain to the 120 Gregory basin runs north-westwards along the rear of 110 Gregory Drive. If this Option 2a outfall were to be constructed, then this section of drain would fall away from the basin. Further investigation and hydraulic assessment will need to be given to how this arrangement could be made to work, however it is assumed it will likely involve a section of drain that progressively conveys flows in differing directions as the water level in the basin increases.
- It is noted that the Water Technology modelling indicates that this proposed mitigation option will result in increased flood levels along a significant section of the flow path and within a number of properties. From a technical perspective, this makes sense as water is being diverted from one location to another. However, we note that the legal implications of these increased flood levels and extents within private property particularly where it is not within a drainage easement should be appropriately assessed by a qualified person. The below Image 18 shows the extent of the increased flow extents from Figure 6-7 in the Water Technology report.

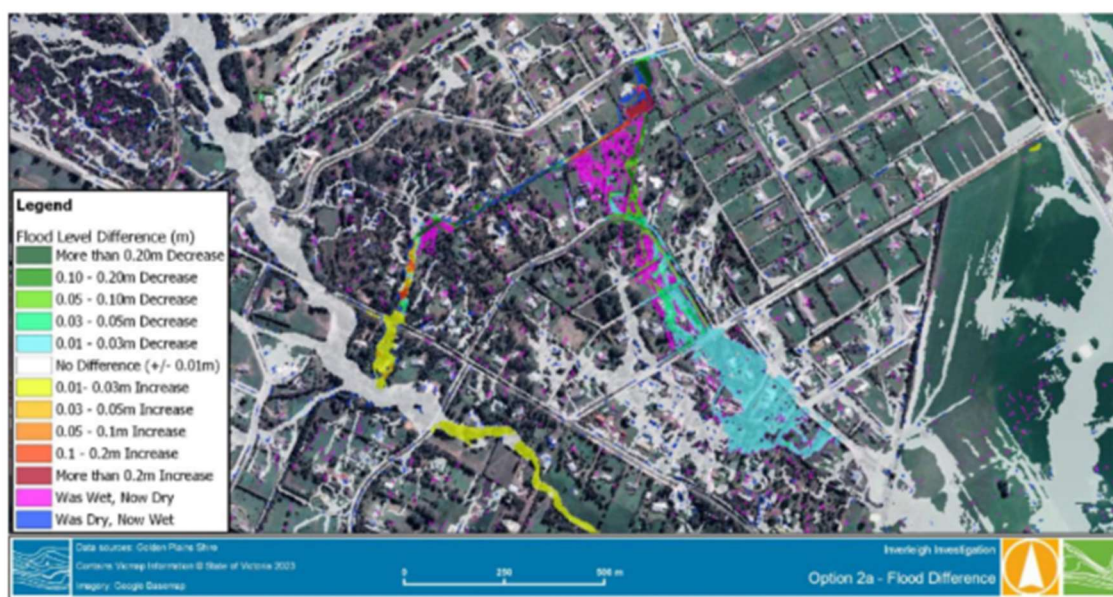


Figure 6-7 Option 2a – 1% AEP Flood Level Difference

Figure 18 – Flood level difference (afflux) due to Option 2a (Image courtesy of Water Technology)

Opportunities

- Whilst it is noted above that there are some access and easement acquisition queries related to several of the properties that the drain is proposed to traverse, given at least some of these properties have had flood impacts on them, there may be synergies to both parties that would enable mutual agreement to be met.

Should this option be considered further, it is recommended the following assessments should be made,

- Flora and Fauna assessment of the proposed route be made to ascertain potential impacts.
- Survey of the key information in the area including levels along the proposed drainage alignment and around the high point located at 86 Gregory Drive.
- Legal advice on liabilities and risks to Council from the effects of increased flood depth and extent on impacted private properties.

4.4 Preliminary Costing of Proposed Drainage Strategy

The estimated construction and related cost for Option 2a is \$1,780,000 (Excl. GST).

Excluded from this cost is any costs associated with acquisition of additional easements or reserves to facilitate the works and costs of tree clearing and associated permits and offsets.

Please refer to figure 21 for additional detail.

4.5 Areas of Suggested Discussion / Investigation / Alternative Options

Some identified areas for further discussion in conjunction with Council and the Water Technology team include.

- Consideration could be given to piping part of the alignment. This option would provide some alleviation of the issues identified above particularly in the width of the required swale & easement, however it is considered that the other identified issues would largely still be in place.

Also considered during this assessment were two alternative solutions to the Option 2a proposal. It is recommended that these undergo further discussion in conjunction with Council and the Water Technology team. These include.

4.5.1 Potential 'Option 2b – Piped Conveyance of Flows along Argyle Park Court to Savage Drive

This option proposes to route the diverted flows along a parallel alignment to Option 2a generally along Argyle Park Court, the fire access reserve, and Savage Drive. Given the pronounced high point in Argyle Park Drive, a significant portion would need to be piped flow. The concept option is detailed in Figure 19 below with the red flow arrows depicting the general alignment.

- It is estimated that a pipe in the order of 1050mm dia. running at 1 in 500 grade would be required to convey the nominal 1.3m³/s flow and still be able to achieve minimum at grade velocities of 1.0m/s which would minimise sedimentation in the pipe and accordingly maintenance requirements. At the high point in Argyle Park Court, it is estimated that this pipe would be at approximately 2.5m depth.
- This vertical alignment would be capable of daylighting back to the surface at the location shown in Figure 20. At this point, there may be opportunities to surcharge some of the flow and convey the flows in a combination of above and below ground pipes or continue with the flow below ground to a discharge point adjacent to the waterway in Savage Drive. The cost estimate below assumes a surcharge with a low flow pipe of a nominal 450mm diameter, plus a culvert arrangement at Common Road. However, it is noted that this option is likely to result in adverse impacts along the overland flow path, further modelling would be required to identify impacts on private property and potentially overland flow hazards at Common Road and Savage Drive.

- This alignment has the advantage of being contained in Council controlled road reserves and reserves, and initial assessment suggests that there would be significantly reduced vegetation impact comparative to Option 2a.
- There would however be a potential impact on the underground electrical, water and telecommunications services to avoid and potentially relocate. Similarly, there is likely to be some rectification of the road pavements to allow for.
- Consideration would also need to be given to the form and location of the inlet structure which may have some spatial challenges in the existing road reserve.
- A very high-level cost assessment of this option gives an indicative cost of \$2,040,000 (Exc. GST).
- If the works on the Gregory basins were dropped from this scenario, then the estimated cost is reduced to \$1,290,000. It is unclear what the effects of the removal of the basin upsizing would have to the modelling results and downstream impacts.
- If the proposal were to be modified to take the full-size pipe all the way to the existing waterway in Savage Drive (i.e. remove the daylighting component), then it is estimated to add \$280,000 to the total cost.

Whilst it is noted that the direct construction costs of Option 2b are slightly higher than Option 2a there is a significant advantage in that no easements are required to be acquired, there is minimal impact on vegetation, and the downstream impacts on private property in the form of increased flood depths and extents are restricted to the location of road reserves and the receiving waterway, where the impacts are anticipated to be comparatively relatively minor and restricted to already encumbered areas and well clear of any dwellings and public access locations (roads and paths).

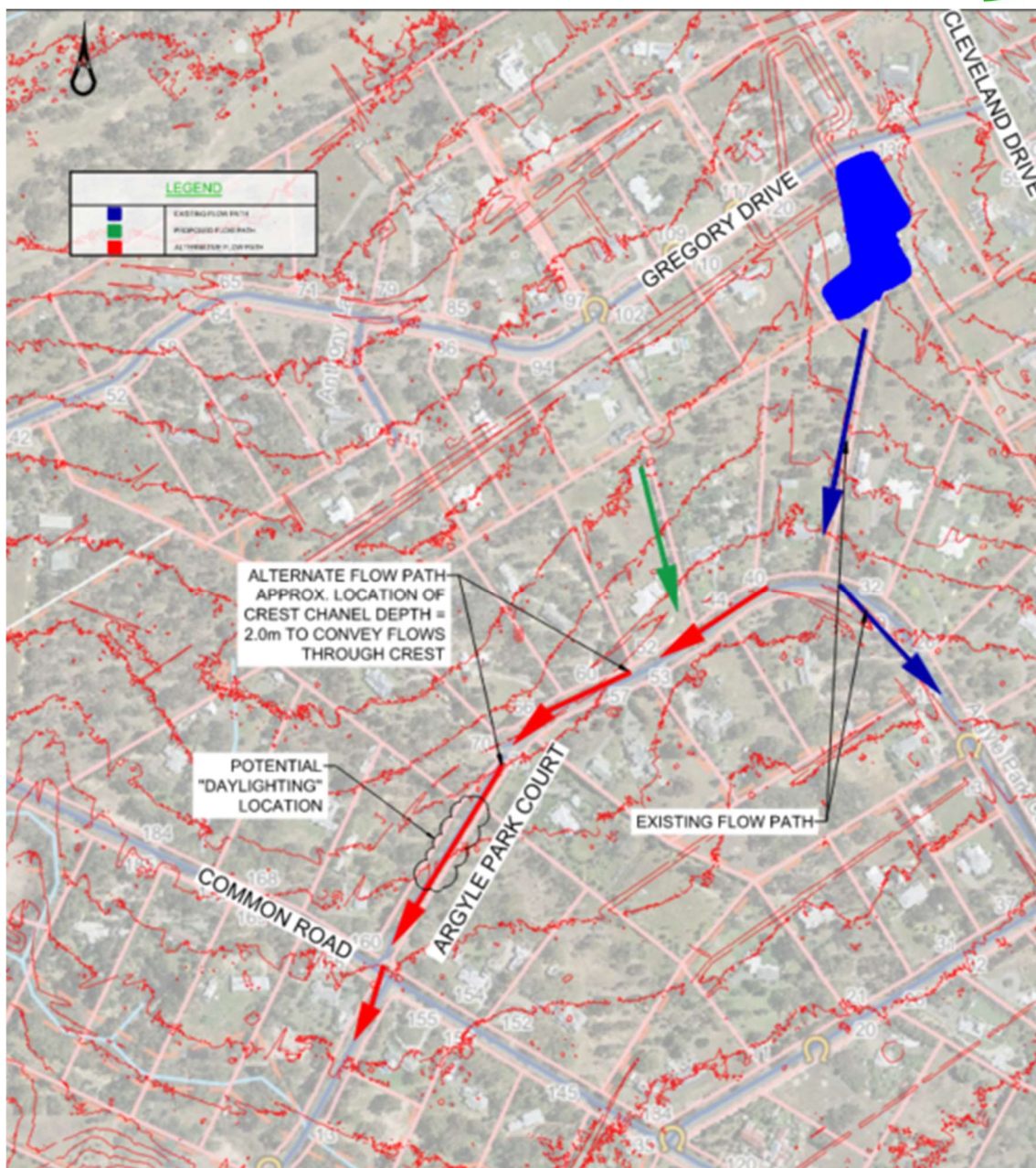


Figure 19 – Alignment of Option 2b Proposed Western Outfall (Big Basin + outfall via Argyle Park Court)

It is unclear what the impact of installing the Option 2b pipe without any upgrade to the Gregory basins would be, however it is assumed that an increase in the pipe size would be required to compensate for the storage reduction. It is recommended that this be discussed with the Council and Water Technology teams and potentially be modelled to ascertain the results.

Similarly, it is unclear on the impacts and potential extent of mitigation works at the location of the 'daylighting' of part of the flow upstream of Common Road. This would need to be assessed further.

4.5.2 Potential 'Option 2c – Revised Overland Flow alignment combining 2a & 2b

An 'Option 2c' has also been considered. This option proposes to route the flows initially along the route of the Option 2a, before then deviating towards Option 2b. This alignment generally follows the green line in Figure 20.

This alignment was initially assessed to follow a more sensitive alignment relative to the existing surface contours, however on closer assessment still required significant excavation traverse the high point.

Additionally, however, there are no existing drainage easements within the properties 40-60 Argyle Park Court, so easement acquisition within one or more properties would need to be obtained. These properties also have existing vegetation and or buildings that restrict potential alignments.

Accordingly, given these constraints, this Option 2c alignment is not considered feasible for further assessment.

4.6 Option 2 Phase 1 – Western Outfall (Big Basin) Summary

Based on the above assessment, it is considered that the delivery of the proposed western outfall (big basin) will result in significant impacts on existing vegetation and would require acquisition of significant additional easements. Therefore, it is not considered feasible to provide a significant outfall along the proposed Option 2a alignment.

Although it comes with a high-cost comparative to alternate options, it is considered that the Option 2b alignment has significant merits on the basis that no easement / reserve acquisition is required and the impacts on native vegetation are assessed to be comparatively low.

Further if the 2b pipe is taken all the way to the waterway at the Savage Drive crossing, the impacts of increased flow depths and extents are anticipated to be comparatively relatively minor and restricted to already encumbered areas and well clear of any dwellings and public access locations (roads and paths).

Although noting the high cost of this option, on the basis of not requiring any easement or reserve acquisition and having minimal adverse impacts it is recommended that Option 2b be assessed further as part of a hybrid solution.

5 MITIGATION OPTION 3a – FAULKNER ROAD UNDERGROUND

DRAIN

This option has been further assessed in detail following the original feasibility investigation (Phase 1) for the flood mitigation works. The option is referred to as Option 3a “Faulkner Road Underground Drain” and was partially assessed in earlier work as outlined in section 6.6 of the Water Technology report, however this option more generally looked at the option to lower Faulkner Road to regrade the surface and direct water towards Common Road.

In summary, this option looks to provide a diversion of flows from the intersection of King Road and Faulkner Road to the southwest along Faulkner Road along with a lifting of the footpath along the low (southeast side of Faulkner Road top prevent overtopping of the path in large rainfall events.

5.1 Existing Conditions

The proposed works extent is located within the LDRZ zone and part of the alignment traverses through land that has a design and development overlay – Schedule 5 (DD05) and Development Plan Overlay – Schedule 5 (DD05). All of the alignment is within designated bushfire prone areas.

Argyle Park Court, Faulkner Road and Common Road all have formations typical of low-density residential areas, with a raised roadway with wide swale drains on both sides of the road that convey the drainage. There are several culverts of limited capacity conveying flows from the swales on the ‘high side’ of the road to the downstream swales. There is a concrete footpath along the south side of Faulkner Road and a gravel path on the southwest side of Common Road.

There are existing established trees on the corner of Argyle Park Court and Faulkner Roads, with established trees on the northwest side of Faulkner Road both within and immediately adjacent to the road reserve. There is limited vegetation in the southeast side of the Faulkner Road road reserve and the vegetation within the front of the properties on this side of the road is limited, probably due to earlier maintenance works around the overhead electrical lines.

There are existing overhead electrical lines in Faulkner Road and Common Road and existing underground electrical, water and telecommunications assets in both road reserves.

Figures 20 below shows the existing area with approximate service locations shown.



Figure 20 – Existing Conditions Plan

There are no identified heritage or drainage overlays on the properties and road reserves.

There are no existing drainage easements within 119 and 135 Common Road along the proposed pipeline flow path. There is an existing easement along the east boundary of 135 Common Road, however it is understood that this is in favour of Powercor for electrical purposes and possibly Barwon Water for water purposes. Located within this easement are an overhead Powercor owned powerline and Barwon Water owned watermain. There is also an existing shed and dwelling within close proximity of the eastern boundary of 135 Common Road.

There is a large easement that encompasses a defined waterway that runs from the northeast to southwest within 119 & 135 Common Road. This waterway drains a larger catchment of some 1,100Ha and is considered the receiving waterway for this mitigation option.

The below Figure 21 shows the Faulkner Road road reserve looking southwest. Figure 22 shows the intersection of Common Road and Faulkner Road and numbers 119 and 135 Common Road beyond.



Figure 21 – Image of Faulkner Road looking southwest



Figure 22 – Image of Intersection of Common Road and Faulkner Road (Image courtesy of Google Maps)

5.2 Proposed Works Detail

This concept proposes to capture flows in the Argyle Park Court road reserve immediately upstream of Faulkner Road and divert these flows to the southwest along Faulkner Road in an underground pipe and discharging into the existing waterway along the rear of 119 / 135 Common Road.

The alignment of the proposed outfall drain is detailed in Figure 23 below.



Figure 23 –Concept sketch of Option 3a Piped conveyance of flows along Faulkner Road

5.3 Identified Opportunities & Constraints

Through this investigation, it has been identified that there are a number of constraints and opportunities that govern the ability to deliver an underground outfall drain along the proposed alignment.

Constraints

- The alignment of the pipe would require acquisition of an easement to connect between Common Road and the existing waterway. Nominally this has been identified as being along the boundary of 119 & 135 Common Roads, however theoretically it could be pushed further east, albeit at additional length

of pipe runs and additional financial cost. It is considered outside the scope of the Loetis investigation to ascertain these financial, legal and community impacts of meeting this requirement.

- The existing road reserve within Faulkner Road is somewhat constrained. Preliminary assessment and conceptual design suggest optimal location of the pipe under the edge of seal / shoulder on the southeast side of the road. This is clear of the underground services (communications and water) located closer to the boundary and adjacent to the overhead electricity at an offset of ~3-4m. This proximity will require consideration in the design and construction and be within the zone requiring a spotter during construction.
- The construction is considered to have some impact on local residents during construction, however with local closures and contra flow arrangements, access will be able to be maintained to all residents through the construction.
- Consideration would also need to be given to the form and location of the inlet structure which may have some spatial challenges in the existing road reserve in Argyle Park Court.
- This design scenario is essentially sized up to a 1% AEP event. It doesn't provide as much overland flow conveyance certainty.

Opportunities

- Whilst not modelled in the preliminary works undertaken to date, there is considered to be opportunity to investigate installing intermediate inlet pits along the pipe route and direct water from the existing swale drains into the pipe. This in turn would enable a reshaping of the existing drain to a more accommodating batter that is easier to maintain, and less hazardous to pedestrian and road users.
- Option 3a is considered to have minimal impact on vegetation, and the downstream impacts on private property in the form of increased flood depths and extents are restricted to the location of road reserves and the receiving waterway, where the impacts are anticipated to be comparatively relatively minor and restricted to already encumbered areas and well clear of any dwellings and public access locations (roads and paths).
- Whilst not part of the objectives of this investigation, it is noted that there is a significant erosion problem at / adjacent to 93 Common Road where the existing drainage network tips from the 'plateau' on the Common Road road reserve down the 'escarpment' onto the 'floodplain' below. Whilst previous remediation has been undertaken, it is understood that the problem is ongoing and will require significant works to be undertaken to fully remediate the problem. Installation of this cut of drain will enable capture and diversion of much of the flows causing issue at this location and significantly reduce the erosion issue at this location.

Should this option be considered further, it is recommended the following assessments should be made,

- Flora and Fauna assessment of the proposed route be made to ascertain potential impacts.
- Survey of the key information in the area including levels along the proposed pipe alignment and service locations (depthing).
- Legal advice on liabilities and risks to Council from the effects of increased flood depth and extent on impacted private properties.

5.4 Preliminary Costing of Proposed Drainage Strategy

The estimated construction and related cost for Option 3a is \$1,728,000 (Excl. GST).

Excluded from this cost is any costs associated with acquisition of additional easements or reserves to facilitate the works and costs of tree clearing and associated permits and offsets.

5.5 Areas of Suggested Discussion / Investigation / Alternative Options

N/A.

5.6 Option 3a Phase 1 – Faulkner Road Underground Drain Diversion Summary

It is considered that Option 3a does have a significant advantage comparative to Option 1, in that rather than re-directing flows into a location where there will be downstream impacts on private property in the form of increased flood depths and extents, it essentially diverts the water to the location of the receiving waterway, where the impacts are anticipated to be comparatively minor and restricted to already encumbered areas and well clear of any dwellings and public access locations (roads and paths). It is considered that this outcome has significant value to Council, the community and all landholders and should be given strong weight when assessing alternate options.

Option 3a is also considered to have a less disruptive impact on residents during construction, with road access being able to be maintained during construction (1 way contraflow) and short duration closures during driveway crossings.

Whilst financially more expensive than option 1, it is considered that there are significant advantages to Option 3a and that this option should be assessed further including being flood modelled in Phase 2 of the report.

6 Part 1 – Interim Recommendations

6.1 Discussion

Following the Part 1 phase of the investigation, assessment of the initial three options along with recommendations on the options to take to the next stage.

The recommendations were;

- Confirmation of flooding reductions and or removal of targeted dwellings (feature survey & flood model result comparisons).
- Council obtains legal opinion on impact and liability of increased flood level and extents on private properties.
- Option 1 (Ultimate 7), Option 3a (Ultimate 8) and Ultimate 9 be assessed in more detail in phase 2 of this investigation via functional design and updated flood modelling.

Following the completion of the part 1 works, consultation was undertaken with Council officers and with some of the effected residents in the area and additional flood modelling was undertaken by Water Technology to better inform the assessment.

Through this process, it was decided to not proceed with further assessment of Options 1a, 2, 2a and 2b outlined in the earlier phases of this report.

It was decided to take Option 1 and Option 3a through to Phase 2 and Phase 3 of this assessment.

To avoid confusion in this version of the report, we have redacted the full Part 1 assessment from this version of the report. Please refer to the version V02 of this report should you wish to review this part of the report.

7 Functional Design - Part 2 & 3

7.1 Introduction

The following section outlines the iteration of the two designs including the works undertaken and the modelled outputs including discussion on them.

7.2 Option 1 Further Investigation, Optimisation & Reporting

Following the completion of the part 1 works, a functional design surface was prepared by Loetis. This surface included,

- The lowering of the intersections of Argyle Park Court / Faulkner Road and King Roads
- Alterations to the swale in Argyle Park Court across the frontages of 19 & 29 Argyle Park Court to contain overland stormwater flows to the road reserve.

This surface was then tested in the Water Technology Flood models.

Following initial model runs, it was found that despite the majority of flows being directed into King Road, flows continued to overtop the footpath in Faulkner Road and flow through the properties. Additional design elements were added to include a 'glass wall' along the Faulkner Road footpath. The 'glass wall' is effectively a function in the modelled surface that represents a levee of infinite height along the alignment.

This levee can then be reverse engineered to calculate its effective required height. In practise this levee would be achieved by effectively lifting the level of sections of the footpath and or constructing a small plinth along the boundary line of the footpath along the southeast side of Faulkner Road to prevent the flows overtopping in a 1% AEP event.

The exact detail of this levee to be adopted will be subject to the detail design phase. It is noted that where there are driveway crossover locations along the proposed levee, there will be a requirement to lift these to retain property access and also prevent ingress of the water at these locations.

Figure 24 below depicts a part of the functional design of the lowering of the intersections of Argyle Park Court, Faulkner and King Roads.

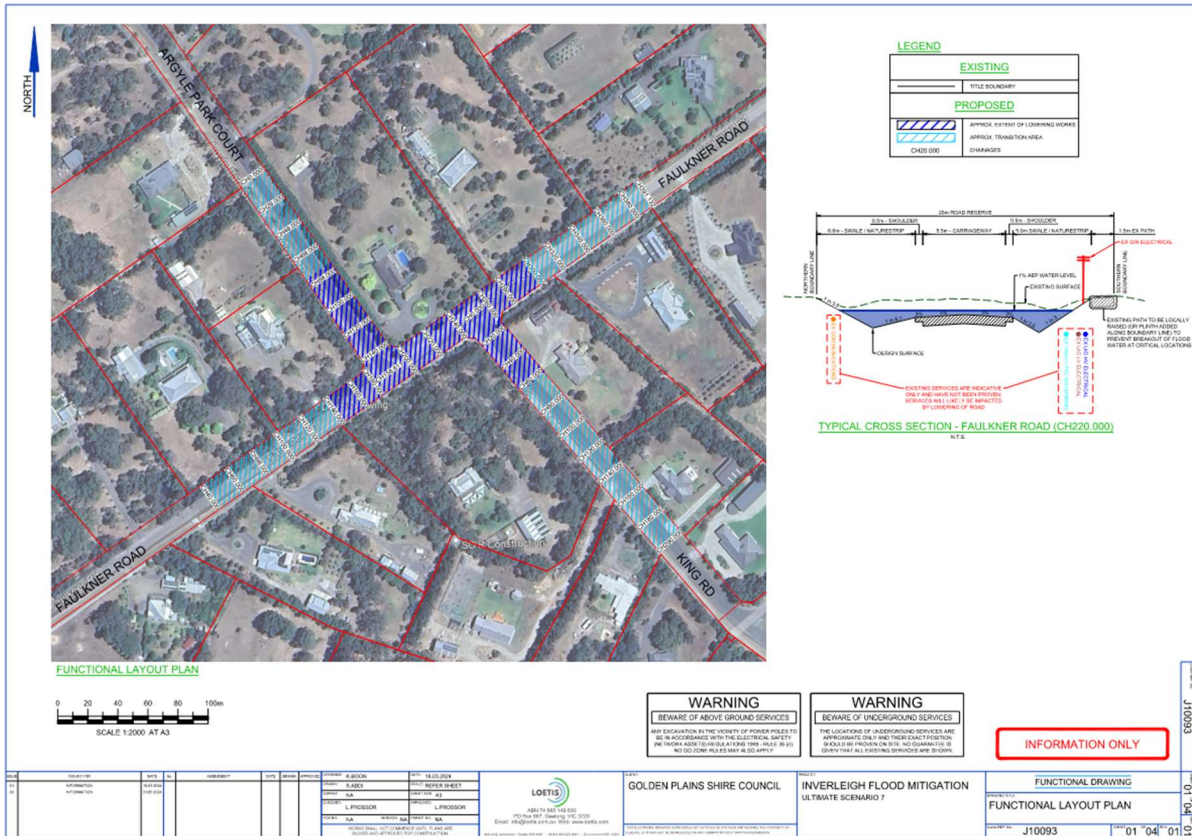


Figure 24 – Image of (part) Functional Design Option 1

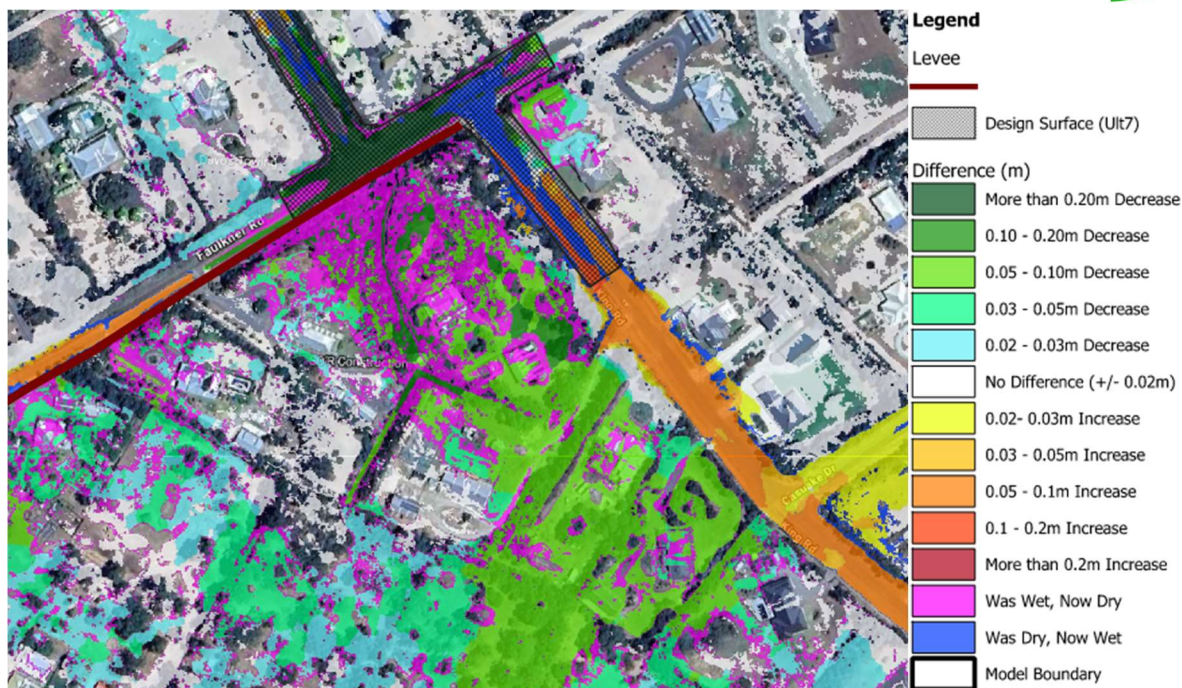
Figure 25 below depicts the resulting flood depths in the vicinity of Faulkner and King Roads. The red line reflects the ‘lifting’ of the footpath and navy-blue hatched area depicts the area of adjusted (lowered) surface to redirect the flows. It is noted that complete plans are enclosed as an appendix to this report.



Figure 25 – Image of Flood Depths – Option 1 design

It is noted that the model outputs show that in this design (Option 1), there are no flows overtopping the footpath on the southeastern side of Faulkner Road.

Figure 26 below shows the afflux (Change in flood depth) for the Option 1 design. It is also noted that while there are reasonable reductions in flood depths, there remains residual flooding remaining in the vicinity of the existing dwellings at numbers 16, 22 & 30 King Road.



It is also noted that this design results in increased flow depths and extents to the southeast along King Road and the downstream properties, this is detailed in figure 27 below.

Whilst not specifically addressed in the modelling work undertaken through this phase, it is considered that most of the increases within the properties fronting King Road will be able to be resolved in detail design through upgrades to the culverts and the swale drain in King Road.

However, it is considered that due to the increased peak flow rates and total volumes directed down King Road, there will be some residual increases in flood depths or extents particularly on the downstream property(s), being Lot 3 TP668795 (Common Rd) that will not be possible to be designed out.

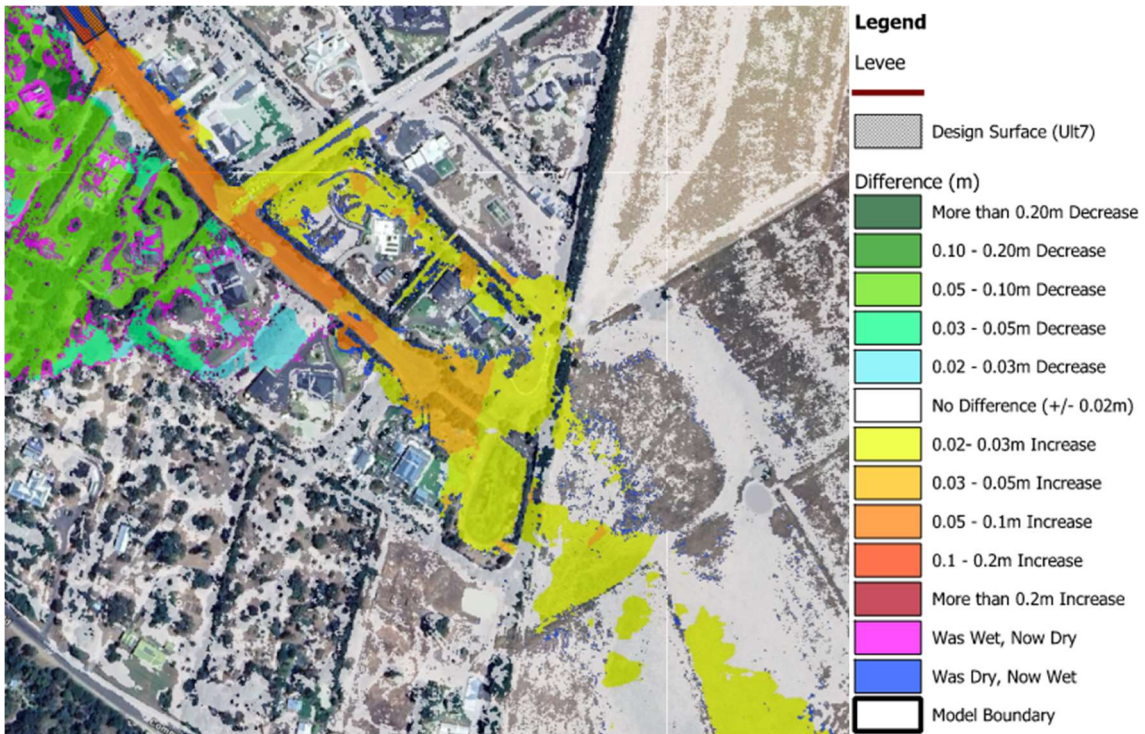


Figure 27 – Image of ‘Downstream’ Flood Afflux – Option 1 design

Figure 28 shows the required height of the modelled levee in the Option 7 design. It is noted that these heights do not include a freeboard allowance. Consideration of the appropriate freeboard to adopt in this circumstance should form part of the detail design works brief.



Figure 28 – Image of Indicative minimum levee hieght along Faulner Road – Option 1 design

Consideration of the opportunity to stage the works was given. The majority of the works cost is in the main intersection lowering which essentially all needs to be in a single works package. There is a significant minor component in upgrades along King Road, however if these were deferred past the main intersection lowering then flood impacts on the adjoining properties would be increased which is not considered acceptable.

Minor works in the form of the footpath lifting and the swale drain works in Argyle Park Court could be deferred with no increases in flood risk, just reduced positive impacts, however they are not considered financially significant.

7.3 Option 3a Further Investigation, Optimisation & Reporting

Following the completion of the part 1 works, a functional design of the proposed underground pipe along Faulkner Road was prepared by Loetis.

This design included,

- The design of the underground stormwater pipe(s).
- Alterations to the swale in Argyle Park Court across the frontages of 19 & 29 Argyle Park Court to contain overland stormwater flows to the road reserve.

This was then tested in the Water Technology Flood models under the Option 3a designs.

Several iterations of pipe sizes and inlet configurations in Argyle Park Court were trialled. Similar to Option 1, a 'glass wall' was added to the design along the footpath in Faulkner Road to prevent overtopping, please refer to the option 1 commentary on the levee detail.

It is noted that the inlet arrangements to the pipeline will be a critical design element in the detail design phase. These pits need to be sufficiently large to capture the flow and minimise the risk of blockage, whilst also be safe to pedestrians and road users and maintainable.

The flood modelling undertaken to date indicates that a 1,500mm diameter pipe would be required along the Faulkner Road section, reducing to twin 1,200mm pipes at the inlets to the underground system in Argyle Park Court. It is considered that further iterations of the design, inlet points and outlet location may yield a more efficient pipe size along part of the route.

The maximum depth in the vicinity of the Common Road crossing is likely to be in the order of 2.5m and is considered as likely able to pass under the existing underground services without their relocation, noting that there may still need to be some works to protect them during construction.

The pipe has been modelled to nominally run into the existing waterway parallel with Common Road, nominally along the western side of 119 Common Road, however alternate alignments could be considered subject to discussion / negotiation with landholders.

It is noted that in the modelling, the pipe is depicted as discharging midway between Common Road and the receiving waterway which is in error. The actual proposal will take the discharge point closer to the waterway which will eliminate the impacts on private property outside the waterway.

Figure 29 below depicts the functional design of the proposed pipeline route along Faulkner Road.

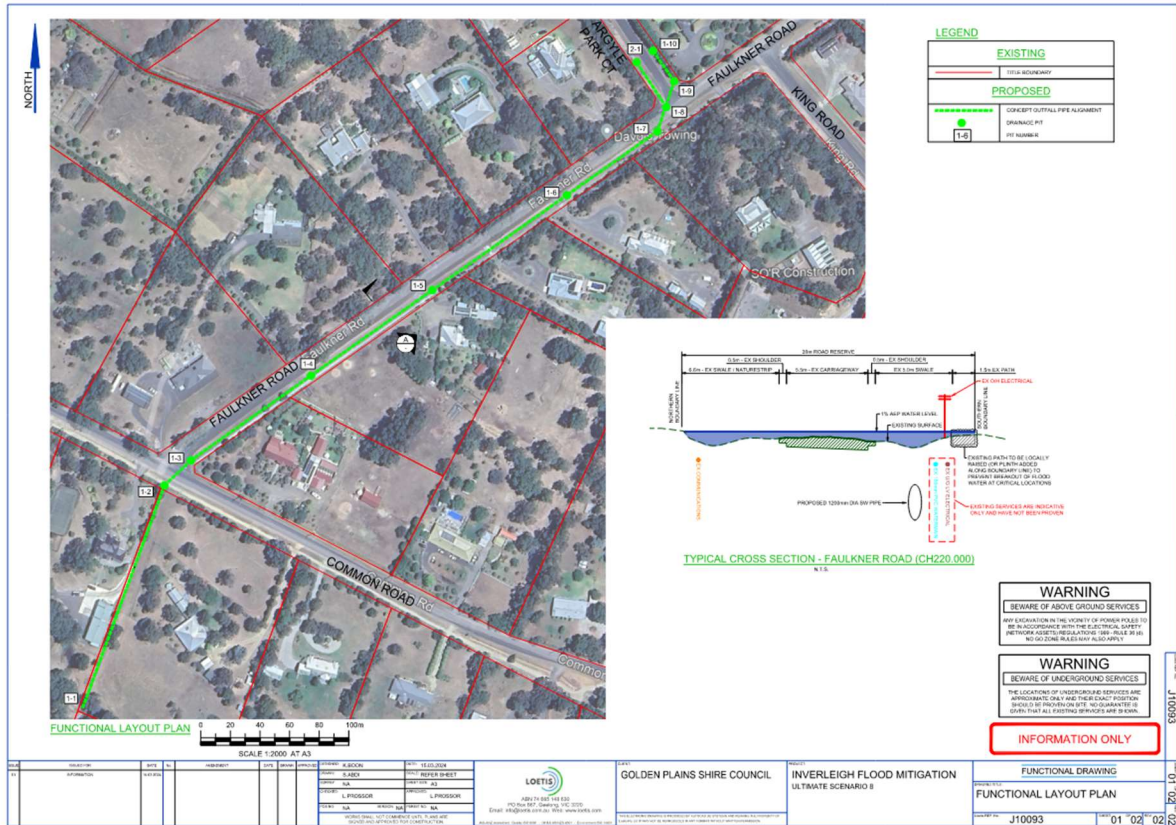


Figure 29 – Image of Functional Design Option 3a

Figure 30 below depicts the resulting flood depths in the vicinity of Faulkner and King Roads for the Option 3a design. The red line reflects the ‘lifting’ of the footpath and black hatched are depicts the area of adjusted (lowered) surface to redirect the flows. The pipeline alignment is not depicted in this plan. It is noted that complete plans are enclosed as an appendix to this report.



Figure 30 – Image of Flood Depths – Option 3a design

It is noted that the model outputs show that in this design (Option 3a), there are no flows overtopping the footpath on the southeastern side of Faulkner Road. It is also noted that while there are reasonable reductions in flood depths, there remains residual flooding remaining in the vicinity of the existing dwellings at numbers 16, 22 & 30 King Road.

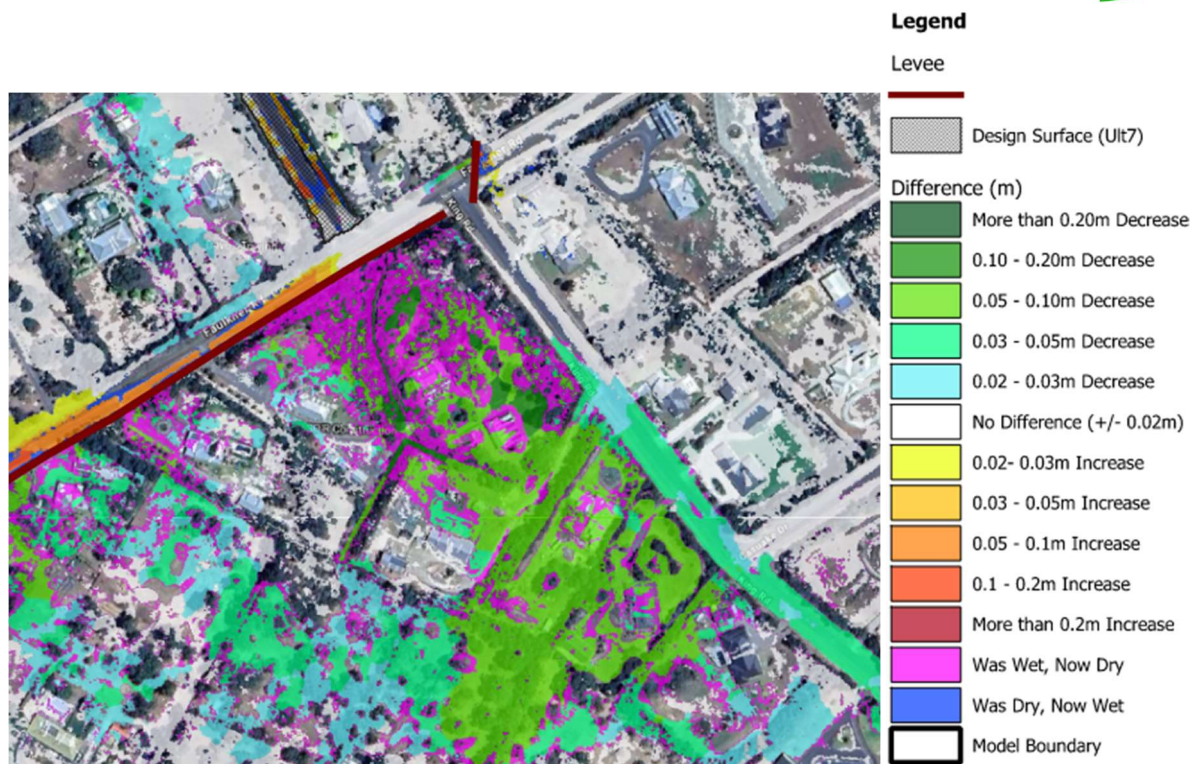


Figure 31– Image of Flood Afflux – Option 3a design

It is also noted that this design results in increased flow depths and extents to the southwest along Faulkner Road, with nominally some afflux in the front of the properties in Faulkner Road and the downstream properties. Whilst not specifically addressed in the modelling work undertaken through this phase, it is considered that most of the increases within the properties fronting Faulkner Road will be able to be resolved in detail design through upgrades to the pipe and inlets pit locations.

Increases of between 20 and 30mm are also evident in the waterway parallel with Common Road, noting that the extents of the inundated area do not appear to have altered. Whilst noting that these are in private property, they are located within an existing drainage easement that has existing flooding >1m in depth and are well away from any dwellings.

As noted earlier, the area of increase on 117 & 135 Common Road outside the waterway reflects an error in the model setup with the pipeline daylighting before entry to the channel. This is anticipated to be able to be rectified in the detail design phase.

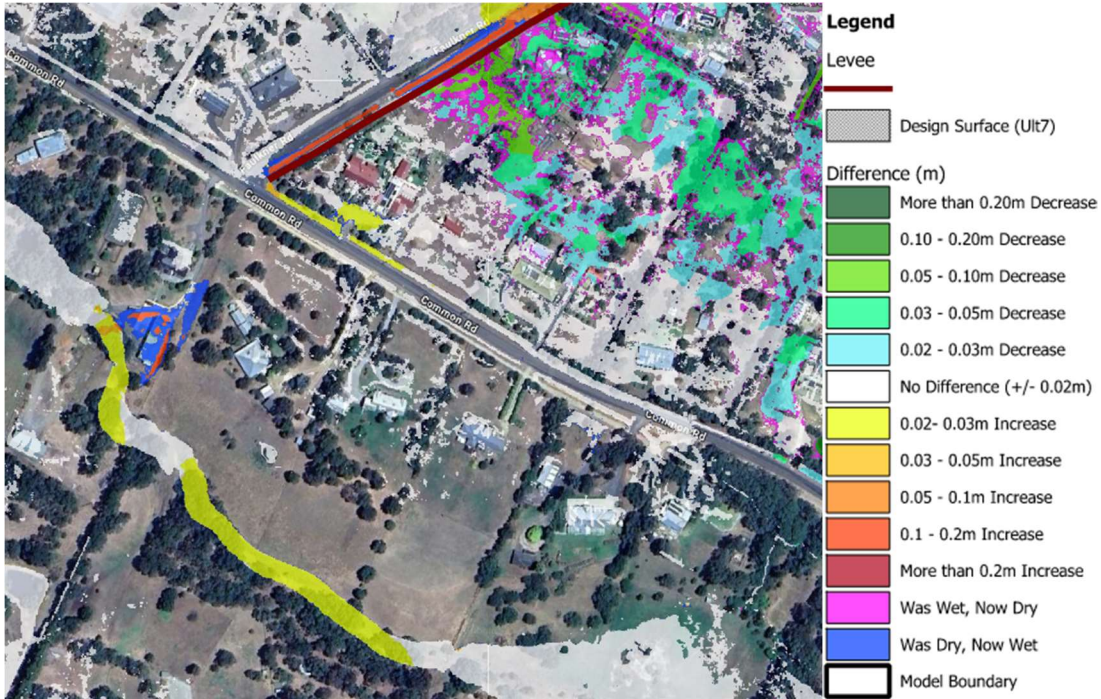


Figure 32 – Image of ‘Downstream’ Flood Afflux – Option 3a design

Figure 33 shows the required height of the modelled levee in the Option 3a design. It is noted that these heights do not include a freeboard allowance. Consideration of the appropriate freeboard to adopt in this circumstance should form part of the detail design works brief.

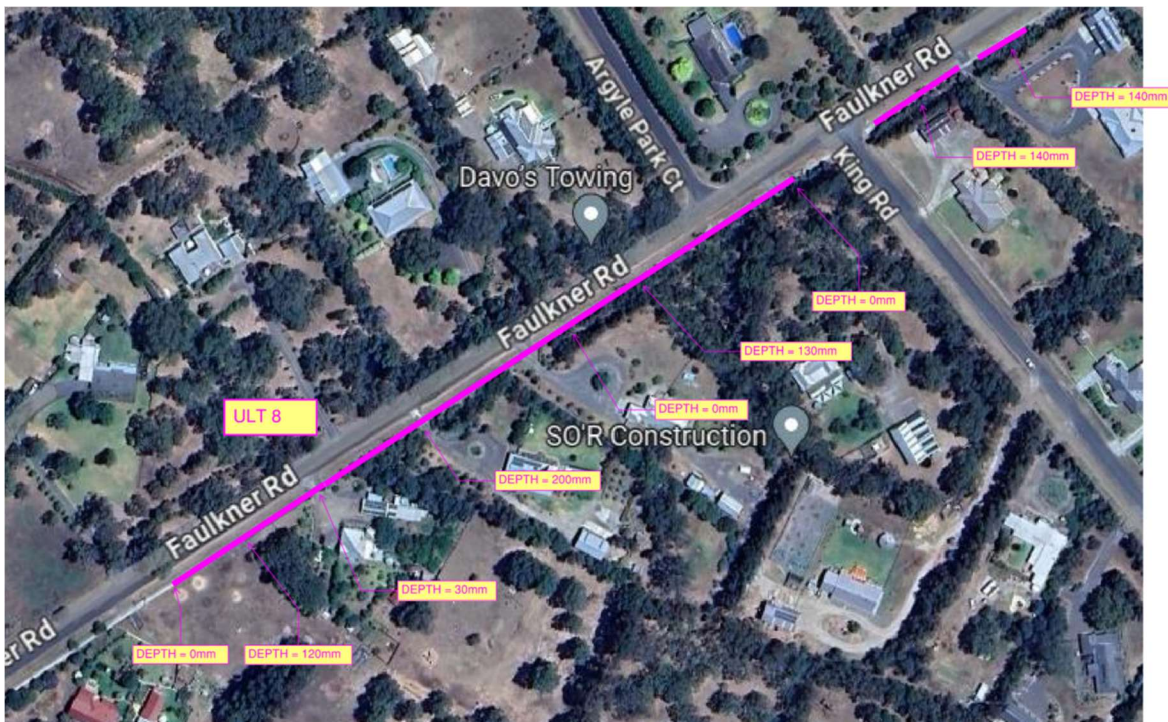


Figure 33 – Image of Indicative minimum levee hieght along Faulner Road – Option 1 design

Consideration of the opportunity to stage the works was given. The majority of the works cost is in the main pipe and associated works which theoretically could be delivered in stages, however it is considered that there is unlikely to be significant positive impact on the downstream flooding until the full pipeline is delivered. Additional flood modelling could be undertaken to test this theory.

Minor works in the form of the footpath lifting and the swale drain works in Argyle Park Court could be deferred with no increases in flood risk, just reduced positive impacts, however they are not considered financially significant.

7.4 Option 1a (Ultimate 10) Further Private Property Works

As noted above in both the Option 1 and Option 3a functional design and model, the designs and modelling resulted in the prevention of any flows overtopping the footpath in Faulkner Road, however, there remained a residual level of flooding around the existing dwellings at numbers at 16, 22 & 30 King Road.

This outcome is depicted in images 25 & 30 earlier in the report and the extent and depth of flooding is largely similar in both modelled cases. Additional interrogation of the flood models was undertaken, including checks to ensure that flows were not entering this area from King Road.

From this process it was confirmed that the flows in this area were all originating from the properties within the area bounded by King, Faulkner and Common Roads, i.e. that this residual flooding was occurring due to the local catchment and not as a result of upstream catchment flows.

This was important to confirm, as it is considered to demonstrate in the modelling undertaken by Water Technology that even with the removal of the external flood impacts from higher up the catchment, residual flooding remains on these properties in the vicinity of the dwellings. It is considered that there is not a scenario where works can solely be undertaken in the road reserves to fully alleviate the flooding on these properties and that at least part of the works will need to be undertaken within these properties.

Following this an additionally model scenario was investigated that added in additional swale drains within the area of 16, 22 & 30 King Road, with several iterations of this modelling undertaken. This scenario (modelled as Ult 10) utilised the option 1 (lowering of Argyle Park / Faulkner / King intersection) scenario for its upstream inputs as this scenario was considered the 'worse case' of Option 1 and Option 3a given the increased flows in King Road. It is considered, that modelling of the Ult 10 drains in the area of 16, 22 & 30 King Road coupled with the Option 3a upstream works would result in very similar outcomes in the area of 16, 22 & 30 King Road.

It is noted that there are several caveats to the modelling in this area.

- The modelling has been undertaken using LiDAR surface data (Light Detection and Ranging, is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth). Inherent in LiDAR data is a degree of inbuilt variability, this is exacerbated by the presence of trees buildings and other structures and small intricate changes in elevation are typically not well defined.
- Since the LiDAR data was captured and particularly following the November 2022 flood event, there has been considerable known but undefined local earthworks, bunds, levees and open drains constructed in this localised area. These are not reflected in the modelled surface.

- No survey work has been undertaken to capture the floor levels of the effected dwellings and particularly the floor levels relative to the surrounding surface.

Accordingly, it is considered that the modelling in this area is at or beyond the level of accuracy able to be undertaken with the existing data. To confirm the outcomes and undertake further modelling particularly of any proposed detail designs in this area, it is considered that a feature survey of the localised area should be undertaken.

Furthermore, the design swales have generally where possible aligned to follow the boundaries of the properties and where possible drainage easements. However,

- There are not existing easements in this area for several of the proposed drainage alignments.
- No investigation has been undertaken of the impact of these proposed alignments on existing vegetation, structures, landscaping, septics / effluent fields etc. Further investigation in conjunction with the property owners in the detail design would be needed to validate the proposed drain alignments.

Noting the information and assessment outlined above, Figure 34 below depicts the schematic design of the proposed swale drains modelled in the Option 1a (Ultimate 10) option, with the residual flood depths depicted behind.



Figure 34 – Image of (part) Functional Design Option 1a

Figure 35 below depicts the resulting flood afflux in the vicinity of depths in the vicinity of 16, 22 & 30 King Road.



Figure 35 – Image of (Flood Afflux – Option 1a design

It can be noted that in the above figures, the residual flooding around dwellings 14 & 22 King Road has been significantly alleviated, however there remains flood impacts around the dwelling at 16 King Road. We highlight the above comments around the accuracy of the modelling at this micro level of detail. Additional options such as pumped systems may need to be investigated to obtain mapped flood immunity for this dwelling.

Detailed cost estimates (Engineers Opinion of probable cost) were not prepared specifically for the concept drainage swale works on the private properties, however it is anticipated that the actual drainage works would be well below \$50,000 in total cost. However, pending the exact alignments adopted and the impacts on vegetation and existing private assets, there may be additional costs to rectify these impacts.

8 Cost Estimates

Following the above phase of works including the functional design of the assessed options, an engineers opinion of probable cost was prepared for the two assessed options being Option 1 and Option 3a.

PROJECT:		
Client. : Golden Plains Shire Council		
Project Description. : Inverleigh Flood Mitigation Investigation		
ASSESSMENT ID. : Option 1 - Lowering of Argyle Park Court, Faulkner and King Roads		
Plan reference: J10093 - Ultimate 7 Rev 02		
Total Works Costs		
A	Preliminaries	\$ 139,500.00
B	Civil Construction (Roads, Drainage & Earthworks)	\$ 738,450.00
C	Services Construction (Water, Sewer, Electrical & Comms)	\$ 160,000.00
D	Contingency (10% of Construction Cost for Items A, B & C)	\$ 103,795.00
E	Landscaping (Landscaping & Street Trees)	\$ -
F	Council and Authority Fees	\$ 33,700.00
G	Consultancy Fees	\$ 152,500.00
H	Authority Bonds Cost	\$ 3,000.00
Total Works Costs (Items A-G exc.GST)		\$1,327,945.00
Total Works Costs (Items A-G inc.GST)		\$1,442,119.50
Total Works Costs (All Items exc.GST)		\$1,330,945.00
Total Works Costs (All Items inc.GST)		\$1,464,039.50

Figure 36 – Engineers Opinion of Probable Cost Summary – Option 1 design

PROJECT:		
Client. : Golden Plains Shire Council		
Project Description. : Inverleigh Flood Mitigation Investigation		
ASSESSMENT ID. : Option 3a - Underground stormwater pipe along Faulkner Road		
Plan reference: J10093 - Ultimate 8 Rev 01		
Total Works Costs		
A	Preliminaries	\$ 100,500.00
B	Civil Construction (Roads, Drainage & Earthworks)	\$ 1,246,800.00
C	Services Construction (Water, Sewer, Electrical & Comms)	\$ 22,500.00
D	Contingency (10% of Construction Cost for Items A, B & C)	\$ 136,980.00
E	Landscaping (Landscaping & Street Trees)	\$ -
F	Council and Authority Fees	\$ 44,500.00
G	Consultancy Fees	\$ 177,500.00
H	Authority Bonds Cost	\$ 1,500.00
Total Works Costs (Items A-G exc.GST)		\$ 1,728,780.00
Total Works Costs (Items A-G inc.GST)		\$ 1,879,458.00
Total Works Costs (All Items exc.GST)		\$ 1,730,280.00
Total Works Costs (All Items inc.GST)		\$ 1,903,308.00

Figure 37 – Engineers Opinion of Probable Cost Summary – Option 3a design

9 Summary & Recommendations

9.1 Discussion

Following the Part 1 phase of the investigation, assessment of the initial three options was completed with a fourth option added to the list following the initial recommendations and discussion with Council officers.

In undertaking the assessment of the various options, it is considered that there are a number of elements that need to be considered. These include but are not limited to,

- **Performance of the outcome (reduction in flooding on properties).**
It is considered that where works are proposed to be undertaken, a higher priority should be placed on rectifying issues where above floor flooding has previously occurred in dwellings.
- **Cost of construction and ongoing maintenance costs over the life of the assets.**
- **Impact on residents and property owners during construction works.**
- **Requirement to acquire additional easements or reserves in private property, including the effect on the resident / owner, financial and time constraints for this process.** It is considered that acquisition of easements or reserves from private owners / residents is likely to cause significant impact and angst on the owners and residents and at best even with all parties being willing participants will take considerable time to work through the processes. As such, options that require easement or reserve acquisition are considerably less favourable as options comparative to alternate options that do not require this.
- **Impact on existing native vegetation and the environment.**
- **Adverse impacts on private property and public land due to increases in flood depth or extent and the legal and financial liabilities that may arise from this.**
- **Complexity of the constructed outcomes and risks to the ongoing operation of the asset** including performance in rainfall events greater than the design event e.g. November 2022 event. Timeliness of delivery, incorporating the design, public and landowner consultation, approvals, and construction processes.
- **Worse case rainfall event scenario.** The performance solutions have been tested up to 1% AEP events however, as was evident with the 2022 flooding scenario, rainfall in excess of this AEP has a probability of occurring. The design solution should consider its continued operational suitability should substantially extra rainfall occur in the catchment and also account for potential changes due to climate change.

Following this initial phase of Part 1 works, the following outcomes were agreed for each option.

Option 1 - “Argyle Park Court & Faulkner Road Lowering & Redirection of Flows to King Road” This option was taken through to Part 2 and Part 3 of the works scope.

- Option 1a “Argyle Park Court & Faulkner Road Culvert Redirection of Flows to King Road” - This option was taken through to Phase 2 & 3 of the works.

- Option 1a “Argyle Park Court & Faulkner Road Culvert Redirection of Flows to King Road” - This option was not taken further
- Option 3a “Argyle Park Court to Common Road Outfall Pipe” - This option was taken through to Phase 2 & 3 of the works.
- Option 2 “Big Basin” - This option was not taken further
- Option 2a “Big Basin & Western Outfall” - This option was not taken further
- Option 2b “Big Basin & Argyle Park Court Outfall” - This option was not taken further

9.2 Part 2 & 3 Assessment

Following the Part 2 and 3 investigation, functional design and preparation of the engineers opinion of probable cost, the assessment of Option 1 and Option 3a were undertaken.

The following table in Figure 38 summarises the key assessment elements on the two options that were taken to part 2 and part 3 of this assessment.

Assessment Criteria	Option 1 “Argyle Park Court & Faulkner Road Lowering & Redirection of Flows to King Road”	Option 3a “Argyle Park Court to Common Road Outfall Pipe”
Cost (excl. GST & easement acquisition)	\$1,330,950	\$1,728,780
Easement / Reserve Acquisition	No	Yes (single property)
Level of Vegetation Removal Requirement	None to Minimal	None to Minimal
Increased Flood Extents / Depth on Private Property	Yes – largely confined to King Road and downstream	Confined to Existing Waterway
Extent of Resolution of Issues	Rectifies majority of ‘King Estate’ Properties, however, requires additional works to fully rectify the dwellings of 14, 16 & 22 King Road.	Rectifies majority of ‘King Estate’ Properties, however, requires additional works to fully rectify the dwellings of 14, 16 & 22 King Road.
Is there risk of blockage and reducing effectiveness in larger than design events	No	Yes
Delivery Timeliness	< 12 months	6-18 months pending easement acquisition process

Table 38 – Options Comparison Assessment

In order to assess these complex and often competing assessment elements, the following table 39 presents the elements in a weighted matrix format. A very favourable score on that item is indicated by a low number (1), whilst a poor outcome on the assessment is indicated by a high number (5). Three items (Easement / Reserve Acquisition, Increased Flood Extents/ Depth on Private Property & Extent of Resolution of the issues) were deemed to be of a higher relative importance and were thus weighted to be scored out of 10.

Assessment Criteria	Option 1 "Argyle Park Court & Faulkner Road Lowering & Redirection of Flows to King Road"	Option 3a "Argyle Park Court to Common Road Outfall Pipe"
Cost (excl. GST & easement acquisition)	2	5
Easement / Reserve Acquisition	1	5
Level of Vegetation Removal Requirement	2	2
Increased Flood Extents / Depth on Private Property	8	1
Extent of Resolution of Issues	2	2
Is there risk of blockage and reducing effectiveness in larger than design events	2	4
Delivery Timeliness	1	3
Total Score	18	22

Table 39 – Options Comparison Assessment Weighted Matrix

As can be seen, Option 1 scores better than Option 3a, however it is considered as not significantly so.

9.3 Analysis

Following analysis of all of the above information, it is noted the following;

- The flood modelling undertaken for both adopted options both prevent all 'external' catchment water entering the properties from Faulkner Road, however local drainage flows still result in residual flooding around the dwellings at 14, 16 & 22 King Road.
- With the addition of local drainage swale works in the vicinity of 14, 16 & 22 King Road, within the constraints of the modelling, all dwellings with the exception of 16 King Road appear to be flood free for the design event.
- Option 1 provides a lower cost solution comparative to Option 3a.
- Option 1 results in downstream increases in flood depths and extents on private land.
- Option 3a has some limited downstream increases in flood depths and extents, however these are limited to the within existing easements.
- Option 3a requires acquisition of an easement or reserve within private property.



Accordingly, Option 1 is considered to provide a superior outcome on all assessed elements except for the impacts on the downstream landholdings. To further assess this impact, the legal implications of the increased flood extents and depths on private property and the net public impact and benefits of the proposed alternate arrangements should be considered further. This is considered to be beyond the scope of this report to consider these two issues.

We note that our assessment is largely considers the suitability of engineering outcomes. We acknowledge that other factors such as budgetary funding, political commitments and Council priorities need to be considered in conjunction with our demonstrated findings.



**Appendix A – Flood Impact Plans – Prepared by Water
Technology**



Appendix B – Functional Design Plans – Prepared by Loetis



**Appendix C –Engineers Opinion of Probable Cost – Prepared
by Loetis**
