Technical Memorandum:
Review of MW Proposed DSS for Casey Fields South (Employment) and Devon Meadows PSPs – Supplementary Submission 1

Date: 28/05/2025

Project Number: 2101096, 2102129, 2300328

Project Name: **Casey Fields South (Employment) & Devon Meadows PSP drainage strategy consultation**

Authors: [redacted]

Reviewer: [redacted]

Version: 1

1. OVERVIEW

- Beveridge Williams (BW) have been commissioned by Villawood Pty Ltd, Pask Group and [redacted] and [redacted] of 1805 South Gippsland Highway to provide specialist water resources engineering advice during the consultation phase for the Casey Fields South (Employment) & Devon Meadows precinct structure plan (PSP) drainage strategy.
- BW have provided a previous submission containing a preliminary review of the proposed drainage strategy which identified the following concerns:
    1. Insufficient evidence had been provided justifying the diversion proposal especially in the context of significant unknowns around how the additional flood and volume directed to Clyde South will be managed in the interim (current condition) and how much additional burden in the form of additional waterway and basin reserve and other assets will be placed on the owners and residents of future Clyde South PSP area;
    2. There was a lack of detail around how Casey Fields South PSP area would outfall, especially in the absence of sufficient drainage downstream. There is the potential for significant impact to the residents of Clyde South and it is not clear what interim measures will be required here;
    3. How difficult aspects of the design such as excessive cut and fill requirements, groundwater issues and more could be managed; and
    4. No clear justification in the reporting as to why the existing waterways though Devon Meadows could not be utilised.
- BW scope is to:
    1. Quantify what would have been required for Clyde South drainage at a high level following typical DSS principles to be used as a baseline and identify any potential issues for implementing this strategy;
    2. Incorporate the proposed diversion and quantify the impacts to Devon Meadows, Casey Fields South and Clyde South PSPs;
    3. Investigate the implications of the new ARR2019 version 4.2 climate change requirements on the strategy at a high level; and
    4. Propose some high level solutions aimed at addressing any identified issues.
- To address this scope the following work has been completed:
    1. Additional hydrological modelling including climate change sensitivity testing
    2. High level terrain analysis relying on 1m gridded LiDAR supplied by MW
    3. Preparation of 3 scenarios based on the additional analysis:

- **Scenario 1 (S1) – Base Case**: developed using SSP2-2100 climate change and typical DSS principles to use as a baseline for comparison. Basin and waterway configuration in Devon Meadows and Casey Fields was generally in line with GHD's concept but levels adjusted where possible to work in more closely with the existing terrain.
- **Scenario 2 (S2) – Diversion Case**: GHD diversion added to the base case and adjustments made to diversions and basins to ensure that all the general objectives were still met
- **Scenario 3 (S3) – BW Concept**: An alternative approach aimed at addressing the identified issues in a way that is more cost effective and sensitive to other constraints

- Noting time constraints, it has not been possible to compile a formal report on work completed to date. Instead, an overview of analysis undertaken and the results are summarised in sections below.

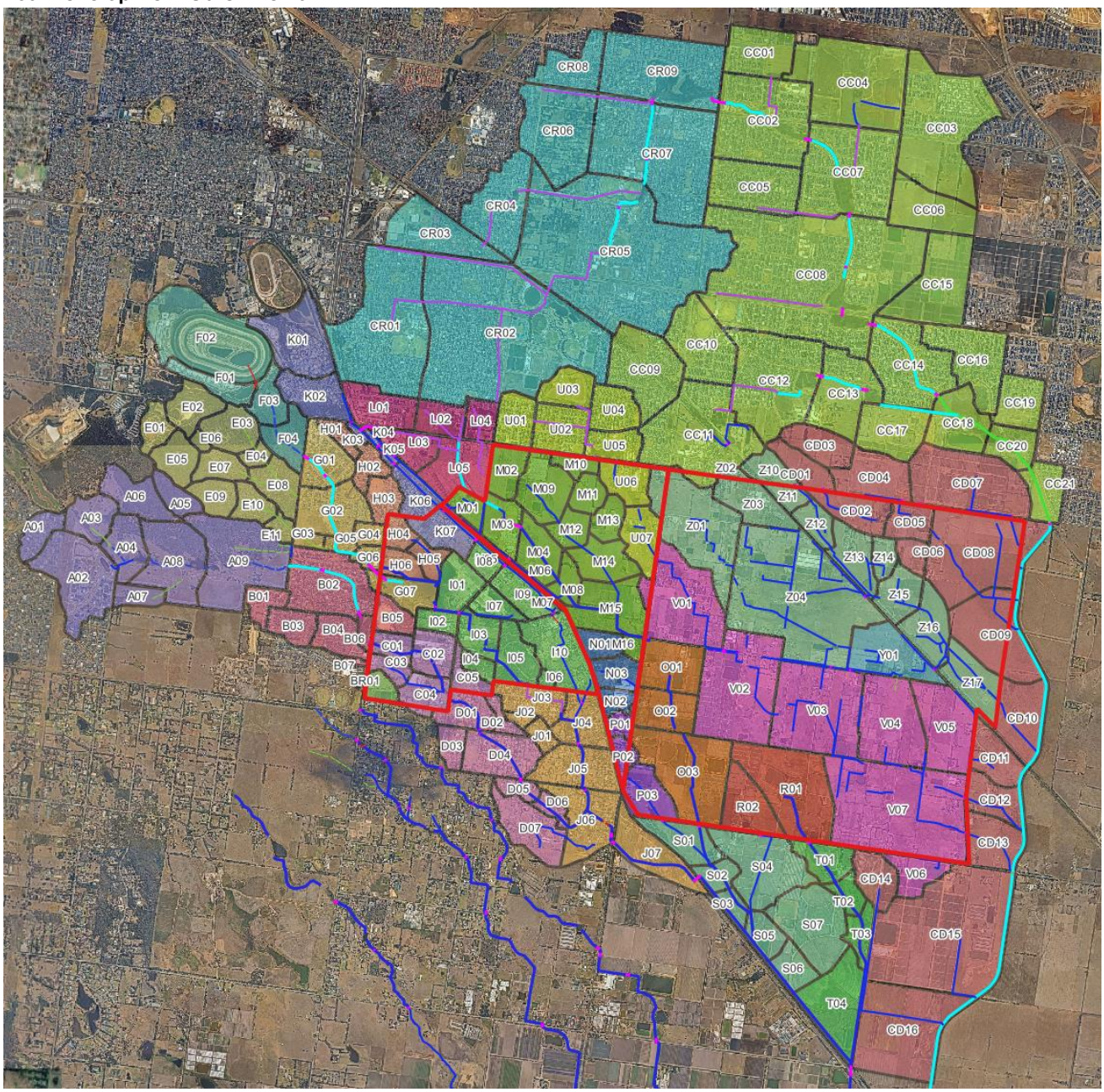
2. ADDITIONAL HYDROLOGICAL MODELLING

- Additional hydrological modelling was completed using WBNM as applied in the DRAINS software package. WBNM is a storage routing model similar to RORB and has the same underlying approach to hydrograph estimation. The reason for this change was to enable our design team to work more swiftly.
- The study area was expanded to cover the catchment area presented below and 5 scenarios were set up:
    1. Pre-development scenario: Land use based of 2014 aerial photo (i.e. excluding Botanic Ridge PSP and Basins) and used to test the model parameter calibration against the RFFE, Nikolaou/Vont Steen Eqn., MW Rule of Thumb, and previous modelling by Cardno in "Casey Flood Mapping – Christies Drain, Wylies Drain and Quail Inlet" 2021 and by Neil Cragie in "Thompsons Road PSP 53 and Clyde Creek PSP 54 Stormwater Management Strategy" 2013.
    2. Existing scenario: Land use updated to 2025 effectively including Botanic Ridge, Junction Village, and Clyde north of Ballarto Road as developed. Basins were incorporated into the model based on information supplied by MW including plans, reports and LiDAR as well as detailed aerial photography. Note that the final basins proposed under the Clyde Creek DSS were excluded for now and their impervious area retained as farmland due to time constraints.
    3. 3 Development Scenarios as noted above.
- A range of parameter sets were tested including the default recommended ARR settings with both TIA and EIA approaches and the adopted settings in GHDs strategy report. All of the tested parameter sets gave reasonable comparison with the calibration points, with the default parameters giving the most reasonable results. It is noted that GHDs parameter selection also gave reasonable results within the range of options tested.
- The final selected parameter set was:
    1. TIA approach (more conservative than the EIA approach)
    2. Default IL/CL parameters (25mm | 4.6 mm/hr)
    3. 75% preburst
    4. ARF 0.97 (highest of the ARF range covering the PSP area)
    5. Impervious assumptions directly from MW Flood Mapping technical specification (AM STA 6200)
    6. WBNM C value of 1.6 (recommended for ungauged catchments)
- The reason for selecting the above parameters in favour of GHDs results was primarily due to the new climate change requirements where IL, CL, Preburst and Rainfall depth are all adjusted and it was assumed that the supplied climate adjustment factors on the ARR Datahub would work best with default values. This should be further tested in future modelling to see how sensitive climate assessments are to initial parameterisation.
- Additionally, in GHD's report, informal storages were identified in the Botanic Gardens and incorporated into the modelling. Upon review of the data, BW believe that while these storages exist, the effects of these storages are far less than as modelled by GHD and are currently undertaking our own modelling to assess the sensitivity of the catchment response to these storages. In the interim, they have been

excluded from the modelling for a more conservative assessment. This should be further reviewed and refined.

- In general, BW's model compares well under ARR2019 assumptions when validated against previous studies with the exception of GHD's Devon Meadows RORB model, primarily due to different assumptions in the Botanic Gardens and Racecourse Areas.
- The model was then subjected to the following climate change scenarios:
    1. Current Climate (SSP2 – 2030)
    2. Best Case (SSP1 - 2100)
    3. Do nothing scenario (SSP2 – 2100)
    4. Worst Case (SSP3 – 2100)
- It is noted that SSP5 was not considered in detail as the general consensus in the scientific community is that this scenario is no longer realistic/extremely unlikely due to the progress made on climate change in the last decade.
- The conclusions of the climate assessment can be summarised as follows:
    1. Significant increases in flow rates and runoff volume occur as a result of climate change. There is variability in catchment response dependent on impervious cover and how existing basins respond. Change in flow rates can be anywhere between 40%-70% increase in flows on the predevelopment catchment under the SSP2-2100 climate projection.
    2. In general
        - Current Climate (SSP2-2030) and SSP1-2100 1% AEP is roughly equivalent to a 2019 1 in 200 AEP
        - SSP2-2100 1% AEP is roughly equivalent to a 2019 1 in 500 AEP
        - SSP3-2100 1% AEP is roughly equivalent to a 2019 1 in 1000 AEP
        - SSP5-2100 1% AEP is roughly equivalent to a 2019 1 in 2000 AEP
    3. These increases in flows result in a reduction in level of service to existing assets along the lines of:
        - Assets designed to cater for a Major Storm in 2019 (1% AEP) will have already had a decrease in level of service to 2% AEP by 2030 (SSP2-2030) and can be expected to reduce further to a 5% AEP level of service under the SSP2-2100 projection. Under SSP3-2100 this would be a 10% AEP level of service.
        - Assets designed to cater for a Minor Storm in 2019 (20% AEP) will have already had a decrease in level of service to 0.5EY by 2030 (SSP2-2030) and can be expected to reduce further to a 50% AEP level of service under the SSP2-2100 projection. Under SSP3-2100 this would be a 63.2% AEP level of service.
- For the purposes of the concept design SSP-2100 was adopted with some high level sensitivity testing done using SSP3-2100

Post Development Catchments



3. SCENARIOS ASSUMPTIONS

- For **Scenario 1**, the following assumptions were made:
    1. The intent of scenario 1 was to generate an impartial concept layout following clear principles that can be used as a baseline for assessing future proposals and identifying overall issues. It is noted that there are other potential basin and waterway alignments and configurations that could be explored here.
    2. Retarding basins were required at all PSP boundaries including where Casey Fields discharges to Clyde South.
    3. Basins in Devon Meadows and Casey fields were located generally in line with GHD's strategy (without the diversion). It is noted that the Devon Meadows basins were accidentally renamed and it would take too long to update all modelling to align with GHDs plan at this stage of the process. The names used in this memorandum align with BW's scenario layout plans.
    4. Basin locations in Clyde South were generally positioned to provide wetlands per 100ha catchment (note, central wetland reserves on waterways are assumed to be offline in the reserve with a wetland on each side of the channel) with sizes based on 5% of catchment area to accommodate sediment pond, macrophyte area, dry out area and ancillary requirements such as batters.
    5. End of line reserves upstream of Yallambee Road and Manks Road are proposed to incorporate retarding storages except where some catchment reduction/redirection has occurred (e.g. YR2)
    6. Retarding basins in Casey Fields and Clyde South were sized to retard the SSP2-2100 flows back to an existing case flow also derived using the same climate projection where Devon Meadows was further restricted to achieve ARR2019 targets at the outfalls to protect downstream dwellings. Additionally, the basin draining to the existing Ø1350 pipe was limited to the capacity of this pipe to protect homes along Facey Road.
    7. Footprints for the WLRB are based on storing the RB volume at somewhere between 1-2m deep to restrict filling and large embankments as much as possible. Levels were adjusted to try and achieve a reasonable cut where practical.
    8. It was assumed that wetland inverts could be lowered to 0.5m below the discharge point.
    9. On Devon Meadows and channel WDB (Wylies Drain B) though Clyde South, groundwater was generally 0.5-1m below ground surface based on the supplied groundwater data. Along the future Moore Road Catchment, it is assumed that groundwater level would be lower as the soil and aquifer type are different and the monitoring well near CFS4 indicates groundwater depths of 4-5m below surface level. It is noted that the available monitoring is coarse and much more investigation is required to confirm groundwater levels in all 3 precincts.
    10. Waterway alignments were placed generally in line with where existing waterway alignments are (or remnants of where disturbed by the land use). Some relocation in flatter areas was made to push the waterway to the site boundary, but not onto properties that did not already have a waterway.
    11. Discharge levels for Devon Meadows and Clyde South were based on existing LIDAR levels. It was assumed that the channels would be lowered though Clyde south, where possible, to allow the discharge levels basins CFS3 and CFS4 to be lowered as well relative to the existing terrain.
    12. Channels were sized to try and keep the depth from invert to freeboard level generally at 2.0m or below, incorporating 600mm freeboard.
    13. It is noted that the estimated reserves are indicative only, and BW are in the process of creating some 3d surfaces to get more accurate estimates of footprint, cut and fill etc.

- For **Scenario 2**:
    1. The diversion channel is added and sized to divert the SSP2-2100 1% flow to Clyde South along the alignment proposed by GHD.
    2. Basins on DM were resized to allow discharging at the SSP2-2100 1% existing flow rates.
    3. The channels on Clyde South and basin MR1 were reassessed keeping to the same requirements for basin/channel estimates in scenario 1

- For **Scenario 3**:
    1. It is proposed that MW acquire some additional land along Wylies Drain Main Branch and Branch F through existing Devon Meadows and is sized to convey the SSP-2100 1% flow with some freeboard
    2. Basins in Devon Meadows are resized to discharge at the SSP2-2100 1% existing flow rates.
    3. Retrofit/redesign occur to some of the upstream basins to adapt them to be effective under the SSP2-2100 climate conditions and not overtop the roads in a major event
    4. A significant redesign of the Quarry basin is proposed to provide additional storage and treatment for upstream areas.
    5. In Clyde South, 600m of external waterway is acquired so that the Moores Road Drainage network can tap into the Contour Drain, lowering the network by 1.5m.
    6. Problem areas of the Clyde Five Ways DSS are redirected into the Moores Road DSS leveraging the additional depth to more efficiently convey and store water as it passes through the precinct.

- Markups of the 3 scenarios are presented below along with summary tables of key data

Due to size and location, DM2 will be very difficult to build either impacting groundwater or posing a huge dam failure risk to DS properties

School has filled the existing waterway and replaced with culverts

Pavillion RB overtops Ballarto Road under SSP2-2100

Excess Flows above Pipe Outfall Capacity Routed to DM3

This area is addressed under Clyde Creek DSS

Unattenuated Flows from Existing Development Proposed to Bypass Quarry RB, causing additional storage requirement at DM2

Acacia RB overtops road under SSP2 1% AEP

Basins need to restrict flows to 2019 climate to prevent worsening of flooding downstream resulting in huge basins under SSP2-2100 climate.

Existing Ø1350 Pipe only has capacity for approx 3.8 cumec

Existing Channel Capacity is Approx 20% AEP under 2019 Climate. Relies on development upstream going ahead to maintain this level of service. Flows exceeding channel capacity affect existing homes in pre-development conditions

Landowner has filled and piped the channel, reducing capacity to somewhere between 1.3 and 5 cumec (depending on what actually ended up being built). 1% AEP (2019 Climate) here is estimated to be around 28.8 Cumec

Discharging under Manks Road and Yallambee Road at existing levels in these locations results in probably needing to fill upstream areas by at least 2m. Due to the terrain, this fill would be required over a significant area resulting in significant increases in development cost. Additionally, these roads would need to be raised by 1.5m or more to secure flood free roads in the 1% AEP and get sufficient culverts underneath. The concern is that developers would be unable to afford the required works and no outfall could be built, effectively preventing Clyde Five Ways Road DSS and Moores Road DSS from progressing

Pavillion
Ballarto Road
Junction Village
JV_OF_1
MD_1
CFS1
CFS2
CFS3
WDB_1
WDB_2
Clyde Five Ways Road
MD_2
YR4
CT_2
CT_1
YR3
Yallambee Road
CT_3
YR2
YR5
JV_1
Craig Road
Quarry
WDF_1
CFS4
MD1
Moore Road
Acacia West
Acacia East
Devon Rd
DM2
DM3
WDA_1
MD_3
MD2
DM1
DM4
Facey Road
Browns Road
MD_4
WDB_4
YR1
Finsbury Rd
MR3
MR1
MR2
South Gippsland Highway
Manks Road
Worthing Road
Fisheries Road

Scenario 1 - Base Case

- PSP Boundaries
- Cadastre
- LSIO (Out of Date)
- Indicative WQ Catchments
- Retarding Basin
- Wetland
- Combined WLRB
- Upstream Basin
- Indicative Waterway Reserve
- External Drainage/Waterways
- Locations for Flow Control

Imagery from Nearmap - Feb 2025

0 0.25 0.5 0.75 1 km

N

Diversion will probably require 60m wide waterway downstream of the highway. DIV_3 and DIV_4 pass through the area where known indigenous artifacts were found

Waterway needs to be upgraded to convey additional flows, probably to 60m wide and also deeper as well, potentially increasing fill across the precinct

Pushing the channel through the hill requires up to 10m cut, so reserve width here could reach as wide at 100m including batter to existing significantly increasing construction cost. We were only able to raise by 0.5m due to level constraints so this has all the issues identified in the preliminary submission

The diversion allows DM2 and DM3 to be significantly reduced

Its not clear what happens in extreme storms when capacity exceeds the channel. Will this be directed into Existing Devon Meadows?

While channel redirection improves the expected flow rates in existing Devon Meadows, due to timing and climate change, peak flow discharging via Wylies Drain Main Branch under SSP-2100 1% AEP is still expected to reach 18 cumec, meaning these properties will still be flood affected in the major event

Basin volume blows out by approximately 450,000 cu.m to accommodate additional flood volume from the Devon Meadows catchment. Note that the Devon Meadows catchments are approximately 2.5 times bigger than what naturally drains here, so this volume all needs to be stored so that peak flows can be discharged to downstream at pre-dev flow rates. The increase in land take would probably exceed reductions in Devon Meadows upstream

Issues with Yallambee Road unaddressed in this proposal meaning some of Casey Fields Precinct cannot be progressed

Scenario 2 - Diversion

- PSP Boundaries
- Cadastre
- LSIO (Out of Date)
- Indicative WQ Catchments
- Retarding Basin
- Wetland
- Combined WLRB
- Upstream Basin
- Indicative Waterway Reserve
- External Drainage/Waterways
- Locations for Flow Control

Imagery from Nearmap - Feb 2025

0 0.25 0.5 0.75 1 km

N

Redesign Junction Village WLRB outfall for SSP2-2100 1% AEP and redirect around school

Networks to rejoin DS of school at start of Waterway

Upgrade RB outfall and provide additional 500mm fill (min) on south side to adjust to meet SSP2-2100

Consolidate water assets into 1 large reserve (wetlands can be split in reserve area to prevent size being too large). Leverage lower channel to maximise storage reducing impact to downstream Clyde South

New 45m wide waterway diversion connecting Wylies Drain Branch B to the Moore Road Drain via shortest alignment. Alternative alignments and locations of CFS4 are possible, but would probably increase cost and land take

Existing School Drainage to only take local flow and overflow from the Junction Village WLRB, reducing risk to the School

Deeper channel allows additional flows to be accommodated without increase in reserve width. Would also reduce fill requirements to adjacent development

Redirect this catchment and the existing outfall from Old Junction Village to the Quarry WLRB. Redesign the WLRB to more effectively utilise the reserve area

Lower basin YR1 allows additional flows from Casey Fields to be absorbed, while also reducing top basin level by around 1.2m, significantly reducing cost of development in this area

Provide an additional outfall and overflow weir from Acacia East to WDA_1 to prevent overtopping of Craig Road in SSP2-2100 1% AEP

Post development catchment redirected to Moore Rd Catchment to minimise flows draining to Manks Road

Upgrade existing waterways from ~6-8m wide to 12m wide and 1.5m deep (to convey approx 12.5 cumec) upstream of the confluence and 15m wide and 1.8m deep downstream of the confluence. This would convey the 1% AEP (SSP2-2011) with 300mm freeboard to top of channel providing improved flood protection to existing properties and protecting against climate change. We believe this could be done by only acquiring 2 properties on Fisheries Road and improving/upgrading access to a further 17 along the channel alignments

Reduced catchment area means that peak discharge requirement can be met without a RB, lowering levels significantly and meaning less raising of Manks Road is required, and less fill/development cost

Acquire 600m waterway connection to the Western Contour Drain/Clyde Creek. This would allow the entire Moore Road Drainage network to be lowered by approx 1.5m

Scenario 3 - BW Concept

- PSP Boundaries
- Cadastre
- LSIO (Out of Date)
- Indicative WQ Catchments
- Retarding Basin
- Wetland
- Combined WLRB
- Upstream Basin
- Indicative Waterway Reserve
- External Drainage/Waterways
- Locations for Flow Control

Imagery from Nearmap - Feb 2025

0 0.25 0.5 0.75 1 km

N

Flow Rate Summary

LOCATION	EXISTING 1% (2019 RF)	EXISTING 1% (SSP2-2100)	PROPOSED 1% (SSP2-2100) NO BASINS	PROPOSED 1% (SSP2-2100) SCENARIO 1	PROPOSED 1% (SSP2-2100) SCENARIO 2	PROPOSED 1% (SSP2-2100) SCENARIO 3
DM1	12.8	17.5	14.5*	9.9**	10.0	11.4
DM2	11.0	18.5	26	3.7***	24.5	Redirected to DM3
DM3	5.5	10.2	23.7	4.7***	10.1	11.6****
DM4	0.75	1.3	3.4	0.74**	0.74**	0.74**
CFS4	14.6	22.0	43.4	22.6	17.9	7.85
CFS3	5.1	8.6	11.6	6.3	6.3	6.0
MR1	16.2	24.7	38.9	23.5	24.2	24.0
MR2	4.9	6.6	27.2	6.6	6.6	6.6
YR1	11.9	18.4	55.1	18.4	18.4	18.4
YR2	8.4	13.7	12.9	12.9	12.9	12.9
YR3	6.0	9.8	51.3	9.3	9.3	9.3
YR5	18.3	29.8	38.2	18.3	18.3	18.3

Note: * Acacia WLRB upstream provides reasonable attenuation in the SSP2 scenario but causes overtopping of Craig Road.

** Flow target is existing 1% (2019 RF) to protect homes in Scenario 1 for Devon Meadows Basins DM1, DM3 and DM4

*** Flow target in Scenario 1 is 3.8 cumec for DM2 which is approximately the capacity of the existing Ø1350mm pipe flowing full under gravity

****Flow rate target assessed downstream of the confluence of DM2 and DM3 with upstream channel upgraded to fully contain this flow

Basin Reserve Summary S1

Precinct	Asset Name	Type	Estimated Wetland Reserve (ha)	Estimated 1% AEP Storage (cu.m)	Estimated Drainage Reserve Area(ha)
Casey Fields South Employment	CFS1	WL	2.6	0	2.6
	CFS2	WL	3.3	0	3.3
	CFS3	WLRB	1.65	22000	2
	CFS4	WLRB	4.5	75000	7
Clyde South	MD1	WL	3	0	3
	MD2	WL	6	0	6
	MR1	WLRB	3.5	27000	4
	MR2	WLRB	4	25000	4
	MR3	WL	1.4	0	1.4
	YR1	WLRB	9	120000	13
	YR2	WL	1.55	0	1.55
	YR3	WLRB	10	72000	10
	YR4	WL	1.5	0	1.5
	YR5	WL	5	0	5
Devon Meadows	DM1	WLRB	2.6	35000	3.4
	DM2	RB		135000	16
	DM3	WLRB	8.5	135000	10
	DM4	WLRB	3.5	2300	3.5

Basin Reserve Summary S2

Precinct	Asset Name	Type	Estimated Wetland Reserve (ha)	Estimated 1% AEP Storage (cu.m)	Estimated Drainage Reserve Area(ha)
Casey Fields South Employment	CFS1	WL	2.6	0	2.6
	CFS2	WL	3.3	0	3.3
	CFS3	WLRB	1.65	22000	2
	CFS4	WLRB	4.5	75000	7
Clyde South	MD1	WL	3	0	3
	MD2	WL	6	0	6
	MR1	WLRB	3.5	480000	25
	MR2	WLRB	4	25000	4
	MR3	WL	1.4	0	1.4
	YR1	WLRB	9	120000	13
	YR2	WL	1.55	0	1.55
	YR3	WLRB	10	72000	10
	YR4	WL	1.5	0	1.5
	YR5	WL	5	0	5
Devon Meadows	DM1	WLRB	2.6	35000	3.4
	DM2	WLRB	4	25000	4
	DM3	WLRB	4.5	29000	4.5
	DM4	WLRB	3.5	2300	3.5

Basin Reserve Summary S3

Precinct	Asset Name	Type	Estimated Wetland Reserve (ha)	Estimated 1% AEP Storage (cu.m)	Estimated Drainage Reserve Area(ha)
Botanic Ridge	Quarry	WLRB	3.8	100000	8
Casey Fields South Employment	CFS3	WLRB	1.65	22000	2
	CFS4	WLRB	10.4	200000	14
Clyde South	MD1	WL	3	0	3
	MD2	WL	6	0	6
	MR1	WL	2.8	0	2.8
	MR2	WLRB	4	25000	4
	MR3	WL	1.4	0	1.4
	YR1	WLRB	9	225000	13
	YR2	WL	1.55	0	1.55
	YR3	WLRB	10	72000	10
	YR4	WL	1.5	0	1.5
	YR5	WL	5	0	5
Devon Meadows	DM1	WLRB	2.6	35000	3.4
	DM2&3	WLRB	7	155000	10.5
	DM4	WLRB	3.5	2300	3.5

Waterway Summary S1

Name	Section	Precinct	Approximate Length (m)	Design Flow Rate (cumec)	Minimum Reserve Width	Estimated Reserve Area (ha)
CT (Clyde Township)	1	Clyde South	1100	24	45	4.95
	2	Clyde South	610	3.5	30	1.83
	3	Clyde South	1300	18.3	45	5.85
JV (Junction Village)	1	Devon Meadows	1100	9.4	40	4.40
JV_OF	1	Casey Fields South Employment	210	18	45	0.95
MD (Moore Road Drain)	1	Casey Fields South Employment	1050	11	45	4.73
	2	Clyde South	1100	21	45	4.95
	3	Clyde South	1550	31	60	9.30
	4	Clyde South	1900	31	60	11.40
MR3_OF	1	Clyde South	170	11.6	45	0.77
WDA (Wylies Drain A)	1	Devon Meadows	800	10.8	45	3.60
WDB (Wylies Drain B)	1	Casey Fields South Employment	930	21	45	4.19
	2	Casey Fields South Employment	500	31	45	2.25
	3	Casey Fields South Employment	170	45	55	0.94
	4	Clyde South	1800	22.3	45	8.10
WDF (Wylies Drain F)	1	Devon Meadows	970	27	45	4.37

Waterway Summary S2

Name	Section	Precinct	Length	Design Flow Rate (cumec)	Minimum Reserve Width	Estimated Reserve Area (ha)
CT (Clyde Township)	1	Clyde South	1100	24	45	4.95
	2	Clyde South	610	3.5	30	1.83
	3	Clyde South	1300	18.3	45	5.85
DIV (Diversion Channel)	1	Devon Meadows	800	10	45	3.60
	2	Devon Meadows	570	30.3	45	2.57
	3	Devon Meadows	550	38.2	60	3.30
	4	Clyde South	550	38.3	55	3.03
JV (Junction Village)	1	Devon Meadows	1100	9.4	40	4.40
JV_OF	1	Casey Fields South Employment	210	18	45	0.95
MD (Moore Road Drain)	1	Casey Fields South Employment	1050	11	45	4.73
	2	Clyde South	1100	21	45	4.95
	3	Clyde South	1550	31	60	9.30
	4	Clyde South	1900	31	60	11.40
MR3_OF	1	Clyde South	170	11.6	45	0.77
WDA (Wylies Drain A)	1	Devon Meadows	800	10.8	45	3.60
WDB (Wylies Drain B)	1	Casey Fields South Employment	930	21	45	4.19
	2	Casey Fields South Employment	500	31	45	2.25
	3	Casey Fields South Employment	170	45	55	0.94
	4	Clyde South	750	22.3	45	3.38
	5	Clyde South	480	52.5	60	2.88
WDF (Wylies Drain F)	1	Devon Meadows	1080	27	45	4.86

Waterway Summary S3

Name	Section	Precinct	Length	Design Flow Rate (cumec)	Minimum Reserve Width	Estimated Reserve Area (ha)
CT (Clyde Township)	1	Clyde South	1100	24	45	4.95
	2	Clyde South	610	3.5	30	1.83
	3	Clyde South	1300	18.3	45	5.85
MD (Moore Road Drain)	1	Casey Fields South Employment	1050	11	45	4.73
	2	Clyde South	1100	21	45	4.95
	3	Clyde South	1550	45	60	9.30
	4	Clyde South	1900	45	60	11.40
	5	External	540	18.6	60	3.24
MR3_OF	1	Clyde South	200	11.6	45	0.90
WDA (Wylies Drain A)	1	Devon Meadows	800	12	45	3.60
	2	Existing Devon Meadows	2100	12.5	12	2.52
	3	Existing Devon Meadows	325	26	15	0.49
WDB (Wylies Drain B)	1	Casey Fields South Employment	1050	22	45	4.73
	2	Casey Fields South Employment	950	30.5	45	4.28
	3	Clyde South	720	8	45	3.24
WDF (Wylies Drain F)	1	Devon Meadows	1360	18	45	6.12
	2	Existing Devon Meadows	1250	13	12	1.50

Preliminary Estimates of Land Allocated to Drainage Summary

Scenario 1	Total Area (ha)	Basin Reserve Area		Waterway Reserve Area		Total Reserve Area	
		ha	%	ha	%	ha	%
Devon Meadows	258.5	32.9	12.7	12.4	4.8	45.3	17.5
Casey Fields	272.5	14.9	5.5	13.0	4.8	27.9	10.3
Clyde South	1044.2	49.5	4.7	47.2	4.5	96.6	9.3
TOTAL	**1575.2**	**97.3**	**6.2**	**72.6**	**4.6**	**169.8**	**10.8**

Scenario 2	Total Area (ha)	Basin Reserve Area		Waterway Reserve Area		Total Reserve Area	
		ha	%	ha	%	ha	%
Devon Meadows	258.5	15.4	6.0	22.3	8.6	37.7	14.6
Casey Fields	272.5	14.9	5.5	13.0	4.8	27.9	10.3
Clyde South	1044.2	70.5	6.7	48.3	4.6	118.8	11.4
TOTAL	**1575.2**	**100.8**	**6.4**	**83.7**	**5.3**	**184.4**	**11.7**

Scenario 3	Total Area (ha)	Basin Reserve Area		Waterway Reserve Area		Total Reserve Area	
		ha	%	ha	%	ha	%
Devon Meadows	258.5	17.4	6.7	9.7	3.8	27.1	10.5
Casey Fields	272.5	16.0	5.9	13.7	5.0	29.7	10.9
Clyde South	1044.2	48.3	4.6	45.7	4.4	93.9	9.0
External*		8.0**		4.5***		12.5	
TOTAL	**1575.2**	**81.7**	**5.2**	**71.4**	**4.5**	**155.3**	**9.9**

Note: * Existing Waterways in Downstream Devon Meadows and the proposed Quarry Lake in Junction Village

** External Basin excluded from land take estimate as it is already owned by Melbourne Water

*** Half of the downstream channel has been excluded from land take estimate as it is already part of the existing waterway

4. Issues Summary

Scenario 1:

- Critical Issues:
    1. Significant basin volumes are required in Devon Meadows to try and maintain existing flood conditions on properties within the LSIO downstream within existing Devon Meadows. It should be noted that the existing channels have been degraded to a point where they only convey a minor storm (except for at the Fisheries Rd outfall where the existing landowner has further reduced the system capacity by filling/piping the channel) and that these properties will be worse off if development does not proceed, as increasing climate risk could result in a situation where these properties are uninsurable.
    2. Due to the existing terrain, DM2 will be extremely difficult to build due to the significant fall when compared with the required storage volume. There is a high groundwater table here which would make lowering the basin below ground level difficult. Raising the basin however creates a situation where a significant volume of water (approx. 135,000 cu.m) is perched above existing homes. If this embankment were to fail, it could pose serious risk to downstream properties.
    3. The proposed discharge point of the Clyde Five Ways Rd DSS at Manks Road is extremely flat, with the current road level only around 0.8 - 1m above the waterway invert. The area here has a natural grade of 0.4% (1 in 250) which extends nearly 1500m along the proposed channel alignment. The groundwater here is expected to be high, based on the supplied geotechnical information, meaning that constructing a WLRB here plus 600mm freeboard would require significant fill of at least 2m covering a significant area. This fill area would likely follow the proposed channel upstream to maintain freeboard, setting significant fill requirements for this whole development area. Additionally, Manks Rd itself would need to be filled by at least 1.5m to achieve flood free roads in the 1% AEP and a crossing underneath the road. The concern here is that the significant cost of these works mean that no developer can afford to progress these works, meaning that the outfall of this DSS is unsecured. Without this section of development, the outfall from Casey Fields (CFS4) would also need to discharge at surface level causing a similar issue for Casey Fields PSP.
    4. Similar to #3, the proposed discharge point of Moore Road DSS at Yallambee Road is extremely flat and the road only a small height above the existing channel invert. It is likely that building a WLRB and channel here would result in even more fill across the precinct than in the area described in #3 and the concern is that developers here would also not be able to afford to progress these works. This means that Moores Road DSS also would not be able to progress.
- Additional Issues
    1. Existing upstream basins have not been designed for SSP2-2100 resulting in overtopping of roads and uncontrolled flow during the major event.
    2. The proposed Quarry Basin would have significant upstream areas bypass the basin despite having spare space in the reserve area. The bypassed flows add further pressure on basins DM2 and DM3
    3. The school site downstream of Junction Village has been filled and piped the channel, therefore obstructing flows. It is not clear what would happen in case of a blockage or extreme event here either, but this requires further analysis.

Scenario 2:

- Critical Issues:
    1. The proposed diversion channel would allow both the reduction of flows to downstream Devon Meadows and size of basins required in Devon Meadows DSS. However, the impact of this diversion to Clyde South is significant and as a result basin MR1 would need to store an additional approx. 450,000 cu.m to maintain discharge control under Manks Road. The reason this is so significant is that the catchment size contributing to DM1, DM2 and DM3 is approximately 2.5 larger than what naturally drains to MR1 and therefore causes a significant increase in the flood volume directed to this catchment. Compared with Scenario 1, the total basin area required would increase by 3.5ha, with all area reductions on Devon Meadows effectively shifted to MR1 plus some extra, resulting in a basin reserve requirement of around 25ha upstream of Manks Road.
    2. Section DIV_1 of the diversion channel cuts through 10m of hill despite efforts to redesign this to more appropriate levels. This will be expensive and once full batters are considered could reach as wide as 100m. Some areas of the channel will be cut below the groundwater level which was raised as a concern in the previous submission.
    3. Section DIV_3 and DIV_4 cut directly though areas where known indigenous artifacts have been found and DIV 3 also impacts an existing viable business
    4. Rather than resolving the implementability issues identified in Scenario 1 for the Clyde Five Ways Road DSS outfall, they are exacerbated in this Scenario.
    5. This scenario does not address issues with securing an outfall for the Moore Rd DSS.
- Additional Issues:
    1. While flow rates are reduced to downstream of Devon Meadows by diverting the catchment, modelling indicates that the local catchment could still generate flood peaks as much as 18 cumec under an SSP2-2100 1% AEP event (more if climate change worsens) which is still far in excess of the capacity of these channels. While the diversion reduces the overall volume, these peaks could still be quick and dangerous to existing residents which warrants further analysis and consideration. It is unlikely that the flood risk to these areas is significantly improved.
    2. It is not clear what will happen if an extreme event occurs that overtops the proposed diversion. Will it be directed into existing Devon Meadows or will additional works be required to push flows across the South Gippsland Highway
    3. The overall land take in this scenario is increased relative to the baseline scenario by approximately 15ha, most of which is in the form of additional waterways. This is equivalent to 300-450 new homes lost assuming lot density of 20-30/ha in addition to the cost of earthworks and fill. This is a significant cost for a scenario which does not resolve the critical issues in the baseline scenario.

5. Proposed Alternative Concept (Scenario 3)

To address the identified issues, the following is proposed:

- It is clear that the diversion results in significant impact to Clyde South and would likely mean that all areas that are a part of the Clyde Fiveways DSS would be unable to progress including the majority of Casey Fields South. Devon Meadows makes up 16% of the combined development area and it is not reasonable to hold up development of Clyde South or Casey Fields South by translocating Devon Meadows issues to these catchments. It is also unreasonable to expect these landowners or developers to bear the financial cost of providing drainage outcomes for Devon Meadows or providing free flood protection to existing residents of an unrelated catchment. It is likely that to attempt to do so goes against Melbourne Waters Development Services Scheme Principles and would also be challenged through the planning scheme amendment process or in court if it were to proceed past planning phase. As such it is recommended that these two areas are treated as separate strategies going forward which would allow 84% of the development to proceed regardless of what occurs with Devon Meadows.
- To address issues in **Devon Meadows DSS and Downstream** we recommend exploring:
    1. Upgrading the existing waterways downstream in Devon Meadows from ~6-8m wide to 12m wide and 1.5m deep upstream of the confluence and 15m wide and 1.8m deep downstream of the confluence. It is estimated that this would convey the 1% AEP under SSP2-2100 climate change conditions with 300mm freeboard plus upgrading the 7 existing culvert crossings. This would provide flood protection and climate change adaptation to these properties, effectively removing them from the LSIO and also likely keeping their insurance premiums at a reasonable cost. We believe this could be done by only acquiring the two worst affected properties on Fisheries Road immediately downstream of the confluence and improving the access to a further 17 properties along the channel alignments. It is proposed that this cost would be covered under the Devon Meadows DSS which is developer funded.
    2. The upgrade of downstream channels would allow additional flows to be released from the proposed basins, so it is recommended that DM2 and DM3 are combined and relocated to the natural low point where the basin would not be perched above existing properties. The upstream waterway could also be rationalised into a single central waterway servicing the precinct.
    3. It is recommended that the Quarry Basin be redesigned to more effectively utilise the available space, with additional storage and wetland area provided to cater for existing Junction Village west of the highway and the northern portion of Devon Meadows.
    4. An additional outlet and spillway should be constructed from Acacia RB Eastern Cell to waterway WDA_1 to prevent flows overtopping Craig Road during a 1% event under climate change conditions with the additional flow out to be managed in basin DM1
- To address issues in **Casey Fields South and Clyde South** we recommend the following should be explored
    1. The funds proposed for the PAO recommended to be used to secure a connection for the Moore Road Drain to the contour drain allowing the entire network to be lowered by approx. 1.5m
    2. Basins CFS1, CFS2, and CFS4 to be consolidated into a single reserve (with potentially separate smaller wetland cells for each incoming flow) to make the layout more efficient
    3. Discharge from CFS4 to be diverted to the lowered Moore Drain Waterway and both CFS4 and YR1 lowered to manage additional flood volume resulting from the diversion and maintaining discharge requirements at YR1. As the size of the catchment draining to CFS4 is smaller than Devon Meadows, the impact is less than the diversion proposed in Scenario 2. We believe that the additional volume can be managed without significant additional land take by deepening the basins. We also believe that this will result in lower fill requirements on adjacent property.
    4. Regrade some of the area in Clyde South that formerly drained to MR1 to the lowered Moore Road channel so that the RB can be removed from MR1, significantly reducing fill requirements in the catchment and eliminating the need for an additional waterway.

5. Design the outlet for the Junction Village WLRB to meet SSP2-2100 1% AEP and divert the pipes around the north of the school, reducing the pressure on the school drain which would now only take local flows and overflow from the WLRB if there is a system failure. Each system would probably carry less than 10 cumec removing the need for a waterway upstream of the school. These pipes would recombine and drain into the waterway downstream of the school.
6. Include an upgrade to the Pavillion RB to fix the outfall pipe and raise earthworks levels on the south side so that the basin meets SSP2-2100 requirements.
7. Combine the Clyde Five Ways DSS and Moore Road DSS into one DSS so that the cost savings/enabling works/other benefits like reduced fill levels are shared equally across the land owners and the drainage strategy can be progressed here holistically, facilitating the speedy implementation of both Casey Fields South PSP and Clyde South PSP.

- Overall, we believe these measures would eliminate the identified drainage issues for the 3 precincts in a cost effective way and facilitate a smoother PSP and DSS preparation process. We estimate that this strategy could reduce land take significantly, by nearly 15 ha against scenario 1 and nearly 30 ha against scenario 2. In the case of comparison to scenario 2, this would be the equivalent of nearly 600-900 additional homes across the three precincts (assuming 20-30 lots/ha) which would mean that there is significant additional funding to support infrastructure implementation and long term maintenance and progress the State Government's housing targets.
- Further assessment and analysis is recommended to develop this concept including:
    - Flood modelling to determine impacts to downstream properties
    - 3d modelling of basins and channels to get a more accurate estimate of levels, fill requirements and reserve areas
    - Costing of the 3 scenarios based on the above
    - Liaising with other stakeholders to improve the concept layout

6. Conclusions and Recommendations

It can be concluded that:

- BW have conducted additional hydrologic modelling and undertaken some concept analysis to:
    1. Quantify what would have been required for Clyde South drainage at a high level following typical DSS principles to be used as a baseline and identify any potential issues for implementing this strategy;
    2. Incorporate the proposed diversion and quantify the impacts to Devon Meadows, Casey Fields and Clyde South PSPs;
    3. Investigate the implications of the new ARR2019 version 4.2 climate change requirements on the strategy at a high level; and
    4. Proposed some high level solutions aimed at addressing any identified issues.
- The following were identified as part of the additional assessment:
    - The implications of climate change are significant, with flow rate increases of approximately 40-70% expected on the predevelopment catchment under a SSP2-2100 climate projection. It is expected that the level of service of existing assets will decrease significantly under climate change.
    - There are significant issues in a applying a typical DSS approach to Clyde South with the main concern being that the required outfalls at Manks Road and Yallambee Road for the Clyde Five Ways Road DSS and Moores Road DSS would be unable to be implemented due to significant cost associated with developing these areas primarily due to fill and land take required by drainage assets.
    - The proposed diversion strategy makes some improvement to Devon Meadows and downstream areas, however it does this entirely at the expense of landowners in Clyde South. It is expected that the overall cost and land take would increase and the issues already identified with developing the downstream portion of the Clyde Five Ways Road DSS would be even further exacerbated.
    - BW have proposed an alternative concept that involves separating Devon Meadows from Clyde South and Casey Fields and recommends improving downstream channels to minimise drainage requirements while protecting downstream homes. BW believe that this strategy could significantly reduce cost and land take required for drainage across the three precincts, facilitate the PSP DSS process and distribute the cost of infrastructure more equitably.

It is recommended that;

- Further analysis be undertaken to develop BW's proposed alternative
- The VPA, MW and other stakeholders coordinate to support and refine this concept to improve outcomes for all 3 PSP areas.