A SIMPLE, PRAGMATIC APPROACH TO PREVENTIVE MAINTENANCE OF PUMP STATIONS

G D Wells and A J Hanafin, CH2M Beca Ltd - 2010

ABSTRACT

Timaru District Council has a number of sewer and stormwater pumps for which a condition assessment was needed and a preventive maintenance program prepared to minimise the risk of unexpected failure.

This paper reviews both parts of the project which necessitated a generic and pragmatic approach appropriate to the asset be used.

1) The condition assessment approach: From a developed check list, inspections were carried out in conjunction with Council field staff capturing valuable institutional knowledge. Key to the application of the data obtained and its translation into documentation supporting the Long Term Council Community Plan was the establishment of an "operational importance ranking scale", and a service life schedule for pumps that reflected their date of manufacture and kW rating.

2) Preventive maintenance program development: The KISS (keep it safe and simple) principle was used and an easy to follow wall mounted chart / program developed that identified the tasks and frequency, spread the work load throughout the year, reflected seasonal demands / effects and short weeks, and fitted in with regular visits already in place. This created a preventive maintenance schedule that field staff could and did take ownership of.

This approach to asset management was a system created with the operators, for the operators and minimises middle management input leading to organisational efficiencies through delegated responsibility.

KEYWORDS

Preventive Maintenance, Pump Stations, Pump Service Life.

1 INTRODUCTION

1.1 BACKGROUND

Timaru District Council encompasses the South Canterbury urban area of Timaru and the surrounding towns of Temuka, Geraldine and Pleasant Point with a combined population of approximately 44,000. Timaru is the largest community, housing nearly two thirds of the district’s population.

The Council's wastewater team has a Milliscreen Plant and 24 pump stations (21 sewer and 3 stormwater) in its care. There are a total of 50 field mounted pumps, the oldest of which was 50 years and 30% were beyond their service life, with flow capacities in the range of 3 to 379 l/s, and pumping heads of 3 to 27m. This paper outlines the condition assessment and replacement scheduling project that was undertaken to minimise the risk of unexpected failure.

In 2008, CH2M Beca was commissioned by Timaru District Council (TDC) to undertake condition assessments of its pump stations, both sewer and stormwater. The aim of the condition assessment was to determine the future capital expenditure profile necessary to minimise the chance of unexpected failure and to maintain working order of the sewer systems. TDC would then use this information in its Long Term Council Community Plan (LTCCP) process as guidance toward timing and costs for future pump replacements and other maintenance work.

The initial task in this project was to determine the level of complexity to be used in assessing the pump stations. It was necessary to find a balance between the cost of undertaking the assessment and the level of detail which would be of most use to TDC, within a constrained budget environment.

1.2 FINDING THE RIGHT APPROACH

Both TDC and the authors believe it is necessary to tailor the approach taken to asset management to meet the needs of the situation. In this case, TDC is a relatively small council with a small number of pump stations, and a high level of institutional knowledge, as opposed to a large authority more reliant on historical asset details held in a database. In this situation it was practical to use the extensive knowledge of longstanding TDC staff to gain a greater understanding of the history of its pump stations. This knowledge, combined with an inspection of the pump stations and pump details such as installation date and size, provided sufficient information from which to develop a replacement schedule and also a preventive maintenance program.

Figure 1 diagrammatically illustrates the trade off between detailed information accuracy and cost. Certainty and structure in an asset maintenance strategy come at a price. As the extent of field inspection, testing and performance calibration increases, so too does the cost of the assessment strategy.

A middle ground approach was taken in this case. A field assessment was undertaken but at an overview level. A detailed assessment of each pump in terms of flow performance, testing vibration and temperature, which might give a greater assessment of condition was not done. Instead a visual inspection of each installation was undertaken to determine an overall condition assessment and combined with the history and significance of the pump station.

The inspections were undertaken with senior operators in order to gain from their knowledge of the station’s history. Good communication between the assessor and the operators was integral in determining issues with each particular station.

Using all the human senses (except taste), was the foundation of the assessment; listening to what the operators had to say and for irregular pump noises, smelling for odour, touching to check for temperatures and vibration, and looking for issues such as corrosion.

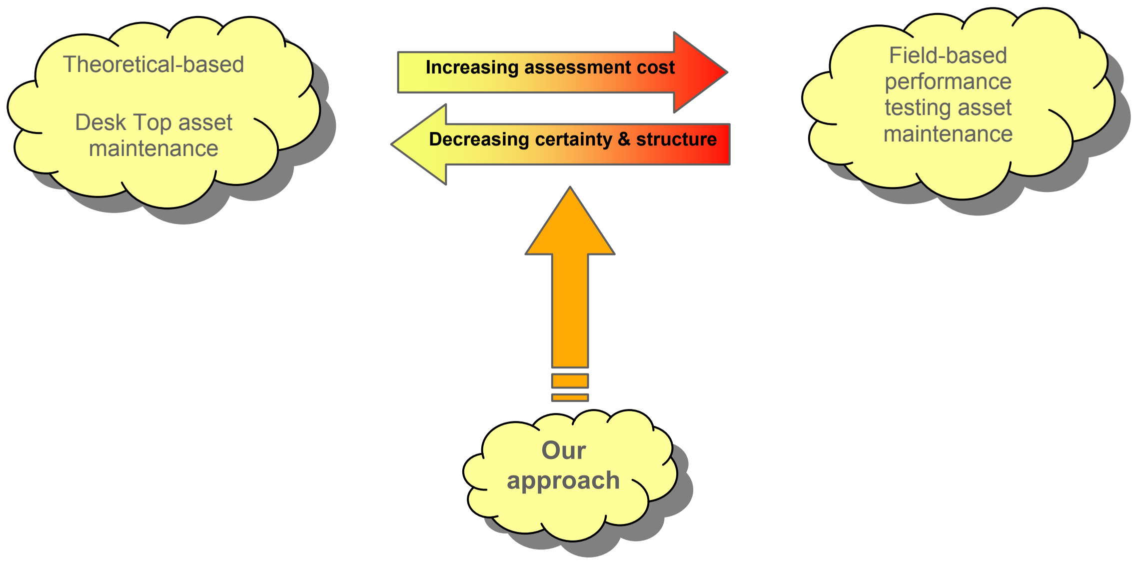

Figure 1: Finding the appropriate level of assessment

1.3 OUTCOMES

The first outcome of the condition assessment was the development of a 20 year financial plan. The level of accuracy aligns with the level of detail from the condition assessment, so in this case the budget has an accuracy of say +/- 30%. Greater accuracy should be possible as replacements get closer to due date.

Information from the condition assessment was then also used to create a preventive maintenance schedule for the operators to use. The schedule assists in reducing the extent of reactive maintenance and has a number of benefits including:

- Less disturbance of operators personal time
- Reducing operational costs to the Council due to less call-outs
- Identifying issues before they become a problem
- Increased level of reliability
- Extending the Service Life that would otherwise prevail.

2 DEFINITIONS

Design Life - the time period between manufacture and major refurbishment.

Service Life - the period over which a manufactured item can be expected to be serviceable or supported by its originating manufacturer.

Life Expectancy - the number of years remaining.

Replacement – literally like with like.

Renewal – component refurbishment that may or may-not include replacement.

3 THE CONDITION ASSESSMENT

The aim of the condition assessment was to prioritise replacement to enable spreading of the financial commitment necessary. This then reduces current service life status which in time will bring about greater reliability and level of service.

The assessment process focused on five key areas; Operational Importance, Pump Service Life, Pump Station Details, Odour and Field Inspection.

3.1 OPERATIONAL IMPORTANCE

The pump stations were assigned an operational importance ranking between 1 and 12, with 1 being most important. This was done by a TDC staff member with over 30 years of experience and knowledge of the TDC sewer network. It is important to capture this institutional knowledge held by experienced staff members and thus this condition assessment also became a step in enabling information transfer as part of succession planning.

This operational importance was intuitively assessed based on a number of factors including, but in no particular order:

- Catchment characteristics
- Operational history
- Significance within the overall sewer collection system
- Overflow provisions and discharge location
- Consequence of pump station failure
- Public perception in the event of a failure.

3.2 PUMP SERVICE LIFE

The service life of the pumps has been based on the power rating of each pump. The larger the pump motor is, the longer the service life. For the purposes of this assessment and prediction of capital expenditure, the following assumptions were made as outlined in Table 1. It may appear a little conservative, however this is neither unexpected as is explained shortly, nor inappropriate for use when establishing replacement programs, and some individual pumps may well exceed service life expectations for other reasons. It must also be realised that to maintain levels of service expected, pumps will be replaced before they die.

Table 1: Service Life (years) of Different Size Pumps and Date of Manufacture

kW Rating	Pre 1990	1990-2000	Post 2000
>40	40	35	30
30 ≤ 40	35	30	25
20 ≤ 30	30	25	20
10 ≤ 20	25	20	15
<10	20	15	10

For example, some Lee Howl pumps have operated for over 40 years in several of TDC's pump stations, but their replacements would probably not.

The explanation for this is due to an ongoing process of change:

- Design refinement with closer tolerances; energy efficiency is now of more importance
- Less robust equipment; more probes on the pump and thus reduced design factors in componentry
- Cheaper materials being used; e.g. lighter weight materials used due to better understanding and knowledge of stress distribution
- Greater range of pump manufacturers
- Selection based on initial purchase cost, rather than life cycle cost
- Combination of pump maintenance costs and reducing levels of skilled resource for this
- Unavailability of spare parts; manufacturers do not hold stock of all or any spares beyond a certain period. They will fabricate on request, but this is costly
- The convergence of Life Expectancy from new toward that of Service Life toward Design Life, to the extent that Design Life (and major refurbishment) is becoming irrelevant especially for mass produced pumps. Figure 2 shows this diagrammatically.

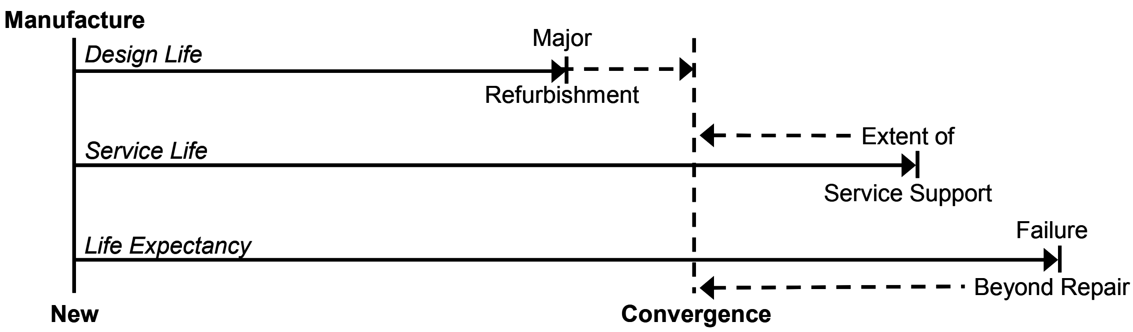

Figure 2: Convergence of Design Life and Life Expectancy

However, despite a reduced service life, maintenance for reasons other than blockages can be expected to be less, due to improved technical understanding by manufacturers. i.e. Increased Design Life with greater reliability, but also less warning of pending failure, and the disappearance of major refurbishment as part of the pumps life. The pump is becoming a consumable, and a process of planned obsolescence needs to be allowed for.

This is an important discussion because too often we base our service expectations on past performance, when in fact pump manufacture and operation is changing without our recognition of that.

Further to this explanation justifying the reduction in service life over time, it follows that preventive maintenance becomes more important if service life expectations are to be achieved.

3.3 PUMP STATION DETAILS

When undertaking a high level assessment of a pump station, details such as age of pump, and pump size and type become important as discussed in the previous sections. Other key factors in assessing the risk of failure of a pump station include:

- Overflow: are there overflow provisions and what is the sensitivity of the receiving water / area?
- Standby power: does the station have a standby generator, or plug-in capability?

Overflow and standby power are both key factors as identified in section 3.1, where the consequence of pump failure contributed to the 'Operational Importance' ranking that was assigned to each pump station. Table 2 outlines the key factors for some of the pump stations.

Table 2: Summary of the Town Pump Stations in the Timaru District (listed in order of operational importance)

Pump Station Name[4]	Operational Importance Ranking	Station Details Motor Power per pump	% Service Life	Overflow Storage Y / N	Standby Generation	
					Y / N	Plug-in Y/N
Pacific Street	1	2 x LH[5] @ 33 kW 2 x LH[5] @ 89 kW	129 113	N	N	Y (one diesel)
Seadown Drain – Process Water	2	1 x KSB @ 6 kW 1 x Flygt @ 5.9 kW	115 10	NA	Y[3]	-
Redruth Stormwater	2	2 x MacEwans @ 22.5kW		Y (pond)	N	N[1]
Washdyke Stormwater	2	2 x MacEwans @ 22 kW	95	N	N	NA (diesel engine)
Queen Street	2	2 x LH[5] @ 19 kW 1 x LH[5] @ 67 kW	172 108	N	Y[2]	-
Kensington	3	2 x LH[5] @ 11 kW 1 x LH[5] @ 43 kW	196 123	N	N	Y
Caroline Bay	4	2 x Flygt @ 3.1 kW	20	N	N	Y
North Mole	4	2 x Flygt @ 3.1 kW	100	Y	N	Y
Dawson Street	5	2 x LH[5] @ 5.6 kW	250	N	N	Y
Ashbury Park	6	2 x Flygt @ 3.1 kW	40	N	N	N[1]
Blair Street	7	2 x Flygt @ 3.1 kW	70 40	Y	N	Y
Coonoor Road	11	2 x Flygt @ 1.5 kW	170	N	N	N[1]
Hayes Street	11	1 x Flygt @ 2 kW	unknown	N	N	N[1]
Ben Venue Stormwater	12	1 x Flygt @ 0.55 kW	93	N	N	Y

[1] No provision for emergency power.
[2] Portable standby Genset (110 kVA) normally located at Queen Street.
[3] The Seadown Drain pumps are on the Milliscreen Standby Generator Circuit.
[4] Pump Stations are in sewage service unless stated otherwise.
[5] LH is an abbreviation for the pump manufacturer – Lee Howl

3.4 ODOUR

At each pump station a generic assessment of odour was undertaken. The basis for this was taken from the 'Good Practice Guide for Assessing and Managing Odour in New Zealand (MfE 2003)'. It details intensity, character and adverse effects rating of odour.

The scale referenced in table 4.2 of the Guide for use in describing odour intensity during field observations comes from the German Standard VDI 3882 (I) (1992): Olfactometry Determination of Odour Intensity. This scale is used in Europe and Australia for grading intensity and as given in Table 3 below.

Table 3: German VDI 3882 Odour Intensity Scale

Odour Intensity	Intensity Level
Extremely Strong	A
Very Strong	B
Strong	C
Distinct	D
Weak	E
Very Weak	F
Not Perceptive	G

The odour impact scale referenced in table 4.4 of the Guide is shown in Table 4.

Table 4: Scale for Rating Odour Impact

Scale	Odour Impact
a	The odour can be detected but is not annoying under normal conditions.
b	The odour can be detected but is not annoying, unless it is continuous.
c	The odour is moderately strong and is annoying if it is continuous or if its occurrence is very frequent.
d	The odour is moderately strong and is annoying if it occurs for periods of more than 5 to 10 minutes. Shorter, infrequent occurrences are not annoying.
e	The odour is strong and is annoying even in periods of short duration.

Odour ratings can provide information on other aspects of the condition of a pump station. A simple "sniff test" can assist in highlighting issues such as corrosion potential due to hydrogen sulphide, and in the case of TDC, concentrated industrial flows. This knowledge can then aid in determining the regularity of particular maintenance practices. Odour level being recorded as combined reference, eg Db.

5.5 PUMP STATION FIELD ASSESSMENT

To record the conditions at each pump station, a specific pump station condition assessment form was developed and used. This listed various aspects of a typical pump station along with some less common pump station issues. A similar form has also been developed for Electrical Condition Assessment but was not used in this engagement.

The field investigations undertaken provided visual identification only of asset condition, an overview assessment of the pump station without any tests.

The assessment was undertaken with TDC Operators in order to benefit from their day-to-day experiences and understanding of the historical maintenance requirements of the station.

It is noted that the ‘design pump capacity’ for each pump was recorded having been taken from information about flow capacity, pumping head and motor size of the existing pump. If part or all of this information was not available, then capacity was estimated from pump curves. However presentation of this data has not been included within this paper as in this case it was not a determining factor in the outcomes.

The following photos illustrate the type of recording which was undertaken.

Photograph 1: Corrosion of wet well pump lifting chains and guide rail supports

Photograph 2: Corrosion of control cabinet

Photograph 3: Pump Station Overflow

3.6 PRIORITISATION

The outcome of the condition assessment was to recommend a schedule for replacement of TDC's pumps with a realistic capital expenditure profile. Many pump replacements were due in the same year and therefore some had to be prioritised ahead of others.

Replacement works at pump stations were prioritised primarily around a combination of operational importance and service life.

From this prioritisation a 20 year financial plan was able to be prepared spreading pump replacements throughout the 20 year period within reason.

4 PREVENTIVE MAINTENANCE PROGRAM DEVELOPMENT

4.1 INPUTS

The second aspect of this project was to develop a preventive maintenance program for the operators. At the time the operators were undertaking reactive maintenance on a daily basis and had little time for preventive maintenance. As described in section 1.3 there are benefits for all parties if reactive maintenance can be reduced and replaced with preventive maintenance.

In order to develop a program, a range of inputs were used. These included:

- The condition assessment undertaken
- Historical maintenance records
- Consultation with Operators
- Location of each pump station
- Seasonal influences
- Operation manuals from pump suppliers.

TDC has records for over 25 years of maintenance history on the pump stations. This provided an account of common problems at a pump station and the frequency with which certain component replacements were required in that particular situation.

Consultation with the operators provided real experience of the pump stations and filled in any gaps in information from the maintenance records. In this case, the operator had been with TDC for 15 years and therefore had extensive knowledge of the pump stations.

Depending on the location of each pump station, annual maintenance checks were scheduled prior to busy periods. This applied to the pump stations located near major seasonal industries such as fish processing, meat works, vegetable processing, and the camping ground. Similarly annual maintenance checks for the storm-water pump stations were scheduled before the often wet winter season.

Operation manuals from pump suppliers provided specific recommendations for the annual pump service.

4.2 USABILITY

Working with the operators and their work systems was very important in creating a usable schedule. Without the buy-in of the operators it would become just another piece of paper, and time has proven the worth of their involvement in its ongoing use and the benefits they are now seeing.

A number for factors were taken into account to create the schedule. These included:

- Having three levels of preventive maintenance by splitting tasks into annual, 3 monthly and weekly frequencies.

- Ensuring there is less preventive maintenance scheduled in weeks with public holidays when staff numbers are potentially lower than usual and the short week is busier anyway.

- Basing the weeks on the operators shifts. The operators generally alternate on ‘Town’ pump stations for a week, and then ‘Country’ pump stations the next. This means that a fresh set of eyes see the pump station on a regular basis providing a greater chance of detecting any issues.

- Consultation with the operators as mentioned previously.

The 52 Week Preventive Maintenance Schedule is shown below. Using a 52 week template provides for ongoing repeat use. This schedule (A1 size and laminated) is mounted on the wall of the control room for daily reference at the Milliscreen Plant where the operators are based, and they tick them off as they are done.

The schedule refers to a task sheet which outlines the list of jobs required for that week. The task sheet resides in the maintenance folder for the operator’s ease of reference.

TDC Pump Stations
Preventive Maintenance
(refer Task Sheet 114)

52 Week Preventive Maintenance Schedule

TIMARU TDC DISTRICT COUNCIL   CH2M Beca

Diary Week: Jan (1–5), Feb (6–9), Mar (10–13), Apr (14–17), May (18–22), Jun (23–26), Jul (27–31), Aug (32–35), Sep (36–40), Oct (41–44), Nov (45–48), Dec (49–52)

Line #	Station Name		Operational Importance	Standby Genset	Plug Provision	Overflow Storage	Over - flow	Monthly Interval	Line #
1	Pacific Street	TOWN	1		√		√	3 / 12	1
2	Redruth Stormwater	TOWN	2			Upstream retention		3 / 12	2
3	Milliscreen Process Water - Seadown Drain	TOWN	2	√			-	3 / 12	3
4	Washdyke Storm Pumps (Diesel driver)	TOWN	2					3 / 12	4
5	Queen Street	TOWN	2	√			√	3 / 12	5
6	Kensington	TOWN	3		√		√	3 / 12	6
7	Caroline Bay	TOWN	4		√		?	3 / 12	7
8	North Mole	TOWN	4		√	√	√	3 / 12	8
9	Dawson Street	TOWN	5		√		?	3 / 12	9
10	Ashbury Park	TOWN	6				√	3 / 12	10
11	Blair Street	TOWN	7		√	√	√	3 / 12	11
12	Coonoor Road	TOWN	11				√	3 / 12	12
13	Hayes Street	TOWN	11					3 / 12	13
14	Ben Venue	TOWN	12		√			3 / 12	14
15	Temuka Plant Pumps	COUNTRY	1		√		√	3 / 12	15
16	Temuka Pond Pumps	COUNTRY	4		√			3 / 12	16
17	Princes Street	COUNTRY	8		√	√	√	3 / 12	17
18	George Street (PP)	COUNTRY	9		√		√	3 / 12	18
19	Cass Street	COUNTRY	10				√	3 / 12	19
20	Murray Street	COUNTRY	11				√	3 / 12	20
21	Fraser Street	COUNTRY	11				√	3 / 12	21
22	Harris Place	COUNTRY	11					3 / 12	22
23	Kabul Street (PP)	COUNTRY	11					3 / 12	23
24	Cascade Place (G)	COUNTRY	11					3 / 12	24

Note 1) Annual Checks
- Process/Industrial locations prior to seasonal increase (weeks 35-38)
- Higher importance stations before Christmas (weeks 39-49)
- Stormwater Stations prior to wet season (weeks 12-14)
- Less importance stations after Christmas (weeks 3-11)
- Winter/wet season - no annual checks (weeks 18-34)
- Combined with three monthly check

Note 2)
Weeks with no maintenance are short weeks due to public holidays and have been left clear for this reason

Note 3)
Three monthly checks spaced according to Annual check and can be completed in conjunction with weekly check

5 CONCLUSIONS

This paper outlined a method of pump station assessment and preventive maintenance scheduling that has been tailored to the situation for which it was required. For many smaller TA's, a simple and pragmatic approach has the most benefit and a number of contributors led to the success, usability and value of such an approach including:

- Open communication with the client at a variety of levels.
- Involving the operators directly in the process.
- Capturing institutional knowledge.
- Finding a balance between field testing and theory-based asset management assessment methods, that met the client's needs within budget constraints.
- Recognition of the changing service life for pumps.

ACKNOWLEDGEMENTS

Ashley Harper – District Services Manager Timaru District Council

REFERENCES

MfE (2003), "Good Practice Guide for Assessing and Managing Odour in NZ" – Ministry for the Environment, Wellington, New Zealand.