# Decision Support Tool for the Maintenance and Renewal of Sewer Access Chambers

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**Abstract**

*Water Corporation maintains over 200,000 access chambers in its wastewater network. High concentrations of hydrogen sulphide ($H_2S$) gas in sewers have resulted in accelerated corrosion of access chambers, costing ~$15 million annually. Potential cost-effective improvements to the current asset renewal process were investigated, including the feasibility of deleting redundant sewer access chambers and magnesium hydroxide (MgOH) dosing to increase access chamber service life.*

*A criterion to identify redundant access chambers was constructed from Water Corporation standards. Asset data was then extracted from Water Corporation's geographical information system database and analysed using the criterion, which identified 5877 access chambers. A cost analysis, conducted using data from Water Corporation's asset class management plan, found $32.3 million in potential savings over 10 years. 41,361, access chambers were identified using lenient criteria, saving potentially $187 million in 10 years.*

*Access chamber $H_2S$ concentrations a MgOH dosing trial data were compared with simulations conducted in Sewex. 29 dosing configurations utilising 14 different dosing locations were simulated. Access chamber corrosion rates and expected service lives were then calculated using SCORe $H_2S$ corrosion data. Results indicate dosing only increases service life for a small proportion of access chambers. Further cost and benefits analysis should be conducted.*

# 1. Introduction

Water Corporation operates most of Western Australia's wastewater conveyance network. The wastewater or sewer network consists of gravity sewers, and pressure mains, which collect and transport wastewater to treatment plants. Water Corporation needs to constantly inspect and maintain sewer assets to ensure a reliable level of service is delivered. Sewer maintenance is done via sewer access chambers which provide sewer access to working personnel and maintenance equipment (Water Corporation, 2023a). Sewer access chambers generally consist of channeled base, a cylindrical or rectangular shaft with a ladder or step irons, and removable cover. The majority are constructed from concrete. Water Corporation maintains over 200,000 access chambers interspersed evenly across the wastewater network such that access to every part of the sewer is achievable (Water Corporation, 2023a).

Water Corporation's wastewater network operates under a closed system, where sewers are sealed with no ventilation (Water Corporation, 2016). The wastewater network is also expansive with high wastewater retention times (Water Corporation, 2023a). This has resulted in the increased build-up of hydrogen sulphide gas ($H_2S$) in the wastewater network (SUEZ Water, 2019). This poses a significant health risk to workers and causes accelerated corrosion of assets. The renewal and maintenance of sewer access chambers currently contributes a substantial amount of Water Corporation's operating expenditures, costing an estimated $15 million annually. As part of their asset management plan to operate in a safe, reliable, and cost-effective manner, Water Corporation is invested in increasing the service life of access chambers in its sewer network and improving the current access chamber renewals process to reduce long term financial costs and increase safety (Water Corporation, 2023b).

## 1.1 Access Chamber Asset Management

Due to the high $H_2S$ levels, the expected service life of Water Corporation concrete access chambers is only 50 years, significantly lower than the Australian standard of 100 years. (Water Corporation, 2023a). The actual service life can vary significantly depending on environmental conditions. Water Corporation's current sewer maintenance and inspection strategy operates under a risk-based approach, to be cost effective whilst preventing premature failure. Routine inspections are conducted every 5-10 years, to estimate the remaining service life. Nearing the estimated end of service life formal inspections are conducted, before they are finally refurbished. (Water Corporation, 2023a). The refurbishment method currently used by Water Corporation is the MC Roberts 10mm PVC lining. The process consists of replacing the exiting benching and pipes with a prefabricated PVC channel. A PVC sheet is then lowered and secured to the walls using grout. The resultant lining is gas tight and protects the concrete walls from $H_2S$ exposure, preventing corrosion.

Chemical dosing is a common method to reduce $H_2S$ and other hazardous gases in sewers. Currently Water Corporation utilises magnesium hydroxide (MgOH) dosing to reduce methane levels in a regional sewer distict, following an incident resulting in a gaseous explosion, and is trialing its use in another regional sewer district to reduce $H_2S$ gas concentrations (SUEZ Water, 2019). MgOH reduces $H_2S$ levels by increasing the pH of wastewater, which keeps the $H_2S$ in aqueous form.

## 1.2 Project Objectives

Objective 1 is to investigate the feasibility of deleting sewer access chambers when they reach the end of their service life. Deleting access chambers is cheaper than the current refurbishment method and eliminates the need for further refurbishments and inspection. Implementation of this strategy could significantly reduce expenditure as approximately 90,000 access chambers are approaching their expected design life in the next 20 years.

Objective 2 is to investigate the cost effectiveness of a regional MgOH chemical dosing trial. Dosing is expected to reduce $H_2S$ gas levels and extend the service life of access chambers, reducing renewal costs. The aim is to the determine cost-benefits from extending service life, which will contribute to assessing the overall viability, cost and benefits to Water Corporation sewers. If deemed beneficial, Water Corporation could continue to dose MgOH in the trial location and potentially expand to other sewer networks to improve safety and cost-effectiveness.

# 2. Process

## 2.1 Access Chamber Deletion

Assessing the feasibility of deleting access chambers involved identifying redundant sewer access chambers that, when deleted, standards were still met to allow for a reliable level of service. A criterion was developed to filter for redundant access chambers. Subsequently a cost analysis was conducted to determine the cost benefits.

The criterion was developed based on Water Corporation design standards for gravity sewers (Water Corporation, 2023b). Access chambers were filtered if located at an intersection or drop, or adjacent pipes had different pipe diameters or stiffness. A strict and lenient criterion was used to filter access chambers for changes in pipe direction and grade, and maximum distance between upstream and downstream access chambers. The criterion is shown in Table 1 below.

| | Direction | Grade | Spacing Dn < 300mm | Spacing Dn > 300mm |
|---|---|---|---|---|
| Strict | 1.7° | 1° | 100 m | 150 m |
| Lenient | 22.5° | 3° | 150 m | 200 m |

**Table 1** Strict and lenient limits for direction, grade and spacing for deletion of sewer access chambers.

Access chamber and pipe data was extracted from the Water Corporation geographical database using ArcGIS. Pipe and access chamber data sets were combined using a spatial join then extracted to Excel. The criterion was then applied, resulting in 8 data sets. “S” meaning strict limits and “L” meaning lenient limits. (e.g., “SLS” meaning strict limits to direction and spacing with a lenient limit to grade). Access chambers for each criterion were then mapped back onto ArcGIS to provide a visual identifier for redundant access chambers.

Costing data for refurbishment and inspection was extracted from Water Corporation’s asset class management plan on Power BI. The standard refurbishment costs increased linearly with access chamber depth, with 2 equations depending on the diameter of the access chamber pipes. The inspection cost was set to $1,000 per access chamber. The ArcGIS data was utilised to obtain the age, depth, and diameter of each access chamber to determine the refurbishment cost. It was assumed deletion costs were $20,000 per access chamber, with inspections occurring every 10 years. The NPV cost for refurbishment and deletion were then calculated and compared over 10, 25, 50 and 100 years.

## 2.2. Trial Magnesium Hydroxide Dosing

Assessing the effectiveness of MgOH dosing was done by comparing trial data from a physical MgOH dosing trial with Sewex simulations. Sewex is a computer modelling tool which simulates the physical, chemical, and biological activity in sewers. The tool can model the $H_2S$ profile throughout the sewer network and predict the effect of chemical dosing at different locations. 3 Sewex models were run with the same location and dosage concentrations as the physical dosing trial. The $H_2S$ gas concentration measured in access chambers during the physical trial was compared with the simulated values to obtain a correction factor for the Sewex models.

Subsequent models were run with varied dosage rates and dosing locations. The simulated $H_2S$ levels for each access chamber for each simulation were then extracted to Excel and corrected. The corrosion rate and expected service life based on the simulated $H_2S$ was then calculated using the results from the SCORe project on sewer corrosion (Advanced Water Management Centre, 2015).

Using asset age and refurbishment cost data obtained from the Water Corporation geographical database and asset class management plan, and the predicted service life determined by the Sewex models. A cost analysis will be conducted to determine the overall renewal and maintenance costs for the baseline case, and potential chemical dosing cases for the trial sewer network. The potential cost benefits of increased service life will be calculated for each case and compared with the respective dosing equipment and chemical costs for each case to determine the overall cost effectiveness.

# 3. Results and Discussion

## 3.1 Access Chamber Deletion

Filtering for intersections, drops and, adjacent pipes diameters and stiffness, identified 94,000 access chambers. 5,877 access chambers were identified after using the "SSS" criterion. The identified access chambers were mapped onto ArcGIS, shown in Figure 1. The cost of deleting access chambers was found to be significanlty lower than refurbishment costs. A significant reduction to overall inspection costs were also found. The cost comparions are displayed in Table 2. Expanding the range of access chambers using the "LLL" criterion identified 41,361 access chambers with total savings of $187 million and $547 million over the next 10 and 100 years repsectively.

| | Refurbishment | | Deletion | | Total |
|---|---|---|---|---|---|
| **Years** | **Refurbishment** | **Inspection** | **Deletion** | **Inspection** | **Savings** |
| 10 | $65.7 | $4.73 | $33.4 | $4.73 | $32.3 |
| 25 | $101 | $7.56 | $51.6 | $5.33 | $51.9 |
| 50 | $117 | $10.1 | $59.5 | $5.69 | $62.0 |
| 100 | $133 | $11.4 | $59.5 | $5.74 | $79.3 |

**Table 2** Refurbishment and deletion NPV cost comparison of access chambers identified using "SSS' criterion (in millions of dollars)

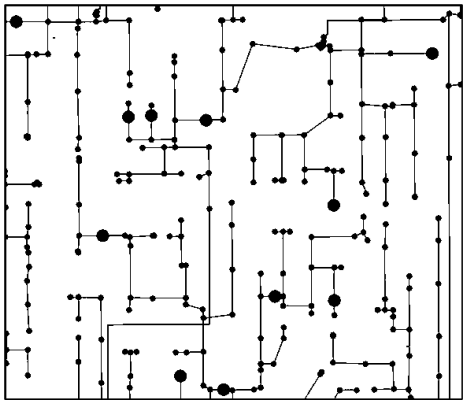

**Figure 1** ArcGIS map of redundant access chamber identified using "SSS" criterion.

Implementing the deletion of redundant access chambers offers a significant cost savings. The cost savings are calculated using the expected service life of access chambers, and standard refurbishment costs. These values can vary significantly depending on the specific location and environmental conditions of each individual access chamber. While results from this project can be used to help identify redudant access chambers, it is recommended that results from detailed onsite access chamber inspection be used to determine costing and ensure standards are met due to the limits and unreliability of the data used.

## 3.2 Trial Magnesium Hydroxide Dosing

29 chemical dosing configurations utilising 14 pump stations were simulated in Sewex. The 14 largest pump stations were selected to ensure the availability of sufficient infrastructure to install the chemical dosing units. Dosing amounts varied from 250 kg to 750 kg of MgOH (Measured in kg of $Mg(OH)_2$). Configurations dosing at both single and multiple pump stations were simulated. “Nth PS” cases simulated dosage split between 4 pump stations connected to the north gravity main upstream of the wastewater treatment plant. “Sth PS” cases were 4 south pump stations respectively and “Nth & Sth” cases simulated dosing split between all 8. The recommended dosing locations for reducing $H_2S$ and increasing service life, based on the Sewex models, are displayed in Figures 2 and 3.

The results from the Sewex simulations indicate that chemical dosing has minimal impact on decreasing $H_2S$ levels and increasing service life when considering the whole sewer network. Chemical dosing does significantly decrease $H_2S$ levels, however it is limited to access chambers directly downstream of the dosing location. The trial sewer network is relatively short, meaning dosing only affects a small number of access chambers. Although the number of access chambers affected is small, a significant proportion of the high-risk chambers show an increase to their expected service life. Dosing at multiple locations was found to be the most effective strategy to reduce $H_2S$ levels. At some point, increased dosage rate was found to have diminishing returns. The cost analysis is not currently complete, however the preliminary results suggest that chemical dosing will not be cost effective when purely considering the cost benefits of extending access chamber service life.

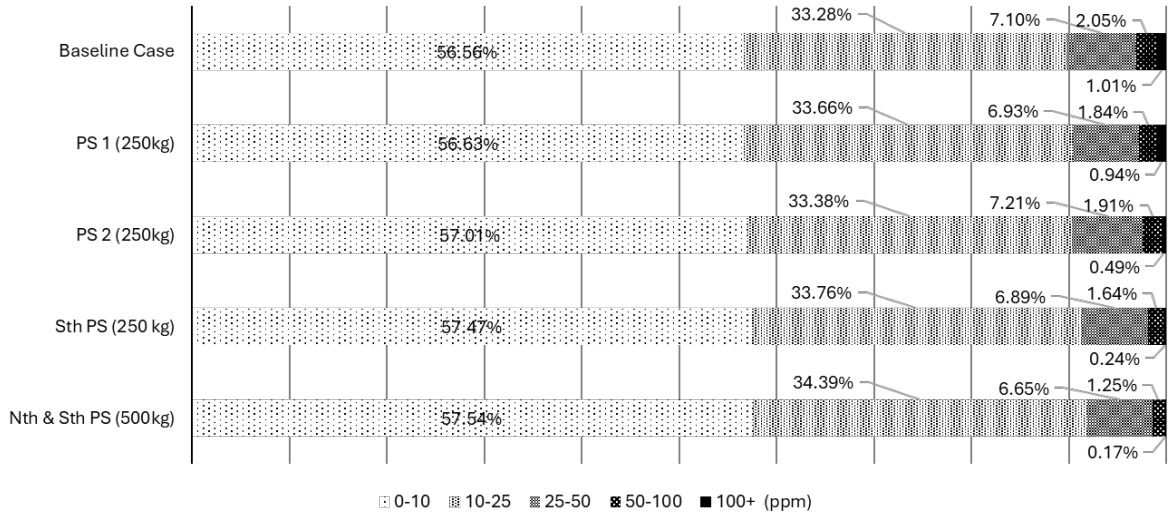


**Figure 2** Percentage distribution of $H_2S$ gas concentration in access chambers in trial sewer network based on Sewex models.

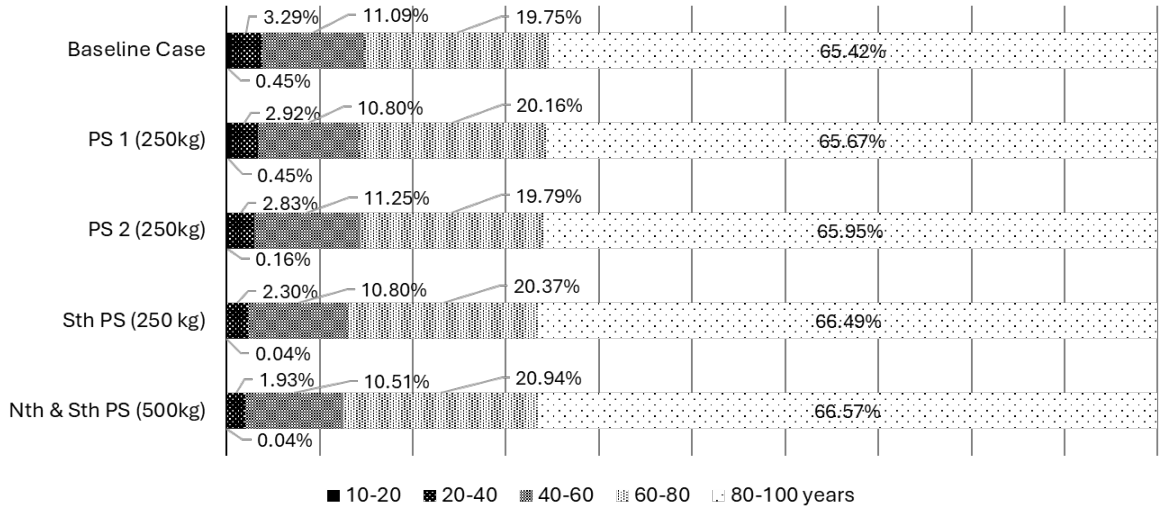


**Figure 3** Percentage distribution of expected service life of access chambers in trial sewer network based on Sewex models.

# 4. Conclusions and Future Work

Deleting redundant end of service access chambers has significant potential cost benefits. Under current standards, 5877 access chambers were identified, with total savings of $32.3 million over 10 years. MgOH dosing was found to be effective at increasing the service life of high-risk access chambers. However, MgOH dosing is not expected to be cost-effective, as only a small percentage of access chambers in the network have improved service lives.

The cost analysis for MgOH dosing needs to be completed to determine the cost benefits from increased asset life and expenditure required to dose MgOH. Potential future works include a wider scope cost and benefits analysis for chemical dosing, considering factors such as safety and downstream effects to wastewater treatment. A study to model the $H_2S$ distribution in access chambers could allow for more accurate corrosion rate estimations. Other corrosion reduction methods such as ventilation should also be investigated.

# 5. Acknowledgements

I would like to express my sincere gratitude to Kate Bowker for mentoring me at Water Corporation. To Katherine Cochrane for her chemical dosing expertise and providing access to Sewex and trial data. As well as to the Water Corporation Research and Development Program for the funding and opportunity to work on this project at Water Corporation.

# 6. References

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