THE WASTEWATER SAFETY PLAN – PILOTING A QUALITY MANAGEMENT DOCUMENT

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ABSTRACT (500 WORDS MAXIMUM)

There have been several regulatory initiatives in the wake of the Havelock North Inquiry in 2017. Notable initiatives include the New Zealand Three Waters review and the establishment of Taumata Arowai as an independent regulator operating at a national level and the New Zealand Three Waters Review, which began in mid-2017. Two relatively immediate modifications made to the drinking-water industry were a revision of the Drinking-Water Standards of New Zealand and the Water Safety Plan (WSP) framework.

With the increased focus on understanding the current regulatory practices and standards as part of the three waters review, Matamata-Piako District Council (MPDC) and Lutra identified potential value in developing the wastewater equivalent of a WSP. The team decided to pilot the development of a Wastewater Safety Plan (WWSP) for the Te Aroha wastewater network. The goals of the pilot were to identify whether there is value in developing such a quality management document, increase understanding of environmental outcomes through wastewater treatment, improve industry consistency and versatility by streamlining quality management approached across water and wastewater, and provide thought leadership and experience to the industry.

This paper describes pilot programme including the background, process, and outcomes of the planning, development, and implementation of the WWSP.

KEYWORDS

Wastewater, Planning, Compliance, Operations, Quality Management

PRESENTER PROFILE

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1 INTRODUCTION

The Havelock North Campylobacter Outbreak in 2017 exposed several weaknesses across the New Zealand water industry. The industry response has resulted in several approaches to improvement and reform, most notably and increased scrutiny and emphasis on drinking-water treatment, quality, and management. Short term reform included revisions to the Drinking Water Standards of New

Zealand and to the Water Safety Plan (WSP) including a renewed emphasis on ensuring these are maintained to a satisfactory quality and kept current. In concert with these reforms, a National Three Waters Review was initiated by the Department of Internal Affairs with the intent to evaluate the current state of the three waters industry. It established a suitable strategy to move forward with improving three waters infrastructure, operations, and service delivery for all of New Zealand. One of the key findings of the report, National Stocktake of Municipal Wastewater Treatment Plants, is that the approach to regulation of WWTP's (monitoring, reporting, and enforcement) by regional councils across New Zealand is very inconsistent (GHD and Boffa Miskell, 2019).

The proposed strategy of the national regulator, Taumata Arowai, is to take a phased approach for improving environmental outcomes, first focusing on understanding of environmental performance of wastewater and stormwater service suppliers. This phase is to be followed by the establishment and adoption of national good practice guidelines across the wastewater and stormwater industries.

With all of these developments occurring simultaneously, MPDC and Lutra postulated that there would be value in developing the wastewater equivalent of a WSP, which councils and treatment service suppliers could use to assume a more proactive approach rather than reactive to wastewater treatment.

Development of a Wastewater Safety Plan (WWSP) aligning similarly with a WSP would likely provide the following benefits:

- **Improve environmental outcomes** – The process of preparing a WSP typically increases understanding and awareness for water suppliers and reduces risk around maintaining drinking water standards compliance. It is assumed that the preparation of a WWSP will provide similar benefits for maintaining resource consent compliance, which will result in improved environmental outcomes.
- **Improve industry consistency and versatility** – The alignment of documents, terminology, risk mitigation strategy, etc. allows for a more versatile and agile workforce across drinking-water, wastewater, and stormwater treatment.
- **Provide industry thought leadership and experience** – By testing the first iteration of a quality management system and establishing outcomes and feedback, the industry is better poised to develop a manageable and useful national approach with lower potential for rework.

It was decided that MPDC and Lutra would pilot the design, development and implementation of a WWSP for one of the council's wastewater networks, including both reticulation and treatment plants. The pilot team selected Te Aroha for the trial as it was considered to have a well operated treatment plant, and its performance and limitations were well understood by both MPDC and Lutra.

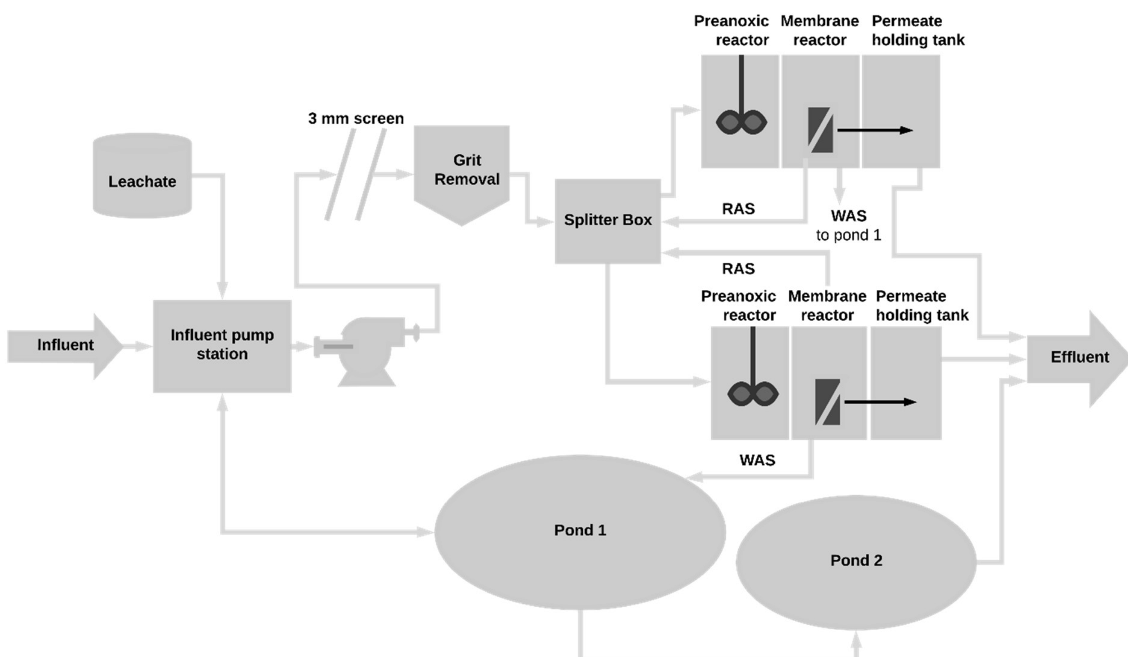
2 TE AROHA WASTEWATER RETICULATION AND TREATMENT PLANT

The town of Te Aroha has a population of approximately 4,250 people and is located in the north east of Matamata-Piako District Council. The wastewater reticulation network is a sanitary sewer with very little trade waste aside from local cafes and small businesses. The network is prone to suffer from a high degree of infiltration and inflow during wet weather and can experience overflows from manholes and pump stations on occasion in extreme weather events.

The wastewater treatment plant was originally built in the 1970's as a two-pond oxidation system. It was upgraded in 2006 to include a flat sheet MBR process utilizing the existing oxidation ponds for influent equalization. As a result of the large equalization volume, the MBR is operated as a constant flux system as the oxidation pond manages diurnal flow and pollutant concentration patterns. 10-20 m^3/d of landfill leachate is delivered to site, stored in a bulk tank, and bled into the MBR influent pump station via a manual valve.

The treatment plant includes a package headworks system utilizing a 3mm spiral sieve screen and horizontal flow grit removal system before flowing into an MBR splitter box. The MBR system consists of two process trains with each train including a swing zone, which allows for anoxic or aerobic operation, followed by a membrane tank. A plant schematic is provided in Figure 1

Figure 1: Schematic of Te Aroha WWTP



The resource consent obtained in 2015 allows for the discharge of up to 7,000 m^3/d of treated effluent and establishes effluent water quality limits as defined in Table 1. In addition to these conditions, there are conditions which define seasonal limits on effluent Total Nitrogen (TN) pollutant load and an annual average effluent Total Phosphorus (TP) pollutant load.

Table 1: Te Aroha WWTP Effluent Discharge Resource Consent Conditions

Parameter	**Unit**	**Median**	**90^{th} Percentile**
Unfiltered $CBOD_5$ ($ufCBOD_5$)	mg/L	5	10
Total Suspended Solids (TSS)	mg/L	7	10
Total Ammoniacal Nitrogen (TAN)	mg/L	2	4
Escherichia coli (*E. coli*)	MPN / 100 mL	10	126

A wet weather discharge consent condition allows for the direct discharge of partially treated wastewater from the pond system provided that the Waihou river flow exceeds 33.83 m^3/s. The discharge is executed manually with a pond discharge valve. Use of this condition requires additional water quality monitoring.

Aside from the landfill leachate bleed and a wet weather discharge valve, the treatment plant is fully automated. Due to the effluent TN limit, the swing zone is operated almost exclusively as an anoxic zone. Due to the high DO concentration recycled in the RAS to the anoxic zone, meeting the TN limit can be challenging depending on the seasonal limit. The means for meeting the E. coli limits is provided by the membrane filtration. The flat sheet membrane panels pore size is small enough to prevent E. coli passing through, provided that the integrity of the membrane panels is not compromised.

3 WWSP PILOT DESIGN

The development of the WWSP was executed through a series of workshops similar to a WSP. The development was planned over the following stages:

- Development of a Multi-Criteria Analysis (MCA) to quantify organizational benefits acquired through the preparation of the WWSP;
- Development of WWSP framework;
- WWSP Population - Data review and gap analysis;
- Risk assessment workshop followed by improvement plan;
- Final MCA and outcomes;

4 PILOT EXECUTION

4.1 MCA DEVELOPMENT

Ideally, the benefit and impact of a WWSP would be tracked over the course of several years, and any change in environmental outcomes (e.g. frequency and severity of non-compliances) are monitored and compared with historical performance. While it is the intention of the team to perform this assessment, an MCA was used as a tool to quantify immediate short-term benefit.

The MCA criteria were formulated and agreed upon by the pilot team with the intention that each criterion would be given a score from 1-10 prior to developing the WWSP and following the completion of the WWSP. This approach would provide a crude quantification of short-term organizational benefit. The agreed upon criteria including supplementary descriptions are summarized in Table 2.

Table 2: Te Aroha WWTP Effluent Discharge Resource Consent

Criteria	Description
Commitment	Organisation commitment to the environment and public health including outcomes
Awareness	Organisational awareness of wastewater treatment as it pertains to the Te Aroha community and council vision, policy, and stakeholders
Competency and Knowledge Base	Operational and compliance knowledge, experience, and technical expertise
Efficiency and Effectiveness	Organisational efficiency and effectiveness when completing objectives and performing failure management tasks.
Consistency and Sustainability	Organisational approach to maintaining consistency and sustainability towards achieving and maintaining compliance
Transparency and Auditability	Documentation and operations transparency and traceability
Completeness	The degree of overall thoroughness and comprehensiveness of procedures, documentation, etc.

4.2 DEVELOPMENT OF WWSP FRAMEWORK

The proposed WWSP framework aligns with the format and order as defined in the Ministry of Health Handbook for Preparing a Water Safety Plan 2019. Much of the existing framework traverses from drinking-water quality management to wastewater quality management, however, there were several exceptions and adjustments made. These include the following:

- Wastewater quality assessment to include assessment of infiltration and inflow, trade waste, domestic waste, raw influent, and final effluent performance;
- WWTP capacity assessment in addition to a plant description;
- Documented PPE and hygiene policy;
- Sludge/biosolids management plan.

A comparison of the WSP framework (MoH, 2019) and the WWSP framework is presented in Figure 2.

Figure 2: Comparison of WSP (MoH, 2019) and Proposed WWSP Frameworks

WSP Preparation

Components		Subcomponents
1. Commitment to drinking-water quality management	1.1	Relationship of WSP to organisational policy and strategy
	1.2	Engaging stakeholders
	1.3	Engaging community
2. Assessment of the drinking-water supply system	2.1	Water supply system description and analysis
	2.2	Assessment of water quality data
	2.3	Hazards & hazardous event identification & risk assessment
3. Preventative measures for drinking-water quality management	3.1	Assessment of existing preventative measures and multiple barriers
	3.2	Identification of additional preventative measures
4. Operational procedures	4.1	Operational procedures
	4.2	Operational monitoring and inspection
	4.3	Critical Control points
	4.4	Correcting actions
5. Verification monitoring programme	5.1	Drinking-water quality management
	5.2	Consumer satisfaction
	5.3	Short-term evaluation results
6. Improvement plan	6.1	Drinking-water quality management improvement plan
7. Management of incidents and emergencies	7.1	Incident and emergency response plan
8. Documenting and reporting	8.1	Management of documentation and records
	8.2	Reporting
9. Investigations	9.1	Investigative studies
	9.2	Validation of equipment, processes and practice
10. Oversight review and continual improvement	10.1	Long-term evaluation of results
	10.2	Audit of drinking-water quality management
	10.3	Review by senior leadership

WWSP Preparation

Components		Subcomponents
1. Commitment to wastewater quality management	1.1	Relationship of WWSP to organisational policy and strategy
	1.2	Engaging stakeholders
	1.3	Engaging community
2. Assessment of wastewater treatment system	2.1	Wastewater treatment system description and analysis
	2.2	Assessment of wastewater quality data
	2.3	WWTP Capacity assessment
	2.4	Hazards and hazardous event identification and risk assessment
3. Preventative measures for wastewater quality management	3.1	Assessment of existing preventative measures
	3.2	Identification of additional preventative measures
4. Operational procedures	4.1	Operational procedures
	4.2	Operational monitoring and inspection
	4.3	Critical Control points
	4.4	Correcting actions
	4.5	Personal Protective Equipment Policy
	4.6	Hygiene Policy
	4.7	Sludge/biosolids management plan
5. Verification monitoring programme	5.1	Treated effluent quality monitoring
	5.2	Community satisfaction
	5.3	Short-term evaluation reports
6. Improvement plan	6.1	Wastewater quality management improvement plan
7. Management of incidents and emergencies	7.1	Incident and emergency response plan
8. Documenting and reporting	8.1	Management of documentation and records
	8.2	Reporting
9. Investigations	9.1	Investigative studies
	9.2	Validation of equipment, processes and practice
10. Oversight review and continual improvment	10.1	Long-term evaluation of results
	10.2	Audit of wastewater quality management
	10.3	Review by senior leadership

The purpose and function of these deviations and additions are explained in the following sections.

4.2.1 WASTEWATER QUALITY ASSESSMENT

Service suppliers and councils should understand the raw wastewater mass balance as it enters the reticulation network and eventually the WWTP. This includes infiltration and inflow, tradewaste, domestic wastewater, and any additional tankered waste such as leachate or septage. Additionally, the final effluent quality should be well understood under various operating conditions. This is similar to the expectations of a WSP, but the transition to wastewater requires a review of any and all waste streams, trade waste monitoring programmes, and infiltration and inflow monitoring/reduction programmes.

4.2.2 WWTP CAPACITY ASSESSMENT

The requirement of a capacity assessment is a relatively significant departure from the WSP requirements but is critical. Unlike WTP's, WWTP's cannot demonstrate compliance in real time through online instrumentation. Compliance in a WWTP is demonstrated through sampling which may take several days for the result to be available. As a result, it is critical to understand both the hydraulic and biological treatment capacity (considering solids retention time, aeration requirements and capacity, etc. An understanding of a WWTP's theoretical capacity and true capacity if possible is important data, which can signal to service suppliers when a treatment plan is approaching an operational state where it may become non-compliant. This is often only anecdotally understood anecdotally by an operations team. Without validating and documenting the plant capacities, the knowledge and information is of limited value and use to a council or service supplier.

Depending on the WWTP, an appropriate capacity assessment can be simple and based on rules of thumb such as an oxidation pond system. Alternatively, the capacity assessment can be relatively complex and require a full mass balance, such as for an activated sludge plant with effluent nutrient limits and biosolids treatment with recycle streams. In either case, the capacity assessment should be reviewed on a regular basis, and updated as necessary, to maintain consistency with any treatment plant equipment, process, and/or control changes.

4.2.3 PPE AND HYGEINE POLICIES

A PPE policy is a self-explanatory requirement, and its inclusion in the WWSP framework is the result of the workers high risk of exposure to biohazardous materials. This can lead to a certain degree of complacency depending on the vigilance of the service supplier. Ensuring that a PPE policy is in place, regularly reviewed, and kept current is considered best practice and serves as an important tool to avoid negative outcomes.

A hygiene policy is important to maintain as it helps protect the general public from biohazards that may be transmitted away from the treatment environment by Operations staff. The policy should address how employees prevent carrying microbiological contaminants from the wastewater treatment environment to the general public through PPE, handwashing, showering, laundry facilities, etc. This is particularly important in councils where drinking-water and wastewater utilities are services provided by the same operations group. A hygiene policy aids in preventing cross-contamination from wastewater treatment environments to drinking-water treatment environments.

4.2.4 SLUDGE AND BIOSOLIDS MANAGEMENT PLAN

Sludge and biosolids treatment and disposal are a common pinchpoint for WWTP's across New Zealand. This pinchpoint often has a significant impact on the ability of WWTP's, service suppliers, and councils to maintain resource consent compliance for both final effluent quality and odour.

A management plan for sludge and biosolids should provide a preventative approach to maintaining treatment and disposal. It should include:

- Details of performance monitoring;
- Identification of potential upset/failure and long-term effect to the WWTP;

- Contingency planning;
- Assessment of the potential costs incurred in the event that a contingency must be put into action.

Scenarios which were specifically discussed in the workshop are presented in Table 3 below:

Table 3: Sludge and biosolids management plan scenarios discussed during WWSP framework development workshop

WWTP	Upset	Preventative Approach	Reactive Approach
WWTP A Oxidation Ponds with UV disinfection	Excessive, long-term sludge accumulation withing pond resulting in non-compliance and odour generation	Regularly scheduled sludge surveys Pond desludging costs periodically evaluated and budgeted for in LTP Appropriate scheduling of pond desludging while maintaining compliance	Sludge survey performed due to non-compliances and odour complaints Desludging cost not appropriately budgeted for in LTP resulting in delay Extended period of non-compliance until desludging can be performed
WWTP B Activated sludge with dewatered cake to landfill	Change in landfill management/ ownership results in disruption of agreement for sludge disposal	Alternative disposal sites identified, and cost implications evaluated in MP Limited or no disruption in sludge disposal	Rapid options assessment required following service disruption Limited contingencies due to shortened available planning time Higher short term cost for disposal until long term solution identified Potential period of non-compliance due to high TSS caused by excessively high SRT in AS basin
WWTP C Activated sludge with dewatering and biosolids drying to produce AA biosolids	Critical mechanical equipment failure in biosolids dryer	Disposal site for dewatered cake identified Organisations previously identified for transport Change in operational costs previously evaluated Like increase in cost due to increased transport and disposal costs	Rapid options assessment required following service disruption Limited contingencies due to shortened available planning time Higher short term cost for disposal until long term solution identified Potential period of non-compliance due to high TSS caused by excessive SRT in AS basin

4.3 WWSP POPULATION - DATA REVIEW AND GAP ANALSYSIS

The project team identified and reviewed available documents and policies following the establishment of the WWSP framework, and the following observations were made relatively early in the process:

- Most required information that was not directly related to treatment or monitoring was available in some form through a variety of council owned documents, but they are either not familiar or not readily available to most treatment staff. Therefore, population of the WWSP would not be an onerous process as the information would only require adjustment or repurposing.
- Most required information that was directly related to treatment or monitoring was located in the Operations and Maintenance (O&M) manual, but it was not organized in such a way to make it a user-friendly document.
- There was considerable overlap between what would be considered critical control points (CCP's) and various standard operating procedures (SOP's).

The following gaps were identified during the data review process:

- While MBR influent was monitored via spot sample at a monthly interval, a plant influent mass balance had not been fully prepared. This is particularly important for Te Aroha WWTP as the landfill leachate can contribute a significant nitrogen load to the plant. The impact towards effluent TN was broadly understood but had not been fully evaluated via wastewater mass balance.
- A capacity assessment was not available for the WWTP. The hydraulic capacity of the MBR was understood anecdotally and had even undergone further optimization trials the previous summer, but the biological capacity to meet effluent nutrient limits and corresponding operational settings such as SRT and MLSS had not been fully evaluated.

To fill these specific gaps, a review of the WWTP performance including influent water quality assessment was undertaken using historical plant data and a steady state Biowin model. The findings of the assessment provided clarity into treatment and compliance risks including the following:

- The spot sampling regime was ineffective in capturing representative samples into the WWTP.
- Compliance with effluent nutrient loads is more impacted by high effluent flow rate caused by inflow and infiltration during wet weather events. The risk to compliance can be mitigated by reducing the severity of the inflow and infiltration or improving the management of equalization volumes in the oxidation ponds.
- The risk to compliance for effluent TN would be better managed if the leachate feed system was automated rather than bled in via manual valve position. There are times when it would be beneficial to have supplemental carbon dosing into the swing zone to improve denitrification.

4.5 RISK ASSESSMENT AND IMPROVEMENT LIST

The risk assessment process closely followed the approach as defined in the Ministry of Health Handbook for Preparing a Water Safety Plan 2019. The only deviation from the approach was the preparation of consequence ratings to suit wastewater treatment. These ratings are presented in Table 5.

Table 5: Consequence ratings used for the risk assessment

Consequence	Description
Insignificant	Insignificant impact on treatment
Minor	Limited environmental, treatment impact – manageable process upset, slight deterioration of effluent quality, maintains compliance
Moderate	Moderate environmental, treatment impact- significant effluent quality deterioration and/or process upset which threatens compliance.
Major	Major environmental, treatment impact which will have a small impact on stakeholders – Non-compliance or potentially small volume of localised raw or partially treated wastewater release into the environment.
Catastrophic	Major environmental, treatment impact – significant impact on environment, safety, and public health – Major exceedance and/or large volume of raw or partially treated wastewater released into the environment.

The pilot team felt that the risk assessment process and subsequent improvement list was the most valuable exercise throughout the WWSP pilot. The process of objectively identifying hazards with intolerable residual risk helped lay a clear path for identifying necessary improvements. While the systematic approach to risk hazard and risk identification and assessment is commonplace to the drinking-water treatment industry, it is only in limited use across the wastewater industry.

4.5.1 INTOLERABLE RISK DISCUSSION

There were 14 identified hazards which carried an intolerable amount of residual risk. Of those 14 hazards, 7 were identified within the reticulation network. The distribution of these hazards across the process area are presented in Table 6.

Table 6: Distribution of Hazards Carrying Intolerable Residual Risk in the Te Aroha Wastewater Treatment Network

Area	Number of Hazards Carrying Intolerable Residual Risk
Reticulation	7
Leachate Storage and Dosing	2
Equalisation and Pretreatment	3
Secondary Biological Treatment	1
MBR Filtration	1

While several improvements can and are being made to the reticulation network, most of these risks can only be partially mitigated without major infrastructure overhauls. When further discussed within the team, it was surmised that the increased risk is because wastewater reticulation networks are reactive systems. Examples of this include the following:

- Wastewater reticulation networks are collection rather than distribution systems. They cannot be operated under a capacity limitation to prevent upsets under non-ideal conditions. They are designed to accommodate influent flows rather than produce and maintain treated water flows like a drinking-water reticulation network. The ability for a wastewater reticulation network to operate without upset relies on design, which if too aggressive results in overflow potential and if to conservative can result in stagnation.
- Reticulation networks are vulnerable to upsets caused by community disposal practices including wet wipes, fat, etc. This makes monitoring reticulation networks a reactive process as these behaviors can only be influenced but not controlled.
- Resource consents emphasize the performance and monitoring of treatment plants and do not comment on reticulation networks; therefore, council and operations staff focus is primarily centered on treatment related processes. While the performance of a wastewater reticulation network must still be maintained, it is often treated secondary to the treatment plant.

The remaining hazards carrying intolerable residual risk ranged from automating the leachate dosing system, bunding the leachate storage tanks, desludging the oxidation ponds, and considering supplemental carbon addition into the anoxic reactor to reduce effluent TN. While straightforward, the identified improvements mitigate several compliance risks. They will make a significant impact on improving environmental outcomes by reducing the potential for high effluent TN loads and oxidation pond direct discharge events.

4.5.2 MULTIBARRIER APPROACH

One hazard stood out as it directly correlated to the findings of the Havelock North Inquiry regarding the employment of a multibarrier approach to treatment.

Te Aroha achieves its effluent E. coli limit through membrane filtration. The median limit is relatively low at 10 MPN/100 mL. The flat sheet membrane panel pore size is small enough to prevent the passage of E. coli without the need for a separate disinfection process. This single barrier approach is used in many places in New Zealand and throughout the world to meet biological constituent limits.

This approach lacks robustness, however, as a single membrane panel tear or rupture will result in high effluent E. coli results. At Te Aroha downstream monitoring of the permeate quality is undertaken by a UV-Vis spectrolyser for both nutrient and TSS concentrations using surrogates. MPDC also executes a rigorous MBR quality management plan which consists of periodically testing permeate from specific membrane cassettes on a rotating basis to identify if E. coli is passing through membrane panels. All of these approaches are reasonable and effective, but they are reactive rather than proactive.

It was proposed that the feasibility of procuring and installing UV disinfection units be evaluated, with the intention to provide a robust, proactive, secondary (i.e. multibarrier) approach to maintaining E. coli compliance. Another benefit is in the event of a ruptured membrane panel, the operations team can schedule maintenance at a convenient time while maintaining compliance This would use the same approach as the water industry to a multibarrier approach.

4.6 FINAL WORKSHOP

The final workshop was dedicated to scoring the second half of the MCA and identifying lessons learned.

4.6.1 MCA SCORING

The pilot team was made up of a distribution of treatment and compliance team members with varying degrees of wastewater experience. Some had significantly more water industry experience. The first scoring was completed at the commencement of the pilot, and the final scoring was completed at the conclusion. The MCA results are summarized in Table 7 below.

Table 7: WWSP MCA Scoring Results Matrix

Parameter	Before WWSP		After WWSP	
	Range	**Average**	**Range**	**Average**
Commitment	6-7	6.7	7-9	8
Awareness	5-6	5.7	7-8	7.7
Competency and Knowledge Base	5-7	6.3	8-9	8.3
Efficiency and Effectiveness	7-8	7.3	7-9	8
Consistency and Sustainability	7-8	7.7	8	8
Transparency and Auditability	4-6	5.0	7-10	8.3
Completeness	6	6.0	7-10	8.3

The results of the MCA scoring suggest that the experiences and knowledge gained from piloting the WWSP were of significant benefit to the treatment team as the average MCA score before and after the WWSP was 6.4 and 8.1, respectively. While this MCA scoring can only serve as momentary measurement of the overall efficacy of this type of quality management approach, the perceived short-term benefits to the team are compelling.

4.6.2 OUTCOMES

There were several outcomes regarding the benefit of the pilot and the WWSP. Many of these outcomes reaffirmed the value of a WSP style risk approach. When applying the approach to the wastewater industry, valuable data was produced. The most pertinent outcomes included the following:

- Most information required to populate the WWSP was available in some form. The population of a WWSP is not onerous and should not require more effort than the population of a WSP.
- By establishing a single reference document to organize and manage council wastewater treatment documents, not only is transparency and auditability improved, but it also empowers staff. The degree of organization and thoroughness establishes the completeness required by a service supplier to achieve and maintain sustainable compliance and provides a foundation for new staff onboarding.
- The process exposed that the purpose and structure of O&M's are not optimal. O&M's should be composed in such a way to best support Operations staff rather than act as a catch all for information ranging from recommended process improvements to asset data. By making the O&M a part of a larger quality management programme, the excess and peripheral material that is not valuable to an Operations staff can be removed from that document and preserved in another location of the WWSP.
- Utilising the risk assessment process resulted in the identification of new improvements from exposed risks, which likely would not have been discussed or explored. These improvements will have a direct impact on improving environmental outcomes by mitigating risk around achieving resource consent compliance.
- There is a distinct difference in risk when comparing a wastewater treatment reticulation network to the treatment plant. The Te Aroha wastewater reticulation network carried more residual risk than the treatment plant. As resource consents address the treatment plant effluent discharge, some consideration should be given to the reticulation network in resource consents.
- While not commonly employed in the wastewater industry, the multibarrier approach to compliance is relevant and should be considered due to the reduction of risk it provides. In many cases, it is the only way to guarantee compliance. This attitude is being adopted throughout the drinking-water treatment industry because of the potential impact on human health. In the future, however, the multibarrier approach will likely take a more prominent role in the wastewater industry to maintain clean environments.

5 CONCLUSIONS

When reflecting on the WWSP pilot, the initial goals need to be considered:

- **Improve environmental outcomes** – Several improvements were identified during the risk assessment process, which once implemented will have a beneficial impact towards achieving compliance. Additionally, by identifying, locating, and maintaining important documentation and policies, the operations and compliance effort becomes more organized and streamlined.
- **Improve industry consistency and versatility** – While the MCA did not include any provision for measuring cross industry commonalities, the reuse of critical water treatment industry tools and terminology will assist in bridging the gap between water and wastewater. The risk assessment also validated the multibarrier approach to compliance, which has been broadly accepted across the water industry but is typically not employed in the wastewater industry. Future use of a similar risk assessment will probably

lead to the wastewater industry adopting the multibarrier approach more often. This should further align the design and operational philosophies across the entire industry.

- **Provide industry thought leadership and experience** – The WWSP framework used in this pilot was found to be effective and likely no more burdensome than populating a WSP as most information was available in some form. Using this WWSP framework for quality management of wastewater treatment plants is sufficient, but there is room for further optimization.

Based on these outcomes, the pilot can be considered a success. The pilot team intends on tracking changes in environmental outcomes and collecting long-term feedback when utilising the WWSP to provide a greater insight into the effectiveness of a WWSP.

ACKNOWLEDGEMENTS

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