



**DRAFT FINAL REPORT**

**ISSUES PAPER:**

City of Greater Dandenong Green Wedge

Water issues and constraints

December 2013

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# Executive Summary

This paper provides a discussion on water related issues associated with the City of Greater Dandenong Green Wedge. The paper is first in a series of water related papers developed to assist in the development of a Management Plan for the City of Greater Dandenong Green Wedge

## Land uses in the City of Greater Dandenong Green Wedge

There are many land uses associated with the City of Greater Dandenong Green Wedge that impact or are dependent on water and water related issues. These land uses include:

- Agriculture
- Flood storage and capacity
- Commercial
- Public utilities and infrastructure
- Rural residential
- Environmental / ecological uses
- Public health (to provide cooling)
- Recreation
- Visual amenity

## Management of the CGD Green Wedge

To date the City of Greater Dandenong Green Wedge has been managed under a broad objective that there will be no change to management unless there is a demonstrable benefit to Dandenong and Greater Melbourne.

However ongoing drivers such as the inherent low lying swampy character of the landscape, ongoing urban development in the catchment and climate change will impact on these land uses. These drivers are likely to result in increased flooding, increased water logging, and increased water quality issues. In the absence of a change in management, negative outcomes for some land uses in and adjoining the Green Wedge will be inevitable. Declines in the condition of infrastructure, agricultural productivity and rural residential living can and should be expected in response to the water related issues and drivers in the region.

As a consequence the conservative management approach that has driven the past management of the CGD Green Wedge (that there be no change unless it has a positive outcome) may no longer be appropriate. Some change in landuse and or management may be necessary and could provide for positive outcomes in the CGD Green Wedge and adjoining lands.

## Opportunities for the CGD Green Wedge

The SE Green Wedge was in part initially identified because of constraints associated with the land. These constraints included the poor drainage and flood susceptibility. However more importantly the Green Wedge was identified and selected because of the opportunity and potential the land presented to Greater Melbourne. The opportunities and potential associated with the CGD Green Wedge still exist and are becoming increasingly important. While the land can be assessed in terms of its constraints that limit development (e.g. flood extent), such an assessment undervalues the Green Wedge and the opportunity and potential that the Green Wedge presents to Greater Melbourne. These opportunities include:

- Ecological outcomes that link and contribute to broader ecological goals, sustainability and liveability
- Public and commercial (e.g. golf courses) recreation venues that provide space, connectivity and opportunity for active and passive recreation

- Agricultural production outcomes (an important outcome in the context of maintaining and support an ‘urban food’ movement and limiting ‘food miles’)
- Provision of utilities to support local and broader Melbourne

### Constraints on future land uses

Future plans for the Green Wedge must be conscious of the following constraints and issues:

Category	Constraint/issues
Physical form	<ul style="list-style-type: none"> <li>• Low lying elevation</li> <li>• Capacity for flood storage</li> <li>• The inherent characteristics of the landscape</li> <li>• Physical form and barriers within drains and waterways</li> <li>• Raised road formation impact on overland stormwater flow paths</li> </ul>
Environmental	<ul style="list-style-type: none"> <li>• Groundwater</li> <li>• Acid sulphate soils</li> </ul>
Green Wedge management	<ul style="list-style-type: none"> <li>• Presence and buffer around Eastern Treatment Plant</li> <li>• Management of existing assets</li> <li>• Land ownership and titles</li> <li>• Public utilities and infrastructure</li> <li>• The use and management of land within the CGD Green Wedge</li> <li>• Long term maintenance and operational costs for raised road formations, retention systems and open drain network</li> </ul>
External forces	<ul style="list-style-type: none"> <li>• Upstream and downstream residents and businesses</li> <li>• Cultural Heritage</li> <li>• Climate change</li> <li>• The connectivity of green links</li> <li>• Ongoing urban development within the catchment (i.e. upstream and downstream of the CGD Green Wedge).</li> <li>• State government policy</li> </ul>

### Next steps

Further work is now required to:

1. Identify and address gaps in the knowledge of the CGD Green Wedge and
2. Explore alternate management trajectories to identify a preferred management of the water related uses and issues in the CGD Green Wedge.

These will be the subject of subsequent papers on water related issues in the CGD Green Wedge.

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# 1 Introduction

This paper provides a preliminary discussion on existing and emerging water related issues in the South East Green Wedge within the City of Greater Dandenong (CGD Green Wedge) and its associated catchments.

The paper has been prepared by Alluvium Consulting Australia (Alluvium) for the City of Greater Dandenong (CGD) and Planisphere, as an input into the development of CGD's broader Green Wedge Management Plan.

This paper is the first of a series of related papers developed by Alluvium on water related matters associated with the CGD Green Wedge. These papers are set out below

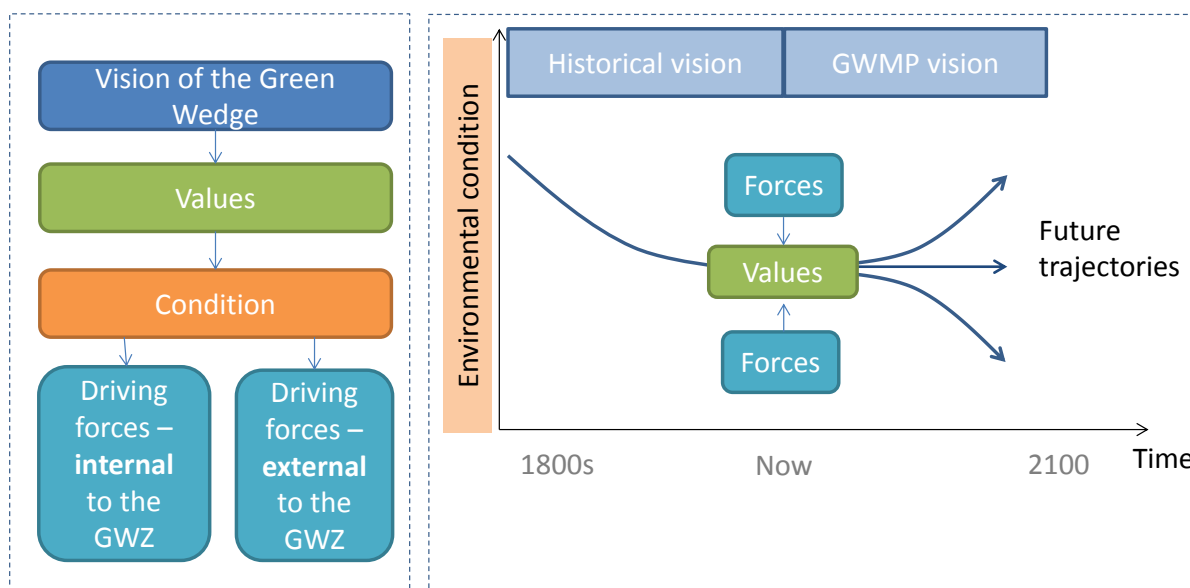
1. Issues discussion paper (this paper)
2. Gap analysis
3. Trajectories development

This paper is based on the following background materials and references:

- The Green Wedge Review Report (Planisphere, 2013)
- Summary of consultation (Planisphere, 2013)
- Site visit to the Green Wedge with CGD (25<sup>th</sup> September 2013)
- Draft report: Integrated Water and Pollutant Balance (2013)
- Healthy Waterways Strategy (Melbourne Water, 2012).

The figure below outlines how the paper links the larger water issues in the catchment, with the condition of the waterways and the land, and how a variety of forces are influencing the future trajectory of the green wedge and in particular the water related issues.

The issues paper stretches across a number of themes including the vision, the land uses, the condition and the driving forces of change.



**Figure 1.** Conceptual diagram through which water issues are presented.

## 2 Background

Green Wedges are the non urban areas of metropolitan Melbourne outside the Urban Growth Boundary. They are a legacy of the visions and planning decisions of the past, having first been proposed in the planning strategies in the 1960's (Planisphere 2013).

The CGD Green Wedge forms a component of the larger South East Green Wedge (SEGW) which extends from the City of Kingston through to Cranbourne South in the City of Casey. The location of the SEGW and the City of Greater Dandenong is shown in Figure 2.

The CGD Green Wedge has significant water related issues, constraints and opportunities. The CGD Green Wedge is low lying and contains some remnants of the Carrum Carrum Swamp. The swamp provided sustenance to indigenous communities and habitat for water birds, fish, and mammals. Much of the Carrum Carrum Swamp was drained in 1879 as part of a wider program of land drainage across Victoria. Similar to elsewhere across Victoria, these drainage works were undertaken to improve transport links and to enable the development of land for agricultural purposes. Other similar swamp drainage projects across Victoria included the draining of the Elwood Swamp, the Moe Swamp, the Greta Swamp, and the Koo Wee Rup Swamp. The drainage of the Carrum Carrum Swamp included the excavation of the Patterson Cut and other drainage works. The Patterson Cut was initially installed to prevent flood waters from Eumemmering Creek discharging into the Carrum Carrum Swamp.

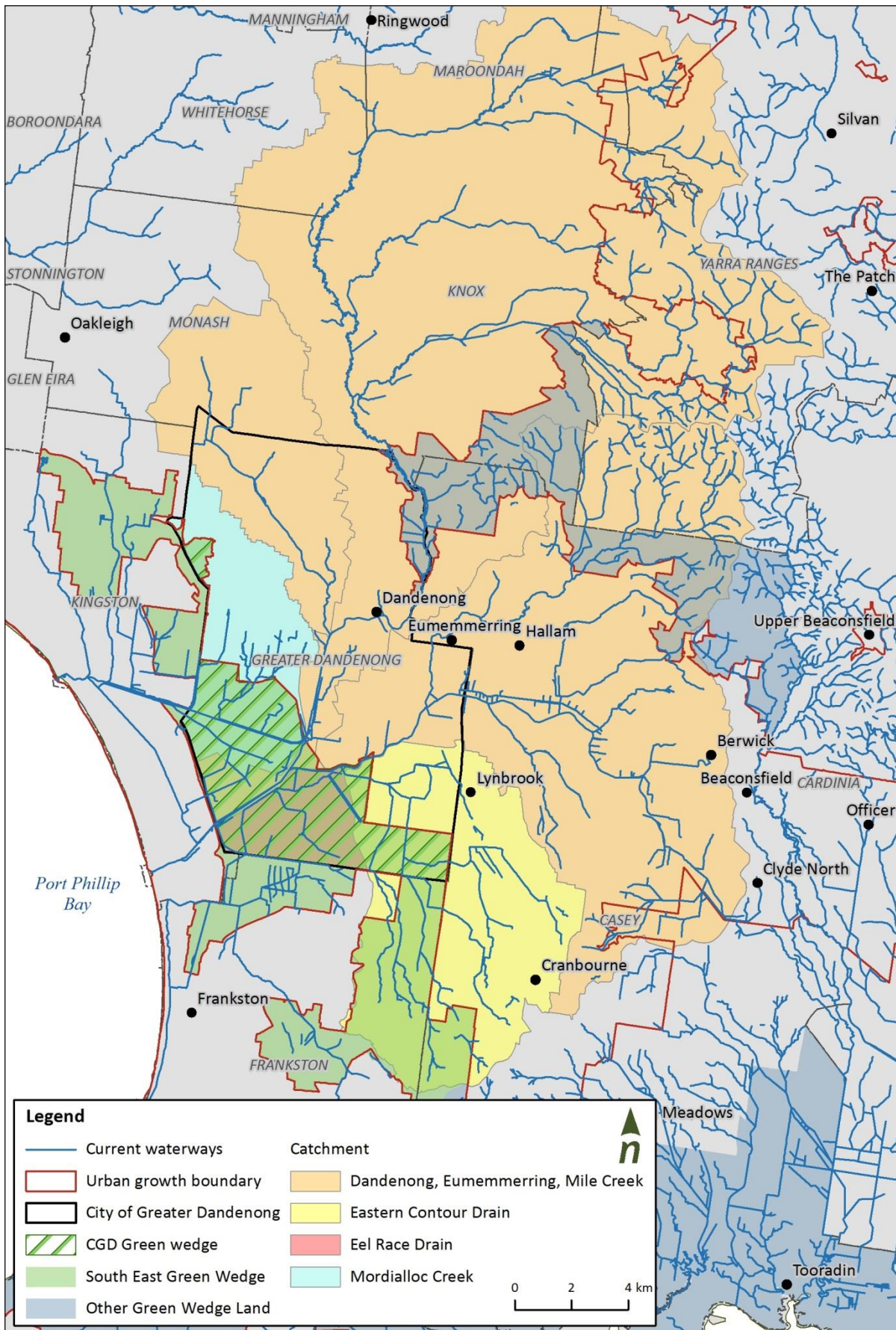
The focus of this paper is on the southern part of the Green Wedge, by far the larger area of the CGD Green Wedge.

Despite the original and subsequent drainage and flood mitigation works, the CGD Green Wedge continues to have drainage and flooding issues, while also containing significant remnant ecological values. These issues and values are consistent with the low relief, low elevation and swampy character of the landscape, and were recently highlighted in the outcomes of the consultation process conducted as a component of the development of the CGD Green Wedge Master Plan (Planisphere 2013).

The consultation process revealed that residents would like to see the waterway and other environmental values of the Greater Dandenong Green Wedge preserved if not enhanced. There were also some submissions from landholders seeking the rezoning of land to enable development.

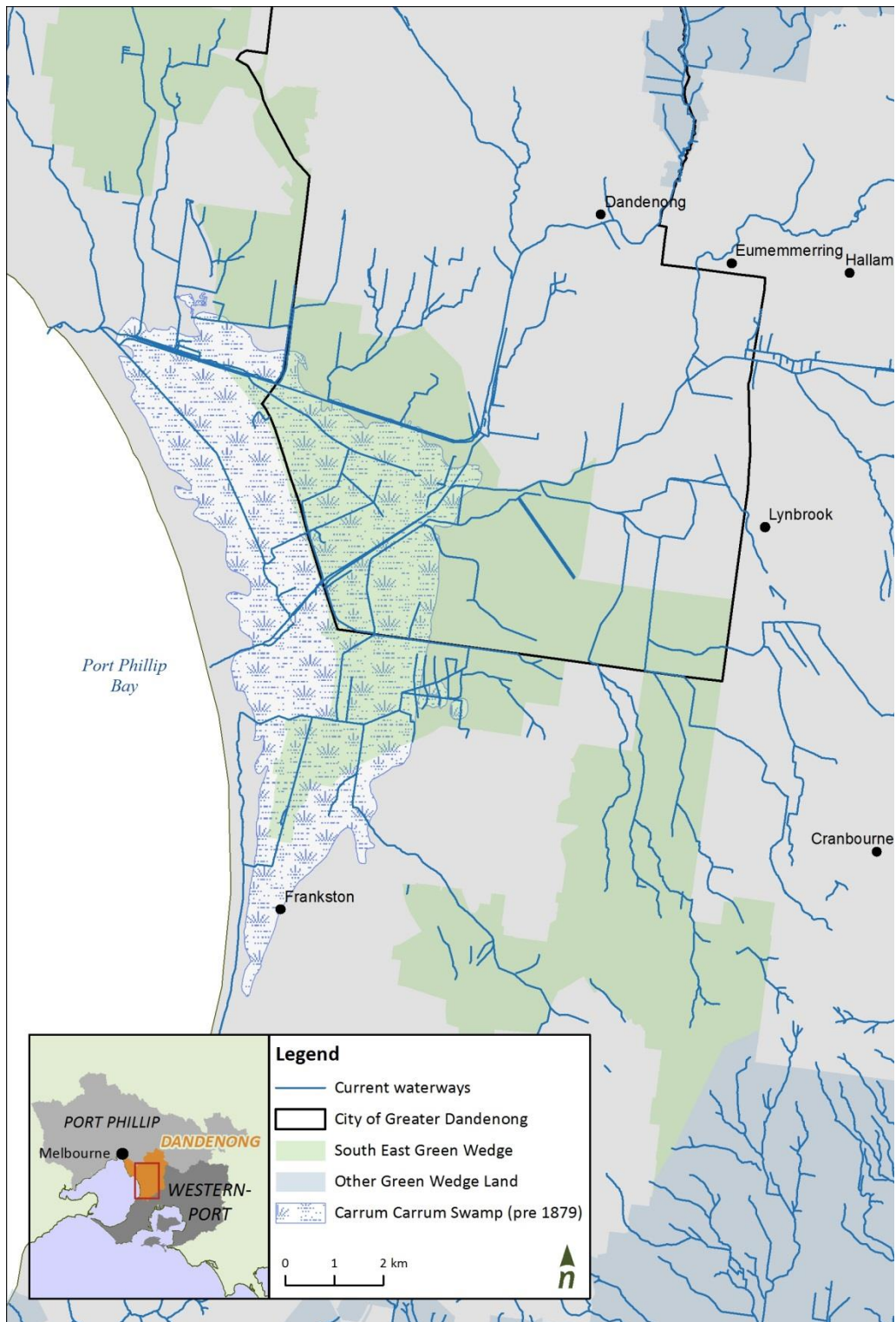
The issues and water related land uses of the CGD Green Wedge are not only a function of the past land management and character of the CGD Green Wedge, they are also a function of upstream and adjoining land management within the City of Greater Dandenong and beyond. The CGD Green Wedge receives runoff, either directly or indirectly, from the Cities of Yarra Ranges, Maroondah, Whitehorse, Monash, Knox, Kingston (very minor), Frankston and Casey, and flows from the CGD Green Wedge discharge into the City of Kingston and to a minor extent the City of Frankston. Flooding and drainage issues are a function of both the landscape within the CGD Green Wedge and ongoing urban development within the whole of catchment (not just within CGD). Similarly the ecological role of the CGD Green Wedge is a function of the swampy character of the land and the connection of the CGD Green Wedge to adjoining regions (to the north east Dandenong Valley, the west, Port Phillip Bay, the south Mornington Peninsula and Western Port). As a consequence, any decline in ecological condition, or fragmentation of the CGD Green Wedge will affect the overall connectivity of the green space through the Port Phillip and Westernport catchments (refer Figure 2 and Attachment A). Similarly any improvement in the ecological condition of the CGD Green Wedge would contribute to broader improvements in the green space and ecological outcomes through the Port Phillip and Westernport catchments.





**Figure 2.** Location of the South East Green Wedge and current waterways





**Figure 3.** Approximate extent of the former Carrum Carrum Swamp (Source: DSE geospatial layer on pre-European wetlands)

### 3 Land use and issue identification

The CGD has inherent land use values including agriculture production, commercial uses, and ecological uses. However importantly the CGD Green Wedge contributes to the uses associated with a wider network of green space in Melbourne. This CGD Green Wedge and the wider network of connected green space provides for public utilities, recreation, and ecological outcomes that will be increasingly required and desired within a developing Greater Melbourne. The CGD Green Wedge also provides for important flood storage and capacity for its flood prone catchments.

However with more infill development and increasing population in the catchment there will be change. This change will lead to increased and poorer quality runoff to the CGD Green Wedge. The issues will be compounded and confounded by climate change and the ongoing management of the drainage network. The SE Green Wedge and the CGD Green Wedge provide a buffer to 'soak up' these impacts.

The land uses and related issues discussed in this paper have been identified based on four main sources:

- The Green Wedge Management Plan – Review Report (Planisphere 2013)
- The Green Wedge Management Plan – issues and opportunities consultation report (Planisphere 2013)
- Discussions with the City of Greater Dandenong
- Our experience in working with waterways and catchments in the greater Melbourne region

These sources provide a basis to outline the land uses impacted by water. For the purpose of this paper we have assumed that there will be no substantive change in the management and landuse within the Green Wedge. In this respect we have identified and reviewed the impacts on land uses associated with maintaining current land and water management. We have not assessed the impact of increased urban development within the CGD Green Wedge on the ecological uses and outcomes in the CGD Green Wedge.

#### 3.1 The status quo

While this paper has been prepared based on an assumption that there is no substantive change to zoning and management in the Green Wedge, the current trajectory of the Green Wedge is that the landscape will change anyway. These changes are driven through natural processes and the current level of service that road and drainage assets are receiving. This means that with the current level of road and drainage maintenance (as identified through the consultation process in July 2013), the region will slowly revert back to its former natural swampy environment. This process may take decades to centuries, depending on the level of maintenance and repair applied to existing infrastructure.

The purpose of this paper is to identify the existing land uses in the Green Wedge and the nature and extent of change that will occur in the absence of a change in management. We have used an assessment, based on existing landuse, to explore the validity of the '*do nothing*' scenario prior to undertaking an exploration of alternate options for management. This '*do nothing*' or '*existing management*' scenario is consistent with a principle that has driven past management of the CGD Green Wedge i.e. *that there be no change to the function and use of the Green Wedge unless there is a demonstrable positive outcome for the City of Greater Dandenong, and Greater Melbourne. (Pers comm.)*

#### 3.2 Land uses dependent on the Green Wedge

Based on our review of available information, we have identified the following land uses within the CGD Green Wedge, that are dependent on or impacted by, water:

- Agriculture
- Commercial uses

- Public utilities and infrastructure
  - Transport networks such as roads including Eastlink
  - The Eastern Treatment Plant and its associated buffer area
  - Gas mains
  - Electricity mains
  - Local drainage and associated infrastructure
- Rural residential living
- Environmental / ecological uses including water dependent species and ecosystems such as red gum, waterbirds, amphibians, reptiles
- Public health (to provide cooling)
- Recreation
- Visual amenity

### 3.3 Beyond the Green Wedge

In addition there are land uses outside the CGD Green Wedge that are impacted by or dependent on current water management within the CGD Green Wedge. These include:

- The ecological use and visual amenity of the broader SE Green Wedge
- The ecological use and visual amenity of adjoining land units including the Dandenong Valley, Port Phillip Bay, Edithvale and Seaford Wetlands, the Dandenong Ranges and Westernport.
- Infrastructure, and residential and commercial land use downstream of the CGD Green Wedge that are dependent on the flood storage and detention capacity of the CGD Green Wedge
- The surrounding urban environment (potentially Dandenong CBD) that is cooled by evaporation and evapotranspiration within the CGD Green Wedge. The CGD Green Wedge is vegetated and contains a large volume of surface and subsurface water. The surface and subsurface water will be subject to both evaporation and evapotranspiration and can cool the lower atmosphere and can have some influence on temperatures in the surrounding built up environments. There are no studies that we are aware of that quantify or verify the extent of such cooling in the Dandenong Region. However, cooling effects are generally localised. As a general rule, the cooling effect of a park or green area tends to extend outside the green area to a distance that is equivalent to half the green area's width, this can be highly variable and depends on vegetation cover in the park, irrigation (extent and frequency) and the nature of the surrounding built environment.

The location and extent of these connected land units are shown in Attachment A.

### 3.4 Water elements

For the purpose of this paper we have sought to identify the components of water that have the potential to impact on the above land uses. More specifically we have sought to identify whether changes to these components have a positive or negative impact on these existing uses. The components can be largely distilled to the location, duration, variability and timing of surface and groundwater, quantity and quality. The components are:

- Surface water and groundwater
  - Quantity (hydrology and hydraulics) including the timing duration and location of:

- Flood events (refer below)
    - Pondage and drainage of water as a result of summer and winter rainfall events (freshes)
  - Quality
- Treatment and supply
  - Eastern Treatment Plant
  - Supply of Class A water to surrounding industries and users

### **Flooding and flood extents**

One such element of water is the flood regime. The management of floods (mapping, mitigation, warning, maintenance of assets etc) is a major issue for the City of Greater Dandenong. Various CGD projects are currently in progress (and some completed) to develop and understanding of the nature and extent of flood issues in this region. Alluvium is aware that there is a Draft Flood Management Plan for the City of Greater Dandenong, which covers the CGD local government area. Hotspots, where land owners have reported flood related issues, were identified as a part of the development of that Draft Plan. The Keys Road area and the Soden, McMahan and Riverend Road precinct were identified among several areas in the municipality that are particularly prone to flooding. The location of these hotspots provides useful insights into community and land owner issues regarding floods and flooding within the CGD Green Wedge.

Alluvium (2013) brought together past flood studies and flood mapping for the CGD into a single spatial layer. While the studies and subsequent mapping do not cover the entire CGD area, they can be used to assist and guide planning.

The flood studies included in the single spatial layer comprised:

- Mile Creek flood study
- Dandenong Creek flood study
- Edithvale Flood Study
- Available flood mapping from Melbourne Water

One of the common items of discussion around flooding is the lack of certainty in the extent of the flood mapping in the southern part of the region, covering the CGD Green Wedge. In this respect we are concerned that the flood extent is not accurately mapped in the Green Wedge, and would caution against any decisions made purely on existing data. It is possible that the extent of flooding is greater than that currently presented through the overlays and mapping. In addition, climate change and associated increases in peak runoff and rise in sea level will increase the extent of inundation and the level of impact from that shown in the mapping.

### **Water consumption, drainage and impervious**

Alluvium (2013) reviewed the current consumption of potable water, recycled water, and the generation of stormwater and pollutants. The table below presents the results for the Green Wedge.

**Table 1. Integrated water and pollutant balance results for current condition in Green Wedge**

<b>Attribute</b>	<b>Value</b>
Total area (southern portion of Green Wedge only)	3640 ha
Impervious area (roads and roofs)	56 ha
Number of dwellings connected to South East Water's distribution network (2012 data based on suburb boundaries Lyndhurst and Bangholme )	140
Average annual potable consumption (MI / year)	93

Average annual recycled water consumed (ML / year)	14,400 (on site at ETP)
Sewage generation (ML / year)	70
Number of septic tanks	250
Sewage treated at ETP	Minimal
Average annual Total Nitrogen load	12.9 tonnes
Average annual Total Phosphorous load	1.7 tonnes
Average annual Total Suspended Sediment (TSS) load	454 tonnes
Baseflow (water that travels to the creek from pervious areas ML / year)	6600

The results of the water balance demonstrate that within the Green Wedge the potable consumption (93 ML/year) is significantly less than the local runoff entering waterways (6,600 ML/year). It also highlights that the volume of recycled water consumed at the ETP (14,400 ML) exceeds any volumes of runoff or potable demand.

The tonnes of nitrogen, phosphorous and total suspended sediment relates to the flow of particulates and nutrients that flow in storm events from two sources. The two sources are the impervious surfaces in the region (essentially the local roads), and the agricultural areas. An increase in development triggers an increase in the flow of these nutrients to waterways, that have an influence on the health of local waterways and Port Phillip Bay.

The quantum of loads is quite low in a whole of catchment sense, as the whole of CGD generates in the order of 119 tonnes of Nitrogen, 16 tonnes of Phosphorous, 6900 tonnes of TSS.

## 4 Issues and constraints

Based on the history of the region, the current management approach of 'no change', and the land uses listed above, a range of issues and constraints have been identified that impact on future management of the CGD Green Wedge.

The term 'constraint' refers to a physical or institutional limitation of the Green Wedge that will affect the water system or the land uses that water influences, either now or into the future.

The term 'issue' refers to a range of topics that are relevant for the Green Wedge and that will affect the water system or the land use that water influences, either now or into the future.

### 4.1 Constraints

The system constraints include both natural and man-made influences.

**Natural constraints**      **Low lying elevation:** The CGD Green Wedge is a low point in the catchment (refer Figure 4). The area has in the past and will increasingly be subject to floods. The lowest lying parts of the CGD Green Wedge have poor drainage with implications for stormwater and wastewater management. Any additional infrastructure such as tanks and pumps required to store and remove stormwater and wastewater will add to the cost of water management in the region and be passed on to land users or the community in one form or another. The low lying terrain also has implications for new and existing roads which need to be constructed on a raised rural road type formation.

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**Groundwater:** The close proximity of the water table (which is the top of groundwater) is a constraint in the way the land form is altered, both now and into the future. The proximity of groundwater to the land surface has implications for road construction, building foundations, and most land uses.

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**Acid Sulphate Soils.** The soil profile of the region identifies that in some areas there is a risk of mobilising acid sulphate soils. These are naturally forming soils, that if drained, result in a mobilisation of acids into the subsurface and waterways. This has significant implications for both the waterways and habitat, and for foundations and the infrastructure. Exposing acid sulphate soils to the atmosphere (oxygen) can initiate release of acid generating material.

Acid sulphate produced by acid sulphate soils can corrode concrete, iron, steel and certain aluminium alloys. It prevents plants growing in affected areas. In waterways, the impacts of sulphuric acid, derived from acid sulphate soils, are extensive, including fish kills, stunted growth or death of aquatic vegetation and sedentary organisms and an increase in mosquitoes.

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**Combination of natural and man-made constraints**      **Capacity for flood storage:** While the area is known to flood, there is a constraint in the capacity (or volume) available for flood retarding within the current system. It is for these reasons that Melbourne Water has and continues to engage with local land owners. Melbourne Water has proposed the placement of retarding basins within the CGD Green Wedge to manage inflows to the Green Wedge and limit the impacts of upstream development on downstream communities and stakeholders.

Flooding in the area is likely to be exacerbated by increasing volumes of stormwater runoff associated with increasing urban development in the catchment and predicted impacts of climate change.

Man-made constraints

**Upstream and downstream residents and businesses:** Any changes to the system may impact on the downstream areas of Kingston and Frankston and the upstream areas within CGD. The residents and businesses of these regions would no doubt be interested in any changes to the nature of flood and water management in the SEGW.

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**Public utilities and infrastructure:** The presence of transport networks like Eastlink and other large utility trunk supplies (gas and electricity) are a constraint in particular areas of the SEGW. These pieces of infrastructure typically have planning constraints that limit activities within nominated proximity to the subject infrastructure. The provision of public utilities such as sewer, power, telecommunications and others will be constrained by the low lying terrain and high groundwater levels. It is probable that wider raised road formations will be required to accommodate the provision of such services.

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**Management of existing assets:** The presence and use of a range of roads and drains are a constraint to the extent that they restrict flows, and require regular repair and maintenance.

The combination of low lying elevation and high groundwater levels will require roads to be constructed on raised rural road type formation, to ensure the protection of road pavements from high water tables. Existing roads such as Pillars Road, McMahrens Road, Keys Road and Riverend Road suffer from high maintenance and repair costs due to the road pavements being subject to both water logging and flood inundation. Such roads will require reconstruction as a raised rural road formation to protect the road pavement from water damage. An elevated road network will also create a need for additional drainage works. The existing outfall downstream of the CGD Green Wedge is limited in capacity and grade.

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**Cultural Heritage:** In a similar manner to public utilities and infrastructure, there is a constraint in modifying particular areas of the Green Wedge for the purposes of water management where there are known cultural heritage issues. Refer to the Cultural Heritage Review for further information on this constraint.

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**Presence and buffer around Eastern Treatment Plant:** Eastern Treatment Plant has regional significance in managing the wastewater from almost half of greater Melbourne. The buffer around the ETP is a constraint in the uses of the land.

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**Land ownership and titles:** Representatives of Melbourne Water have indicated that there are some properties (near Worsley Driver in Bangholme) within the CGD Green Wedge that are impacted by changes in flooding regimes. Representatives of Melbourne Water have also indicated that the land use constraints are recorded on the land titles of the subject land and that the subject landholders have been compensated for such impacts. The large percentage of land that is privately owned is also a constraint in the future use of the region.

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The low lying area of the CGD Green Wedge is shown in Figure 4. The blue and dark green areas represent ponded areas which store flood waters when the channel capacity is exceeded. The blue, green and yellow areas represent the former Carrum Carrum Swamp area prior to its draining in 1879.



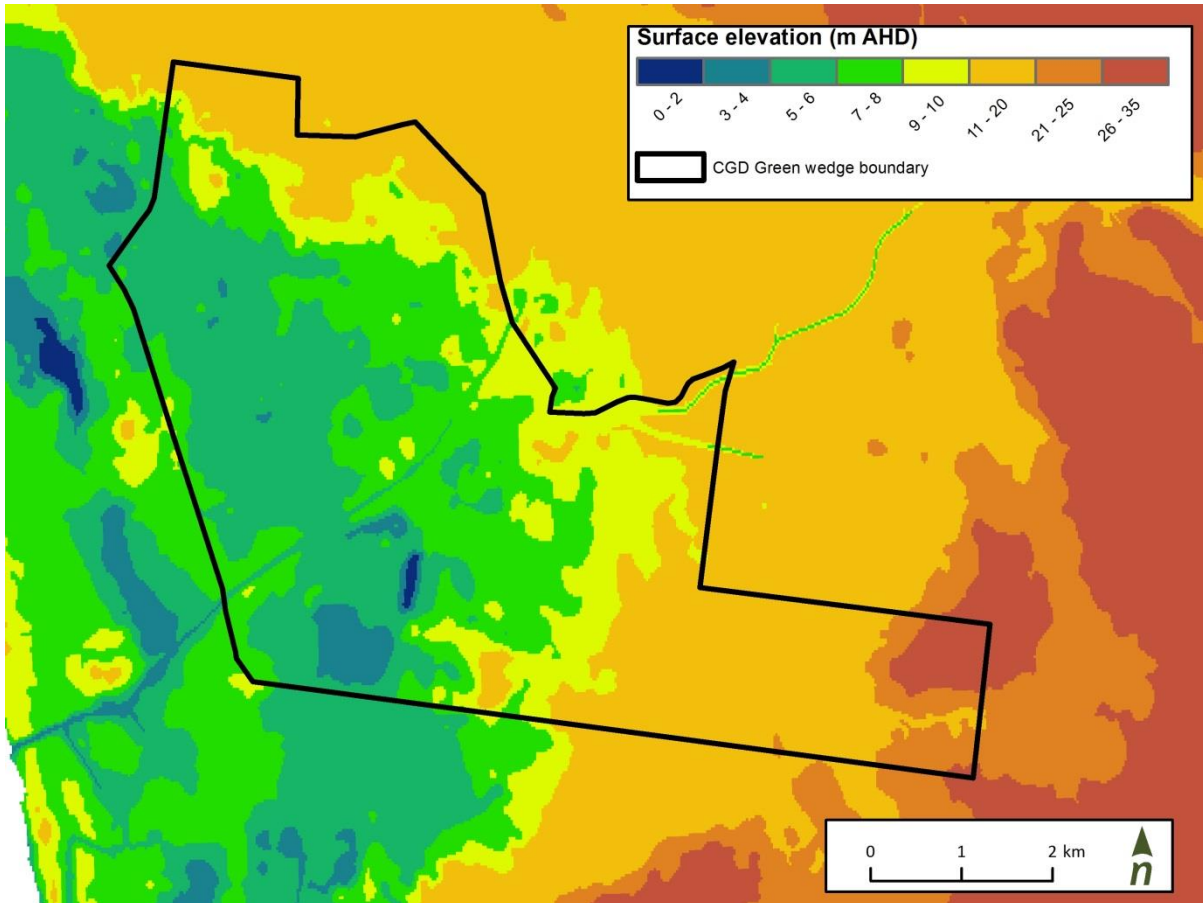


Figure 4. Elevation across the Green Wedge.

## 4.2 Issues and driving forces

There are a number of issues and driving forces that will influence surface and groundwater quality and quantity and impact on the land uses of the CGD Green Wedge. These include

- The inherent characteristics of the landscape:** Including the soils, topography and climate. These characteristics will result in an ongoing process of water and sediment delivery to the CGD Green Wedge that are largely independent of other driving forces. In the absence of ongoing management (drainage maintenance, levee maintenance) these forces will result in the reformation of the Carrum Carrum Swamp, with a resultant improvement in ecological outcomes, but a decline in residential, agricultural and commercial land use.
- Climate change:** Climate change will lead to increased severity of drought, increased peak flood events and increased sea level and associated storm surges. Together these will have an adverse outcome for most residential, agricultural and commercial landuses in the CGD Green Wedge. The increased drought will result in a decline in ecological use for water dependent ecosystems.
- The use and management of land within the CGD Green Wedge:** Land management activities within the Green Wedge impact on these issues and land use values. Drainage work within the CGD Green Wedge has the potential to maintain and improve rural residential land use, agricultural landuse and commercial landuse. However drainage works will have a net adverse impact on the ecological outcomes for the CGD Green Wedge and have the potential to impact on the ecological and visual amenity outcomes sought for adjoining areas of land. Drainage works will be costly, potentially ineffective if the groundwater levels are near the surface, and are potentially problematic if they cut through acid sulphate soils. Improved drainage of the land could be difficult requiring coordination among the many private landholders and stakeholders with often conflicting land use and drivers.

- **The connectivity of green links:** Development has encroached into the Green Wedge in the Dandenong South area. Such development has a direct impact on the particular lots and an indirect influence beyond the immediate edge of the development. This broader influence is referred to as an 'edge effect'. Further development within the Green Wedge has potential to further expand the edge effects, to the point where the edge effects start to meet and as a consequence disproportionately decrease the (or result in the loss of) land use values of the Green Wedge.
- **Physical form and barriers within drains and waterways:** The watercourses of the CGD Green Wedge including the drainage network provide a potential corridor for wildlife (fish, mammals, birds, reptiles and amphibians) connectivity. The watercourses are currently in poor to moderate condition and limit such connectivity. The connectivity is constrained by barriers such as weirs, poor riparian vegetation and the absence of suitable in-stream habitat. Ongoing drainage work continues to diminish and constrain the condition. The connection of the waterways would be further impacted if raised roads and additional drainage infrastructure are implemented in the future.
- **Ongoing urban development within the catchment (i.e. upstream and downstream of the CGD Green Wedge).** Ongoing development within the catchment will result in
  - Increased runoff and increased peakiness of runoff delivered to the CGD Green Wedge
  - Reduced water quality delivered to the CGD Green Wedge
- **State government policy:** the current state government policy direction is a significant piece of policy that could have an influence for the management of the green wedge. *Plan Melbourne* is the government's vision for Greater Melbourne to 2050 and is currently open for consultation. *Melbourne's Water Future* presents the future direction for water management in Greater Melbourne which is run through the relatively new Office of Living Victoria. These policies are important as they focus on the smarter use of water resources, and advocate for a more integrated approach to water management. Expanded urban development in the catchment, with more imported water, more drainage, more wastewater generation, more energy consumed, and more impacts on the whole of the system, is unlikely to align with these state government policies.

## 5 Future trajectories

The water dependant and water impacted land uses of the Green Wedge are changing in response to the issues and driving forces outlined above. While ongoing levels of maintenance and management will assist to limit and forestall change, we expect that changes to the land uses and related values will be inevitable. The degree to which the changes are positive or negative will depend on perspectives. For the purpose of this discussion we have identified the likely trajectory for selected land uses associated with the issues and driving forces outlined above. We have included a qualitative statement on whether such change will be a positive or negative outcome for the each use.

Some examples of the likely trajectory of changes to the CGD Green Wedge and for adjoining land are discussed below.

### 5.1 Increased urban development in the catchment, increasing runoff to the CGD Green Wedge reducing agricultural productivity, and rural residential amenity

There is strong evidence of existing water ponding problems in the CGD Green Wedge. These problems were identified and highlighted through the community consultation process (Planisphere 2013) and through more recent investigations into drainage issues in the CGD Green Wedge (TGM, 2013 and Alluvium 2013). The location of these existing issues is shown in Attachment B.

Melbourne's population is expected to grow from approximately 4 million to 6 million people by 2050 (Victorian Government, 2013). It is proposed that this population growth is permanently contained within a boundary around Melbourne and a selection of satellite regional centres. The increased population will result in increased development within the catchments draining to the CGD Green Wedge. This increased development will result in increased volume of runoff to the CGD Green Wedge and a reduction in the quality of runoff to the CGD Green Wedge. While some effort can be applied within the new development to reduce the impact of such development, not all impacts can be avoided. Best Practice urban development design and construction (EPA, 1999), provides for controls on changes to stream flow and sediment and nutrient loads. However some residual increase in runoff and reduction in water quality can and should be expected within the CGD Green Wedge. A recent study estimated that annual stormwater volumes could increase by 70%, total suspended sediments by 69% and total nitrogen by 50% (2013) (Alluvium, 2013).

As a consequence we would expect

- Ongoing (and increased rate of) decline in transport infrastructure (roads), including deterioration due to increased exposure to high water tables
- Reduced rural / residential amenity , associated with nuisance inundation
- Reduced agricultural production associated with nuisance inundation
- Potentially increased ecological outcomes for frogs, wetland vegetation and water birds associated with increased inundation, but decreasing outcomes associated with contamination of such water

### 5.2 Climate change, increasing the length of drought reducing the health of red gum communities

The above impacts are likely to be compounded and confounded by the impacts of climate change. Climate change is forecast to result in an up to a 7.5% reduction in mean annual rainfall, but an increase in extreme events and especially floods. While such changes would exacerbate the above flooding and drainage issues, climate change is likely to have an adverse impact on the health of red gum communities. In addition, climate change is likely to increase sea levels and storm surges, potentially impacting on groundwater levels.

### **5.3 Drainage work reducing the pondage of water and reducing habitat for water dependent birds**

The continuation of existing drainage maintenance works, can assist to reduce impacts and maintain the condition of infrastructure and landuse (agricultural, residential, commercial). However such drainage work has a significant adverse impact on existing and potential ecological outcomes within and adjoining the CGD Green Wedge. These impacts include:

- Decline in existing water dependent ecosystems and species within the Green Wedge
- Decline in water dependent ecosystems within adjoining and connected units
- Potential exposure of acid sulphate soils and contamination of water, wetlands and watercourses.

### **5.4 Decline in recreation associated with declining water quality arising from existing and proposed upstream urban development**

One example of existing water quality problems are algal blooms in the Patterson River that impact on the recreation uses of the National Water Sports Centre. It is likely that these problems will be exacerbated as a result of the increasing urban development within the catchment.

## **6 Commentary**

As outlined above, there are likely to be adverse outcomes for some land uses associated with a continuation of existing management within the CGD Green Wedge. These changes are a function of the swampy character of the CGD Green Wedge, ongoing development within the catchment and other factors such as climate change. Declines in the condition of infrastructure, agricultural production and rural residential living amenity can and should be expected in response to the issues and drivers in the region.

As a consequence the management principle that has driven the past management of the CGD Green Wedge (that there be no change unless it has a positive outcome) may no longer be appropriate. Some change in landuse and or management may be necessary and could provide for positive outcomes in the CGD Green Wedge and adjoining lands.

The SE Green Wedge was in part identified because of constraints associated with the land. However more importantly the Green Wedge was identified and selected because of the opportunity and potential the land presented to Greater Melbourne. The opportunities and potential associated with the CGD Green Wedge still exist and are becoming increasingly important. While the land can be assessed in terms of its constraints that limit development (e.g. flood extent), such an assessment undervalues the Green Wedge and the opportunity and potential that the Green Wedge presents to Greater Melbourne. These opportunities include:

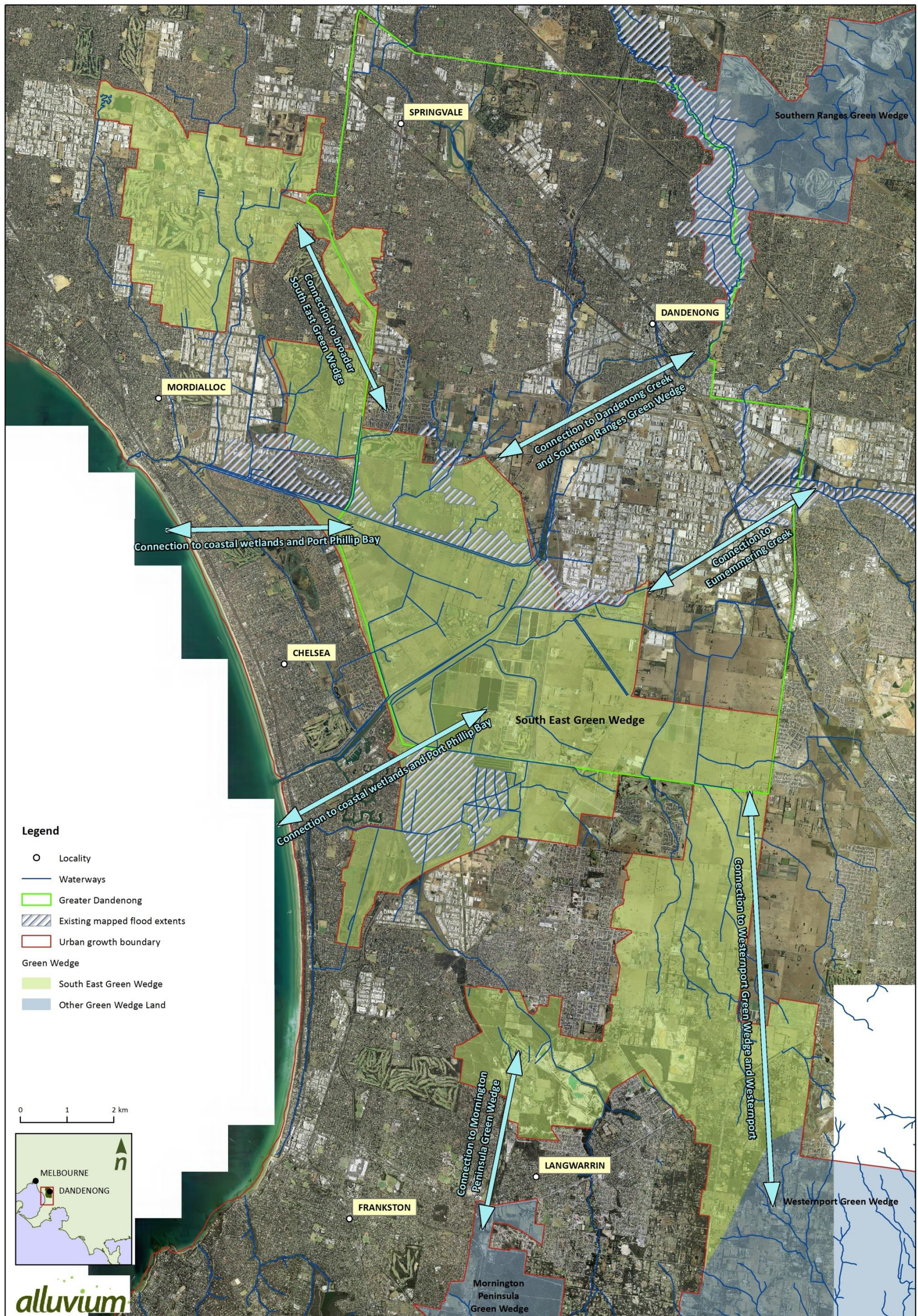
- Ecological outcomes that link and contribute to broader ecological goals, sustainability and liveability
- Public and commercial recreation venues and facilities that provide space, connectivity and opportunity for active and passive recreation. These could include golf courses, walking, cycling and horse riding trails, sporting ovals and parklands.
- Agricultural production outcomes (an important outcome in the context of maintaining and support an 'urban food' movement and limiting 'food miles')
- Provision of utilities to support local and greater Melbourne

## 7 Next steps

From this point it is proposed the following steps are undertaken:

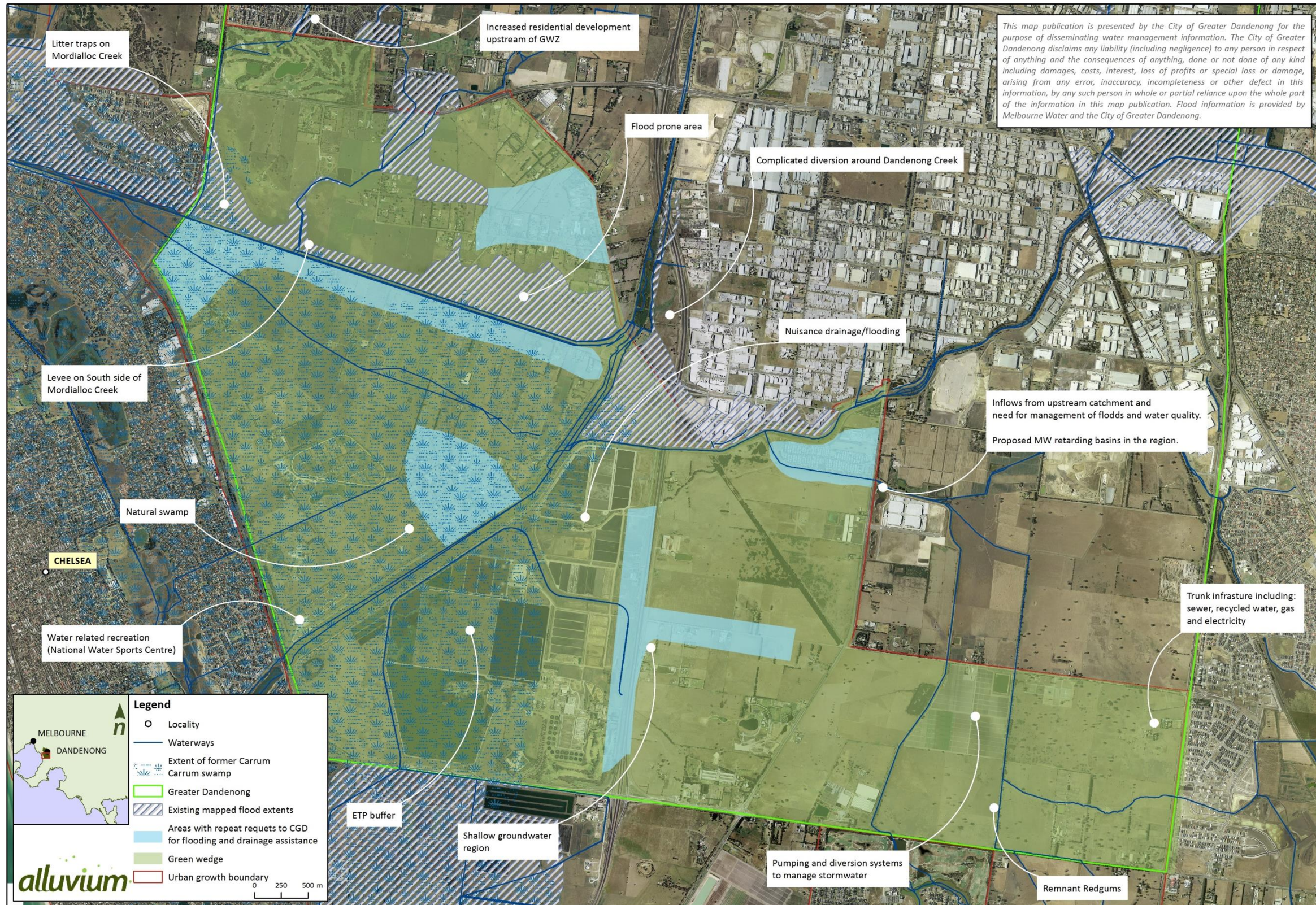
- Engagement with key stakeholders such as Melbourne Water and the Department of Transport, Planning and Local Infrastructure and teams from within CGD
- Documentation of gaps in information
- Development of options of how to manage water in a range of future trajectories or policy options
- Review and consultation with CGD and agreement on a preferred trajectory and water management approach.







## Attachment B – Local issues







**DRAFT FINAL REPORT**

**GAP ANALYSIS:**

City of Greater Dandenong Green Wedge

Gap Analysis

December 2013

## Document history

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<b>4</b>	<b>Conclusion</b>	<b>13</b>
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# 1 Introduction

This paper provides a gap analysis of information relating to existing and emerging water related issues in the South East Green Wedge within the City of Greater Dandenong (CGD Green Wedge) and its associated catchments.

The paper has been prepared by Alluvium Consulting Australia (Alluvium) for the City of Greater Dandenong (CGD) and Planisphere, as an input into the development of CGD's broader Green Wedge Management Plan.

This paper is the second of a series of related papers being developed by Alluvium on water related matters associated with the CGD Green Wedge. These papers are set out below

1. Issues discussion paper
2. Gap analysis (this paper)
3. Trajectory development

The purpose of the gap analysis is to identify any issues or values for which we do not have sufficient information to assist later stages of the project. Once identified, these information gaps may be addressed or noted as a limitation to the project.

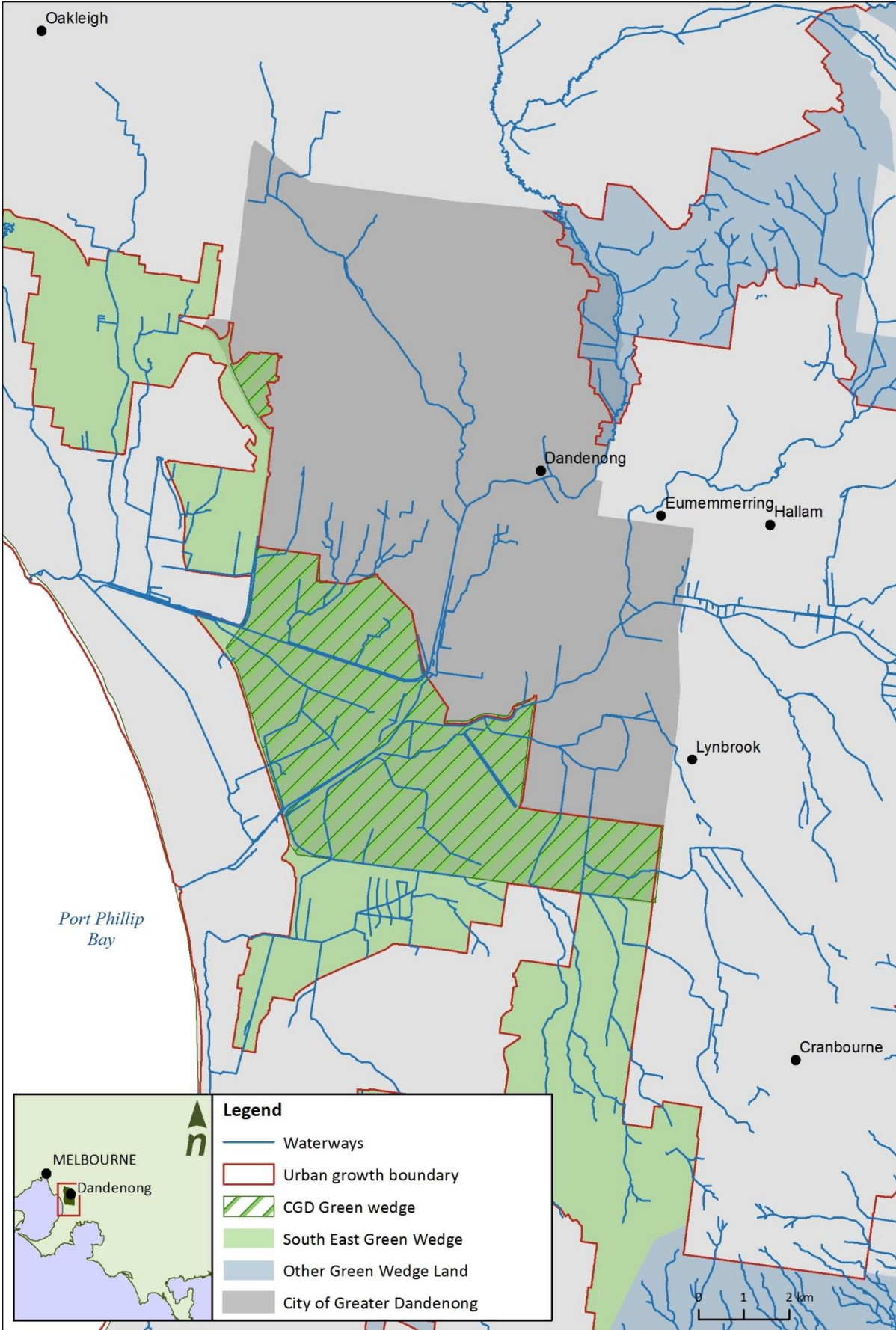
## 2 Background

Green Wedges are the non urban areas of metropolitan Melbourne outside the Urban Growth Boundary. They are a legacy of the visions and planning decisions of the past, having first been proposed in the planning strategies in the 1960s (Planisphere 2013).

The CGD Green Wedge forms a component of the larger South East Green Wedge (SEGW) which extends from the City of Kingston through to Cranbourne South in the City of Casey. The location of the SEGW and the City of Greater Dandenong is shown in Figure 1.

The CGD Green Wedge has significant water related issues, constraints and opportunities. The SEGW is low lying and contains some remnants of the Carrum Carrum Swamp. The swamp provided sustenance to indigenous communities and habitat for water birds, fish, and mammals. Much of the Carrum Carrum Swamp was drained in 1879 as part of a wider program of land drainage across Victoria. Similar to elsewhere across Victoria, these drainage works were undertaken to improve transport links and to enable the development of land for agricultural purposes. A more comprehensive discussion of the CGD Green Wedge background, values, issues and constraints is provided in the *South East Green Wedge – Water issues and constraints* document (Alluvium 2013).

In compiling this gap analysis, Alluvium met with representatives from Melbourne Water, City of Greater Dandenong and the Department of Transport, Planning and Local Infrastructure and reviewed a number of strategies, plans, databases, assessments and studies that relate to the CGD Green Wedge. Information gathered during the meetings and literature review was collated, summarised and any missing information identified.



**Figure 1.** Location of the South East Green Wedge

### 3 Gap analysis

This gap analysis builds on the “Water issues and constraints” paper (Alluvium 2013) and is based on a review of the available data and other information relating to water issues in the CGD Green Wedge. The issues paper identified what we do know about the CGD Green Wedge, while the gap analysis identifies what information we don’t have that could constrain the level of detail considered in the development of future management options and associated trajectories for the CGD Green Wedge.

The purpose of this gap analysis is to be clear on what evidence or data is lacking for the completion of the next phase of the project: the development of future visions.

Some information regarded as a gap may exist but was not available at the time of the analysis. The table below provides a summary of the information and data that is relevant to water issues in the CGD Green Wedge that was available to Alluvium at the time of the analysis.

The gaps listed in this paper are not necessarily required to be filled with further studies.

**Table 1. Summary of available information and information gaps relating to water issues in the CGD Green Wedge**

What we need	Why information may be useful	Available data/information	Information gaps
Flood mapping and analysis	Identifies areas prone to flooding and flood retention, which can determine appropriate land uses in those areas	<p>100 year ARI flood extent for natural drains and underground drains (geospatial data)</p> <p>Land subject to inundation overlay (LSIO) (geospatial)</p> <p>Additional flood studies have been completed by CGD and Melbourne Water:</p> <ul style="list-style-type: none"> <li>• Mile Creek flood study (draft)</li> <li>• Dandenong Creek flood study</li> <li>• Edithvale Flood Study</li> <li>• Bangholme Flooding investigation Discussion Paper</li> <li>• Flow gauging station data</li> </ul>	<p>There is uncertainty regarding the flood extents mapped to date (Alluvium 2013). There is evidence of inundation beyond that currently included in the LSIO. The existing flood maps and LSIO do not adequately cover the full extent of the CGD Green Wedge. More detailed, site specific flood mapping and flow path mapping are required.</p> <p>Flood extents based on projected inflows to the CGD Green Wedge should take into account impacts of increased urbanisation of the catchment and climate change scenarios.</p> <p>The Flood Management Plan (Melbourne Water 2013). (Action 3.1.4) is to assess the need and then, if required, complete flood mapping for Dandenong South.</p>
Waterways, drainage lines and drainage assets	Waterways, drainage lines and other drainage assets facilitate movement of floodwater out of the study area or retain floodwater within designated storage areas. Understanding the location, function and condition of these is important for providing flood protection or retention.	<p>Drains, an extensive network of levee banks and other drainage assets have been constructed over time to facilitate better drainage and to support a broader range of land uses, including uses that are not conducive to regular flooding.</p> <p>There are three waterways with total length of 12 km within the study area. These are:</p> <ul style="list-style-type: none"> <li>• Mordialloc Creek</li> <li>• Patterson River</li> <li>• Eumemmerring Creek</li> </ul> <p>In addition, there are a number of small tributary drainage lines, with a total length of 25.6 km, including:</p> <ul style="list-style-type: none"> <li>• Smythes Drain</li> <li>• Eastern Contour Drain</li> <li>• Wadsley’s Drain</li> </ul> <p>Average energy slope (slope of water surface) can be estimated using contour data or LiDAR.</p>	<p>Modelling and mapping flood extents and drainage paths, including how the existing levees impact these. Identifying and mapping areas where water ponds and flow paths in and out of those areas</p> <p>Flood extents that take into account catchment land use changes and climate change impacts</p> <p>Channel survey for major waterways and drainage lines, from which channel slope and other geometry can be derived</p> <p>Impact of the proposed removal of levee bank north of Mordialloc Creek, downstream of Dandenong Creek.</p> <p>Identification of capacity and grade limitations of outfall drains downstream of the Green Wedge. The low lying nature of the southern Green Wedge will limit the options for drainage capability to service potential land developments.</p>



What we need	Why information may be useful	Available data/information	Information gaps
Riverine quality	Provides an understanding of the environmental 'health' of the waterways within the CGD Green Wedge	<p>A database of City of Greater Dandenong's drainage assets, including pipes, pits and culverts and retarding basins is being collated and mapped in an ongoing fashion, as more information becomes available.</p> <p>Melbourne Water have indicated locations of existing and currently proposed retarding basins.</p> <p>Local drainage reports and plans prepared for isolated development proposals.</p> <p>Riverine quality (water quality and geomorphic form) was assessed at a broad scale as part of the development of the Healthy Waterways Trajectories. The lower reaches of the Dandenong catchment (all estuarine influenced reaches including Patterson River, Mordialloc Creek) have "poor water quality due to upstream urban impacts. Physical form and flow are completely altered from their pre-European state." Eumemmerring Creek was included in the assessment of the middle reaches of the Dandenong catchment, which were found to have "poor water quality and generally altered form."</p> <p>The Healthy Waterways Trajectories assessments were undertaken at the management unit scale based on ISC and RRHS1 data provided at the reach scale. Available information is for reaches and management units that extend beyond the study area and is thus not specific to the study area. The data was supplemented by relevant geomorphic studies.</p>	<p>High ground water tables and flood levels will place limitations upon minimum floor levels. This will also impact upon the overland flow paths and accessibility to residential developments.</p> <p>Database of VicRoads assets that impact or are impacted by drainage in the CGD Green Wedge</p> <p>Other "private" drains associated with ongoing lot scale changes to drainage patterns that are undertaken by landowners. These can have a significant impact on movement of water through the area and on adjoining landholders</p> <p>There were no environmental flow studies for the CGD Green Wedge available at the time of the gap analysis. Melbourne Water indicated that they are currently investigating environmental flow requirements for Mordialloc Creek. The lack of environmental flow requirements relates to both the waterways and the floodplain.</p> <p>Specific targeted CGD Green Wedge waterway health assessments</p> <p>Water quality data</p>
Riverine connectivity	Provides understanding of ecological connectivity along the waterways and drainage lines. This indicates the role or potential role of the CGD Green Wedge in the broader catchment setting.	Riverine connectivity was assessed at a broad scale (upper, middle and lower reaches of the Dandenong catchment) as part of the development of the Healthy Waterways Trajectories. In the lower reaches, "Physical barriers at the upstream ends of this system are impediments to migratory organisms. There are many minor and major barriers within the system due to urban development (underground sections, culverts, pipes, weirs). Riparian vegetation has largely been removed however important revegetation and	

What we need	Why information may be useful	Available data/information	Information gaps
		<p>some remnants occur in some sections. These sections are largely of a weedy nature and have a simplified structure. Bike paths connect much of the system.”</p> <p>The Healthy Waterways Trajectories assessments were undertaken at the management unit scale based on ISC and RRHS1 data provided at the reach scale. Available information is for reaches and management units that extend beyond the study area and is thus not specific to the study area.</p>	
Floodplain quality and connectivity	<p>This is an indicator of floodplain health as well as broad-scale potential for flooding</p>	<p>Floodplain quality and floodplain connectivity were assessed at a broad scale (upper, middle and lower reaches of the Dandenong catchment) as part of the development of the Healthy Waterways Trajectories. In the lower reaches,” floodplains have been largely cleared but have been set aside from urbanisation because of flooding. Floodplains are extensive and are generally connected in some form”. While this may be applicable at the broader “lower reaches” scale, within the study area, there is a substantial network of levees in varying condition that do impact upon floodplain connectivity.</p> <p>The Healthy Waterways Trajectories assessments were undertaken at the management unit scale based on ISC and RRHS1 data provided at the reach scale. Available information is for reaches and management units that extend beyond the study area and is thus not specific to the study area.</p>	<p>Site scale flood mapping (see flood mapping and analysis), mapping of existing levees and priority rating of levees (particularly in relation to the 2012 Parliamentary Inquiry into Flood Mitigation Infrastructure in Victoria).</p> <p>Changes in levee bank configuration proposed by Melbourne Water for Mordialloc Creek, downstream of Dandenong Creek, will impact on the Keys Road area.</p>
Recreational uses	<p>Recreational uses help provide an understanding of the social or community values associated with the CGD Green Wedge</p>	<p>The Patterson River is a popular gateway to Port Phillip Bay and supports a wide range of water-based recreation, including the National Water Sports Centre. Other recreational activities undertaken in the CGD Green Wedge include golf, equestrian, soccer and other team sports.</p> <p>The use and visitation to the Edithvale Seaford Wetlands Discovery Centre is monitored by Melbourne Water, but this centre is technically outside the SE Green Wedge zone.</p>	<p>Frequency of visits to study area for active and passive recreation. The National Water Sports Centre may have data on visitation and memberships.</p>
Acid sulphate soils	<p>The presence of acid sulphate or potential acid sulphate soils can have</p>	<p>Potential acid sulphate soils are known to exist in several specific locations within the study area and are considered likely to occur elsewhere throughout the study area.</p>	<p>The extent and depth below surface of acid sulphate soils across the study area.</p>

What we need	Why information may be useful	Available data/information	Information gaps
Locations and performance of retarding basins and other WSUD, both existing and proposed	significant environmental, infrastructure and economic implications if disturbed.  Indicates sub-catchments where some measures are being or have been undertaken to manage and/or improve flooding and water quality issues	The locations of Council owned retarding basins upstream of study area are mapped.  Anecdotal locations of current and some proposed retarding basins owned by Melbourne Water.  JAYCO and Glasscocks Road MUSIC model to assess water quality performance of specific assets.  Bunurong Cemetery has informed CGD of their intentions to modify the landscape (according to the Bunurong Cemetery Master Plan), which may include the building of some retarding basins within the cemetery grounds to assist in managing shallow groundwater.	Absence of flood modelling to assess the combined impact of raised road formation works, open drains and retention systems on land development requirements. In particular, the impact on the eco system, location of retarding systems and economic feasibility of land development proposals. Limited grade and capacity of outfall drains downstream of the Green Wedge will require the provision of major retention systems, with the probable use of pumping stations.
Cooling effects of the Green Wedge for surrounding suburbs	This is one of the ways in which land use and management in the CGD Green Wedge can have positive or negative impacts beyond the Green Wedge's boundary. While as a general rule, the cooling effect of a park or green area tends to extend outside the green area to a distance that is equivalent to half the green area's width, this can be highly variable and depends on vegetation cover in the park, irrigation (extent and frequency) and the nature of the surrounding built environment.	It is recognised that the Green Wedge provides some degree of cooling for surrounding urban areas, however specific effects are not known.	Specific data/information regarding the cooling effect of the south east green wedge and the spatial extent and variability of this.  It is unknown how far the cooling effect of the CGD Green Wedge extends, though it is unlikely to reach the Greater Dandenong CBD
Community views	Community engagement is vital for the success of future management of the CGD	Extensive community engagement has been undertaken for stakeholders located within the CGD Green Wedge.	Community views outside of the CGD Green Wedge.

What we need	Why information may be useful	Available data/information	Information gaps
	Green Wedge		
Setbacks/corridors	New urban developments are required to allow a minimum distance between properties and natural or constructed waterways.	<i>Waterway Corridors – Guidelines for Greenfield development areas within the Port Phillip and Westernport Region</i> specifies minimum setbacks for existing and constructed waterways based on the Strahler stream order for the reach.	Strahler stream order for waterways in the CGD Green Wedge to determine the minimum setback and corridor widths for these streams
Fish and fish passage	The CGD Green Wedge was key habitat for the nationally vulnerable Dwarf Galaxias  Migratory fish species travel up and down streams at different stages in their life cycle. Fish passage is particularly important for facilitating reproduction.	Fish passage has been installed at Pillars Crossing, on the weir in Patterson River and two locations in Mordialloc Creek downstream of the study area.  No other barriers to fish passage have been identified within the study area, although barriers do exist on the reaches upstream of the study area.	Whether there is a need for off-stream wetlands or water storages for fish breeding.  The potential for the CGD Green Wedge to contribute to the ecological recovery of fish species such as Dwarf Galaxias
Platypus and other semi aquatic and terrestrial mammals	Platypus are an important value of the Dandenong Creek catchment.  The CGD Green Wedge can provide important role in ecological recovery programs such as that for the southern brown bandicoot	Two platypus populations are known to exist in the upper Dandenong catchment. No platypus has been recorded in the study area.	It is unlikely that the CGD Green Wedge would provide ideal platypus habitat. However the CGD Green Wedge is likely to provide habitat for native water rats. The presence or absence of semi aquatic mammals in the CGD is poorly documented and understood  An understanding of the potential for the CGD Green Wedge to provide important habitat and corridor for the endangered southern brown bandicoot.
Macro invertebrates	Macro invertebrates can indicate water quality and waterway condition	Macro invertebrate condition is available through ISC scores compiled at the reach scale. For the reaches in the study area, condition is generally poor to moderate, with the exception of the Eastern Contour Drain, where condition is high  Macro invertebrate condition was assessed in 1999 and 2010 ISC studies, although fewer reaches were assessed in 2010. For those reaches with repeat assessments, there was a general decline in condition over the period.	Macro invertebrate condition specific to waterways within the study area.  Locations of macro invertebrate “hotspots” (if any) that may benefit from extra effort to preserve or enhance the site.

What we need	Why information may be useful	Available data/information	Information gaps
		Available information is for reaches and management units that extend beyond the study area and is thus not specific to the study area.	
Frogs	Species within the CGD Green Wedge that are listed under the Commonwealth EPBC Act (1999) or the State FFG Act (1998) need to be reported and should not be negatively impacted by development or other activities within the Green Wedge.	<p>The Healthy Waterways Trajectories provide condition and trend scores at a management unit scale for 5 year time periods from 1990. Within the management units that meet in the study area, frog condition declined between 1995-1999, then remained steady before increasing again after 2005 in the Eumemmerring and Kananook management units while remaining steady in Dandenong Creek Lower.</p> <p>We have spatial data for frogs recorded during about 800 frog surveys undertaken in the study area between 1988 and 2009. Striped marsh frog, common froglet, spotted marsh frog, southern brown tree frog and southern bullfrog have all been recorded in the study area throughout that period.</p> <p>No frog species listed under either the Commonwealth EPBC Act (1999) or the State FFG Act (1998) have been recorded within the CGD Green Wedge or within a 500 m buffer zone around the Green Wedge since 1995</p>	<p>It is unknown whether and where any EPBC or FFG listed species are present in the CGD Green Wedge</p> <p>The potential for the CGD Green Wedge to contribute to the ecological recovery of species such as Growling Grass Frog</p>
Birds	Species within the CGD Green Wedge that are listed under the Commonwealth EPBC Act (1999) or the State FFG Act (1998) need to be reported and should not be negatively impacted by development or other activities within the Green Wedge.	<p>Observed to expected species scores, per cent native for birds surveyed between 1990-2010 are available at the management unit scale through the Healthy Waterways Trajectories reports. Species richness improved from low to moderate over the time period in all three management units that extend into the study area. Nativeness was high and relatively steady throughout the time period in each management unit.</p> <p>Observed to expected species scores, per cent native for birds surveyed between 1990-2010 for specific wetlands (ETP, Edithvale, Seaford, Mordialloc Creek wetland, some others) are also available.</p> <p>There are expected species lists for management units, which represent the bird species that have historically been recorded</p>	<p>Site specific data for birds may not be so relevant as they are migratory and an individual's range can be very large. However, it would be useful to know the locations of bird "hotspots", outside the ETP, (if any) that may benefit from extra effort to preserve or enhance the site.</p> <p>Presence of any EPBC or FFG listed species or communities</p>

What we need	Why information may be useful	Available data/information	Information gaps
		within those areas.	
		Available information is for reaches and management units that extend beyond the study area and is thus not specific to the study area.	
Fish	Species within the CGD Green Wedge that are listed under the Commonwealth EPBC Act (1999) or the State FFG Act (1998) need to be reported and should not be negatively impacted by development or other activities within the Green Wedge.	<p>Species richness and nativeness scores are available for two altitude zones in the Dandenong Catchment (0-200m, 200-400m) as part of the Healthy Waterways Trajectories. Species richness and nativeness were found to have both been in decline until 2004, after which both metrics improved again. However, these metrics should be used with caution due to limitations of the data and collection of the data that underpins the metrics.</p> <p>Spatial data is available for fish surveys completed in the study area and within 500 m of the study area between 1982 and 2008. Prior to 1995, five exotic species were recorded, while native species consisted of eight freshwater species and eight estuarine species. Since 1995, seven exotic species have been recorded, while five native freshwater and eight native estuarine species were recorded.</p> <p>No fish species listed under either the Commonwealth EPBC Act (1999) or the State FFG Act (1998) have been recorded within the CGD Green Wedge or within a 500 m buffer zone around the Green Wedge since 1995</p>	Presence of any EPBC or FFG listed species or communities
Vegetation	Species and communities within the CGD Green Wedge that are listed under the Commonwealth EPBC Act (1999) or the State FFG Act (1998) need to be reported and should not be negatively impacted by development or other activities within the Green Wedge.	<p>Condition scores based on ISC data at a catchment scale. This is quite broad, and not very applicable to the Green Wedge</p> <p>Melbourne-wide EVC mapping shows that there are some very small pockets of the endangered Plains Grassy Woodland EVC within the study area. Elsewhere, EVC is given as "Private Land No Tree Cover".</p> <p>Remnant vegetation, dominated by river red-gum, now consists predominantly of scattered trees within exotic pasture, lawn or</p>	<p>Condition of instream, riparian and wetland vegetation in the study area, including locations of any remnant vegetation or other significant vegetation.</p> <p>Presence of any EPBC or FFG listed species or communities.</p>



What we need	Why information may be useful	Available data/information	Information gaps
		marked garden. The most notable patches of remnant red gums are between Springvale Road and Perry Road north of Mordialloc Main Drain and between EastLink and Dandenong-Hastings Road south of Glasscocks Road.	
Soils	Soil types, particularly acid sulphate soils may need to be accommodated for in future development. There may be additional costs associated with this.	<p>According to the Digital Atlas of Australian Soil, soils in the CGD Green Wedge west of EastLink consist of:</p> <p>Swampy plains with sand-ridges: swampy plains of peaty soils(O) and their burnt remains, with various other soils largely undescribed but including (Dy3) and (Dy5) with organic surface horizons; sand-ridges of leached sands (Uc2.2 and Uc2.3)</p> <p>East of EastLink, soils consist of:</p> <p>Coastal plains: plains of leached sands (Uc2.33) and other (Uc2.3) soils in association with sandy acidic yellow mottled soils (Dy5.41 and Dy5.81) and small areas of (Dy3.4) soils with dunes of leached sands, (Uc2.2) on dune crests. and (Uc2.3) on dune slopes; and with small swampy areas and possibly some lunettes both with undescribed soils</p>	The extent and depth of acid sulphate soils across the study area. Soil properties at specific locations within the study area.
Cultural heritage (related to water and waterways)	Cultural heritage sites should be protected	Sites of Aboriginal significance are often located near waterways and wetlands. There are clusters of known Aboriginal heritage sites in the northern and southern parts of the study area. It is possible that there are other sites within the study area that have not yet been identified.	Site specific cultural heritage assessments. These may be undertaken during planning for specific activities
Groundwater	Groundwater quality, quantity, depth below surface and recharge locations can influence which land uses may be suitable in terms of the impact of groundwater on specific land uses and the impact of specific land uses on groundwater.	<p>Groundwater is known to be quite shallow in places in the study area, particularly in and near the Bunurong Cemetery.</p> <p>Depths to water table have been mapped across Greater Melbourne. While this is at quite a coarse scale, it suggests that the water table is within 10 m of the surface across the CGD Green Wedge and may be within 5 m of the surface in some locations.</p>	<p>Groundwater – surface water connectivity in the broader study area.</p> <p>More detailed mapping of the depth to water table within the CGD Green Wedge.</p> <p>Location of groundwater recharge areas</p> <p>Identification and mapping of groundwater dependent ecosystems</p> <p>Climate change impacts on groundwater recharge, depth and quality</p>



What we need	Why information may be useful	Available data/information	Information gaps
Economic implications of environmental factors on development	Environmental factors such as flooding, ponding and acid sulphate soils are likely to complicate construction and maintenance of new and existing assets		<p data-bbox="1395 304 1957 355">Impacts of increased urban development on groundwater recharge, depth and quality</p> <p data-bbox="1395 403 2051 571">Areas such as the Soden and keys Roads areas have inherent very high water tables. This high water table limits drainage options, exacerbated by the low relative level differentials between the high water tables and sea level. This limitation will adversely impact on surface water connectivity within the low lying areas within the Green Wedge.</p> <p data-bbox="1395 619 2051 699">The impact of long term development plans for areas such as the Bunurong Cemetery requires local flood modelling to ensure that abutting areas are not adversely impacted upon.</p> <p data-bbox="1395 719 2051 831">Additional direct costs associated with constructing and maintaining infrastructure such as roads, water supply and wastewater pipelines and other utilities within the environmental constraints of the CGD Green Wedge.</p> <p data-bbox="1395 879 2051 1110">The high ground water level will require roads to be constructed on raised rural road type formation, to ensure the protection of road pavements from high water tables. This will create a new eco system that will require a new open drain network to drain the area to enable development to proceed. The absence of information on this implication and impact on floodplain quality and connectivity could lead to an underestimation of the impact of road network raised formation levels on same.</p>



## 4 Conclusion

The information and input from Melbourne Water, City of Greater Dandenong and other stakeholders provides a good picture of the values, condition and processes in the CGD Green Wedge, however, some information gaps remain. The key gaps in information and understanding include:

- Detailed flood mapping for the CGD Green Wedge, including flood extents that reflect future climate change and urbanisation scenarios
- Identification and mapping of areas where ponding from both riverine flooding and flooding from local rainfall runoff is a particular issue
- Drainage asset (open drainage) performance and identification of low-lying areas
- Understanding of the flood retention capacity of the CGD Green Wedge
- Waterway values and condition that are specific to the CGD Green Wedge, such as birds, mammals fish, amphibians, reptiles and aquatic, riparian and floodplain vegetation and macroinvertebrates, and the potential role of the CGD Green Wedge in provision of habitat and corridors for ecological protection and recovery programs
- Specific locations and depth below surface of acid sulphate and potential acid sulphate soils within the CGD Green Wedge
- Groundwater-surface water connectivity throughout the CGD Green Wedge

## 5 Next steps

Not all information gaps will need to be filled, depending on the adopted future management approach. However, some areas should be further explored regardless of which management approach is adopted.

Flood assessments, with and without levee failures, will be important for all planning and future management of the CGD Green Wedge. They will also provide insight into how flooding may impact public safety both within the Green Wedge area and downstream.

While various agencies have been monitoring different ecological components of the CGD Green Wedge, these have not been brought together to give an overarching indicator of ecological or environmental condition of the CGD Green Wedge and the broader SE Green Wedge and adjoining green wedges. Establishing and implementing a process for an overarching indicator or green wedge environmental report card would provide a consistent, methodical and robust monitoring and reporting program for assessing the condition and change in condition of the CGD Green Wedge.

Understanding the location of acid sulphate and potential acid sulphate soils will be important for whichever management scenario is adopted. All construction activities are at risk of disturbing these soils if they are present. There can be significant implications for the environment and infrastructure if these soils are disturbed. It would also be useful to investigate the additional costs associated with construction and maintenance of assets in areas where acid sulphate or potential acid sulphate soils exist.

Filling these information gaps will assist with the future management of the CGD Green Wedge. However understanding these current gaps helps to identify some of the limitations with the trajectories assessment undertaken within the next paper (Paper No 3, Future Trajectories) in this series on water related issues in the CGD Green Wedge.

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DRAFT FINAL REPORT

TRAJECTORIES DEVELOPMENT:

City of Greater Dandenong Green Wedge

Future trajectories

December 2013

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# 1 Introduction

This paper presents the future trajectories for water related land uses in the South East Green Wedge within the City of Greater Dandenong (CGD Green Wedge) and its associated catchments under different development scenarios.

The paper has been prepared by Alluvium Consulting Australia (Alluvium) for the City of Greater Dandenong (CGD) and Planisphere, as an input into the development of CGD's broader Green Wedge Management Plan.

This paper is the third of a series of related papers developed by Alluvium on water related matters associated with the CGD Green Wedge. These papers are set out below:

1. Issues discussion paper
2. Gap analysis
3. Trajectories development (this paper)

**The purpose of this paper is to identify and describe potential trajectories for water related land uses in the CGD Green Wedge and to understand the impact and benefits of different development alternatives on these uses.**

This paper describes the water related trajectories for land uses within the CGD Green Wedge associated with alternate management scenarios. For each of the management scenarios, the assessment has considered the issues associated with

- Importing of potable water
- Exporting of sewage
- Impact on stormwater runoff
- Impact on the potential flood storage

For the purpose of this assessment three alternate management scenarios have been explored

1. An enhanced environmental and community / social scenario
2. A continuation of current management scenario, and
3. An increased urban development scenario

## 2 Summary of land uses

In the 'Issues and Constraints' paper (Alluvium, 2013) a selection of water related land uses were identified within the CGD Wedge. These water related land uses comprised:

- Agriculture
- Flood storage and capacity
- Commercial
- Public utilities and infrastructure
- Rural residential
- Environmental / ecological uses
- Public health (to provide cooling)

- Recreation
- Visual amenity

### 3 Summary of issues, constraints, gaps

The preceding papers in this series developed by Alluvium describe the issues and constraints on management and the gaps in the understanding of the CGD Green Wedge. The first paper in the series 'Issues and Constraints' (Alluvium 2013) sets out some of the water related constraints that limit land use in the CGD Green Wedge. These constraints are summarised in Table 1.

**Table 1. Summary of issues and constraints**

Category	Constraint/issues
Physical character of the landscape	<ul style="list-style-type: none"> <li>• Low lying elevation</li> <li>• Capacity for flood storage</li> <li>• The inherent characteristics of the landscape</li> <li>• Physical form and barriers within drains and waterways</li> </ul>
Environmental	<ul style="list-style-type: none"> <li>• Groundwater</li> <li>• Acid Sulphate Soils</li> </ul>
Green Wedge management	<ul style="list-style-type: none"> <li>• Presence and buffer around Eastern Treatment Plant</li> <li>• Management of existing assets</li> <li>• Land ownership and titles</li> <li>• Public utilities and infrastructure</li> <li>• The use and management of land within the CGD Green Wedge</li> </ul>
External forces	<ul style="list-style-type: none"> <li>• Downstream residents and businesses</li> <li>• Cultural Heritage</li> <li>• Climate change</li> <li>• The connectivity of green links</li> <li>• Ongoing urban development within the catchment (i.e. upstream and downstream of the CGD Green Wedge).</li> <li>• State government policy</li> </ul>

The Gaps paper (Alluvium 2013) in this series described the gaps in knowledge associated with the water related issues in the CGD Green Wedge. These gaps in knowledge related to water issues in the CGD Green Wedge include:

- Detailed flood mapping for the CGD Green Wedge, including flood extents that reflect future climate change and urbanisation scenarios
- Identification and mapping of areas where ponding of water (poor drainage) is a particular issue
- Understanding of the flood retention capacity of the CGD Green Wedge
- Some waterway values and condition that are specific to the CGD Green Wedge, such as birds, amphibians, reptiles, mammals, aquatic, riparian and floodplain vegetation and macroinvertebrates
- Specific locations and depth below surface of acid sulphate and potential acid sulphate soils within the CGD Green Wedge
- Groundwater-surface water connectivity throughout the CGD Green Wedge



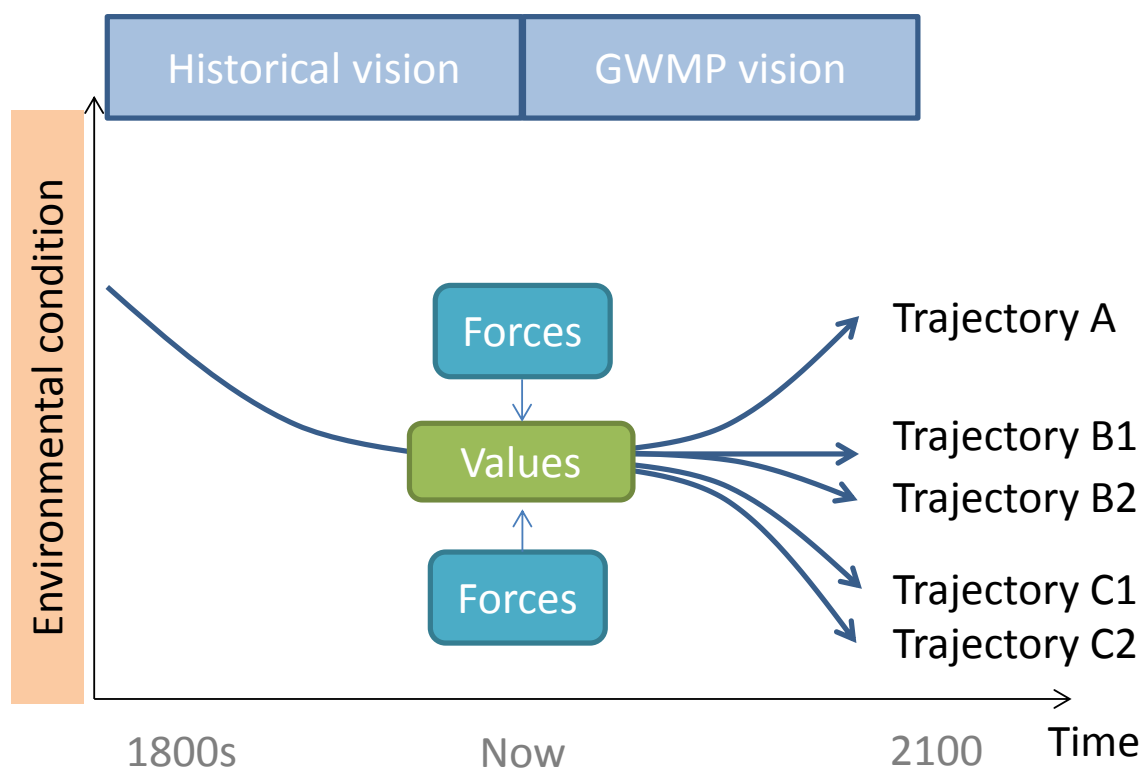
## 4 Defining future trajectories

We have explored alternate management scenarios for the CGD Green Wedge and the implication of these scenarios on the future for the identified water related land uses. These alternate futures are described as 'trajectories' and describe the expected outcome in the CGD Green Wedge and surrounding areas for the **next 100 years** (Figure 1). The analysis has identified the likely impact of both the ongoing external and internal forces and the management scenarios on the identified land uses.

For this paper, we have assessed three different future trajectories based on three different management scenarios. These management scenarios and trajectories are based on:

- A – Ecological and community focussed outcome
- B – No or limited change in management
- C – Increased development within the CGD Green Wedge

These management scenarios and trajectories were developed in consultation with staff from CGD and Planisphere.



**Figure 1.** Conceptual diagram showing potential future trajectories for the Green Wedge over the next 100 years

### 4.1 A – Ecological and community outcome

Under this management scenario and trajectory, there would be no further commercial or residential development within the CGD Green Wedge and action would be taken to improve the environmental uses and ecological and community outcomes within the CGD Green Wedge and in the surrounding areas. Features of this trajectory are:

- Rehabilitated waterways and wetlands (with approximately 47 kilometres of natural waterways)

- Increased capacity for natural flood storage and detention throughout the Green Wedge

The implication of this scenario is that there would be:

- More native trees and vegetation
- More birds, fish, frogs
- Increased biodiversity
- Less dwellings
- Less agricultural production

Rehabilitation of the natural waterways and wetland would change the landscape to more closely resemble the natural swampy environment of the former Carrum Carrum Swamp. This would mean increasing the capacity to store flooding within the area. Works would involve revegetation of waterways and removal of structures, thereby improving habitat and passage for fish, birds, frogs and other native species. The scenario would result in greater biodiversity and improved ecological outcomes for the CGD Green Wedge. We have assumed that under this scenario the major roads and existing public use zones would be retained and the rehabilitation would be implemented outside these areas. The rehabilitation would not completely return the landscape to its pre-European settlement state. However the scenario would provide for an improvement to environmental uses currently found in the area.

For the purpose of the assessment wetlands have been included in areas that already experience drainage issues and provide a degree of floodwater retention. Under the ecological and community outcome scenario, the natural ponding function in these locations would be enhanced through wetland construction, landscape modification or other works to be determined on a site-by-site basis. The existing waterways or drainage lines would be converted to a more natural, meandering and or chain or pond form with a wider, vegetated riparian corridor.

The rehabilitation of the area would include planting of native trees across the landscape to promote biodiversity, ecological linkages and provide additional shade and enhanced visual amenity. Increased vegetation will increase the cooling effect of evaporation and evapotranspiration resulting in lower temperatures in the surrounding built environments. Integrated in the design of the site are linkages providing community access to the recreational and amenity features of the site.

The wetlands, vegetation areas and improved waterways will together form the area covered by the combined ecological and community outcome. This area will comprise a network of green areas with high ecological value that will link with green areas outside the CGD Green Wedge, providing ecological connectivity throughout the Dandenong Catchment.

The trajectory includes a movement towards transferring some areas of the green wedge away from rural residential and agricultural uses towards greater ecological and community uses. In some instances uses may be able to co-exist, in other instances they may not. The assumption in this trajectory is that there will be less dwellings and less agricultural production, as this long term ecological and community outcome trajectory is realised.

The cost to implement this vision includes the purchase of land, and costs to remove levees and restore waterways, wetlands and vegetation. Some of these costs may need to be covered by CGD.

A graphical representation of what this trajectory could look like is presented in Figure 2. Note that this is conceptual only. A more detailed example of what this could look like is provided in Attachment A together with a brief discussion on riparian corridor widths.

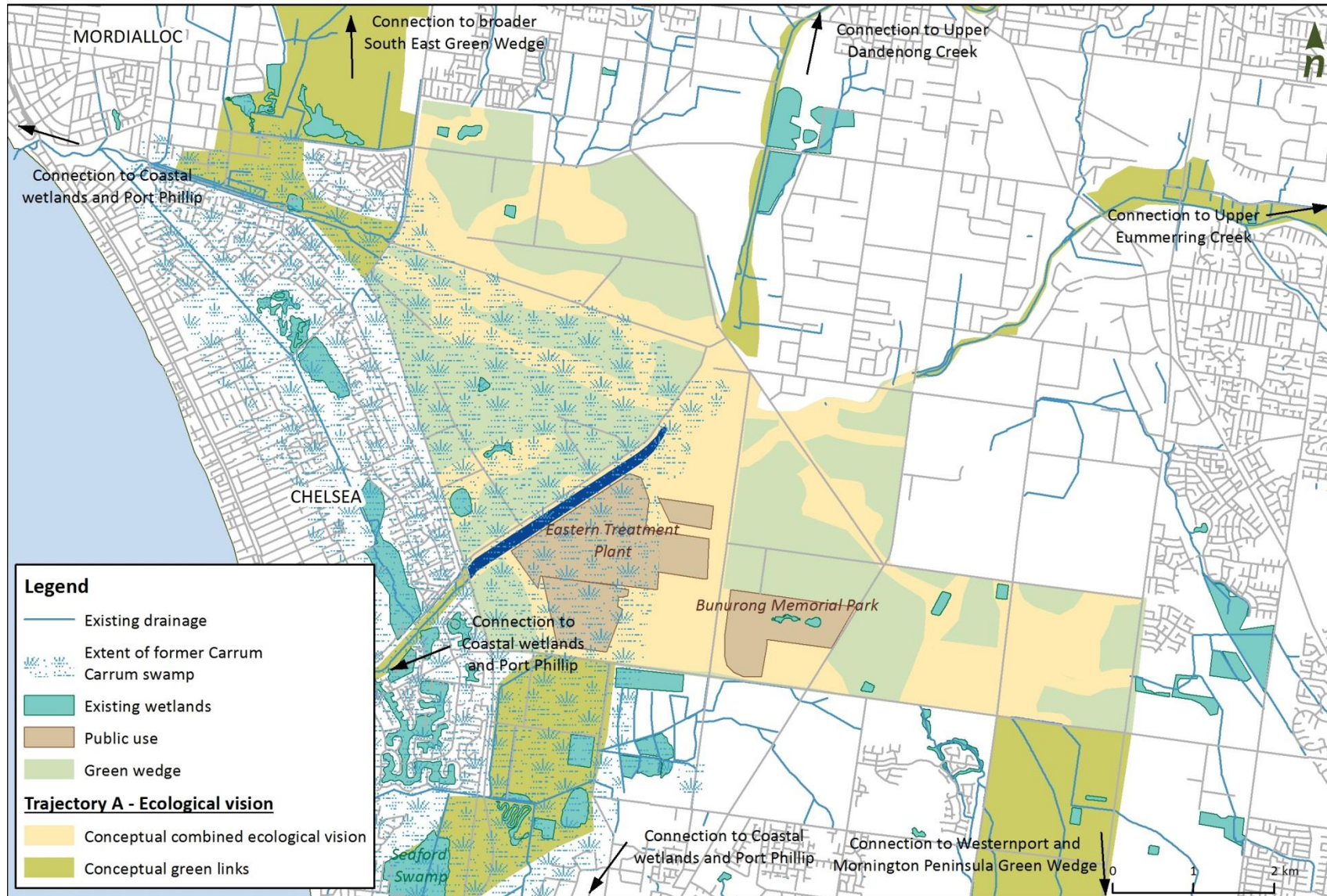


Figure 2. Conceptual presentation of the 'Ecological Vision' (A)

## 4.2 B – Continuation of existing management approach

This scenario explores the future trajectory of water related land uses in the CGD Green Wedge if there is no substantive change to land use zoning or management activities in the CGD Green Wedge. This is essentially the 'do nothing' approach. But as identified in the previous paper on 'Water Issues and Constraints', even with a 'do nothing' approach natural processes will change the landscape and the long term trajectory will see changes to the identified land uses.

Based on discussions with CGD and Planisphere we have identified two specific variations on this scenario:

- Maintain existing management arrangements with no new dwellings
- Permit new dwellings as per current zoning and existing land titles

For both these variations, it is recognised that the future trajectory will be impacted by a number of factors external to the area. For example, it is expected that there will be increased urbanisation upstream, downstream and adjacent to the CGD Green Wedge including new residential dwellings and potentially commercial operations. It is also likely that an increased population of Greater Melbourne will be affecting the public road infrastructure through the site. The potential for climate change to alter the condition of the site is also a constraint that cannot be altered.

### B1 – Maintain existing management arrangements

The 'no change' scenario involves continuing to manage the landscape in the current manner. This includes:

- No changes to any land use within the CGD Green Wedge.
- No additional dwellings (including on properties where the current land use zone would permit this).
- Continuation of existing management approach to road and drainage assets.

Under this management scenario, some change to land uses would be expected. The land uses would change in response to the external factors (climate change and upstream development) and the inherent characteristics of the land. In particular, the current level of investment in local road and drainage maintenance is unlikely to keep pace with the ongoing decline in these infrastructure assets.

### B2 – Permit additional dwellings as per current zoning

The 'limited change' scenario differs from B1 in that it considers the trajectory of the region where dwellings are constructed on the 43 properties (Riddle L., pers. comm., 2013), where the current zoning would permit such development. Each of these properties would contain a large dwelling which is raised above the flood level and supports an average household.

This limited change trajectory includes:

- No changes to zoning within the CGD Green Wedge.
- Additional 43 dwellings (on properties where the current land use zone would permit this), with the condition that these residential developments do not impact on surface water management, drainage assets, sewage assets and the flood storage capacity of the region (i.e. no net impact from each of these developments on the water system).
- Continuation of existing management approach to road and drainage assets.

Each additional dwelling is assumed to have an average footprint of 500 m<sup>2</sup> (based on a review of existing residential properties in Cranbourne South and Langwarrin). It is assumed that each dwelling is representative of an average Melbourne household (i.e. average number of people, water consumption and discharge) and is compliant with CGD development requirements (i.e. there is no illegal floodplain filling).

Both B1 and B2 are assumed to have no impact on stormwater flows and drainage discharges. This assumes that the 43 properties that develop a rural residential dwelling manage all runoff (from impervious surfaces) within the site boundary, and are not adding to the regional volumes of stormwater runoff, drainage maintenance and also flood storage impacts.

If any of the 43 dwellings that are developed have the potential to impact on the flood storage capacity, it is assumed that this change to the storage volume is offset in another part of their development, and hence there is no net change to the storage capacity of the whole system.

A graphical representation of this trajectory is presented in Figure 3.



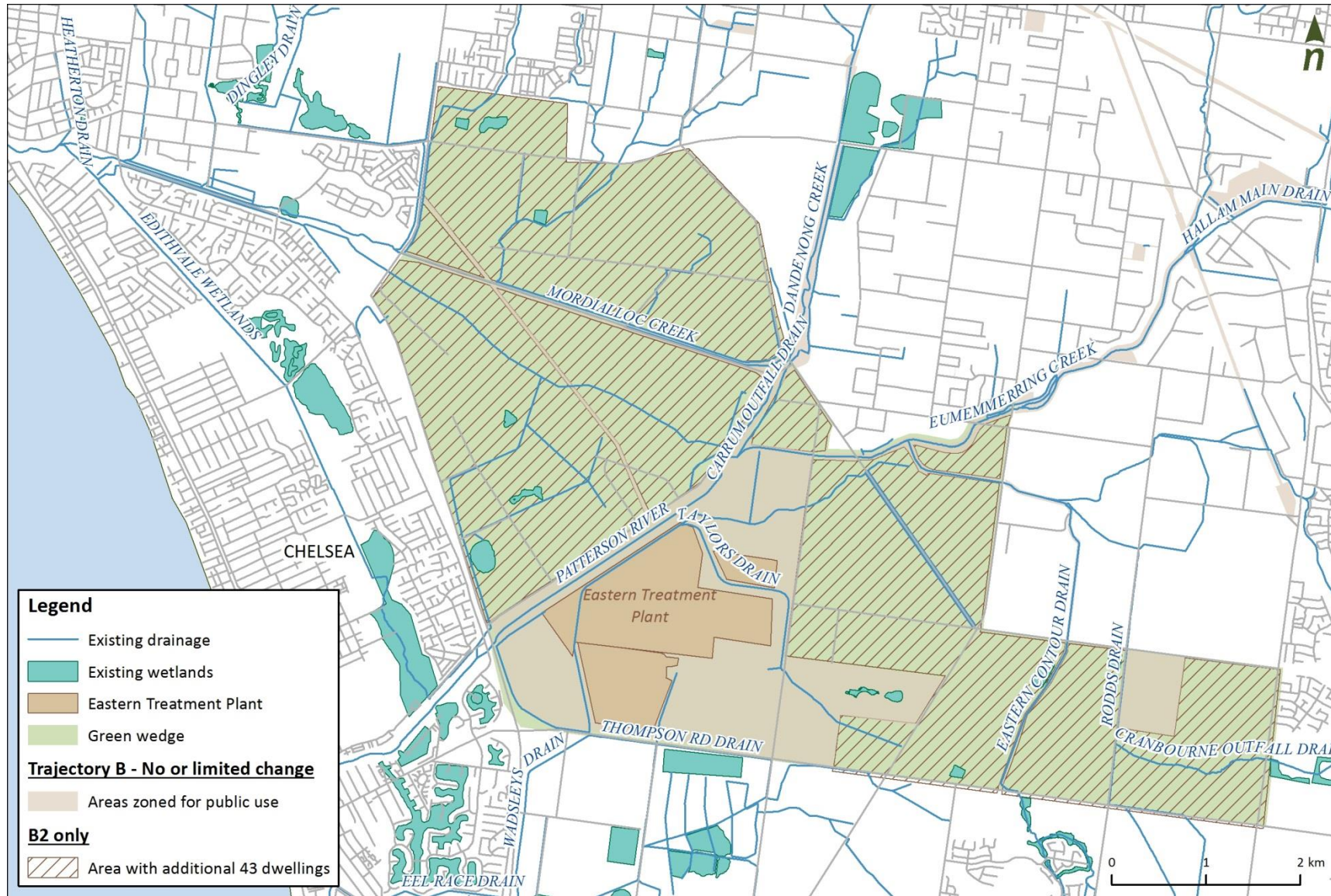


Figure 3. Conceptual presentation of the 'Status Quo' trajectory (B1 and B2)

### 4.3 C – Increased development

Under this scenario increased urban development would be permitted within the CGD Green Wedge. Two variations of this management scenario have been assessed:

- Urban development and subdivision to allow one dwelling per 5 hectare lot across the CGD Green Wedge, excluding Public Use Zones and Urban Flood Zone (C1)
- Urban development and subdivision to allow one dwelling per 1 hectare lot across the part of the CGD Green Wedge lying to the west of Patterson River (C2), and no new dwellings in the part to the east of Patterson River.

These two scenarios were developed based on discussions with representatives of Planisphere and the City of Greater Dandenong.

To support the development of these new houses, new roads and associated drainage infrastructure would be required. The high ground water level and low lying elevation of the CGD Green Wedge will require roads to be constructed on raised rural road type formation, to ensure the protection of road pavements from high water tables. Existing roads such as Pillars Road, McMahrens Road, Keys Road and Riverend Road suffer from high maintenance and repair costs due to the road pavements being flooded. Such roads would require reconstructed to a raised rural road formation to protect the road pavement from water damage and to support the additional traffic.

Similarly, an elevated road formation network will create the need for the provision of an open drainage network, including retention systems connected to outfalls. The outfall drain downstream of the CGD Green Wedge has severe capacity and grade limitations. As a result increased drainage from the CGD Green Wedge could impact on downstream land uses.

The provision of public utilities such as sewer, power, telecommunication and others will face severe limitations that are likely to require wider raised road formations to accommodate the provision of such services.

A land development feasibility assessment may be required to determine the cost feasibility of proposed land developments, including long term liabilities for operational, maintenance and renewal of road, drainage and other assets that will be required to service the proposed developments. The requirement for landfills and elevated finished floor levels will also add to the land development costs.

#### **C1 – 5 hectare blocks**

Under this scenario, the area shaded in non-public use zone parts of the Green Wedge would be subdivided for residential development with one dwelling per 5 hectare lot. This area excludes parts of the CGD Green Wedge zoned as Public Use Zone and Urban Flood Zone and some areas where existing properties are already less than 5 hectares in area. The total area for new residential development in this scenario is 1,835 hectares, which corresponds to an additional 367 properties with dwellings (Pleban K., pers comm, 2013).

Each new dwelling is assumed to have an average footprint of 500m<sup>2</sup> (as per scenario B2). It is assumed that each dwelling is representative of an average Melbourne household (i.e. average number of people, water consumption and discharge) and is built in compliance with CGD development requirements.

An estimated 57 kilometres of new roads would be required and another 26 kilometres of existing roads would need to be upgraded to support the increased traffic flow. These estimates are based on an examination of a 200 hectare sample of the catchment, which when subdivided into 5 hectare properties required 31 metres of new road per hectare to provide access to all properties. This is a much lower estimate than the 150-180 metres per hectare of development provided by CGD (pers comm Phillip C, 2013), however this estimate is understood to be based on much more intensive residential development (i.e. 10-20 properties per hectare) when compared to the developed modelled in this trajectory.

## **C2 – 1 hectare blocks**

Under this scenario the part of the Green Wedge lying to the west of Patterson River would be subdivided for urban developments with one dwelling per 1 hectare lot. This area represents the section of the Green Wedge that is under greatest pressure for development due to its proximity to Port Phillip Bay, good roads and existing urban development. The total area available for subdivision under this scenario is 1,200 ha. This area of land is also the lowest lying and the most constrained by issues such as poor drainage, flood risk in the event of levee breach and acid sulphate soils.

Under this trajectory, the area to the east of Patterson River is not subdivided at all and would remain in its current state.

Each new dwelling is assumed to have an average footprint of 500m<sup>2</sup> (as per scenario B2 and C1). It is assumed that each dwelling is representative of an average Melbourne household (i.e. average number of people, water consumption and discharge) and is built in compliance with CGD development requirements.

Using a 200 hectare sample of the catchment subdivided into 1 hectare properties, the rate of additional roads required was identified as 54 metres per hectare. Using this rate, the estimated length of additional road required under this scenario is 64 kilometres. Another 13 kilometres of existing roads would need to be upgraded to support increased traffic volumes.

The small graphics or inserts in Figure 4 (in the top and bottom right of the figure) are used to illustrate the density of development (the small blocks in these graphics represent the actual building footprint of 500 m<sup>2</sup>, which is to scale).

A graphical representation of this trajectory is presented in Figure 4 and Figure 5.



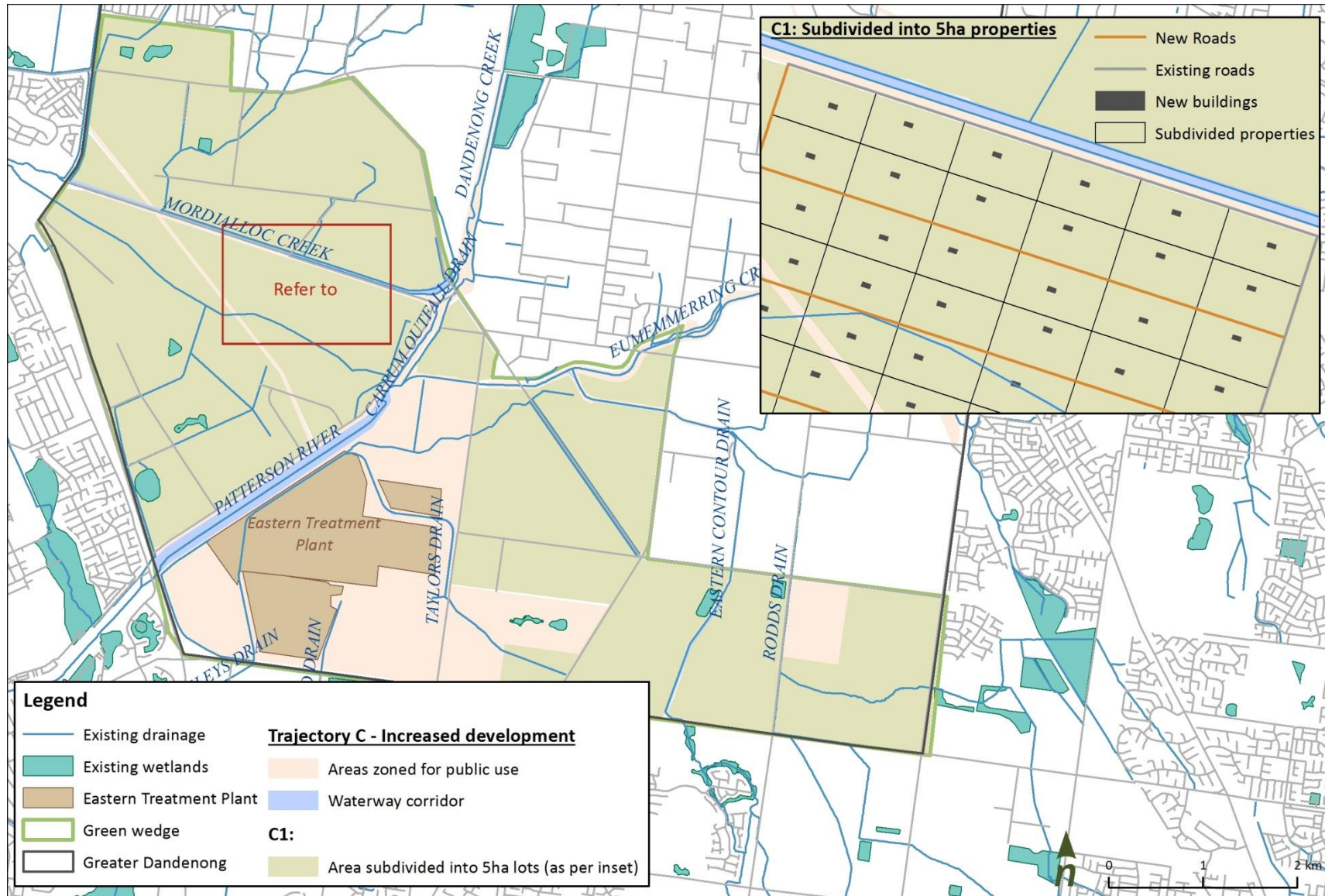


Figure 4. Conceptual presentation of the 'Urban development vision C1'

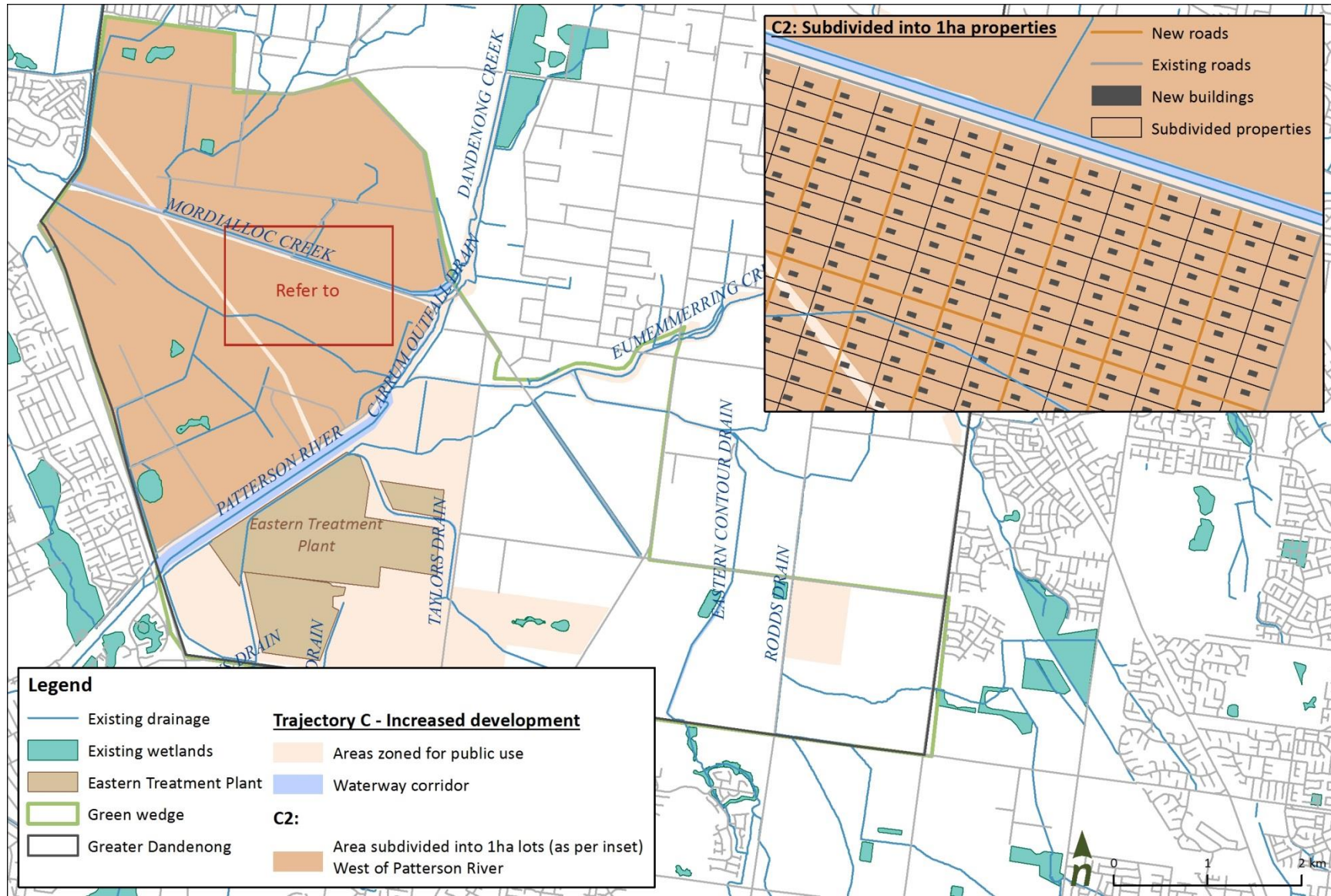


Figure 5. Conceptual presentation of the 'Urban development vision C2'



## 5 Results

This section details the results from the assessment of the trajectories against a range of specific water services and issues. The results are presented in the following manner:

- Changes to water services - i.e. water flows into and out of the system
- Changes to flood storage
- Implications for zoning
- Impacts on council budgets to deliver basic infrastructure services
- Qualitative impact on land uses

### 5.1 Changes to water balance

The current water balance for the CGD Green Wedge, as documented in the previous paper on 'Water Issues and Constraints' (Alluvium, 2013a), shows that in an average year there is:

- 93 ML of potable consumption
- 70 ML of sewage discharge
- 6,600 ML of stormwater runoff

If there is no change from the current management approach for the green wedge, the potable consumption and sewage discharge are not expected to change. However the potential impact of climate change could reduce the stormwater runoff. Under a high climate change scenario (7.5% reduction in mean annual rainfall and evapotranspiration, Alluvium 2013b) the average annual stormwater runoff would be reduced to 5,700 ML.

The impacts on the water balance for each of the trajectories are summarised in Table 2. This analysis is based on the following assumptions:

- Each new property has an average of 2.6 people per household
- Each person consumes 150 litres per person per day of potable water
- 75% of potable water consumed in residential properties becomes sewage and must be treated or disposed of.
- New impervious areas become connected only when a new road network is also constructed (i.e. scenarios C1 and C2)
- For scenario A we have assumed that potable demand will be reduced by 25% of the residential component and 50% of the non-residential component.
- The average width of a road reserve is 16 metres.

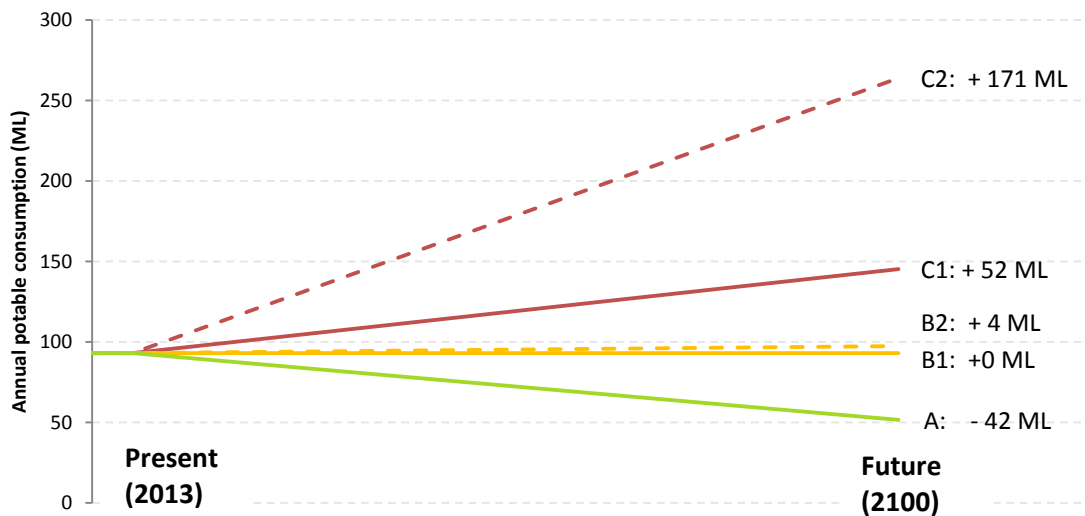
**Table 2. Impact on water balance of proposed trajectories**

Variable	Future trajectory				
	A	B1	B2	C1	C2
Number of additional properties	0	0	31	367	1,200
Change in annual average potable demand (ML)	-46	0	+4.4	+52	+171
Change in annual average sewage (ML)	-32	0	+3.3	+39	+128
Additional impervious area - properties (ha)	0	0	1.6	18	60
Additional impervious area - roads (ha)	0	0	0	88	96
Total increase in directly connected impervious area (ha)	0	0	0	106	156
Total increase in annual average stormwater runoff into waterways (ML)	-900	-900	-900	90	581

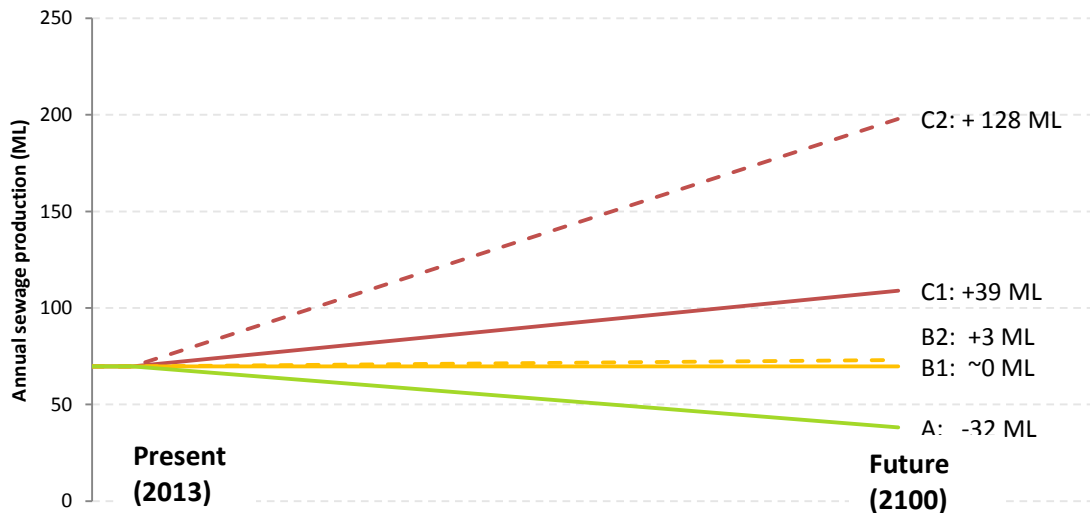
The impact on potable demand, sewage production and stormwater runoff generation are presented in Figure 6 to Figure 8 below. These trajectories are based on the present levels of demand and production identified in the Issues Discussion Paper prepared under this project

Potable consumption and sewage production would increase nearly three-fold from current levels under scenario C2, and would be halved under scenario A.

While the importing of potable water is not a major barrier or concern from an infrastructure perspective (though it should be noted there is a wider movement away from continuous increases in potable consumption), the management and disposal of up to 128 megalitres a year of sewage is an issue as the area of quite low lying, and a series of pumps may be required to connect the dwellings to Melbourne sewer system and Eastern Treatment Plant.

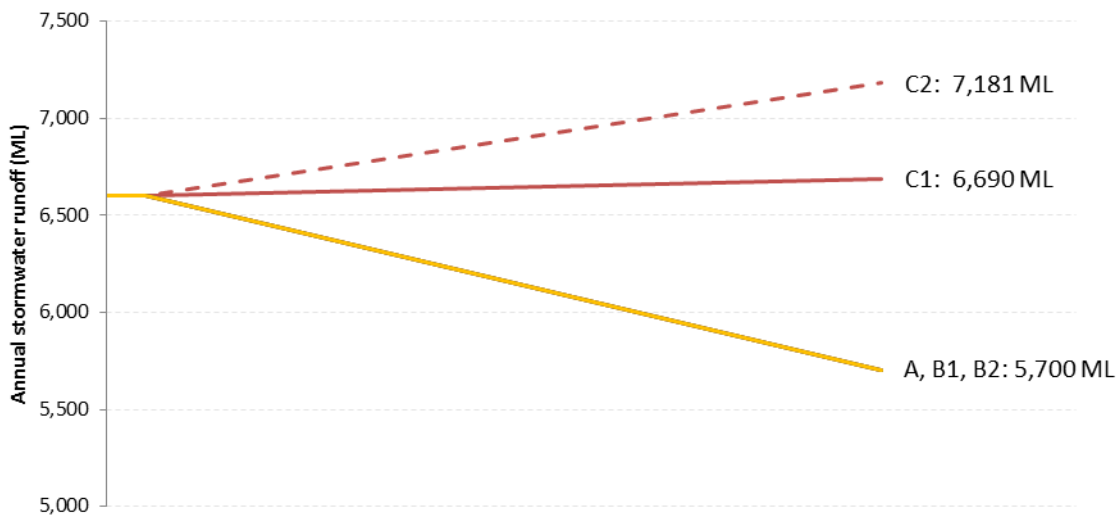


**Figure 6. Trajectories for potable water consumption in the CGD Green Wedge**



**Figure 7.** Trajectory for sewage production in the CGD Green Wedge

For stormwater runoff generation the reduction caused by climate change is predicted from the current levels for scenarios A, B1 and B2. Under scenarios C1 and C2 runoff volumes would be expected to increase due to the increased impervious area offsetting the reductions from climate change. It is important to note that this analysis has not considered the impacts of urban development upstream of the Green Wedge.



**Figure 8.** Trajectory for stormwater runoff generation in the CGD Green Wedge

## 5.2 Changes to flood storage capacity

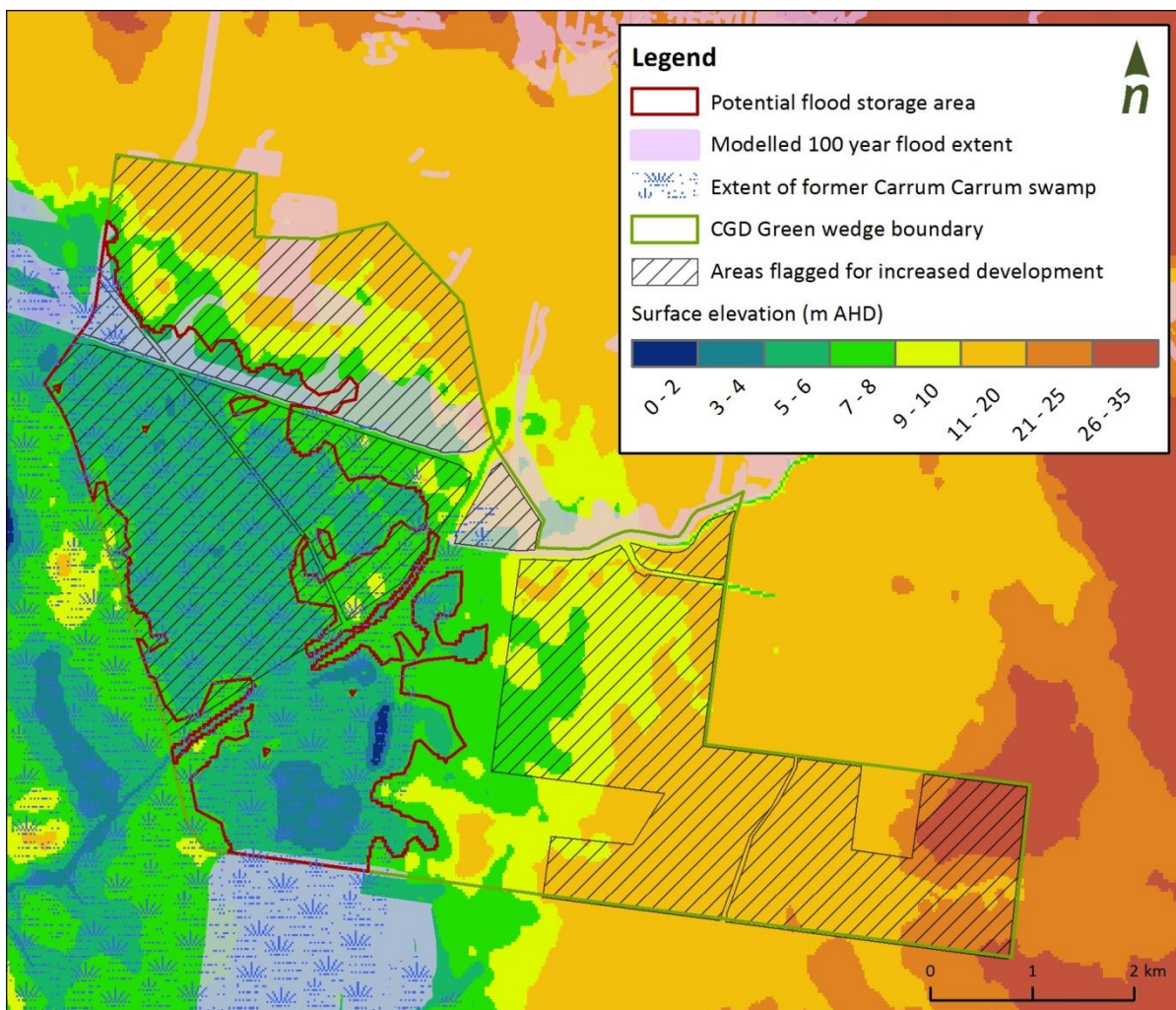
In the previous papers it has been highlighted that one of the gaps is the knowledge of flooding in the Green Wedge. To more accurately assess the changes to the extent, depth, and behaviour of floods in the region through urban development or ecological restoration works, it would be necessary to run a detailed and complex two-dimensional (2D) hydraulic flood model.

In the absence of a detailed 2D modelling approach, a simple method was adopted which can broadly be referred to as the ‘bath tub’ approach. The method is simply to estimate the storage available in the region based on surface area versus elevation relationship. This approach is indicative only and should not be mistaken for flood modelling or used for any design.

The estimate of available storage is based on the following key assumptions –

- The area of storage available within the CGD Green Wedge broadly aligns with the location of the former Carrum Carrum swamp (as mapped in the Department of Environment and Primary Industries' inventory of pre-European Victorian wetlands).
- All areas with surface below 6.3 m AHD would be inundated (this level was selected from the state-wide digital elevation model (DEM) because it roughly coincides with the extent of the former Carrum Carrum swamp).

The estimated flood storage area is shown in Figure 9, and this corresponds to an area of 1,190 hectares (which includes 365 hectares within the Eastern Treatment Plant boundary). When this entire area is inundated, flood depths of over 4 metres would be observed, however the average depth would be 1.08 metres. Based on an average depth of 1.08 metres and a total area of 1,190 hectares, the estimated flood storage volume is 12.8 GL.



**Figure 9.** Estimated flood storage area

The impact of the proposed development scenarios are summarised in Table 3. This analysis is based on the following assumptions:

- The average flood depth in the developable areas is 0.92 metres (as identified in the DEM excluding the storage area within the Eastern Treatment Plant boundary where no additional dwellings will be constructed).
- 40% of the new dwellings under scenario B2 and C1 will be located in the flood prone area and will reduce the flood storage capacity. This is based on the proportion of developable area located within the flood prone area (Figure 9).

- 62% of the new dwellings under scenario C2 will be located in the flood prone area and will reduce the flood storage capacity. This is based on the proportion of the area to be developed under this scenario which is located within the flood prone area (Figure 9).

**Table 3. Impact on flood storage of proposed trajectories**

Variable	Future trajectory				
	A	B1	B2	C1	C2
Number of new dwelling footprints	0	0	43	367	1200
Area of new dwelling footprints (ha)	0	0	2.2	18	60
Area of new roads (ha)	0	0	0	91	104
% of dwellings and roads located in flood prone area	0	0	40%	40%	62%
Area of increased storage (ha)	212	0	0	0	0
Assumed average depth of new and reduced flood storage (m)	0.5	N/A	0.92	0.92	0.92
Total change in storage volume (m3)	+1.063	0	-0.008	-0.068	-0.340
Change to flood capacity	+8.25%	0.00%	0.06%	3.16%	7.23%

### 5.3 Implications for Council services

The implications of the trajectories on CGD services are set out in the following table. The key issue in these results are that there are two issues that come together in trajectories B1, B2, C1 and C2: more roads and drains, and the natural landscape and low-lying nature of the region itself. It can be assumed that most of the new roads will be council roads.

Anecdotal evidence from CGD officers is that the maintenance of roads and drains in the Green Wedge is at least double the cost of similar assets outside the Green Wedge, or more importantly in areas that are not former swamps and low lying regions.

We have assumed that for all assets a rate of \$4 million per hectare of increased development would apply. While this has some uncertainty, there would clearly be a significant investment required from council to accompany additional development. The fact that the construction and maintenance of these assets is more expensive than is normally associated with urban development, is an important consideration.

The higher value associated with the trajectory C2 (\$258 million capital investment) must be seen in the context of the whole Green Wedge, a 3,741 hectare region.

**Table 4. Council infrastructure and costs projections**

Council infrastructure	Future trajectory				
	A	B1	B2	C1	C2
Length of new road (km)	0	0	0	57	64
Length of existing road to be updated (km)	0	0	0	54	13
Estimate cost to construct new roads, including footpaths and drainage assets (\$ millions)	0	0	0	229	258
Estimated annual maintenance cost for maintaining roads, footpaths and drainage (\$ million / year) *	0	0	0	~18	~20

\* Maintenance rates to be confirmed by CGD

In addition to increased requirements for services under trajectories B2, C1 and C2, there are also likely implications for Melbourne Water and their maintenance of existing levees. As the number of dwellings downstream of a levee increases (as proposed in these trajectories) the consequence of a levee failure becomes higher and the current maintenance and management of existing levees may need to be reviewed.

## 5.4 Impact on land uses


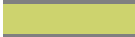

Based on the data above, and in light of the various issues and constraints of the region, the following table describes how each of the trajectories will influence the land uses of the region.

In most instances the rating of ‘improvement in value, stay the same or decline in value’, is based on a qualitative assessment rather than a quantitative assessment. In most instance the land use and zoning is a key driver for this rating.

The purpose of summarising the trajectories and their impact on the land uses is to not just focus on the water services and infrastructure, but consider the broader impact on land use and be clear that each trajectory has an impact on the values of the green wedge.

	Agricultural landuses / productivity	Flood storage and capacity	Commercial landuses and productivity	Public utilities and infrastructure	Rural residential land uses	Environmental uses in and adjoining the CGD Green Wedge	Adjoining residential and commercial land uses	Recreation and visual amenity uses
A (ecological and community scenario)	Decline in the value	Improvement in the existing value	Value stays the same	Improvement in the existing value	Improvement in the existing value	Improvement in the existing value	Improvement in the existing value	Improvement in the existing value
B1 - Current	Decline in the value	Value stays the same	Decline in the value	Decline in the value	Value stays the same	Decline in the value	Decline in the value	Value stays the same
B2 - Current with allowable development	Decline in the value	Value stays the same	Decline in the value	Decline in the value	Value stays the same	Decline in the value	Decline in the value	Value stays the same
C1 - 5ha subdivision	Decline in the value	Decline in the value	Decline in the value	Decline in the value	Value stays the same	Decline in the value	Decline in the value	Decline in the value
C2 - 1ha subdivision	Decline in the value	Decline in the value	Decline in the value	Decline in the value	Value stays the same	Decline in the value	Decline in the value	Decline in the value

	Improvement in the existing value
	Value stays the same
	Decline in the value

The points below explain why particular land uses and trajectories have been rated as increases, declines or stay the same.

### Trajectory A

- Agriculture – Less land will be available for agriculture, with potentially more water logged low lands.
- Flood storage capacity – Increases to more than offset the increased flows from upstream urban development. The assumption for this trajectory is that in the long term several of the existing levees may be decommissioned.
- Public infrastructure – This scenario will result in less reliance on and hence lower maintenance requirements for public roads and drainage infrastructure
- Rural residential – The scenario should result in improved rural residential outcomes in those areas with retained rural residential landuse.

### Trajectory B1 and B2

- Agriculture – With increased development upstream, and without a strong driver to increase the soil and land capabilities, and without the opportunity to install large scale processing facilities, a do nothing approach will see a decline in this value.
- Flood storage capacity – Would be maintained at current levels. However this would impact on adjoining (downstream land uses).



- Environmental uses – The current trajectory has seen a decline in value, and without a more interventionist approach this decline will continue. There is the possibility, without a significant push for restoration and rehabilitation in the region, that the remaining areas of red gums and the small biodiversity values would also decline.
- We would expect ongoing decline in the adjoining landuses associated with flood storage and water treatment areas not expanding to meet upstream development and climate change outcomes
- While B2 includes the building of up to 43 dwellings, which may have some minor influence on the rural residential land, B1 and B2 do not have any significant differences in their impact on any of the land uses.

### **Trajectory C1 and C2**

- Agriculture – Productivity is forecast to decline in value as more land is subdivided, and remaining land is impacted by stormwater runoff and associated drainage issues. This is applicable to both C1 and C2.
- Flood storage capacity – There is a decline in flood capacity as there is both less space in the green wedge due to more roads, and also increased flows from upstream development. This may also be exacerbated by the reduced impervious areas reducing the seepage rates into the soil.
- Rural residential – We would not expect a significant change to rural residential outcomes associated with water related issues.
- Environmental, public health and visual amenity uses – These will all decline as there would be a loss of green space.

## **6 Summary**

### **6.1 Summary of assessment**

While it is difficult to anticipate the nature of change and the impact on the local and regional environment in the year 2100, this paper presents a picture of alternate management arrangements, and their trajectories or influence on future water related land uses.

Trajectory B is likely to result in an ongoing decline or at best a status quo for each of the land uses assessed. Ongoing upstream urban development, climate change and the inherent swampy nature of the landscape will conspire to adversely impact on existing values. The costs to maintain the existing drainage and road network are high given their exposure to high water levels. The current level of road and drainage maintenance is insufficient to prevent the ongoing decline in this infrastructure. This option fails to capitalise on the potential value of the Green Wedge.

Trajectory C (C1 and C2) provides the greatest development opportunities. However there are limited broader beneficial community outcomes. Significant declines in flood storage and ecological outcomes would be associated with this trajectory. While there is no detailed modelling to assess the potential impact on flood storage and capacity, the C1 and C2 trajectories potentially could see a 5% reduction in flood capacity in the region. On top of this, there would be increased runoff from upstream development that adversely impact on downstream properties. The high ground water level and low lying elevation will require roads to be constructed on raised rural road type formation, and an associated drainage network constructed within the highly constrained drainage system. The provision of public utilities such as sewer, power, telecommunication and others will face severe limitations that are likely to require wider raised road formations to accommodate the provision of such services. This option in isolation fails to capitalise on the values of the Green Wedge.

Trajectory A provides for ecological, community and greater public good outcomes. The option links to adjoining Green Wedges and other corridors and capitalises on the values of and potential for the CGD Green Wedge. However the trajectory comes at the expense of available agricultural land and land use. A significant proportion of the CGD Green Wedge would be required to achieve the ecological and community outcomes, and may be progressively acquired or zoned over a long time frame (100 years).

## 6.2 Conclusions and recommendations

The CGD Green Wedge has a number of significant water related constraints that limit land use. These constraints include the very low elevation, potential acid sulphate soils, water logging of soils, poor water quality in waterways and creeks, poor surface drainage, flooding and land at risk of flooding in the event of levee failures. These constraints will be exacerbated by climate change (changes to rainfall, runoff and sea level) and ongoing upstream development that will increase runoff and reduce runoff quality. These constraints impact on the suitability of the CGD Green Wedge for many land uses.

However, these constraints also provide opportunities. In particular the constraints provide opportunity to enhance the ecological character and enhance and water related outcomes from the CGD Green Wedge for surrounding populations and greater Melbourne as a whole. The CGD Green Wedge provides opportunities for water related public utilities, flood mitigation, and water quality improvement. The CGD Green Wedge can provide opportunities for the protection and recovery of flora and fauna species and communities through direct habitat and linking corridors. And the CGD Green Wedge has potential to provide major recreation opportunities with potential for both a destination and a corridor with facilities that include parklands, active recreation facilities, wetlands and linking water related access (walking, cycling and horse riding) networks.

Further subdivision (e.g. Trajectory C1 and C2) and related industrial, commercial, urban and / or rural residential development of the CGD Green Wedge will be limited by the existing constraints of the land and will fail to capitalise on the opportunities provided by these constraints. Any such development would be costly in terms of construction and maintenance of suitable flood mitigation works, drainage works, wastewater discharge and roads. In light of the constraints and broader public good afforded by the CGD Green Wedge, we would not recommend this trajectory.

While the status quo (e.g. existing land use zoning controls under Trajectory B1 and B2) recognises the constraints on the land, and retains future options for the land, the status quo and its related trajectories fail to capitalise on the opportunities provided by the land and historic land use zoning. The maintenance of current land use controls and levels of management will result in an ongoing decline in some land uses including a decline in the road and drainage infrastructure. Trajectory B2 provides for the inclusion of an additional 43 dwellings within the CGD Green Wedge, consistent with existing planning controls. With appropriate planning and construction, these additional 43 dwellings could be developed with only a negligible impact on the existing and developing water related issues. However, such dwellings and households would be impacted by and / or at risk arising from these existing and developing water issues.

Based on the work completed in this series of papers, Alluvium recommends adoption of a pathway that recognises the constraints on the CGD Green Wedge and capitalises on the opportunities arising from these constraints. We recommend the adoption of a management approach based on Trajectory A, providing broader community benefits including flood mitigation and water quality improvement, an approach that enhances the ecological function and character of the land and provides for improved recreation and other social outcomes. This trajectory will not be easy and will require good leadership, effective engagement with all stakeholders and community, a robust debate, and sound public planning. However the outcome is achievable and with an appropriate plan and strategy could be achieved over a 30 to 100 year horizon. As a minimum, Trajectory A will require the retention of existing land use controls. These controls will be required to prevent development that close off and/ or further limit the potential associated with Trajectory A.

Further investigations and research is required to develop and implement a plan that achieves the wider community benefits associated with Trajectory A. The investigations and research should lie within an agreed framework and plan providing a practical pathway for implementation. Elements of such a plan should include cost assessments and opportunities for funding, planning and engagement requirements and risk assessments. Information gaps that will require further investigation include many of those set out in the gap analysis (paper 2) in Alluvium's series of papers. Priority investigations include:

- **Flooding and flood management:** Identification of the role of the CGD Green Wedge in flood management including:
  - CGD Green Wedge flood inundation mapping including an update of the land subject to inundation overlay (LSIO).
  - Flood risk assessment associated with levee failure
  - Impact of climate change (increased rainfall intensity and increased sea level rise) on flood inundation and risk
  - Impact of ongoing upstream development of flood inundation and risk
  - Identification of downstream flood management requirements, consistent with climate change predictions
  - Development of flood management alternatives and strategy consistent with Trajectory A
  - Economic evaluation of flood management and mitigation alternatives, consistent with Trajectory A
- **Water quality management:** Identification of the role of CGD Green Wedge in water quality management including
  - Existing water quality assessment, inputs, and outputs
  - Development of water quality targets for the CGD Green Wedge and discharges consistent with beneficial uses of the CGD Green Wedge and downstream receiving waters
  - Development of conceptual long term water quality management plan consistent with expected inputs, target outputs and Trajectory A.
  - Economic evaluation of water quality management alternatives consistent with Trajectory A
- **Drainage management:** Identification of the potential role of the CGD Green Wedge in reducing the drainage problems in adjoining residential, commercial and industrial lands including the mapping of existing drainage issues in and adjoining the CGD Green Wedge
- **Ecological management:** Identify the role and risks of the CGD Green Wedge in the provision of ecological habitat and corridors consistent with the existing and future constraints on the land, existing native species and opportunities associated with native species and ecological community recovery plans, including:
  - CGD Green Wedge flora and fauna surveys
  - CGD Green Wedge land and waterway condition assessment
  - CGD Green Wedge (land and water) suitability assessment for ecological recovery programs
- **Recreation:** Identify the role and risks of the CGD Green Wedge in recreation
  - Passive recreation and active recreation
  - As a destination and a network of links between nodes
  - For the local community and greater Melbourne
- **Funding models:** Identification and development of funding models and opportunities for the provision of integrated flood management, water quality management, drainage management ecological services and recreation outcomes.
- **Other:** Other related investigations should include, those that are likely impact on the delivery of the Trajectory A outcome and could include acid sulphate soil assessment and groundwater assessments for the CGD Green Wedge.

## 7 References

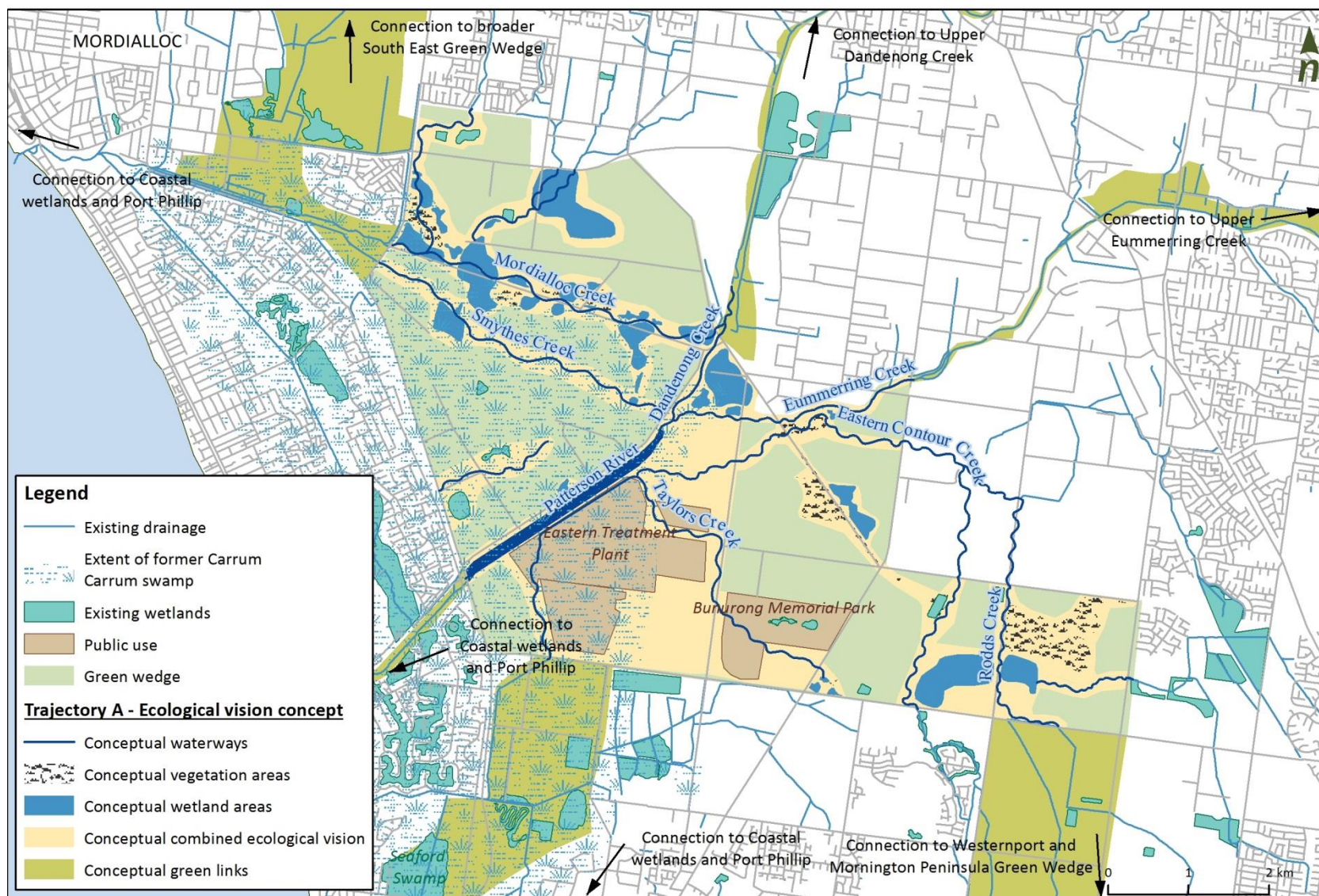
Alluvium, 2013a. South East Green Wedge - Water issues and constraints. Report for the City of Greater Dandenong, December 2013.

Alluvium, 2013b. Integrated Water and Pollutant Balance Study. Report for City of Greater Dandenong, November 2013.

Alluvium, 2013c. South East Green Wedge – Gap analysis. Report for the City of Greater Dandenong, December 2013.



## ATTACHMENT A – ECOLOGICAL VISION (TRAJECTORY A) – POTENTIAL CONCEPT



## Riparian corridor widths

The widths of the waterway corridors set out in Trajectory A have been based on three primary sources:

1. Melbourne Water 2013., Waterway Corridors; Guidelines for greenfield development areas within the Port Phillip and Westernport Region
2. Dept of Infrastructure Planning and Natural Resources. 2004., Riparian Corridor Management Study. Report to Wollongong City Council 2004
3. Knutson, K. L., and V.L. Naef. 1997 Management recommendations for Washington's priority habitats: riparian. Wash. Dept. Fish and Wildl., Olympia.

Waterway (riparian) corridors provide a number of roles. These include temperature control for the waterway, a source of large wood to stream systems, sediment filtration, pollutant filtration, erosion control, wildlife habitat and corridors. The width of corridor required for any particular stream is dependent on the specific outcome desired for the watercourse and the purpose of the corridor. The different purposes require different corridor widths.

Melbourne Water (2013) provides guidance to corridor purposes and minimum widths required for greenfield developments. However the document does not specifically address the riparian corridor requirements for agricultural areas and wetlands. Further the document identifies that the minimum widths may be increased to reflect site specific factors such as for biodiversity conservation, or where the corridor form an important part of an existing or potential high value habitat corridor. None the less Melbourne Water (2013) provides some guidance to the minimum riparian corridor width requirements. The minimum corridor widths on each side of the watercourse, for greenfield development sites are set out in Table A1:

**Table A1: Minimum watercourse corridor widths (adapted from Melbourne Water 2013)**

	Strahler stream order			
	1	2	3	4
<b>Existing waterways</b> -distance (metres) from reference point- approx top of bank	20m	20m	30m	40m
<b>Constructed waterways</b>	1 in 100 year flood flow extent			

As set out these are minimum setbacks or corridor widths for each side of the watercourse and do not take into consideration broader corridor purposes and requirements. Knutson and Naef (1997) reviewed the literature on watercourse corridors and identified that required for the range of riparian corridor functions. These are set out in Table A2.

**Table A2: Range and average widths from top of bank required to maintain a range of riparian zone functions (source Knutson and Naef, 1997).**

Riparian Habitat Function	Range of reported widths in metres	Average of reported widths in metres
Temperature control	11 – 46	27
Large woody debris	30 – 61	45
Sediment filtration	8 – 91	42
Pollution filtration	4 – 183	24
Erosion control	30 – 38	34
Microclimate maintenance	61 – 160	126
Wildlife habitat	8 – 300	188

The NSW Dept of Infrastructure Planning and Natural Resources (2004) recommended the greater of the 100 year flood extent and a minimum 50 metre set back from the top of bank, where the watercourse corridor was required for riparian habitat and or wildlife protection. The outcomes of the NSW Dept of infrastructure and planning (2004) assessment are set out in Table A3.

**Table A3. Recommended riparian widths from a range of sources in the US and Australia (source NSW DIPNR 2004)**

Function	Study	Details	Width (m)	Average	DIPNR RCMS	
Riparian Habitat Area	Washington State (2001)	Based on nearly 1500 reviews	46 – 76 or 100 yr floodplain	61	50	
	Wollondilly Shire Council (1998) DIPNR (2003)	Maintenance of ecological values Environmental corridor Category 1 stream	50 - 100 40 plus 10 vegetated buffer	75		
Wildlife Protection	Rabeni (1991) Cross (1985) Brown et al (1990)	Fish, amphibians, birds Small mammals Provision of food, water, cover	8 – 61 9 - 18 91 – 183	62	50	
	Wollondilly Shire Council (1998) DIPNR (2003)	Wildlife corridor Environmental corridor Category 1 stream	100 - 200 40 plus 10 vegetated buffer			150
	Riding & Carter (1992)	Minimum for most birds & mammals	80 - 100	90		
	NSW Fisheries (1998)	Precautionary approach to protection of fish habitats	50 - 100	75		
Fish, Marine Vegetation and Aquatic Habitats	Riding & Carter (1992)	Protection of stream environment from forest operations	30			
Water Quality	Ahola (1990) Pinay & Decamp (1988) Correll & Weller (1989) DIPNR (2003)	General improvements As above Nitrate control Nutrient control Category 3 stream	49 1 – 2 18 10 no buffer	33	10	
	NSW Native Vegetation Reform Implementation Group (Wentworth Group) (2003)	Major rivers Creeks Streams	50 – 100 20 – 50 10 - 20			75 35 15
Sediment control	Peterjohn & Correll (1984) Riding & Carter (1992)	Nutrient control Protection from sediment & fertiliser (from Victorian DEC 1990)	18 30			
	Riding & Carter 1992	Sedimentation control (from Victorian SR & WSC 1982)	20			
	DIPNR (2003)	Category 3 stream	10		10	
Bank Stabilization	Ontario Ministry Agriculture (1998) DIPNR (2003)	Agricultural ditch bank stabilization Category 3 stream	3 10		10	
Urban stream buffer	Schueler (1995)	Survey of 36 buffer programs	6 – 61	33	30	
	DUAP (1999)	Vegetated buffer from urban development	100 existing bushland 40 elsewhere	40		
	Illawarra Commission of Inquiry (1999) Wollongong City Council (2000)	Vegetated buffer from urban development DCP No 99/7 vegetated buffer from urban development	40 40			
	DIPNR	Terrestrial habitat Category 2 stream	20 plus 10 vegetated buffer			
Native Vegetation Conservation	Benson & Howell (1993)	Conservation of native riparian vegetation	50			

In the absence of specific guidance, and reflecting some generalised ecological corridor requirements, we have adopted corridor widths for the CGD Green Wedge Trajectory A as being the larger of:

1. 50 metres from the top of bank on each side of the watercourse
2. The 1 in 100 year flood extent

The riparian corridor widths required and adopted for the CGD Green Wedge should reflect the intended purpose of the waterways and their riparian zone. This will require further investigation to define the habitat and corridor width requirements for target species including those species that may form part of ecological recovery programs.