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Featherston WWTP Resource Consent Applications - Further Points of Clarification Response to Request for Further Information (s92)

11 October 2017

Dear Nicola,

Further to the resource consent applications submitted for the proposed Featherston Wastewater Treatment Plant (WWTP) discharges to land, water and air on 1 March 2017, Greater Wellington Regional Council (GWRC) issued a Section 92 (s92) request for further information on 19 April 2017. Mott MacDonald, on behalf of South Wairarapa District Council (SWDC), subsequently submitted a response to this s92 request on 2 June 2017. Further points of clarification have since been requested by GWRC by e-mail on 28 June 2017 to address matters considered to be outstanding from the original s92 response.

This letter and appendices has been prepared on behalf of SWDC as a response to the further points of clarification request, to specifically address the outstanding matters relating to Section 107(1)(d). The enclosed responses are presented in a tabular form to capture GWRC's comment, SWDC's response and proposed solutions.

Further requests for clarification relating to the land application scheme, Overseer modelling, soil type and groundwater mounding will be addressed in a subsequent response.

1 Section 107(1)(d)

Further to our response presented in Section 5 of the letter dated 2 June 2017, our response on visual clarity is provided below and in the relevant appendices.

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Ref.	GWRC comment	SWDC response	Proposed Solution
1.1	The discharge does meet S107(1)(d) conspicuous change in water clarity or colour (based on it not meeting the PNRP 33% change target), and the Section 92 response says that the discharge may still breach it during Stage 1 and Stage 2B - which raises concerns.	The land application scheme at Featherston WWTP has been designed to progressively remove treated effluent discharges to Donald Creek, during the summer months when there is lower baseflow. Further water quality data has been collected to supplement Section 6.4.4.9 of the AEE, as provided in **Appendix A1**. The assessment predicts significant reductions in exceedance frequency over the Project life up to Stage 2B.	From the outset, the Project staging has been designed to prioritise the removal of treated effluent discharges to the Donald Creek during summer months where water quality effects are more pronounced. No additional changes are proposed.
1.2	It seems that the effects on water clarity/ colour are likely to remain an issue when the discharge is occurring and this causes concerns for us – accepting however that the discharge to water will occur less often during Stage 1 and even less during Stage 2.	The ecological assessment summarised in Section 6.4.4.15 of the AEE and detailed in Section 3 of Appendix 11B of the AEE, identifies the anticipated ecological effects of the proposed project stages. The Project staging has prioritised the removal of summer discharges to the Donald Creek, and the ecological effects of this progressive reduction in river discharges can be summarised as follows: - Stage 1B – moderate to minor - Stage 2B – minor to less than minor.	The progressive removal of treated effluent discharges to the Donald Creek during summer months is expected to significantly improve water quality. No additional changes are proposed.
1.3	Concerns regarding the $6 million figure for the upgrade to remove particulates, including algae from the effluent prior to the discharge to Donald Creek. We need to see some detail provided as to what type of upgrade has been assessed.	The $6 million cost for the dissolved air floatation (DAF) plant was based on two supplier quotations; one for a water treatment plant, the other for a Tegal processing plant (including chemical dosing and sludge dewatering). Scaling these plants down to the proposed maximum discharge flow rate of 6,000 m^3/d at Stage 2B and including costs for professional services (15%) and contingencies (25%) provided a cost range of $5.6M - $6.4M. Therefore, $6M was considered a reasonable estimate at the conceptual stage of the design. Other technologies available have been reviewed by SWDC and provided in **Appendix A2**.	No additional changes are proposed.

Ref.	GWRC comment	SWDC response	Proposed Solution
1.4	The response cites a lack of clarity data for the discharge as an obstacle to undertake a more detailed assessment, would like some more detail as to why such data couldn't have been collected (or why it couldn't be collected now).	Additional receiving water and discharge flow and quality data was collected in July and August 2017 to provide further information for the detailed clarity assessment, provided in **Appendix A1**.	Addressed in **Appendix A1**. No additional changes are proposed.
1.5	The Section 92 response develops an argument that the effects would only occur infrequently in summer and that the effects on winter won't matter because recreational use would be low in winter, and ecological effects less likely. Section 107(1) standards (and PNRP guidelines) are not dependent on season, or recreational use.	This has been noted. Our Section 107(1)(d) response provided above in item Ref. 1.1 and 1.2, further assess the anticipated clarity effects against the s107(1) and PNRP Policy 71 criteria. It should be noted that the progressive improvement in receiving water quality across the project stages are expected to result in minor to less than minor effects at Stage 2B.	No additional changes are proposed.

We believe the above and associated appendices address the matters raised in GWRC's comments.

2 Conclusion

In summary, this letter and its attachments forms our response to the Section 92 request for further clarification of outstanding matters relating to Section 107(1)(d).

Should you have any further queries, please do not hesitate to contact the undersigned.

Yours sincerely,

On behalf of Mott MacDonald New Zealand Limited

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A1. Clarity Assessment

An assessment of clarity exceedances by Mott MacDonald following the collection of additional receiving environment and discharge quality data (July to August 2017).

MOTT MACDONALD

Technical Note

Project:	Featherston WWTP		
Our reference:	336641-BB-05-B	**Your reference:**	
Prepared by:	Emma Hammond	**Date:**	27-Sep-2017
Approved by:	Steve Couper	**Checked by:**	Steve Couper
Subject:	Clarity Assessment for Proposed WWTP Upgrades		

1 Background

The assessment of effects on the environment (AEE) evaluated the staged implementation of the best practicable option (BPO) for Featherston wastewater treatment plant (WWTP)[1]. The BPO is proposed to progressively remove treated effluent discharges from Donald Creek, favouring a combination of land application and discharges to the Creek as infiltration and inflow is removed from the wastewater network.

The AEE concluded that the receiving water quality standards specified in Section 107 of the Resource Management Act 1991 (RMA) and Policy 71 of the Proposed Natural Resources Plan (PNRP)[2] would largely be met after a reasonable mixing zone of some 50m in the waterbody, following Stage 2B of the proposed upgrades. The only exception to this was for water clarity in the receiving environment. Policy 71 of the PNRP stipulates that for rivers classified as River Classes 2 to 6, a point source cannot contribute greater than a 33% change in clarity in the receiving watercourse. Donald Creek is classified as River Class 5 under the PNRP. The AEE states that it is expected that there would be progressive improvement in receiving water quality, however, the frequency of any non-compliances with Policy 71 and thus s107(b)[3] were not fully understood.

The AEE states that the ultimate discharge scenario, Stage 2B, will not discharge treated effluent into Donald Creek except during the winter months of July and August, and in some years it won't discharge at all depending on the hydrological conditions, resulting in improvements in receiving water quality from the current situation during most of the year. When the discharge is in operation (July and August only) there may be reduced clarity and changes in colour downstream.

Further information regarding the effects on clarity in Donald Creek from the proposed activity was requested by Greater Wellington Regional Council in a Section 92 information request on 19 April 2017 and in a further points of clarification request on 28 June 2017. Specifically, an assessment of existing data against the proposed 33% change in water clarity standard and an assessment of whether the discharge is likely to comply in future was requested. Upon further discussion with GWRC, it is our understanding that quantification of the frequency and scale of exceedance with the 33% change standard is desired for the proposed project stages, Stage 1B (partial land application) to 2B (ultimate scenario).

[1] Mott MacDonald, 2017. Featherston Wastewater Treatment Plant Resource Consent and Assessment of Effects on the Environment. 28 February 2017.

[2] Greater Wellington Regional Council, 2015. Proposed Natural Resources Plan for the Wellington Region (PNRP). Notified in June 2015.

[3] Consent shall not be granted if the discharge to water, after reasonable mixing is likely to result in any conspicuous change in the colour or visual clarity of the receiving waterbody.

Additional water clarity monitoring has since been undertaken during the 2017 winter months to quantify a frequency of exceedance with the proposed clarity standard. This technical note provides this further information.

2 Data collection

2.1 Historical compliance monitoring

Water clarity is measured by SWDC 20m upstream (Longwood 2) and 130m downstream (Longwood 3) of the existing discharge into Donald Creek on a quarterly basis using black disc. Monitoring has been undertaken since August 2012 with a total of 23 matched upstream/ downstream measurements collected to present day (data presented in the AEE was up to May 2016).

A temporary flow gauge was installed in February 2016 by South Wairarapa District Council in Donald Creek, approximately 20m upstream of the WWTP discharge point, which has provided useful flow data for the clarity assessment.

Continuous treated effluent flow data is recorded from the outlet of the ultraviolet (UV) disinfection plant. A daily data set is available between March 2005 to present (data presented in the AEE was up to May 2016). Discharge clarity measurements are not a requirement of the consent and therefore are not monitored.

2.2 2017 winter monitoring

A period of focused discharge quality and receiving environment monitoring was undertaken between 16 July and 25 August 2017 to increase the number of clarity monitoring results in the limited dataset for the discharge and receiving environment to enable a more thorough assessment of the WWTP effects on Donald Creek.

One monitoring date (10-Aug-2017) has been excluded as external factors (a discharge of dewatered groundwater from a development site upstream of the plant) were observed to be influencing the water course. The monitoring period aligns with the months of the proposed Stage 2B discharge regime providing some further information on flow and discharge characteristics during the winter months.

The monitoring programme was designed to record water and discharge quality across a range of river flows achievable in winter months i.e. typically greater than median flow, and supplement the quarterly quality data gathered between 2012 and 2017. A summary of the flow data collected during the sampling programme is presented in **Table 1**.

Table 1: Donald Creek Upstream Flow Monitoring Data (July – August 2017)

River Flow Statistic	Synthetic Flow (l/s)*	Number of Samples (-)	Actual Recorded Flow (l/s)**
Median to 2x median	208 – 416	2	287 (1.4x), 335 (1.6x)
2x median to 3x median	416 – 625	3	451 (2.2x), 488 (2.3x), 587 (2.8x)
> 3x median	> 625	3	654 (3.1x), 704 (3.4x), 935 (4.5x)

Note: * In the absence of a permanent gauging station in Donald Creek, synthetic flow data were generated for Donald Creek and used in the AEE (see Appendix A.6 of the AEE).
** Numbers in brackets show flow as a factor of the median flow (median flow = 208 l/s).

Treated effluent quality monitoring from the compliance point at the WWTP (immediately downstream of the UV plant) was undertaken at a similar time as the flow readings and included total suspended solids (TSS),

volatile suspended solids (VSS), turbidity, clarity (by clarity tube) and UV transmittance (UVT), as summarised in **Table 2**. TSS in the discharge is largely comprised of VSS, therefore VSS has not been presented in the table. Black disc clarity readings were not possible in the treated effluent, only clarity tube readings were taken.

Table 2: WWTP Discharge Monitoring Data (July - August 2017)

Quality Statistic	Flow (l/s)	TSS (mg/l)	Turbidity (NTU)	Clarity by Clarity Tube (m)	UVT (%)
No. of samples (-)	7	7	7	7	4
Median	41.5	23.0	11.2	0.12	61.8
Minimum	29.4	10.0	7.2	0.10	56.4
25%-ile	36.5	22.0	10.9	0.11	57.2
75%-ile	77.0	25.5	13.7	0.12	67.0
Maximum	82.8	27.0	15.3	0.22	70.0

Water quality samples were taken for Donald Creek at monitoring stations 20m upstream and 150m downstream of the discharge, as summarised in **Table 3** and **Table 4**, respectively. It is evident that there are differences between the water clarity readings recorded by black disc and clarity tube. New Zealand guidelines[4] recommend the use of the black disc method; clarity tube readings were taken for comparison with the treated effluent values (where the black disc method was not possible).

Table 3: Donald Creek Water Quality Monitoring Data - upstream (July - August 2017)

Statistic	Flow (l/s)	TSS (mg/l)	Turbidity (NTU)	Clarity by Clarity Tube (m)	Clarity by Black Disc (m)
No. of samples	7	7	7	7	4
Median	587.0	5.00	4.49	0.69	1.15
Minimum	287.0	4.00	1.87	0.53	0.55
25%-ile	469.5	5.00	3.24	0.62	0.94
75%-ile	679.0	5.75	5.89	0.76	1.33
Maximum	935.0	17.00	10.70	0.83	1.53

Table 4: Donald Creek Water Quality Monitoring Data - downstream (July - August 2017)

Statistic	Flow (l/s)	TSS (mg/l)	Turbidity (NTU)	Clarity by Clarity Tube (m)	Clarity by Black Disc (m)
No. of samples	7	7	7	7	4
Median	623.0	7.00	5.76	0.45	0.80
Minimum	316.4	4.00	2.99	0.37	0.45
25%-ile	548.4	5.50	3.85	0.40	0.59
75%-ile	718.3	8.50	6.48	0.55	0.80
Maximum	1,007.0	19.00	10.10	0.69	1.20

[4] Davies-Colley, R. 1988. Measuring water clarity with a black disk. Limnology and Oceanography 33: 616-623.

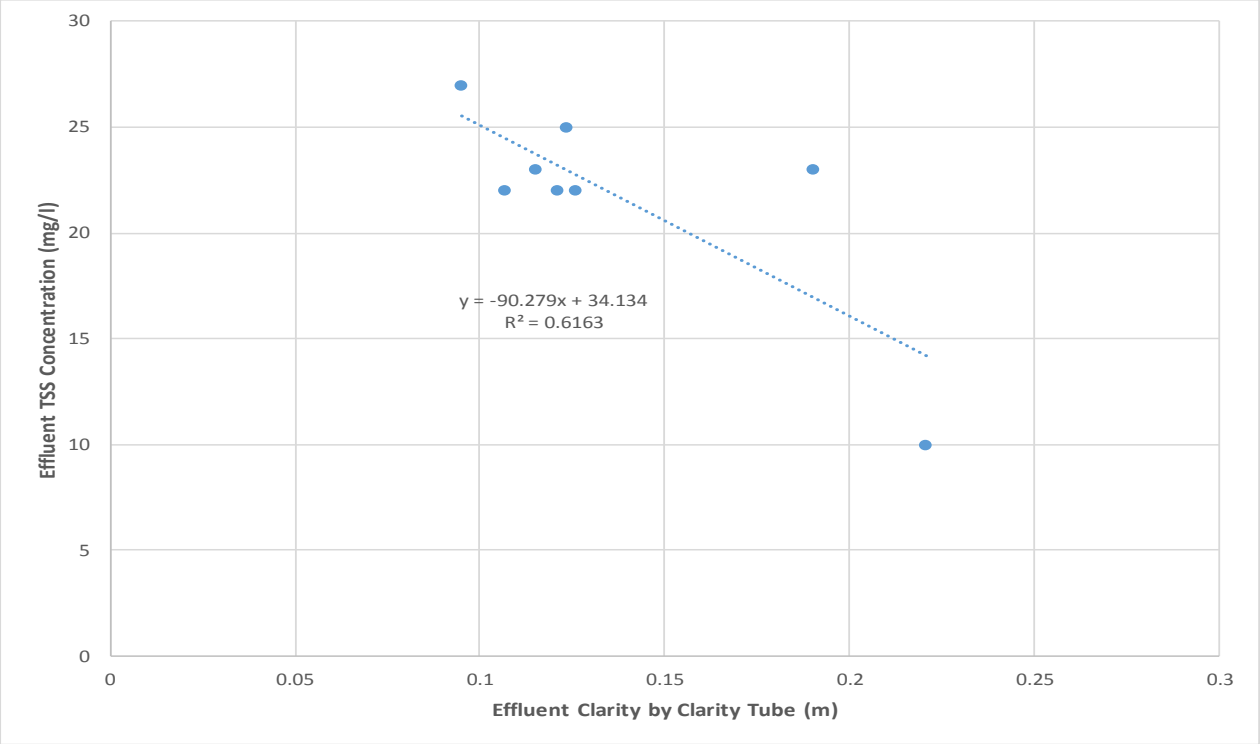
3 Data analysis

3.1 2017 monitoring data

Treated Effluent

Recent monitoring of the treated effluent showed that there is an emerging relationship between TSS and clarity in the treated effluent as illustrated in **Figure 1**, as is to be expected.

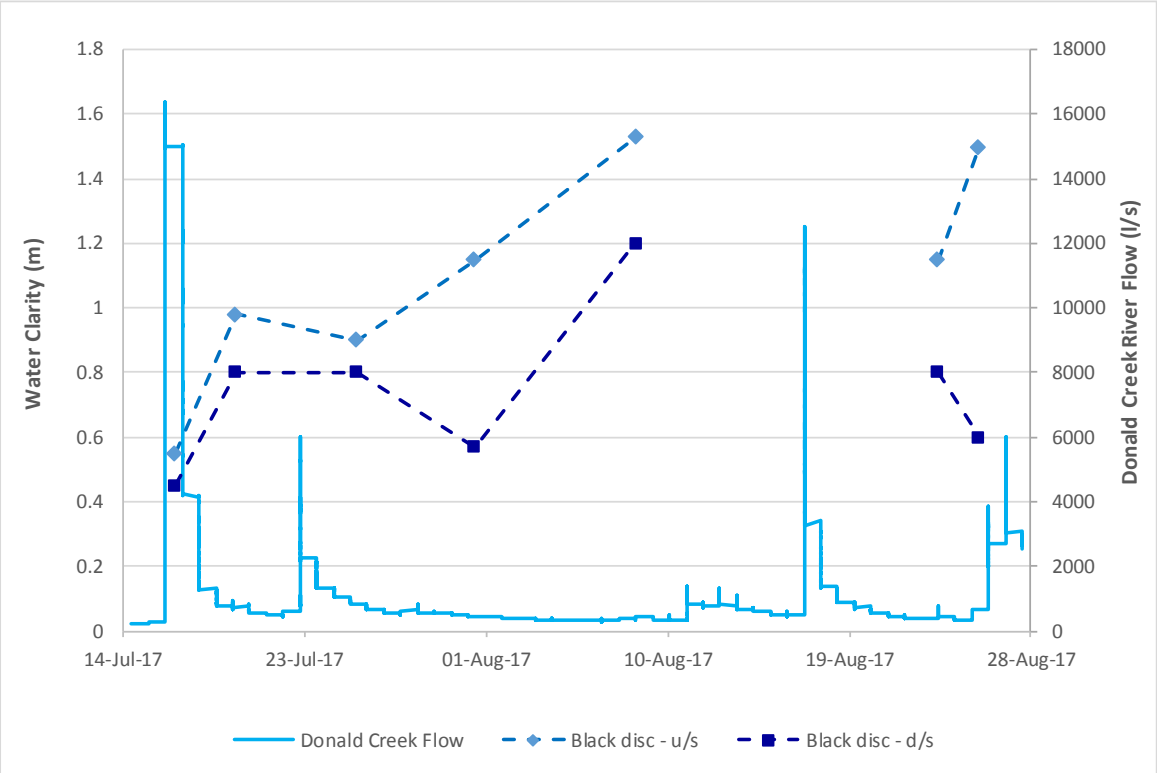
Figure 1: Treated effluent clarity and TSS (July – August 2017)



Receiving Watercourse

Water clarity in a watercourse is dependent on its flow; at lower flows clarity is expected to be better than at higher flows owing to the suspended sediments mobilised in the water column during higher flow events. This relationship was observed during the July-August 2017 monitoring as presented in **Figure 2**.

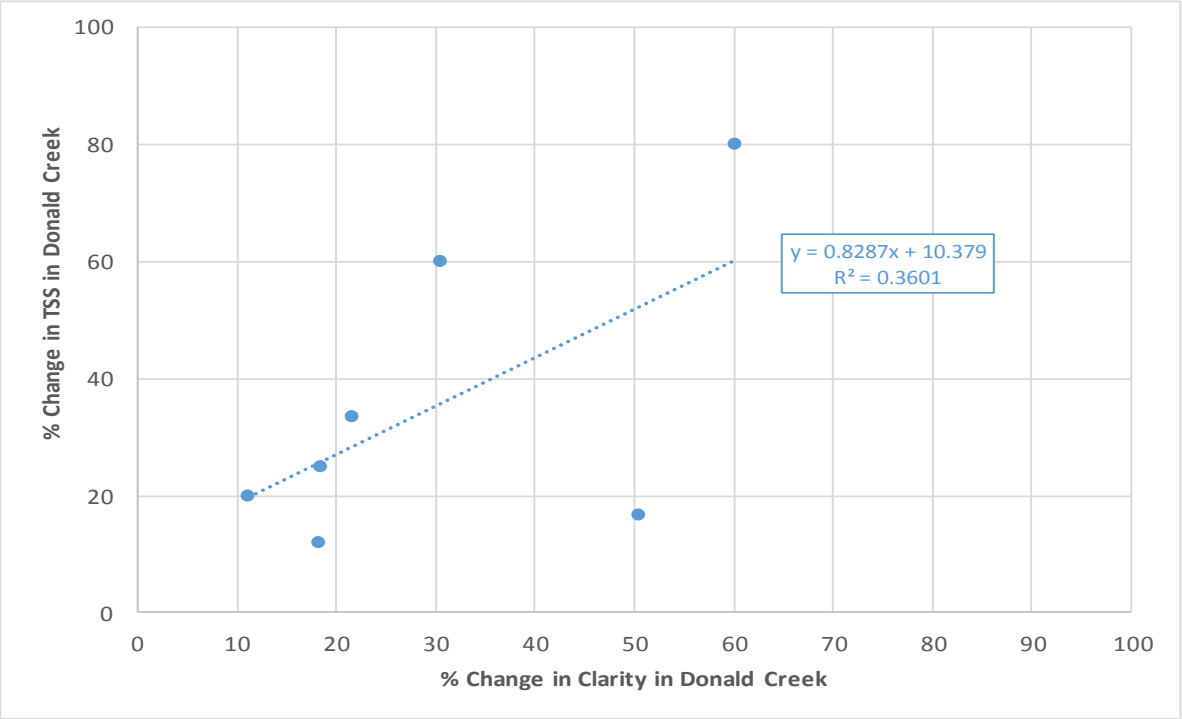
Figure 2: Receiving water clarity and river flows (July - August 2017)



The lowest recorded clarity for both upstream and downstream sites, coincided with the falling limb of the hydrograph on 16 July 2017, representing turbid flood waters. Deviation in the downstream readings from the upstream readings on 31 July and 25 August 2017 reflect monitoring periods where treated effluent discharged to the Creek exceeded 14% of the river flow, leading to 50 to 60% change in clarity between the upstream and downstream monitoring sites. The river flows on these two occasions were 2.2 and 2.3x median flow. All other points showed less than a 33% change in clarity.

Although there is a likely relationship between TSS and clarity observed in the treated effluent, as mentioned above, the in-stream relationship is less defined as illustrated in **Figure 3**. This is even less pronounced using the longer term data set extended back to August 2012, largely owing to the role that both WWTP discharge as a percentage of river flows, and river flows as a factor of median river flows have on clarity. This makes it difficult to use a mass balance approach to analyse the water quality impacts of future project scenarios.

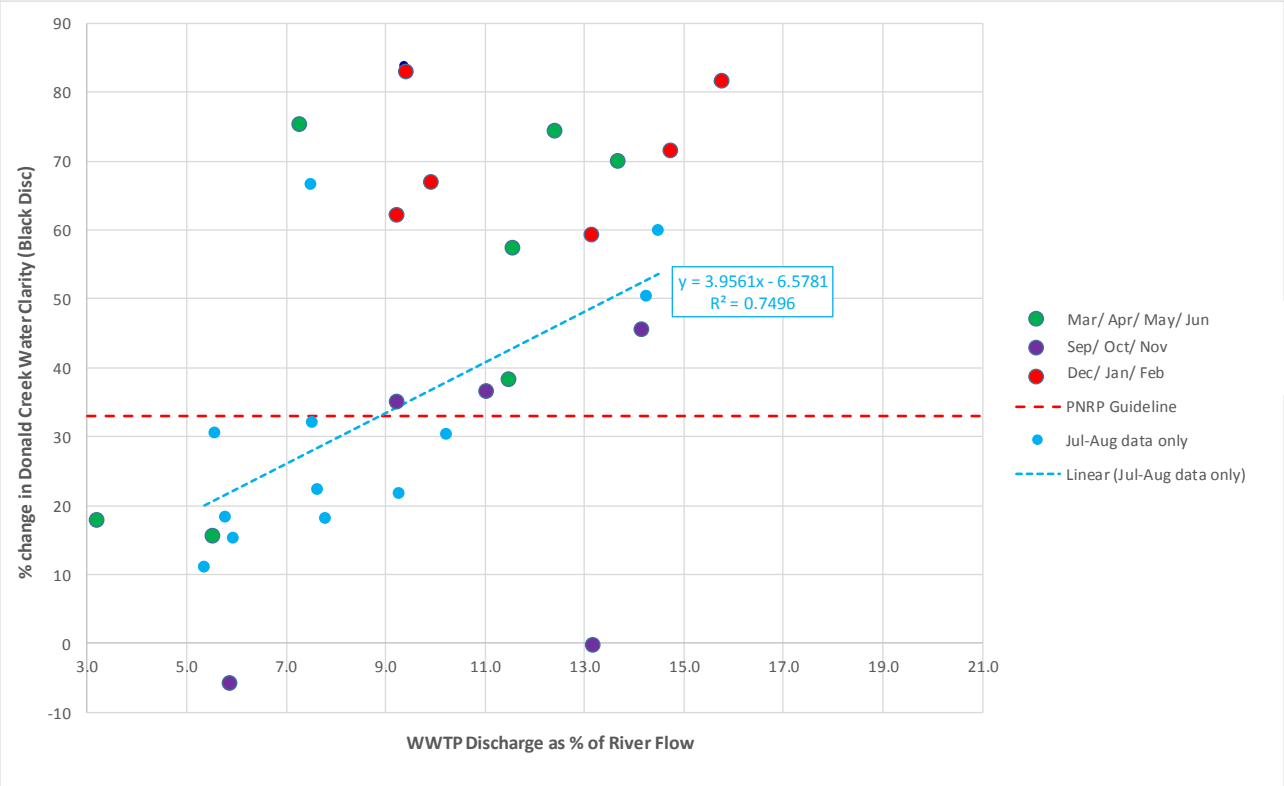
Figure 3: Receiving water clarity and TSS (July – August 2017)



3.2 Comparison with longer term data set

The 2017 July to August data (including those recorded as part of the annual compliance monitoring) is presented in **Figure 4** as the % change in water clarity between upstream and downstream monitoring sites, against the longer term monitoring data recorded quarterly between August 2012 and May 2017.

Figure 4: Receiving water clarity in relation to WWTP flows (August 2012 – August 2017)



Based on synthetic flow data for Donald Creek, the data represents a range of hydrological conditions which included river flows above and below the synthetic 10-year average of 11,147,260 m^3/ year, with no distinct trends attributable to periods of low flows.

It is evident that water clarity data recorded using the black disc method between 2012-2017 shows no discernible relationship. However, regression analysis of the July and August data only, including the most recently collected data, shows a significant relationship between the portion of treated effluent, the dilution potential and the % change in clarity in Donald Creek.

It is also clear that the majority of historic exceedances of the 33% change in clarity did not occur in the winter months of July and August, these occurred in Summer and Autumn. These exceedances typically coincided with river flows that were less than half the median flow, and where treated effluent exceeded approximately 9% of the river flow.

4 Water quality assessment

4.1 Discharge frequency and treated effluent quality

Currently the WWTP discharges treated effluent 99% of the time, with 13% of discharges occurring when river flows are greater than 3x median flow. As the project stages progress, higher proportions of the treated effluent will be applied to land and following the implementation of Stage 2B, the frequency of discharge is expected to reduce substantially to 3.7% of the time, with 73% of discharges expected to occur when river flows are greater than 3x median flow, as summarised in **Table 5** and **6**.

Table 5: Percentage of current volume discharged to Donald Creek

Flow Statistic	Current (%)	Stage 1A (%)	Stage 1B (%)	Stage 2A (%)	Stage 2B (%)
January	5	3.7	0.06	0.008	0
February	4	2.6	0.07	0.01	0
March	4	4.1	0.23	0.23	0
April	6	6.2	1.9	0.77	0
May	9	9.4	4.0	1.4	0
June	10	10.6	11.0	7.1	0
July	14	14.4	14.0	10	1.6
August	13	13.8	14.0	9.1	4.9
September	11	10.7	5.3	2.2	0
October	11	10.5	5.1	2.1	0
November	8	6.7	0.4	0.03	0
December	6	4.7	0.3	0.03	0
Total	**100**	**97**	**56**	**32**	**6**

Source: Taken from Table 19 in AEE (Mott MacDonald, 2017).

Table 5 shows that in all project stages, except Stage 2B, treated effluent will be discharged in all months of the year with progressively lower volumes than the existing scenario as treated effluent is applied to land.

Table 6: Frequency of discharge to Donald Creek

Flow Statistic	Current (%)	Stage 1A (%)	Stage 1B (%)	Stage 2A (%)	Stage 2B (%)
< 0.5x Median	27	20	1.8	1.0	0
0.5 – 1x Median	22	20	6.1	3.6	0
1x – 2x Median	26	25	19	14	0.3
2x – 3x Median	11	11	11	9.4	0.7
> 3x Median	13	13	13	13	2.7
Total	**99**	**90**	**51**	**40**	**3.7**

Source: Taken from Table 21 in AEE (Mott MacDonald, 2017).

It should be noted that discharge quality across the proposed project staging (Stages 1A to 2B) is not anticipated to change significantly from that currently discharged from the WWTP, therefore this historic data can be used to estimate the receiving water quality effects across these project stages.

4.2 Receiving water quality

The progressive reduction in treated effluent discharge occurrences to Donald Creek expected across the project stages, will result in notable year-round improvements to the receiving water quality, as described in this section.

A statistical assessment of the quarterly recorded receiving water quality data and a recently recorded water clarity sample taken on 8 Aug 2017 (to represent winter 2017), has been undertaken to present the current year-round water clarity changes observed in Donald Creek (‘current scenario’). As ‘Stage 2B’ is the only project stage which is not likely to discharge in all months of the year, statistical analysis has only been applied to historic data recorded in the months of July and August between 2012 and 2017, supplemented with the most recent, focused 2017 winter monitoring data.

The data used in the assessment are provided in **Table 7** and include a spread of average hydrological years (2012), lower flow years (2013 & 2015) and higher flow years (2014).

Table 7: Receiving water clarity assessment – observed data

% Change Current Scenario	Current - Description	% Change Stage 2B Scenario	Stage 2B - Description
32.0	Change in water clarity data recorded quarterly between 6-Aug-12 to 8-Aug-17 (excludes Feb-15, 1-Nov-16 and 27-Feb-17 as there was no record, no change recorded and negative change recorded, respectively).	32.0	Change in water clarity data recorded annually between 6-Aug-12 and 11-Aug-16, supplemented with the focused winter monitoring data between 16-Jul-17 and 25-Aug-17.
66.8		22.2	
59.4		15.3	
38.5		30.4	
22.2		67.0	
36.7		18.2	
81.4		18.4	
70.0		11.1	
15.3		50.4	
35.0		21.6	
74.1		30.4	
30.4		60.0	
45.5			
83.6			
57.3			
67.0			
18.0			
21.6			

Log-normal distributions have been calculated for each of the data sets; current scenario – to show current compliance with the 33% change in water clarity criteria, and Stage 2B July-Aug Only data - to demonstrate possible non-compliances for Stage 2B, as summarised in **Table 8**.

Table 8: Receiving water clarity assessment – summary statistics

Summary Statistics	Current Scenario	Stage 2B Scenario
Count (Nr.)	18	12
Mean (ln(x))	3.7	3.3
Standard Deviation (ln(x))	0.5	0.6
ln(x)	3.5	3.5
Annual Compliance with 33% Clarity Change (%)	**33.0**	**94.0**
Annual Exceedance of 33% Clarity Change (%)	**67.0**	**6.0**
Maximum Observed % Change in Clarity	83.6	67.0

Based on existing receiving water quality data, it has been estimated that while current compliance with the 33% change in clarity criteria is met 33% of the time, once the ultimate discharge scenario (Stage 2B) has been implemented, compliance is likely to be met 94% of the time, with exceedances expected approximately 6% of the year. The scale of observed exceedances are also identified for each scenario, with the scale of exceedance in intermediate stages likely to be equivalent to the current scenario.

For the intermediate stages, Stage 1A to 2A, as there is no temporal change to the discharge (discharge will be maintained across all months of the year), compliance with the 33% change in clarity criteria can be estimated by multiplying the discharge frequency (from **Table 5**), by the % exceedance calculated for the current scenario, as follows:

- **Stage 1A** – 37% compliance/ 63% exceedance annually
- **Stage 1B –** 64% compliance/ 36% exceedance annually

- **Stage 2A –** 79% compliance/ 21% exceedance annually.

For Stage 2B, the compliance and exceedance ratio estimated using the log-normal distribution approach in **Table 8** provides a more conservative assessment, using observed data.

4.3 Ecological effects

The ecological effects presented in Appendix 11 of the AEE report, show that for intermediate project stages, there are likely to be progressively less effects on freshwater ecology in Donald Creek. The staging has been designed to remove summer and low river flow discharges to minimise the impact on stream ecology as far as practicable, the assessed effects are summarised as follows:

- **Stage 1B** will significantly reduce the magnitude and frequency of summer and shoulder month discharges, leading to minor effects in summer with moderate to minor effects in winter.
- **Stage 2A** will almost eliminate summer effects as discharges to the river will decrease significantly, with winter discharges occurring in higher flows resulting in scour of the river bed causing the clarity effects.

Ultimately, Stage 2B will remove summer discharges and significantly reduce the duration and magnitude of winter discharges, assessed as minor to less than minor effects.

5 Conclusions

This assessment uses recorded river and treated effluent flow and quality data for the existing discharge regime over the winter months to enhance the understanding of the proposed Stage 2B discharge on Donald Creek. The frequency of the discharge to Donald Creek will decrease significantly and the quality of the treated effluent will be comparable with that of the existing discharge.

The AEE demonstrates that water clarity in Donald Creek is expected to improve throughout most of the year, however, in the winter months when the WWTP discharges to the Creek, there are still likely to be exceedances of the PNRP Policy 71 criteria of no more than a 33% change in the water clarity.

Based on the current discharge regime, the water quality assessment demonstrates that current compliance with the 33% change has been estimated to be met 33% of the time. Through the implementation of project improvement stages, this compliance will progressively increase through the intermediate stages of Stage 1A, 1B and 2A, to Stage 2B where compliance is estimated to increase to 94% of the year, resulting in exceedances of the criteria only 6% of the year.

The discharge regime has been designed to remove summer and low flow discharges from the WWTP as a matter of priority, progressively, the intermediate project stages will lead to significant improvements in receiving water clarity.

A2. Alternative Clarity Technologies

A high-level review by SWDC of alternative treatment technologies available to manage clarity in the treated effluent.

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Memorandum

To: Greater Wellington Regional Council

From: Lawrence Stephenson

Date: 11 October 2017

Subject: Alternative clarity technologies

To Whom It May Concern,

At the conclusion of the workshop with Greater Wellington District Council on 13 September 2017, one of the actions for South Wairarapa District Council, SWDC, was a review of alternative technologies that may clarify the discharge for the Featherston Consent. The three technologies identified are:

- Dissolved Air Flotation, DAF.
- Sedimentation (lamella settlers) following UV.
- Coagulation, Sedimentation Filters (intermittent sand, rotating disc).

Background

The discharge consent application for Featherston Wastewater Treatment Plant, WWTP is set-out as a staged approach. Over 20 years, the discharge to freshwater will change to a discharge to land with winter deferred storage. The stages will be:

- Stage 1A/1B discharge to land of 70ha.
- Stage 2A discharge to land of 116ha.
- Stage 2B discharge to land of 116ha with deferred storage.

It has been raised that due to the lack of dilution in Donald Creek in comparison to the discharge flow, causes a clarity effect in the receiving water of greater than 33%, which is a conspicuous change according to the Proposed Natural Resources Plan (PNRP).

To provide additional treatment of the colour and algae which is causing the clarity change in the stream, a review of alternative technologies that may clarify the discharge for the Featherston Consent has been undertaken.

The original options assessment undertaken by Mott MacDonald, MM was a $6 million solution using Dissolved Air Floatation, based on a maximum daily flow rate of 6,000 m^3/d in Stage 2B.

The technologies identified in the high level review are:

Dissolved Air Floatation, DAF

This is the option identified by Mott MacDonald, MM as the best solution to treat the clarity issue. Dissolved air floatation is similar to sedimentation, except instead of using gravity air combines with particles to float to the surface for removal.

No confirmation of plant sizing is available, however MM has estimated $6 million.

Coagulation, Sedimentation (lamella settlers) following UV.

Sedimentation by itself is not sufficient due to the particle size of the algae, so coagulation is required to increase the particle size. The slow velocities through a settling tank, or lamella settlers allow the particle to settle under gravity for removal from the base.

The sizing of the tanks is based on flow through, which would require at least $1000m^3$ or 4 package lamella settlers. It is estimated that the whole life cost including a package dosing plant with a mixing tank would be in the order of $6 million.

Coagulation, Filters (intermittent sand, rotating disc)

As with sedimentation above coagulation is required to increase the particle size. A filter separates the particles to settle through a media, either sand or mechanical filter. Due to the possible size of the algae, the minimum size has been assumed at 10microns. This has the effect of reducing the flow through and hence the number.

The accumulated particles are removed by filtration, either the sand particles of the pore size through the rotating filter. It is estimated that the whole life cost including a package dosing plant with a mixing tank would be in the order of $8.6 million.

Options evaluation and cost estimates (assumed over 20year life)

Option Description	**Risk**	**Cost, Capital**	**Cost, Operating pa**	**Total Cost**
Dissolved Air Flotation, DAF.	Low, proven in NZ	$2.5 million	$63,000	$6 million
Sedimentation (lamella settlers) following UV	Medium, used in NZ	$1.8 million	$80,000	$6 million
Filters (intermittent sand, rotating disc)	Low, proven in NZ	$3 million	$108,000	$8.6 million

Lawrence Stephenson