Impact of Inflow and Infiltration on Wastewater Assets

Nicole van Rooyen

Matt Hardin
School of Mechanical and Chemical Engineering

Richard Forrest, Geoff Hughes and Cheryl Delport
CEED Client: Water Corporation

Abstract

Inflow and infiltration into the wastewater system results in increased costs to the Water Corporation from the need to handle increased volumes of wastewater. Extra pumping to transport the wastewater and increased volumes requiring treatment lead to increased operating and capital costs. This project was undertaken to investigate where the effects of inflow and infiltration could be occurring within selected areas in the Perth region and to identify possible causes for any observed inflow or infiltration. After completion of this investigation, recommendations for further research into more specific areas regarding inflow and infiltration will be provided to the Water Corporation in the deliverables. Inflow data for the Beenyup and Subiaco Wastewater Treatment Plants have been compared to daily rainfall information collected from the Bureau of Meteorology. The trends observed suggest the possibility of inflow due to high intensity short duration rainfall periods as the inflow data generally responds to the increase in rainfall. Specific sewerage pumping stations within the Beenyup and Subiaco treatment plant catchment areas are under investigation for further information regarding the existence of inflow and infiltration during wet periods. Physical information, such as the age and type of the pipe work and other infrastructure, the surface geology of the catchment area, and land development density will be considered when compiling the final recommendations for the Water Corporation.

1. Introduction

Excessive inflow and infiltration has implications for the Water Corporation in regards to increased maintenance requirements, increased capacity requirements for conveyance infrastructure and treatment works, and in extreme cases the potential for overflows from the conveyance system and discharges to the environment. Excess wastewater in the conveyance network will require extra pumping hours and greater volumes of water to be treated. Minimising these costs and reducing and monitoring the sources of significant inflow and infiltration will significantly benefit the Water Corporation. Inflow and infiltration are often incorrectly defined. For the purpose of this project, inflow is surface water entering through above-ground connections, manhole covers and other breaches or defects and is mostly associated with rainfall events. Infiltration is groundwater entering through walls of the facilities below ground, including pipe and manhole defects. It is generally affected by water table levels (CCD Australia, 1998). This project is an attempt to identify key areas within the Perth region that experience inflow and infiltration and the possible causes of this problem. Recommendations based on the results of the research will be made for further areas of research and to monitor and improve the issues associated with inflow and infiltration.

1.1 Current Situation

There have been three major desktop investigations completed prior to this project carried out on sewer infiltration in Perth, the South-West and regional towns in Western Australia (CCDAustralia 1998) (GHD 2004) (SKM 2006). These studies were conducted on behalf of the Water Corporation and separate the flow regime into wet weather flow and dry weather flow to differentiate between inflows due to factors such as illegal household connections and inflow and infiltration due to excess rainfall (CCD Australia, 1998). These papers were primarily concerned with locating regions with high inflow/infiltration into the system and providing insight into the causes behind the inflow/infiltration. Once these factors were identified, they were not investigated in more detail. This project will focus on smaller catchment areas and specific pumping stations to provide more detailed research regarding a particular cause of inflow and infiltration.

1.2 Project Objectives

The main project objectives to be completed are set out below.

- Identify two specific catchment areas within the Perth region in which to investigate the effects of inflow and infiltration. Beenyup and Subiaco catchment areas were selected.
- Collect rainfall data and relevant flow and pumping data for the chosen catchment areas for analysis and comparison.
- Determine specific wet and dry periods to investigate in an attempt to determine whether inflow is proportional to rainfall and which areas are more prone to this problem.
- Refine the catchment areas by selecting prominent sewerage pumping stations for a more detailed analysis. Selected Sewerage Pumping Stations (SPS) are as follows; Flora St, Charles St, Stirling Cres, Elvire St, Riverbank Blvd, Helmsedale Rd and Bridge St for the Beenyup catchment and John St, Johnson Rd, Kelvin St, Deeley St, Claisebrook, Gloucester Park and the Causeway for the Subiaco catchment.
- Provide recommendations for further (and more specific) research into the issues associated with inflow and infiltration based on the observed results.

2. Process

This project is primarily based on analysing historical data recorded by the Water Corporation which requires access to specific data bases. The project relies heavily on identifying and locating the correct data located at the Water Corporation to enable comparisons of flow information and results for discussion. There are no experimental or fabrication components to this project, but a site visit to the Subiaco WWTP has provided a better understanding of some important concepts regarding WWTP operations that are relevant to the project. There are a number of sections within the project that require different approaches to enable important research and results to be identified. Each project objective is outlined below with the processes required to achieve each target.

2.1 Initial Project Scoping

Inflow and infiltration occurs over a number of areas in the Perth region. In the initial scoping of the project, it was decided that two catchment areas, Beenyup and Subiaco, would be selected as a focus area to research, allowing for detailed investigation of smaller catchments. Within these regions, specific SPS would be identified and used to compare flow data and pump hours with the recorded rainfall information to determine possible trends and relationships between the recorded information on wet and dry days. The observed results should suggest possibilities as to whether there is inflow or infiltration occurring in particular regions and possible causes for any extra flows observed can be investigated. Recommendations for further research into specific areas and problems are expected to be provided as part of the deliverables to the Water Corporation. A basic cost estimate may be prepared, depending on the progress of the project and the relative time remaining after completion of the data analysis.

2.2 Literature Review

Inflow and infiltration has been recognised across Australia as an issue that should be investigated. The Water Corporation has previously released three important research papers (*Infiltration to Sewers in Perth, South-West Sewer Infiltration and Inflow Study (Group 2)*and *Sewer Infiltration and Inflow in Regional Towns, Western Australia*) that have provided the main background information for the project. The major findings of this research was that the most likely times for inflow to be observed was during short duration high intensity (S/H) rainfall. Medium duration medium intensity (M/M) and low duration low intensity (L/L) periods were also investigated, but the results showed minimal inflow and infiltration possibilities compared to that of the short duration high intensity periods (CCD Australia, 1998). This result has lead to the investigation of two specific wet day events (that would fall under the S/H category) in 2008 to be investigated for this project. Wet weather flow (WWF) and dry weather flow (DWF) factors were used to identify the possibility of inflow by assuming WWF to be the sum of the DWF and inflow. This gave inflow factors that could be used to compare the inflow observed between different catchments and the worlds best practice (CCD Australia, 1998).

2.3 Data Collection

Collecting the correct data for this project is essential in identifying the possibilities of inflow and infiltration occurring in the wastewater system. Daily rainfall information for Beenyup and Subiaco WWTPs from 1980 - 2010 was obtained from the Bureau of Meteorology. The daily inflow data for the two WWTPs was taken from the ODDS database at the Water Corporation. Pump running hours are also located on this database and can be accessed through Process Books at the Water Corporation. This information is being analysed and graphed using Microsoft Excel to identify any relevant trends or inconsistencies. An interactive GIS map of the catchment areas has also been constructed by the Water Corporation on their system which shows the surface geology, type/material of the piping and the age of the piping and infrastructure. This system will help define the cause of any anomalies observed when comparing the flows observed at the pumping stations.

2.4 Project Specifics

After conducting a macro analysis of the Beenyup and Subiaco catchment areas and wastewater treatment plants (WWTP), smaller areas within these catchment areas containing specific sewerage pumping stations (SPS) were identified for a more detailed analysis. The pumping stations chosen to investigate in more detail are listed in Table 1 below. These specific SPS were identified from a model created by Ian Scott at the Water Corporation which identified these SPS as experiencing excessive flow to normal operation during wet weather events. Two wet weather events (5/04/2008 and 31/05/2008) were chosen for this analysis from observations of the collected rainfall data. These events are compared to dry weather data, which is an average of a few dry days (dry days generally have similar flows).

Investigated Sewerage Pumping Stations	
Beenyup Catchment Area	Subiaco Catchment Area
Flora St	John St
Charles St	Johnson Rd
Stirling Cres	Kelvin St
Elvire St	Deeley St
Riverbank Blvd	Claisebrook
Helmsedale Rd	Gloucester Park
Bridge St	Causeway

Table 1 Specific Sewerage Pumping Stations selected for detailed analysis within the Beenyup and Subiaco Catchment areas.

3. Results and Discussion

The first stage of this project, which involved the initial project scoping, utilised rainfall data and WWTP inflow information to create a macro view of the three possible catchment areas to consider (Beenyup, Subiaco and Woodman Point). The data was plotted in Microsoft Excel to give a visual indication of the trends that were occurring throughout the year and gave a basic indication whether the inflow volumes observed at the WWTPs follow the rainfall trends recorded by the Bureau of Meteorology. An example of these graphs and trends is shown in Figure 1. This figure shows the daily inflow information of the two selected major WWTPs (Beenyup and Subiaco) and the corresponding rainfall data recorded in the area. In the initial comparisons, Beenyup and Woodman Point followed a similar trend, while the Subiaco inflow remained more constant throughout the year. This observation was generally consistent over the six years (2004-2009) of data that were graphed. The Beenyup and Subiaco catchment areas were chosen to investigate in more detail as the difference in their trends in relation to the rainfall data recorded would hopefully provide results that will give good comparisons regarding the possibilities of inflow and infiltration occurring.

Some observations that were made from the graphs such as seen in Figure 1 below provided initial speculations to whether inflow and infiltration were occurring at the WWTPs. The Subiaco inflow trend shown in Figure 1 generally follows the Subiaco rainfall data, however the inflow doesn't appear to be very sensitive to the rainfall as the peaks are still relatively small in comparison to those observed in the Beenyup catchment. The Beenyup WWTP inflow trend appears to be more sensitive to the rainfall recorded. The first major inflow peak recorded in April at Beenyup occurs after a small lag in time after a rainfall period. This shows the reaction of the WWTP to the increased water in the network and this could suggest

inflow is occurring. The second set of inflow peaks recorded in July/August show excess flows of water into the WWTP but there is no significant rainfall recorded. This could suggest infiltration occurring rather than inflow from rainfall. A more detailed analysis will expand on these initial observations.

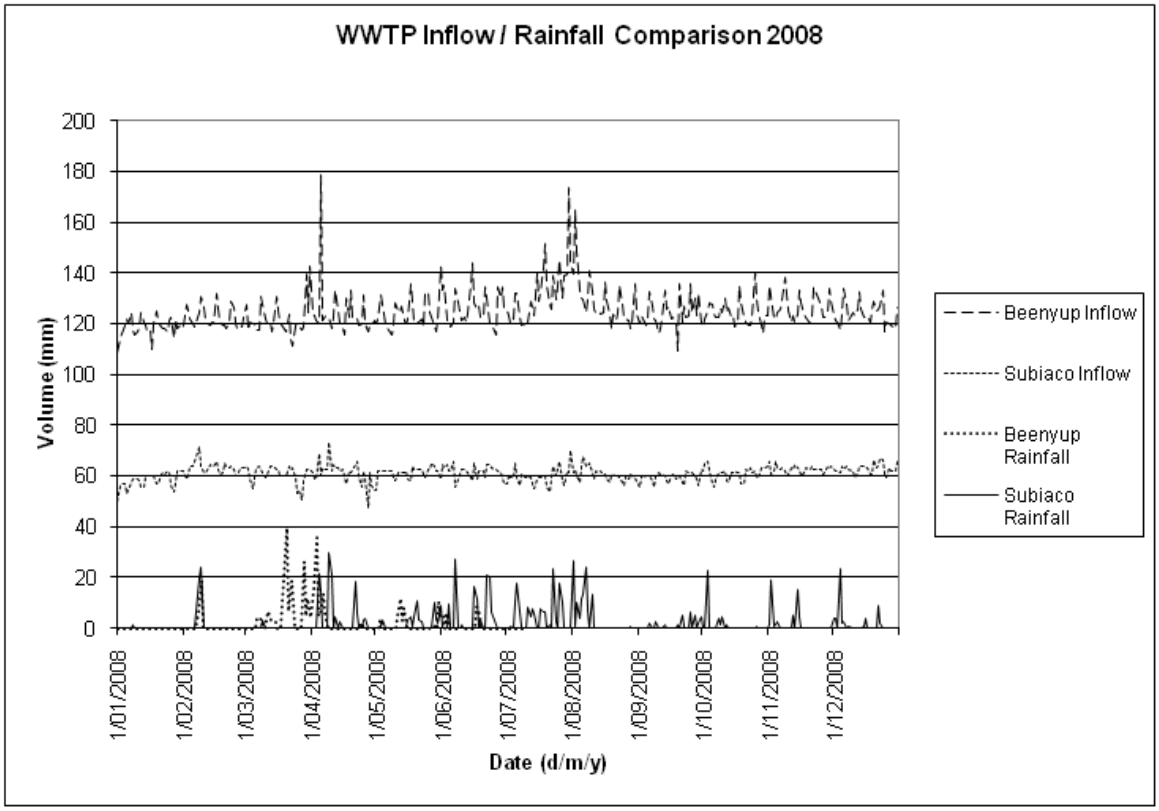

Figure 1 Daily inflow data for the Beenyup, Subiaco and Woodman Point WWTPs with the corresponding rainfall trends.

The next stage of the project involved identifying specific wet periods to investigate to determine the effect of rainfall on inflow and infiltration within the Beenyup and Subiaco catchment areas. Two specific wet days were identified from the rainfall data collected and through recommendations from Richard Forrest and Ian Scott at the Water Corporation. These days are 5/4/2008 and 31/5/2008. These wet days will be compared to information collected during a dry period, which is taken as the average flow for a number of dry days. Taking the average provides more consistency in the final results.

To refine the research on this project, specific SPSs were chosen to provide a more detailed analysis of the collected data. The pumping stations were selected due to their high flows observed on the two wet days and are listed in section 2.4 Table 1.

The detailed analysis of these SPS is not yet complete and as such, the results cannot be published. A GIS mapping system has been set up by the Water Corporation which will assist in identifying the possible causes of inflow and infiltration (if any is observed at the selected pumping stations). The mapping system is interactive and shows the catchment area boundaries, surface geology, type/material of the piping and the age of the piping and infrastructure. An example of the system (showing the age of the pipes) is shown in Figure 2.

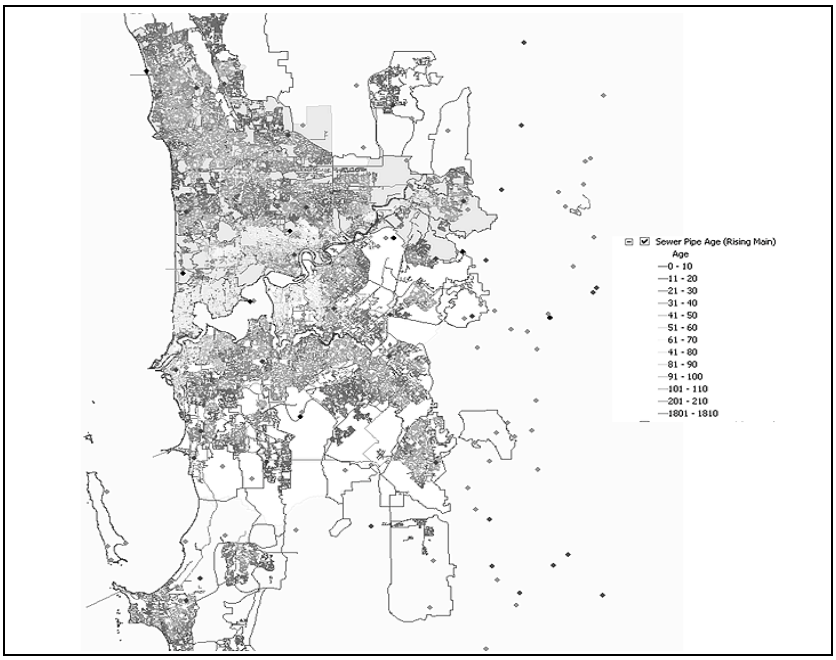

Figure 2 GIS schematic showing the age of the piping networks within the Perth region.

4. Conclusions and Future Work

At this stage of the project, it appears that there could be inflow into the wastewater system that is associated with periods of heavy rainfall. This is suggested by the response of the WWTPs to the extra inflow data recorded after a rainfall period as discussed in section 3 and outlined in Figure 1. This observation will be further tested once the analysis on the specified pumping stations within the Beenyup and Subiaco catchment areas has been completed.

The project is currently ongoing, but some significant results are expected to emerge within the next couple of weeks. The main objectives should be reached before the project closeout and recommendations will be made from these results for future research in more specific areas regarding inflow and infiltration within the wastewater system.

5. Acknowledgements

In addition to the project supervisors named on the front page of this report, I would like to thank Gus Formato and Ian Scott from the Water Corporation for their contribution and assistance on the project.

6. References

CCDAustralia (1998). Infiltration to Sewers in Perth, The Water Corporation. Part 1 - Study.

GHD (2004). South-West Sewer Infiltration and Inflow Study (Group 2), The Water Corporation. Stage 1: Desktop Investigation.

SKM (2006). Sewer Infiltration and Inflow in Regional Towns, Western Australia. The Water Corporation. Rev 4.