BEFORE THE INDEPENDENT HEARINGS PANEL

UNDER	the Resource Management Act 1991
AND	
IN THE MATTER OF	the submissions of B & A Stokes on the Waimakariri Proposed District Plan (#214) and Variation 1 (#29)

SUPPLEMENTARY EVIDENCE OF ANDREW HALL ON BEHALF OF B AND A STOKES

(Infrastructure)

2 August 2024

GREENWOOD ROCHE
LAWYERS
CHRISTCHURCH
Solicitor: R Murdoch
(rmurdoch@greenwoodroche.com)

Kettlewell House
Level 3, 680 Colombo Street
P O Box 139
Christchurch
Phone: 03 353 0574

1 EXECUTIVE SUMMARY

1.1 My evidence responds to the infrastructure matters raised in the report prepared for Hearing Stream 12E of the Proposed Waimakariri District Plan (**PDP**) under section 42A of the Resource Management Act 1991 (**RMA**) (**Section 42A Report**). In particular, it addresses the feedback provided by Waimakariri District Council's (**WDC** or **Council**) expert engineer, Mr Aramowicz, to the proposed rezoning of 81 Gressons and 1375 Main North Road (the **Site**) to Medium Density Residential, subject to an Outline Development Plan (**ODP**) (the **Proposal**). It then addresses the way in which that feedback has informed the recommendations of Mr Wilson, the Council's reporting planner and author of the Section 42A Report (**Council Officer**).

1.2 The Council Officer has recommended rejection of the Proposal, in part, because of a perceived lack of evidence regarding:

(a) downstream capacity for stormwater resulting from the Proposal; and

(b) the rule framework and/or other mechanisms that will ensure that necessary upgrades occur prior to beginning development and/or staged throughout the development.

1.3 The Proposal includes substantial stormwater facilities along the eastern extent of the Site (described as the **Eastern SMA / Open Space**). These facilities will be sized and designed to attenuate stormwater from the Proposal to a 1:50 Annual Exceedance Probability (**AEP**) event to achieve hydraulic neutrality (i.e. post-development flows are approximately the same level as pre-development flows).

1.4 Amendments have been made to the ODP narrative to make that intention clear.

1.5 Provision of these facilities (and the ability to achieve those outcomes) will be assessed as part the subdivision resource consent (which requires alignment with the ODP) and as part of the regional consents to

authorise that discharge. The specific triggers for this in the PDP are addressed in the evidence of Mr Clease.[1]

1.6 In conclusion, with those features provided for, I do not consider that the Proposal will result in any additional adverse effects on downstream stormwater capacity. For his part, Mr Aramowicz appears to agree, noting that "the effect of any additional stormwater runoff from a future subdivision can be largely mitigated using onsite attenuation".[2]

1.7 I am aware that existing flood flows from the Site have previously contributed to downstream flooding. This is attributed to an undersized culvert under State Highway 1 (**SH1**), unmaintained drainage channels and a blocked flap valve in the Ashley River Stopbank. As stormwater will be attenuated on Site through the Proposal, the Proposal will not exacerbate these effects.

1.8 If however those matters have not already been addressed by the responsible agencies, any works required to manage those issues can be dealt with at the subdivision consent stage (noting that the updated ODP now records that the culvert is to be upgraded).

1.9 My primary evidence identifies a range of options for servicing the Proposal. I have consulted with the Council's engineers on those options, and we agree that there are no significant constraints on servicing the Proposal that would prevent the rezoning. I have reviewed that assessment again in light of the proposed increase in yield from the Site to 15 households per hectare (**hh/ha**). I remain of the opinion that the options identified in my primary evidence would be suitable for accommodating that additional yield.

1.10 The specific PDP rules relating to infrastructure assessments for subdivision consents are identified in Mr Clease' evidence.[3] Those provisions enable the imposition of conditions which would require the completion of any necessary upgrades or connections at the appropriate time, which is standard practice.

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1 Supplementary evidence of Jonathan Clease on behalf of B & A Stokes, 2 August 2024 (**Clease Supplementary**) at [5.25].

2 Memorandum to Peter Wilson (Council Officer) from John Aramowicz, *Proposed District Plan Rezoning Requests Stream 12E – Servicing, Natural Hazards, Geotechnical* Matters, at [160].

3 Clease Supplementary at [5.25].

1.11 In terms of funding and/or the allocation of responsibility for those upgrades/connections, again, that will be a matter for determination at the subdivision stage. In general, connections to existing services will be funded by the developer. Where a development triggers that requirement for unplanned upgrades, the cost of that will usually be borne (at least in part) by the developer. Those arrangements can be secured through development agreements, or costs can be recovered through development or financial contributions.

1.12 As identified in my primary evidence, planned upgrades to WDC's existing wastewater and water supply network will ensure there is sufficient capacity to accommodate the Proposal.

1.13 In that context, I remain of the opinion that there are no infrastructure constraints which should preclude the Proposal.

2 QUALIFICATIONS AND EXPERTISE

2.1 My full name is Andrew James Emil Hall. I am a Chartered Professional Engineer, Registered Surveyor and a Director of Davie Lovell-Smith Ltd, an engineering firm based in Christchurch.

2.2 I have the qualifications and experience set out in my primary evidence of 4 March 2024.

3 CODE OF CONDUCT

3.1 While this is not an Environment Court proceeding, I confirm that I have read the Code of Conduct for Expert Witnesses set out in the Environment Court Practice Note 2023. I have complied with the Code of Conduct in preparing this evidence and will continue to comply with it while giving oral evidence. Except where I state that I am relying on the evidence of another person, this written evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

4 SCOPE OF SUPPLEMENTARY EVIDENCE

4.1 I have reviewed the Section 42A Report and the supporting advice provided by Mr Bacon and Mr Aramowicz.

4.2 This evidence:

(a) responds to that report and the advice of Mr Bacon and Mr Aramowicz; and

(b) addresses the infrastructure implications of:

(i) increasing the proposed yield of the Proposal from 1,500 – 1,900 households (reflecting the shift from 12hh/ha – 15hh/ha); and

(ii) rezoning the entire Site to Large Lot Residential as an alternative option.

5 SECTION 42A REPORT

5.1 The Section 42A Report recommends that the Proposal is rejected on the basis of a perceived lack of evidence regarding:

(a) ***Downstream capacity*** *for stormwater, both through the culverts under SH1, and beyond.*

(b) ***The rule framework****, and/or other mechanisms that will ensure that the* ***necessary upgrades*** *occur prior to beginning development, and/or staged throughout the development.*

5.2 I address these in turn.

Downstream stormwater capacity

Flood flows

5.3 As detailed in my primary evidence, the WDC stormwater flood model has been interrogated and further modelling was undertaken by DHI to determine 1:200 AEP flood flows entering into the Site. That modelling included an allowance for the anticipated effects of climate change in accordance with High Intensity Rainfall Design System (**HIRDS**) representative concentration pathway (**RCP**) 8.5 for the period 2081-2100.[4] The results of that modelling are shown in **Appendix D** of my primary evidence.

5.4 As set out in that evidence, through the Proposal this upland flow will be transferred through the Site in specifically designed bypass channels located on the western boundary of the Site (the **Western Diversion**)

[4] In accordance with the National Institute of Water and Atmospheric Research.

and through the centre of the Site (the **Central Flood Bypass Channel**) sized to accommodate a 1:200 AEP event. Those channels will bypass the Eastern SMA / Open Space before discharging via the SH1 culvert at a pre-development rate.

Stormwater runoff

5.5 Development enabled by the Proposal will increase impermeable surfaces such as roads and roofs which in turn result in increased stormwater runoff.

5.6 The additional flows created by the Proposal will be mitigated on the Site though the attenuation of stormwater by the routine method of capturing the storm event in large basins, treating it and releasing it slowly through a choked pipe that restricts flows to the downstream natural waterways. The discharge flow will also closely replicate pre-development flows and no additional flows will enter the downstream catchment as a result of the Proposal.

5.7 Both the attenuated flows and the bypass flows will drain through the stormwater culverts under SH1 (as shown on the ODP).

5.8 This attenuation approach is a standard, well-understood method for managing stormwater and flood flows. As set out in Mr Clease's evidence, the PDP includes specific provisions which will enable a more fulsome assessment of those stormwater facilities as part of the more detailed subdivision consent stage.[5] I have nevertheless prepared preliminary stormwater calculations showing how those facilities could achieve adherence to predevelopment flows at **Appendix B**.

5.9 As noted, the Council Officer has received expert advice in regard to stormwater from Mr John Aramowicz. Mr Aramowicz's advice is detailed in paragraph 856 of the Section 42A Report:

- *The DLS (Davie Lovell Smith) Infrastructure Design report did not investigate whether the discharge of stormwater could result in an increased flood hazard to downstream properties where there is already an existing high flood hazard.*

[5] Clease Supplementary at [5.25].

- *However, based on existing WDC flood hazard modelling, and given the nature of the site, I expect that with careful engineering, the effect of any additional stormwater runoff from a future subdivision can be largely mitigated using onsite attenuation.*

And also in paragraph 859:

- *While there are areas of low-medium flood hazard associated with a large overland flow path that crosses the site, based on existing WDC flood hazard modelling and the submitter's submission, I expect that with careful engineering, the effect to downstream property from any additional stormwater runoff from a future subdivision can be largely mitigated using onsite attenuation.*

5.10 I am in full agreement with Mr Aramowicz. The Site's existing flood hazards, while certainly not unique in the Waimakairi district context, are well understood. Through the Proposal and the provisions of the PDP, any future development on the Site will be required to mitigate additional resulting stormwater flows to achieve hydraulic neutrality. The design of the mitigation, by way of attenuation, will be to the satisfaction of both WDC and the Canterbury Regional Council. As Mr Clease identifies, the provisions of the PDP will enable that design to be scrutinised at the subdivision stage.[6]

Off-site constraints

5.11 In his advice, Mr Aramowicz references a high hazard flood issue downstream of the Site.

5.12 I am aware of previous flooding issues which have received contributing flows from the Site. In particular, a significant storm occurred in the area of the Site on the 23rd of July 2023. The effects of this storm were observed and documented by the land owner and submitter Mr Brian Stokes. He observed flooding on his own residential property adjacent to SH1 to the north of the Site, and further downstream on the Site and along Stokes Drain. Images of the extent of the flooding are attached as **Photos 1 – 3** at **Appendix A**.

5.13 Through various investigations it became become clear that the existing culverts under SH1 were unable to accommodate the flood water flows experienced that day. In addition, SH1 is elevated above the Site and acts as a dam. This causes a flood nuisance through backwater buildup on the Site and neighbouring land.

6 Clease Supplementary at [5.25].

5.14 Further investigations also identified that drainage channels had not been maintained. At a number of locations, the adjacent foliage has inhibited the flows in the drains and caused stormwater to spill out onto surrounding land. Please refer to **Photos 5 and 6** at **Appendix A**.

5.15 Finally, the end of the local drains enter into the Ashley River near Waikuku Beach. The drains are protected from the flood effects of the Ashley River by a stopbank and culverts with backflow prevention. The backflow prevention is in the form of flap valves that allow the drains to flow towards the river but prevents the rising river levels from entering back into the drain. It was observed on the 23rd of July 2023 that the flap valves were being held open by logs and debris (see **Photo 4** of **Appendix A**). This restricts drain water entering the river, causing backwater flooding and also allows river flooding to enter into the drain.

5.16 As the Proposal will not increase the stormwater/flood flows from the Site, it will not exacerbate downstream floodings effects beyond what is currently being experienced.

5.17 However, if these off-site issues have not already been resolved by the responsible agencies (Waka Kotahi New Zealand Transport Agency (**NZTA**) and the Council), they can be addressed as part of the subdivision consent stage for the Proposal or through direct engagement with those agencies. For instance, the updated ODP notes that the SH1 culvert needs to be upgraded. As part of the subdivision consent, the developer can address how that will be achieved in conjunction with NZTA.

5.18 It is expected that the downstream drainage network will receive some overdue maintenance. I understand that this maintenance has commenced with the drain directly downstream of the Site (shown in **Photo 6** of **Appendix A**) being cleared on 29 July 2024.

5.19 Attention to the culvert upsizing, channel maintenance, flap valve clearing and potentially other management corrections should improve the apparent flood issues brought to light by the flooding event of 23 July 2023.

Rule framework for the upgrade and installation of infrastructure

5.20 Mr Aramowicz also provided advice to the Council Officer regarding the water supply and wastewater servicing of the Proposal. His advice is detailed in paragraphs 857 and 858 of the Section 42A Report:

- *… in summary, there are no known significant wastewater constraints that would prevent the proposed land use.*
- *… there are no existing water services to the site, and therefore a new development would need to connect to the existing services located at either Waikuku Beach or Ravenswood (or alternatively establish a compliant onsite water supply well).*
- *DLS note issues with nearby onsite wells. There is no certainty provided that a DWSNZ compliant water supply could be provided onsite. Given this, it seems the lowest risk option is to connect to the existing WDC network.*

5.21 I agree with Mr Aramowicz's assessment, which has been informed by his discussions with Mr Bacon. As identified in my primary evidence, I also discussed servicing of the Proposal directly with Mr Bacon, who confirmed that there were no significant constraints which would preclude rezoning of the Site.[7]

5.22 The Council Officer has however gone on to state that "I lack evidence to determine if it can be provided economically and efficiently, particularly around who pays for upgrades and any mechanism that requires the necessary upgrades ahead of development".[8]

5.23 Mr Clease has identified the specific PDP rules and assessment criteria which allow for the assessment of infrastructure capacity and sufficiency associated with the Proposal.[9] These rules will allow for the imposition of conditions of the subdivision or land use consent relating to the timing and delivery of necessary upgrades and connections, which is standard practice. I consider that is the appropriate method for ensuring that those works occur at the appropriate time of development.

5.24 In terms of funding, where new infrastructure is required (a new connection, for example), that cost will be borne by the developer, and they will incur development contributions (usually charged at the time

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7 Primary evidence of Andrew Hall on behalf of B & A Stokes, 4 March 2024 (**Hall EiC**) at [10.1].
8 Section 42A Report at [883].
9 Clease Supplementary at [5.25].

of subdivision consent) to contribute to the cost of the main Council asset.

5.25 Should Council wish, the proposed new infrastructure can be upsized to meet the demands of other developments. The cost of this upsizing will be paid by the Council back to the developer once installed. The funding arrangements for this are usually secured via a private development agreement between the applicant and Council. The developer is happy to work with Council in this regard.

5.26 It may be the case that there are capacity constraints within the Council's existing infrastructure network which need to be addressed to accommodate additional demand. As set out in my primary evidence, Council has confirmed that such constraints exist within the Council's water supply and wastewater network, but that upgrades to those facilities are planned which will provide sufficient capacity to accommodate the Proposal.[10]

5.27 In such cases, it is recognised that immediate connection to a particular service or facility may not be available until those upgrades are complete. It is not uncommon for development to proceed prior to the availability of that capacity with connection being made and certification under section 224(c) of the RMA being issued immediately upon the availability of the new infrastructure. Alternatively, a developer could also seek to accelerate the completion of those upgrades by agreeing to partially fund those works. Again, the development agreement provisions of the Local Government Act 2002 provide the means through which that could occur.

5.28 To illustrate as an example, I refer to the proposed wastewater connection which will be required as part of the Proposal. The potential pipe route was shown in **Appendix E** of my primary evidence. A 250mm PE pipe would connect from the Site to the Woodend Wastewater Treatment Plant (**Treatment Plant**). The length of this pipe is approximately 3.3km (3300m). The installation cost for this pipe is approximately $450.00/m, which amounts to approximately $1.5M. The Proposal will contain 1900 lots so this cost is only $789/lot. Pumping is expected to be by Local Pressure System and there will be a

[10] Hall EiC at [11.4].

development contribution towards the Treatment Plant. Even if costs doubled, it would still be easily feasible.

5.29 In summary, I consider that there are existing mechanisms in place to ensure that connections and upgrades needed to service the Proposal can be economically and efficiently provided at the appropriate time.

6 INCREASED YIELD

6.1 In response to the Section 42A Report, consideration has been given to increasing the potential development yield from the Proposal from around 12 hh/ha to 15 hh/ha. That would result in an increase from approximately 1500 dwellings to 1900 at the upper limit.

6.2 I have considered the findings of my primary evidence regarding the infrastructure requirements of the Proposal in light of this increased yield. In my opinion, the options for servicing the Proposal outlined in that primary evidence would still be suitable for accommodating 1900 households.

6.3 The expected use of an Local Pressure System wastewater system provides some attenuation of sewer flows through the individual on-site tanks at each new home. Added to that, the ingress of groundwater and stormwater into the sewer is much reduced with an Local Pressure System. This results in reduced flows. This reduction in flows should compensate for the increased house numbers.

6.4 The increase in homes would lead to an increase in stormwater runoff which will require a proportional increase in the size of the attenuation basins. That increase will be small and should still be accommodated within the Eastern SMA / Open Space area shown on the ODP. The attenuation will ensure that the stormwater discharge from the Site will remain at predevelopment rates and will have no added effect on downstream stormwater capacity.

6.5 Water supply is not expected to present an issue given there is the option to construct a new bore. This is not expected to be required in this case. Added house numbers generally lead to an overall reduction in the average household demand. The increase in house numbers is not

proportional to the increase in demand as the fire flow is already accounted for, regardless of house numbers.

7 LARGE LOT RESIDENTIAL ZONING

7.1 I understand that, if the Proposal does not find favour with the Panel, an alternative zoning option may be Large Lot Residential across the Site.

7.2 If that is the case, I consider that servicing of that zoning outcome would take largely the same approach as what is proposed through the Proposal, except that:

(a) The extent of the stormwater facilities provided in the Eastern SMA / Open Space area would be considerably smaller as the lot sizes themselves would provide additional attenuation.

(b) Water supply may or may not be restricted with on-site fire reserve tanks.

8 CONCLUSION

8.1 Attenuation of stormwater through significant basins on the eastern side of the Site is a key mechanism for ensuring that the Proposal does not generate any increase in adverse effects on downstream stormwater capacity.

8.2 It is recognised that there are existing issues with off-site infrastructure which are contributing to adverse flooding effects experienced on the Site and downstream of the Site. It is also recognised that it would be beneficial for many properties (including the Site) if those issues were attended to.

8.3 These upgrade and maintenance matters are not considered technically challenging and can be addressed at the time of subdivision consent, if not beforehand.

8.4 As outlined in my evidence and in Mr Clease's evidence, there are mechanisms within the PDP to ensure that infrastructure connections and upgrades are required and delivered at the appropriate time. There are also a number of different funding options available to ensure that

that infrastructure can be economically and efficiently delivered. These mechanisms are well understood and are common place.

8.5 For these reasons, I remain of the opinion that the Proposal can be adequately serviced, and there are mechanisms in place to ensure that those servicing arrangements are delivered to the appropriate standard. I note that Mr Bacon and Mr Aramowicz appear to share my conclusion in that regard, and it is therefore somewhat surprising that these issues have been identified as reasons for rejecting the Proposal.

Andrew Hall
2 August 2024

APPENDIX A – FLOODING PHOTOGRAPHS – 23rd July 2023.

Photo 1 – Flooding across SH1 and into the proposed Eastern SMA area of the Site (right), looking south

Photo 2 – Flooding, looking west across SH1 to the proposed Eastern SMA area of the Site

Photo 3 – Flooding in the proposed Eastern SMA area of the Site due to backwater from the culverts

Photo 4 – Log stuck in flap valve

Photo 5 – Unmaintained drainage channels

Photo 6 – Unmaintained channel that was cleared 29/7/24

APPENDIX B – PRELIMINARY STORMWATER BASIN CALCULATIONS

DAVIE LOVELL·SMITH

20605 - Waikuku - Stokes Block
STORMWATER TREATMENT AND DETENTION CALCULATIONS

Completed by:	Adam Lill	Date:	13-Nov-2023
Checked by:	Andy Hall	Date:	

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Assumptions:

1. Critical storm duration is 48hrs - Maximum Volume Event
2. First Flush Basin to discharge over 96 hours
3. Wetland to be flooded 0.5m above design depth for stormwater attenuation
4. Average basin depth of 1.00m for First Flush Basin and Detention Basin
5. Detention basin to discharge at predevelopment flow rate
6. Pre development flows assume minimal soakage due to high groundwater and heavy soils
7. Development Zoning assumed to be Residential New Neighbourhood density

Stormwater flow and volume calculations using the requirements of Ecan consent CRC120223 and the Christchurch City Council Waterway, Wetlands & Drainage Guide (WWDG).

	Area (Ha), A	FF Runoff Coefficients, Cff	Pre development runoff coefficents (50yr), C	Peak Flow Runoff Coefficients (50 year),C
Catchment 1 (Orange)	13.6	0.63	0.35	0.65
Catchment 2 (Blue)	61.5	0.63	0.35	0.65
Catchment 3 (Magenta)	55.60	0.63	0.35	0.65
			NZBC E1 Table 1 Heavy clay soil types: – pasture and grass cover - minus 0.05 Slope Factor	WWDG Table 21-5 RNN <=2%

HIRDS V4 Intensity-Duration-Frequency Results — Coordinate system: WGS84 — Longitude: 172.6808
Sitename: Stokes Block — Latitude: -43.3023
Rainfall intensities (mm/hr) :: RCP8.5 for the period 2081-2100

ARI	20m	30m	1h	2h	6h	12h	24h	48h
5	30.8	25.2	18.3	13.3	7.7	5.3	3.5	2.21
10	38.5	31.5	22.7	16.4	9.43	6.45	4.24	2.67
50	59.9	48.6	34.6	24.6	14	9.41	6.1	3.8
100	70.6	57.1	40.5	28.6	16.1	10.8	6.97	4.31
250	85.8	69.1	48.6	34.2	19	12.7	8.11	4.98

The Basin Areas have been calculated to be approximately 10% of the catchment area. This is slightly higher than the typical figure supplied by the WWDG of 5%-8% due to the conservative assumptions made in these preliminary calculations. Detailed Design once the assumptions are confirmed by the council may result in a reduction of this overall area.

DAVIE LOVELL·SMITH

20605 - Waikuku - Stokes Block
STORMWATER TREATMENT AND DETENTION CALCULATIONS

Completed by:	Adam Lill	Date:	13-Nov-2023
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Catchment 1 Basin Volume Calculations

First Flush Volume

(WWDG,Eqn 6-2), V = 10CAd, d = 25mm as per CCC requirements

		Cff	A	d			
	10	0.63	13.60	25	V =	2142	m^3

With 5% sediment retention added.	**V =**	**2249 m^3**
Area of First Flush Basin at 1.0 Average Depth	**A =**	**2249 m^2**
First Flush Discharge over 4 days	**Q =**	**6.51 l/s**

Wetland Sizing

Simplified Wetland Sizing Calculation A = (Q x t) / (y x n) WWDG Eqn 6-24

Q =	562	cu.m/day	average flow rate through wetland
t =	2	days	hydraulic residence time
y =	0.25	m	average water depth in wetland
n =	0.75		porosity of wetland once heavily planted
A =	**5998**	**sq.m**	

Full Flood Volume Attenuation

Q =2.78 C i A

Fully Developed Storm Flow			Q =	93.4	l/s
Full Storm Volume over 48 hr Event	V =	0.0934	*60*60*48=	16137	m^3 for 18hrs
Pre Devlopment Discharge Rate			Q =	50	l/s
Volume Discharged During Storm Event	V =	0.050	*60*60*48=	**8689**	**m^3**

Full flood volume less discharge over storm event,		7448 m^3
First Flush Basin Volume		2249 m^3
Storage Volume of wetland (0.5m ponding above operating level)		2999 m^3
Detention Basin Volume Required		**2200 m^3**
Area of Detention Basin at 1.0m average depth	**A =**	**2200 m^2**
Combined Area of First Flush, Wetland and Dention Basins	**A =**	**10447 m^2**
Additional 30% for landscaping and access	**A =**	**13581 m^2**
Time to drain detention storage volume	**T =**	**1.7 Days**

DAVIE LOVELL·SMITH

20605 - Waikuku - Stokes Block
STORMWATER TREATMENT AND DETENTION CALCULATIONS

Completed by:	Adam Lill	Date:	13-Nov-2023
Checked by:	Andy Hall	Date:	

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Catchment 2 Basin Volume Calculations

First Flush Volume

(WWDG,Eqn 6-2), V = 10CAd, d = 25mm as per CCC requirements

		Cff	A	d			
	10	0.63	61.50	25	V =	9686	m³

With 5% sediment retention added. **V = 10171 m³**

Area of First Flush Basin at 1.0 Average Depth **A = 10171 m²**

First Flush Discharge over 4 days **Q = 29.43 l/s**

Wetland Sizing

Simplified Wetland Sizing Calculation A = (Q x t) / (y x n) WWDG Eqn 6-24

Q =	2543	cu.m/day	average flow rate through wetland
t =	2	days	hydraulic residence time
y =	0.25	m	average water depth in wetland
n =	0.75		porosity of wetland once heavily planted

A = 27122 sq.m

Full Flood Volume Attenuation

Q =2.78 C i A

Fully Developed Storm Flow				Q =	422.3	l/s
Full Storm Volume over 48 hr Event	V =	0.4223	*60*60*48=		72973	m³ for 18hrs
Pre Devlopment Discharge Rate				Q =	227	l/s
Volume Discharged During Storm Event	V =	0.227	*60*60*48=		**39293**	**m³**
Full flood volume less discharge over storm event,					33680	m³
First Flush Basin Volume					10171	m³
Storage Volume of wetland (0.5m ponding above operating level)					13561	m³
Detention Basin Volume Required					**9948**	**m³**
Area of Detention Basin at 1.0m average depth				**A =**	**9948**	**m²**
Combined Area of First Flush, Wetland and Dention Basins				**A =**	**47240**	**m²**
Additional 30% for landscaping and access				**A =**	**61413**	**m²**
Time to drain detention storage volume				**T =**	**1.7**	**Days**

DAVIE LOVELL·SMITH

20605 - Waikuku - Stokes Block
STORMWATER TREATMENT AND DETENTION CALCULATIONS

Completed by:	Adam Lill	Date:	13-Nov-2023
Checked by:	Andy Hall	Date:	

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Catchment 3 Basin Volume Calculations

First Flush Volume

(WWDG,Eqn 6-2), V = 10CAd, d = 25mm as per CCC requirements

		Cff	A	d			
	10	0.63	55.60	25	V =	8757	m^3

With 5% sediment retention added.	**V =**	**9195 m^3**
Area of First Flush Basin at 1.0 Average Depth	**A =**	**9195 m^2**
First Flush Discharge over 4 days	**Q =**	**26.61 l/s**

Wetland Sizing

Simplified Wetland Sizing Calculation A = (Q x t) / (y x n) WWDG Eqn 6-24

Q =	2299	cu.m/day	average flow rate through wetland
t =	2	days	hydraulic residence time
y =	0.25	m	average water depth in wetland
n =	0.75		porosity of wetland once heavily planted
A =	**24520**	**sq.m**	

Full Flood Volume Attenuation

Q =2.78 C i A

Fully Developed Storm Flow		Q =	381.8	l/s
Full Storm Volume over 48 hr Event	V = 0.3818	*60*60*48=	65972	m^3 for 18hrs
Pre Devlopment Discharge Rate		Q =	206	l/s
Volume Discharged During Storm Event	V = 0.206	*60*60*48=	**35523**	**m^3**
Full flood volume less discharge over storm event,			30449	m^3
First Flush Basin Volume			9195	m^3
Storage Volume of wetland (0.5m ponding above operating level)			12260	m^3
Detention Basin Volume Required			**8994**	**m^3**
Area of Detention Basin at 1.0m average depth		**A =**	**8994**	**m^2**
Combined Area of First Flush, Wetland and Dention Basins		**A =**	**42708**	**m^2**
Additional 30% for landscaping and access		**A =**	**55521**	**m^2**
Time to drain detention storage volume		**T =**	**1.7**	**Days**