WATERMAIN BREAK ANALYSIS AND CONDITION ASSESSMENT

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ABSTRACT

- One of the improvements identified as part of the Water Services Association of Australia asset management processes benchmarking was to undertake further analysis to support the risk-based maintenance strategy. The strategy would include analysis of pipe failures, modes and effects to confirm the economic asset life and the replacement criteria.

- The current strategy is that low risk pipes are not replaced until they reach an unacceptable level of failure and are then prioritised for replacement. The consequence of failures will be managed through a rapid response to breaks via the maintenance contract. A pipe condition assessment study is being carried out to help identify when assets are likely to fail and to predict the end of their economic lives.

- Manukau Water owns and operates approximately 2,077km of watermains servicing approximately 103,000 residential, commercial and industrial customers. The asset management plan separates the pipes by type into the following categories; fibrolite, copper/galvanised steel, PVC, MDPE, concrete lined steel, ductile iron and other. There are approximately 964km, 667km and 342km of fibrolite, PVC and MDPE pipe in the network respectively. The remaining 104km of pipe consists of other materials such as concrete-lined steel, ductile iron, cast iron and galvanised steel. This analysis was carried out on main pipe types only.

KEYWORDS

Manukau Water, Watermain, Break, Condition assessment

1 INTRODUCTION

In the past four years since Manukau Water Limited was formed as a council controlled organisation, the company made considerable progress towards its vision to be a world class water and wastewater company.

Manukau Water Limited's asset management plan looks forward twenty years to ensure that the company's plan for, design, construct, operate, maintain, and replace its water and wastewater assets in a manner that meets the demands and expectations of its customers.

In 2008 Manukau Water Limited participated in the International Water Association/Water Services Association of Australia asset management process benchmarking project. The project confirmed the sound asset management practices used and that the operations and maintenance practice is at the top end of the achievement range.

Manukau Water Limited has developed a risk framework to identify and categorise strategic risks to the company. Due to the large number of assets, most of which have a low consequence of failure, a risk assessment approach is used to identify critical asset classes and assets serving important facilities and customers. A reliability maintenance programme will continue to be developed for critical assets, while non-critical assets will be allowed to fail before being replaced.

The value of Manukau Water Limited's water and wastewater infrastructure assets is $1 billion. In managing these assets the objectives of Manukau Water Limited are:

- To operate and maintain the water and wastewater system in an efficient manner.
- To ensure there is sufficient infrastructural capacity to meet growth and demand.
- To meet regulatory requirements and levels of service.
- To replace assets when they reach the end of their economic life.

Manukau Water owns and operates approximately 2,077km of watermains servicing approximately 103,000 residential, commercial and industrial customers. The asset management plan separates the pipes by type into the following categories; fibrolite, copper/galvanised steel, PVC, MDPE, concrete lined steel, ductile iron and other. There are approximately 964km, 667km and 342km of fibrolite, PVC and MDPE pipe in the network respectively. The remaining 104km of pipe consists of other materials such as concrete-lined steel, ductile iron, cast iron and galvanised steel. This report analyses the three main pipe types only.

The fibrolite pipes are between 25 and 60 years old, the copper and galvanised steel are between five and 60 years old while the PVC, MDPE and others are generally from new to 40 years old. Over the last four years the total number of watermain breaks has averaged approximately 400 breaks per year across all of the pipe types and diameters, and for all fault types, excluding damage by third parties. Discussions with operations staff indicate that this is historically consistent.

In July 2008 the key performance indicator target for watermain breaks was reduced from 60 to 30 breaks per 100km of pipe length. The rolling 12 month average number of breaks per 100km for all pipe types and diameters historically fluctuates from 17 to 22. The current rolling average to June 2010 is 21 breaks per 100km of watermain.

2 NETWORK ASSETS AND PERFORMANCE

The water reticulation system comprises trunk feeder mains running from Watercare's bulk water meters to 20 distribution zones within Manukau City. The size of these feeder mains vary from 300mm diameter to 600mm diameter.

Smaller diameter pipes, commonly referred to as fire mains and rider mains, then feed individual streets. Fire mains, generally 100mm diameter to 250mm diameter pipes, run down one side of the road providing water to the service connections on that side of the road and fire protection (hydrants) to both sides of the road. Rider mains, generally 100mm diameter or less, run down the other side of the road and provide water to service connections only.

Service connections run from the fire and rider mains to the water meter, usually located just outside of the customer's property. Service connection diameters vary from 15mm diameter up to 200mm diameter for large industrial users. Approximately 94% of service connections are 15mm in diameter. The service connections are operated by Manukau Water Limited up to and including the water meter and backflow prevention device.

The total length of pipes versus pipe size is shown in Figure 1. Approximately 90% of Manukau Water Limited's water pipes have a diameter of 150mm or less.

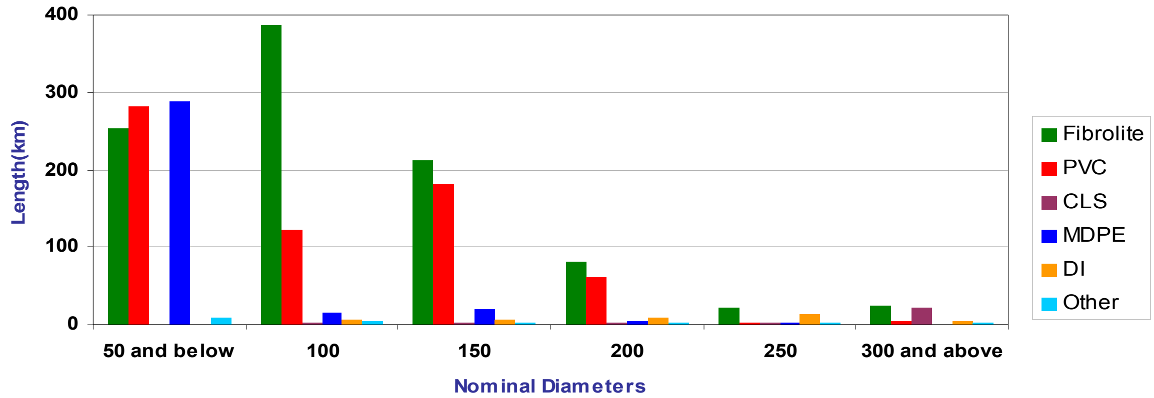

Figure 1: Total length of pipes versus pipe diameter

Manukau City is a relatively young city, with correspondingly young infrastructure. The oldest recorded water pipes operated by Manukau Water Limited are in the order of 70 years old.

The different pipe materials used include:

- Fibrolite
- Poly Vinyl Chloride (PVC)
- Concrete lined steel (CLS)
- Medium Density Polyethylene (MDPE)
- Ductile iron (DI)
- Other materials such as galvanised steel, copper and reinforced concrete

The length of each of the pipe materials in the network and the decade of installation are shown in Figure 2:

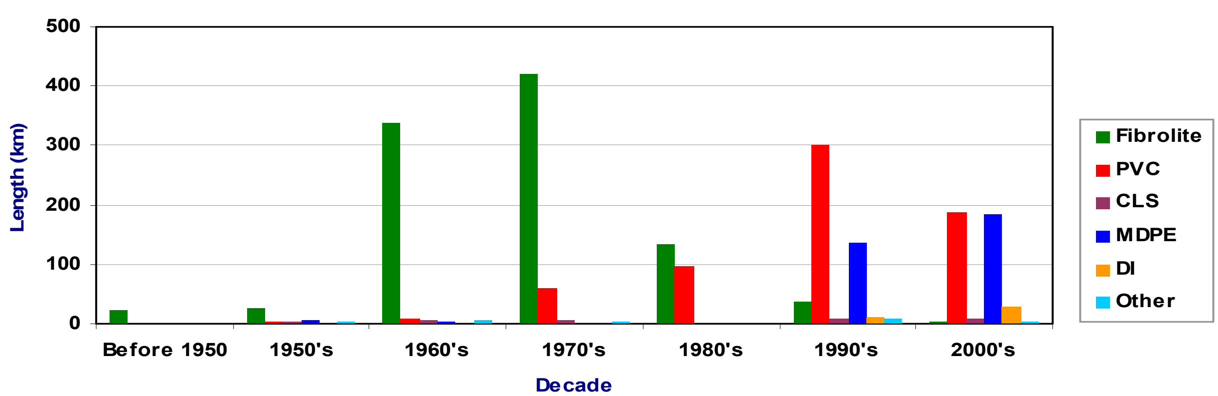

Figure 2: Length of watermains constructed in each decade

Overall, Manukau Water Limited's water network experiences approximately 400 breaks per year, with a rolling 12 month average of approximately 20 breaks per 100km. Total breaks and the rolling average between July 2007 and June 2010 are shown on in Figure 3.

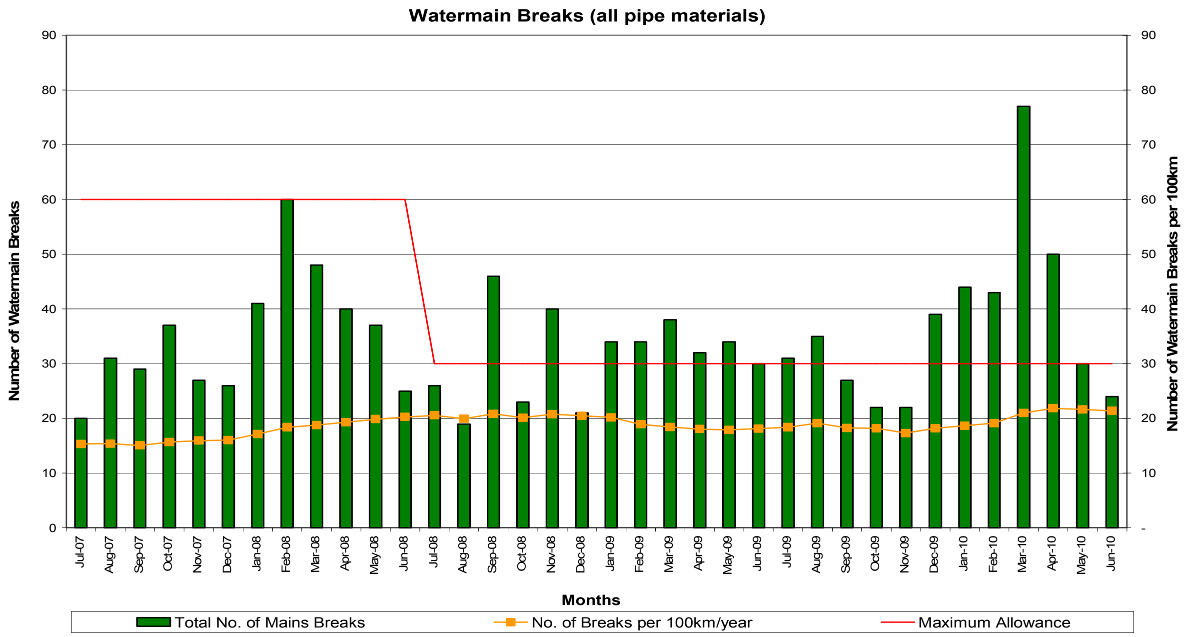

Figure 3: Number of watermain breaks in each month versus threshold

The graph clearly shows in July 2008 the Statement of Intent target for this key performance indicator was reduced from 60 to 30 breaks per 100km to introduce tension into the maintenance contract. The graph shows that while there can be significant fluctuation on the total number of breaks on a monthly basis, ranging from 20 up to 77 per month, the total number of breaks per 100km remains relatively constant. Table 1 indicates the total number of breaks, excluding damage by third party contractors, in each of the financial years.

Financial Year	***Fibrolite***	***PVC***	***MDPE***	***Other***	***Total***
2006/07	*114*	*138*	*28*	*42*	***322***
2007/08	*246*	*105*	*44*	*26*	***421***
2008/09	*239*	*81*	*34*	*23*	***377***
2009/10	*264*	*120*	*39*	*21*	***444***
Total	***863***	***444***	***145***	***112***	***1564***

Table 1: Number of breaks for each pipe type during last four years

These breaks occur right across the city as seen in Figure 4 below from the December 2009 Asset Management Plan:

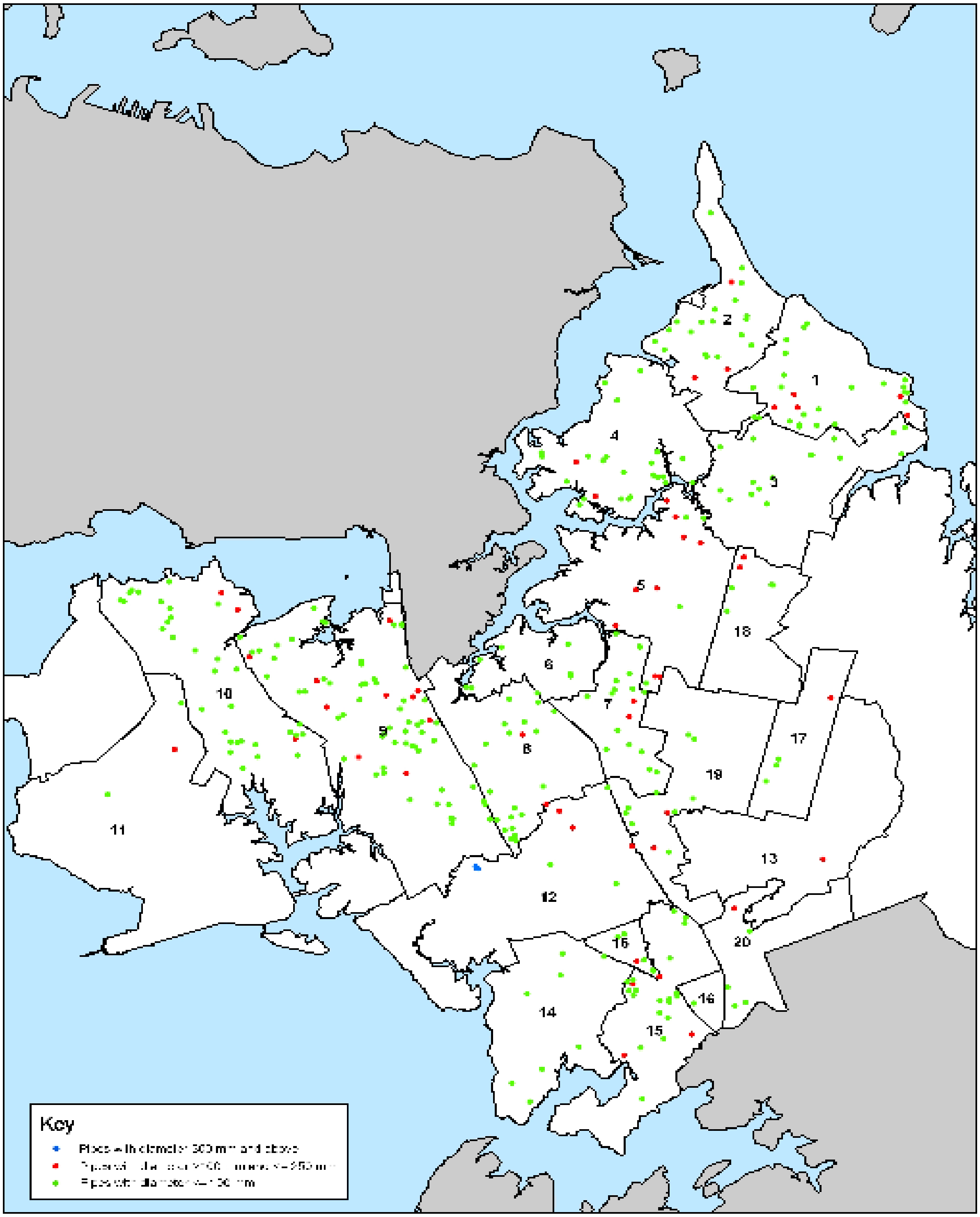

Figure 4: Locality of water main break events

General indications are that the breaks occur on pipes of all materials and all diameters. This is investigated further below.

2 .1 ANALYSIS OF PIPE MATERIAL

Although the total rolling average of breaks per 100km is fairly consistently around 20 within the network, excellent performance of some pipe materials may be masking poor performance by others. Graphs similar to the overall breaks graph above were produced to identify any discrepancies between pipes of differing material. The materials investigated were fibrolite, PVC and MDPE, as these materials make up the significant majority of the network. Figures 5, 6 and 7 compare the breaks for each pipe materials.

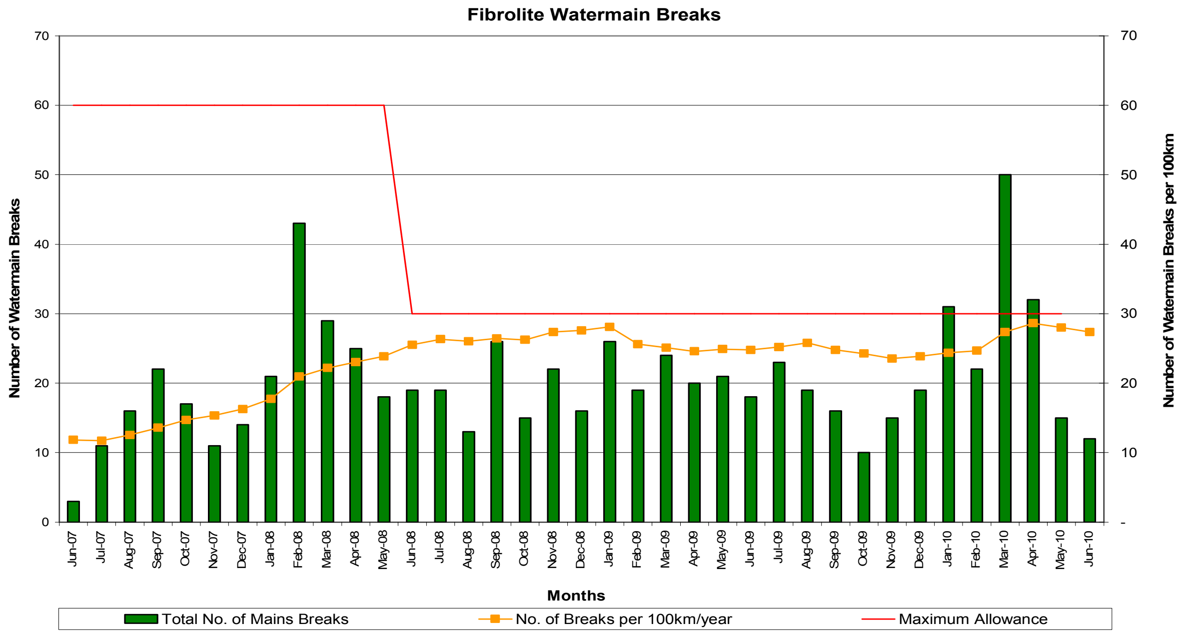

Figure 5 : Breaks in Fibrolite watermains

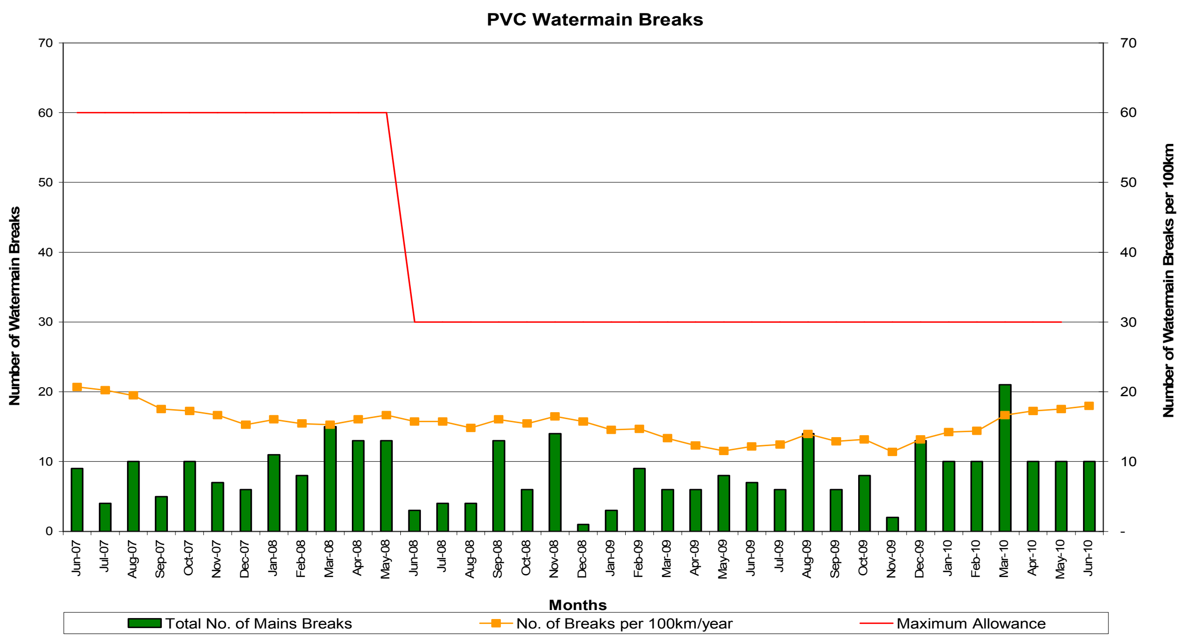

Figure 6 : Breaks in PVC watermains

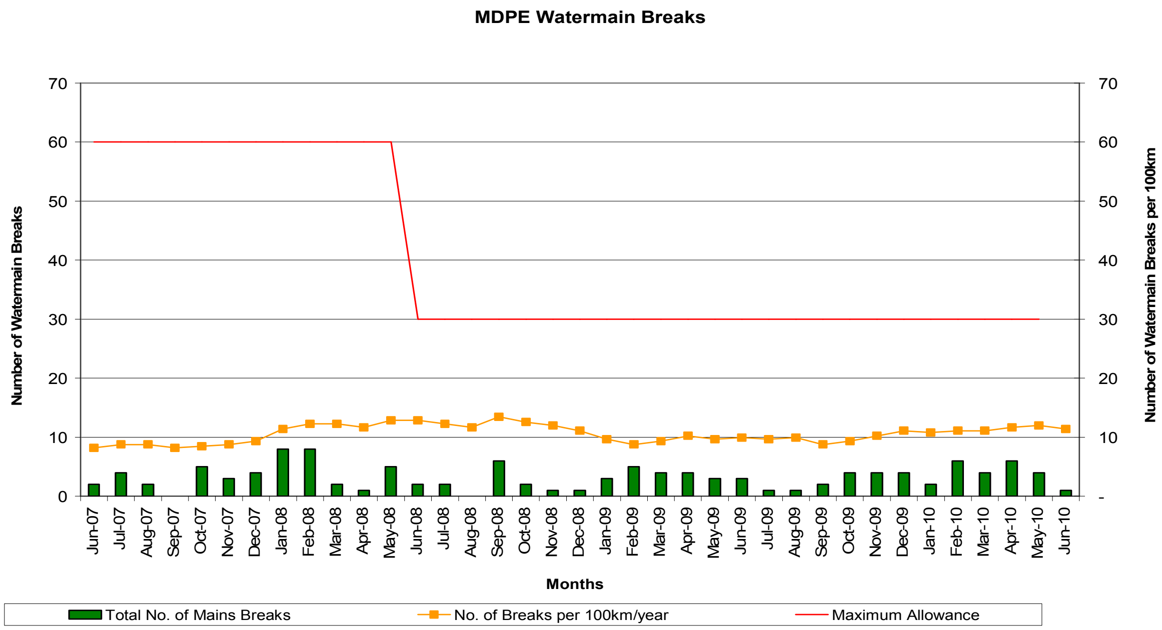

Figure 7 : Breaks in MDPE watermains

There are also a number of breaks in the copper/galvanised steel, however due to the extremely small lengths of these pipe types any comparison of breaks per 100km is severely distorted.

The graphs indicate that there is some difference in pipe breaks depending on the material of the pipe. Fibrolite pipes tend to have a greater number of breaks per month on average, with a correspondingly higher number of breaks per 100km. These pipes also seem to be more susceptible to seasonal variations than the other pipe materials, as evidenced by the increases in breaks during January, February and March. After an initial increase in breaks across the 2007/08 financial year, the fibrolite pipes have remained fairly consistent around 25 breaks per 100km. This is still below the target of 30 for this indicator. Also, the total length of fibrolite pipes is not increasing, but actually decreasing year on year. As time goes on, there may be some distortion of any future comparisons due to this effect.

The breaks per 100km for PVC dropped slowly between July 2007 and November 2009 before increasing again. Generally the PVC pipes experience approximately 17 breaks per 100km.

There is some variability in the breaks per 100km for the MDPE pipe, but on average this pipe material experiences approximately 12 breaks per 100km. These graphs indicate that there is some validity in carrying out investigations into the pipe materials, even though all materials are performing under the expected target

2.1.1 Fibrolite Pipes

As shown in the overall fibrolite graph above, fibrolite pipes have a recent rolling average of approximately 25 breaks per 100km, across all pipe diameters. Approximately 87% of the fibrolite pipes are 150mm in diameter or smaller, indicating that there is likely to be differences in pipe break rates depending on pipe diameter. The following four graphs (Figures 8,9,10 and 11) show the pipe break information for fibrolite pipes of nominal diameters 50mm, 100mm, 150mm and 200mm and greater.

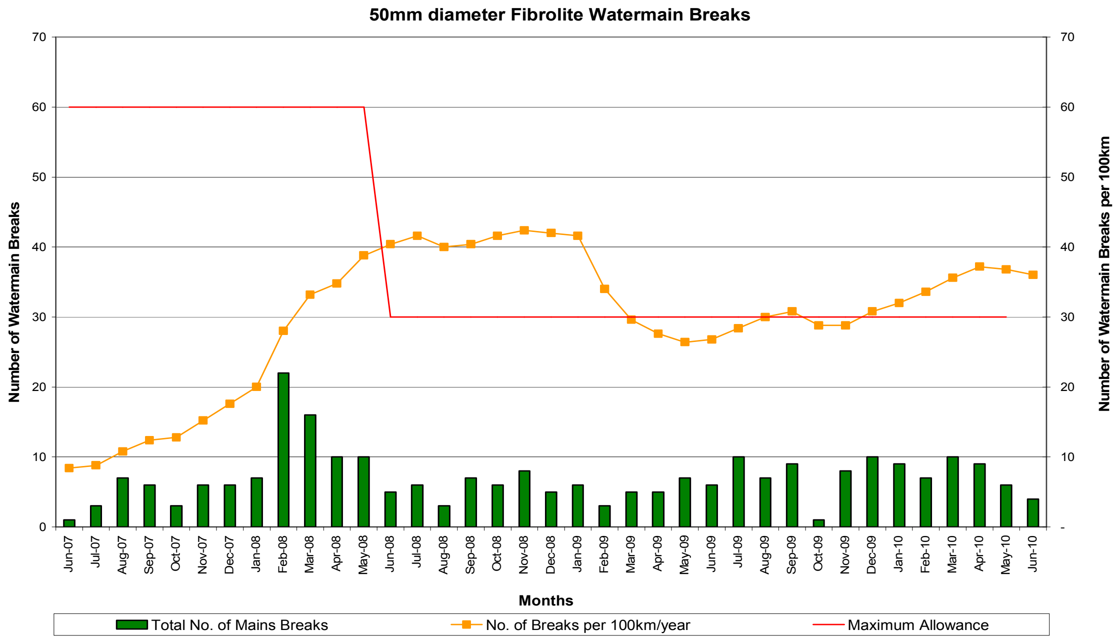

Figure 8 : Breaks in 50mm Fibrolite watermains

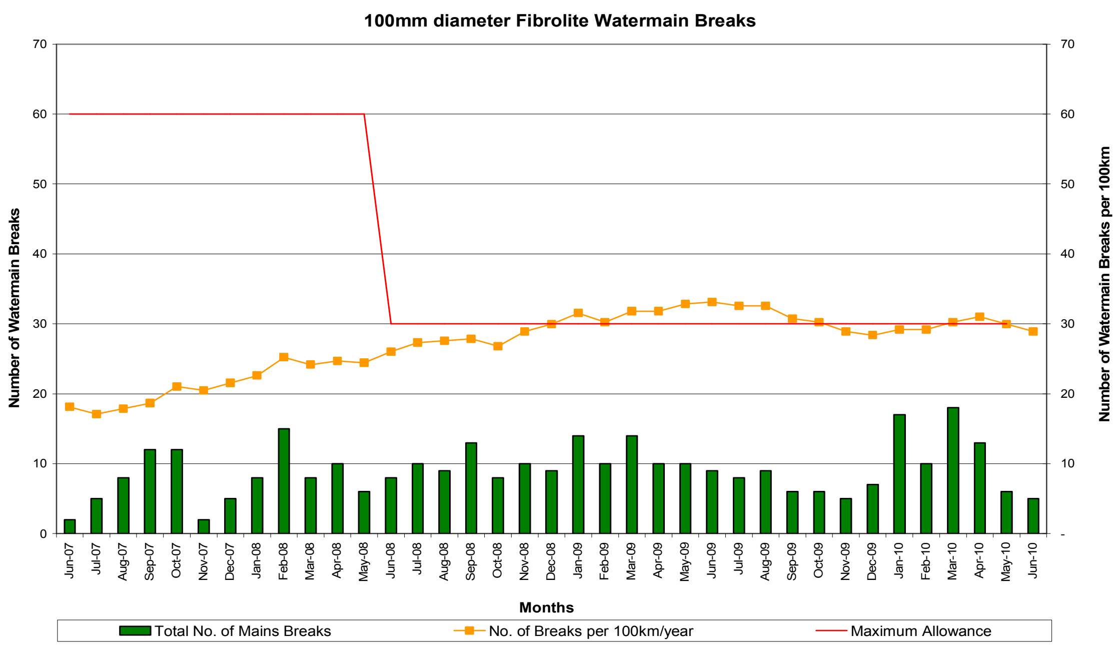

Figure 9 : Breaks in 100mm Fibrolite watermains

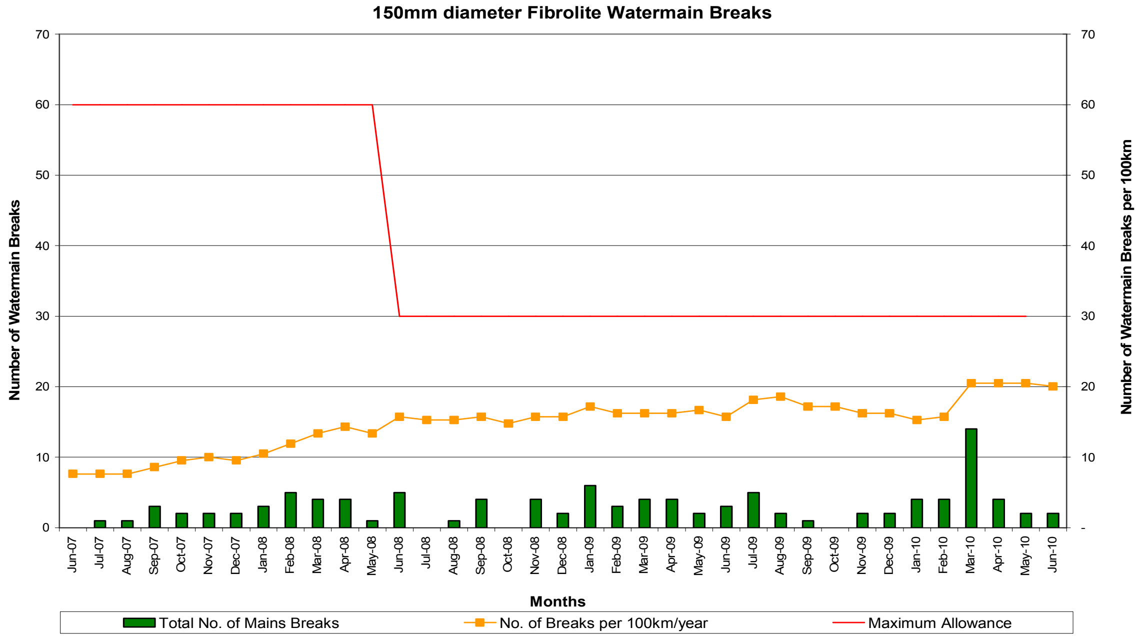

Figure 10 : Breaks in 150mm Fibrolite watermains

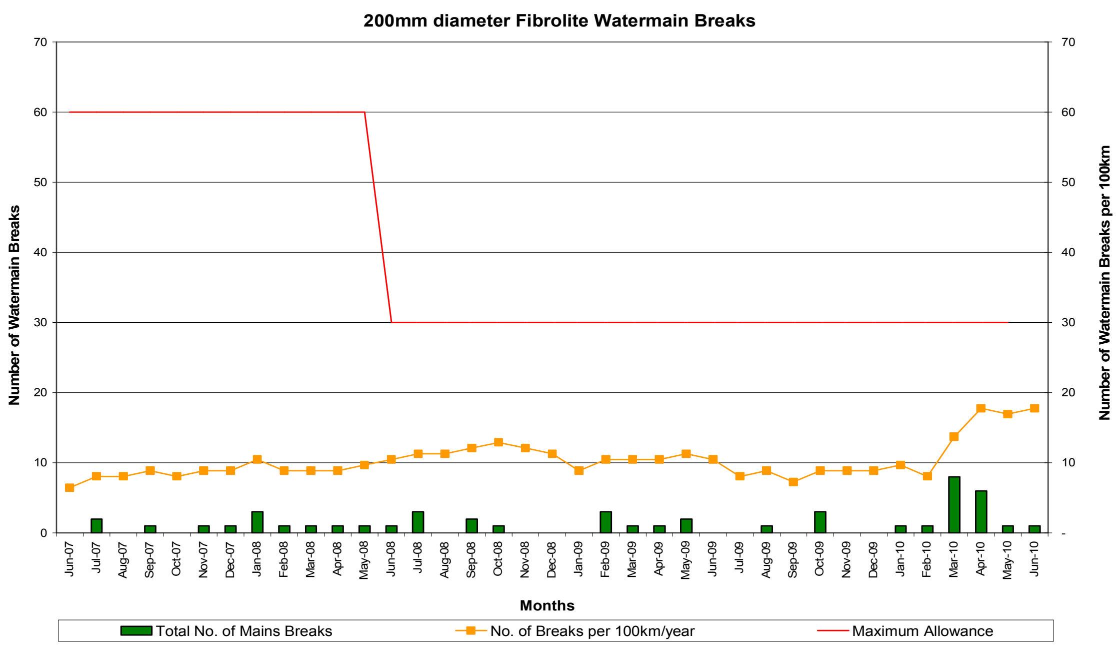

Figure 11 : Breaks in 200mm and above Fibrolite watermains

The graph for the 50mm diameter fibrolite pipes indicates a severely fluctuating number of breaks per 100km, ranging from 9 in July 2007 up to a high of 42 between June 2008 and January 2009. The high spike in the value is largely explained by the two extreme months in February and March 2008, where total breaks in the month were 22 and 16 respectively. Because the graph shows a rolling 12 month average of breaks per 100km, these high figures then elevate the following 12 months data. However, even disregarding the spike, breaks per month for the 50mm diameter fibrolite pipe seems to be generally trending upward.

Both the 100mm and the 150mm diameter fibrolite pipes are also generally trending upwards, with the 100mm diameter pipes having approximately 30 and the 150mm diameter pipes having approximately 16 breaks per

100km over the last year.

Pipes up to 150mm diameter are considered non-critical and are generally run to failure or replaced by the compliance or growth drivers. There was a significant increase in 150mm diameter fibrolite pipe breaks in March 2010, due to the very dry weather conditions. This has created a sharp rise in the rolling breaks per 100km ever since.

The pipes of 200mm diameter and greater have a small total number of breaks annually, but because these pipes also make up a relatively small portion of the overall pipe lengths in the city they have still been experiencing an average of 10 breaks per 100km up to March 2010. There was a significant increase in 200mm diameter fibrolite pipe breaks in March and April 2010, due to the very dry weather conditions. This has created a recent sharp rise in the rolling breaks per 100km, to approximately 18 breaks, however prior to March 2010 the general trend for pipes of this diameter was a slow decline.

All of the fibrolite pipes are older than 25 years. The 50mm, 100mm and 150mm diameter fibrolite pipes have expected ages of 55, 55 and 65 years respectively. Some of the oldest pipes are already reaching these ages and this supports the increasing trends in break rates. Comparing the break rates to the expected ages, the estimated life of a 50mm diameter fibrolite pipe appears correct, while potentially the 100mm and the 150mm diameter pipes could have their expected lives extended further.

The larger diameters of fibrolite pipe have expected lives of 95 years. The oldest pipes are 55 years, approximately 58% of the way through their expected lives. The break rate is approximately half of the expected target, which appears consistent.

2.1.2 PVC Pipes

As shown in Figure 6, PVC pipes have a recent rolling average of approximately 15 breaks per 100km, across all pipe diameters. Approximately 90% of the PVC pipes are 150mm in diameter or smaller, indicating that there is likely to be differences in pipe break rates depending on pipe diameter. The following four graphs (Figure 12,13,14 and 15)show the pipe break information for PVC pipes of nominal diameters 50mm, 100mm, 150mm and 200mm and greater.

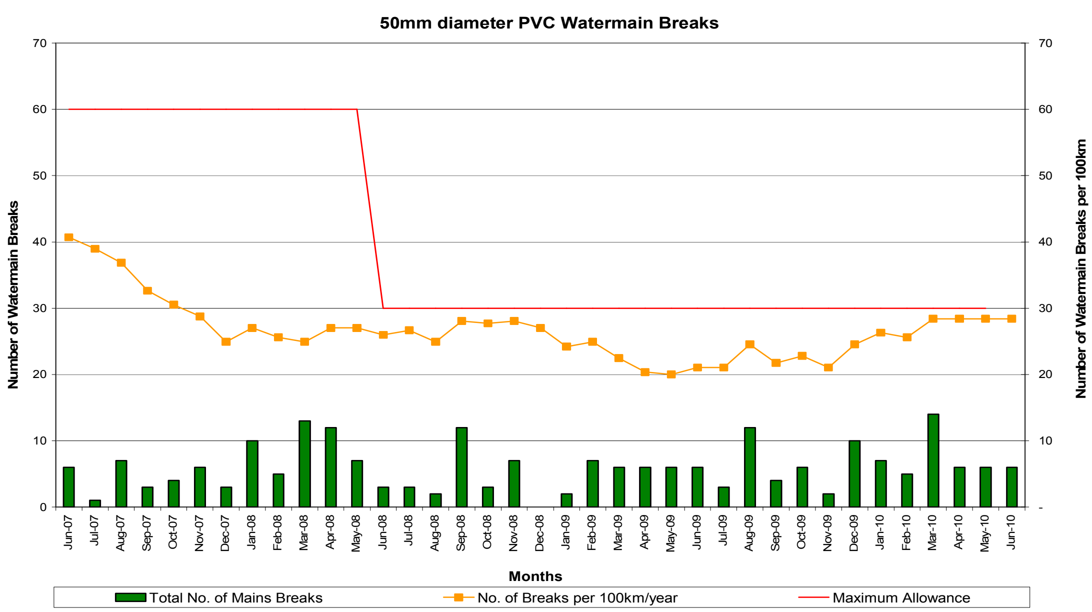

Figure 12 : Breaks in 50mm PVC watermains

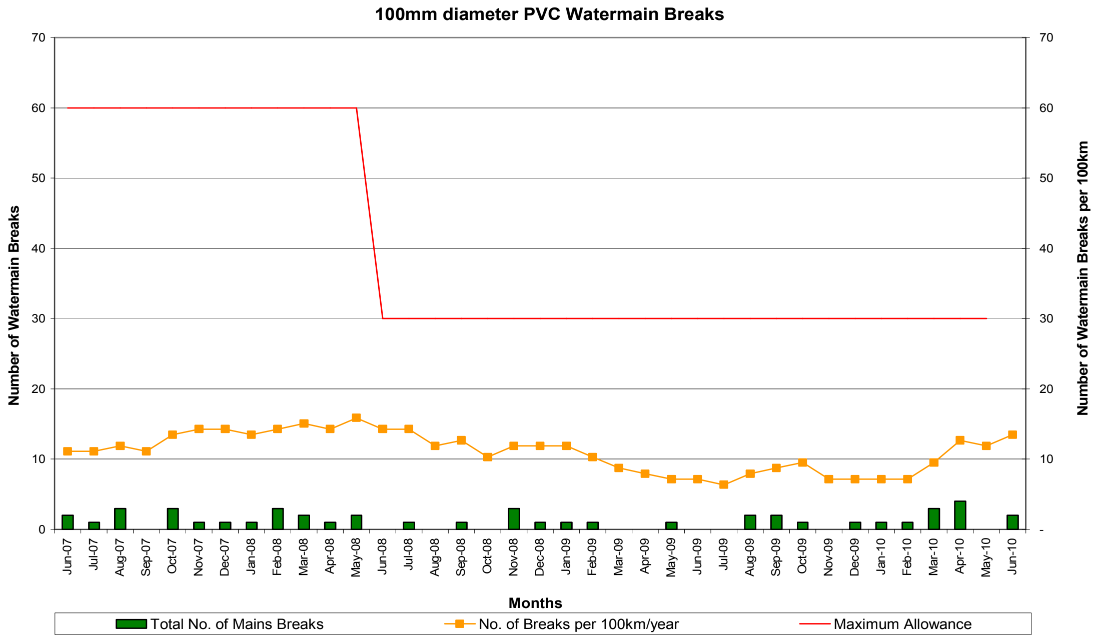

Figure 13 : Breaks in 100mm PVC watermains

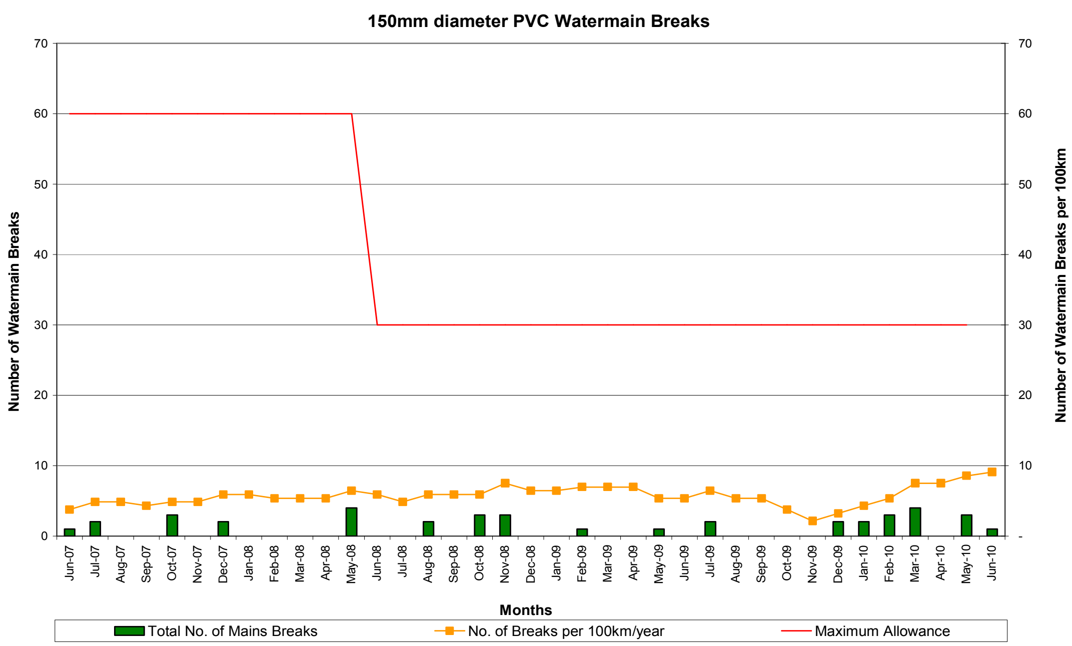

Figure 14 : Breaks in 150mm PVC watermains

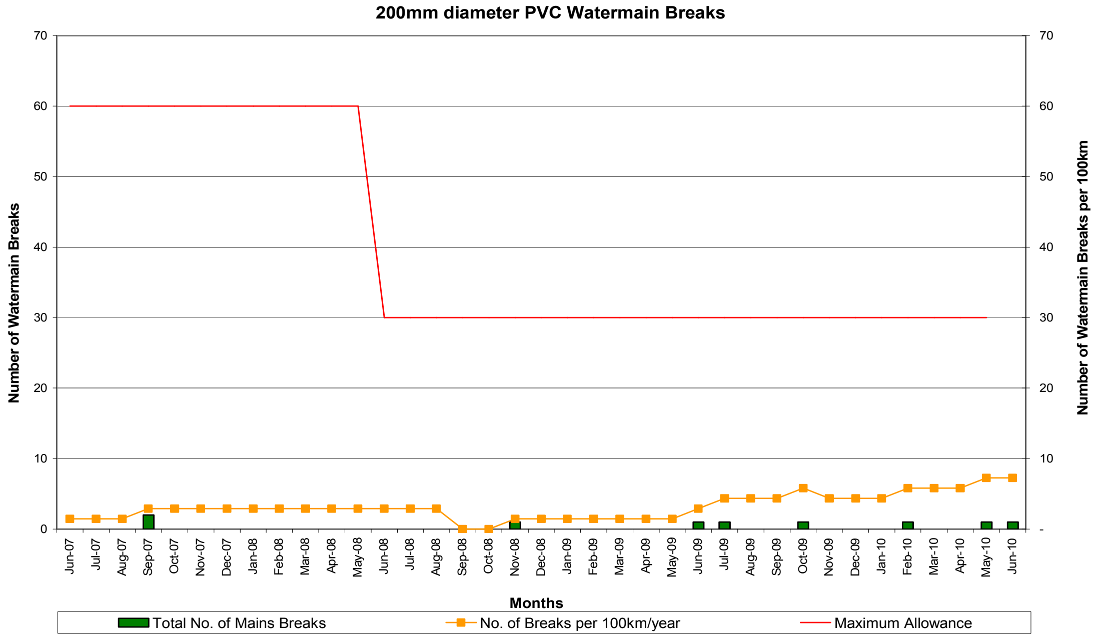

Figure 15 : Breaks in 200mm and above PVC watermains

It can be seen from the graphs that the breaks per 100km for 50mm diameter PVC pipes experienced a significant reduction in the first six months of the 2007/08 financial year, from approximately 40 to 25 breaks per 100km. The reason for this reduction has still not been validated. The downward trend continued until approximately April 2009, when the number of breaks per 100km started to increase again. Over the last year the 50mm diameter PVC pipe has averaged around 25 breaks per 100km.

The 100mm diameter PVC pipe had a relatively constant break rate of approximately 15 breaks per 100km until May 2008 when a significant declined started, with the break rate dropping to seven breaks per 100km by July 2009. Since this time the rate has shown a general increase, with the relatively high break numbers for March and April 2010 exacerbating the effects.

The 150mm diameter PVC pipe has had a relatively constant break rate of around five breaks per 100km up to November 2009 since when a sharp increase has been apparent. Again, this will be enhanced by the relatively high and consistent break numbers between December 2009 and March 2010.

The larger diameter pipes are experiencing a break rate of less than five per 100km, indicating that these pipes are experiencing significantly less breaks than the other diameters.

PVC pipes have an expected life of 95 years irrespective of diameter. The oldest PVC pipes recorded in the fixed asset register are approximately 55 years old, or 58% of the way through their expected lives, however approximately 86% of PVC pipes are less than 25 years old. The low break rate is therefore consistent with the relatively young age of the pipes.

2.1.3 MDPE Pipes

As shown in the Figure 7, MDPE pipes have a recent rolling average of approximately 12 breaks per 100km, across all pipe diameters. Figure 16 shows the pipe break information for 50mm diameter MDPE pipes. There were only fifteen breaks in total in pipes of 100mm diameter and above, so these pipes therefore have not been included for analysis.

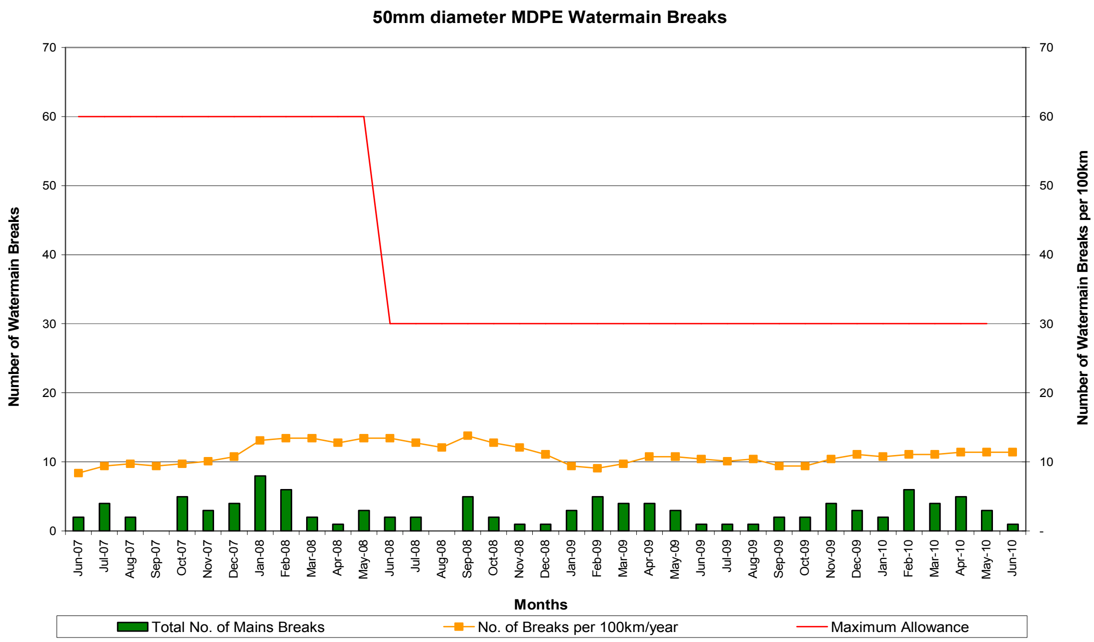

Figure 17 : Breaks in 50mm MDPE watermains

The break rate for the MDPE pipe is almost exclusively related to the break rate of the 50mm diameter pipe. This pipe diameter also has a break rate of 12 breaks per 100km. Generally commenting on the larger diameters pipe breaks, there are significant fluctuations due to the combination of low total number of breaks and significantly decreasing pipe lengths.

Similar to PVC pipes, MDPE pipes have an expected life of 95 years irrespective of diameter. The oldest pipes MDPE pipes recorded in the fixed asset register are approximately 55 years old, or 58% of the way through their expected lives, however approximately 86% of MDPE pipes are less than 25 years old. Again the low break rate is therefore consistent with the relatively young age of the pipes.

3 MULTIPLE BREAKS ANALYSIS

Since the start of the 2007/08 financial year there have been a total of 1564 breaks on all watermains. Approximately 380 of these have been multiple breaks on a total of 151 different assets, with the remaining 1184 breaks being single occurrences, on a different asset each time. A total of 1335 assets, or approximately 5% of all water assets, have experienced at least one break in the last 36 months.

Of the 151 assets that have experienced multiple breaks, over half are fibrolite. The assets with multiple breaks are broken down by pipe type and diameter as shown in Table 2.

	Number of assets with multiple breaks				
Nominal Diameter	***Fibrolite***	***PVC***	***MDPE***	***Other***	***Total***
50mm	*37*	*26*	*9*	*7*	*79*
100mm	*48*	*6*		*1*	*55*
150mm	*9*	*2*			*11*
200mm and greater	*5*		*1*		*6*
Total	*99*	*34*	*10*	*8*	*151*

Table 2: Number of multiple breaks in each pipe type

41 of the 151 assets have experienced three or more breaks during that time period. This is approximately 0.16% of all of the water assets in the network.

The analysis shows that pipes can experience two breaks in close succession followed by an extended period without any further breaks.

Of the fibrolite pipes that have experienced multiple failures, the most common age is 50 years old, as shown in Figure 18.

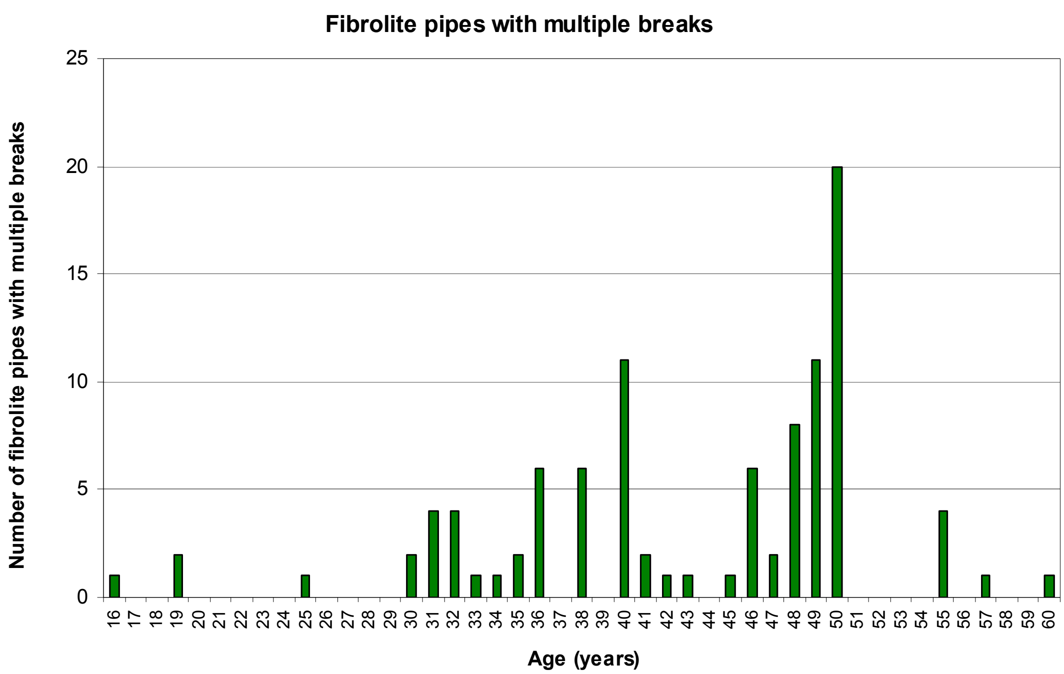

Figure 18: Multiple breaks in Fibrolite pipes

The majority of the pipes experiencing multiple breaks are 100mm diameter and less (as shown in the Table 2 above) have an expected useful life of 55 years. This supports the current expected useful life for these smaller diameter pipes. Generally there is not enough of a sample size to make similar comparisons with the larger diameter pipes.

380 breaks were related to the pipe condition or failure of pipe fittings. No analysis has been made for pipes that have been damaged by third parties. By break type, 133 breaks were identified as blowouts, 105 were

identified as splitting of the pipe, 40 were ring breaks, 51 were identified fitting failures, 19 were pinhole failures, nine were rotten pipes and 23 failures were associated with the glue joints.

By pipe material, 259 breaks occurred on fibrolite pipes, 78 on PVC pipes and 23 on MDPE, 18 breaks on galvanised steel pipes and two breaks on cast iron pipe.

The detailed analysis of breaks by material and diameter is shown in Table 3.

Pipe Type	*Blow out*	*Split*	*Ring break*	*Fitting failure*	*Pin hole*	*Rotten pipe*	*Glue joint failure*
50mm Fibrolite	*16*	*37*	*9*	*9*	*5*	-	*14*
100mm Fibrolite	*79*	*31*	*14*	*7*	*3*	*1*	-
150mm Fibrolite	*15*	*2*	*2*	*5*	-	-	-
>=200mm Fibrolite	*4*	*2*	*3*	-	-	-	-
50mm PVC	*7*	*22*	*4*	*10*	*5*	*4*	*8*
100mm PVC	*3*	*5*	*5*	-	-	-	-
150mm PVC	*2*	-	*1*	*2*	-	-	-
50mm MDPE	*2*	*2*	-	*15*	*2*	-	-
200mm MDPE	*2*	-	-	-	-	-	-
50mm Other types	*3*	*3*	*1*	*3*	*3*	*4*	*1*
100mm Other types	-	-	*1*	-	*1*	-	-
Total	***133***	***105***	***40***	***51***	***19***	***9***	***23***

Table 3: Failure modes for each pipe type and diameter

It can be seen from the table above that the most common failure mode for pipes with multiple breaks is a pipe blowout, and that this type of failure is most common on 100mm diameter fibrolite pipes. 21% of all non-third party related breaks are on these pipes, which account for 18% of the water network. Blow out failures indicate structural weakening of the pipe and multiple failures of this type occurring in a relatively short period of time.

Table 4 gives a breakdown of the failure mode percentages compared with the percentage length of the water network by category, for pipes that have experienced multiple failures in the current financial year.

Pipe Type	*% of the network length*	*% Blow out*	*% Split*	*% Ring break*	*% Fitting failure*	*% Pin hole*	*% Rotten pipe*	*% Glue joint failure*	*Total*
50mm Fibrolite	*12.0*	*4.2*	*9.7*	*2.4*	*2.4*	*1.3*	-	*3.7*	***23.7***
100mm Fibrolite	*18.3*	*20.8*	*8.2*	*3.7*	*1.8*	*0.8*	*0.3*	-	***35.5***
150mm Fibrolite	*10.1*	*3.9*	*0.5*	*0.5*	*1.3*	-	-	-	***6.3***
>=200mm Fibrolite	*6.0*	*1.1*	*0.8*	*0.8*	-	-	-	-	***2.6***
50mm PVC	*13.7*	*1.8*	*5.8*	*1.1*	*2.6*	*1.3*	*1.1*	*2.1*	***15.8***
100mm PVC	*6.1*	*0.8*	*1.3*	*1.3*	-	-	-	-	***3.4***
150mm PVC	*9.0*	*0.5*	-	*0.3*	*0.5*	-	-	-	***1.3***
50mm MDPE	*14.3*	*0.5*	*0.5*	-	*3.9*	*0.5*	-	-	***5.5***
50mm Other	*0.6*	*0.8*	*0.8*	*0.3*	*0.8*	*0.8*	*1.1*	*0.3*	***4.7***
Total		*34.5*	*27.6*	*10.3*	*13.4*	*4.7*	*2.4*	*6.1*	

Table 4: Failure mode percentages for each pipe type and diameter

It can be seen from the table above that fibrolite pipes with diameter less than or equal to 100mm have a disproportionate number of failures compared with the length of these types of pipe in the network. 59% of the multiple failures (23.7% for the 50mm and 35.35% for the 100mm diameter pipes) occur on pipes that account for only 30.3% of the total network.

Blowouts are also significantly over represented, with this category of pipe having 34.5% of the total multiple failures in the water network.

3 ASSET CRITICALITY

The current strategy is that pipes that have a relatively low consequence of failure, or criticality, are not investigated until they reach an unacceptable level of failure and are prioritised for replacement. The consequence of failures is managed through a rapid response to breaks via the maintenance contract. Watermain criticality is assessed on a number of criteria including, diameter, connected customers and redundancy in pipework to supply zones. Critical pipes will be analysed after each failure incident to determine replacement protocols.

For non-critical pipes, a valid investigation criterion is the total numbers of breaks each individual asset experiences. From a purely economic perspective comparing the cumulative costs of breaks for a particular asset with the replacement costs for that same asset would allow a significant numbers of breaks to occur before replacement work is carried out. This method does not allow for the inconvenience to customers, or the effect on Manukau Water's reputation and perception in the community. In Manukau pipes that have had three breaks within six months, or six breaks within 12 months, undergo a detailed assessment to confirm the potential for replacement. This analysis is carried out monthly.

4 CONDITION ASESSMENT

Opus International Consultants (Opus) has recently completed a condition assessment project, analysing fibrolite watermain samples from around the city. The pipe samples were representative of the various diameters and locations of fibrolite pipe found in the water network. The analysis confirmed that deterioration related failures of fibrolite water pipes are largely due to both internal chemical attack from the chemicals in the water and external attack from particularly aggressive soils conditions. The internal deterioration is aggravated by high flow rates and the presence of entrained solids. However, the overall rate of deterioration was consistent with other New Zealand examples.

The water pipes were generally assumed to be Class C fibrolite pipes, experiencing a mean deterioration rate of 0.25mm per year. The minimum and maximum rates were calculated at 0.16 and 0.40mm per year respectively, in alignment with the sampling analysis and consistent with other New Zealand examples. Using this information, useful lives were predicted for various pipe diameters. Opus analysed the water pipes accounting for the installation year, with pipes being installed prior to 1961 generally having longer lives than those installed after 1961. This is due to the wall thickness of the pipes reducing, as well as the removal of a bituminous coating that protected the pipes from deterioration, around 1961. Approximately 17% of the fibrolite pipes in the water network were installed prior to 1961. To utilise a consistent and conservative age profile, the figures for pipes installed after 1961 have been used. These are summarised in the Table 5.

Nominal Diameter	*Proposed valuation life*	*Predicted life minimum*	*Predicted life maximum*
<100mm	*55*	*35*	*65*
100mm	*55*	*40*	*80*
150mm	*60*	*40*	*100*
200mm	*70*	*65*	*100*
225mm	*80*	*70*	*100*
250mm	*85*	*75*	*100*
300mm	*100*	*100*	*100*
375mm	*100*	*100*	*100*

Table 5: Proposed valuation lives for watermains

Further condition assessment work will require ongoing sampling of water (and wastewater) pipes to increase the accuracy of deterioration predictions for fibrolite pipe. Further work will be carried out to identify a practical and effective means to keep the condition-related information current. It is anticipated that this will involve a system to acquire, store and record opportunistic samples and to process them in a cost effective manner.

This information will then be used with other performance and service-related information to provide an indication of asset condition and, in particular, whether it is stable or changing. Based on the above data and any rate of change information obtained, the asset replacement programme for fibrolite pipes will be refined.

5 CONCLUSIONS

Generally, the break rate for all pipes, irrespective of material, diameter or location, is currently around 21, well within the target of 30 breaks per 100km. However there is some variation in the rate when analysing by pipe material - where fibrolite pipes experience more breaks than other materials, and by diameter - where the smaller diameter pipes are more susceptible to breaks.

Over the last three years, there have been 1,564 breaks in the water network. The breaks have occurred on 1,335 individual assets. 1,184 assets experienced only one break while the remaining 151 assets have experienced two or more breaks. Of the assets that have experienced multiple breaks, 41 have experienced three or more breaks. Overall, breaks have affected only 5% of the water assets, with only 0.16% of assets experiencing three or more breaks. A watchlist of pipes has been created from the breaks criteria noted in section 3 above.

Generally, pipe failure rates are consistent with the category lengths in the network. However, fibrolite pipes with diameter less than or equal to 100mm as a category are significantly over represented in the percentages of multiple failures, with 59.2% of multiple failures occurring on only 30.3% of the water network by length. Blowouts account for 25.0% of pipe failures in this category of pipes alone, and 34.5% of all multiple pipe failures.

As shown in Figure 4, there is no correlation between location and break rate. All of the water supply districts in Manukau have experienced at least one break during the last financial year. Spatially oriented breaks analysis would not seem to provide any greater benefits than those already based on material and diameter.

There is a correlation between both the pipe material and the pipe diameter with the break rate of the pipe per 100km. The condition assessment project has provided more information on the deterioration rates of fibrolite pipe, which impacts on the replacement profiles. The proposed lives for fibrolite water pipes are summarised table 5 above.

The number of breaks in six or 12 months is an indicator of further investigation required on a particular asset. This system is used for low criticality assets with a low consequence of failure. High criticality assets, and assets with a medium to high consequence of failure, will have each break incident analysed, after which a decision will be made as to whether or not the watermain needs to be replaced.

REFERENCES

Manukau Water Limited – Asset Management Plan, December 2009

Opus Consultants - Condition Assessment report for Fibrolite Watermains, June 2010