MWA solutions

14 October 2010

Burrell Demolition Limited,
P.O. Box 24 481,
Royal Oak,
Auckland

Attention: Mr Alex Burrell

Dear Sir,

BURRELL DEMOLITION LIMITED – CONSTRUCTION AND DEMOLITION MATERIALS LANDFILL LANDFILL ROAD, HAPPY VALLEY, WELLINGTON

We report that we have now considered the CCTV survey carried out to establish the condition of the existing culvert that lies under your above landfill. This landfill was consented and built across the lower part of a natural gully, and the stream (an un-named tributary of Carey's Stream) is transferred under this landfill to Carey's Stream and thence to the Owhiro Stream.

New Resource Consent applications have been made to Greater Wellington Regional Council and Wellington City Council to extend the landfill footprint and height, and in Section 92 requests both Councils have requested further information to establish the possible condition and service life of the existing culvert.

The nominal implications of failure of the culvert would be that the landfill would act as a dam, and while the saturated geotechnical stability of the landfill is not the subject of this report, it is believed that there would be considerable concern over the "lake" that would form on the upstream side of the landfill

We have reviewed a report and video information supplied by Wellington City Council, and now comment as follows:

1 History

The subject culvert lies under partially under Landfill Road and the remainder lies under the existing landfill, and carries stormwater from the upper parts of the catchment to discharge into an un-named tributary of the Owhiro stream, which leads to Owhiro Bay on Cook Strait.

This drain is a 900mm diameter reinforced concrete rubber ring jointed (RCRRJ) culvert.

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The inlet to the culvert lies on the north-western side of the present landfill, and the point of discharge to the stream is on the northern side of Landfill Road, adjacent to a Wellington City facility.

It is understood that the eastern part of the drain was installed about the time Landfill Road was constructed, and that it has been extended under the landfill footprint area in at least two stages, the first in the mid-1990's following the granting of Resource Consents for the landfill activity, and the second about 2007.

2 Construction

The eastern portion of the culvert (under Landfill Road) is thought to have been built under Wellington City direction at the time Landfill Road was formed, and is not considered to be at issue.

The second stage of the culvert, which lies under the body of the landfill, and the third stage, which lies generally outside the landfill footprint and was installed to protect the inlet from erosion and minor slippage within the landfill materials, were both built by Burrell Demolition Limited.

The details of bedding and haunching of the second stage of the culvert are not known; what is known is that, during construction, the open drainage trench with the culvert sections placed in it was inundated with stormwater prior to backfilling, and the pipe sections floated.

Given this event it is reasonable to expect that there would have been some dislocations of the rubber ring joints, and possibly some circumferential cracking as the pipe sections were placed in longitudinal bending.

It is further understood that the pipes were replaced by being "pushed down" with an excavator, and were not lifted and re-laid. As a consequence we might expect that the bedding conditions, particularly as to uniformity and bearing conditions, may have been haphazard at that time. This could have contributed to further circumferential and perhaps some longitudinal cracking and joint damage both under the replacement operation and later as any settlements of the pipe sections on the bedding took place.

We also understand that some of the pipes were traversed with earthmoving equipment prior to being adequately covered, and that this resulted in some longitudinal cracking which was repaired by concrete encasement of the pipes. We do not know precise location of these repairs, the thickness of the encasement or the grade of concrete used.

3 CCTV Survey

A closed circuit television (CCTV) survey of the culvert was undertaken in June 2010 by Associated Environmental Systems Limited (AES). This survey commenced at the upstream (north-western) end of the culvert and covered a length of approximately 170 metres, being limited by the length of cable available. This length does, however, cover the greater part of the present landfill area.

The results were recorded on DVD and have been reviewed.

In its report AES found a total of 114 defects over this length, and scored the culvert overall as having a peak defects score of 125 and a mean score of 18.88.

The peak defects score is the maximum defect score in any one metre of pipeline. Scores are aggregated where more than one defect occurs in any one metre.

The mean score reflects the overall condition of the pipeline, and is the average of the peak defects scores.

It should be particularly noted that the defects identified in the report do not include any measurement or assessment of crack widths; this information may be of premium importance as to whether or not the cracking seen is in fact important or is aesthetic, and from this standpoint, and notwithstanding the experience of the reporting personnel, the survey may be considered to be somewhat subjective,.

4 Defects shown in the survey

The defects identified can be categorised into those that represent potential Structural and/or Hydraulic Defects, and those that would be considered unusual in a normal element of city infrastructure, but do not necessarily contribute to any inadequacy in the culvert, and this yields:

4.1 Structural and/or hydraulic defects

Feature Code	Description	No.
CC	Circumferential Crack	8
CL	Longitudinal Crack	7
CM	Multiple Cracks	12
DE	Silty Debris	4
DF	Deformed Pipe	8
ED	Encrustation Deposit	2
IP	Infiltration at pipe wall	9
JF	Faulty Joint	35
JO	Joint Open	2
PH	Pipe Holed	2
RI	Root Intrusion	7
SD	Surface Damage	2
	Total number of structural and/ or hydraulic defects	98

4.2 Non-structural defects

Feature Code	Description	No.
CF	Construction Feature	1
GC	General Comment	3
LD	Line deviates down	1
LL	Line deviates left	9
LR	Line deviates right	2
	Total number of other comments	16

4.3 Detailed Defect Catalogue

The defects reported have been taken into categories, and we comment below on each category in turn:

4.3.1 Defect reported : Circumferential Cracking (Coded as CC)

Circumferential cracking is cracking that occurs around part or the entire circumference of the pipe.

These cracks would normally arise from the effects of:

(i) Longitudinal bending stresses – that is when the pipe has been placed in bending on a transverse axis such as would arise from the pipe either being incorrectly handled as it was being unloaded at the site or during laying operations, or being supported unevenly on its bedding either at the time of being first laid or when being repositioned after flotation occurred, or

(ii) Shrinkage stresses that may occur during the initial concrete curing period. Because of the long experience of concrete pipe manufacturers this latter cause is considered unlikely to have been a major factor in the cracking observed.

We consider that the most likely cause of circumferential in this case is likely to have been longitudinal bending.

4.3.1.1 Defect Locations

There are 8 places where circumferential cracking occurs without other identified defects identified in the report:

Dist From U/S end	Feature Code	Severity	Remarks
53.6	CC	L	
54.3	CC	L	
83.4	CC	L	Infiltration at pipe wall, Encrustation Deposits
87.4	CC	L	Infiltration at pipe wall, Encrustation Deposits
90.7	CC	L	Evidence of Leakage
97.2	CC	L	Evidence of Leakage
98.0	CC	L	Evidence of Leakage
109.8	CC	L	Infiltration at pipe wall, Encrustation Deposits

4.3.1.2 Defect severity:

These defects are all coded with the highest level of severity. As noted earlier, it is thought that the cracks probably occurred either during initial handling and laying, during re-laying after flotation occurred, or during the early part of their service as a result of settlements arising from damage to the pipe bedding during flotation.

We consider that circumferential cracking, accompanied sometimes with infiltration, is not in itself a major structural defect. It represents some concern in connection with the possibility of corrosion occurring in the pipe reinforcement, but there is modern evidence that indicates that some exposed reinforcing steel, particularly longitudinal reinforcement, is not subject to major corrosion

The Concrete Pipe Association of Australasia (CPAA) publication "The Facts about Cracking in Steel Reinforced Concrete Pipe" states:

> *Circumferential cracks can occur from loads imposed during installation, uneven bedding, or connection of the pipe to another structure followed by relative movement due to settlement. Unless closely spaced, circumferential cracks will have little if any effect on the ability of the pipe to carry external loads.*

And continues:

> *Effect of crack width*
>
> *A steel reinforcing bar or wire surrounded by concrete is normally protected from corrosion by the alkalinity of the concrete. In an alkaline environment, a very thin, coherent layer of oxide which prevents corrosion is formed on the surface of the steel. In this state the steel is described as being passivated. Only if this passivity is broken down will corrosion commence. Two states by which the passivity can be destroyed are (1) by carbonation of the concrete surrounding the bar, which reduces the alkalinity, or (2) by ingress of chloride ions, which appear to break down the passive layer at the steel surface. Carbonation is the result of the reaction between the hardened cement paste and carbon dioxide in the atmosphere or pipeline environment. Chloride ions are present in sea water and in saline ground water.*
>
> *The existence of a surface crack in the concrete pipe permits easier access of either chloride or carbon dioxide into the concrete, which may lead to depassivation of a small area of bar in the region of the crack. In the electrolytic process necessary for corrosion, the depassivated area becomes the anode, while portions of the bar still protected by sound alkaline concrete become the cathode. At the anode, metal ions are released. At the cathode, oxygen combines with water to form hydroxyl ions which flow through the electrolyte to the anode, where they combine with the metal ions to form iron hydroxide. As a secondary reaction, this hydroxide combines with further oxygen to form rust.*
>
> *The rate at which corrosion can progress depends on the electrical resistance of the path external to the bar between anode and cathode. This path passes through boundary layers at the steel surface, and the surrounding concrete. The rate also depends on availability of oxygen at the cathode, which is situated in sound concrete — see Figs 1 and 2 (below), reproduced from Ref. 3. Thus the role of the crack is to allow the process to be initiated by local loss of passivity but the rate of corrosion depends on the properties of the sound concrete. Results of corrosion tests shown in Fig. 3 (from Ref. 4) confirm that, within the range shown, the crack width has very little effect.*
>
> *Where the sound concrete is highly impermeable as it is in spun concrete pipes, diffusion of oxygen to the cathode is so slow that the corrosion rate is negligible.*
>
> *On this basis, flexural cracks up to 0.5 mm wide in pipes having correctly specified cover are not considered to be a threat to the long term load bearing capability of the pipe.*

4.3.1.3 Defect Rectification

The *CPAA* "Engineering Assessment and Acceptance Guideline – Circumferential Cracking, November 2008" also suggests alternative repair scenarios as follow:

> *Where repair work or rectification of a pipe is required to allow it to remain in service, a number of options are available to the asset manager. The repair method used is dependant on the extent of the problem and the following table offers some suggested options.*

1 *No rectification required – for minor cracking there is no need for repair or, alternatively, autogenous healing may fill any cracks.*

2 *Access the defect via pit or manhole and grind out crack. Fill and seal the defect zone with an approved epoxy paste or resin. – applicable for minor cracks, 0.15mm to 0.5mm in width, that are not "live" and are not subjected to any further movement. This method is generally applicable where number of cracks is small.*

3 *Provide an internal lining with an approved non-structural patching repair mortar (epoxy based or polymer modified cement based) to cover the defect – applicable for minor cracks, 0.15mm to 0.5mm in width, that are not "live" and are not subjected to any further movement. This method is generally applicable where there are multiple cracks.*

4 *Seal cracks with an approved flexible PVC bandage using appropriate epoxy adhesive – applicable for minor cracks, 0.15mm to 0.5mm in width that may remain "live" (i.e. continue to grow) or larger cracks that are not subjected to any further movement.*

5 *Apply shear bands, rubbers straps or 'concrete stitching" for non-structural repairs to prevent the ingress of fines. Large cracks (> 0.5mm) that won't affect the structural capacity of the pipe but may affect the long term durability.*

6 *Provide an internal structural lining that is designed in accordance with the appropriate standard (for flexible pipe, AS2566.1) to ensure it satisfies the required loading criteria. Large cracks (> 0.5mm) where the durability of the pipe may be affected.*

7 *Replace the pipe using appropriate techniques such as shear bands. Contact your local CPAA member company for more details. Where the pipe affected is an isolated problem and is beyond repair from a durability persepctive.*

8 *Replace the entire pipeline. Contact your local CPAA member company for more detail.*

4.3.2 Defect reported: Longitudinal cracking (Coded as CL)

Longitudinal cracking is cracking that occurs in the pipe wall along part or all of the length of the pipe.

These cracks would normally arise from transverse bending stresses, such as occur when the pipe is overloaded vertically at or near its crown but is inadequately supported by haunching at the sides, so that it deflects into an "oval" shape. Such cracking will normally show on the exterior of the pipe at the sides, and the interior of the pipe at the top and possibly the bottom, depending on the severity of the overload applied.

4.3.2.1 Defect locations

There are seven places in which longitudinal cracking is visible without other defects noted in the report:

Dist. From U/S end	Feature Code.	Severity	Remarks
40.9	CL	L	
46.1	CL	L	
50.6	CL	L	
55.6	CL	M	
58.2	CL	M	
101.7	CL	L	
112.2	CL	L	

4.3.2.2 Defect Severity

This cracking may be more significant than circumferential cracking, depending n the location of the cracking. In general the report does not identify the location of the cracking, but it we think that cracking visible on the interior at the top of the pipe probably indicates that the pipe has been overload at some time. Note our previous comments on damage and repair during construction.

4.3.2.3 Defect Rectification

The CPAA "Engineering Assessment and Acceptance Guideline – Longitudinal Cracking, November 2008" suggests that the available repair options may be:

> *Where repair work or rectification of a pipe is required to allow it to remain in service, a number of options are available to the asset manager. The repair method used is dependant on the extent of the problem and the following table offers some suggested options.*
>
> *1 No rectification required No need for repair or autogenous healing may fill any cracks.*
>
> *2 Access defect via pit or manhole and grind out crack to solid concrete. Fill and seal defect zone with an approved epoxy paste or resin. Minor cracks, 0.15mm to 0.5mm, that are not live and are not subjected to any further movement. Applicable where number of cracks is small.*
>
> *3 Provide an internal lining with an approved non-structural patching repair mortar (epoxy based or polymer modified cement based) to cover defect. Minor cracks, 0.15mm to 0.5mm, that are not live and are not subjected to any further movement. Applicable where there are multiple cracks.*
>
> *4 Provide an internal structural lining that is designed in accordance with the appropriate standard (for flexible pipe, AS2566.1) to ensure it satisfies the required loading criteria. Large cracks (> 0.5mm) where the durability of the pipe may be affected.*

5 *Replace the pipe using appropriate techniques such as shear bands. Contact your local CPAA member company for more details. Where the pipe affected is an isolated problem and is beyond repair from a durability perspective.*

6 *Replace the entire pipeline.*

7 *Provide a concrete cup to the pipe to transfer load to the side fill Large cracks (> 0.5mm) where loading is likely to increase crack width.*

Size of crack	*Action recommended*
< 0.15 mm	*No action required - crack unlikely to extend through the wall and equivalent to the design serviceability load crack defined by AS/NZS4058.*
0.15 mm to 0.5 mm	*Monitor for stability of crack. Cracks up to 0.5 mm are not considered to be a durability risk. If crack is stable, no further action required.*
0.5 mm >	*Engineering assessment required to consider effects of long term loads.*

4.3.3 Defect reported:Multiple Cracking – coded as CM.

Multiple cracking indicates a combination of circumferential and longitudinal cracking, and will generally have occurred as a result of a combination of the causes of each as noted above.

4.3.3.1 Defect locations

There are 12 places in which combined or multiple cracking is reported as occurring:

Dist. From U/S end	Feature Code.	Severity	Remarks
31.1	CM	L	Root intrusions and infiltration in pipe wall to 32m.
53.0	CM	L	
53.0	CM	L	
55.6	CM	L	Assumed End
62.8	CM	L	Circumferential Cracking, Longitudinal cracking with Encrustation Deposit Stains
67.1	CM	L	
68.0	CM	L	Encrustation Deposits, Infiltration at pipe wall, and multiple circumferential cracks
69.1	CM	L	
70.4	CM	L	3 No. Longitudinal cracks, multiple circumferential cracks, encrustation deposit stains, and infiltration through pipe wall
77.9	CM	L	
112.2	CM	L	2 No. Longitudinal cracks, encrustation deposits and infiltration through pipe wall
113.6	CM	L	

Again, severity is assessed subjectively as large in each case.

4.3.3.3 Defect Rectification

Defect rectification will consist of a combination of the various rectification measures noted in Sections 4.3.1.3 and 4.3.2.3 above.

4.3.4 Defect reported:Silty Debris (Coded as DE)

In the case of this culvert there is a significant flow of large and small debris arising from erosion in the stream gully upstream of the landfill, and windblown materials from the nearby municipal sanitary landfill. There is comparatively little debris from the subject landfill itself admitted at the culvert inlet.

Larger items (generally sizes >150mm nominal size) are effectively screened at the inlet by a large steel cage that is cleared regularly, but it is possible for items that are less then 150mm or are sufficiently flexible to be washed through the screen to be admitted to the culvert.

These items will be washed through the culvert until they are arrested either by a minor obstruction or by hydraulic conditions. The silt components are often "washed out" when larger flows with attendant higher pipe flow velocity occur, and under those conditions the pipe flow capacity is again largely restored.

4.3.4.1 Defect Locations

There are 4 places reported where this defect occurs:

Dist. From U/S end	Feature Code.	Severity	Remarks
127.3	DE	S	Debris dams flow
132.1	DE	S	Debris dams flow
134.7	DE	S	Debris dams flow
160.9	DE	S	Debris dams flow

4.3.4.2 Defect Severity

From the video data supplied it would appear that these are fairly minor items, and that the hydraulic effect is quite small.

4.3.4.3 Defect Rectification

Rectification is best dealt with by clearing the silt and other debris around which it has accumulated and checking for and removing any surface imperfections in the culvert invert, making good where necessary with an epoxy mortar.

4.3.5 Defect reported: Deformed pipe (Coded as DF)

This defect may occur from either manufacturing problems or from elastic or plastic deformation under load. In some cases in the video there appears to be some dislocation of the two edges of a cracked section, and in others the pipes have developed ovality.

Neither the report nor the video information gives any actual measures of the extent to which the deformations have occurred.

4.3.5.1 Defect Locations

There are 8 places reported where this defect occurs:

Dist. From U/S end	Feature Code.	Severity	Remarks
40.9	DF	S	
46.1	DF	S	
50.6	DF	S	
53.0	DF	S	
70.4	DF	S	
75.0	DF	S	
108.7	DF	M	
112.2	DF	M	

4.3.5.2 Defect Severity

The defect severity is rated in the report as being generally small (rated “S”) with two cases being moderate (rated “M”).

In the case of the two severely rated locations the pipe has become oval:

(i) At 108.7m the pipe has deformed vertically downwards at the crown causing the sides to bulge outwards, and

(ii) At 112.2m the pipe has deformed upwards at the crown, causing inwards movement at the sides.

In both cases there is significant cracking at the crown of the pipe, accompanied by efflorescence, which may indicate that a degree of autogenous healing may have taken place.

Given that the pipes have been in service for some 20 to 25 years it is thought that there is presently no imminent danger of structural collapse, and therefore that to a large degree autogenous healing may have taken place.

4.3.5.3 Defect Rectification

The requirement for rectification depends generally on the nature of the defect, the level of damage and the degree to which the concrete pipes have autogenously healed.

Where the concrete has been shown to be cracked and not healed it is thought that either bandaging with polythene lining as in item 4 of clause 4.3.1.3 above may be appropriate.

4.3.6 Defect reported: Encrustation deposits – coded as ED

Encrustation deposits occur from water ingress through the pipe wall, and indicate that infiltration has either taken place or is still taking place. The encrustation may be result of transport of mineral salts from the materials lying outside the pipe, calcareous deposits from the concrete pipe itself, or a mixture of the two.

4.3.6.1 Defect locations:

This defect is reported in 2 locations

Dist. From U/S end	Feature Code.	Severity	Remarks
92.3	ED	S	
99.5	ED	S	

4.3.6.2 Defect Severity

The major element associated with this defect will be that it increases the "roughness" of the interior of the pipe and may, generally to a very minor degree, impede and therefore reduce the pipe flow capacity.

The question of pipe flow capacity has been addressed separately in Section 2.2.5 of the Stormwater, Erosion and Sediment Control Plan that was included as Appendix 7 of the Assessment of Environmental Effects supplied to Wellington City Council as part of the current land use consent application, and will be supplied as part of the Section 92 request documentation to Greater Wellington Regional Council.

In that document the peak stormwater flow in the culvert was calculated at 1.61 cumecs, implying a requirement for a hydraulic gradient of 0.5%. The hydraulic gradient of the culvert is not known, but is thought to be greater than 5%, so that the capacity of the culvert is not at issue, and the the effects of these defects is therefore minor in this case.

4.3.6.3 Defect Rectification

No rectification of small deposits is thought necessary. However, large deposits may need to be removed to ensure that there is no underlying pipe defect.

4.3.7 Defect Reported Infiltration through the pipe wall – coded as "IP"

Infiltration through the pipe wall indicates that the pipe is porous or damaged in some way. The damage normally takes the form of very minor cracking that has not completely autogenously healed, and may indicate the need for repair of the pipe or continuing periodic inspection.

4.3.7.1 Defect locations

This defect is reported in 9 locations:

Dist. From U/S end	Feature Code.	Severity	Remarks
28.5	IP	S	
31.0	IP	M	
52.0	IP	M	
72.9	IP	S	
75.0	IP	S	
75.5	IP	S	
77.9	IP	S	
81.0	IP	S	
85.0	IP	L	Under pressure

4.3.7.2 Defect Severity

One of the defects reported us graded as large ("L") in severity – this particular location shows water being injected into the pipe under pressure. The two defects rated as medium ("M") show moderate sized areas of seepage into the pipe, and need to be investigated by visual inspection to determine the scale of any cracking present.

4.3.7.3 Defect rectification

Cracking may be dealt with by bandaging as noted under Clause 4.3.1.3 (4) above.

4.3.8 Defect Reported Faulty Joints – coded as JF

This is the largest defect category, and is somewhat general in that there are a number of reasons for which the joint may be faulty, including one or more of the following:

Pipe Broken: Generally represents damage to the collar or spigot of the pipe, involving partial failure with exposure of the reinforcement or complete failure with separation of parts of the collar or spigot.

Reinforcing Exposed: This usually takes the form of mechanical damage to the interior surface of the pipe collar or spigot, resulting in exposure of the reinforcing steel. It may also arise from serious cracking that has allowed air and water to penetrate to the reinforcing steel, thus introducing conditions where corrosion of the reinforcing may take place, and failure of the inner surface of the pipe from expansion of the corrosion scale.

Evidence of Leakage: There are a number of possible causes for this, including damage (cracking or complete failure) to the collar beyond the rubber sealing ring but outside the end of the spigot, displacement of the rubber sealing joint, circumferential cracking to the collar beyond the rubber sealing ring but outside the end of the spigot and a missing rubber sealing joint.

Circumferential cracking Refer to Item 4.3.1 above.

Multiple cracks Refer to item 4.3.3 above.

Infiltration through pipe wall Refer to item 4.3.7 above (indicative of a problem, but not in itself a “defect”).

Encrustation deposits: Refer to item 4.3.6 above (indicative of a problem, but not in itself a “defect” and may actually indicate that autogenous healing has taken place).

Root intrusion: Refer to item 4.3.11 below – in the more extreme cases this may indicate that rubber ring joint has either been displaced from its locating groove, of compressed by the root growth to the extent that water may pass through the gap between the root and the sealing ring.

O-Ring obstruction: In this case the rubber sealing “o-ring” has been displaced during construction.

4.3.8.1 Defect Locations

There are 35 incidences of faulty jointing reported, as below:

Dist. From U/S end	Feature Code.	Severity	Remarks
3.9	JF	S	Pipe Broken
8.9	JF	S	Pipe Broken
16.2	JF	L	Reinforcing Exposed
27.3	JF	L	Evidence of Leakage
28.5	JF	L	Circumferential cracking, multiple cracks, Infiltration through pipe wall and encrustation deposits
29.8	JF	L	Evidence of Leakage
31.0	JF	L	Circumferential cracking and infiltration at pipe wall
33.7	JF	L	Evidence of Leakage
46.1	JF	L	Circumferential cracking and evidence of leakage
48.3	JF	L	Circumferential cracking, multiple cracks and evidence of leakage

50.6	JF	L	Multiple cracks and evidence of leakage
52.0	JF	L	Circumferential cracking, root intrusion and infiltration at pipe wall
53.0	JF	L	Circumferential cracking and root intrusion,
55.6	JF	L	Circumferential cracking
56.8	JF	L	Circumferential cracking and evidence of leakage
58.2	JF	L	Circumferential cracking and infiltration at pipe wall
60.6	JF	L	Circumferential cracking and infiltration at pipe wall
62.8	JF	M	Circumferential cracking, multiple cracks and encrustation deposit stains
67.8	JF	L	O-Ring obstructs
70.3	JF	L	2 No. Circumferential cracks, encrustation deposits, infiltration at pipe wall and O-Ring exposed
72.9	JF	L	2 No. Circumferential cracks, encrustation deposits, infiltration at pipe wall
75.0	JF	L	2 No. Circumferential cracks, encrustation deposits, infiltration at pipe wall
79.9	JF	L	Circumferential cracking, infiltration at pipe wall, pipe broken and encrustation deposits
82.3	JF	L	Circumferential cracking and root intrusion
85.0	JF	L	Circumferential cracking and infiltration at pipe wall
89.7	JF	L	Root intrusion, infiltration at pipe wall and encrustation deposits
92.3	JF	L	Circumferential cracking, encrustation deposits and infiltration at pipe wall
94.4	JF	L	Evidence of Leakage
99.5	JF	L	Circumferential cracking, encrustation deposits
101.6	JF	L	Multiple cracks, infiltration at pipe wall and encrustation deposit stains
104.2	JF	L	Multiple cracks, infiltration at pipe wall and encrustation deposits
106.8	JF	L	Infiltration at pipe wall and encrustation deposit stains
112.2	JF	L	Infiltration at pipe wall and encrustation deposit stains
151.7	JF	L	Evidence of Leakage
154.7	JF	L	Evidence of Leakage

4.3.8.2 Defect Severity and Rectification

The severity varies in each case, but we believe it reasonable to state that the joints in question should be inspected by a suitably qualified person and a comprehensive report on the actual condition at each joint with repairs described for each joint.

In most cases it will be possible to make repairs using conventional and well-proven methods such as removal of broken concrete and repair using epoxy mortar materials, suitable sealants, flexible bandaging as described elsewhere above, and passivation of corrosion where necessary.

4.3.9 Defect reported; Joint open – coded as JO

This defect arises from either a complete fracture of the pipe at the joint between the barrel and the collar, or a missing sealing "o-ring".

In either case the cause is damage to the pipes during handling or laying, or accidental omission of the rubber ring in the joint, and may in the case of this culvert be due to poor re-laying technique after flotation occurred.

4.3.9.1 Defect Locations

Dist. From U/S end	Feature Code.	Severity	Remarks
94.4	JO	M	
154.7	JO	S	

4.3.9.2 Defect severity

Insofar as it is impossible to refit a rubber ring joint from the interior of the pipe joint after the pipe has been laid this condition must be considered a severe defect, and the ratings given in the report reflect this. However, repairs may be more complex than other problems if the joint has hydrostatic water pressure in the bedding materials. It is not considered practicable to relieve or materially reduce this hydrostatic pressure.

4.3.10 Defect reported: Hole in pipe – coded as PH

This defect is thought most likely to be the result of mechanical damage during handling on site, laying or rectification after flotation occurred.

4.3.10.1 Defect locations

Dist. From U/S end	Feature Code.	Severity	Remarks
75.5	PH	M	Infiltration at pipe wall, no repair seen
81.0	PH	S	Infiltration at pipe wall, encrustation deposits, no repair

4.3.10.2 Defect Severity

This is considered to be a serious defect in any pipe, and this again is reflected in the severity ratings contained in the report.

4.3.10.3 *Defect rectification*:

Repairs will be generally by removal of any un-sound concrete materials around the hole, passivation of the reinforcing steels and patching from the inside. However, again this repair will be complicated by the presence of hydrostatic water pressure within the pipe bedding materials, and again it is not considered practicable to remove or materially reduce this hydrostatic pressure.

4.3.11 *Defect reported:Root Intrusion – coded as RI*

Root intrusions are fairly commonplace in pipe drains, and the severity will normally reduce with pipe diameter.

4.3.11.1 *Defect locations*:

The defect occurs in 7 locations as follows:

Dist. From U/S end	Feature Code.	Severity	Remarks
31.3	RI	S	
52.0	RI	S	
53.0	RI	S	
68.2	RI	S	
82.3	RI	S	
89.7	RI	S	
109.8	RI	S	

4.3.11.2 *Defect severity*

In each case the report describes the defect as “Severe”. Substantial root growth can block smaller pipes, and in larger pipes may act as a net in which rubbish carried in the pipe flow may be entrained, thus causing further blockage.

4.3.11.3 *Defect Rectification*:

The rectification of this defect will involve removal of the intruding roots, and inspection of the collar for damage. It will not be possible to remove the some of the larger roots from within the collar-spigot joint, and it may therefore be necessary to seal the joint from within the pipe using a flexible sealant.

4.3.12.1 Defect reported:Surface Damage – coded as SD

Defects of this type usually take the form of chipping of the interior surface of the pipe, and arise from accidental damage. They may also be associated with blown reinforcing cover due to water ingress, and the pipe will need visual inspection to determine the actual cause of the damage.

4.3.12.2 Defect locations

Dist. From U/S end	Feature Code.	Severity	Remarks
85.0	SD	M	Reinforcing Corrosion
86.2	SD	M	

4.3.12.3 Defect Severity

The defects are rated moderate (“M”) – this refects a medium level of damage, which should be repairable from t he interior of the pipe.

4.3.12.4 Defect Rectification

Repairs will be generally by removal of any un-sound concrete materials around the damaged area, passivation of the reinforcing steels and patching from the inside using a suitable epoxy mortar.

5 Effect of loading

Insofar as the capacity of the reinforced concrete culvert to carry the loads imposed on it, we have used “Pipeclass v1.2”software developed by Iowa Engineering Experiment Station and modified for New Zealand use by the Concrete Pipe Association of Australasia (CPAA).

The software indicates that the type of bedding and haunching is of primary importance in achieving high cover levels, and with type H2 bedding in sand and gravel:

(i) For fill levels up to 51 metres pipes to Class 3 are adequate.
(ii) For fill levels up to 1.2 metres with A160 axle load or W80 wheel load pipes to Class 4 are adequate – this is the case during the early stages of construction.

We are advised that the present pipe is old Class Z, which is the equivalent of current Class 4.

On this basis the pipes are thought to be structurally adequate if the pipe and bedding (particularly in respect of side constraint) is in good condition. Except for the longitudinal cracking (which may have arisen from overload during construction) and deformed pipes, the failures generally are not indicative of excessive overburden loads.

6 Summary

Given the number of defects present in this culvert, the culvert itself may be considered to be prematurely aged in comparison with similar city infrastructure assets, and it is not considered feasible to prescribe a future life.

However, if the landfill is to be extended the present culvert does not have the requirements for longevity that would be required from a stormwater drain that forms a part of a city infrastructure stormwater disposal system in the normal sense, in that:

(a) Structurally, the drain must last only as long as is required for the completion of filling in the landfill and construction of the overland flow channels. We believe that adequate repairs can be carried out to provide an acceptable level of service hen those channels are completed the section of drain beneath the landfill will become totally redundant.

    It may be necessary to inspect this section of drain periodically and carry out further repairs to ensure that structural adequacy is maintained.

    The first section of drain, which lies to the east of the landfill, is believed to have been built to acceptable standards, and was not inspected as a part of this project. It is, however, believed that this section of drain is probably in acceptable condition and we expect that it should have considerable life.

(b) Hydraulically, the drain under the landfill will have a reducing capacity demand on it as sections of overland flow path are completed and brought into service thus reducing the area of the catchment served by the culvert. Again, the culvert will become completely redundant when the landfill is completed.
    While the culvert is in service some infiltration and exfiltration may be considered acceptable as there is little potential for damage to other structures or to the stability of the landfill.

If, however, the landfill is not extended this culvert must be considered to have a limited lifespan and will need maintenance "in perpetuity". In this case the "fail" grading assigned would be a fair assessment of the culvert's condition.

We trust that the foregoing will assist in explaining the CCTV survey results. We understand that you have employed Goodman Contractors Limited to advise on the strategy for the repair works, and look forward to reading their report in due course.

Yours faithfully,
MWA Solutions Limited

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