Merricks Beach Stormwater Strategy (Final)

August 2025

Merricks Beach Residents' Association Inc
www.merricksbeach.org.au

Melbourne Water

Community Bank Balnarring & District
Bendigo Bank

wave CONSULTING

Traditional Owners

The authors wish to acknowledge the Bunurong People as the traditional custodians of Merricks Beach.

Document Management

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1 – Revised report summary	9 June 2025	2021-061-D4	R.Catchlove & C.Scott
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Disclaimer

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Cover image

Bayview Road, Merricks Beach. Source: Wave Consulting Australia.

Table of contents

1 Overview of this stormwater strategy

The Merricks Beach Residents Association (MBRA) in collaboration with the Mornington Peninsula Shire Council, and funded by Melbourne Water and Bendigo Bank, are developing a Merricks Beach Stormwater Strategy which combines the need to manage stormwater flows with the desire of the community to retain its unique natural landscape character.

The Merricks Beach community is made up of a wide range of people who all cherish the unique environment that the small, seaside village provides.

The Village is characterised by its bushland setting, small (low) scale dwellings located along unsealed roads, lined by significant vegetation on roadsides and within property boundaries. The narrow, unsealed roads are bordered by (mostly) open drains and channels. These drainage channels direct the stormwater along the roadsides into Westernport Bay, located directly south of the Village.

The MBRA is an association that has worked for the community for over 80 years and the preservation of the ecology and environment of this low-key coastal village is one of its principal aims. Accordingly, MBRA is active in dealing with local government regarding roads and other matters.

This strategy seeks to document a 20-year vision for the village and a list of prioritised actions that:

- Considers climate change and development and the impact it will have on the Village landscape and the Merricks Beach environment;
- Responds to known flood risks and provides solutions that mitigate where possible damage to properties and assets through the recommendation of best practice stormwater management techniques;
- Considers current and future maintenance regimes for the drains and pipework which complement a network of integrated water management assets such as raingardens and swales;
- Identifies how residents can contribute to the solution through stormwater education, tips and ideas that can be actioned within private property.
- Identification of best practice dirt road and drainage maintenance that can be understood and followed by all stakeholders

This document is presented in three parts:

1. Overview of the problem, integrated water solutions, scenarios, climate and final strategy action plan
2. Educational materials
3. Technical assumptions and detail

Figure 1. Images of Merricks Beach and surrounds

2 The village

Merricks Beach is a small, low-key coastal village located on the eastern shoreline of the Mornington Peninsula, known for its bushland character, unsealed roads, and close proximity to Western Port Bay. The village comprises 255 lots spread across 10 main streets, with road surfaces consisting primarily of gravel (9 roads) and only one asphalt road. Properties range in size from 400 m² to 12,000 m², with most connected to sewer, and 55% are connected to the potable water mains network. 70% of the impervious surfaces are in private land, and 30% in public spaces.

Approximately 80% are estimated to be holiday homes, and 20% permanently occupied, which is typical of coastal villages.

Set within a vegetated landscape and bounded by a distributed foreshore reserve, Merricks Beach has a distinctive environmental identity. However, this same setting leaves it highly sensitive to the impacts of stormwater and climate change. The village relies on an informal drainage system consisting mainly of open swales and spoon drains. These open channel systems run adjacent to the narrow, vegetated road reserves, ultimately discharging into Western Port Bay. During rainfall events, especially under more intense storm conditions, water frequently collects along roadways, private driveways, and in low-lying backyards. Poor drainage, erosion, sediment movement, and waterlogging are widespread concerns raised by residents.

With most properties draining to Surf Street and a smaller sub-catchment flowing north toward Merricks Creek, the hydrology of Merricks Beach is highly localised but susceptible to cumulative impacts. The effects of climate change, rising sea levels and increasing rainfall intensity, are already evident in reduced performance of the existing swale network and in persistent surface flooding. These impacts are expected to worsen, prompting calls for targeted stormwater resilience measures.

This strategy has been shaped in close collaboration with the MBRA and aligns with broader climate adaptation objectives established by Mornington Peninsula Shire and Melbourne Water.

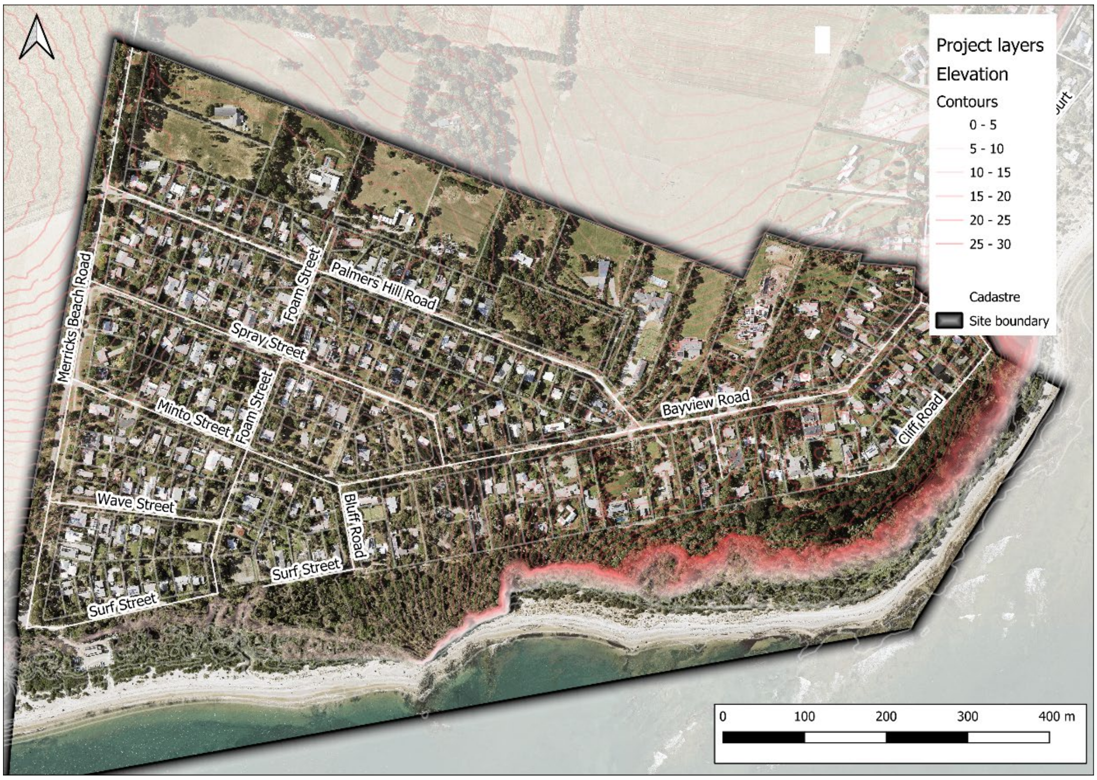


Figure 2. Merricks Beach and study area of interest as determined by MBRA

3 What is Integrated Water Management best practice?

Integrated Water Management (IWM) is a holistic approach to managing the urban water cycle that seeks to balance social, environmental and economic outcomes. It recognises the interconnection between potable water supply, wastewater, stormwater, and groundwater, and aims to manage these systems in an integrated way across both public and private domains.

Rather than relying on traditional, centralised infrastructure alone, IWM encourages a mix of decentralised and nature-based solutions that work with the landscape and community. This can improve resilience to climate change, reduce water demand, enhance local amenity, and protect natural ecosystems. Key practices in IWM can include the following:

- Rainwater harvesting: capturing rainwater for reuse in homes, gardens, or businesses helps reduce demand on mains water and manage runoff more effectively.
- Stormwater infiltration and retention: features such as swales, raingardens, and infiltration trenches help absorb stormwater into the ground, reducing erosion and flood risk while supporting natural recharge.
- Decentralised storage: localised water storages, such as tanks or small-scale retention systems, provide flexibility and resilience, particularly during dry periods or emergencies.
- Water sensitive design: designing urban spaces to slow, absorb, and treat water on site supports both liveability and environmental health. This includes using permeable surfaces, green infrastructure, and landscape integration.
- Collaborative planning: IWM is most successful when it involves input and responsibility from across the community, local government, utilities, and landowners. Effective governance is central to achieving shared water outcomes.

Implementing these types of approaches can lead to a wide range of benefits for a community:

- Improved flood resilience and reduced surface runoff
- Reduced reliance on centralised water and wastewater systems
- Enhanced water quality in downstream environments
- Cooler, greener, and more liveable public spaces
- Cost savings through reduced infrastructure pressure
- Stronger community engagement and awareness around water

IWM represents a shift from conventional engineering approaches to one that values the role of water in shaping sustainable, liveable and climate-resilient communities. It is particularly important in areas facing development pressure, changing rainfall patterns, or water resource constraints.

Section 15 (links to other projects) lists various projects from around Australia and the world that have used an IWM approach to improve the management of water and increase the variety of benefits that this delivers. While there is no place that can be directly replicated in Merricks Beach, there are themes and ideas that may be useful to consider.

4 Stormwater pollution, the pollution you cannot see

A stormwater strategy or integrated water management plan explicitly models and reviews the volume of water (potable, sewage, recycled water and stormwater) and its impact on the environment, on supplies, and within the town or village itself. But in addition to this issue of managing the volume of stormwater, it is worth considering the impact of stormwater pollution (the invisible and visible pollution) on the downstream environment.

Stormwater typically has excess concentrations of nutrients, suspended sediments, gross pollutants, and occasionally E.coli, heavy metals and hydrocarbons. These pollutant loads are worse in built up areas and inner city, particularly with busier roads that have asphalt pavements and kerb and guttering. Merricks Beach does not have that type of road environment, so it assumed to have less pollution than the same size village would have elsewhere with paved roads. But while it is not obvious, there is an excess amount of pollution from the impervious surfaces that do exist. In some instances you may see black water or algae growth on drains or pipes, which is linked to stormwater pollution concentrations.

Microplastics are an emerging pollutant, mostly invisible to the naked eye, which are prevalent in stormwater and wastewater. More research is required to determine how much a problem they are in this type of environment, and where those microplastics would be coming from. They might not be present in large quantities in stormwater but are in greywater and blackwater (which becomes a South East Water and Melbourne Water problem when they take and treat wastewater).

Stormwater pollution is known as a diffuse source pollutant. While the concentration of pollution is relatively small, compared to toxic spill and wastewater, there is a cumulative impact of this pollution on the environment (much like carbon emissions and the impact on the atmosphere).

From the modelling (noting we do not have any observations of water quality and stormwater pollution concentrations in this area) we can report on the estimated load of pollutants that will go through the foreshore and into the bay, each year, from stormwater runoff.

By modelling the stormwater system we can estimate how much pollution is associated with the stormwater runoff in this area. The modelling uses the following inputs: a representative rainfall pattern, area of impervious, and indicative concentrations of pollutants from a roof and road. The pollution we can most reliably estimate is:

- Total Nitrogen (measured as a concentration of stormwater on a surface, in mg/L)
- Total Phosphorous (measured as a concentration of stormwater on a surface, in mg/L)
- Total suspended solids (i.e. particles of sand and silt of various sizes) (measured as a concentration of stormwater on a surface, in mg/L)
- Gross pollutants (measured as a concentration of stormwater, in kg/L) (usually this is made up of 90% organic pollution (i.e. leaves) and 10% inorganic (cigarette butts, plastic, bottles))

Two key results come from this that are important for Merricks Beach. Firstly recognising that there is excess load of sediment that accumulates in downstream environments, and secondly an excess load of nutrients that flow to the beach and Western Port.

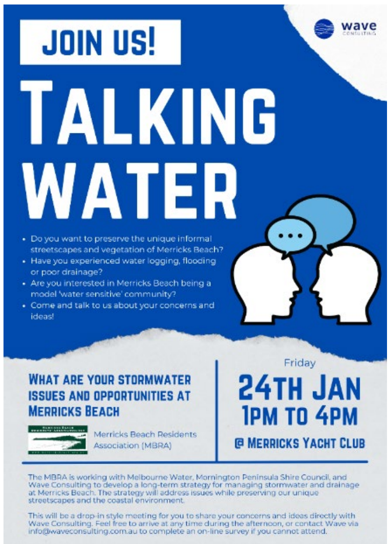
Even a small area like Merricks Beach results in an excess amount of 10 tonnes of sediment a year, and almost ½ a tonne of total nitrogen a year, flowing to the local environment. This contributes to the maintenance challenge of the swales and outlets.

The pollution is not that visible or obvious every time it rains, but it does add excess pollution to Western Port.

5 Community views on water issues and opportunities

Two methods were used to engage with the community in the Merricks Beach area, on the topic of water and drainage. The first was a face to face "Talking Water" open session at the Merricks Beach Yacht Club (with approximately 40 attendees), in January 2025. The second was an online survey, open for all of February 2025 (with 62 responses). This was considered a very high rate of response and engagement.

The community had strong views about water and were very attached to the local and rural / coastal nature of the environment, so were generally not seeking infrastructure solutions to water issues.



The online survey of Merricks Beach residents revealed widespread concern about drainage and stormwater management. Eighty percent of respondents reported stormwater issues on their street, most often during heavy rainfall, while 93% cited broader impacts such as infrastructure damage and street flooding.

Drainage was commonly described as inefficient, with many noting that stormwater "does not drain properly." Observations of blocked drains and overflow were frequent. Environmental concerns were also strong, particularly regarding water quality at the beach and foreshore.

Residents valued the natural landscape highly and identified multiple flood-prone areas across the township. They called for better maintenance, infrastructure upgrades in the form of crossovers and swales, and prioritisation of drainage improvements to address the recurring issues.

Some key statistics from this survey (with 62 responses, considered to be a very large sample size by the team), included:

- **80%** of respondents reported experiencing drainage or stormwater problems on their street.
- **93%** of respondents indicated they had experienced **impacts** from drainage or stormwater issues.
- The most frequently cited impacts were **damage to infrastructure (e.g. roads, footpaths)** and **flooding of streets or properties**.
- In response to drainage efficiency, **24 respondents** said stormwater **"does not drain properly"**, the most common selection for that question.
- Only **7%** of survey participants stated they had **not observed** drainage or stormwater issues in their area.
- **53 responses out of 62** identified **blockages** (e.g. debris, litter, vegetation) in local stormwater drains.
- **36 responses out of 62** reported observing **overflowing water** from stormwater systems near their residence.
- **93%** of respondents reported **slower or poorer drainage** during heavy rainfall, reinforcing the community-wide extent of the problem.

6 The problem

Stormwater is both a problem and an opportunity!

The problem in Merricks Beach is the excess amount of stormwater that is generated from all impervious surfaces, the uncontrolled nature of where stormwater flows, the impact of these flows on residents that live in lower lying areas of the village, the lack of maintenance of stormwater infrastructure, and lack of incentives to change the way stormwater is managed.

There is approximately 10.5 hectares of total impervious area in the study area. A hectare is 10,000 square metres, and about the size of a football field. The whole village is 54 hectares, so therefore approximately 21% of the region is impervious.

70% of this impervious area (the 10.5 hectares) is within private lots, so 70% of runoff originates in private lots. A stormwater strategy in Merricks Beach is therefore predominantly about reducing runoff from roofs and driveways, within the private realm. The remaining 30% of impervious area is related to the roads (that while are mostly not asphalt, still act like impervious surfaces and generate a lot of runoff). Hence Section 12, the "Action Plan", focuses a lot on actions to manage stormwater from private lots.

Every time it rains, more than 1 millimetre in a day, these impervious surfaces send water into gutters, into drains, and create surface water runoff. On average the Merricks Beach area has an average annual runoff of 662 mm per year. More than 30% of rainfall days have more than 1 mm of rainfall in a day.

Roads explicitly have drainage alongside them to allow for both the runoff off the road itself, and to then convey runoff that comes from private lots and enters the above or below ground drainage system (managed by council). Council then struggle with the maintenance of the drainage system, noting that when it is not functioning as per its intended design, roads or private properties get flooded. The Foam Street drain needs upsizing (see in Section 17.7 for more detail).

Water is difficult to model with its variability in a spatial and temporal sense, variability of rainfall, of groundwater, of climate, and the changing nature of the landscape due to new developments and upgrades to infrastructure. There is a connection between the surface water system and groundwater, which is hard to quantify in a localised area.

As was reported in the section above, the community is adversely affected by the runoff. It affects the quality of life of many residents and the liveability of all residents when we have extreme wet and dry periods.

The problem goes beyond the properties and road maintenance, and impacts on the ecological value of Western Port. The Western Port Catchment Integrated Water Management Plan was explicitly written to address stormwater and other environmental impacts on Western Port.

Climate change is forecast to make this problem worse. The Victoria Climate Futures Tool notes that in this region of Victoria, by the 2050s (assuming the worst case emissions scenario), the average annual rainfall will decrease by around 10% percentage (which will reduce overall stormwater flows), but also increase the risk of bushfire, and increase the risk of intense rainfall events.

The solution to all stormwater problems around the world can be described by this series of options (applicable to private lots, commercial areas, and roads):

a) Reduce the amount of impervious area, and / or,
b) Disconnect the impervious area from downstream drainage and the environment, and / or,
c) Collect the rainwater or stormwater for reuse
d) Absorb or retain the stormwater in the local environment
e) Detain and filter stormwater (to reduce the impact on the downstream environment)
f) Discharge safely

7 Method to explore options

The process to explore stormwater options at Merricks Beach involved an iterative engagement with Melbourne Water, Mornington Peninsula Shire Council, and the community. The strategy development began with a comprehensive data collection phase, incorporating geospatial datasets from the council, infrastructure data, and additional layers from DataVic. Community-sourced materials, such as anecdotal flooding evidence and private infrastructure layouts, also informed the process.

Three phases of community consultation were conducted: an in-person session at Merricks Yacht Club, an online survey, and a review of the draft report. These engagements helped capture local knowledge and refine modelling assumptions.

Stormwater modelling was central to the strategy. It involved mapping runoff from individual lots and roadways, with particular emphasis on the role of rainwater tanks. Around 55% of properties do have not access to mains water and therefore have larger rainwater tanks, which can reduce runoff. The modelling utilised high-resolution contour data and a node-based approach to simulate flows through the catchment to multiple beach outlets. 8 modelling runs were completed. These are shown in the graphic below.

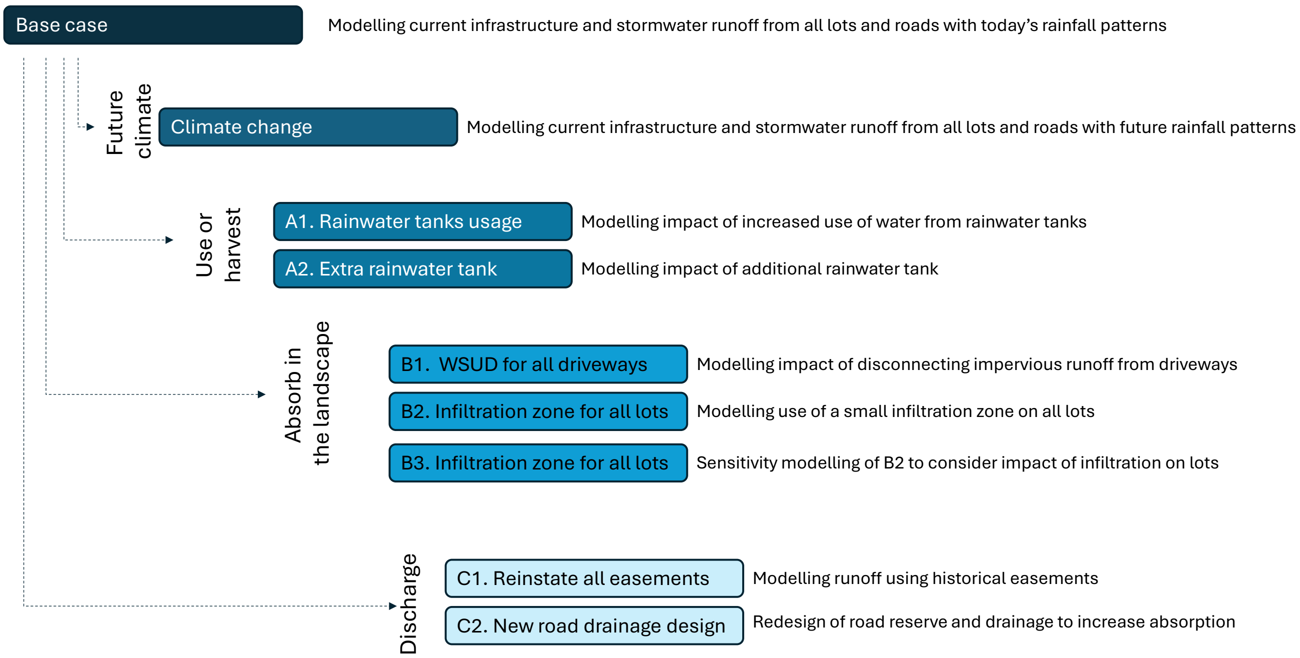


Figure 3. Options and modelling approach to assess improvements to stormwater

An important influence on the ability to model the current environment, and future options, is the availability of data, and assumptions used. These are listed in detail in Part 3 of this report. Some of the most influential parameters are climate and rainfall patterns (Melbourne Water recommend a decade of rainfall from 1984 to 1993), estimating impervious areas (Wave used aerial imagery to trace areas), the percentage of people on mains water (Dial Before you Dig), and the percentage of people that are holiday versus permanent residents (anecdotal evidence is that 20% of the whole village is made up of permanent residents).

Modelling undertaken in this project simulates the urban water system every six minutes, at every lot and on every street, for at least a decade. The results create a detailed dataset of simulated stormwater flows and water consumption at each lot, and across the stormwater network. There is a huge amount of variability in the use, absorption and discharge of stormwater, every day, every week and every year. To report on the impact of a changed set of options designed to change the stormwater is generated or flows to, we look at the annual average flow, as measured in ML / year. This will hide the variability and the ongoing wet and dry periods but is used as an industry standard in how best to assess options.

8 Quantifying the stormwater problem (now and into the future)

In order to understand the impact of any new initiative to manage stormwater, we have to model the nature of stormwater flows and issues within the village right now. Modelling how stormwater is predicted to flow through the village, and how much stormwater (and when) there is, is important, and becomes our 'base case' to compare the options against.

Firstly 45 % of the village area flows north, through an existing underground concrete council drainage system. There were no reports of issues with this part of the village around Palmers Hill Road. The remaining 55 % of the area of the village flows to the beach, and this is the focus of the analysis as this is where the majority of the issues were raised.

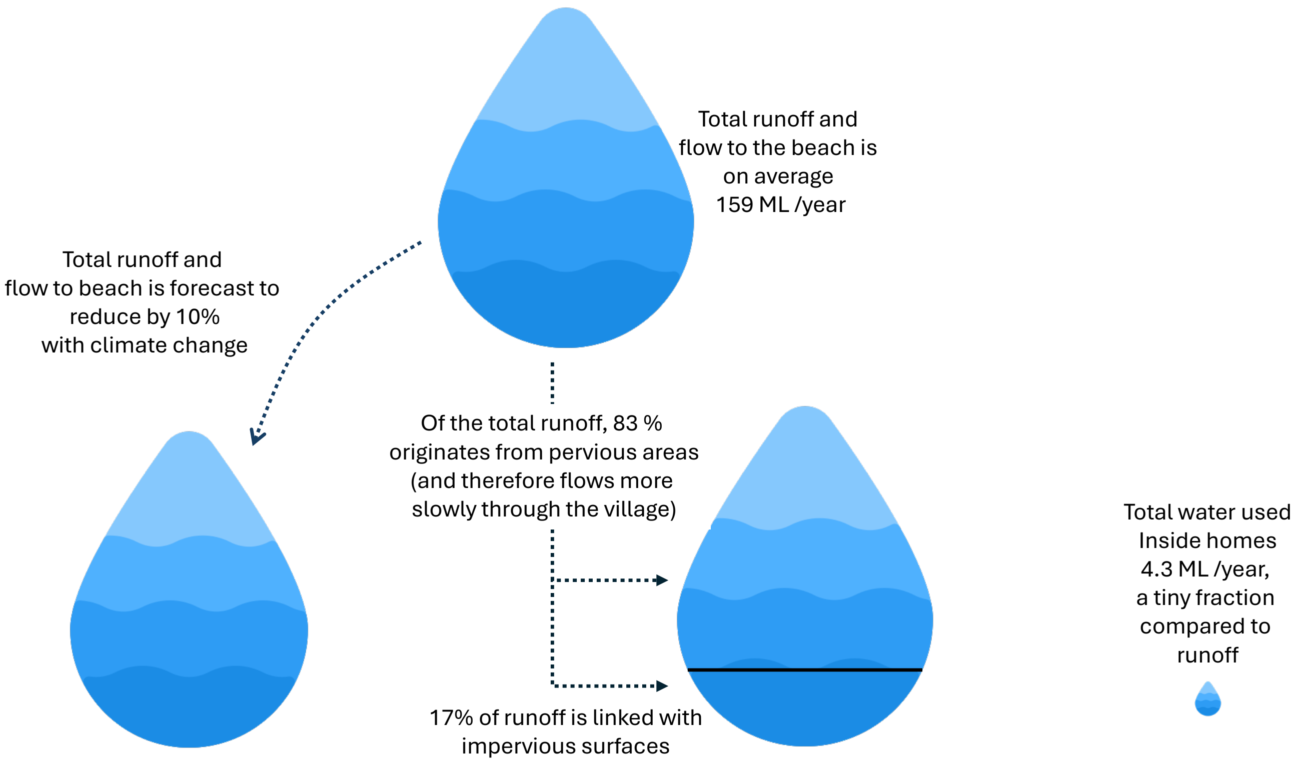
We also need to estimate that even if we do nothing in the future, how climate change will change the nature of water management and stormwater. Climate change forecasts of future rainfall in 2100, using an RCP of 8.5 (the worst of the possible trajectories the IPCC develop, because we are on that trajectory)

The team was not able to forecast the growth in urban development, but it would be safe to say that there will be more development, and hence more impervious surfaces, in the coming years and decades. If that development is not permeable (i.e. permeable driveways and green roofs), then it will increase impervious volumes.

The base case models both the total of all roofs, driveways, and roads, and the remaining pervious area, and estimates on average how much runoff will become stormwater, and how much will become baseflow or groundwater recharge. More details on some of these modelling assumptions are in the Technical Appendix.

In this current situation (shown visually below):

- All 255 lots and roads generate on average 218 ML / year of runoff (and of that 159 ML / year flows to Merricks Beach, and the remaining flows north to Merricks Creek and then Balnarring Beach)
- The pervious areas absorb and slowly release 133 ML / year of water
- On average, each year 4.3 ML of water is used at all homes and buildings, some of which is sourced from rainwater.



The average annual flow hides another issue with the current stormwater problem, it is not just how much water, but where it goes. The fact that the majority of easements exist on paper, but do not work in practice, results in excess flows being directed into neighbouring properties, not to the nearby swale drain / road.

There are two main findings from this modelling of the base case, relevant to how we see the problem, are:

1. The amount of water from impervious surfaces is far less than the volume that comes from pervious flows (and is partly absorbed in the landscape). This volume that is associated with the pervious areas results in a wetting and drying of the landscape, and irrespective of any stormwater runoff initiatives, will create wet and dry periods in the village that are naturally occurring.
2. The amount of water required for use inside and around a house is insignificant compared to the amount of water that the impervious surfaces generate. Rainwater tanks will help but are not the silver bullet.

Climate change results in less overall runoff, in pervious areas and with stormwater runoff, by about 10 percent. There is a non-linear relationship between less rainfall and less stormwater. Less stormwater will reduce the impacts on drainage maintenance and liveability, but less rainfall in the landscape will have significant impacts on bushfires, extreme heat, evaporation rates, evapotranspiration rates, and the whole environment.

Climate change is particularly of concern regarding the impact on the intensity of storms and the associated increased risk of flash flooding. An analysis of the two main outfalls (near the tennis courts and Foam Street) were completed to look at the capacity of these pipes to cope with increased intense storms. The method and results are detailed in Section “17.8: Outfall capacity review”.

Figure 4. Outlet from Foam Street to the foreshore, which will need upgrading to cope with climate change.

9 Stormwater solutions on lots (using more water) (Option A)

The first set of options was a review and modelling of how to increase the use of rainwater that falls on roofs across every house in Merricks Beach. Removing rainwater before it becomes stormwater is usually an effective strategy.

We anticipate that this will not have a substantial impact on overall runoff volumes, as the demand for water is quite low, compared to the amount of runoff from a lot.

Nonetheless this section outlines how big a difference we can make if every house was able to increase their use of water from a rainwater tank. This assumes that all houses that are connected to mains have a tank, and that they are able to increase the amount of uses for that rainwater. For the houses that are not on mains, it is assumed they are already using rainwater for all internal water demands (i.e. every shower, bath, laundry cycle etc is using rainwater).

The result of modelling the increased use of rainwater (option A1), is we get a 2% reduction in average runoff.

The second option to add a rainwater tank for a potential collaborative firefighting resource, is where a tank is added but there is no daily demand for the water in that tank, and instead it is designed to be available for the remote chance of being needed in a fire. It is therefore effectively the same as the base case.

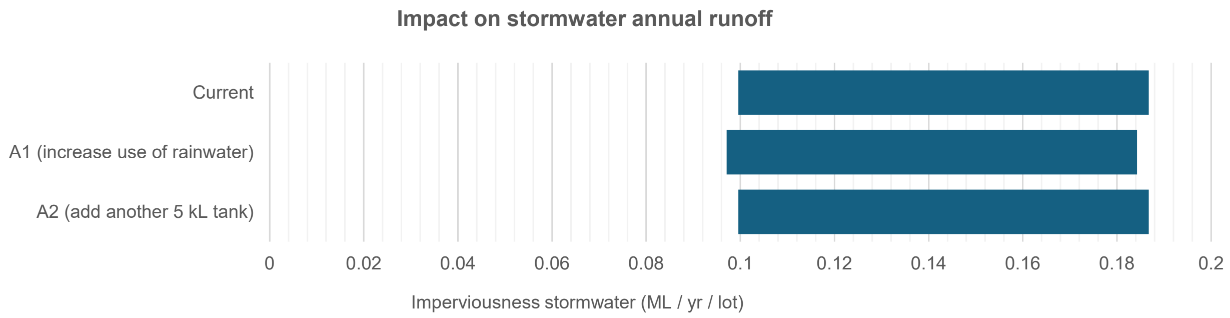
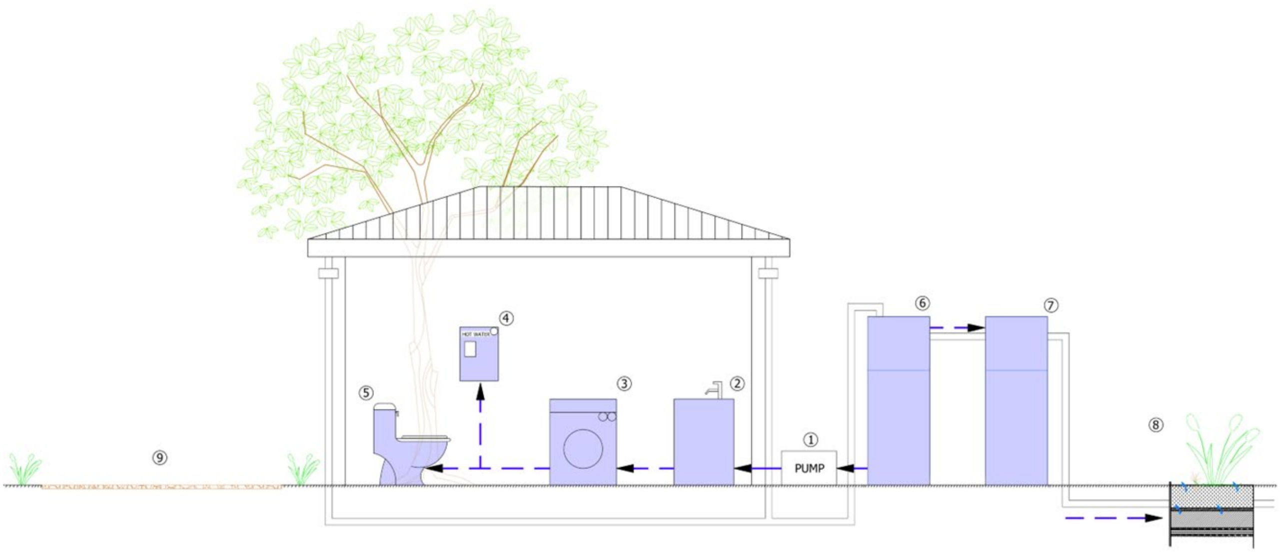


Figure 5. Modelling results for options that look at increasing rainwater usage

There is a range presented to capture the uncertainty in modelling these results, the difference in runoff between the houses that are holiday houses, and permanent, and those with mains water and those without mains. So in summary, using more rainwater is a good thing, but unlikely to make any noticeable difference to the amount of stormwater that flows down through the village. A cross section of a house that maximises rainwater use, and retains stormwater, is shown below.



10 Stormwater solutions on lots (absorbing more water) (Option B)

If we have maximised the use of all captured rainwater and stormwater, then our next option is to explore how we can retain that excess stormwater.

This chapter models the impact of two different ways to retain stormwater on the lots. Firstly by redirecting runoff to existing landscape areas. The aim is to avoid stormwater travelling in pipes, or gutters, or in any subtle depression to get to the road. The second option is to explicitly intercept the drainage pipes with an infiltration zone, and they continue the pipe on the downstream side of the infiltration zone.

This modelling is a best case scenario! We assume that all lots will try this intervention, and then we report on the maximum potential benefit of these initiatives. Obviously in practice there are all sorts of drivers and incentives (and regulation) that would influence how many people would adopt these solutions.

The chart below indicates that just diverting the runoff off a driveway (every 5 or 10 metres ideally) could see a 20% drop in the volume of runoff. This assumes that the nearby landscape can absorb that runoff and it does not go to the nearby road or easement.

Infiltration zones (options B2 and B3) offer the largest potential impact by intercepting all runoff from the lot. Runoff can reduce by 15 to 40%, depending on nature of the soils and size of the infiltration zone.

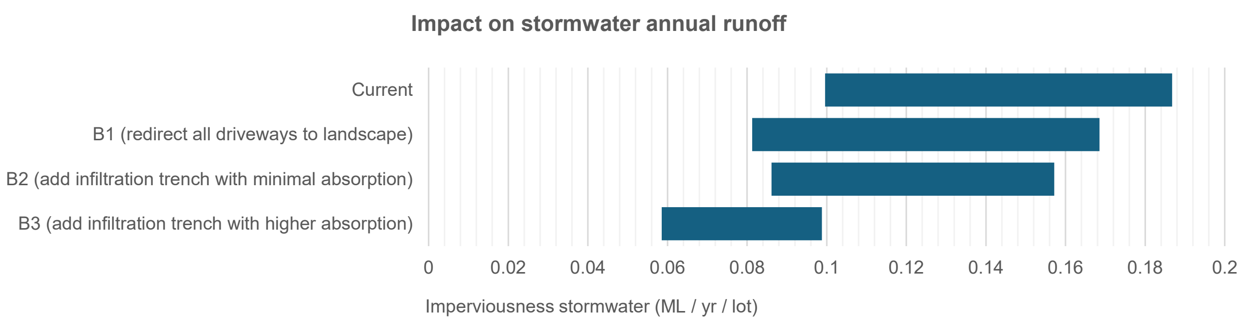
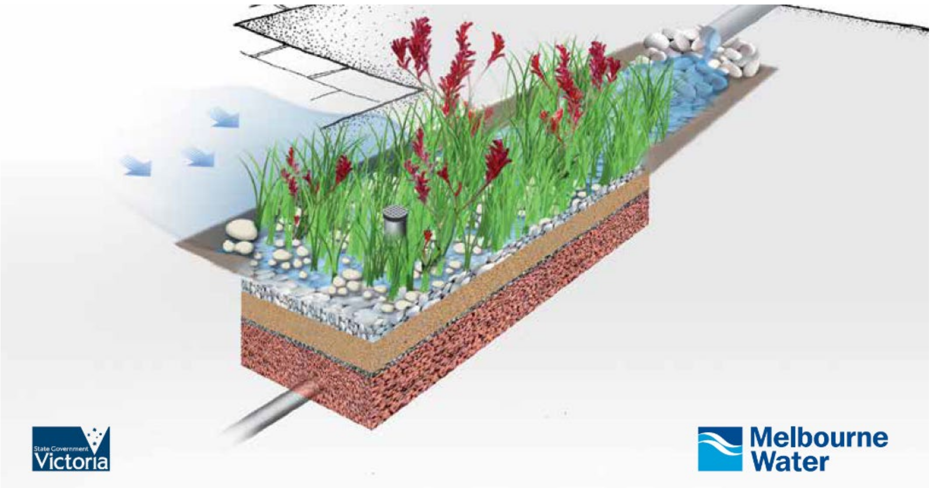


Figure 6. Modelling results for options that look at retaining more runoff from lots within the lot

To be clear in terms of how this works, we have included a Melbourne Water visual of these infiltration systems. They can be built to be quite shallow, and have native vegetation planted in them. A passer-by would hardly be able to distinguish between this area of landscaping and one that does not have any infiltration properties.



Note that these options are all modelled as independent scenarios, i.e. they are not reliant on the delivery of other options.

11 Stormwater solutions in roads and precincts (discharging water and road runoff) (Option C)

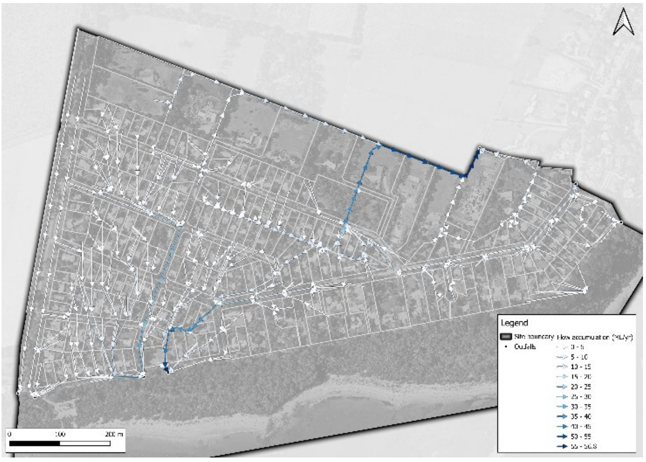
Our third option for stormwater, after harvesting and retaining stormwater, is to safely manage the discharge of the water to the downstream environment. 30% of impervious area in the village is related to the roads, so this in part relates to the runoff from lots, and also the additional stormwater generated on the roads. And as per the community feedback and survey responses, there are a number of issues around the drains and roads.

This chapter describes three options that are considered to improve stormwater management and also have a corresponding benefit in terms of assets protection and maintenance. These options are:

1. Ensure easements are operating and directing flow to the nearest road and swale
2. Regrade swales to ensure the invert matches the crossovers
3. Introduce a secondary swale

It must be acknowledged that there is no way to avoid ongoing maintenance of the swale network.

Anecdotal evidence and on site observation confirms that most of the drainage easements, located typically between the houses (and on the low side of the upstream property) do not work. The figure below illustrates that if they were working as intended, then the flow direction from over 70 properties would change. This would increase flows to the main swale drainage network, which is preferable to stormwater flows into another property in an uncontrolled way. A program or option to reinstate these easements is important for the liveability of several downstream properties around Wave and Surf Street, but also a very difficult one to deliver as residents have likely become accustomed to this situation over several decades.



Current drainage flow path across the village

Ideal drainage flow path across the village

The current situation results in inundation of backyards in a number of properties, sometime for weeks or months, and is shown below (photos sourced from local community).




The second option is not modelled, but presented in a simple graphic below, to illustrate how stormwater flows will improve if there are less changes in levels along the chainage of the swale (i.e. the long section). In some instances this means shallows swales, and in other instances it means deeper swales.

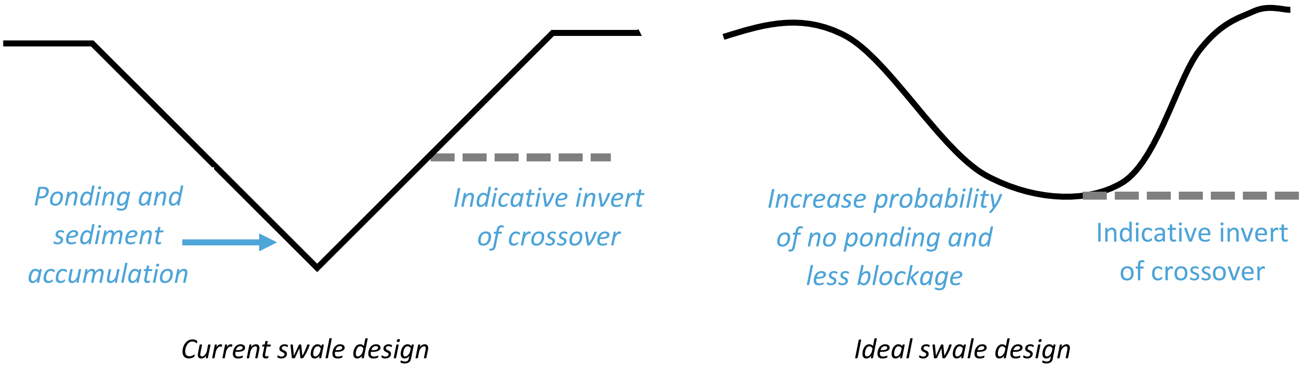


Figure 7. Swale and cross section

The third option for improved swale drainage is to replicate what exists now along parts of Foam Street, and that is have a secondary drainage / infiltration zone parallel to the swale. This would act as a buffer for all runoff from lots and easements, before it enters the main swale, and reduce the volume and frequency to flows. This effectively promotes the idea of an absorption zone in the road reserve, which as per the modelling in the section above for infiltration on lots, would reduce flows by 15 to 40 %.

A graphic of this design is shown below. This is a very unique and smart way to manage runoff and also should have its own maintenance plan.

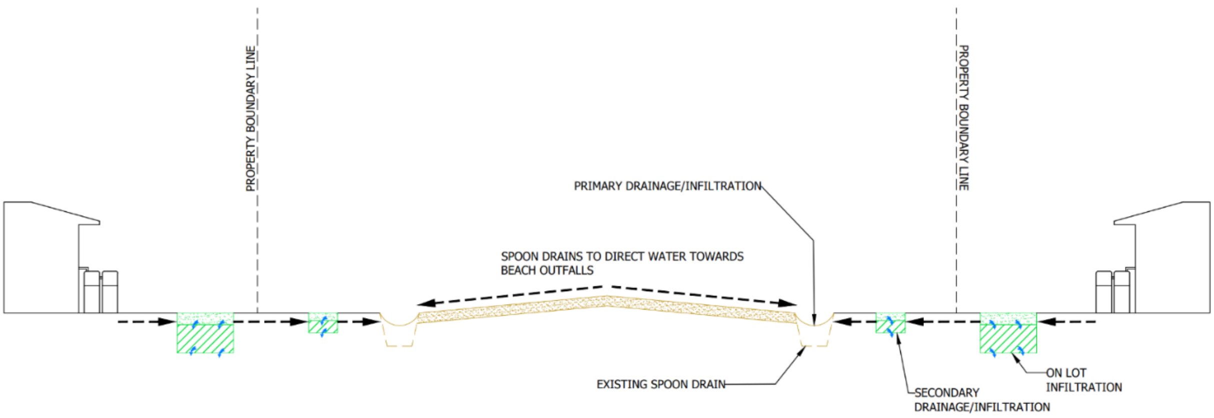


Figure 8. Proposed water sensitive road cross section

12 Priority projects and indicative cost

There are variety of potential projects that this strategy has identified. They often require support or investment from Council or Melbourne Water and also require a concerted effort to change the way water is managed, and where it flows, by each resident and land owner.

Based on the identification of issues by the community, and confirmed with stormwater modelling, the majority of projects are in the western area of the village, and the lower lying areas.

The figure below maps out a series of projects that relate to improving stormwater management and are consistent with the rural / coastal nature of the village.

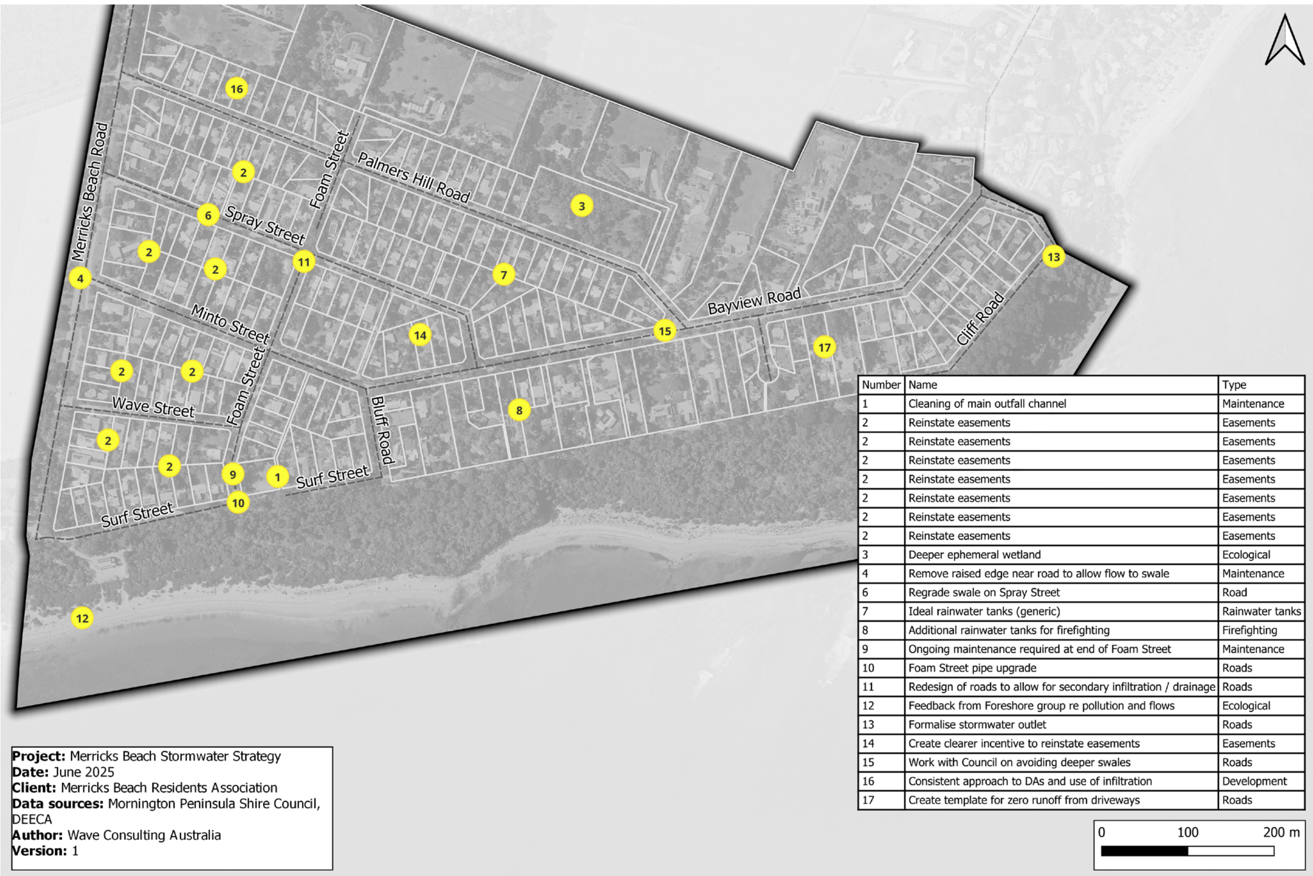


Figure 9. Map of recommendations

The following list then describes these projects, and some additional ones, with some indicative costs per project or per property. These are listed in no particular priority order.

Council

- **Merricks Project #1., (Vision).** Work with the MBRA and community to confirm a vision for Merricks Beach roads and roadside swales, including sketches or images showing an ideal design for roads, easement drains and on lot stormwater management on properties, in both dry weather and major storms. Explore options such as excavating and partially filling swales with vegetation to reduce erosion, improve amenity, and enhance walkability. Identify a 100 m section of road to be constructed to this standard as a demonstration site and note any existing sections in ideal condition. Indicative cost: $10,000–$25,000.
- **Merricks Project #2. (Easement auditing).** Audit all easements to understand the condition and operation and create a co-design process to create a pathway to reinstate all easements. Indicative cost of this project would be $5,000 to $10,000.
- **Merricks Project #3. (Road survey).** Survey all roads and swales to determine where there is a misalignment of levels between the swale and the crossover. Indicative cost of this project would be $3,000 to $6,000.

- **Merricks Project #4. (Crossovers).** Trial a regrading of the swales to align with the level of the crossovers, and redo crossovers to create a more efficient and faster drainage system Indicative cost of this project would be $5,000 to $25,000.
- **Merricks Project #5. (Pilot road design).** Identify opportunities to retrofit one road with 'secondary drainage' channel. Select a site based on community interest and support. Indicative cost of this project would be $10,000 to $50,000.
- **Merricks Project #6. (Review town planning requirements).** Review the past 5 years of planning applications and how stormwater management was considered and what conditions were imposed on new developments. Create a draft 'stormwater conditions' list that can be applied to all future development applications. Indicative cost of this project would be negligible and should be funded through existing council resources.

Residents

- **Merricks Project #7. (Sharing the maintenance).** Review this report and confirm how the maintenance of the swales and outlets is working, in discussion with Council, to ensure that all parties are clear on their role, and there is equity in how maintenance is shared between the MBRA and Council.
- **Merricks Project #8. (Tracking stormwater on your house).** Audit your house to understand where water flows, and where runoff is coming from. Indicative cost of this project would be negligible (but would be done by a plumber for $100 to $200, per house).
- **Merricks Project #9. (Rainwater use and optimisation at your house).** Review usage of your rainwater tank and consider how to double or triple the use of rainwater. Indicative cost of this project would be negligible (but would be done by a plumber for $100 to $200, per house).
- **Merricks Project #10. (Driveway runoff diversions at your house).** Divert all runoff from driveways and hard surfaces. The indicative cost is mostly related to the labour to dig some simple diversions near the driveway and is estimated to be $500 to $2000 project per house).
- **Merricks Project #11. (Pilot infiltration zone).** Build a small infiltration zone on the downstream side of the property prior to discharging all stormwater. This includes planting specific vegetation to maximise stormwater usage. The indicative cost of this project would $1,000 to $5,000 per property.
- **Merricks Project #12. (Pilot zero runoff).** Seek expressions of interest to be a pilot house for a 'zero runoff' model. This would demonstrate how the rainwater and stormwater system, with consideration for the roof runoff and driveway runoff, works, to use or retain and infiltrate all runoff, and create a near zero runoff scenario from a lot. This includes the planting of specific vegetation to maximise use of stormwater. The indicative cost of this project would $2,000 to $20,000 per property.
- **Merricks Project #13. (Slow leaks from rainwater tanks).** With 80% of properties forecast to be holiday homes, it is important to look for opportunities for rainwater tanks to be drawn down, every single day, not just during holiday periods. This project is to introduce a controlled slow leak from rainwater tanks on holiday homes, to a nearby landscape area, for the purposes of creating an environmental flow for the environment and reducing the chance of a rainwater tank being full and overflowing to the street. This would reduce the volume of stormwater runoff and reduce stormwater pollution to the beach as well. The indicative cost of this project would $200 to $1,000 per property.

Melbourne Water / Council / South East Water / CFA

- **Merricks Project #14. (Zero pollution precincts).** Review this report and consider how to create a 'zero stormwater runoff' model for a small village, through investment in private and public spaces.
- **Merricks Project #15. (IWM and rainwater tanks for firefighting resource).** Consider funding a research project to set up a distributed set of rainwater tanks, which can collectively be used for precinct scale stormwater management (firefighting, and flood mitigation) and operated by South East Water with smart tank technology to allow for the optimisation of rainwater volumes to suit forecast conditions.

13 Actions

Actions to deliver on the above projects have been grouped into short and longer term projects, and advocacy and on ground works. This is a suggested set of actions and will be reviewed and updated by MBRA in discussion and partnership with Melbourne Water, South East Water and Mornington Peninsula Shire Council. Delivery of these actions is also dependent on funding and budgets. DEECA and Melbourne Water are known to support IWM projects and may be a source of funding to trial some of these projects.

13.1 Short-Term Advocacy (0 to 5 years)

Community Awareness and Education: Promote understanding of stormwater impacts through community workshops, local guides, and MBRA-led engagement. Emphasise nature of runoff, infiltration options, and pollution prevention within private lots.

Clarification of Maintenance Responsibilities: Establish clear agreements between MBRA and Mornington Peninsula Shire regarding roles in swale and drain maintenance.

Vision and Policy Alignment: Engage with Council to endorse the strategy’s vision and ensure its integration into planning assessments. Develop standard stormwater conditions for new developments.

13.2 Short-Term On-Ground Works (0 to 5 years)

Property-Level Stormwater Audits: Encourage residents to assess their lot’s runoff patterns and opportunities for disconnection, detention, diversion, or infiltration.

Rainwater Tank Optimisation: Promote increased use of existing tanks for laundry, toilet, irrigation, and hot water to reduce overflow to drainage systems.

Driveway Runoff Diversion: Implement low-cost earthworks or trenching near driveways, or detention areas, to redirect runoff into adjacent landscape zones.

Pilot Infiltration Zones: Construct small on-lot vegetated infiltration areas, targeting discharge points prior to connection with public drains.

13.3 Medium-to-Long-Term Advocacy (6 to 20 years)

Precinct Resilience Planning: Advocate for a distributed rainwater tank network for fire-fighting and precinct-level reuse. This would require third-pipe infrastructure and smart valve systems so will require further investigation and a cost benefit study.

Catchment-Wide Zero Pollution Initiative: Collaborate with Melbourne Water and South East Water on a pilot ‘zero stormwater runoff precinct’ integrating lot, road, and open space strategies.

Easement Reinforcement Program: Work with Council to audit, reinstate, and legalise non-functioning drainage easements, guided by a co-design process.

13.4 Medium-to-Long-Term On-Ground Works (6 to 20 years)

Swale and Road Cross-over Upgrades: Implement targeted regrading of swales to improve alignment with driveways. Trial deeper or shallower swales where flow control has been identified as problematic and results in inundation of properties.

Secondary Drainage in Road Reserves: Retrofit a pilot road with a dual-swale system, replicating the successful Foam Street cross section to create additional infiltration capacity.

Slow Leak Rainwater Tank Installations: Equip holiday homes with controlled tank drawdown systems to release stored water into vegetated zones year-round.

14 Summary of strategy

The stormwater strategy for Merricks Beach aims to deliver a resilient, sustainable water management system through coordinated changes at lot, road, and precinct scales. This integrated approach responds to the challenges of climate variability, supports local character, and promotes responsible water stewardship across the community.

Lot-Scale Initiatives. Each property plays a critical role. All homes are encouraged to maximise rainwater harvesting, using tanks to supply water for toilets, laundry, irrigation, hot water, car washing, and even landscape recharge. Driveways and hard surfaces should direct runoff into on-lot landscaped infiltration zones before entering the drainage network. Properties will ideally include an operational easement and crossovers aligned with road swales. A second rainwater tank may be added for use in firefighting, contributing to a precinct-wide distributed water supply managed with a smart valve and control system.

Road-Scale Solutions. Merricks Beach's unsealed roads are valued, but they require sensitive drainage upgrades. Each road will be progressively regraded and redesigned to accommodate dual swales: a primary roadside swale and a secondary infiltration trench. This configuration absorbs local runoff from adjacent lots, reduces volumes entering the main swale, and supports plant growth in suitable areas. Shallow swales are favoured to align with crossovers and reduce erosion from vehicles, with regular maintenance and occasional weirs to improve flow control.

Precinct-Wide Measures and Fire Readiness. In considering options to create a water source for firefighting, a single stormwater harvesting scheme was difficult to locate in the foreshore, and instead the team looked at the option of a distributed network of 5 kL rainwater tanks across all lots, linked via a third pipe system and with solenoids to allow for each tank to capture rainwater and not overflow to another downstream tank. Collectively, these tanks would store over 1.5 megalitres of water, accessible for firefighting through remotely operated valves and smart sensors. This system mirrors successful models like Aquarevo, offering both redundancy and accessibility during emergencies when power may be unavailable and mains water unreliable. This is ambitious as it requires a new 'third pipe network' to be built to connect all of these tanks (which would be costly), but it would also be a demonstration of innovative solutions to reduce flooding, harvest more water, and support a resilient water system for firefighting.

Community Involvement and Climate Awareness. The strategy emphasises collective action. It encourages all residents to engage with the implications of climate change and the shifting patterns of floods and droughts. There is a call to initiate ongoing conversations around water use, resilience, and shared responsibility. Collaboration with Traditional Owners is encouraged to better understand water's cultural significance. It may be worth considering how to track outcomes, promote accountability, and share success with other communities.

Climate change and town planning. An important issue into the future is the influence of climate change, and variability in stormwater flows, and also how future development takes account of both the stormwater problem, and climate variability, so future developments are resilient and part of the solution to managing stormwater.

Maintenance. Finally all work relies on maintenance of private and public infrastructure. Maintenance of the road and reducing the degradation of the swales and crushing the swale edge is critical to ensuring that stormwater can flow.

This strategy outlines a low-maintenance, high-impact approach designed to reduce ongoing Council maintenance of swales, while supporting a thriving, climate-conscious Merricks Beach.

15 Links to other projects

An integrated water management, or water sensitive approach has been considered and adopted at various places across Victoria and Australia, and around the world. This section lists various references to these projects.

1. **Aquarevo, South East Water.**

Aquarevo is a joint development between South East Water and Villawood Properties to create a residential development in Lyndhurst, where homes feature a range of water saving features. Aquarevo homes have three types of water to highlight the possibilities of harnessing all sources of water available to us: drinking, recycled and rainwater. https://www.clearwatervic.com.au/resource-library/case-studies/aquarevo.php

2. **Evermore Heights, Rockingham (Western Australia)**

This residential development incorporates dual reticulation systems, rainwater harvesting, and native landscaping, achieving a 68% reduction in scheme water use. It serves as a model for sustainable suburban design. https://www.newwaterways.org.au/key-initiatives/case-studies-fact-sheets/wsud-case-studies/

3. **Mikawomma Reserve, Adelaide**

Mikawomma Reserve is known as a multifunctional public space that combines stormwater detention with Indigenous cultural heritage. The reserve features native vegetation, a dry creek bed, and community-created artworks, reflecting the Kaurna people's connection to the land. https://www.cityofpae.sa.gov.au/visit/playgrounds-parks-gardens/mikawomma-reserve

4. **Sponge City Initiatives, China**

China's Sponge City program aims to enhance urban flood resilience through the integration of green infrastructure. Projects like Sanya Mangrove Park and Dong'an Wetland Park introduce wetlands, permeable surfaces, and bio-swales to manage stormwater, improve water quality, and restore ecosystems. https://earth.org/sponge-cities-could-be-the-answer-to-impending-water-crisis-in-china/

5. **Blue-Green Roofs, Amsterdam**

The RESILIO project retrofits rooftops with blue-green infrastructure to capture and manage rainwater, mitigating flooding and reducing heat stress. These systems store water for non-potable uses and release it gradually, enhancing urban resilience. https://www.theguardian.com/environment/2024/may/02/on-every-roof-something-is-possible-how-sponge-cities-could-change-the-way-we-handle-rain?CMP=share_btn_url

6. **Flussbad Berlin, Germany**

An urban revitalization project transforming a section of the Spree Canal into a natural swimming area. The initiative includes ecological water filtration and aims to reconnect residents with the river, promoting sustainable urban living. https://en.wikipedia.org/wiki/Flussbad_Berlin_%28Project%29

7. **Tanks for Platypus, Yarra Ranges Council**

Tanks for Platypus aims to safeguard the health of Monbulk Creek as well as the platypus, which depend on its survival. Rainwater tanks are installed to capture and release water at times of need, reducing stormwater pollution, litter, habitat loss and flooding events. https://www.yarraranges.vic.gov.au/Our-services/Climate-and-environment/Sustainable-communities/Healthy-Waterways/Tanks-for-Platypus. This is a good reference where we have downstream values such as platypus, but less relevant when no specific species is linked to that catchment area.

16 Glossary

Climate change: Long-term changes in weather patterns, mainly caused by human activities such as burning fossil fuels. It leads to effects such as rising temperatures, more extreme weather, and sea level rise.

Easements: A legal right allowing access to or use of part of your land for a specific purpose, such as drainage or utilities. Councils or utility companies often use easements to maintain stormwater pipes or electricity lines.

Imperviousness: Describes surfaces such as concrete or asphalt that do not let water soak into the ground. These surfaces increase the amount of stormwater runoff during rain.

Infiltration zone: An area of land specially designed to let rainwater soak into the ground instead of running off. This helps to recharge groundwater and reduce pressure on stormwater systems.

Integrated Water Management (IWM): A way of planning and managing water that considers all parts of the water cycle together, including rain, stormwater, wastewater and drinking water. It aims to use water more wisely and sustainably across communities.

MUSIC modelling: A software tool (Model for Urban Stormwater Improvement Conceptualisation) used in Australia to design and test stormwater treatment systems. It helps engineers and planners assess how well a design will reduce pollution and manage flow. (*eWater MUSIC – www.ewater.org.au*)

Outlet: The point where water leaves a system, such as a stormwater pipe or drain. It usually discharges into creeks, rivers or the sea.

Potable water / Mains water: Water that is safe and clean enough for people to drink. In Australia, this meets strict national health standards, and in this area is supplied by South East Water.

Runoff: Rainwater that flows over land or hard surfaces and into drains, instead of soaking into the soil. It may carry pollution into creeks and rivers and the beach.

Stormwater: Rainwater that runs off roofs, roads and other hard surfaces. It flows into the stormwater drainage system and usually ends up in local waterways, often without treatment.

Swale drain: A shallow, grassy channel designed to slow down and filter rainwater runoff. Swale drains help water soak into the ground and reduce flooding but are not as efficient as transporting water as underground concrete drainage pipes.

Water Sensitive Urban Design (WSUD): An approach to planning and building that manages water in a more natural and sustainable way. It includes features such as rain gardens, permeable paving and swales to treat and reuse stormwater. (*CRC for Water Sensitive Cities – www.watersensitivecities.org.au*)

Stormwater @ Merricks Beach

Stormwater flows downhill, and doesn't stop at a property boundary.

Stormwater is the surface water that is created from the runoff of rain from every hard surface (such as roofs, sheds, roads, and driveways).

Naturally, water does not flow on the surface very often. Most rainfall events would naturally reach the beach over a longer period of time, making their way through the subsurface and eventually to a small creek, or would recharge the groundwater table.

70% of all runoff in Merricks Beach comes from private lots. Only 30% of runoff is associated with the roads in the village.

Stormwater should flow in specific pathways and drainage easements, not uncontrolled through properties. Any downpipe from a roof, driveway, or hard surface will become stormwater.

Functional swales and drains are critical to ensuring stormwater can flow and not inadvertently flow into a property.

Maintenance is critical for the road and drainage network to reduce the risk of flooding and minimise asset damage.

Rainwater tanks are useful for a number of reasons: they reduce potable water use, reduce runoff, irrigate landscapes, and create a firefighting resource.

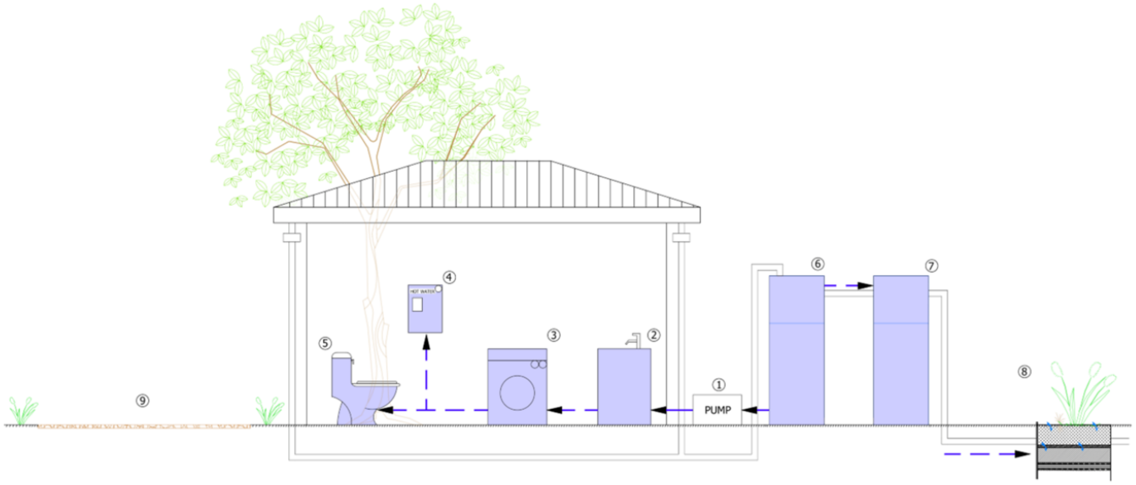
Rainwater tanks have to be drawn down every single day to avoid overflowing and contributing to stormwater flows.

Stormwater flows are very variable, due to the variability of rainfall. Rainfall records indicate that the average for the region is around 662 mm in a year, but wet and dry years vary by 50% or more. Climate change will increase this variability.

How can you improve stormwater management?

There are ***five basic ways to improve stormwater management****:*

1. *Reduce the impervious area (with a green roof or permeable driveway)*
2. *Harvest or collect the stormwater for use*
3. *Divert water to surrounding landscapes*
4. *Retain and filter the stormwater and allow the landscape to act like a sponge*
5. *Safely discharge the stormwater to local drainage*



Increase permeability
Above all else, build permeable structures and surfaces.

Use more rainwater
Harvesting and reusing rainwater is a great way to solve stormwtaer and potable water issues. Increaseing storage is important.

Divert runoff to landscaping
Small scale diversions and channels away from drains and gutters stop runoff adding to downstream problems

Infiltrate
Absorb excess runoff in infiltration zones, with vegetation.

Slow the flow
The more runoff is detained, the better.

Stormwater must have a designated flow path to follow, to reduce impacts on assets, roads and people

17 Appendix A: Modelling and assumptions

17.1 Data availability

To complete a stormwater strategy, several datasets were used to assess the topography, drainage routes, existing infrastructure, condition of the infrastructure, water usage and metering.

Geospatial data is particularly important in this analysis, and Mornington Peninsula Shire Council provided the following geospatial data (in shapefile format) for this project: Contours (0.5 metre intervals)

- Dwellings
- Existing services (e.g. water mains)
- Historical rainfall records
- Impervious areas
- Open space
- Public buildings
- Road alignment and type
- Stormwater pipes
- Stormwater pits
- Stormwater outlets
- Waterways
- WSUD assets

Additional data was obtained from DataVic, including a layer with the location of all easements and a layer with building outlines (in the form of polygons sourced from Microsoft Bing). Sewerage connections were sourced from an enquiry processed by Before You Dig Australia.

Additional data was sourced from the community and the residents association, including:

- Private water mains lines were also provided for the region excluding the east half of Bayview Rd and entirety of Cliff Rd.
- Historical imagery.
- Anecdotal evidence re flooding and drainage problems.

17.2 Modelling of water balance and stormwater flows

Stormwater modelling for Merricks Beach used a ½ meter contour interval dataset to create a 'network node model' that connects each lot and road, routing flows from the top of the catchment to multiple beach outlets.

The Merricks Beach area was broken up, so a polygon was covering every single property, easement and road. Each polygon was assigned a centroid node, with property nodes placed at the lowest elevation point to simulate the legal point of discharge. Water does not drain to a single outlet onto the beach, but rather through several formal (e.g., drainage pipes at Surf Street) and informal flow paths.

All 255 lots were modelled using estimated water demand and impervious area data. Roads were treated as 100% impervious, as per the industry standard approach. Stormwater flows from properties and roads were routed through the network using an accumulation algorithm to calculate flow at each node and outlet.

Modelling scenarios reflect the 'ideal' and the 'actual' drainage surface water pathways.

- **Actual drainage:** Reflects observed water flow between lots and roads. Easements, particularly around Surf Street and Wave Street, which connect to Foam Street, were assumed non-functional, based on community feedback.

- **Ideal drainage:** Assumes all easements function as designed, directing water effectively through designated channels (or spoon drains). Roads such as Wave, Minto and Spray Streets are also assumed to direct flows to nearby streets, not allow water to flow past into a downstream property.

17.3 Modelling

Modelling is undertaken to estimate the volume of rainfall that becomes stormwater, from each lot and road, and how much water is used inside and outside the home, the inflow and outflow of rainwater tanks, the ability of the landscape to absorb runoff, and how much water ends up leaving Merricks Beach

A key to the modelling is the following assumptions and hydrological processes:

- 1 millimetre of rainfall on a 1 square meter area, generates 1 litre of water
- Merricks Beach has an average annual rainfall of 817 mm / year (BOM, 2025)
- The total area of Merrick Beach in the study area is 73 ha, which includes the foreshore area
- An impervious surface will result in 70 to 90% of all rainfall becoming runoff, but in a natural environment, 5% of rainfall will becomes surface flow, with the majority of flows evapotranspired, or recharges groundwater, or contributes to baseflow.
- 75% of water used at a residential home is assumed to be used inside the home (Essential Services Commission, 2018), and 25% for outdoor uses.

17.4 Catchment and impervious analysis

There is a huge difference between the volume of runoff from an impervious surface and a pervious surface.

Using aerial imagery and existing dataset that identify all buildings in the village, it was estimated that there is 10.5 ha of impervious area in Merricks Beach, within a total area of 73 ha. This means the impervious percentage is 14%. But since most impervious areas do not have plumbing and drainage to send that excess runoff water to a nearby drain / swale (instead it drains to the nearby garden / landscape), the effective impervious area is much less and is estimated to be approximately 7%.

The figures in Appendix B illustrate the outputs from the analysis of imperviousness (and other modelling) across the whole area.

17.5 Runoff from lots

Typical, runoff from lots varies between 130 kL / year to 197 kL / year. The figure below illustrates the scale of water use, and runoff, from the four main types of dwellings (those on mains water and those without mains water, and the permanent homes and holiday homes).

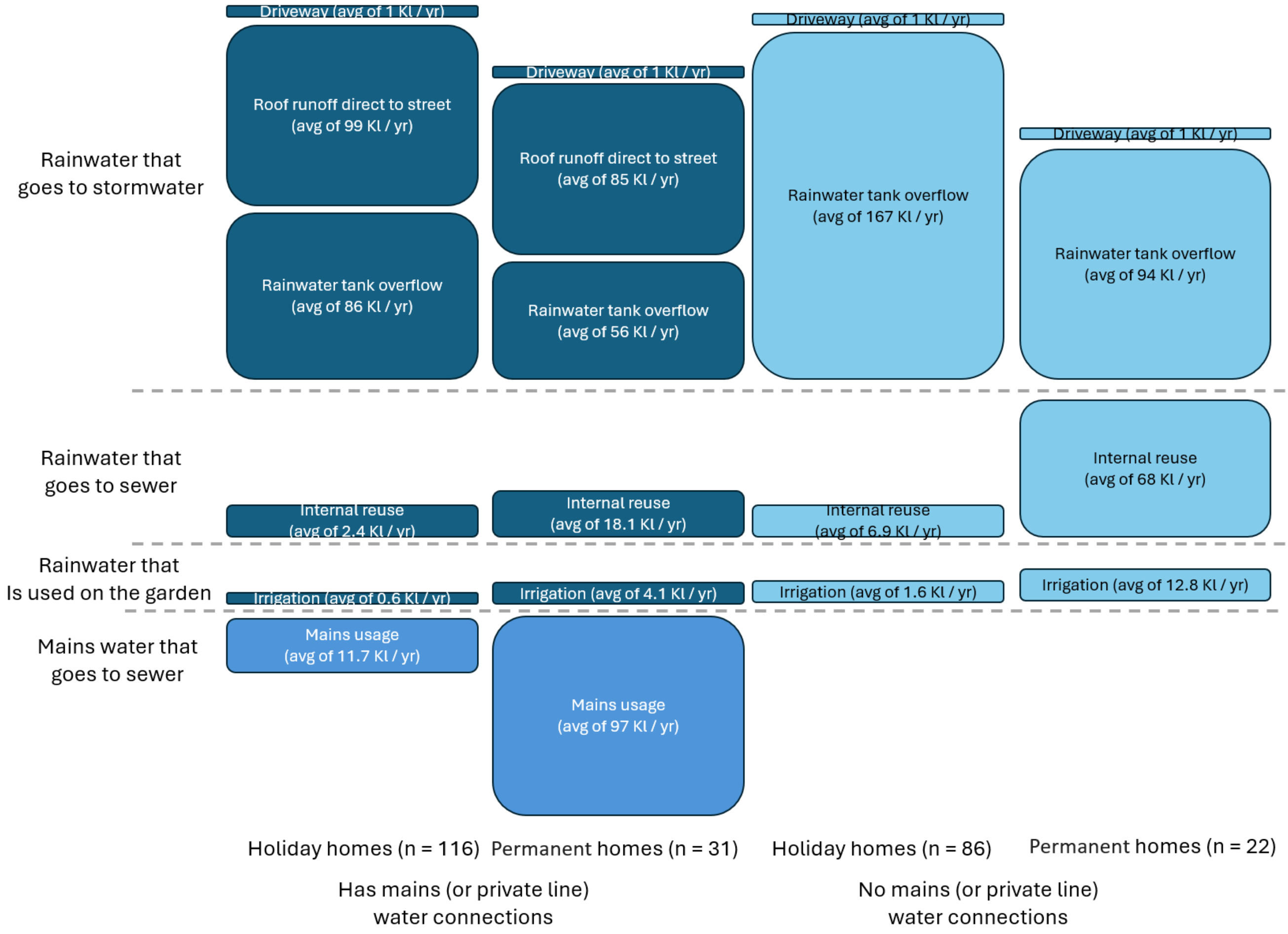


Figure 10. Differences in water importing and runoff from the four types of dwellings for a typical lot area.

The figure below shows how this modelling the estimated runoff, per year, from each lot, ranked in terms of annual volume.

The modelling took account of the exact size of roof, size of driveway and size of lot. The nature of being a holiday house or a permanent resident was randomly assigned to each lot.

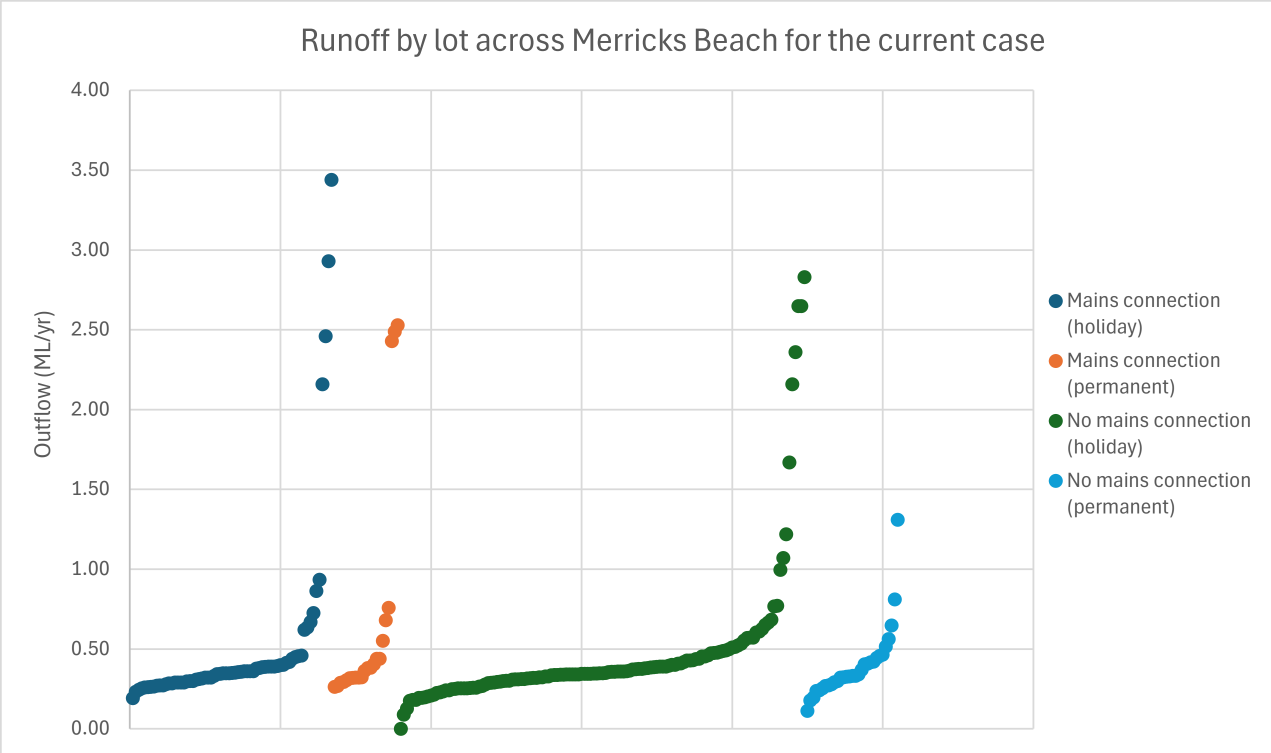


Figure 11. Modelled runoff for all 255 lots (Base case).

The properties that have the largest roof and driveway area as the dots that result in the outflow from the property being greater than 1 ML / year. These properties with a large impervious area exist in areas with mains water and areas without, and in holiday homes and permanent homes.

17.6 Roads

The drainage around the roads is in variable condition. Some observations and community comments on drainage around the roads include:

- The community like the rural and informal nature of roads and how it is aligned with the coastal and environmental feel of the village
- Drainage around the roads is problematic, in that they often do not work, collapse, and the condition varies with the nature and frequency of maintenance
- Speeding on the roads is considered to be a big problem
- The main stormwater issue that residents comment on is the interaction between swales and the crossovers – often the depth of the swale is deeper than the depth of the drain under the crossover
- Some streets do not have swales at all
- Subtle changes to the level of the road reserve along Merricks Beach Road has resulted in most of the water NOT entering the swale, and infiltrating, and instead remaining on the road
- Crossovers were often raised as a concern due to misalignment or inadequate drainage performance.
- Council have attempted to create deeper and wider swales (by scaping out deeper trenches), but this has created safety issue (cars often get stuck in the deeper swale) and result in ponding and a lack of flow along the swale
- Waste collection trucks and other construction delivery trucks cause crumbling and collapsing of the road edge, creating erosion points and pushing more sediment into the swale

Typical unvegetated swale (Foam Street)

Crossover buried/not maintained

Looking west on Wave Street

Subtle build up on edge of Merricks Beach Road, preventing flow into swale

Deeper swale along Bayview Road

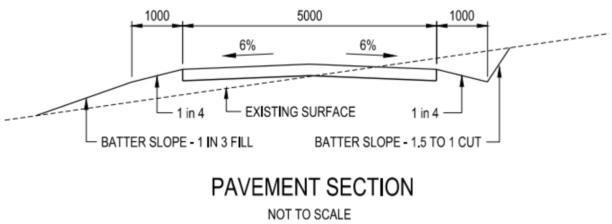
Side entry pit on Bayview Road

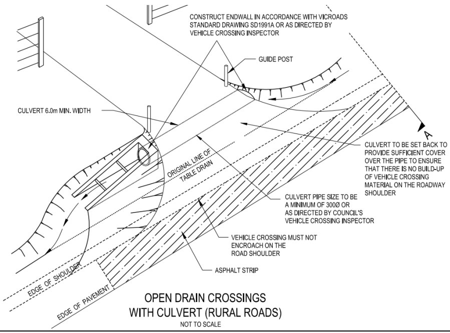
Figure 12. *Example of current road and drainage issues.*

17.7 Crossovers

Due to the fact that Merricks Beach is of a more rural nature than urban, and that the residents are supportive of a more natural design solution, future crossovers should use the Mornington Peninsula Shire Council Standard Drawings MP315 and MP305 (see *Civil Engineering Standard Drawings, 5. Vehicle Crossings* on the MPSC website), to facilitate a simpler and better swale and crossover solution. These designs are copied below.

Additional input and discussions with MPSC in June 2025 have allowed for crossovers in Merricks Beach to be refined to reflect the Shire's agreed approach. While Figure 13 is included for reference, in Merricks Beach it has been agreed that rollover ends are to be removed and the pipe will be a concrete box culvert.





MP315 Minimum construction standard for rural access roads	MP305 Open drain crossings with culvert (rural roads)

Figure 13. *Copies of MPSC standard drawings for crossover and rural roads*

17.8 Outfall capacity review

The available data to complete this modelling of drainage capacity at two key locations at the bottom of the catchment, was as follows:

- Asset data provided by MPSC
- Geospatial data from Vic Government
- Pluvio rainfall series (from Bureau of Meteorology)
- The 2016 Intensity-Frequency-Duration data (from Bureau of Meteorology)
- Climate change factors on IFD (Australian Rainfall and Runoff Data Hub)

The Rational Method (Melbourne Water, 2025) was used to calculate the peak flowrate for two locations of interest, the Foam Street outlet and the outlet near the tennis courts. The peak flowrate resulting from a storm depends on the average recurrence interval (ARI) and land use, which assists in determining the runoff coefficient, the proceeding analysis used a runoff coefficient of 0.4. The time of concentration, which determines the storm duration, was assumed as 5 minutes for all subcatchments.

The effects of climate change on rainfall were incorporated into the analysis using climate change factors provided by the ARR Data Hub (Australia, 2025). The SSP5-8.5 scenario was employed alongside a target horizon of 2100, which combined depicts a worst-case scenario on rainfall severity. **This results in an increase in intensity of between 41% and 86% (by 2100), depending on the storm duration.**

The Hazen-Williams equation was used to determine the maximum capacity of subcatchments with an outfall, using the roughness of the pipe, gradient, and final length. Blockage of 50% was assumed in all cases to model the effect of sediment and debris entering drainage systems.

Climate change is forecast to create more intense storms, and therefore the potential to see more assets failure or not be able to cope with the 10% design rainfall storm. When all the catchments were modelled with a more intense storm, the existing pipes were not always able to handle peak flows that are related to storms in a climate change scenario. The results are shown below.

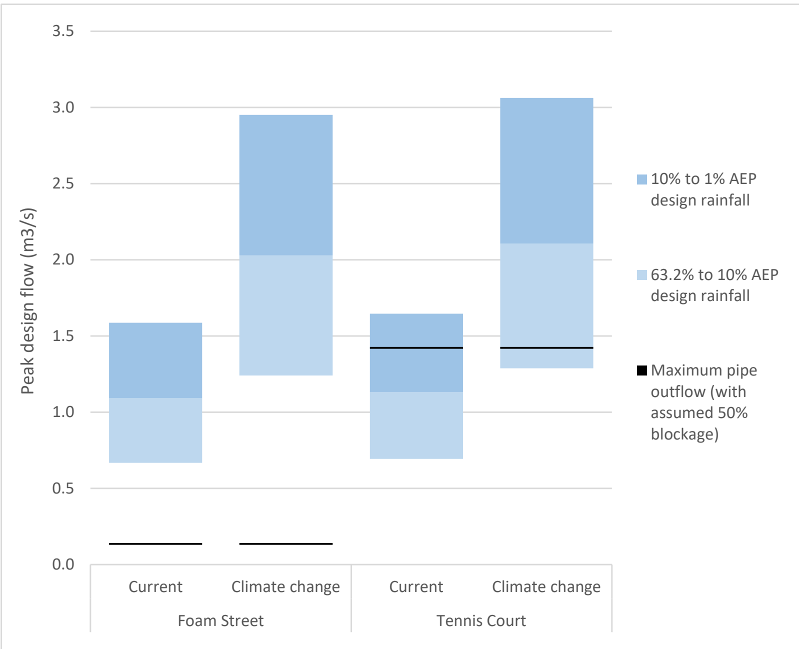


Figure 14. Pipe outlet capacity for the two outfalls at the end of Foam Street.

The pipe at Foam Street definitely needs upgrading. The outlet at the tennis courts may need upgrading in the future.

17.9 Potable water (supplied by South-East water and by private water line)

The supply of potable water by water authorities is connected to only a small portion of lots in Merricks Beach, due to historical issues. South East Water are the water authority in this region and allowed for extensions to the potable water distribution network, known as a ‘private water line.’ A private water line allows for potable water to go beyond the SE Water network and is constructed and maintained by local residents (or consortiums of residents). The more lots that are connected to a private line, the more the pressure is affected.

For those not on potable supply, they rely wholly on rainwater for all water supplies and uses.

17.10 Sewage

The majority of lots are connected to a centralised trunk sewerage system, thereby taking away all of the wastewater that is generated through internal residential uses.

It is estimated that 75% of water used on a lot, flows to the sewer system or septic system.

There are still a few (less than 10%) lots that are still on septic, which has the potential to leak and find its way into the stormwater system, increasing runoff and contributing to drainage related issues.

The fact that the centralised sewer system was introduced, has resulted in a significant improvement to the amount of surface water that flows through the village, due to the reduced seepage that comes from a septic, sometimes not on the property but downstream. The connection to mains sewer is generally considered by residents to be a significant improvement for the village.

17.11 Assumptions and limitations

Due to the unique landscape of Merricks Beach, several assumptions were made to complete the required analysis. It was assumed that lots connected to mains water had a water consumption of 163 L/person/day, however, lots not connected to mains were assumed to have a lower water consumption of 100 L/person/day to reflect occupants having existing smart water usage. Residential lots have an average occupancy of 2.6 persons per household, but due to the nature of the Merricks Beach community being generally smaller, a lower figure of 2.0 persons per household was assumed instead.

A permanent and holiday house use a very different amount of water each year, but there is limited means to understand the percentage of lots that are permanent, and those that are holiday homes. Based on conversation with the working group, it was assumed 20% are occupied permanently throughout the year, and 80% as holiday homes, and for water and stormwater modelling each lot was randomly assigned one of these values. A holiday residency was assumed to be occupied only 45 days a year, primarily covering summer, with an additional period during the mid-year. All runoff from each lot is assumed to converge to the lawful point of discharge, which is then directly connected to either an easement, road or another property (in cases where a non-functioning easement exists).

18 Appendix B: Maps

Seven maps were drafted and saved as A3 images. This series of maps were provided as a separate attachment