Appendix E

Hydraulic Assessment
(Opus)

McPherson Quarry Resource Consent Support

Hydraulics Assessment Report External Stormwater

Contact Details

Name: Andrew Boldere
Opus House, Princes St
Private Bag 3057, Waik
Hamilton 3240
New Zealand

Mobile: +64 22 429

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Prepared By

Andrew Boldero
Senior Stormwater Eng

Reviewed By

Jaco van der Merwe
Principal Water Infrastr

Approved for Release B

Rebecca Francis
Project Manager

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Contents

1 Introduction & Purpose

WSP Opus (Opus) have been engaged by McPherson Resources Limited to prepare a stormwater assessment to assist their consent application that will enable the existing quarry operations to continue, but also allow for future growth in production. This report covers the stormwater outside (external) of the quarry pit. An Erosion and Sediment Control Plan (ESCP) has also been undertaken for the internal quarry pit drainage. This report is to be read in conjunction with the ESCP. This assessment identifies and reports on the following:

- the existing and proposed overland flow paths/changes in catchments;
- the staged designed of the quarry expansion (stages 1-3), and
- the potential impacts and mitigation measures to guarantee the successful operations of the quarry.

This report outlines the strategy for consenting purposes and does not include specific detail on the internal staging (sub-stages) of the quarry operations or the geotechnical safety aspects.

1.1 Objectives

This report outlines the stormwater management required to achieve the objectives of the Waikato Regional Council. These objectives are to minimise and manage the risk on the existing environment from the quarry expansion. This is achieved by limiting the surface water entering the quarry pit by; diverting clean water flows away from the pit into low risk erosion areas and also by diverting 'dirty' water into treatment devices (outlined in the ESCP). This report assesses and manages the surface water outside of the quarry pit operations.

1.2 Site Location and Description

The site is located at Mangatawhiri, northeast of Pokeno. McPherson Road is located on the eastern boundary of the site, while Irish and McComb Road are located on the southern boundary. McPherson Road is accessed from State Highway 2 (SH2). The quarry is owned and operated by McPherson Resources Limited. A summary of the property information is within Table 1 below. Figure 1 shows the site location and the surrounding environment. It is noted that the stage 3 quarry expansion extends into property outside the Appellations below.

Table 1-1: Property Information

CFR	Appellation	Area (ha)	Owner
NA2D/412	Allotment 22 Suburban Section 1 Parish of Mangatawhiri	44.22	MPS and SC McPherson Iggy Limited MFTC Limited
	Allotment 139 Suburban Section 1 Parish of Mangatawhiri		
	Allotment 140 Suburban Section 1 Parish of Mangatawhiri		
	Allotment 161 Parish of Mangatawhiri		
	Allotment 163 Parish of Mangatawhiri		
NA2D/497	Allotment 162 Parish of Mangatawhiri	13.75	
NA2D/961	Allotment 164 Parish of Mangatawhiri	21.21	

Figure 1-1: Site location and surrounding environment

2 Existing Catchments and Drainage

The site has an area of 79.18 ha and it contains a mix of vegetation, with some intermittent forests on the hillsides and pastoral land. The area surrounding the quarry is primarily used for farming purposes. The land towards the northwest changes to steep vegetated hills with some of this making up the quarry as the site is part of the Bombay Hills.

Currently, there are 4 major existing catchments identified in the quarry area (refer to Figures 2 and 3).

Major Catchments

Catchment 1

Catchment 1 is an elongated shape, approximately 900 m long by 200 m wide to the west of the existing quarry and consists of pastoral land and a dense vegetated area on the steep hillside slope. This catchment contains a pond that is formed behind a raised access track. It is not clear if this was intended for sediment control, however, the outlet is such that it appears to be operating as an informal sediment pond. The discharge of the pond is by subsoil type pipes and a lined Vee channel that outlets to a very steep vegetation pathway, finding its way to the base of the natural creek (also densely vegetated). This natural channel conveys the flows to the base of the hill and discharges via a large (1 to 1.2m diameter) culvert into an existing creek.

Catchment 2

Catchment 2 is where the existing quarry is located and where extraction occurs. It is also an elongated shape, approximately 1000 m long by 300 m wide, formed by pastoral land, located at the bottom of on the north portion and the existing quarry. Flows from the top of the hills run down to a sediment pond located on the centre of the catchment, that in time discharges to the northwest face of the existing quarry. Runoff appears to eventually go through the extraction area to two serial ponds at the bottom of the catchment.

Catchment 3

Catchment 3 is on the east side of the quarry and is an elongated shape, approximately 2200 m long by 500 m wide. This catchment, adjacent to the quarry, contains mostly dense vegetation on the hill side. The upper section of the catchment is pastoral. The catchment has a steep access track running along its western side before the eastern excavation of the quarry. The catchment discharges to a pond beside the residential house, near the quarry access road and then to an existing creek.

Catchment 4

Catchment 4 is on the west side of catchment 1. This catchment is split, with the west side being densely vegetated and the east side being pastoral. Like the other catchments, it drains to the south, down the hill side by a densely vegetated natural creek.

Minor Catchments

There are also several smaller catchments that are identified on the drawings. These catchments and runoff have been calculated to enable approximate sizing of the cut off drains and outlet flows.

Existing Drainage

The quarry and surrounding area contains a number of swales, natural watercourses, overland flow paths and culverts. Several existing man-made ponds also exist across the site. These appear to be primarily recreation/animal watering ponds. The lower catchment also contains the existing sediment control/treatment ponds.

Catchments 3 and 4 outlets to larger creeks than catchments 1 and 2, which connect to smaller drains that lead into the main stream flows of these larger catchments. Catchment 1 contains a large 1.2m (approx.) culvert under the access track at the base of the slope. It is understood that the size of the culvert was based upon pipes available on site at the time and did not relate to estimated flows in the catchment. Catchment 2 outlets through the quarry pit via a piped network. Refer to the ESCP for a more detailed description of the internal quarry drainage.

Figure 2-1: Existing Overland Flow Paths (OFP)

Source: WRC online Drainage maps

Figure 2-2: Existing Catchment Delineation (Overall Catchments)

3 Proposed Stages

The expansion of the existing quarry is proposed to be undertaken in 3 stages. Stages 1 and 2 will be explored in the next 10 to 15 years and will provide 10 to 12 million cubic metres of processed aggregate. Depending on demand, stage 3 will be explored in the 30 years' time frame. A future stage 4 is referenced in this report for information only and is not included in the consent application. Refer to the drawings in appendix A for staging plans and proposed stormwater management.

3.1 Proposed Stormwater Management Approach

The expansion of the quarry stages has considered the quarries preferred boundaries to most effectively excavate the materials required as well as the natural topography of the land to minimise effects and mitigation requirements. As the existing quarry expands into surrounding catchments, the overland flow management consists of cut off drains to divert flows away from the quarry face. In most areas for stages 1 – 3, the ground falls away from the quarry and therefore, as the quarry expands, the catchment areas surrounding the quarry will reduce (the internal quarry catchment will increase – refer to the ESCP for an outline of the internal quarry stormwater management). The cut-off drains have been sized using the rational method, refer to appendix B for the calculations. We have assumed 'V' shaped drains will be constructed however trapezoidal channels are also acceptable.

In areas of steep topography, the diversion drains will require energy dissipation and erosion protection. We have assumed this will be provided in the form of rock rip rap protection given the materials availability, however, alternatives such as; flumes, geofabrics etc., are also acceptable.

Areas consisting of vegetation (grazing and bush areas) are considered clean and discharge directly to the existing streams/channels. Any un-stabilised rock faces are considered 'dirty' and are directed towards treatment devices (refer to the ESCP).

Table 3-1: Sequencing of each stage

Asset	Stage 1	Stage 2	Stage 3	Stage 4 (excluded)
Existing Pond A	Operational	Operational	Operational	Removed
Existing Pond B	Operational	Removed		
Existing Pond C	Removed			
Existing Pond D	Operational	Operational	Removed	
Proposed Pond E (refer ESCP)		Constructed	Operational	Operational
Clean water diversion Drain 1.1	Constructed	Removed		
Clean water diversion Drain 1.2	Constructed	Removed		
Clean water diversion Drain 1.3.1	Constructed	Removed		
Clean water diversion Drain 1.3.2	Constructed	Removed		
Clean water diversion Drain 1.3.3	Constructed	Removed		

Clean water diversion Drain 2.1		Constructed	Removed	
Clean water diversion Drain 2.2		Constructed	Removed	
Clean water diversion Drain 3.1			Constructed	Removed

3.1.1 Timing and Order of Works

Each stage consists of many stormwater management devices. These will be installed prior to the completion of the subsequent stage to ensure that the management objectives are met. Enough time shall be allowed so that the stabilisation of drains and earthworks (outside of the quarry) can be achieved before the staged expansion commences. In cases where the swales are to be grassed, this will include enough time for the grass/vegetation to take hold. If sufficient time has not been allowed for or the grass does not establish well enough, then alternative stabilisation methods will be implemented.

The following sections describe the development of the proposed quarry expansion in terms of the individual stages.

3.1.2 Proposed Stage 1

The delineation of Stage 1 boundary has been based on maximizing extraction of the existing quarry, primarily expanding to the north and west with a minor expansion to the east.

As the expansion to the west and east is within areas that already drain away from the quarry, clean water diversion drains are not required. The area to the north does not extend to the top of the catchment and therefore requires a clean water diversion drain to divert clean water away from the main quarry pit.

There is an existing pond (C) within the stage 1 boundary to be removed. This will require dewatering prior to removal. The removal and risk assessment required for this pond (and cut faces within the quarry) are not part of the scope of this document. The stage 1 boundary also comes into close vicinity to pond B which will require a detailed stability check (not part of this report).

An internal drain has been included to align with the Erosion and Sediment Control Plan (ESCP) that drains catchment 1.4. This drain will pick up a series of smaller treatment device outlets (clean water) and discharge to the existing open channel 1.3. Refer to the ESCP for additional information and detail on these internal quarry treatment devices.

The northern area requires two clean water diversion drains (1.1 and 1.2). These are joined by existing pond B which is to remain in place for the duration of stage 1. The pond is utilised to assist the cut off drains intercepting the inflows from the small vegetated catchment above. As this runoff is considered clean, the pond could be removed if required due to safety concerns (water storage above an excavated face). In which case, the clean water diversion drains (1.1 and 1.2) would be connected by a consistent gradient drain. The lower section of drain 1.2 requires the top ridge to be excavated to allow for a constant grade into the pond D catchment. The lower section of drain 1.3 will require erosion protection and energy dissipation due to the steep gradient.

The western edge of stage 1 encroaches on the catchment of pond D. As the stage progresses towards the west the catchment of pond D reduces, however with the connection to Pond B, the total catchment into pond D increases. As pond D appears to be primarily a recreational pond, the pond size is not proposed to be altered to suit the revised inflows, however the outlet and downstream conveyance will need to match the revised inflows. This means the primary outlet of pond D will require upsizing to ensure the secondary overflow is not required in a minor rainfall event (10 year ARI – 10% AEP). Refer to the calculation summaries and appendix B for general sizing options for this outlet. No spring inflows have been allowed for in the calculations.

3.1.3 Proposed Stage 2

Stage 2 extends to the north west of stage 1. No further expansion to the east is proposed in this or subsequent stages.

Pond B is removed in stage 2. The extension of the pit to the north requires a small bund to protect the pit face from surface water. This is to ensure no localised dips cause surface water to enter the pit as the catchment directs flow downhill parallel with the edge of the pit and therefore has a limited catchment.

Pond A is to remain, provided there are no safety issues. A small catchment to the south west of this pond, drains towards the pit. Therefore, a small cut off drain is required to divert the clean water away from the pit excavation. As the flows are relatively small, we are proposing dissipation via a level spreader. Stage 2 reduces the total catchment and therefore also reduces the flows. Refer to the calculations and table summary in section 4.

The Pond D catchment significantly reduces in this stage, therefore no additional works are proposed. The enlarged outlet pipe from stage one is to remain in place until the pond is removed during stage 3.

Stage two includes a central drain that captures clean water treated within the quarry pit (refer to ESCP for treatment information). If during stage 2, additional treatment of the runoff flows is required, or the quarry wishes to move the treatment to outside of the pit floor, an additional (optional) treatment pond is proposed adjacent to the overburden stock pile. If this pond (E) is constructed the clean water drain will be redirected into the pond and transport dirty water to the treatment pond (please refer to the ESCP for the exact location as the location provided on the drawings is indicative only). A new clean water diversion drain (2.2) will be constructed in parallel, to limit the clean water entering the pond. If the stage 2 treatment is managed within the pit area then this pond is not required.

3.1.4 Proposed Stage 3

Stage 3 retains the stage 2 boundaries except for the western side, which extends out to the tree line encompassing the western ridge. Due to the natural gradient directing flows away from the pit excavation, only one clean water diversion drain is required. This drain (3.1) is an extension of the stage 2 drain (2.1). A level spreader is also proposed in this location but will need to be sized for the increased catchment runoff (compared to 2.1). The existing vegetation below the level spreader will provide good erosion protection. As the stage 3 pit extents is removing a substantial portion of this catchment, even with the clean water diversion drain in place, the total flows entering this catchment will be less than the existing.

Pond A is on a ridge line and is understood to be manmade and fed by a natural spring. Due to the ponds location on the ridge line it has been assumed that any outlet flows from the pond are to the north west. However, if during the expansion of stage 3, it is found that the pond outlets in the direction of drain 3.1 then the swale and outlet will need to be upgraded to suit the additional flows. It is possible that pond D may contribute to flows within the pit once the excavation gets closer to the pond. In which case, the pond may need to be drained or removed. Excavation stability and risk will need to be carefully considered during the design stages which is outside the scope of this report.

3.1.5 Proposed Stage 4

Stage 4 is excluded from this consent

3.2 Maintenance and Monitoring

3.2.1 Maintenance Schedule

McPhearson Resources Ltd will develop and implement a maintenance schedule for all stormwater conveyance, bunds and ponds, to ensure the stormwater management provides optimum performance at all times, and avoids or minimises any potential adverse environmental effects of the quarry operation.

Inspection and maintenance of management structures will be carried out by delegated staff with training and experience in erosion and sediment control and stormwater management infrastructure, and with reference to relevant resource consent conditions. It will be the responsibility of the Quarry Foreperson to ensure that stormwater management infrastructure are maintained regularly, and actions are recorded on a Quarry Monitoring Check Sheet.

3.2.2 Monitoring

The Quarry Foreperson to ensure that all drainage structures are maintained as specified, or otherwise twice monthly, including the clearing of inlet and outlet structures, drains and ponds.

Control/treatment structures will be inspected after significant rainfall events, or during prolonged rainfall, in addition to any regular scheduled inspections to ensure they are working adequately at all times.

4 Calculation Summaries

This section outlines the calculations undertaken. Specific calculations are included in Appendix B. The clean water diversion drains have assumed a side slope of 3H:1V (maybe revised to suit type of stabilisations). If the drains are to be grassed a 4H:1V side slope maybe preferred. Please note the drain sizing below includes a freeboard of 150mm and a climate change factor of 2.1 degrees.

Table 4-1: Catchment flows

Catchment No.	Area (Ha)	Av. Slope (%)	Time of Concentration (min)	Rainfall (mm/h)		Runoff Coefficient C	Flows (m³/s)	
				10y	100y		10y	100y
Catchment 1	14.75	15.43	30.0	60.2	105.2	0.30	0.86	1.51
Catchment 2	34.35	14.27	30.0	60.2	105.2	0.50	2.87	5.02
Catchment 3	109.57	10.10	40.0	53.8	94.0	0.25	4.09	7.15

Table 4-2: Stage 1

Drain	Catchment	Flows (10-y)	Size (V) 1V:3H Top width	
	(m²)	(m³/s)	Depth (mm)	Top Width (mm)
Drain 1.1	27,700	0.175	350	2100
Drain 1.2	31,150	0.177	350	2100
Drain 1.3.1	68,950	0.436	400	2400
Drain 1.3.2	81,550	0.535	400	2400
Drain 1.3.3	100,600	0.655	500	3000

Table 4-3: Stage 2

Drain	Catchment	Flows (10-y)	Size (V) 1V:3H	
	(m²)	(m³/s)	d (mm)	Top Width (mm)
Drain 2.1	5,500	0.043	250	1500
Drain 2.2	30,350	0.284	350	2100

Table 4-4: Stage 3

Drain	Catchment	Flows (10-y)	Size (V) 1V:3H	
	(m²)	(m³/s)	d (mm)	Top Width (mm)
Drain 3.1	29,200	0.185	300	1800

5 Risk Identification

The following table outlines identified risks in terms of the stormwater assessment undertaken.

5.1 Risk Summary Table

Identified Risk	Description	Recommendation
Ponds/Dams	Pond D has been identified as being larger that the specified 4m retained height and therefore requires compliance with the NZ Dam Safety requirements (refer to section 5.2). Dam volumes have not been calculated as no survey information below the water level is available.	Complete a dam safety assessment/audit on all ponds and follow any recommendations.
	As the quarry expands closer to the existing ponds, slope/face stability issues and seepage are likely to occur. Potentially water may enter the excavation pit and erode sections of the face increasing the stormwater management requirements (stability assessments have not been	Complete a hydrogeological/geotechnical risk assessment prior to the excavation face extending towards the existing ponds and follow any recommendations.

	undertaken as part of this stormwater assessment).	Storage of large water bodies above excavations are not recommended and removal of ponds maybe required. Manage seepage and inflows.
Ground water/watercourse	As the quarry expands closer to the existing watercourse to the west, slope/face stability issues and seepage are likely to occur.	Complete a hydrogeological/geotechnical risk assessment prior to the excavation face extending towards the existing watercourses and follow any recommendations. Manage seepage and inflows.
Access Track	The unsealed access road around the perimeter provides a conduct to channel water and potential cause erosion and sediment mobilisation.	Manage the access track erosion and sediment mobilisation as outlined in the ESCP.
Springs/seepage	As the quarry expands it is likely the inflows from springs (into the quarry pit) will increase the water management capacity required.	As springs/inflows are identified/uncovered, these are to be assessed and managed. Estimate spring flows will need to be allowed for. It is recommended that any stormwater infrastructure installed includes a contingency for these additional flows.

5.2 NZ Dam Safety Guidelines

The primary focus of these Guidelines is to provide recommended practices for the investigation, design, construction, commissioning, assessment, rehabilitation and operation of dams in New Zealand that are 4m or more in height or impound 20,000m3 or more of water or other fluid. All of the principles and recommended practices in these Guidelines are applicable to dams where the consequences of dam failure would be unacceptable to the public. In addition, all of the principles and many of the recommended practices are applicable to dams that are less than 4m in height, or impound less than 20,000m3 of water or other fluid.

6 Assumptions

- This report is for consenting purposes only.
- Stability checks for the ponds and cut off drains will be completed by a hydrogeologist/geotechnical engineer prior to the expansion with appropriate buffer zones in place as required to ensure slope stability and water retention within the pond. Specific methodologies for pond removal (ie dewatering) will need to be carefully considered as the quarry expands. It is envisaged these aspects will also be covered by the Design process which will include risk management and safety in design.
- Sub-stage expansion and detailed design is outside the scope of this conceptual (consent level) stormwater assessment.
- Spring flows have been excluded from this stormwater assessment and calculations but will be managed as staging progresses based upon observed dry and wet weather flows. Sizing of pipes, open channels, ponds and treatment devices will be revised (increased) as needed to compensate for any springs as they are identified and quantified throughout the expansion. It is understood that several springs have been discovered within the stage 3 boundary, however given the number of springs across the site, springs will likely affect stages 1 and 2 also.
- The ecological value of the existing vegetation is covered by a separate ecological report. The summary and conclusions in this report are for the external stormwater management only and do not assess the impact the existing vegetation has on the water quality.

7 Summary

Due to the quarry pit extension reducing the adjacent catchments, the effects in terms of the external stormwater is considered minimal as the staging will reduce the total surface water flows. This reduction in external quarry flows relates to an increase in the internal quarry flows which is managed through the internal drainage (refer ESCP). Although careful planning and risk management will be required for the expansion(s), the effects to the (external) overland flows and adjacent catchments are relatively easily managed by the staged approached (isolation of the quarry pit) as outlined in this report.

The existing ponds (A, B, C and D) have not been utilised in the treatment process. These however do provide informal sediment reductions, minor peak flow mitigation and stormwater treatment, which provides an additional factor of safety over and above the required mitigation proposed within this report.

The downstream (southern) side of the property should be carefully managed to prevent sediment mobilisation and erosion.

7.1 Recommendations

Due to the size of Pond D (greater than 20,000 litres and >4m height) it is recommended that the Dam Safety Guidelines are followed to ensure the pond complies to the required safety standards.

Slope stability should be continually assessed as the quarry expands, existing ponds removed and spring/inflows/seepage managed.

Disclaimer

This report has been prepared by WSP Opus for Waikato District Council in respect of the McPhersons Quarry, Pokeno for the purposes agreed between the Client and Opus as specified in the report (Purpose). Opus accepts no responsibility for the validity, appropriateness, sufficiency or consequences of the Client using the report for purposes other than for the Purposes and the report is not to be reproduced without Opus' prior written permission.

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- *Opus has provided the report based on the various assumptions contained in this report.*
- *Where we have obtained information from a government register or database, we have assumed that the information is accurate. Where an assumption has been made, we have not made any independent investigations with respect to the matters the subject of that assumption. We are not aware of any reason why any of the assumptions are incorrect.*
- *A change in circumstances, facts, information after the report has been provided may affect the adequacy or accuracy of the report. Opus is not responsible for the adequacy or accuracy of the report as a result of a change.*
- *Opus' professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at this time.*

Appendix A

Drawings

3-39019.00-C01 Overall Layout Plan

3-39019.00-C02 Stage 1 External Drainage

3-39019.00-C03 Stage 2 External Drainage

3-39019.00-C04 Stage 3 External Drainage

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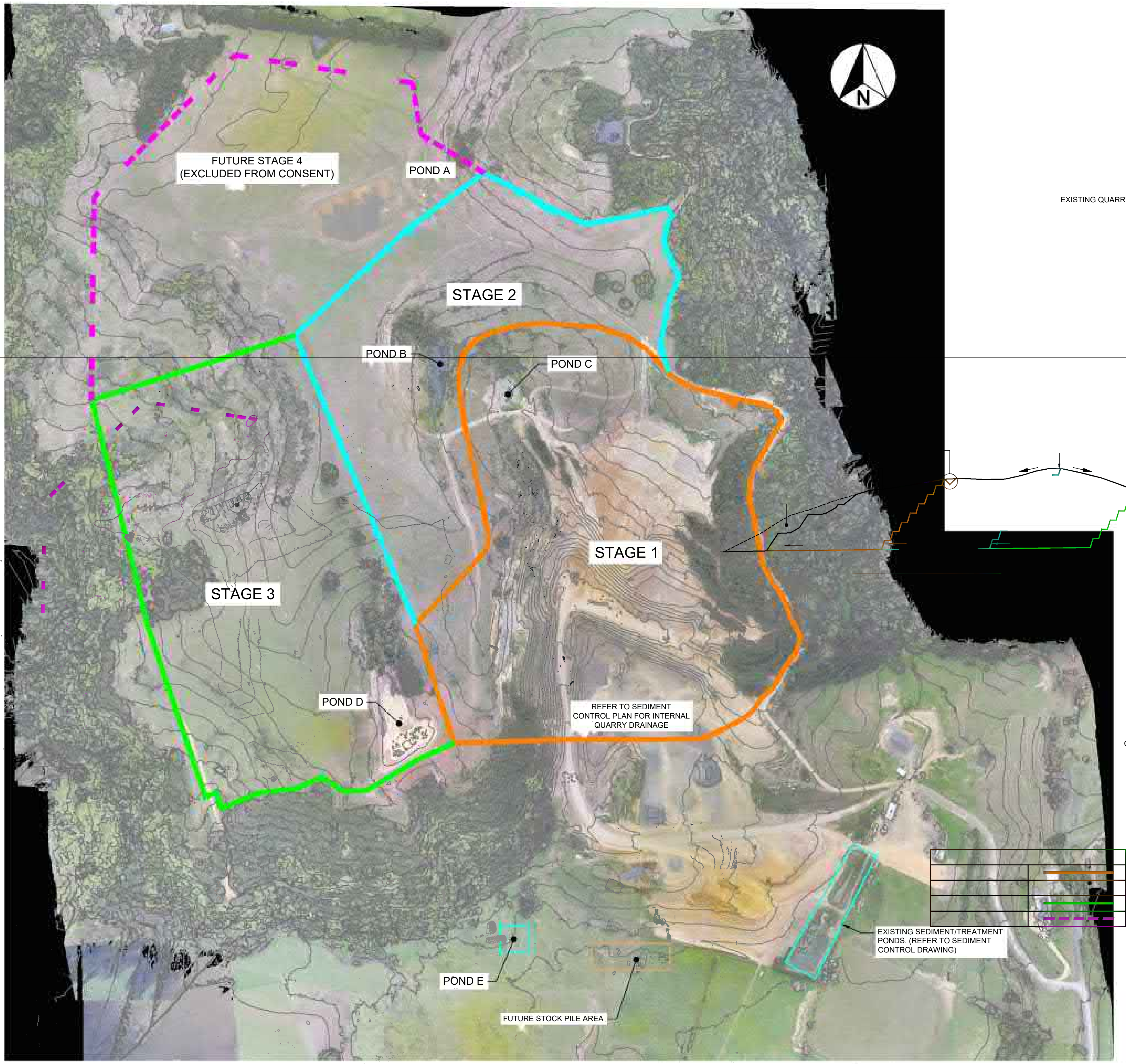

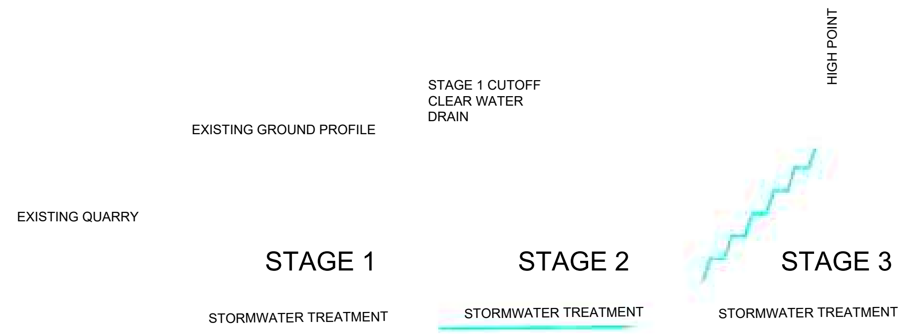

TYPICAL QUARRY SECTION

SCALE: N.T.S.

NOTES:

1. REFER EROSION AND SEDIMENT CONTROL PLAN FOR STORMWATER TREATMENT

CONTOUR INTERVAL IS 5m

LEGEND

STAGE 1	
STAGE 2	
STAGE 3	
STAGE 4	

DRAWING IN PROGRESS

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Revision	Amendment	Approved	Revision Date

wsp OPUS

Hamilton Office
+64 7 838 9344

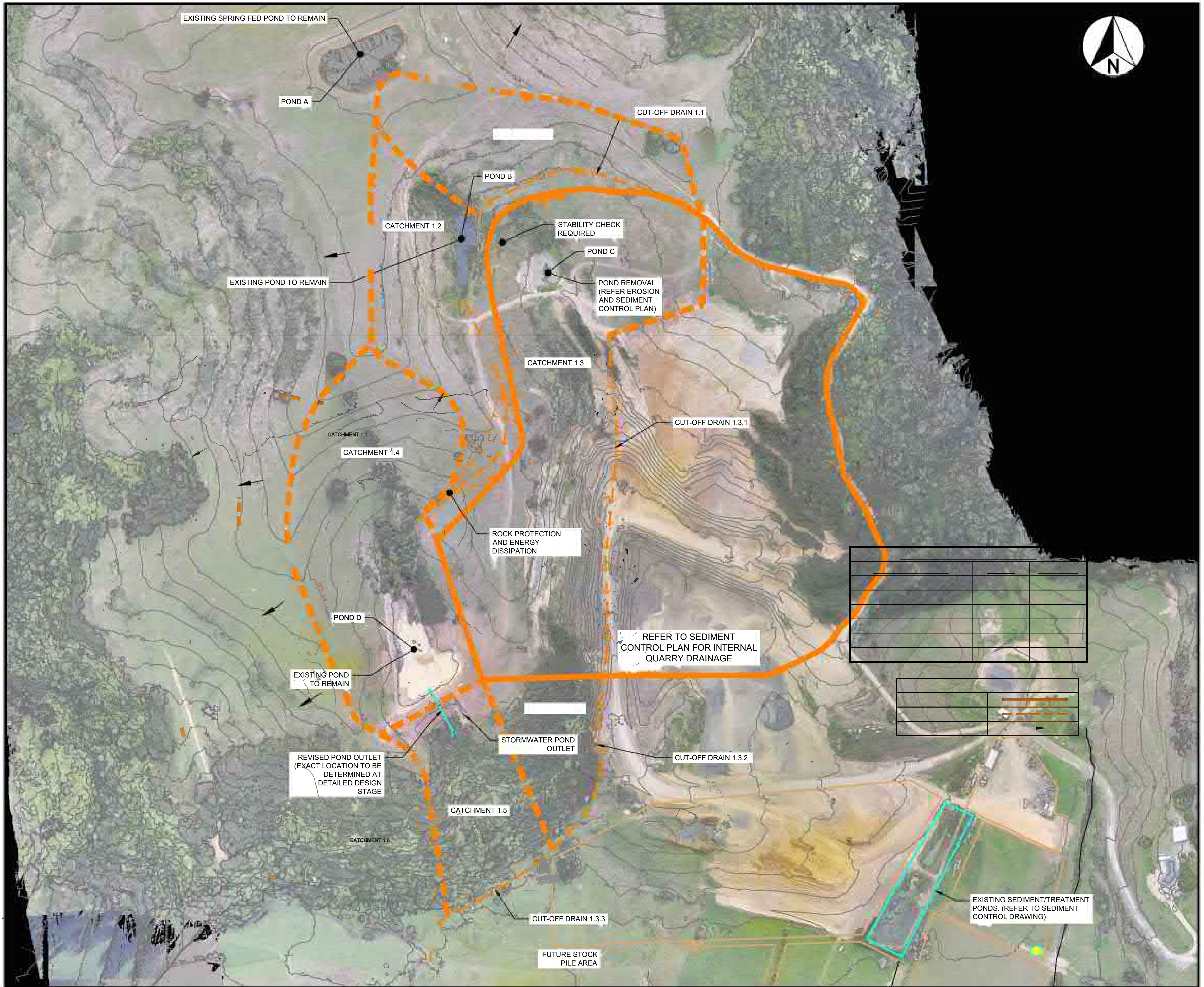
Private Bag 3057
Waikato Mail Centre
Hamilton 3240

Designed	Approved	Approved Date
Drawn	Scales	

Project
McPHERSON RESOURCES LTD
McPHERSON QUARRY
POKENO

Sheet
EXISTING GROUND CONTOURS
PLAN

Project No.	Sheet. No.	Revision
3-39019.00	C01	A



CATCHMENT INFORMATION

CATCHMENT ID	AREA	OUTLET
1.1	27700m^2	POND B
1.2	31150m^2	POND B
1.3	68950m^2	DRAIN 1.3.1
1.4	48600m^2	POND D
1.5	19050m^2	DRAIN 1.3.3
1.6	12600m^2	DRAIN 1.3.2

LEGEND

STAGE 1

CATCHMENTS

FLOW DIRECTION ARROWS

DRAWING IN PROGRESS

PLOTTED ON 2018-8-24 AT 10:04 AM

Revision	Amendment	Approved	Revision Date

wsp OPUS

Hamilton Office
+64 7 838 9344

Private Bag 3057
Waikato Mail Centre
Hamilton 3240

Project: McPHERSON RESOURCES LTD
McPHERSON QUARRY
POKENO

Sheet: STORMWATER
STAGE 1 EXTERNAL DRAINAGE

Designed	Approved	Approved Date
ANDREW BOLDERO	.	.

Drawn	Scales	Project No.	Sheet. No.	Revision
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CATCHMENT INFORMATION

CATCHMENT ID	AREA	OUTLET
2.1	5500m^2	DRAIN 2.1

LEGEND

STAGE 2	
CATCHMENTS	
FLOW DIRECTION ARROWS	

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+64 7 838 9344
Private Bag 3057
Waikato Mail Centre
Hamilton 3240

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Sheet
STORMWATER
STAGE 2 EXTERNAL DRAINAGE

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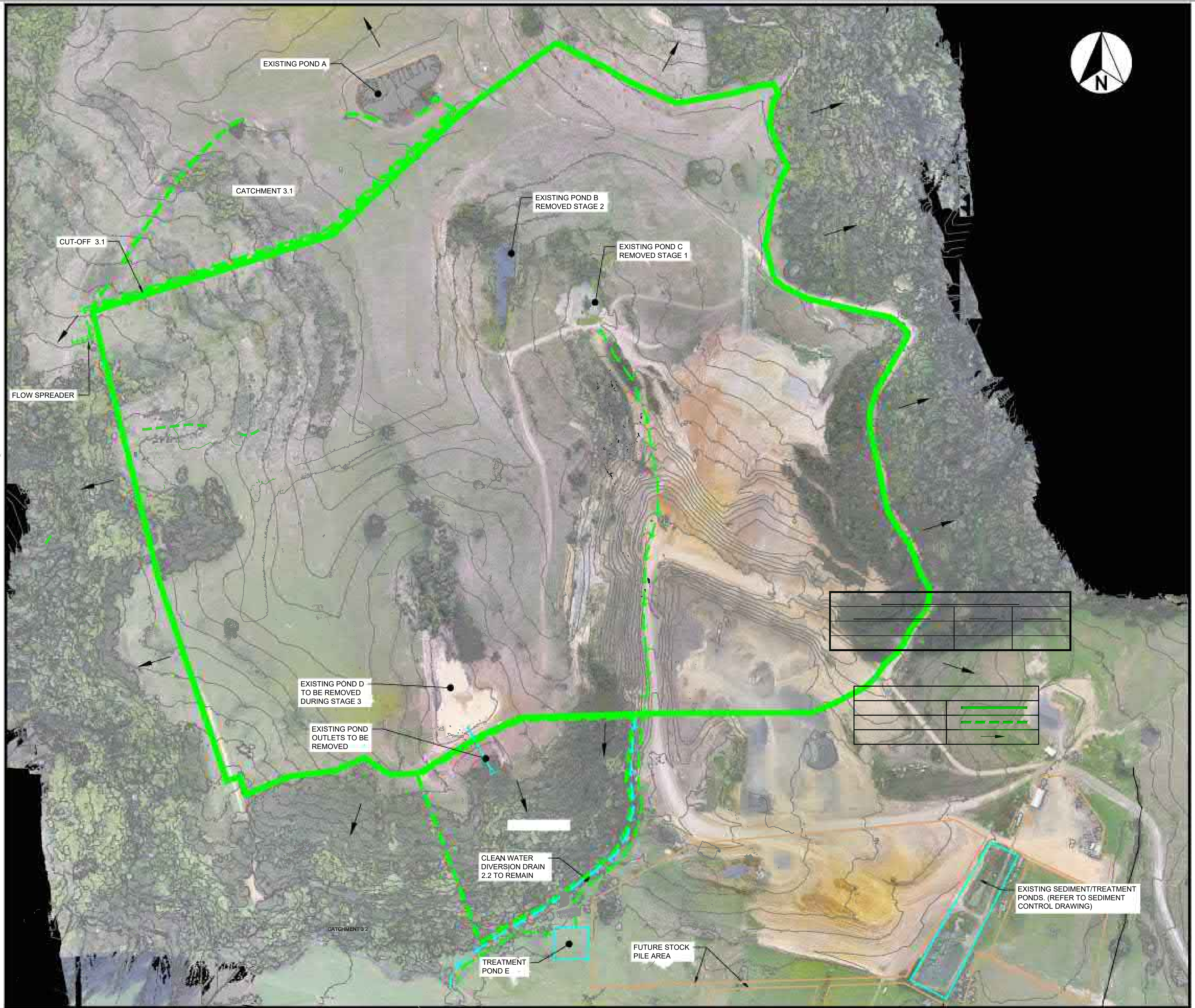

CATCHMENT INFORMATION

CATCHMENT ID	AREA	OUTLET
3.1	29200m²	3.1
3.2	30350m²	3.2

LEGEND

STAGE 3

CATCHMENTS

FLOW DIRECTION ARROWS

DRAWING IN PROGRESS

PLOTTED ON 2018-8-24 AT 10:07 AM

Revision	Amendment	Approved	Revision Date

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+64 7 838 9344

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Waikato Mail Centre
Hamilton 3240

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Drawn | Scales

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STORMWATER
STAGE 3 EXTERNAL DRAINAGE

Project No. 3-39019.00 | Sheet No. C04 | Revision A

1:2000 @ A1
1:4000 @ A3 0 20 40 60 80 100 120 140 160 180 200 m

Original Sheet Size A1 [841x594] Plot Date 2018-08-24 at 10:07:05 AM Path O:\env\heavy_industry\mcpherson_quarry\dwgs\3-39019.00 quarry\(C) Civil\+Civil3D\3-39019.00-C01_C10.dwg stage 3

Appendix B

Calculations

Worksheet 1: Rational Method Flows Calculations for Catchment 1

Project: McPherson Quarry — By: WDH

Location: Pokeno — Checked:

1. Runoff Coefficient

Catchment Name	Cover Description*	Runoff Coeff C	Area
1	Open Spaces	0.35	14.745

*RITS Table 4.8 — Totals 14.7

C (weighted) = Total / Tota

2. Time of Concentration for catchment: 1

Top Elev= 166 — Bot Elev= 15 — Length (L)= 982 m

$tc = 107n \times$

Slope= Top-Bot (H) / Length (L) = 151 / 982 — 0.1538 m/m — 15.3768 %

tc

n= Horton's values for the surface= 0.045
from RITS Drawing 4-1

3. Discharges

(+2.1° C, C.C.)

$Q = C \times I \times A/360$

I10y=	60.2	mm/h	=	Q (10y)=	0.35	60.2	14.74568	=	0.
I100y=	105.2	mm/h		Q(100y)=	0.35	105.2	14.74568	=	1.

Worksheet 1: Rational Method Flows Calculations for Catchment 2

Project: McPherson Quarry   By: WDH

Location: Pokeno   Checked: [signature]

1. Runoff Coefficient

Catchment Name	Cover Description*	Runoff Coeff C	Area
2	Open Spaces	0.50	34.35

*RITS Table 4.9   Totals   34.3

C (weighted) = Total / Tot

2. Time of Concentration for catchment: 2

Top Elev= 180   Bot Elev= 22   Length (L)= 1114 m

$tc = 107n \times$

Slope= Top-Bot (H) / Length (L) = 158 / 1114   0.1418 m/m   14.1831 %   tc

n= Horton's values for the surface= 0.045
from RITS Drawing 4-1

$Q = C \times I \times A/360$

3. Discharges (+2.1° C, C.C.)

I10y=	60.2	mm/h	=	Q (10y)=	0.50	60.2	34.35116	=	2
I100y=	105.2	mm/h		Q(100y)=	0.50	105.2	34.35116	=	5

Worksheet 1: Rational Method Flows Calculations for Catchment 3

Project: McPherson Quarry By: WDH

Location: Pokeno Checked: [signature]

1. Runoff Coefficient

Catchment Name	Cover Description*	Runoff Coeff C	Area
3	Rural	0.25	109.57
		Totals	109.

*RITS Table 4.8

C (weighted) = Total / Tota

2. Time of Concentration for catchment: 3

Top Elev= 258 Bot Elev= 14 Length (L)= 2416 m

$tc = 107n \times$

Slope= Top-Bot (H) / Length (L) = 244 / 2416 0.1010 m/m
10.10 %

tc

n= Horton's values for the surface= 0.045
from RITS Drawing 4-1

3. Discharges (+2.1° C, C.C.)

$Q = C \times I \times A/360$

I10y=*	53.8	mm/h	=	Q (10y)=	0.25	53.8	109.5726	=	4
I100y=*	94.0	mm/h		Q(100y)=	0.25	94.0	109.5726	=	7

* averaged 30/60 min events

Worksheet 1: Rational Method Flows Calculations for Cut-Off Drain 1

Project: McPherson Quarry | By: WDH

Location: Pokeno | Checked: AJS

1. Runoff Coefficient

Catchment Name	Cover Description*	Runoff Coeff C	Area
1.1	Rural Open Spaces	0.3	2.
		Totals	2.7

*RITS Table 4.8

C (weighted) = Total / Tot

2. Time of Concentration for catchment: 1.1

Top Elev= 180 Bot Elev= 146 Length (L)= 280 m

$tc = 107n \times$

Slope= Top-Bot (H) / Length (L) = 34 / 280 = 0.1214 m/m, 12.1429 %

tc

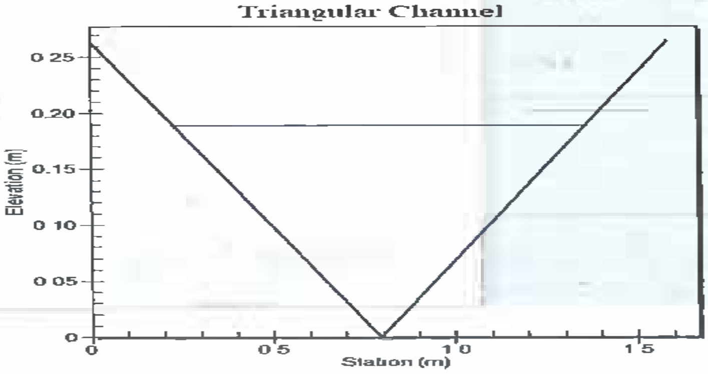
n= Horton's values for the surface= 0.045
from RITS Drawing 4-1

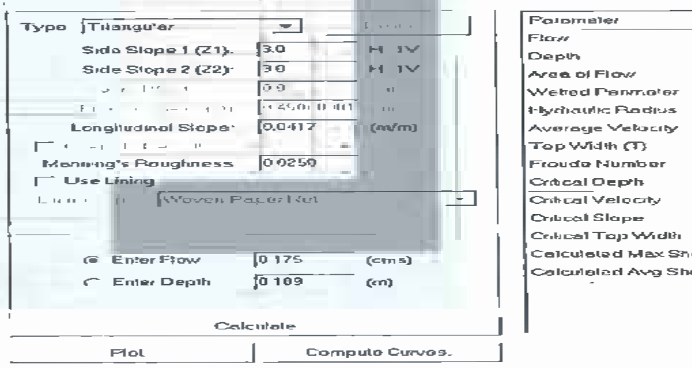
$$Q = C \times I \times A/360$$

3. Discharges (+2.1° C, C.C.)

I10y=	75.9	mm/h	=	Q (10y)=	0.30	75.9	2.77	= 0
I100y=	131.7	mm/h		Q(100y)=	0.30	131.7	2.77	= 0

4. Hydraulic Calculations for Drain: Cut-off Drain 1.1





Worksheet 1: Rational Method Flows Calculations for Cut-Off Drain 1

Project:	McPherson Quarry	By:	WDH
Location:	Pokeno	Checked:	[signature]

1. Runoff Coefficient

Catchment Name	Cover Description*	Runoff Coeff C	Area
1.2	Rural Open Spaces	0.3	3.1

*RITS Table 4.8 Totals 3.1

C (weighted) = Total / Tota

2. Time of Concentration for catchment: 1.2

Top Elev= 176 Bot Elev= 150 Length (L)= 440 m

$tc = 107n \times$

Slope= Top-Bot (H) / Length (L) = 26 / 440 = 0.0591 m/m, 5.9091 %

tc

n= Horton's values for the surface= 0.045
from RITS Drawing 4-1

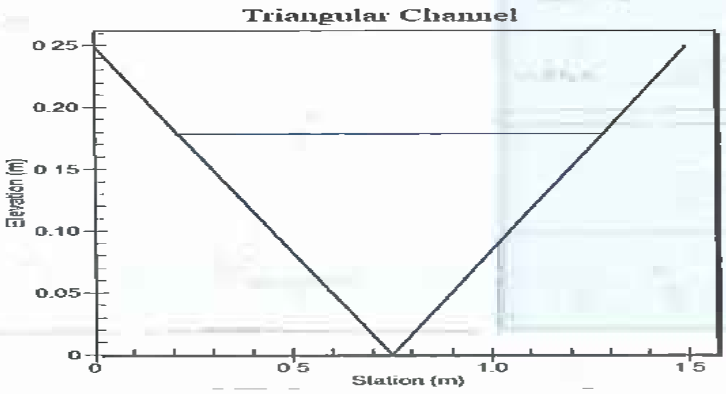
$Q = C \times I \times A / 360$

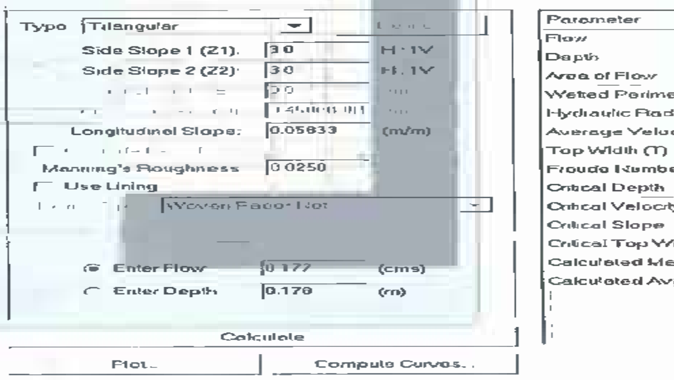
3. Discharges (+2.1° C, C.C.)

I10y=*	68.1	mm/h	=	Q (10y)=	0.30	68.1	3.115	=	0
I100y=*	118.5	mm/h		Q(100y)=	0.30	118.5	3.115	=	0

* averaged 20/30 min events

4. Hydraulic Calculations for Drain: Cut-Off Drain 1.2





* No freeboard - added to results table in report

Worksheet 1: Rational Method Flows Calculations for Cut-Off Drain 1

Project: McPherson Quarry   By: WDH

Location: Pokeno   Checked: AS

1. Runoff Coefficient

Catchment Name	Cover Description*	Runoff Coeff C	Area
1.3	Rural Open Spaces	0.3	6.8

*RITS Table 4.8   Totals   6.8

C (weighted) = Total / Tota

2. Time of Concentration for catchment: 1.3

Top Elev= 142   Bot Elev= 60   Length (L)= 445 m

$tc = 107n \times$

Slope= Top-Bot (H) / Length (L) = 82 / 445   0.1843 m/m   18.42697 %   tc

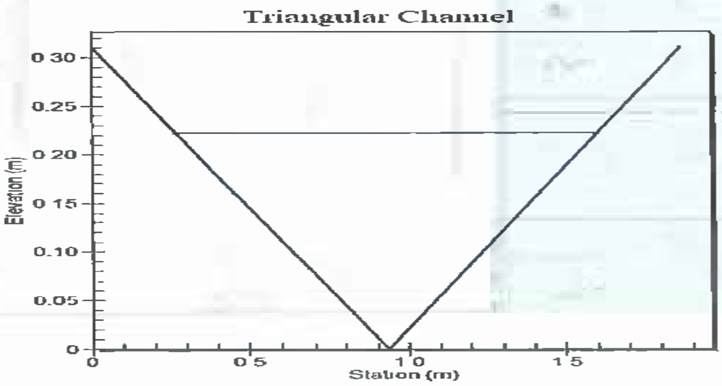
n= Horton's values for the surface= 0.045
from RITS Drawing 4-1

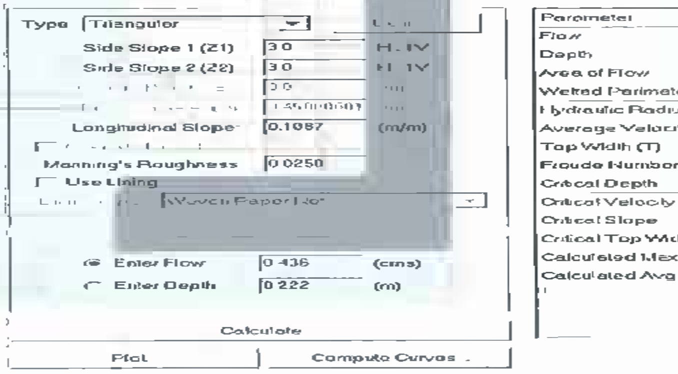
$Q = C \times I \times A/360$

3. Discharges (+2.1° C, C.C.)

I10y=	75.9	mm/h	=	Q (10y)=	0.30	75.9	6.895	= 0
I100y=	131.7	mm/h		Q(100y)=	0.30	131.7	6.895	= 0

4. Hydraulic Calculations for Drain: Cut-Off Drain 1.3.1





* Velocity Control

Worksheet 1: Rational Method Flows Calculations for Catchment 1.6

Project: McPherson Quarry		By: WDH

Location: Pokeno		Checked: [signature]

1. Runoff Coefficient

Catchment Name	Cover Description*	Runoff Coeff C	Area
1.6	Rural Open Spaces	0.3	1.

*RITS Table 4.8		Totals	1.2

C (weighted) = Total / Tot

2. Time of Concentration for catchment: 1.6

Top Elev= 60	Bot Elev= 38	Length (L)= 180 m

$tc = 107n \times$

Slope= Top-Bot (H) / Length (L) = 22 / 180	0.1222 m/m
12.222 %

tc

n= Horton's values for the surface= 0.045
from RITS Drawing 4-1

$Q = C \times I \times A/360$

3. Discharges	(+2.1° C, C.C.)

I10y=*	94.1	mm/h	=	Q (10y)=	0.30	94.1	1.26	= 0
I100y=*	162.5	mm/h		Q(100y)=	0.30	162.5	1.26	= 0

* averaged 10/20 min events

Worksheet 2: Hydraulic Calculations for Cut-Off Drain 1.3.2

Project:	McPherson Quarry	By:	WDH
Location:	Pokeno	Checked:	

1. Areas Tributary to Cut-Off Drain 1.3.2

Catchment Name	Cover Description*	Runoff Coeff C	Area
1.3	Rural Open Spaces	0.3	6.8
1.6	Rural Open Spaces	0.3	1.

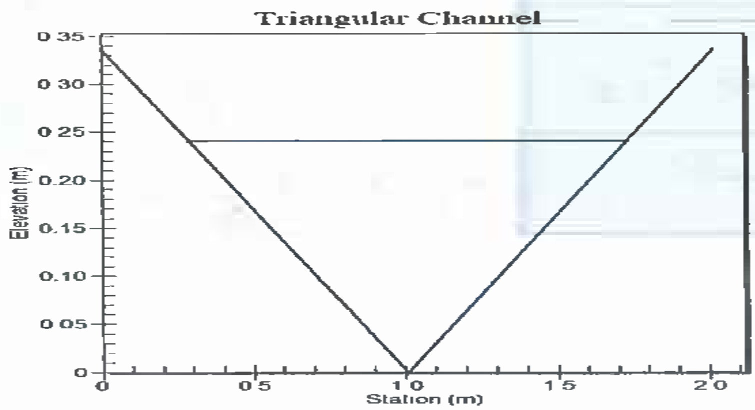
*RITS Table 4.8 Totals 8.1

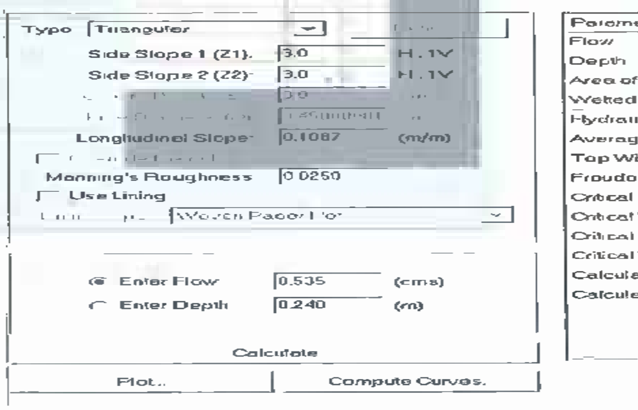
2. Discharges for Cut-Off Drain 1.3.2

Q (10y)= 0.436 + 0.099 = 0.535 m³/s (Q10 from catch. 1.3 + 1.6)

Q(100y)= 0.757 + 0.171 = 0.928 m³/s (Q100 from catch. 1.3 + 1.6)

3. Hydraulic Calculations for Drain: Cut-Off Drain 1.3.2 + added flows fron





* Velocity Control

Worksheet 1: Rational Method Flows Calculations for Catchment 1.5

Project: McPherson Quarry | By: WDH

Location: Pokeno | Checked: AS

1. Runoff Coefficient

Catchment Name	Cover Description*	Runoff Coeff C	Area
1.5	Rural Open Spaces	0.3	1.9

*RITS Table 4.8 — Totals 1.9

C (weighted) = Total / Tot

2. Time of Concentration for catchment: 1.5

Top Elev= 38 Bot Elev= 30 Length (L)= 240 m

$tc = 107n \times$

Slope= Top-Bot (H) / Length (L) = 8 / 240 = 0.0333 m/m; 3.333 %

tc

n= Horton's values for the surface= 0.045
from RITS Drawing 4-1

$Q = C \times I \times A/360$

3. Discharges (+2.1° C, C.C.)

I10y=	75.9	mm/h	=	Q (10y)=	0.30	75.9	1.905	=	0
I100y=	131.7	mm/h		Q(100y)=	0.30	131.7	1.905	=	0

Worksheet 2: Hydraulic Calculations for Cut-Off Drain 1.3.3

Project:	McPherson Quarry	By:	WDH
Location:	Pokeno	Checked:	[signature]

1. Areas Tributary to Cut-Off Drain 1.3.3

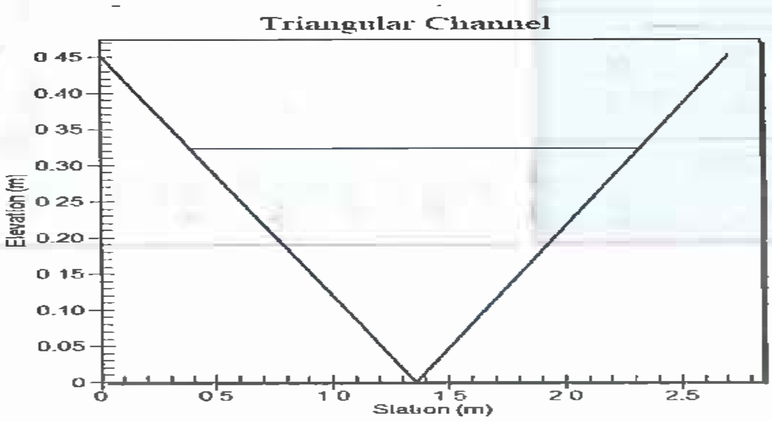
Catchment Name	Cover Description*	Runoff Coeff C	Area
1.3	Rural Open Spaces	0.3	6.8
1.6	Rural Open Spaces	0.3	1.
1.5	Rural Open Spaces	0.3	1.9
*RITS Table 4.8		Totals	10.0

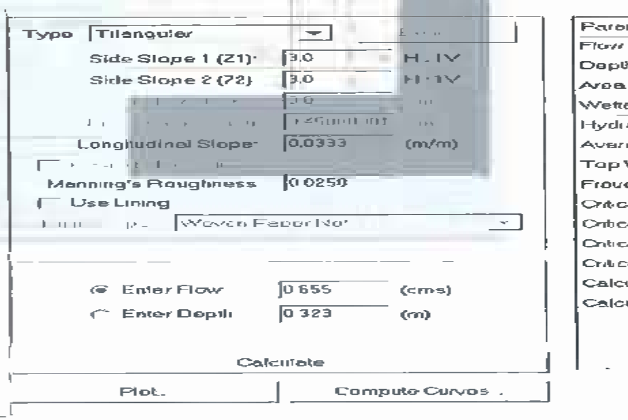
2. Discharges for Cut-Off Drain 1.3.3

Q (10y)= 0.436 + 0.099 + 0.120 = 0.655 m³/s (Q10 from catch. 1.

Q(100y)= 0.757 + 0.17 1 + 0.209 = 1.137 m³/s (Q100 from catch.

3. Hydraulic Calculations for Drain: Cut-Off Drain 1.3.3 + added flows from





Worksheet 1: Rational Method Flows Calculations for Catchment 1.4

Project: McPherson Quarry By: WDH

Location: Pokeno Checked: [signature]

1. Runoff Coefficient

Catchment Name	Cover Description*	Runoff Coeff C	Area
1.4	Rural Open Spaces	0.3	4.8
		Totals	4.8

*RITS Table 4.8

C (weighted) = Total / Tota

2. Time of Concentration for Catchment: 1.4

Top Elev= 166 Bot Elev= 120 Length (L)= 340 m

$tc = 107n \times$

Slope= $\frac{\text{Top-Bot (H)}}{\text{Length (L)}} = \frac{46}{340}$ 0.1353 m/m

13.529 %

tc

n= Horton's values for the surface= 0.045
from RITS Drawing 4-1

$Q = C \times I \times A/360$

3. Discharges (+2.1° C, C.C.)

I10y=	75.9	mm/h	=	Q (10y)=	0.30	75.9	4.86	=	0
I100y=	131.7	mm/h	=	Q(100y)=	0.30	131.7	4.86	=	0

Worksheet 1: Rational Method Flows Calculations for Cut-Off Drain 2

Project: McPherson Quarry By: WDH

Location: Pokeno Checked: [signature]

1. Runoff Coefficient

Catchment Name	Cover Description*	Runoff Coeff C	Area
2.1	Rural Open Spaces	0.3	0.

*RITS Table 4.8 Totals 0.5

C (weighted) = Total / Tota

2. Time of Concentration for catchment: 2.1

Top Elev= 180 Bot Elev= 160 Length (L)= 160 m

$tc = 107n \times$

Slope= $\frac{\text{Top-Bot (H)}}{\text{Length (L)}} = \frac{20}{160}$ 0.1250 m/m

12.5 %

tc

n= Horton's values for the surface= 0.045
from RITS Drawing 4-1

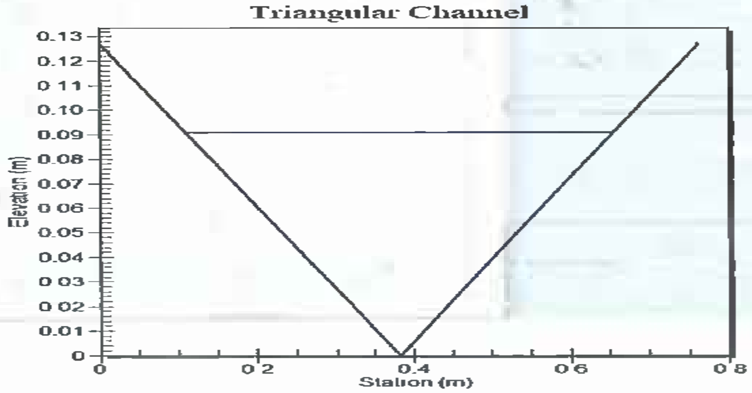
$Q = C \times I \times A / 360$

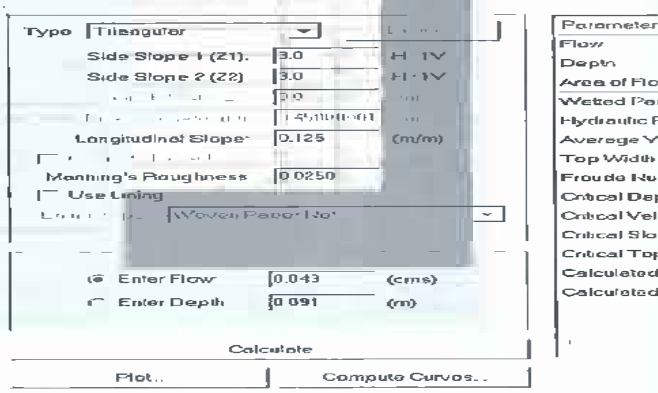
3. Discharges (+2.1° C, C.C.)

					C	I	A		
I10y=*	94.1	mm/h	=	Q (10y)=	0.30	94.1	0.55	=	0
I100y=*	162.5	mm/h		Q(100y)=	0.30	162.5	0.55	=	0

* averaged 10/20 min events

4. Hydraulic Calculations for Drain: Cut-Off Drain 2.1





Worksheet 1: Rational Method Flows Calculations for Cut-Off Drain 2

Project:	McPherson Quarry	By:	WDH
Location:	Pokeno	Checked:	*(signature)*

1. Runoff Coefficient

Catchment Name	Cover Description*	Runoff Coeff C	Area
3.2	Rural Open Spaces	0.3	3.0
		Totals	3.0

*RITS Table 4.8

C (weighted) = Total / Tota

2. Time of Concentration for catchment: 3.2

Top Elev= 122 Bot Elev= 44 Length (L)= 208 m

$tc = 107n \times$

Slope= $\frac{\text{Top-Bot (H)}}{\text{Length (L)}} = \frac{78}{208}$ 0.3750 m/m
37.500 %

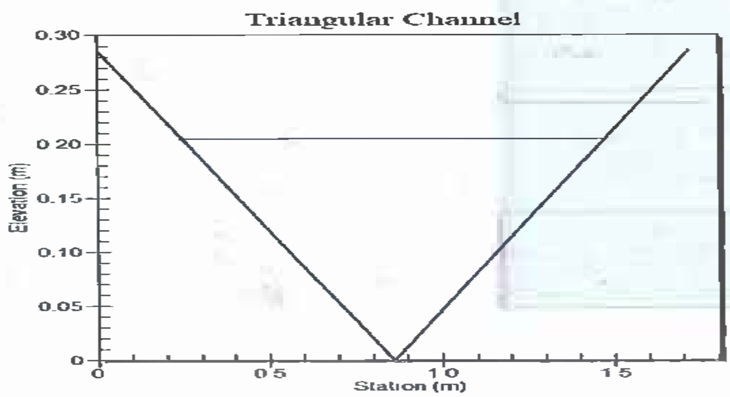
n= Horton's values for the surface= 0.045
from RITS Drawing 4-1

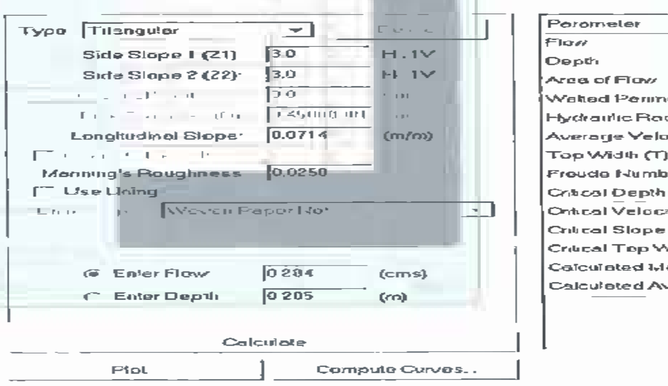
3. Discharges (+2.1° C, C.C.)

$Q = C \times I \times A/360$

I10y=	112.2	mm/h	Q (10y)=	0.30	112.2	3.035	=	0
I100y=	193.2	mm/h	Q(100y)=	0.30	193.2	3.035	=	0

4. Hydraulic Calculations for Drain: Cut-Off Drain 2.2





Worksheet 1: Rational Method Flows Calculations for Cut-Off Drain 3

Project:	McPherson Quarry	By:	WDH
Location:	Pokeno	Checked:	

1. Runoff Coefficient

Catchment Name	Cover Description*	Runoff Coeff C	Area
3.1	Rural Open Spaces	0.3	2.

*RITS Table 4.8 Totals 2.9

C (weighted) = Total / Tota

2. Time of Concentration for catchment: 3.1

Top Elev= 180 Bot Elev= 120 Length (L)= 413 m

$tc = 107n \times$

Slope= Top-Bot (H) / Length (L) = 60 / 413 = 0.1453 m/m, 14.528 %

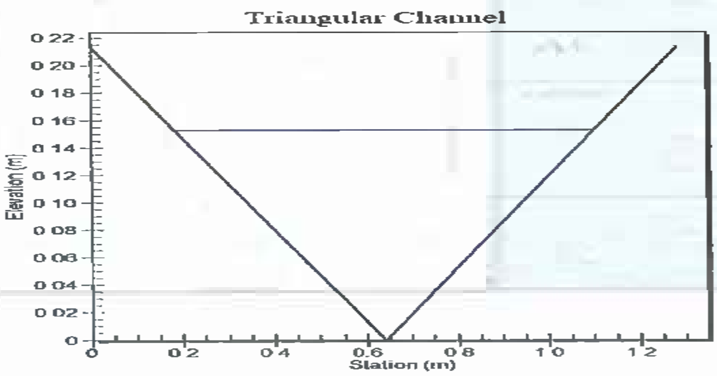
n= Horton's values for the surface= 0.045
from RITS Drawing 4-1

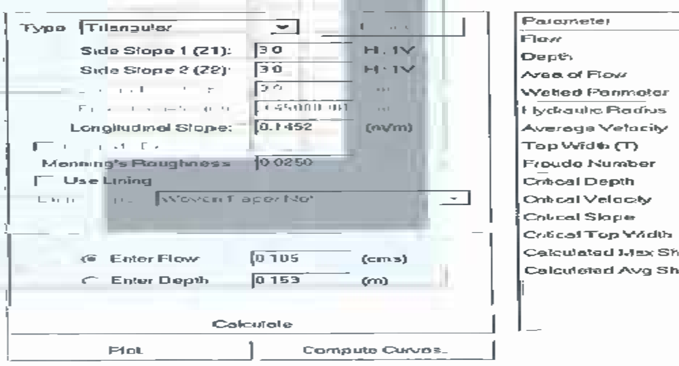
3. Discharges (+2.1° C, C.C.)

$Q = C \times I \times A/360$

I10y=	75.9	mm/h	Q (10y)=	0.30	75.9	2.92	=	0
I100y=	131.7	mm/h	Q(100y)=	0.30	131.7	2.92	=	0

4. Hydraulic Calculations for Drain: Cut-Off Drain 3.1





* Velocity Control