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solutions for your environment

26 March 2024

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Dear Tanvir

BEACHLANDS MARAETAI WWTP RESOURCE CONSENT RENEWAL: STREAM HYDRAULIC ASSESSMENT

1.0 Introduction

This letter prepared by Pattle Delamore Partners Limited (PDP) summarises the characterisation and flow in a tributary and main stem of the Te Puru Stream that receives discharge from Watercare Services Limited's (WSLs) Beachlands Maraetai Wastewater Treatment Plant (Beachlands Maraetai WWTP). This assessment is intended to support the Beachlands Maraetai WWTP resource consent renewal.

The hydraulic assessment of the stream involved:

1. Stream walkover between the pond and the bridge, and topographical survey of the pond outlet, stream channel and weir at the bridge;
2. Installation of a continuous water level sensor and manual flow gauging (three rounds) for assistance to develop flow duration curves;
3. Producing flow duration curves to assist others with assessing the water quality impacts of the WWTP discharge; and
4. Undertaking HEC-HMS modelling and visually inspecting the stream to assess flows, velocities, and erosion within the tributary of the Te Puru Stream.

2.0 Stream Network

Beachlands Maraetai WWTP currently discharges treated wastewater into a tributary of the Te Puru Stream via a pond (i.e., Te Puru Farm Pond which is part of the current overland flow system) as shown in Figure 1. Figure 1 shows an approx. 340 m long reach below the pond with a stream slope of approximately 2%-4% through WSL land, upstream of a bridge culvert. Downstream of this bridge, the tributary continues through farmland before joining the Te Puru Stream main stem at the location indicated as Point C in the Site Plan in Appendix A, and eventually discharges into the Hauraki Gulf at Kelly's Beach.

This erosion assessment has focused on the tributary and main stem upstream of the Quarry, where the contribution of wastewater to total stream flow is greatest. Specific assessment has been made of the reach between the pond and the bridge, and adjacent to water quality sampling point C and the Quarry (shown in Appendix A). These locations have been selected based on the access provided; most of the stream is situated on private property.

Treated effluent discharge occurs into the current overland flow system that comprises a vegetated strip around the northern extent of the pond and the on-line pond itself (Figure 1). The edge of this pond and a section of the stream reach shown in Figure 2 have been surveyed as included in Appendix B.

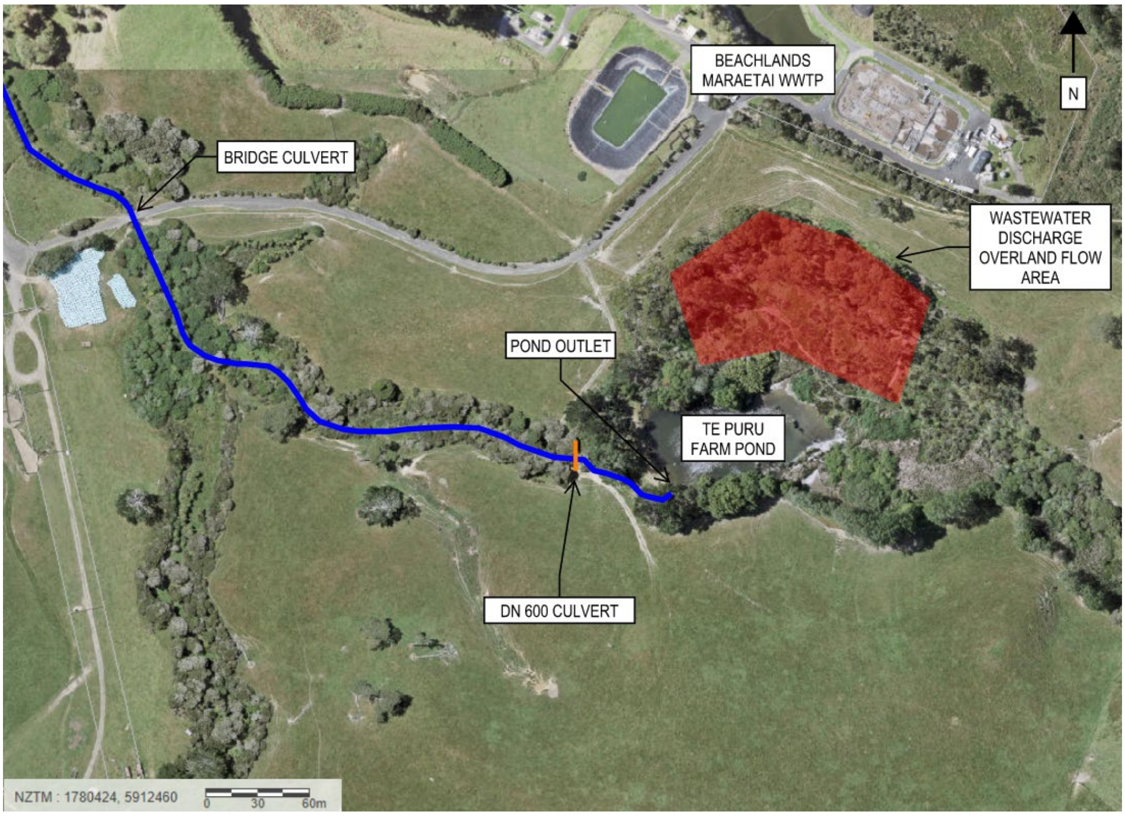

Figure 1: Stream Reach between Pond and Bridge

Figure 2: WWTP Discharge Pond Outlet Channel (18/01/2024)

3.0 WWTP Discharge

Daily discharge data for the period of January 2021 to October 2023 was obtained from WSL. The average existing and future WWTP discharges utilised for our hydraulic assessment are outlined in Table 1. As shown in Table 1, the wastewater inflows to the WWTP are expected to increase significantly in future due to population growth. This assessment has assumed that there is a steady rate of discharge into the pond for each scenario in Table 1 (assuming an approx. pond volume of 450 m^3 prior to storm events). The estimated future scenario has assumed that all WWTP discharge into the pond is upstream of the outlet shown in Figure 2.

Table 1: WWTP Discharge

Scenario	Average Discharge (m^3/s)
Existing WWTP Discharge[1]	0.021
Estimated Future WWTP Discharge[2]	0.070

Notes:
1. *Based on hourly totalised WWTP discharge data from January 2021 to October 2023.*
2. *Based on a future average daily discharge of 6,000 m^3/d.*

4.0 Data Collection

A water level sensor was installed on the downstream side of the bridge culvert, as shown in Figure 3, and on the site plan in Appendix A. This sensor has recorded the level of the stream for the last 3 months (the level sensor was installed on 27th October 2023 and remains in place). The levels have been used to estimate flows within the stream to support its characterisation (i.e., the production of flow duration curves).

To supplement the data from the level sensor, manual flow gauging was undertaken at various cross sections upstream of the bridge. This data was collected on 27th October, 15th November 2023 and 18th January 2024. During these site visits, the majority of flow through the tributary upstream of the bridge was observed to be pond discharge, indicating minimal natural baseflow through this section of stream.

Figure 3: Downstream Extent of Bridge (18/01/2024)

5.0 Flow Duration Curves

Synthetic flow duration curves were created using Hydstra software, utilising the level sensor and stream gauging data records, in addition to data from a stream gauging site for a nearby catchment (Mangemangeroa Stream catchment). The nearby gauging site was used due to the limited data collection time for the Te Puru Stream. Flow duration curves were produced at the locations of Site 1 (the bridge), Site 2 (point C) and Site 3 (adjacent to Manukau Quarries LP, i.e., the Quarry) as shown in Appendix A. Refer to Appendix C for further details on the methodology used and for the flow duration curves themselves.

6.0 Hydrological Modelling

A simple HEC HMS model was developed for the reach between the pond and the bridge to determine the theoretical stream flow and corresponding velocities for the 90%, 2, 5 and 10 year ARI (average recurrence interval) events. These values were used to assess the contribution of wastewater into the stream during storm events and estimate theoretical stream velocities.

Modelling has been limited to the extent of stream between the pond and the bridge; this being the reach where the effects of erosion are expected to be greatest due to the lesser dilution that occurs here.

6.1 Contribution of Wastewater Discharge to Stream Flow

Table 2 summarises the outputs of the hydrological modelling used to determine peak flows from various storm events and the contribution from the wastewater discharges which are 0.021 m^3/s and 0.070 m^3/s for the existing and future scenarios respectively, as per Table 1. It should be noted that the estimated future scenario includes the impacts of an increase in rainfall due to climate change.

Table 2: HEC-HMS Model Outputs					
Scenario[4,5]	**Location[6]**	**Peak Flow (m^3/s)**			
		90^{th} %ile	2-yr ARI	5-yr ARI	10-yr ARI
Existing	Reach between pond outlet and bridge	0.03 (70% WW)	0.62 (3% WW)	1.22 (2% WW)	1.83 (1% WW)
Future		0.08 (88% WW)	1.04 (7% WW)	1.98 (4% WW)	2.91 (2% WW)
Existing	At bridge	0.07 (30% WW)	3.66 (1% WW)	6.55 (<1% WW)	9.06 (<1% WW)
Future		0.12 (58% WW)	5.45 (1% WW)	9.42 (1% WW)	12.88 (1% WW)

Notes:

1. *Modelled using HEC-HMS v1.11 modelling software, based on the SCS Method in accordance with TP108 (ARC, 1999).*
2. *Average Recurrence Interval (ARI).*
3. *Rainfall intensities used for modelling retrieved from NIWA High Intensity Rainfall Design System V4.*
4. *The existing scenario is based on existing rainfall data and existing WWTP discharge as per Table 1.*
5. *The future scenario based on future rainfall intensities with climate change (included as per RCP8.5 for the period 2081-2100) and future WWTP discharge as per Table 1. The 90^{th} percentile storm does not allow for an increase in rainfall for climate change. Pre-development curve numbers have been used.*
6. *Refer to Appendix A for specific locations of these points.*

Table 2 confirms that for storm events where erosion is most likely i.e. the 2-year ARI event (the bank full event), existing and future wastewater is only a minor portion of the total flow in the stream.

6.2 Stream Velocities

The peak flows from Table 2 were used to estimate velocity in the stream as outlined in Table 3 using Mannings equation. This data indicates that velocities in the stream are currently around 0.8 m/s for typical rainfall event flow conditions (i.e. smaller rainfall events and typical WWTP discharge), and in the range of 2 m/s - 5 m/s during larger storm events. There is erosive potential in the 2-year ARI event, with velocities in excess of 2 m/s, the expected threshold for any significant erosion. This data shows that estimated future wastewater discharges create a minimal increase in velocity of up to 0.3 m/s for 90^{th}percentile event flow and no effect on velocities at high flows. Consequently, this change in regime will have less than a minor effect on erosion of the streambed.

Table 3: Estimated Velocities					
Scenario[1]	**Location**	**Average Velocity[2] (m/s)**			
		90^{th} %ile	2-yr ARI	5-yr ARI	10-yr ARI
Existing	Reach between pond and bridge	0.8	2.5	3.2	3.8
Existing + Future WW Discharge		1.1	2.6	3.3	3.8
Existing	At bridge	0.7	3.3	4.2	4.7
Existing + Future WW Discharge		0.8	3.3	4.2	4.8

Notes:

1. *The existing scenario is based on existing stream flows from Table 2, which include existing WWTP discharge as per Table 1. For the second scenario, the estimated future WWTP discharge as per Table 1 was added on.*
2. *Velocities based on Mannings equation, using average cross sections taken from the Topographical Survey (Appendix B), and a Mannings roughness of 0.03 for the natural stream section.*

7.0 Bank and Bed Erosion Assessment

During site visits on 6th September 2023, 27th October 2023 and 18th January 2024, the stream was inspected for erosion as shown in the photos included as Appendix D. As noted in Section 2.0, this was limited to between the pond and the bridge (Figures A-J), and adjacent to water quality sampling points C (Figure K to P) and the Quarry (Figure Q). The locations where these photos were taken is shown in Appendix A.

7.1 Stream Reach between Pond and Bridge

Between the pond and the bridge, some bank erosion was observed:

- Figure B shows velocities in the steep section of the stream a short distance downstream of the pond, upstream of Figure C where the left stream bank has been undercut to bedrock;
- Figure E shows the stream banks being undercut adjacent to the farm track where the stream changes direction upstream of the DN 600 culvert; and
- Figure J shows the toe of stream banks being eroded away, with tree roots observed.

Stream banks are being undercut to bedrock on the outside of meandering points. The majority of this erosion is expected to have occurred during storm events, based on the flows and velocities in Table 2 and 3. While undercutting was observed, the stream banks appear to be stable for the majority of the reach with established vegetation present and no large bank failure was observed. Through this reach, an increase in flow from future wastewater discharges is expected to marginally increase erosive potential where the stream meanders but not elsewhere in the reach. This may weaken banks in storm events / bank full flows but will only be in the localised areas. Vegetation is supporting bank stability in places. The undersized culvert at the farm track will attenuate flows and reduce downstream erosive velocities beyond the culvert outlet (a scour pool was not observed).

Downstream of the pond outlet, riprap was observed on the stream banks as shown in Figure D. Minimal bank erosion was observed here, however it is presumed that this riprap was placed for preventative erosion protection and/or diversion of the stream. Further riprap can be seen at the pond outlet as shown in Figure A, and immediately downstream of the bridge as shown in Figure I .

An existing DN 600 culvert is positioned downstream of the pond as shown on in Appendix B and Figures F and G. Based on the flows estimated from HEC-HMS modelling, this culvert appears to be insufficiently sized for the current and future 10-year average recurrence interval (ARI) stream flows. During a site visit on the 23rd October 2023 this pipe was observed to be over half full at the inlet and outlet at typical stream flows. This indicates that the culvert would be a constriction during storm events, however no evidence of overtopping was observed. The culvert also does not have an adequate upstream headwall or downstream wingwall to protect against erosion. WSL may need to investigate the capacity of this culvert further to prevent localised erosion from the additional wastewater flows.

7.2 Confluence with Te Puru Stream (Point C)

Some erosion was observed adjacent to Point C:

- Figure L shows bank erosion downstream of a farm culvert. This farm culvert, observed to be a DN 1200 concrete culvert, is located upstream of Point C as shown in Appendix A (is outside of WSL land). The culvert was observed to be over half full during typical stream flows (i.e., baseflows and average WWTP discharge), indicating that the culvert would be a restriction in storm events. The erosion observed is assumed to be associated with the farm track overtopping; and

- Figure O shows banks being undercut and some instability adjacent to the stream. This bank erosion was observed downstream of the confluence and appears to be due to eddying formed by this increase in flow from the adjacent catchment during higher flows and the meandering of the stream through this section.

Upstream of Point C away from the culvert, Figure M shows a reasonably stable section of stream with naturally formed riffles, runs, pools and meandering stream.

7.3 Adjacent to Quarry

Figure Q shows the stream adjacent to the Quarry where vegetation growth around the stream increases and the stream widens as the grade of the stream decreases. No more than minor bank erosion was observed here.

8.0 Conclusions

Our assessment indicates that minor bank instabilities are currently occurring in the stream at localised points where weak material is being undercut and stream flow reaches firmer material e.g. bedrock. Any increase in erosive potential due to the increased future wastewater discharge is expected to be minor resulting in no more than a minor effect on stream bank erosion.

9.0 Limitations

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Watercare Services Limited. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared by PDP on the specific instructions of Watercare Services Limited for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

Yours faithfully

PATTLE DELAMORE PARTNERS LIMITED

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Joseph Gibson
Environmental Engineer

Reviewed by

Robert Watson
Technical Director – Water Infrastructure

Approved by

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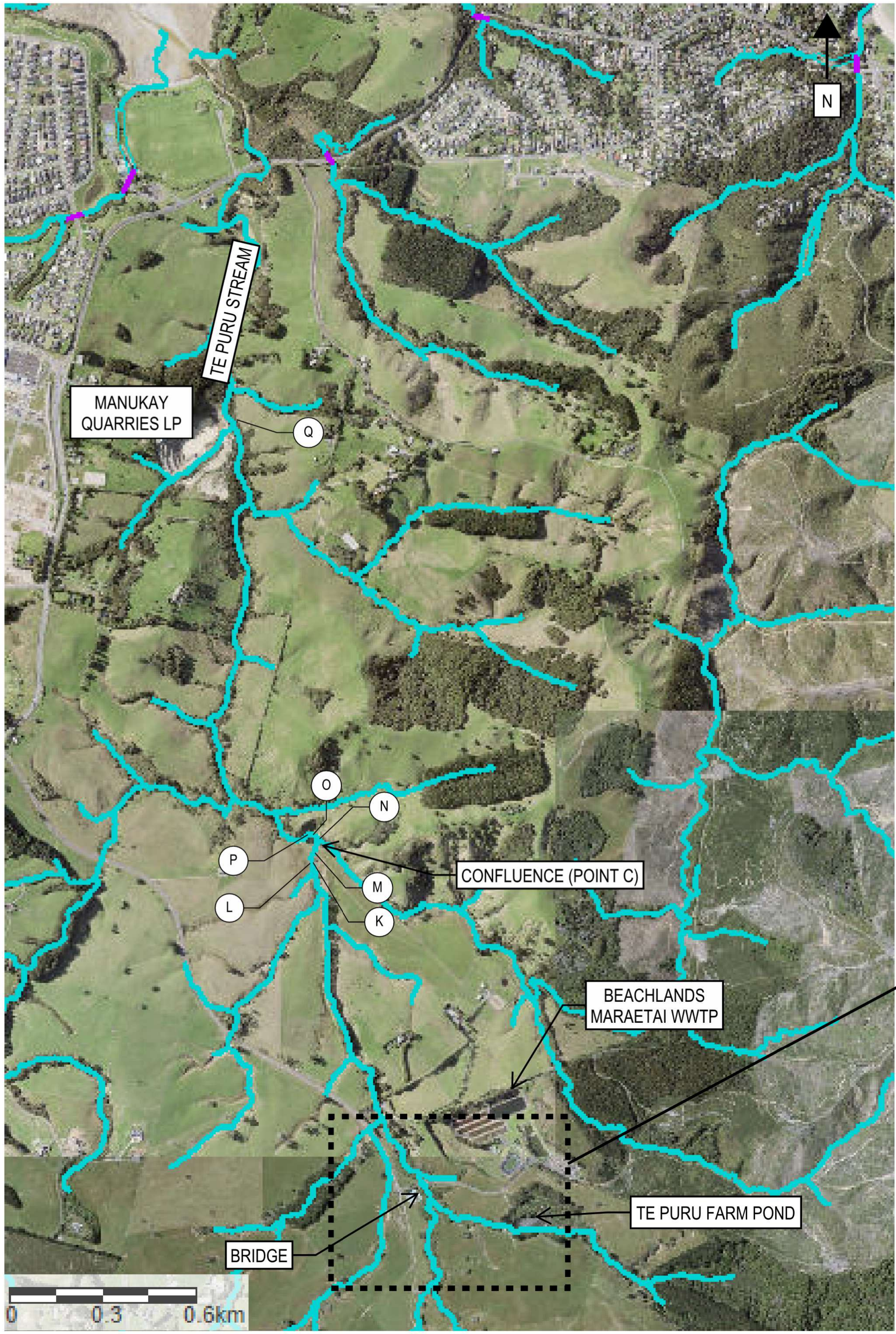
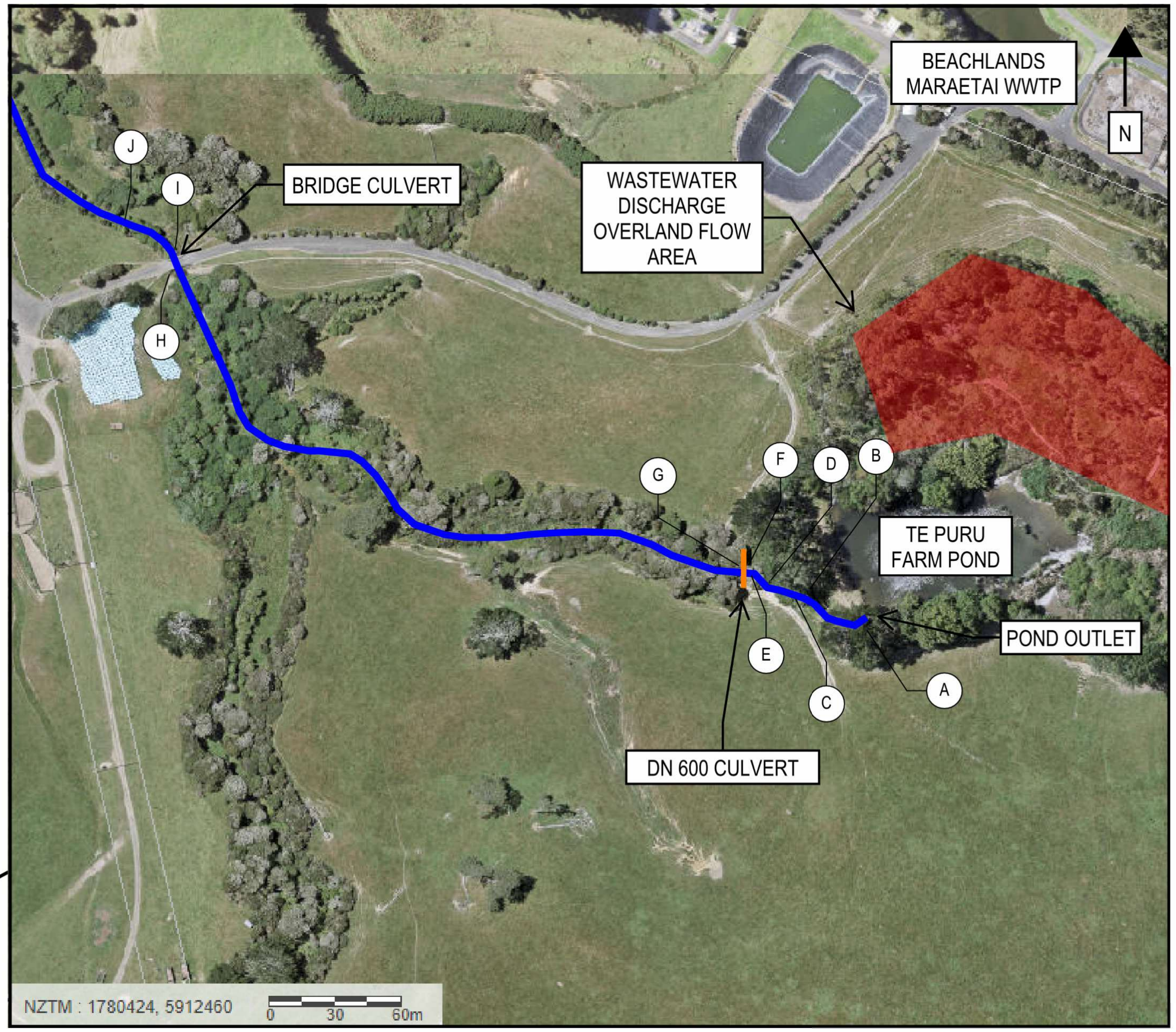
Technical Director – Water and Geotechnics

Appendix A: Site Plan

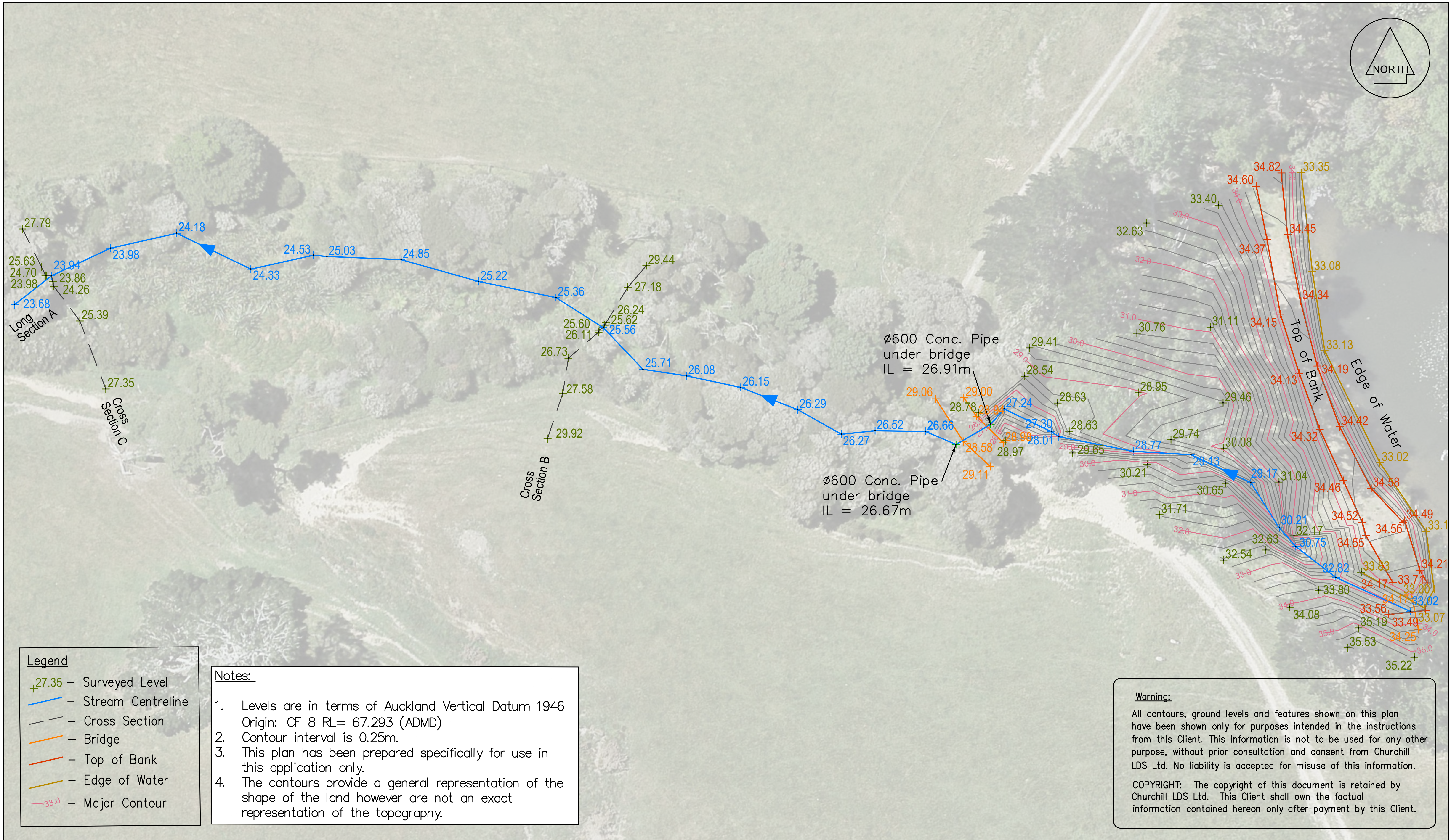




APPENDIX A - SITE PLAN

NOTE: SEE APPENDIX D FOR IMAGES e.g. (A)

Appendix B: Topographical Survey



Legend

- 27.35 – Surveyed Level
- Stream Centreline
- Cross Section
- Bridge
- Top of Bank
- Edge of Water
- 33.0 – Major Contour

Notes:

1. Levels are in terms of Auckland Vertical Datum 1946 Origin: CF 8 RL= 67.293 (ADMD)
2. Contour interval is 0.25m.
3. This plan has been prepared specifically for use in this application only.
4. The contours provide a general representation of the shape of the land however are not an exact representation of the topography.

[redacted]

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TOPOGRAPHICAL SURVEY PLAN

PROJECT: 100 OKARORO DRIVE, BEACHLANDS

AMENDMENT SCHEDULE

CLIENT: PATTLE DELAMORE PARTNERS LTD	
AUTOCAD: N/23035/AUTOCAD/23035-100/101	SCALE: 1:500 (A3)
CIVILCAD: N/23035/12D/23035 TOPO	DATE DRAWN: NOV 2023
SURVEYOR: JB DRAWN: JB	23035-100
DESIGNED: CHECKED: LRF	

Notes:

1. Levels are in terms of Auckland Vertical Datum 1946 Origin: CF 8 RL= 67.293 (ADMD)
2. Contour interval is 0.25m.
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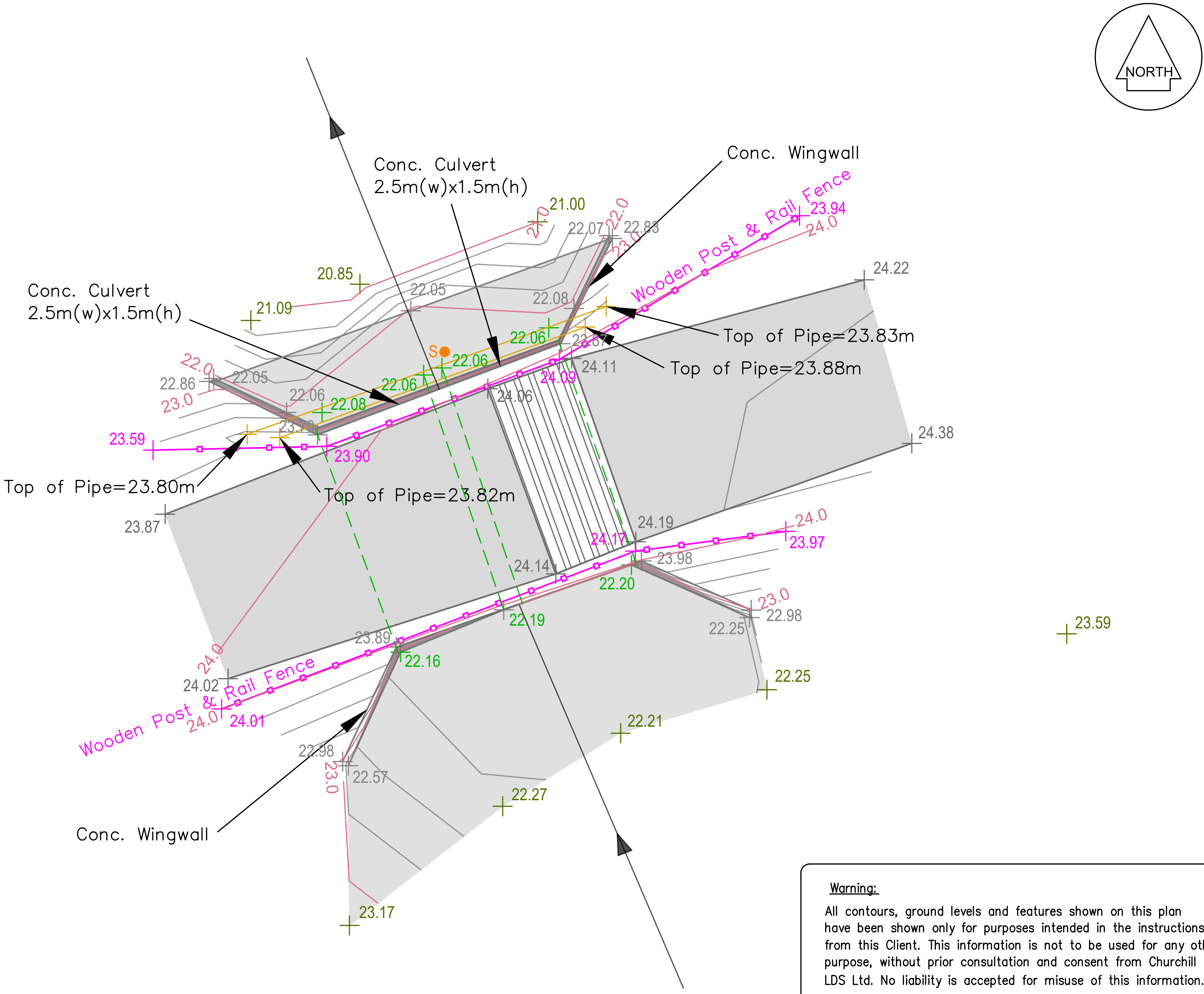

Legend
- 27.35 – Surveyed Level
- 33.0 – Major Contour
- Fence
- S – Sensor
- Cattle Stop
- Concr. Driveway
- Unknown Pipe

Warning:

All contours, ground levels and features shown on this plan have been shown only for purposes intended in the instructions from this Client. This information is not to be used for any other purpose, without prior consultation and consent from Churchill LDS Ltd. No liability is accepted for misuse of this information.

[redacted]

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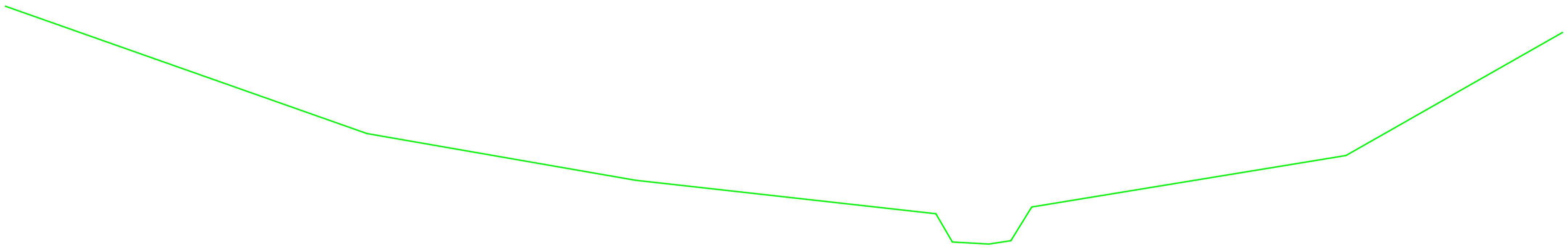
TOPOGRAPHICAL SURVEY PLAN

PROJECT: 100 OKARORO DRIVE, BEACHLANDS

AMENDMENT SCHEDULE

CLIENT:	PATTLE DELAMORE PARTNERS LTD
AUTOCAD: N/23035/AUTOCAD/23035-100/101	SCALE: 1:100 (A3)
CIVILCAD: N/23035/12D/23035 TOPO	DATE DRAWN: NOV 2023
SURVEYOR: JB DRAWN: JB	23035-101
DESIGNED: CHECKED: LRF	



DATUM R.L.23.00

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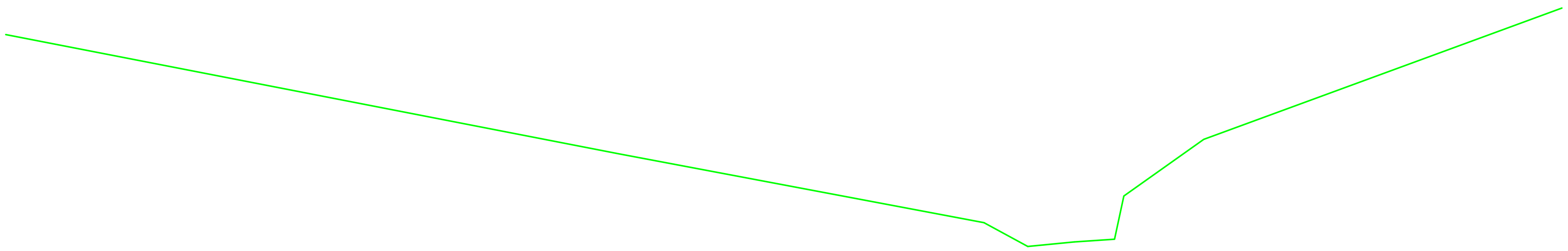
Vertical Scale 1 : 100



DATUM R.L.21.00

CROSS SECTION C
Horizontal Scale 1 : 100
Vertical Scale 1 : 100

Notes:

1. Levels are in terms of Auckland Vertical Datum 1946
   Origin: CF 8 RL= 67.293 (ADMD)
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CROSS SECTION PLAN

PROJECT: 100 OKARORO DRIVE, BEACHLANDS

AMENDMENT SCHEDULE

CLIENT: PATTLE DELAMORE PARTNERS LTD

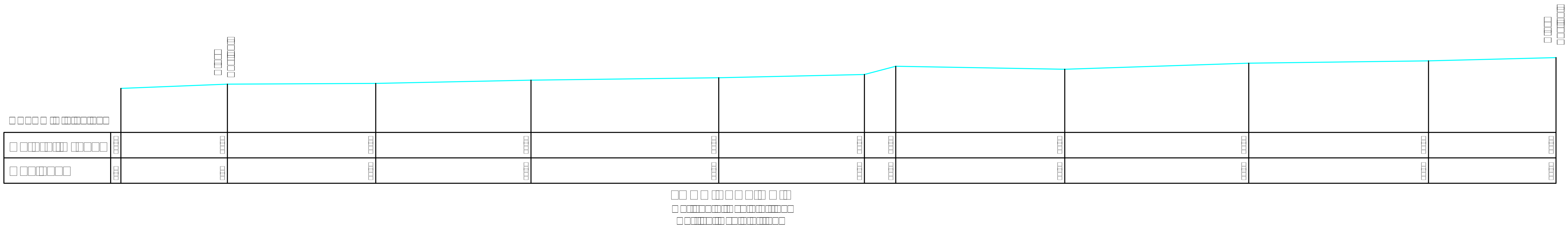
AUTOCAD: N/23035/AUTOCAD/23035-102 | SCALE: 1:100 (A3)

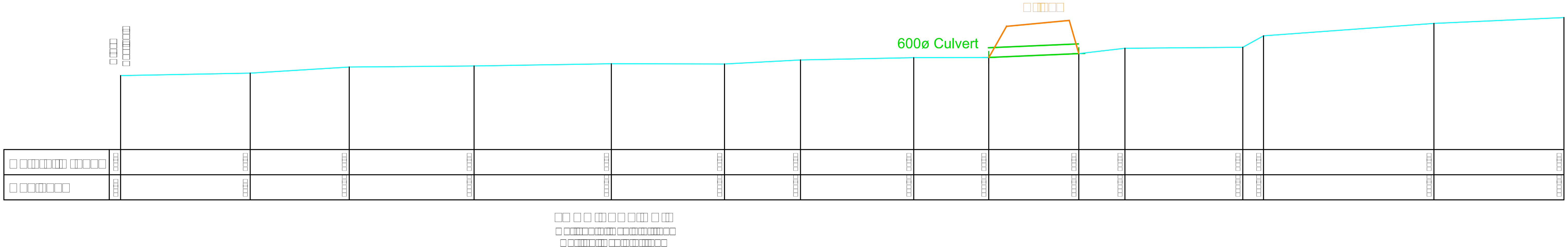
CIVILCAD: N/23035/12D/23035 TOPO | DATE DRAWN: NOV 2023

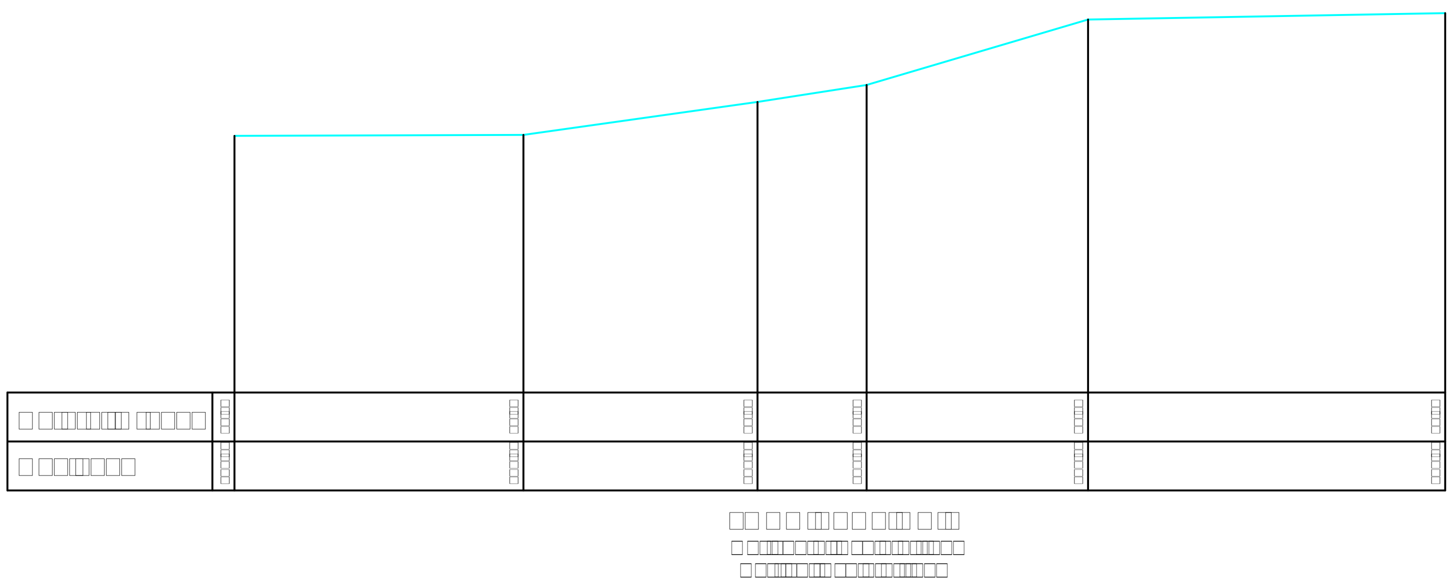
SURVEYOR: JB | DRAWN: JB

DESIGNED: | CHECKED: LRF

23035-102







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   Origin: CF 8 RL= 67.293 (ADMD)
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LONGITUDINAL SECTION PLAN

PROJECT: 100 OKARORO DRIVE, BEACHLANDS

AMENDMENT SCHEDULE

CLIENT: PATTLE DELAMORE PARTNERS LTD

AUTOCAD: N/23035/AUTOCAD/23035-103	SCALE: 1:250 (A3)
CIVILCAD: N/23035/12D/23035 TOPO	DATE DRAWN: NOV 2023
SURVEYOR: JB DRAWN: JB	23035-103
DESIGNED: CHECKED: LRF	

Appendix C: Flow Duration Curves

Te Puru Stream Flow Duration Curve Method

In order to develop a synthetic flow record for the Te Puru Stream at the Bridge, the Auckland Council Flow monitoring site on the Mangemangeroa Stream was used as a surrogate. The Mangemangeroa Stream catchment is of broadly similar size, with a similar landuse and is the closest monitored catchment to the Te Puru catchment (approximately 8 km separation).

To correlate the two sites, relative catchment area was used as a scaling factor. The Te Puru Stream has a catchment of 2.109km^2 at the bridge and the Mangemangeroa Stream Catchment is 4.756km^2 based on the MFE River Environment Classification Network. Thus, the synthetic Te Puru Stream flow record was created by scaling the Mangemangeroa flow record by 0.424. Flow in the surrogate timeseries was compared to flow gaugings obtained by PDP staff and found to be relatively similar for the dates measured.

Once the flow had been synthetically developed for the Te Puru Stream at the Bridge, flow gauging comparisons were done to determine the scaling factor to create synthetic flow records further down the catchment at locations C and Quarry (as shown in Appendix A of A02803201L001). Using the comparison flow gaugings scaling factors of 1.84 and 2.24 were used to develop flow records at C and Quarry respectively.

Auckland Council provided PDP with the flow timeseries from 14/07/2000 through to 01/03/2023. This is the most up to date processed data that Auckland Council holds.

Manual gaugings undertaken at the bridge site compared relatively well with synthetic flow record. For example, for a gauged flow of 24 l/s the synthetic flow indicated 18l/s at the site. This indicates at these flows the synthetic flow record will be conservative (i.e. estimated dilution of wastewater will be less than reality).

For the sites further down the Te Puru catchment, these were again scaled based on flow gaugings as no further information was available to be able to translate the flow series to. Further long term data capture is recommended to enable refinement of the flow duration curves.

PDP has provided the following datasets:

- Te Puru Catchment Flow Duration Curve (FDC) without Naturalisation at the Bridge (i.e. with the wastewater flow still included)
- Te Puru Catchment FDC with Naturalisation at the Bridge
- Te Puru Catchment C FDC without Naturalisation
- Te Puru Catchment C FDC with Naturalisation
- Te Puru Quarry Catchment FDC without Naturalisation
- Te Puru Quarry Catchment FDC with Naturalisation

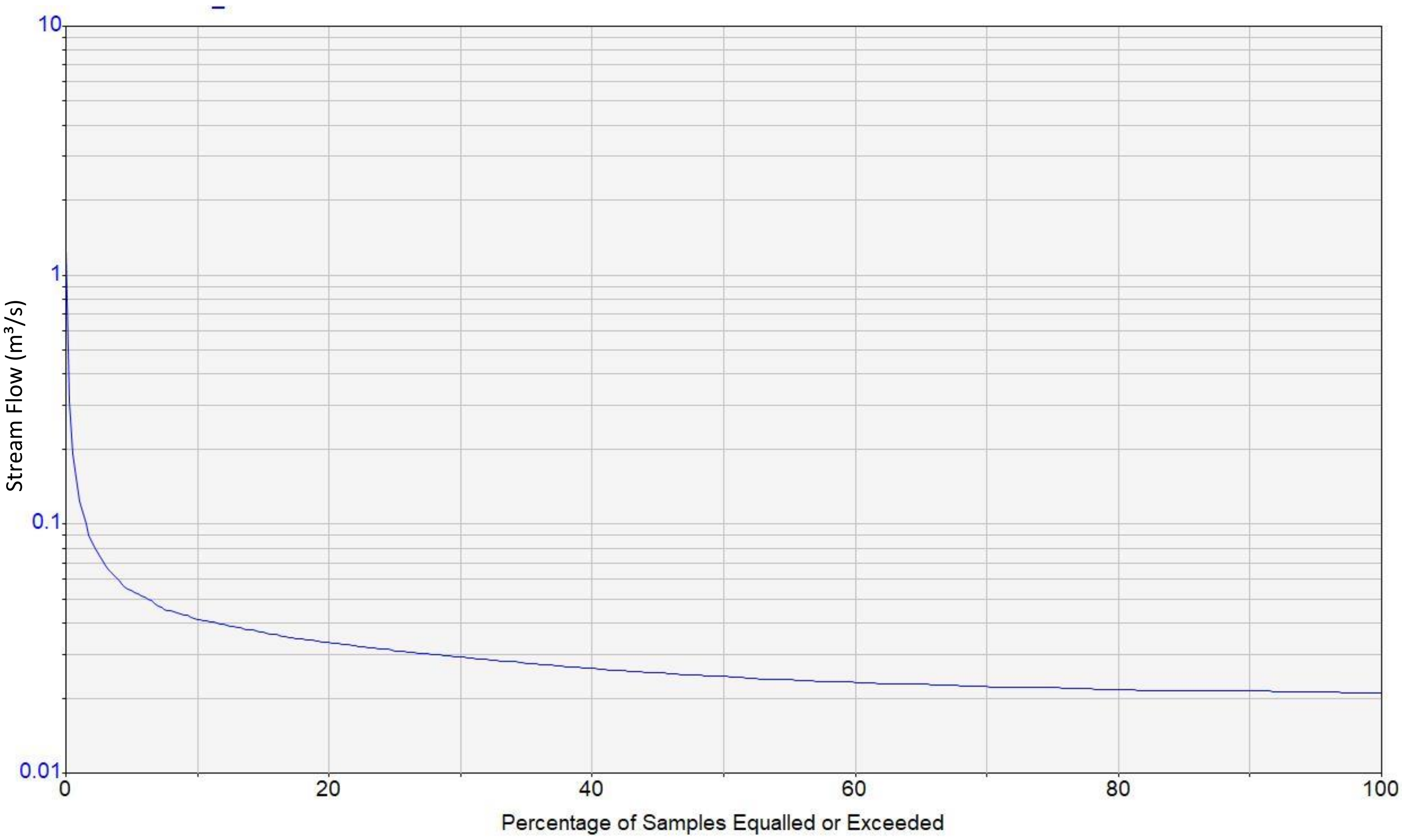

FIGURE 1: BRIDGE SITE FLOW DISTRIBUTION CURVE – WITHOUT NATURALISATION

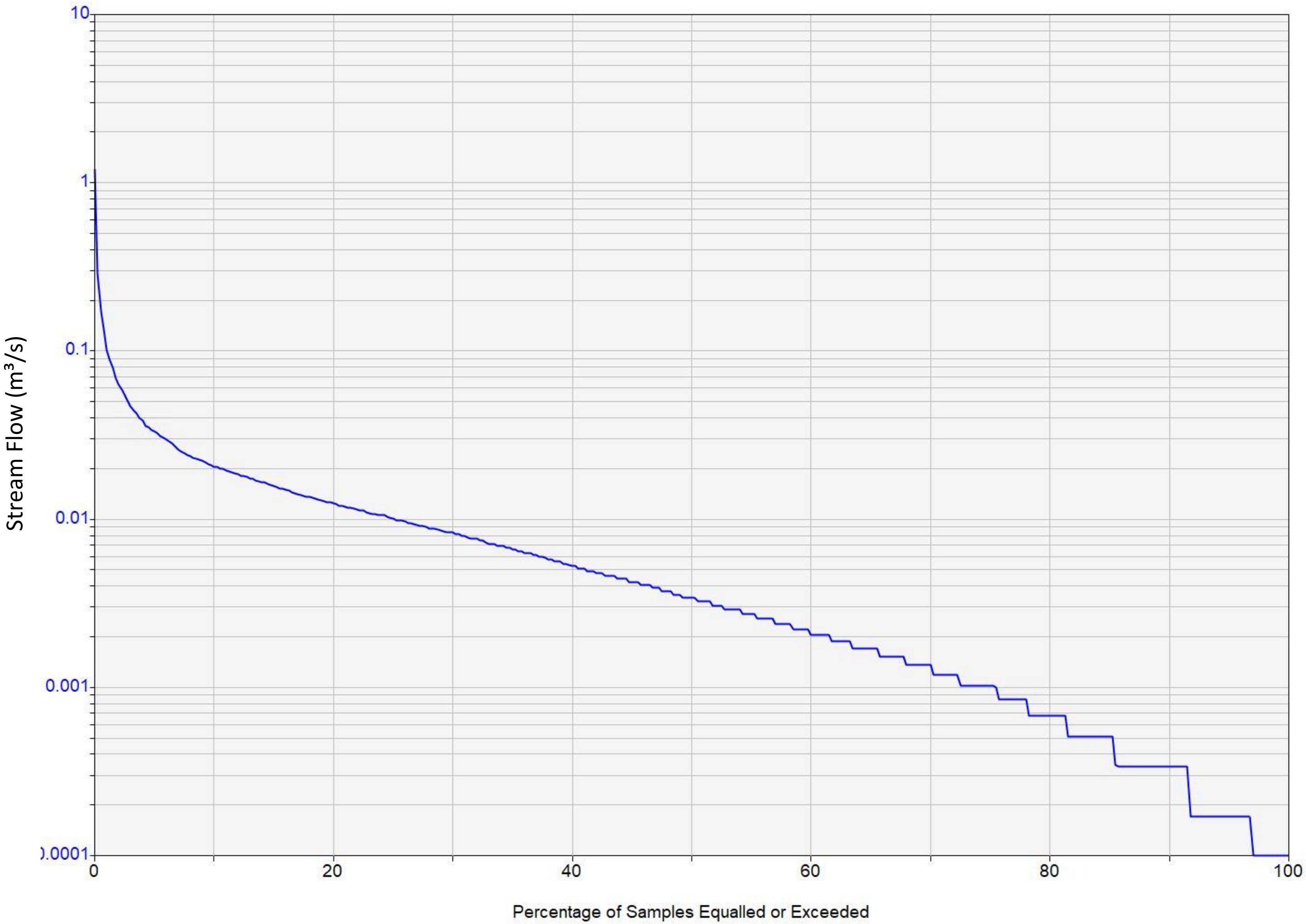

FIGURE 2: BRIDGE SITE FLOW DISTRIBUTION CURVE – WITH NATURALISATION

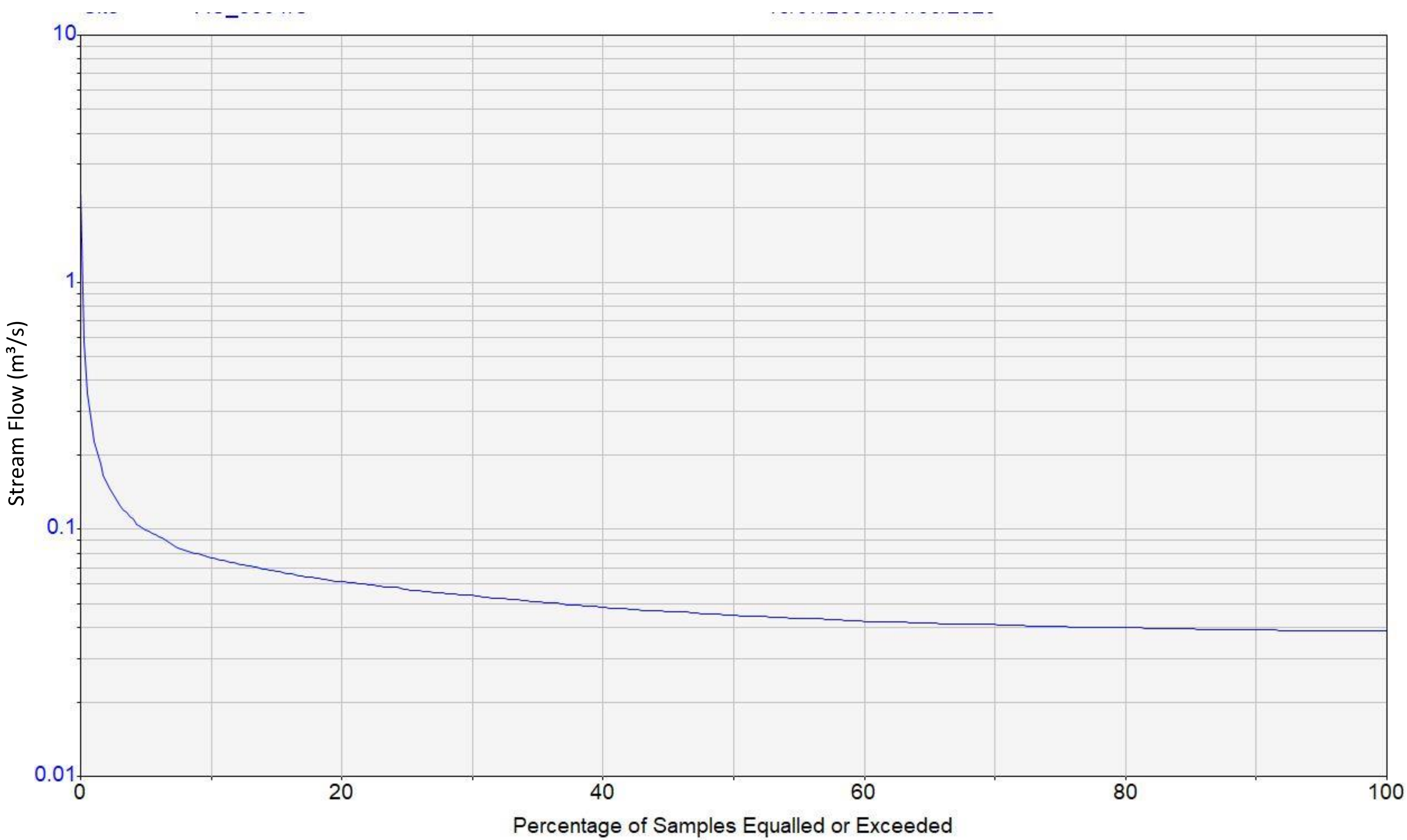

FIGURE 3: SITE C FLOW DISTRIBUTION CURVE – WITHOUT NATURALISATION

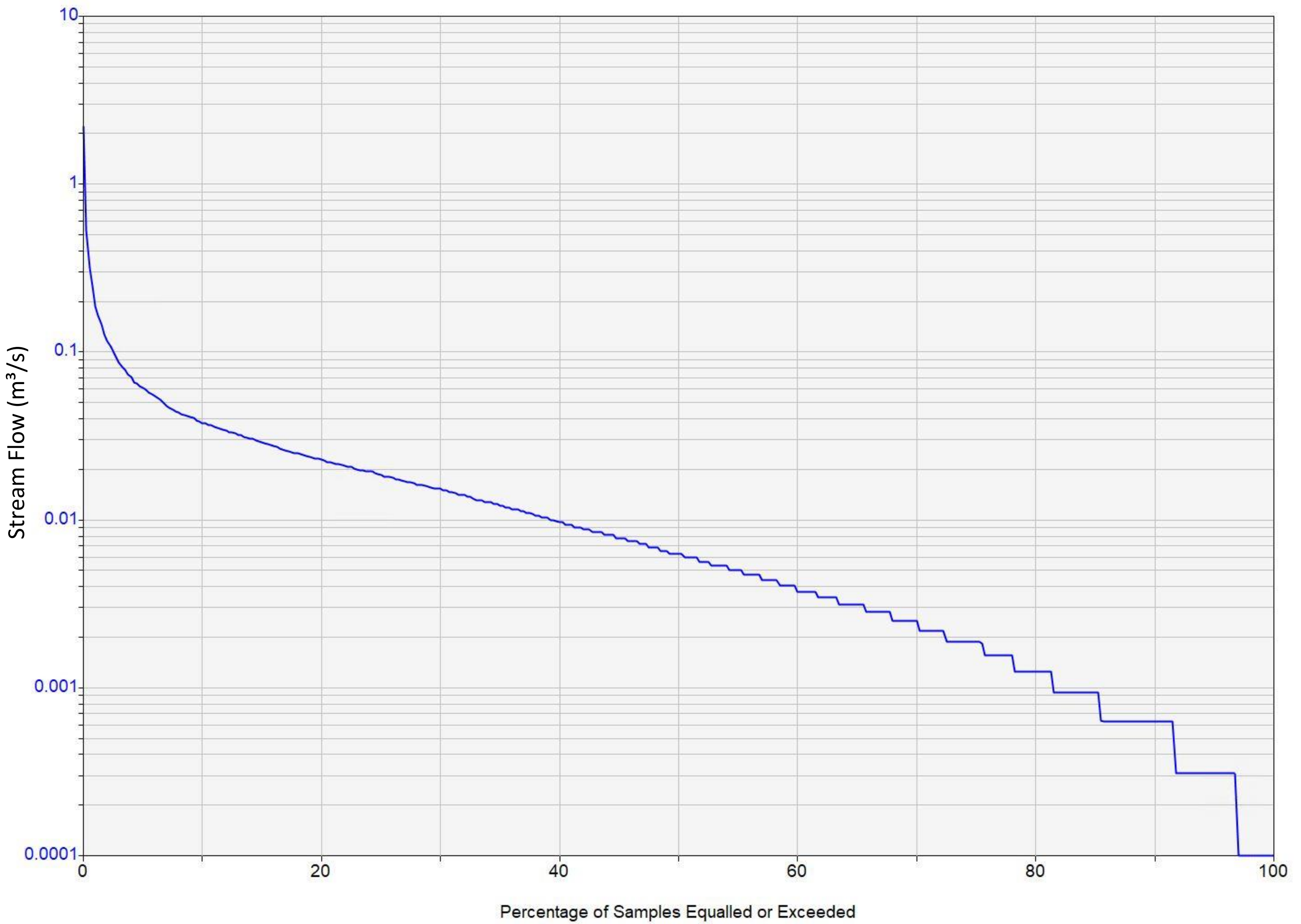

FIGURE 4: SITE C FLOW DISTRIBUTION CURVE – WITH NATURALISATION

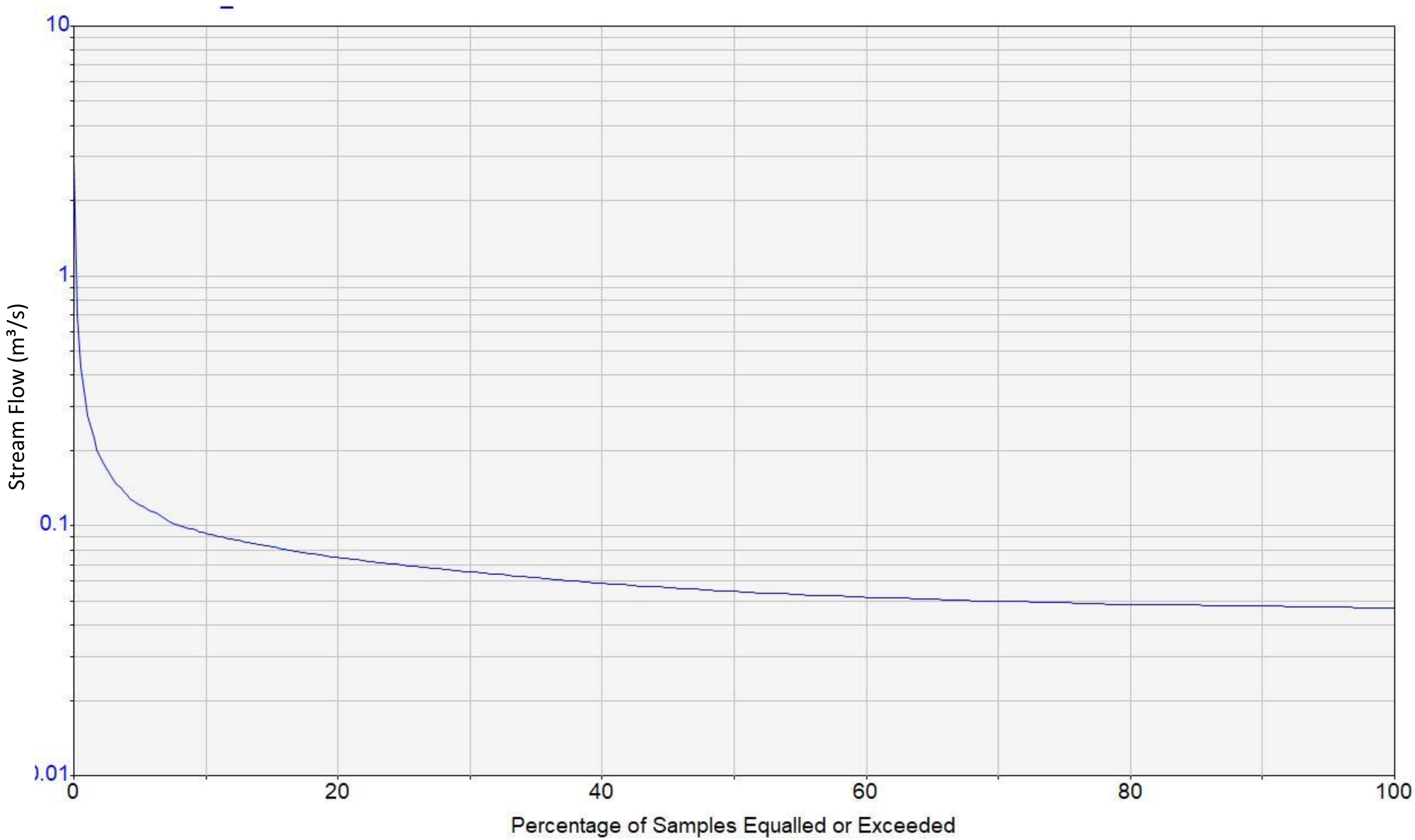

FIGURE 5: QUARRY SITE FLOW DISTRIBUTION CURVE – WITHOUT NATURALISATION

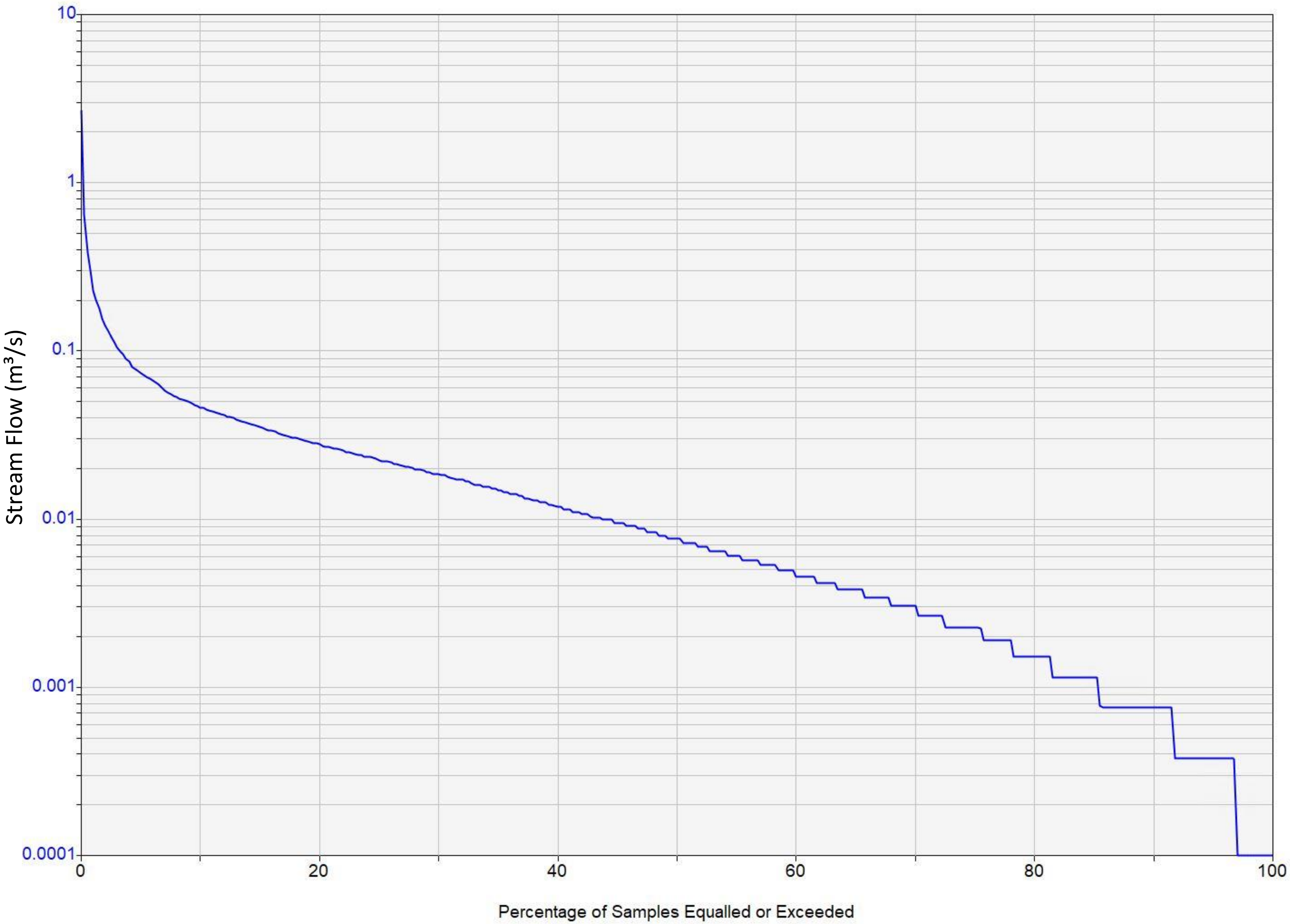

FIGURE 6: QUARRY SITE FLOW DISTRIBUTION CURVE – WITH NATURALISATION

Appendix D: Erosion Assessment Images

Figure A: WWTP Discharge Pond Outlet Channel (18/01/2024)

Figure B: Normal Flow within Stream (18/01/2024)

Figure C: Undercutting of Stream Bank (18/01/2024 – Facing Downstream)

Figure D: Riprap along Stream (18/01/2024 – Facing Downstream)

Figure E: Undercutting of Stream Bank Example 2 (06/09/2023 – Facing Upstream)

Figure F: DN 600 Culvert Inlet (06/09/2023)

Figure G: DN 600 Culvert Outlet (18/01/2024)

Figure H: Upstream Extent of Bridge (18/01/2024)

Figure I: Downstream Extent of Bridge (18/01/2024)

Figure J: Bank undercutting downstream of Bridge (18/01/2024)

Figure K: Downstream Extent of DN 1200 Farm Culvert (18/01/2024)

Figure L: Erosion Downstream of DN 1200 Farm Culvert (18/01/2024)

Figure M: Upstream of Point C (18/01/2024 - Facing Upstream)

Figure N: Point C (18/01/2024 - Facing Upstream)

Figure O: Bank undercutting at Point C (18/01/2024 - Facing Upstream)

Figure P: Point C (18/01/2024 - Facing Downstream)

Figure Q: Stream adjacent to Quarry (18/01/2024 - Facing Upstream)