



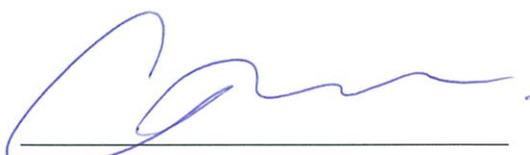
Auckland Council Healthy Waters

Okahukura Drainage District Asset Investigation



March 2018

170477



Callum Thomas

B.E. (Hons)



Brett Chick

B.E. (Hons) MIPENZ

Document Status

Rev	Date	Issued To	Comments

ACH CONSULTING LTD

3 Kawakawa Place, Westgate

PO Box 84 287, Westgate 0657

T: 09 839 7050 E: info@achconsulting.co.nz

© ACH Consulting Limited

This document is and shall remain the property of ACH Consulting. The document may only be used for the purposes for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form is prohibited.

Summary – Okahukura Drainage District

ACH Consulting Limited has been commissioned by Auckland Council Healthy Waters to undertake an investigation of the condition of existing drainage assets in the Okahukura Drainage District, and provide comment on future maintenance costs and requirements.

Existing Condition

On-site investigation showed that the main Drain A was in good condition, with evidence of some ongoing maintenance, however the other drains were generally in poor to moderate condition. It is determined that with regular spraying these drains can be restored to their optimal condition and the spread of nuisance vegetation to other areas can be mitigated.

Maintenance Schedule

Best practice is to spray drains for nuisance plants twice yearly. This has proven to be the most cost effective solution in keeping drains operating effectively, at about 10% the cost of mechanical cleaning.

Mechanical cleaning is generally required on a 5-year rotation, ideally with 1/5th of the total drains being cleaned each year.

Remedial works should be undertaken as soon as possible with priority given according to the Importance factor included in Appendix A.

Costing Summary - Maintenance

Fund Allocation:	Cost/year:	Description:
Annual Maintenance	\$54,285	Spray all drains twice yearly. Mechanically clean drains on a 5-year rotation.
Replacement Contingency	\$7,000	Funds set aside for repair and replacement of critical drainage assets including, culverts, floodgates and stopbanks.
Management Fee (10%)	\$6,129	Based on 10% of the base annual costs as a general management fee for allocating and overseeing works.
Risk Contingency (20%)	\$12,258	Based on 20% of the base annual costs. Fund allocation for dealing with extraordinary events and emergency works.
Total Annual Cost	\$79,672	Total annual cost for managing and maintaining the drainage district.

Costing Summary - Remediation

Fund Allocation:	Cost/year:	Description:
Remedial works	\$47,500	Cost of repairs/replacements of damaged drainage infrastructure.
Management Fee (10%)	\$4,750	Based on 10% of the base annual costs as a general management fee for allocating and overseeing works.
Risk Contingency (20%)	\$9,500	Based on 20% of the base annual costs. Fund allocation for dealing with extraordinary events and emergency works.
Total Remedial Cost	\$61,750	Total cost for repairing and replacing assets in the drainage district.

A full cost breakdown can be found in Appendix A.

Actionable Items

Immediate Priority:

- Spray all drains at first opportunity
- Introduce the ongoing maintenance and cleaning schedule
- Replace Floodgate 3

Secondary Priority:

- Lower Culvert 6

Contents

Summary – Okahukura Drainage District	1
Existing Condition	2
Maintenance Schedule	2
Costing Summary	2
1. Introduction	5
1.1 Objectives	5
1.2 Strategic Goals	5
2. Background	5
2.1 Chemical Spraying	6
2.2 Minimising the need for Mechanical drain cleaning	6
2.3 Mechanical Cleaning Cycle	6
2.3.1 Risks	7
2.4 Cost	7
3. Okahukura Drainage District Investigation	7
3.1 Public Drains	7
3.2 Drainage Assets	7
4. Proposed Maintenance Schedule	8
4.1 Spraying	8
4.2 Mechanical Cleaning	8
4.3 Drainage Asset Renewal and Repair	8
4.4 Asset Inspection Register	9
4.5 Cost	9
5. Discussion and Recommendation	9
6. References	9

1. Introduction

Auckland Council manages the removal and disposal of stormwater runoff in defined rural areas. The activity predominantly relates to inhabited areas and developed farmland where additional drainage is required to prevent flooding and damage to property.

A high-level asset management assessment has been undertaken on the Okahukura Drainage District. The assessment aims to provide Council with the necessary tools and information to implement a generalised management plan for the drainage assets going forward. It also aims to give an indication of future costs for budgeting purposes.

The management assessment identifies the various assets within the area and their respective condition, functionality, and significance to the region. Additionally, the assessment outlines future funding requirements including renewals and maintenance where appropriate.

1.1 Objectives

The key objectives of the Management Plan are to:

- Identify and document condition of drainage assets in the area;
- Provide a future maintenance strategy for drainage assets;
- Provide an estimate of future asset condition and useful life by taking a snapshot of the existing asset condition;
- Aid in the formalisation of future management, maintenance and renewal works for the area;
- Provide a budget estimate for future work.

1.2 Strategic Goals

To plan, maintain and improve the drainage network, minimising the effects of flooding on people, dwellings, damage to property and to promote sustainable management of the drainage network in terms of both monetary and environmental sustainability.

- Develop and implement a planned maintenance and inspection register;
- Review and update the maintenance plan as required;
- Allocate or raise the budget as required.

2. Background

Drainage maintenance is an ongoing issue for communities that rely on utilising farmland for economic benefit. Maintenance generally involves regular spraying of nuisance plants combined with mechanical removal, usually by an excavator. The mechanical excavation process also provides an opportunity to reform the banks of drainage channels where necessary and remove any excess silt.

Drainage that has been neglected and has dense overgrowth and choking may require higher intensity spraying and mechanical cleaning to bring it up to standard. Once recovered, the drain may be maintained under a regular maintenance schedule.

2.1 Chemical Spraying

Vegetation can be both beneficial and detrimental to drains. While grass and other plants can aid in erosion control on the banks of drains by holding together soil, some species can grow excessively, choking drains and impeding stormwater flows.

Vegetative choking greatly reduces the discharge capacity of drains and increases the risk of flooding. Alligator weed, in particular, is prevalent throughout the region and will require targeted treatment. Careful planning and execution is required to mitigate and minimise the growth of alligator weed and other unwanted vegetation, and stop it spreading further.

Regular spraying has proven to be the most effective maintenance practice to keep vegetation under control. Recommended procedure indicates spraying twice a year, which is an effective proactive treatment, staying ahead of weed growth. As well as being very effective when implemented properly, spraying is also very economical at around 10% of the cost of mechanical cleaning per metre.

Keeping to a strict spraying schedule is essential in staying ahead of vegetation growth and having the best results from the treatment. An experienced person should be consulted to advise on the chemicals used and where best to spray dependent on the weeds present to achieve the most effective results.

2.2 Minimising the need for Mechanical Drain Cleaning

Mechanical drain cleaning is primarily required to remove weed growth and/or sediments which impede drainage. Mechanical cleaning can be expensive as it involves the use of a digger and may require trucks to transport the spoil offsite.

A proactive approach to keeping drains clean is generally the most cost-effective way of maintaining a healthy drainage system, which makes regular spraying the first and most preferred option. In general, spraying drains more often to prevent excessive weed growth means that mechanical cleaning will be required less often, resulting in significant cost savings.

Preventing the spread of weeds is essential to limiting growth and maintaining efficient drainage. Two key ways of doing this are:

1. If possible, mechanically removed vegetation should be trucked away to a fill site. If this is not possible, ensure the vegetation is dropped a minimum of 4m away from drainage channels and waterways.
2. Remove vegetation from mechanical equipment, tools and footwear between drainage sites to prevent transfer between sites.

2.3 Mechanical Cleaning Cycle

Research indicates that drains, if well maintained, need to be mechanically cleaned about once every five years. Using this timeline, best practice is to clean one fifth of the district's drains each year. This method gives the highest probability that the overall drainage network will be in sufficient condition to handle an extreme weather event in any given year. It also means that if emergency excavator work is needed it can be done during that year's drain cleaning.

2.3.1 Risks

The greatest risk in the practice of maintaining drains is that of over-cleaning. The risk being that the removal of sediment from drains will lower the level of the drains such that water will no longer flow through permanent structures such as culverts.

Excavator operators should avoid over cleaning drains, excessive removal of soils and over-steepening of banks.

Additionally, there is the risk of damage to the banks. Slips and damage, however minor, may result in encroachment of drains to surrounding infrastructure such as roads, houses, fences etc.

2.4 Cost

Costs have been estimated with consultation from Council's maintenance contractor and other drain cleaning contractors.

In a report prepared by Environment Waikato the conclusion is that, "Undertaking a twice yearly spray program has more than halved the need for mechanical clearance and reduced costs considerably." (Gibbs, M.; 2007). This information was confirmed in discussions with resident farmer's noting that in particular, the alligator weed could not be controlled with yearly spraying. As such, 6 monthly spraying is recommended for all drains.

Extra over costs for cartage of material off site have been included, and assumed no tip fees and a local point of disposal (farmers paddock etc).

The table below indicates costs for drain cleaning.

Maintenance	Estimated Cost Per Metre	Suggested Recurrence
Chemical Spraying	\$0.35	6 months
Mechanical Cleaning	\$3.5	5 years
Cartage of material away	\$3.5	5 years

3. Okahukura Drainage District Investigation

Site inspections were carried out in the Okahukura Drainage District by ACH Engineers during November 2017. The inspections comprised of visual assessments of all culverts, fords and bridges. Additionally, aerial drone footage was recorded of all drains.

The inspections revealed that the drains were in moderate to poor condition with high levels of weeds present. Additionally, there were significant issues with some of the drainage assets.

3.1 Public Drains

ACH identified 25 public drains in the district that fall under the Council's obligation. The drains are identified as 'A' through 'Z' as detailed in Appendix B.

Overall, the majority of the lengths of drainage were clear and free flowing, although some areas were densely vegetated and choked with weed. It is likely that without timely remediation

and control nuisance plants will continue to spread, intensifying the issue and significantly increasing the chance of a catastrophic flood event.

3.2 Drainage Assets

ACH identified six culverts and four floodgates as essential assets in the drainage district.

The assets were inspected and an estimate given for their remaining life, replacement cost and importance in the network.

Three of the culverts and three of the floodgates were in good working condition and allowed free drainage. Culvert 3 has a pipe crossing one end which is blocking flow and should be diverted. Floodgate 3 is completely non-operational with replacement required. Culvert 6 is dry and not transferring water therefore requires remedial work. Culvert 7 is non-operational and will require remedial work.

It is recommended that remedial works be carried out as soon as possible. It is recommended that an asset register be implemented, identifying these assets and updating their condition on a yearly basis.

4. Proposed Maintenance Schedule

The proposed maintenance schedule is designed on best practice and evidence based investigation to achieve a pro-active approach in keeping drains free flowing. As such, it is essential that *both* spraying and mechanical cleaning are undertaken as scheduled to stay on top of vegetation growth and sedimentation. In this way, significant blockages and catastrophic failures will be minimised and the Council will have the resources to deal with them effectively, should they occur.

4.1 Spraying

Chemical spraying should be undertaken twice yearly on all drains. Optimal spraying times are when drainage flows are low, allowing maximum exposure of vegetation.

Ideally spraying is undertaken in February to March and October to November.

A proposed chemical spraying schedule is outlined in Appendix A.

4.2 Mechanical Cleaning

Mechanical cleaning should be undertaken on drains every five years. The cleaning should be staggered such that one fifth of the drains are cleaned each year.

A proposed mechanical cleaning schedule is outlined in Appendix A.

4.3 Drainage Asset Renewal and Repair

All necessary repairs to drainage infrastructure should be commenced as soon as it is practical.

Spraying and cleaning maintenance should be used as an opportunity to inspect the drainage assets, record any damage or blockages and schedule further maintenance.

A contingency cost for renewing the assets within the district is provided, based on the remaining life of the asset and the cost to renew.

An importance factor for the asset is also indicated which should be used to aid in determining where to prioritise funds.

4.4 Asset Inspection Register

Every opportunity should be taken to inspect and record the condition of assets within the districts. Appendix D outlines an asset register for the district which should be filled out by the spraying operator.

4.5 Cost

The cost of immediately recommended remedial works is \$61,750 including a 10% management fee and 20% risk contingency.

The cost of bi-annual spraying of the drains and mechanical removal of vegetation and sediments come to a total of \$70,572 including a 10% management fee and 20% risk contingency.

The fund allocation to asset renewal and repair is \$9,100, including a 10% management fee and 20% risk contingency.

The total yearly cost for the proposed maintenance plan is \$79,672 per year. The total fund allocation should be inflation adjusted on a regular timeframe.

5. Discussion and Recommendation

The drainage assets in the Okahukura Drainage District range from moderate to poor condition drains. The first priority is to implement the remedial works then introduce the maintenance and cleaning schedule. Any issues with the proposed plan that arise should be addressed at the first opportunity.

Most drains are operating inefficiently and require urgent spraying and mechanical cleaning. Priority should be to spray all drains then to replace Floodgate 3. The property owner adjacent to Culvert 6 has indicated that it is causing flooding to his property. It appears that the drains upstream of the culvert have been progressively lowered, resulting in this culvert appearing too high. Lowering of the culvert would reduce upstream water levels, however is not identified as an immediate priority.

Residual funds should be kept and reallocated annually based on investigation and asset inspections.

It should be noted that the farmers in the region believe it would be more efficient and economical to engage local contractors to undertake the required maintenance due to their existing knowledge of the region and its conditions.

The farmers and residents should be notified where possible and used as a source of knowledge for maintenance and monitoring.

6. References

Far North District Council, September 2017: *Kaitaia Drainage Area, Management and Operational Plan*, Far North District Council, reference: A1839401

Gibbs, M. 2007: Best Practice Environmental Guidelines – Land Drainage. Environment Waikato

Appendix A

Maintenance and Cost Sheet

Spraying and cleaning work

I.D.	Drain Type	Length (m)	Maintenance Schedule	Initiate Mechanical Cleaning	Spraying Cost (\$)	Mechanical cleaning Cost (\$)	Cost per year (\$)	
A	Primary	6610	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 0	2313.5	46270	13881
B	Secondary	1010	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 0	353.5	7070	2121
C	Primary	580	Spray twice-yearly. Clean mechanically once every 5 years.		Year 4	203	2030	812
E	Secondary	370	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 0	129.5	2590	777
F	Secondary	1340	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 4	469	9380	2814
G	Secondary	920	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 2	322	6440	1932
H	Secondary	1370	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 2	479.5	9590	2877
I	Secondary	820	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 2	287	5740	1722
J	Primary	1820	Spray twice-yearly. Clean mechanically once every 5 years.		Year 1	637	6370	2548
K	Tertiary	420	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 2	147	2940	882
L	Primary	700	Spray twice-yearly. Clean mechanically once every 5 years.		Year 4	245	2450	980
M	Primary	1200	Spray twice-yearly. Clean mechanically once every 5 years.		Year 3	420	4200	1680
Ma	Secondary	900	Spray twice-yearly. Clean mechanically once every 5 years.		Year 3	315	3150	1260

N	Primary	1040	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 3	364	7280	2184
Na	Secondary	830	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 3	290.5	5810	1743
O	Primary	1240	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 3	434	8680	2604
P	Primary	2200	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 1	770	15400	4620
Q	Primary	730	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 3	255.5	5110	1533
R	Primary	820	Spray twice-yearly. Clean mechanically once every 5 years.		Year 4	287	2870	1148
T	Primary	1350	Spray twice-yearly. Clean mechanically once every 5 years.		Year 4	472.5	4725	1890
U	Secondary	680	Spray twice-yearly. Clean mechanically once every 5 years.		Year 4	238	2380	952
W	Secondary	170	Spray twice-yearly. Clean mechanically once every 5 years.		Year 1	59.5	595	238
X	Secondary	380	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 2	133	2660	798
Y	Secondary	570	Spray twice-yearly. Clean mechanically once every 5 years, truck spoil away.		Year 2	199.5	3990	1197
Z	Primary	780	Spray twice-yearly. Clean mechanically once every 5 years.		Year 4	273	2730	1092

- i. *Spraying based on a cost of \$0.35 per metre*
- ii. *Mechanical cleaning based on cost of \$3.50 per metre*
- iii. *Removal of spoil based on cost of \$3.50 per metre*

Base Annual Cost	\$ 54,285
Management Fee (+10%)	5,429
Risk Contingency (+20%)	10,858
Total Annual Cost	\$ 70,572

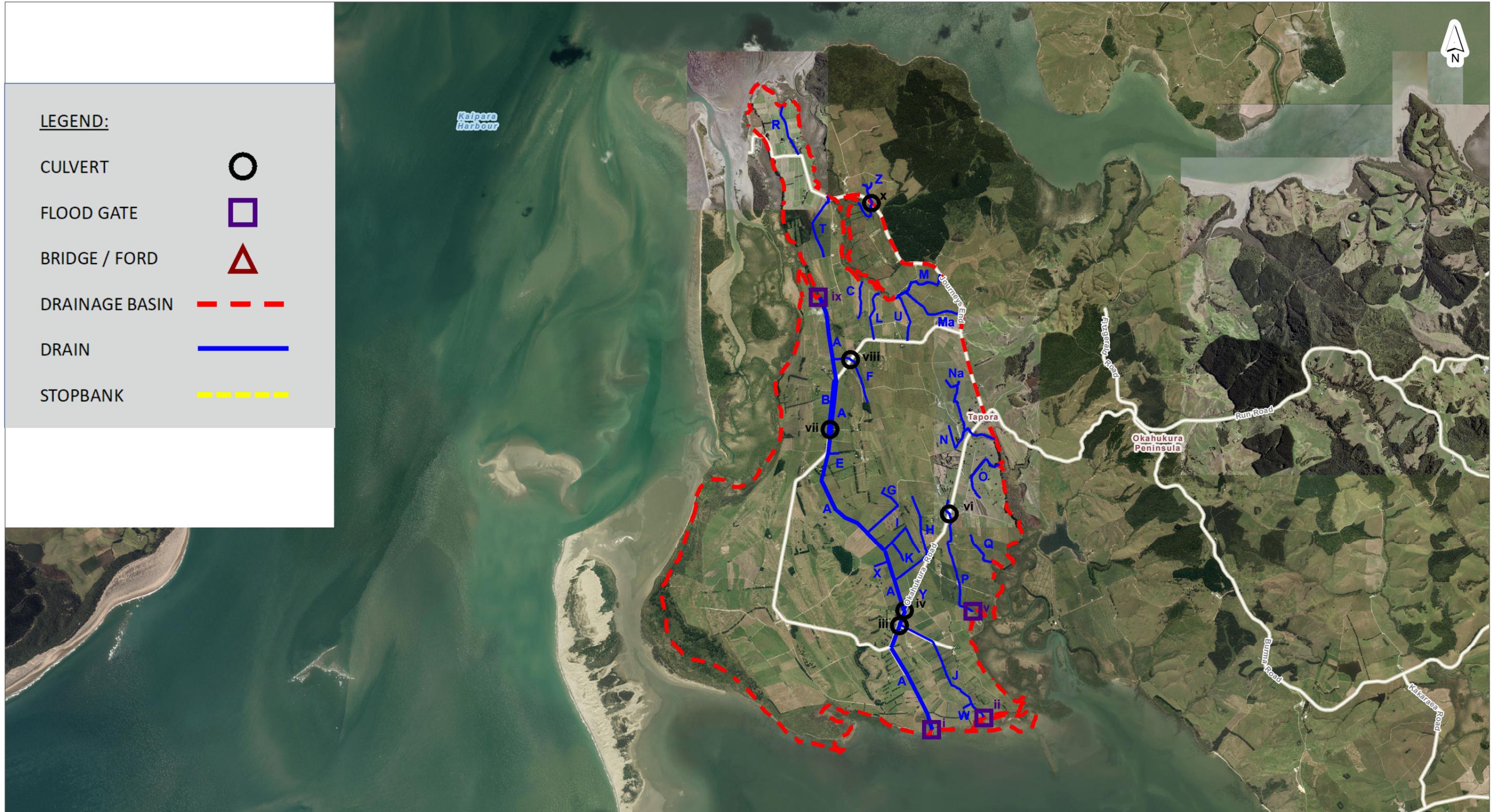
ID	Type	Description and Condition	Ongoing/required Maintenance	Remaining Life	Replacement Cost	Annual Replacement Contingency
i	Floodgate No. 1	Located at the southern end of the drainage district. Appears to be in good condition and working well	Annual inspection and review.	20 years	-	1000
ii	Floodgate No. 2	Located at the southern end of the drainage district. Appears to be in good condition and working well	Annual inspection and review.	20 years	-	1000
iii	Culvert 3	Culverts on main drains. Generally in good condition. Water pipe running across the drain at one end of the culvert is restricting flow and collecting vegetation.	Consider diversion of irrigation pipe to minimise blockage of drain	-	2500	500
iv	Culvert 4	Culverts on main drains. Generally in good condition.	Annual inspection and review.	25 years	-	500
v	Floodgate No. 3	Located at south eastern edge of the district. In poor condition, disjointed and totally submerged, therefore non-operational.	Replacement Floodgate required	-	40000	1000
vi	Culvert 6	Located in centre of district under Okahukura road. Culvert in good condition. Upstream drain has been lowered over time and is ponding	Annual inspection and review	25 years	-	500
vii	Culvert 7	Last pipe in culvert has lost bedding and has slumped.	Culvert repair	20	5000	500
viii	Culvert 8	Culverts on main drains. Generally in good condition.	Annual inspection and review.	25 years	-	500
ix	Floodgate No. 4	Located at the northern end of the drainage district. Appears to be in good condition and working well	Annual inspection and review.	20 years	-	1000
x	Culvert 5	Culverts on main drains. Generally in good condition.	Annual inspection and review.	25 years	-	500
Base Annual Cost					\$47,500	\$7,000
Management Fee (+10%)					\$4,750	\$700
Risk Contingency (+20%)					\$9,500	\$1,400
Total Annual Cost					\$61,750	\$9,100

Appendix B

Drainage district map

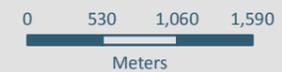
LEGEND:

- CULVERT ○
- FLOOD GATE □
- BRIDGE / FORD △
- DRAINAGE BASIN - - -
- DRAIN —
- STOPBANK - - -



DISCLAIMER:
 This map/plan is illustrative only and all information should be independently verified on site before taking any action. Copyright Auckland Council. Land Parcel Boundary information from LINZ (Crown Copyright Reserved). Whilst due care has been taken, Auckland Council gives no warranty as to the accuracy and plan completeness of any information on this map/plan and accepts no liability for any error, omission or use of the information. Height datum: Auckland 1946.

Okahukura Drainage District



Scale @ A3
 = 1:50,000

Date Printed:
 8/12/2017



Appendix C

Photographs of noteworthy Assets

Culvert iii on A drain

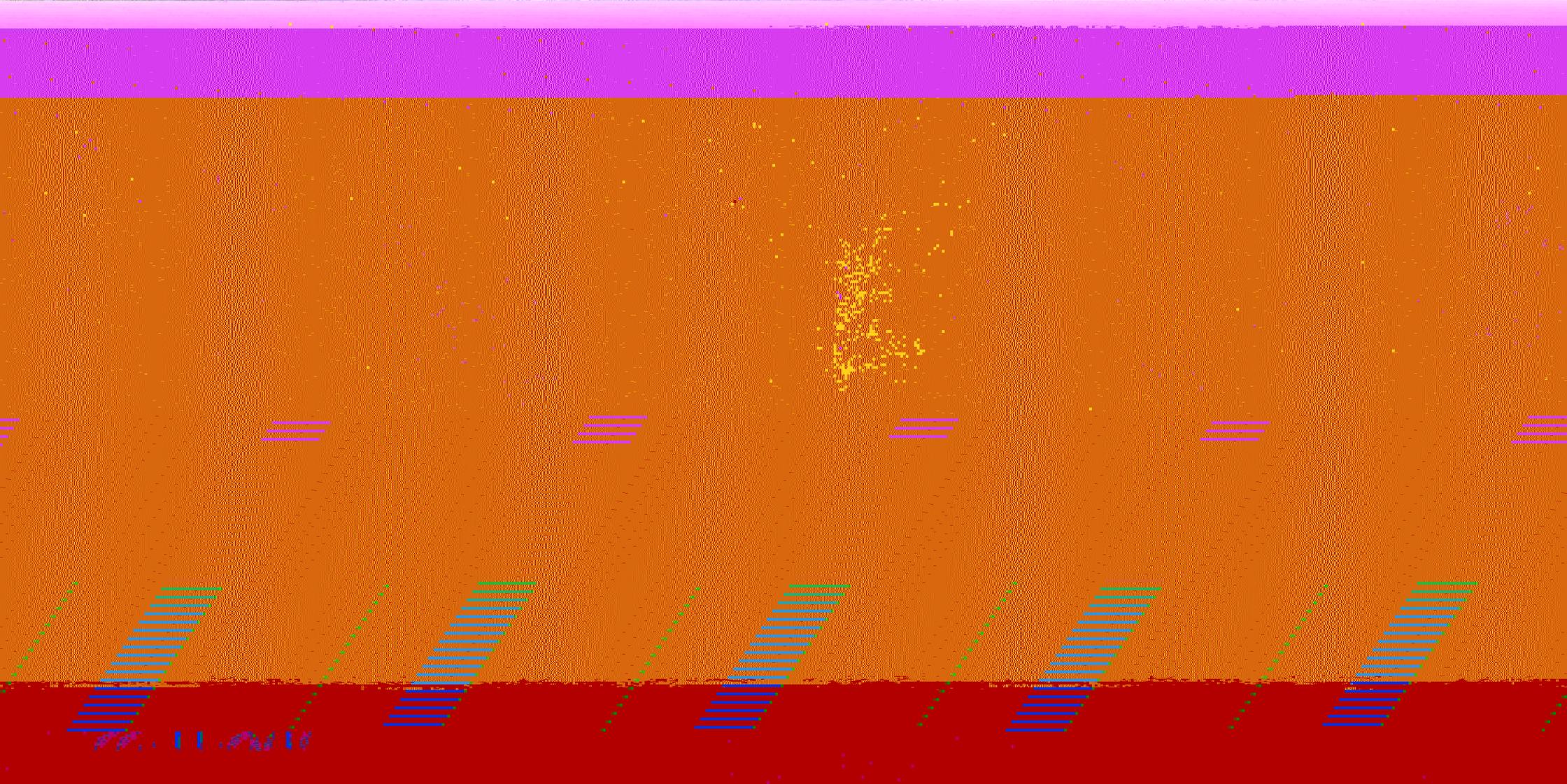
Excessive weed growth.

Pipe blocking flow. Consider diversion

22.11.2017



Bank erosion on A drain



Weed growth on J drain



22.11.2017

Culvert vi on P drain



Culvert dry.
Upstream drains
lower and
holding water

22.11.2017

Floodgate 3 on P drain



Floodgate 3
has failed and
replacement is
required.

22.11.2017

Appendix D

Drain and Asset inspection register

Date: _____

Inspected By: _____

Company: _____

**OKAHUKURA DRAINAGE DISTRICT
PUBLIC DRAIN SPRAYING AND INSPECTION RECORD**

Drain	Date Sprayed	Vegetation Identified	Chemicals Used	Date Last Excavated	Observations (Circle One)			General Notes
					Water Level	Drainage	Drain Condition	
A					High	Free Flowing	Good	
					Mid	Adequate	Adequate	
					Low	Poor	Poor	
					Dry	Blocked	Failed	
B					High	Free Flowing	Good	
					Mid	Adequate	Adequate	
					Low	Poor	Poor	
					Dry	Blocked	Failed	
C					High	Free Flowing	Good	
					Mid	Adequate	Adequate	
					Low	Poor	Poor	
					Dry	Blocked	Failed	
E					High	Free Flowing	Good	
					Mid	Adequate	Adequate	
					Low	Poor	Poor	
					Dry	Blocked	Failed	
F					High	Free Flowing	Good	
					Mid	Adequate	Adequate	
					Low	Poor	Poor	
					Dry	Blocked	Failed	
G					High	Free Flowing	Good	
					Mid	Adequate	Adequate	
					Low	Poor	Poor	
					Dry	Blocked	Failed	
H					High	Free Flowing	Good	
					Mid	Adequate	Adequate	
					Low	Poor	Poor	
					Dry	Blocked	Failed	
I					High	Free Flowing	Good	
					Mid	Adequate	Adequate	
					Low	Poor	Poor	
					Dry	Blocked	Failed	

J					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
K					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
L					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
M					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
Ma					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
N					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
Na					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
O					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
P					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	

Q					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
R					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
T					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
U					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
W					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
X					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
Y					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	
Z					High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	

Date: _____

Inspected By: _____

Company: _____

**OKAHUKURA DRAINAGE DISTRICT
ASSET INSPECTION AND CONDITION RECORD**

Asset ID	Observations (Circle One)				General Notes
	Water Level	Operating Condition	Structural Condition	Overall Condition	
Culvert iii	High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	Good Adequate Poor Failed	
Culvert iv	High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	Good Adequate Poor Failed	
Culvert vi	High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	Good Adequate Poor Failed	
Culvert vii	High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	Good Adequate Poor Failed	
Culvert viii	High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	Good Adequate Poor Failed	
Culvert x	High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	Good Adequate Poor Failed	
Floodgate No. 1	High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	Good Adequate Poor Failed	
Floodgate No. 2	High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	Good Adequate Poor Failed	

Floodgate No. 3	High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	Good Adequate Poor Failed	
Floodgate No. 4	High Mid Low Dry	Free Flowing Adequate Poor Blocked	Good Adequate Poor Failed	Good Adequate Poor Failed	

Site Inspection Record as Prepared By ACH Consulting, Dec 2017



DRAINAGE CHANNEL: POOR FLOW



FLOOD GATE: GOOD CONDITION



CULVERT: GOOD CONDITION



CULVERT: STRUCTURAL FAILURE



CULVERT: POOR FLOW