# Setting Asset Performance Targets

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**Abstract**

*Setting targets is a common way for organisations to establish performance expectations. However the validity of targets is challenged when performance is influenced by factors beyond the control of the manager. This project examines the issue of target setting for a single asset performance measure across different geographical areas. The performance measure is "Wastewater Blockages per 100km" at the Water Corporation (WC). Factors relating to these blockages are examined for eight operating locations with quite different characteristics. A generalised linear regression model is developed to determine the influence of age, pipe type, network length, population, rainfall as well as costs associated with preventative and corrective maintenance. Preliminary results reinforce that age and pipe type significantly influence blockage rates and this confirmation can be used to develop an understanding of how different districts might perform. A key result is that there is no relationship inside a district between management-controlled activities such as preventative maintenance and blockages. Unless a relationship can be established it would be premature to set targets for managers as the variables they can control (costs) do not appear to make an impact on what they are being assessed against.*

## 1. Introduction

An asset manager requires performance expectations in the form of targets to prioritise investments for an asset base. Targets may vary across operating areas due to asset condition, budgeting and environmental challenges. The WC would like robust targets for their asset performance Dashboard developed in 2014. The Dashboard is designed as a corporation-wide gateway to asset performance. This means it must aid all asset management functions – Strategy and Integration, Renewals, Capability Assessment, Maintenance, and Information Systems and Data, as well as regional managers and the broader business (Pascoe 2014). The Dashboard increases the visibility of the WC's siloed databases. With increased visibility questions are more readily raised about who is accountable for poor, average or exceptional performance. The Dashboard currently shows the performance information of four performance measures across the state – Leaks and Bursts per 100km, Wastewater Blockages per 100km, Wastewater Repeat Blockages and Wastewater Overflows. A green display reveals acceptable performance and red indicates poor performance according to a statewide target.

However statewide targets can mask localised poor performance so a more granular performance breakdown is required. The objective of this project is to develop a target setting methodology for the Dashboard's performance measures. To concentrate research efforts, Wastewater Blockages per 100km was selected for investigation. This measure was chosen given the political, environmental and social risks associated with the wastewater sector. These risks were being reviewed at the WC at the time of decision.

Targets are needed by the WC to make effective planning decisions from the Dashboard. De Bruijn (2007) discusses the relationship between the impact of a Performance Measurement System (PMS) and its effectiveness to an organisation. Figure 1 below depicts this relationship – PMS effectiveness to a firm on the vertical axis and PMS impact on a firm on the horizontal axis. Figure 1 shows that reporting performance against appropriate targets has varying consequences. However there is an optimal point when the outcome of performance disclosure benefits the firm. Targets therefore aid the continuous improvement of businesses.

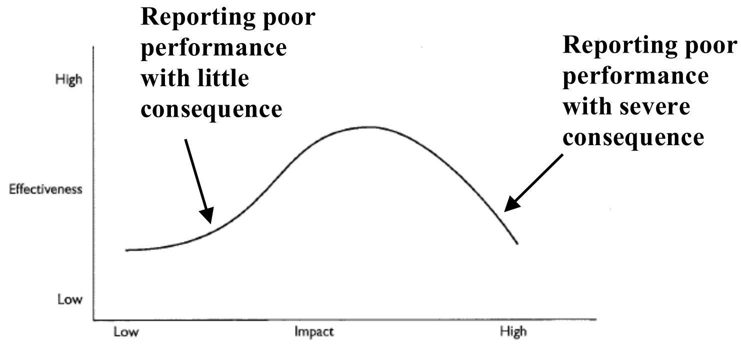


**Figure 1: Law of Decreasing Effectiveness annotated from De Bruijn (2007)**

The current 40 blockages per 100km statewide target on the Dashboard is to be a mere tidemark. Gravity sewer blockage performance varies yearly and between towns. Previous work by the WC indicates that most blockages occur in vitrified clay pipe by tree root intrusion or accumulation of fats (Xie 2014). This project attempts to explain further variation in blockage performance to inform the setting of targets. A series of variables have been selected to help explain the differences. The variables are a combination of what the WC can directly control and what is out of their control (Marlow et al. 2011). The research tests whether less control leads to more performance variation. If performance remains unchanged regardless of the level of control, then opportunities exist for firms to streamline their management-controlled activities.

# 2. Methodology

## 2.1 Data Collection

Eight towns were selected for investigation – Australind (AU), Carnarvon (CA), Eaton (EA), Esperance (ES), Exmouth (EX), Kambalda (KB), Karratha (KA) and Laverton (LA). These towns encapsulate all the operating regions outside of metropolitan Perth. Each region is supervised by its own regional manager. The budgets given to regional managers are used for asset OPEX and CAPEX. At the WC, towns are simpler to analyse than metropolitan areas because asset locations are better defined in towns with little network overlap. To see how much the WC were spending in preventing gravity sewers blockages, preventative maintenance spend versus blockage performance from 2005-2013 was collated from the SAP works management system. As summarised in Table 1, preventative maintenance is categorised into three activity types.

| Code | Maintenance Activity Type | Application |
|---|---|---|
| MP1 | Scheduled | Legacy strategy |
| MP2 | Condition Monitoring | Knowledge gathering |
| MP3 | Condition Based | Acting on the knowledge |

**Table 1: Preventative Maintenance Activity Types for Spending Investigation**

The yearly spends were compiled alongside Gross Blockages, Blockages by Task Code, Length, Avg Install Year, Pipe Type, Population, Rainfall Mean and Max data from GIS and gov.au into a CSV file to be readable in the statistical package R.

## 2.2 Exploratory Analysis

Exploratory analysis was performed through boxplots of the spread of performance from year to year and from town to town. Data irregularities were identified and cleansed. Data irregularities included negative dollar amounts, inconsistent use of asset hierarchical functional locations (FL) and incorrect categorising of work orders.

## 2.3 Statistical Modelling

To see the sensitivity in variables from town to town standard multivariate linear regression models were used. In order for towns of different sizes to be compared, the variables were scaled by network length and population. Linear regressions were performed both on a town by town basis and on all towns together. Prior knowledge and the exploratory analysis narrowed the number of variables in the models. Statistical significance, coefficient magnitude and standard errors were assessed when running the models.

# 3. Results and Discussion

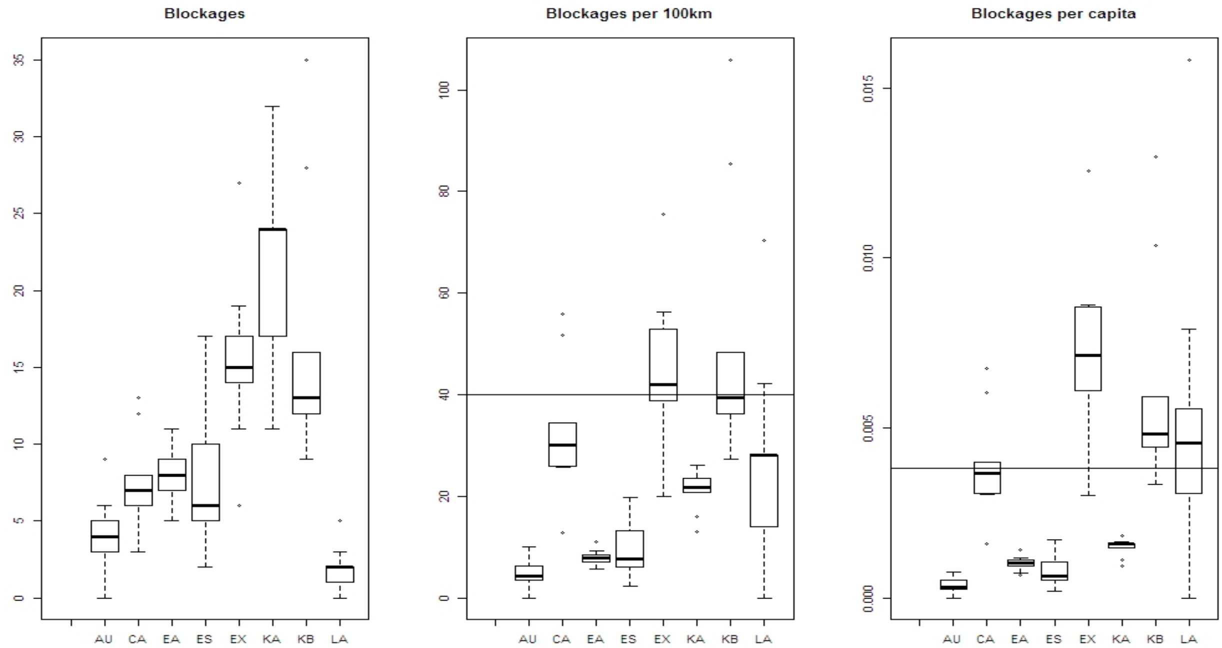


**Figure 2: Blockage Variation across Towns from 2005-2013**

Figure 2 above shows the variation of blockages across three scaling mechanisms – gross blockages, blockages per 100km and blockages per capita from 2005 to 2013. The horizontal line on the blockages per 100km per year plot is the current statewide target. The horizontal line on the blockages per capita plot is the same statewide target on a per capita basis. The presence of the sole dots (outliers) could reinforce the argument by Marlow et al. (2011) that "blockage rates are affected by a range of factors beyond their management control". However not all towns have such erroneous outliers. The boxplots reveal different distributions depending on the scaling factor. For instance, KA has large variation in gross blockages but when compared to the length of the network and population growth, asset performance is more predictable. It can be inferred that the smaller the variation, the blockage rate increases at the same rate as the scaling factor. A plausible argument is that the gravity sewers in KA can accommodate growth better than EX or LA.

Management control is an important concept to further explain Figure 2. Age, rainfall, pipe type and population can be thought of as uncontrollable variables. 100km is the approximate network length of AU, EA, ES and KA. Despite being installed by the WC, 100 km of gravity sewers cannot be easily removed and replaced. This means that age and pipe type can be considered as fixed legacy variables (Marlow et al. 2011). Similarly, population growth can be dependent on the resource sector as was the case with KA. Extreme weather events are decided by mother nature. Rainfall can impact gravity sewers in two ways: collapsed pipe from loss of soil support (blockage) or additional flow that self-cleans the pipe (maintenance).

Figure 3 shows the varying age distributions of the gravity sewers across the towns. The plot reveals the culmination of new and old gravity sewer systems. For example, AU and EA have newer sewers whilst EX and KA have older sewers. With varying install year, the composition of pipe type also varies. Three pipe types dominate the gravity sewer networks – unplasticised polyvinyl chloride (PVC – U), vitrified clay (VC) and asbestos cement (AC). Table 2 below is a summary of the pipe type percentages.

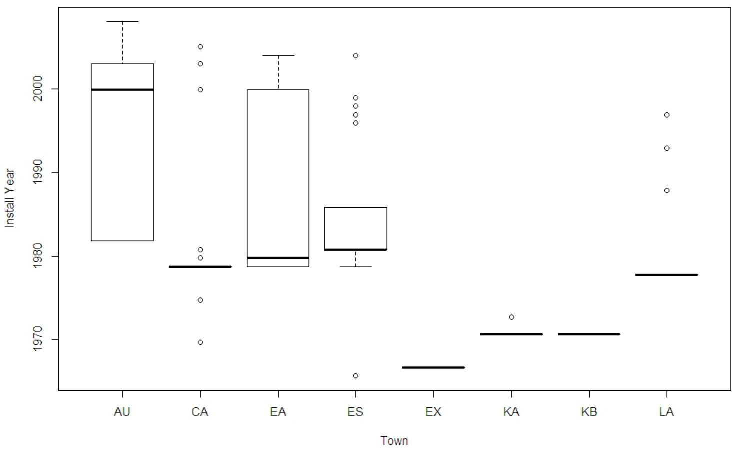


**Figure 3: Network Age Variation across Towns**

| Town | PVC – U % | VC % | AC % |
|---|---|---|---|
| AU | 99 | 0 | 0 |
| EA | 99 | 0 | 0 |
| CA | 70 | 30 | 0 |
| ES | 99 | 0 | 0 |
| EX | 60 | 40 | 0 |
| KA | 80 | 20 | 0 |
| KB | 5 | 0 | 95 |
| LA | 20 | 0 | 80 |

**Table 2: Approximate Pipe Type % of Gravity Sewers across Towns**

Management can always control OPEX to achieve stronger outcomes (Marlow et al. 2011). This comes in the form of proactive asset activities that are billed to work orders. If regions are spending regularly but with no improvement in blockages, what is the spending rationale? A sewer report written for the 2010-2013 financial years found that due to budget constraints, numerous planned maintenance work orders in Perth weren't completed in 2013 and the total number of blockages for 2013 was relatively unchanged (Wilson 2015). However did this catastrophically impact performance in 2014 and 2015 and was it just the lack of maintenance that lead to the blockages? Exactly what have the WC spent their gravity sewer budgets on across the regions? The analysis of this cost data lead to more questions than answers.

## 3.1 Maintenance Cost Data Investigation

Gravity sewers operated by the WC have a 'run to fail' strategy. Until a blockage occurs, the pipe remains untouched. Once a blockage occurs, corrective maintenance is undertaken to clear the blockage. Maintenance and renewals programs are initiated once corrective maintenance reaches an unacceptable level (three blockages on the same pipe section in a year). A maintenance program involves jet washing, root cutting and inspections. These activities are classified as preventative maintenance. Renewals programs involve replacement or relining of pipe sections. These activities are classified as capital works. The cost analysis has shown that when compared to wastewater pumping stations and treatment plants, the gravity sewer network receives less capital funding. However the WC are aware that their sewer assets are ageing and have established a 20 year Strategic Investment Business Case. Nevertheless the cost data acquired shows difficulties in recording the array of activity types. Costs have been placed in the wrong categories. Inconsistencies are being investigated and work order feedback accuracy is improving but a large majority of the inconsistencies go unseen. This is a concern when trying to see the sensitivity in blockages versus unreliable costs for target setting.

After running yearly spend reports on SAP for each town filtering by FL, it was realised that some towns choose not to adopt a FL hierarchy despite it being a main SAP filtering technique. This means a large majority of preventative maintenance work orders were missed in the original data collection. Crudely, the number of FLs increase with network complexity and length. The length and number of FLs for the eight towns are summarised in Table 3.

| Town | Network Length in 2005 (km) | No. hierarchical FLs in 2005 | No. hierarchical FLs per km in 2005 |
|---|---|---|---|
| Australind | 75 | 103 | 1.37 |
| Carnarvon | 22 | 73 | 3.32 |
| Eaton | 86 | 36 | 0.42 |
| Esperance | 76 | 947 | 12.46 |
| Exmouth | 30 | 252 | 8.40 |
| Kambalda | 32 | 92 | 2.88 |
| Karratha | 82 | 7 | **0.09** |
| Laverton | 7 | 147 | **20.7** |

* The change in the number of hierarchical FLs per km from 2005 to 2013 is negligible

**Table 3: FL Inconsistency between Towns of similar Length**

Similarly cases of negative preventative maintenance spend were found. The inconsistencies found don't reflect the goal of the Dashboard – the cost data is not readily accessible nor is regional accounting consistent.

## 3.2 Statistical Tests

'Gross blockages' and 'blockages scaled by length' linear regressions have been executed. The purpose of the two regressions was to explain performance variation within towns and between towns. As expected for the first regression, age and pipe type dominate the regression. The first regression is supported by the second regression – blockages per km reduce as network length increases. This means that newer sections and sections of pipe (PVC – U) reduce blockages per km. All variables were included across the two regressions except preventative maintenance because of the data's unreliability. However it must be noted that an unstable relationship is likely between preventative maintenance and blockages. Preventative maintenance is meant to reduce the onset of future blockages. On the other hand, a maintenance team can perform more preventative maintenance due to a spike in blockages in previous years. Without a well understood time lag, a relationship instability is probable.

# 4. Conclusions and Future Work

Findings have reinforced that blockage performance is governed by age and pipe type. Without knowing exactly how much is proactively spent on gravity sewers and the control's impact, management can't set targets and can only be informed by performance acceptability ranges. Ashley et al. (2002) confirms this argument by saying it is not possible to set targets without reliable data. Until a relationship is found between management-controlled activities (preventative maintenance) and performance, setting specific targets is not meaningful.

Further work aims to set performance acceptability ranges and to populate reliable cost figures to come to the following relationship: to reduce blockages by one next year, the WC need to spend $'x' in preventative maintenance this year. The water sector can also be trialled to see if the same asset hierarchical issue exists. The WC is caught in-between using traditional hierarchical systems and spatial software to define their assets. One recommendation is to make the state comply with one spatial hierarchical system to improve cost accounting consistency. Once the targets are set, an investigation should commence that draws the connection between the targets and the impact on the customer.

# 5. Acknowledgements

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# 6. References

Ashley, R. et al. 2002, "Sewer systems and performance indicators – into the 21st century", *Urban Water 4*, pp. 123-135.

De Bruijn, H 2007, "Managing Performance In The Public Sector", 2nd Edition, Routledge.

Marlow, DR. et al., 2011, "Sewer Performance Reporting: Factors That Influence Blockages", *Journal of Infrastructure Systems*, pp. 42-51.

Pascoe, R 2014, "Launch of the AM Performance Dashboard", Water Corporation Asset Management Memorandum.

Wilson, L 2015, "Effectiveness of the Current Gravity Sewer Maintenance Program", Water Corporation Asset Management – Maintenance.

Xie, Q 2014, "Predictive Modelling of Sewer Blockages in Vitrified Clay Pipes", CEED Project, University of Western Australia.