Williamtown RAAF Base Sewage Treatment Works

Operation and Maintenance Manual

Spotless P&F Pty Ltd

01 April 2008
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Part A - Introduction

1.0 Description and Use of this Manual

Section Outline
1.1 General
1.2 Other Sources of Information
1.3 Work Classification
1.4 Subdivision of this Manual

1.1 General
This operations manual for the Williamtown Sewage Treatment Plant is subdivided into parts as follows:

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The manual contains information on the function, design and operation of each system and process in the plant, as well as general maintenance guidelines. Equipment records, planned maintenance information and equipment manufacturers instructions are not included. The arrangement of the manual is detailed further in 1.4. A monitoring program recommended as part of a review of the monitoring system undertaken in February, 2008, is included in Appendix G.

1.2 Other Sources of Information
There are a number of sources of information relating specifically to this plant which will help personnel involved in the plant’s operation. They should be used in conjunction with this manual and are listed below:

1. Manufacturer’s Maintenance Guidelines, Volumes 1-3, 1986
3. Approved Shop Drawings

1.3 Work Classification
The work to be performed at the plant can be divided into the following four categories:
1. Operation
2. Housekeeping
3. Preventive Maintenance
4. Corrective Maintenance

Operation includes control of the treatment process, minor checking and adjustment of equipment, preparation of reports, and operating records, conducting laboratory control tests, and application of the test results and recorded data to plant functions.

1.4 Subdivision of this Manual

As described in 1.1, this manual is divided into three parts; Part A, B and C.

Part A (Introduction) describes the operating manual and lists other information and documentation that may be of assistance to operating and maintenance personnel. It also discusses a philosophy of plant operation. In addition, Part 1 documents the purpose and upgrades history, and describes the sewage treatment plant (STP) processes.

Part B (Operation) describes the function, design and operation of each system and process in the plant. Operating personnel should become thoroughly familiar with the information contained in Part B before operating major plant components or systems, particularly the outline of safety precautions. In some instances it may be necessary for an operator to refer to manufacturer's instructions for additional information on the operation of a particular item of mechanical equipment.

Each Chapter in Part B describes a system or process in the plant, divided into sections, with sections being further subdivided into sub-sections.

In general, section headings include:

1) General description: A general description of the system and the facilities provided, including relevant design information.
2) Operating Goals: The basic functions of the system; the criteria on which operating decisions should be based.
3) Operation: A description of how the system operates including procedures to be followed by the operator.
4) Maintenance: Routine maintenance, including procedures related to operation and housekeeping which should form part of the operating routine.
5) Troubleshooting: A list of possible problems and appropriate remedies.
6) Monitoring Performance: Method of sampling and testing to monitor the performance of the process.

Part C contains general maintenance guidelines.
2.0 Purpose of the Sewage Treatment Plant

Section Outline
2.1 Operating Goals
2.2 Process Reliability
2.3 Effective Operation

2.1 Operating Goals

An ideal plant operator should display the following attributes:

1) Knowledge of the owner’s objectives and the criteria by which the state of the plant and manner of its operation are to be judged.
2) Knowledge of the anatomy of the plant.
3) Knowledge of the physics, chemistry and microbiology of the parts of the plant.
4) Knowledge of the modes of operation and limitations of all parts of the plant.
5) Knowledge of the way in which the processes behave under varying conditions.
6) Knowledge of the control system’s logic (predetermined patterns of behaviour) and range of control capacity.
7) Knowledge of the repetition frequency of common faults and the action to be taken to prevent or repair them; this is coupled with a knowledge of premonitory symptoms and their interpretation.
8) Ability to imagine or foresee the consequences of unusual or unlikely combinations of events (ability to “plan for breakdowns in advance”).
9) Ability to apply all this knowledge effectively to optimise the conduct of the whole operation of the plant, both in the short and long term.
10) Ability to plan and co-ordinate the tasks of operation and maintenance.

In general terms, the goals of operation and maintenance are to meet the required effluent quality standard at the lowest total cost to the community, whilst satisfying other environmental and occupational requirements in relation to odour, health and aesthetics. Effluent quality is discussed in 2.2 below. Maintaining high standards of housekeeping, area maintenance and community relations are also important operational goals.

2.2 Process Reliability

The effluent quality produced by a treatment process is variable. Variability arises from fluctuations in plant loading and environmental conditions and variations in biological and operational conditions.

Due to this variability, effluent quality goals should be referenced in statistical terms. The concept of process reliability is useful.

Reliability = 100 – probability of failure.

Where:
- reliability is the percent of time that effluent quality meets requirements, and
- probability of failure is the percentage of time that effluent quality does not meet requirements.
In New South Wales the effluent quality requirement for a civilian STP is the licence standard for the plant as set out by the Environmental Protection Authority (EPA; statutory body within the Department of Environment and Climate Change, DECC) in New South Wales. It is not reasonably possible to design or operate a plant which will meet the effluent standard 100% of the time and it is therefore necessary to decide what reliability is satisfactory.

It has been found in the U.S.A that the daily average values for effluent quality at a particular trickling filter plant follow a log-normal distribution. That is, the logarithms of the daily average Biological Oxygen Demand (BOD) and Suspended Solids (SS) values (and presumably other quality parameters) are normally distributed. Figure 2.1 shows how reliability is related to effluent variability. In the figure, \( m_x \) is the mean effluent quality which has been measured over some time period, \( X_s \) is the standard for that parameter, and \( V_x \) is the coefficient of variation for that effluent data (raw values, not the logs). The coefficient of variation is the standard deviation divided by the mean. As an example, suppose that the mean effluent BOD measured over a year is 15 mg/L, the licence standard is 20 mg/L and the coefficient of variation for the year’s data is 0.5. The normalised mean would be 0.75 and Figure 2.1 indicates that the plant reliability would be 0.8. In other words, the licence standard for BOD of 20 mg/L would have been exceeded on 20% of days in that year.

A study of 11 trickling filter plants in the U.S.A found that the coefficient of variation averaged 0.46 for BOD (range 0.15 to 0.75 for different plants), and 0.52 for SS (range 0.27 to 0.79). For 43 activated sludge plants the values were 0.70 (0.34 – 1.27) for BOD and 0.84 (0.32 – 1.70) for SS.

Figure 2.1 Reliability of Effluent Quality
2.3 Effective Operation

The EPA gives no indication of the reliability expected of plants in meeting the licence standards for effluent quality. The standards are nominal values “not to be exceeded”. In view of the information given in 2.2 above it is suggested that a reliability of 0.9 would be reasonable from an administrative viewpoint. Thus, the operation goal for the plant would be met each year if the calculated reliability was not less than 0.9. Costs would be the minimum necessary to achieve this standard of performance.

The pride, enthusiasm and skill of the operator are fundamental to effective operation. Through continuous effort and careful attention to detail, processes can be tuned to high levels of performance at no extra monetary cost. Both a low mean and a low coefficient of variation should be the aim. Attributes 4 to 9 listed in 2.1 above are of particular relevance. Through careful observation an operator can develop a feel for the plant and increase its reliability by early recognition and correction of “premonitory symptoms”. Biological processes have low growth rates and correspondingly long response times when corrective action is taken.

It is required that the reliability of the sewage plant be calculated annually as an indicator of overall performance. If desired, a running 12 monthly reliability could be calculated monthly.
3.0 STP Upgrade History

Section Outline

3.1 General
3.2 Original STP
3.3 Upgrade Phase 1
3.4 Upgrade Phase 2
3.5 Upgrade Phase 3

3.1 General

The Williamtown STP serves the RAAF WLM and adjacent civilian airport. It was originally built to serve a maximum of approximately 3,000 Equivalent Persons (EP). Due to the growth of Williamtown the original plant has been enlarged and updated to increase its capacity to 5,000 EP. Upgrades to the STP have been undertaken over several phases. The upgrades undertaken at each of the phases are identified below.

3.2 Original STP

The original plant consisted of the following process units:

1) Inlet channel with Parshall flume
2) Primary sedimentation tanks 1, 2 and 3
3) Two trickling filters and one humus tank
4) Chlorination works
5) Absorption channels for effluent disposal
6) Two small sludge digesters
7) Sludge drying beds.

3.3 Upgrade Phase 1

Upgrades undertaken in the mid 1980’s included the addition of the following facilities:

1) A bar screen
2) A screenings conveyor
3) A grit trap and grit screen
4) A screenings and grit hopper
5) A Parshall flume flow meter
6) Primary and secondary digesters, and ancillary features to facilitate sludge circulation, withdrawal and overflow
7) Humus tank 2
8) A CCT, including upgrading of the chlorine chamber with an alarm system and new instruments to monitor dosing
9) A new control room.

The original digesters were taken out of service during this phase of upgrades.
3.4 Upgrade Phase 2
The inlet works were upgraded in the mid 1990’s and included the followings additions:

1) An inlet chamber
2) A screening chamber containing an automatic drum screen and dewatering screw press
3) A by-pass channel and manual bar screen
4) A screenings storage and disposal unit
5) A grit trap and pump
6) A grit classifier, storage and disposal unit
7) Two progressive cavity sludge recirculation pumps
8) Treated effluent by-pass.

The bar screen, screenings conveyor, grit screen, screenings and grit hopper, and sludge digester and circulation pumps installed during the 1980’s upgrade were replaced during this phase.

3.5 Upgrade Phase 3
Upgrades undertaken in early 2007 included the following additions:

1) A sodium hypochlorite dosing system for disinfection
2) A magnesium hydroxide dosing system for odour control, installed at the RAAF WLM pumping station (PS 189) which discharges RAAF WLM generated sewage to the STP.

The previous chlorination dosing system was decommissioned during this phase.
4.0 Description of STP

Section Outline

4.1 STP Influent / Effluent
4.2 STP Components
4.3 General Description of the Plant Processes

4.1 STP Influent / Effluent

4.1.1 Influent

Raw sewage originates from the RAAF WLM including the base’s live in accommodation, offices, Military Working Dog Facility and the Tradewaste Treatment Plant (TWTP) which receives flow from a number of industrial activities undertaken onsite. Other contributions include the civilian airport, together with the scum drawn from the STP’s Primary Sedimentation Tank Number 3 (PST No.3). All flows directed to the STP’s inlet works combine to generate a total flow rate of up to 67 L/s.

No specific flow monitoring has been undertaken of the individual inputs to the STP. General characterisation of the influent flows is provided below:

- **RAAF WLM domestic sewage**
  Domestic sewage generated at RAAF WLM is primarily made up of flows from the base’s onsite residences. Some illegal discharges may take place through disposal of materials down sinks and other sewer access points in workshops around the base, however for the purposes of this investigation these inputs are considered minimal and the general characteristics of this wastewater source is considered to be similar to standard domestic sewage.

- **RAAF WLM’s Military Working Dog Facility**
  Activities at the working dog facility are likely to generate wastewater from washing the dogs and hosing down of the kennels. It is assumed that characteristics of the wastewater are similar to standard domestic sewage.

- **RAAF WLM’s TWTP**
  A number of activities including corrosion control, painting, fitting and turning are undertaken around the base. Wastewater from a number of these activities drains to Underground Storage Tanks before being tankered offsite. Flows from other activities around the base are collected and directed to the base’s TWTP which consists of a laminar plate separator to remove contaminants such as oils and lubricants from the wastewater prior to its discharge to the RAAF WLM STP. It is likely that the characteristics of this wastewater are high nutrient and heavy metals loads, however monitoring data reviewed in this report cannot confirm this.

- **Williamtown Domestic Airport**
  Flows from the civilian airport are obtained from bathroom facilities and some commercial restaurants operations. Characteristics are assumed to be similar to standard domestic sewage expected from residential catchments.

- **Sedimentation Tank Scum**
  Scum and foam can originate from a number of sources such as detergents and wastewater’s biological activity. Characteristics of the scum taken from the sedimentation tank may be increased
nutrient and BOD concentrations however it must be noted that this flow is only recycled from total inflows described above and does not impact the overall characteristics of the STP's inflow.

4.1.2 Effluent
Effluent is discharged from the STP firstly into the primary effluent lagoon from which overflows are directed to two secondary effluent lagoons. Storage from these channels is lost through evaporation, and possibly infiltration, however this has not been confirmed. An effluent by-pass also allows discharges to be diverted to the secondary effluent lagoons, when maintenance work is being carried out on the primary effluent lagoon.

4.2 STP Components
The STP consists of the following components:

- Inlet works
- Parshall flume and flow meter
- Sedimentation tanks
- Filter inlets
- Trickling filters
- Humus tanks
- Primary and secondary digesters
- Disinfection facility
- Absorption channel (primary effluent lagoon)
- Effluent lagoons

4.3 General Description of the Plant Processes
Influent enters the STP via the inlet and screenings chamber. This chamber contains an automatic drum screen, which collects screenings material, and a dewatering screw and press to transfer screenings to storage.

Screened effluent continues to the grit trap, where grit settles in a hopper and is pumped to the grit classifier. Removed grit and screenings are emptied into wheelie bins where they are disposed using the domestic garbage collection system.

Sewage flows from the Grit Trap to PST No.3 via the Parshall flume. A flow meter installed in the Parshall flume monitors flow through the facility.

PST No.3 is in constant operation with flows directed to Primary Sedimentation Tank No. 1 (PST No.1) and Primary Sedimentation Tank No. 2 (PST No.2) when flows exceed 60 L/s. After the flow has fallen below 60 L/s, sewage collected in PST No.1 and PST No.2 is transferred to PST No.3 and then processed through the remainder of the plant.

Clarified effluent from the primary sedimentation tanks is directed to the trickling filters and then the two humus tanks. Humus tank effluent gravitates to the effluent chamber followed by the chlorine contact tank (CCT) for disinfection before being discharged to the primary effluent lagoon.

The disinfection facility consists of a pump, a chlorine probe, an analyser/controller and a sodium hypochlorite tank. Sodium hypochlorite is dosed at the base of the weir centre, where it is well mixed.
Treated effluent from the CCT is directed to the primary effluent lagoon. Two junction pits and a 300mm diameter interconnecting pipeline facilitate a diversion of treated effluent to secondary effluent lagoons and enable maintenance work to be carried out on the primary effluent lagoon if required.

Sludge collected from PST No.3 is pumped to the primary and secondary anaerobic digesters. Sludge is mechanically mixed in the primary digester, and then transferred to the secondary digester for further digestion and thickening. Supernatant from the secondary digester is pumped back to the inlet works.

Thickened sludge from the secondary digesters is pumped to sludge disposal channels where it is removed by Veolia Environmental Services trucks equipped with pumping facilities. Veolia transports the sludge to Transpacific Waste Services located in Homebush, Sydney, where it is processed and disposed of in landfill. Figure 1 is a process flow diagram for the STP.

It is the responsibility of the operator to initiate the discharge of sludge from the secondary digester when the sludge level nears its upper limit. To identify if the sludge level needs discharging, the operator determines if sludge is present in the supernatant upper layer of the secondary digester by discharging supernatant from the upper withdrawal valve. If sludge is observed in the supernatant, the sludge level is near to its upper limit and the operator commences the sludge disposal process.

Figure 1: STP Process Flow Diagram
Part B - Operation

5.0 Inlet Works

Section Outline
5.1 General Description
5.2 Operating Goals
5.3 Operation
5.4 Maintenance
5.5 Troubleshooting
5.6 Monitoring Performance

5.1 General Description
The inlet works consist of the following elements:

- Inlet and screening chambers
- Automatic drum screen and screw press
- By-pass channel with manual bar screen
- Emergency overflow channel
- Grit trap
- Grit classifier
- Screenings and grit storage
- Parshall flume and flow meter

Influent flows into the inlet chamber and through the drum screen, where large solid material collects. A dewatering screw and press transfers the collected screenings to the screenings storage, for disposal offsite. The treated effluent continues to the grit trap, which consists of a tank with a grit agitation pump and a paddle for mixing. Grit settles in a hopper below the main chamber of the grit trap, and is pumped to the grit classifier. A dewatering screw contained in the grit classifier dries the grit before it is disposed offsite. The sewage continues on to PST No. 3 through the Parshall flume at the outlet of the inlet works. A flow meter installed in the Parshall flume monitors flow.

5.2 Operating Goals
The purpose of the inlet works is to remove all the larger solid waste, and most of the grit from the incoming sewage. The reasons for taking solid material out of the sewage is to reduce the likelihood of serious blocking and clogging of pipes and pumps throughout the plant. Allowing grit to go through the plant would also increase wear on the pumps.

5.3 Operation
The sewage will normally flow into the screening chamber, in which the rotary drum screen is located, through the screen and into the transfer sump. The depth in the inlet chamber will normally vary between zero and 200mm depending upon the raw sewage inflow rate and the degree of clogging of the fine screen.

If the depth in the inlet chamber increases above 300mm, indicating excessive blockage of the automatic screen, sewage will discharge over a weir into the by-pass channel. The high-levels switch,
currently installed in the existing inlet works, has been repositioned at the weir to indicate an overflow condition.

A manually cleaned bar screen, with 25mm spacing between the bars, is installed in the by-pass channel to remove gross solids in the event of a by-pass occurring. Removal of the solids is effected using the rake provided and a stainless steel drip tray facilitates drainage prior to disposal of the screenings.

If blockage of the manual bar screen also occurs, a 1000mm wide emergency overflow is provided upstream of the screen to direct flow into the existing inlet channel to the grit tank.

Stop gates are provided at the inlet and outlet ends of both the screening chamber and the by-pass channel to facilitate isolation of either for maintenance purposes. Due to the positioning of the dewatering screw press above, the inlet to the screening chamber comprises four stop gates, each about 160mm high. The other three stop gates are single boards, 500mm high.

i. Fine Screening

Fine screening of the raw sewage is affected by means of a proprietary ContraShear Suboscreen having a screen slot size of 1.5mm. The Suboscreen is a self cleaning, rotary drum type, in-line, in-channel semi submerged screen with flow entering the upstream end of the screen drum.

The screening wires are circumferential so that the resultant apertures are perpendicular to the flow, thereby effecting a change in flow direction as the liquid passes through the screen. This change in direction and the edge wire geometry ensure a 90% capture of solids larger than the aperture and discourage stapling of stringy fibrous material.

The solids are removed by lifting staves, progressively moving around the screen and deposited into a flume at the apex of the screen drum for subsequent discharge into and removal by the integral dewatering screw/press.

The screen is driven by a 0.37kW, 415V, 3 phase motor/reducer unit, variable frequency controller being installed in the electrical cubicle MCC9 for manual adjustment of the drum speed within the range 0.5 to 5rpm, approximately.

Transport and dewatering of the screening is combined in a single compact unit. The Combipress is in principle a Spirac conveyor with a press zone at the end for removing excess liquid. The conveyor section terminates in a 1000mm long press zone where the spiral is welded to a central shaft and forms a press screw with a friction area. This arrangement enables a plug of material to be built up and compacted, during which time it is being continuously dewatered. The length of this plug, together with the variable pressure effect of the hinged discharge port, controls the degree of dewatering.

Non-potable water is supplied to the screen and the dewatering screw for washing, flushing and cleaning purposes. During operation of the rotary screen, the drum surface is continuously washed via a spray manifold containing 10 flat jet type nozzles, at a total flow rate of 2.7L/s at about 3 bar. A solenoid valve V142 controls the flow to the spray manifold.

The solids discharge flume has a flushing sparge, controlled by a solenoid valve V141, which is operated in conjunction with the drum screen drive. The dewatering screw is also fitted with two washwater connections for cleaning the press section after each cycle. Total flow requirement is about 0.5L/s and control is exercised by solenoid valve V140.
The compacted solids are discharged from the dewatering press via a 300mm diameter discharge chute into a 240L capacity wheelie bin. In order to minimise odours and insect nuisance, the bin should be lined with a plastic bag which is tied at the top around the discharge chute.

While the screening system can operate continuously, provision has been made for operation on an intermittent basis, either on level or timer control. If the depth in the inlet chamber rises to about 190mm, or if the elapsed time since the last screen operation exceeds a preset time, initially set at 60 minutes, the following operations are initiated:

- Dewatering screw starts
- Screen drive starts
- Screen washwater solenoid opens
- Screen flume flushing timer starts

If starting on an elapsed time basis, the above operations will continue for a certain time period, initially 10 minutes, after which time the following operations occur:

- Dewatering screw starts
- Screen drive starts
- Screen washwater solenoids open
- Screen flume flushing timer starts

This will continue until the level falls below the start level when the sequence of operation will be as for starting on elapsed time.

Should the level of liquid rise above the starting level at any stage of the process all timers will be reset until this level drops below the starting level and operation will be as described in the starting on elapsed timer.

If the screen jams when selected in “Auto” mode, the PLC will automatically reverse the rotation for a pre-set time of 15 seconds and will then try again in the forward direction. If the drive jams again, the PLC will stop the sequence and initiate a “Screen Fail” alarm.

The drum screen is fitted with a motion sensor and detector which monitors drum rotation during operation and initiates the system alarm if the rotation ceases, indicating a drive fault or jammed condition. Operation of the dewatering press is monitored by means of an electronic torque switch which shuts down the drive and initiates a system alarm if an excessive torque condition arises.

Limit switches are fitted to the access covers of both the drum screen and the screw press. Opening of any of these covers will automatically stop the respective item of equipment.

**ii. Grit Handling**

The grit chamber collects grit in a hopper below the main chamber with operation being based on the vortex flow principal. The paddle mixer operates continuously, its purpose being to maintain light solids in suspension while permitting the grit to settle.

Removal of accumulated grit is carried out on a programmed interval basis every 4 hours. Once initiated, the cycle of operation is as follows:
- Start grit agitator pump and allow to run for an adjustable period initially set at 2 minutes
- Start grit pump and allow to run for an adjustable period, initially set at 5 minutes
- Start grit classifier drive and open washwater supply solenoid at same time as grit pump and allow to operate for an adjustable period, initially set at 15 minutes

The grit slurry is pumped from the grit tank at a nominal rate of 10L/s by means of Hidrostal screw impeller centrifugal pump. The pump is fitted with a standard impeller which generates about 5.5m head at 10L/s. As the calculated total head requirement is only 4.5m, and artificial increase of 1.0m in static head has been created in the pipe work in order to limit the flow rate to about 10L/s.

Diaphragm type isolation valves V130 and V132 have been provided on the pump suction and discharge lines respectively, together with a drain valve V131, to facilitate emptying of the lines or the grit tank itself.

A washwater spray, controlled by solenoid valve V143, has been installed on the outlet screw for washing the grit as it exits the liquid pool in the classifier. Non-potable water is used for this purpose.

The electrical controls for the grit classifier include an electronic torque switch which monitors the current draw and initiates a systems alarm if an abnormally high current, indicating a high torque condition, arises.

The grit pumping cycle is initiated on an elapsed time basis, the interval being timer control adjustable within the PLC between one and 12 hours. The initial interval setting is four hours.

### Washwater System

Water required for washing, flushing and cleaning purposes on the Suboscreen, Combipress and Sandsep units is supplied from the existing Non-Potable Water Tanks by means of a new duplex pressure system.

The system comprises the following major components:

- 2 x 100% duty vertical, multi-stage, in-line centrifugal pumps, each having a nominal capacity of 3.8L/s at 50m total head, mounted on a common mild steel base plate. Pumps are driven by 4kW, 2-pole, 415V/50Hz/3 phase, TEFC electric motors
- 1 x 72.5L capacity pressure tank with interval vinyl separator
- 1 x lockable control cubical complete with mains isolator, control and pump circuit breakers, contactors, alternating relay, run and overload indicating lights, TOL reset push button and pump failure flashing warning light with mute switch
- Pump suction isolation valves and discharge manifold complete with non-return and isolation valves
- Pressure and no-flow switches for pump control
- Pressure regulating valve to maintain a supply pressure of 325kPA to the sprays
- 1 x Filtomat self-cleaning filter fitted with 400 micron aperture stainless steel screen, complete with valves and controls

Start-up of the duty pump is initiated when the pressure in the system falls below the preset value of 400kPa, caused by opening of one of the washwater solenoid control valves. The pump continues to operate whenever the solenoid valve(s) remains open.
When washwater is no longer required, the solenoid valve(s) closes and the lack of flow in the system is detected by the no-flow switch which immediately stops the duty pump. An alternating relay in the control cubicle automatically changes the duty cycle so that the other pump becomes the duty unit at the next start.

Failure of the duty pump to start, when requested, is sensed by the no-flow switch and results in initiation of the flashing light alarm and start-up of the standby pump via the alternating relay. The alarm continues to flash until attended by the operator.

In order to protect the sprays from blockage, an automatic self cleaning filter is installed in the washwater supply. The filter is mounted on the grit tank platform. Adjacent to the existing blower, and isolation and by-pass valves V107, V108 and V109 have been provided to enable the unit to be taken out of service for short periods while still maintaining the washwater supply.

The hydraulic flushing cycle is automatically initiated by the differential pressure across the fine screen and results in the entire screen area being cleaned by a suction effect generated within the internal rotor/nozzle assembly. The combined flush cycle take 6 to 10 seconds, the waste water being discharged into the grit tank.

A pressure reducing/regulating valve V160 is positioned downstream of the filter in order to maintain a constant supply pressure to the washwater sprays. The valve has been set at a nominal pressure of 325kPa.

5.4 Maintenance

Included in Table 1 are recommended maintenance procedures, together with their frequency, for the various plant components.

Table 1: Maintenance Schedule for Various Components of the Inlet Works

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<th>System/Item</th>
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<tr>
<td>Concrete Works</td>
<td>No Action</td>
<td>No Action</td>
<td>Inspect foundations and concrete slabs for signs of mechanical damage and cracking. Damage should be repaired and cracks monitored.</td>
<td>Same as Monthly.</td>
</tr>
<tr>
<td>Steelwork, Handrails and Pipe Supports</td>
<td>No Action</td>
<td>No Action</td>
<td>Check that all sliding supports appear to be free. Inspect supports and foundations for signs of failure. Repair as necessary.</td>
<td>Carry out corrosion repairs.</td>
</tr>
<tr>
<td>Drum Screen</td>
<td>No Action</td>
<td>100hrs Operation Grease Trunnions.</td>
<td>Check gearbox oil level. 3 Months Check trunnion tyres for wear. Check sparge nozzles for blockage.</td>
<td>Water blast screen, remove all residue. 2 years or 10,000hrs Replace gearbox oil.</td>
</tr>
<tr>
<td>Grit Pump</td>
<td>No Action</td>
<td>No Action</td>
<td>Check seal oil condition after first 1000hrs operation. Grease</td>
<td>Check seal oil condition more frequently if site experience dictates.</td>
</tr>
<tr>
<td>Operation</td>
<td>Action</td>
<td>Maintenance Checks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
<td>-----------------</td>
<td>---------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dewatering Screw Press and</td>
<td>No Action</td>
<td>Clean if necessary. Check liner for wear. Check</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grit Classifier</td>
<td></td>
<td>packaging box for leaks. Check spiral for wear and/or</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>damage. Clean if necessary. Check liner for wear.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reference should also be made to the manufacturing/supplies proprietary information contained in Appendix D for the plant modifications undertaken in upgrade phase 1, and Appendix E for the plant modifications undertaken in upgrade phase 2. Refer to Section 4.0 or more information on the STP upgrade history. For further maintenance details, refer also to the maintenance and lubrication schedules for all the main plant components shown in Table 11 and Table 12 in Section 16.0.

5.5 Troubleshooting

Drum Screen

Problem: Clogged screen; too much solid matter on screen so sewage cannot go through it.

Solution:

(i) clear screen out thoroughly – may have to stop the flow if the pressure is too high to allow water blasting.

(ii) clean screen more often

Problem: Screen not catching much solid rubbish.

Solution: Allow some build-up of solids – do not clean so often

Grit Trap

Problem: Grit packing on floor of centre well.

Solution: Isolate the grit trap from the sewage treatment system. Drain the grit trap. Manually clear the grit out.

5.6 Monitoring Performance

Refer to Section 13.0 for monitoring to be undertaken of influent flows at the inlet works.
6.0 Primary Sedimentation Tanks

Section Outline

6.1 General Description
6.2 Operating Goals
6.3 Operation
6.4 Maintenance
6.5 Troubleshooting
6.6 Monitoring Performance

6.1 General Description

There are three primary sedimentation tanks at Williamtown. Primary Sedimentation Tank No. 1 (PST No.1) and Primary Sedimentation Tank No. 2 (PST No.2) are only used to store wet weather flows above 60L/s, or for emergency storage. PST No.3, which is a circular tank, 12.8m diameter and 2.9m deep (Volume 373m³), is the operational unit. Flow goes in through a central feed pipe, out under a baffle and into the main part of the tank, where sludge settles out and the effluent flows over the launder around the edge.

PST No.3 has a rotating half-bridge which carries scraper arms. These move the sludge along the floor of the tank towards the sludge outlet pipe. When the sludge withdrawal pump is operated, the collected sludge is removed.

The feed arrangements for PST No.3 have been set up so that it receives all flows up to 60L/s, and peak flows above that figure will be diverted into the older tanks for storage, to be pumped into the plant again after the peak flows have receded. The handstops at the drop structure have been designed to give the particular flow split, and they could be adjusted to another split arrangement, if it becomes necessary.

6.2 Operating Goals

Sewage sedimentation, after screening and grit removal, is intended to remove, as far as possible, the insoluble, small particles of organic matter. This removal helps the operations that follow. If the suspended solids are not removed they will ruin the trickling filters by blocking the openings between stones of the filter. Once the openings are blocked, ponding, odours, poor treatment and other problems occur which lead to very poor quality effluent.

Proper sedimentation is therefore an important part of the treatment process.

Apart from allowing solids to settle, the quiet conditions in the tank also allow scum and grease to float, which is collected and removed.

Since the sludge is sent to anaerobic digesters, it is important it is at a reasonable concentration; if too much water is pumped out with the sludge, then the digester operation might be affected.

If not enough sludge is withdrawn, or if it is pumped out too few times each day, then the sludge on the floor of the PST can start to digest, producing odorous biogases and making the effluent harder to treat.
6.3 Operation

The PST process carries on working without any operational input because, as long as the incoming flow is not too great, the settlement of sludge and floating of scum happen naturally. Where operation does come in, though, is in the proper settling up of desludging cycles, and of scum removal.

It is important to look at the PST several times each day, check that there are no signs of rising sludge (black lumps floating to the surface), gas production (streams of bubbles rising) or general loss of solids over the weir. The effluent should look quite clean, with only very fine particles visible.

The three-way valve on the sludge delivery should be set so that the pump feeds all the raw sludge directly to digester No. 1. The pump is controlled by two times; one which sets the time between starts, and a second one which sets how long the pump runs after each start. The mono pump should deliver sludge at a rate of 10L/s, and the total daily volume of raw sludge, with recirculated humus sludge, should be somewhere between 7000L and 15000L. The total pumping time each day should thus be somewhere between 12 and 25 minutes. Practically, it may be necessary to pump for longer so that water ahead of the sludge (in the pipes) is purged, and to be sure of pulling some relatively clear sewage into the line behind the sludge. The pumping cycles could be set up in any convenient way, as long as all the sludge gets pumped and doesn’t stagnate in the tank for an excessive period of time. A starting point for the programme would be 4 cycles per day, each 5 minutes long.

If the total pumping time is too short, then sludge will start to rise in the PST, and gas bubbles will be pumped into the digester, so it will be necessary to watch the sludge as it drops from the delivery line into the little feed “pot” on top of the first digester. It should be simple to determine whether the liquid at the end of the pumping cycle is almost clear effluent or whether it is still thick sludge. The ideal situation will be when the sludge which enters the pot has just changed to effluent when the pump stops. It is important to keep checking on the sludge discharge because the amount of sludge varies from day-to-day, as well as during the day. Only by looking at the discharge and at the surface of the PST, it is possible to be sure that the operation is performing correctly.

Operation of the scum wiper on the PST should be automatic, and so should the ejector which transfers the scum. Both of these operations should be checked daily to see that they are working. Cleaning and adjustment are the two activities which will affect scum removal most.

PST No.1 and PST No.2 will be used only in times of peak flows, and excess sewage will be stored in them. When the flow drops, the stored sewage can be pumped into the channel entering PST No.3.

The stored sewage should be sent to PST No.3 as soon as possible so it doesn’t become septic.

After storing sewage, tanks 1 and 2 should be cleaned out to prevent fouling and odours.

In case of emergency or cleaning and repairs of PST No.3, tanks 1 and 2 can store the incoming sewage until the cleaning is done, or the problem is addressed.

6.4 Maintenance

Primary Sedimentation Tank 3 (PST No.3)

- Remove grease and fat regularly from inlet baffles and effluent weirs. Frequency found by experience; start with twice a week.
- Clean scum removal equipment regularly.
• Hose down and remove all waste spills as soon as possible.
• Inspect underwater portion of sedimentation tank regularly, such as once a year.
  i. Dewater the tank; discharge the contents to PST No. and PST No.2
  ii. Inspect all equipment for wear and corrosion
  iii. Replace or repair broken parts
• Flush out pumps and pipelines for a few minutes each week.
• Prepare schedules for lubrication and other routine jobs to be posted on a check-chart system so a record is kept.
• Check vacuum pressure and pressure gauges regularly to make sure there are no blockages in pumps and pumping lines.

Refer to Appendix D (p. 30 – 35 and Lubrication Schedule, p. 35) for further details.

6.5 Troubleshooting

Problem: Floating sludge; sludge decomposing in the tank and then floating to the surface.
Solution:
(i) check for and replace broken flights on scraper
(ii) pump sludge out for greater length of time or pump more often

Problem: Contents of the tank are black and odorous – either due to septic sewage or strong digester supernatant.
Solution:
If septic sewage is the cause (noticeable at rising main):
(i) chlorinate ahead of sedimentation tank to delay and reduce decomposition
(ii) check on sewerage system, especially pump station

If strong digester supernatant is the cause:
(i) correct and improve sludge digestion
(ii) reduce or delay rate of withdrawal of supernatant to tank until quality of supernatant improves
(iii) select better quality supernatant from another zone

Problem: Excessive fouling of surfaces and weirs with sewage solids or growths.
Solution:
(i) more frequent and thorough scrubbing of all surfaces in contact with the sewage
(ii) in very severe cases, pre-chlorination for a short period until problem is under control

Problem: Large amount of sewage being pumped to digesters.
Solution:
(i) reduce the number of times sludge is pumped to the digesters
(ii) reduce the length of time the sludge is pumped

Problem: Blocked pump lines.
Solution:
Regular flushing of the lines and pipes will prevent any serious blockages – flushing blocked line will clear it; or removing a blank flange and rodding

Problem: Clutch coupling overloading – coupling “clacks” from one position to another – due to obstruction in tank.
Solution:
(i) shut down gear motor
Problem: Gear motor has stopped.
Solution: (i) check main power local isolator, motor fuses, control circuit fuses and control panel
(ii) with the local isolator on, press reset button or on button – do NOT use local isolator to start up
(iii) If the above does not solve the problem, remove the gear motor and have it examined by a qualified person for mechanical or electrical failure

6.6 Monitoring Performance

Although it is not essential to have samples tested on primary sedimentation tanks, periodical sampling is useful to the performance of the units.

The three main tests for primary sedimentation tanks are BOD, Total Suspended Solids (TSS) and settleable solids. The BOD and TSS tests need to be done in a laboratory, but settleable solids can easily be measured on the plant. Generally, the BOD of the primary sedimentation tank effluent should be somewhere between 60% and 75% of the raw sewage BOD, and the TSS should be somewhere between 20% and 40% of the raw sewage TSS. If the test results show something very different, especially if the effluent strengths are closer to the inlet values than suggested, then there may be a problem. In addition to BOD, TSS and settleable solids, pH monitoring of the primary sedimentation tanks would be useful in providing data to understand how the plant’s treatment processes impact on pH levels.

The settleable solids test is a simple one. Fill an Imhoff cone with the sample, up to the 1L mark, after mixing the sample well. Let it settle for 45 minutes and then stir in gently around the side with a rod, allow to settle for a further 15 minutes, and read the settled sludge volume. The settled sludge volume of the effluent should be less than 10% of the reading for raw sewage.

Table 2 Summary of Monitoring of Sedimentation Tanks

<table>
<thead>
<tr>
<th>STP Component</th>
<th>Weekly</th>
<th>Monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Sedimentation Tank No. 3 Effluent</td>
<td>-</td>
<td>BOD, pH, Total Suspended Solids, Settleable Solids</td>
</tr>
</tbody>
</table>
7.0 Trickling Filters and Humus Tanks

Section Outline
7.1 General Description
7.2 Operating Goals
7.3 Operation
7.4 Maintenance
7.5 Troubleshooting
7.6 Monitoring Performance

7.1 General Description
A trickling filter is a bed of rocks, or other solid media, on which a layer of slime grows. The slime layer is made up of millions of micro-organisms. Sewage is percolated or trickled down through the filter and, as it moves over the slime layer, the organic material in the sewage is broken down by the micro-organisms. As more wastewater is passed through, the slime layer grows. When it gets too thick the micro-organisms at the bottom do not receive any oxygen and there is no organic material reaching them. These micro-organisms can no longer cling to the rocks and are washed off. This is known as ‘sloughing’ and results in pieces of the slime layer coming out with the trickling filter effluent.

The Williamtown plant has two trickling filters which are fed from the filter inlets. They are the same size with a diameter of 16.46m, a depth of 1.65m and a volume of 351.1m³. Sewage enters at the centre of the filter, up the central column, and through four distributor arms which rotate about a central support bearing. Sewage comes out of the nozzles on the arms and trickles down through the media. When the flow to the filter is below 16L/s the effluent from the humus tanks can be recirculated to make sure the filter is kept wet. If the filter goes without sewage feed for more than a few hours the slime layer will dry out.

The effluent from the trickling filters collects in the underdrains and travels to the humus tanks. Humus tank 1 (the original tank) receives half the flow from trickling filter 1 and filter 2. Effluent in the humus tank moves slowly such that most solid matter falls to the bottom. Clear effluent goes over the weir and on to the chlorination chamber. Humus sludge is withdrawn by a pump for tank 2 and returned to PST No.3, and by a valve for tank 1 and returned to the inlet works.

7.2 Operating Goals
The purpose of a trickling filter is to remove most of the dissolved organic material and fine suspended solids not removed in the sedimentation tank. In the trickling filter organic material is caught and absorbed onto the slime layer and most of the organic matter is converted to carbon dioxide and water. If the load on the filters (measured as kg BOD per m³ for filter media per day) is low enough, then specialised organisms will grow in the slime and convert ammonia to nitrate.

The purpose of humus tanks is to allow most of the solids which come out with the trickling filter effluent to be removed by settling.

The target effluent quality for the combined action of filters and humus tanks is 20mg BOD/L and 30mg TSS/L.
7.3 Operation

The trickling filters must be checked regularly (several times per shift). It is essential that the distributor arms are kept rotating so the filter does not dry up. If the flow from the sedimentation tank is so low that the arms are not rotating then the effluent from the humus tanks will be pumped back into the dosing tanks. There are two pumps in the effluent chamber which are automatically controlled by the inlet flume flow measurement. Both pumps operate continuously until the flow rises to 8L/s where the second pump stops. Should the flow increase to 16L/s the first pump stops and remains off until the inlet flow drops below 14L/s and a 3 minute time delay has expired. The second pump restarts when the flow falls below 6L/s and a 3 minute time delay has expired.

The solid matter that falls out of the trickling filter effluent in the humus tanks is sent to PST No.3 where it will thicken the sludge already present in the sedimentation tank.

Humus tank 1 is equipped with a scraper to move the sludge to the centre for easy withdrawal. Sludge is removed from humus tank 1 by a solenoidal valve which sends the sludge to the pump well, near the disinfection facility, from where it is pumped to the inlet works.

Humus tank 2 is equipped with a scraper which is set by a timer. It should be run as much as possible. The sludge is withdrawn by a monopump and pumped to PST No.3. It should be pumped to PST No.3 unless there is an emergency or the sedimentation tank is being repaired.

The sludge should be removed from both tanks so that it has enough time to settle in the sedimentation tank before the raw sludge is pumped to the digesters. Thus the time for both the valve and the pump should be set from the timer for the sludge withdrawal pump on PST No.3. They should both run for long enough to remove all the sludge but very little effluent. A pumping schedule of four times a day for about 2 minutes each time is likely to be required.

7.4 Maintenance

Filter Inlets:
- The filter inlets should be cleaned regularly with checks for leaking or corroded pipes.
- Slime and grease should be washed from the walls and the piping daily.
- The bottom of the tank should be stirred weekly.

Distributor Arms:
- Orifices or nozzles on the arms should be inspected daily for clogging and cleaned if necessary.
- Bearing must be checked and maintained in accordance with the manufacturer’s instructions.
- Guy rods must be checked to keep the arms in a horizontal position.
- If the filter must be shut down, drain the distributor arms and the central riser pipe by opening the valve at the base of the riser pipes.

Underdrains:
- Inspect periodically to make sure channels aren’t blocked.
- Drains blocked with excessive growth should be hosed clean.
- Particles of rock should not be hosed into humus tanks.
Humus Tanks:
- See maintenance of primary sedimentation tanks in the previous section.
- Refer to Table 3 for lubrication requirements of humus tank components.

### Table 3: Lubrication Schedule

<table>
<thead>
<tr>
<th>Item</th>
<th>Location</th>
<th>Type of Lubrication</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sew R40 SF70</td>
<td>Tank Centre</td>
<td>Sae 90 (BPGR 280-XP)</td>
<td>Check Monthly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N. B. Note gearboxes require lubrication</td>
<td>Change every six months</td>
</tr>
<tr>
<td>Centre Bearings</td>
<td>Drive Shafts</td>
<td>Shell Alvania No. R2 Grease</td>
<td>Two shots every month</td>
</tr>
<tr>
<td></td>
<td>Tank Centre</td>
<td></td>
<td>each nipple</td>
</tr>
<tr>
<td>Frame Bearing</td>
<td>Bottom of Drive Frame</td>
<td>Shell Alvania No. R2 Grease</td>
<td>Two shots every month</td>
</tr>
<tr>
<td></td>
<td>Tank Centre</td>
<td></td>
<td>each nipple</td>
</tr>
</tbody>
</table>

Refer to Appendix D (P.5 – 25 and Lubrication Schedule p. 25) for more information.

### 7.5 Troubleshooting

**Filter Inlets**

Problem: Odours and floating sludge due to decomposing wastewater.

Solution: Stir the bottom of the tank and clean it out more often

**Trickling Filter**

Problem: Filter ponding – when the holes between the filter rocks become completely filled in with slime and the wastewater cannot pass through.

Solution: 
(i) rake or fork the filter surface
(ii) wash filter with stream of high pressure water
(iii) if problem occurs regularly then dose the filter with chlorine several hours/week during low flow

Problem: Filter flies.

Solution: 
(i) remove excessive slime
(ii) flood filter 24hrs at weekly or biweekly intervals
(iii) if the problem is very bad, firstly chlorinate the filter for periods of several hours then if this fails apply insecticide cautiously. Other micro-organisms will suffer from the effects of insecticides

Problem: Odours – due to decomposition of wastewater, sludge or slime.

Solution: 
(i) maintain aerobic conditions in all units including primary sedimentation tank
(ii) reduce accumulations of sludge – pump the sludge out of both the sedimentation tank and humus tanks more often
(iii) reduce unusually heavy loadings
Problem: Filter slime drying out because arms are not rotating well.
Solution: Send greater flow through arms by using the pumps to recirculate humus effluent

Humus Tanks
Troubleshooting for humus tanks is consistent with troubleshooting for primary sedimentation tanks.

Problem: Floating sludge; sludge decomposing in the tank and then floating to the surface.
Solution: (i) check for and replace broken flights on scraper
(ii) pump sludge out for greater length of time or pump more often

Problem: Contents of the tank are black and odorous – either due to septic sewage or strong digester supernatant.
Solution: If septic sewage is the cause (noticeable at rising main):
(i) chlorinate ahead of sedimentation tank to delay and reduce decomposition
(ii) check on sewerage system, especially pump station

If strong digester supernatant is the cause:
(i) correct and improve sludge digestion
(ii) reduce or delay rate of withdrawal of supernatant to tank until quality of supernatant improves
(iii) select better quality supernatant from another zone

Problem: Excessive fouling of surfaces and weirs with sewage solids or growths.
Solution: (i) more frequent and thorough scrubbing of all surfaces in contact with the sewage
(ii) in very severe cases, pre-chlorination for a short period until problem is under control

Problem: Large amount of sewage being pumped to digesters.
Solution: (i) reduce the number of times sludge is pumped to the digesters
(ii) reduce the length of time the sludge is pumped

Problem: Blocked pump lines.
Solution: Regular flushing of the lines and pipes will prevent any serious blockages – flushing blocked line will clear it; or removing a blank flange and rodding

Problem: Clutch coupling overloading – coupling "clacks" from one position to another – due to obstruction in tank.
Solution: (i) shut down gear motor
(ii) remove the obstacle

Refer to Appendix D, for more information.

Problem: Gear motor has stopped.
Solution: (i) check main power local isolator, motor fuses, control circuit fuses and control panel
(ii) with the local isolator on, press reset button or on button – do NOT use local isolator to start up
(iii) If the above does not solve the problem, remove the gear motor and have it examined by a qualified person for mechanical or electrical failure

7.6 Monitoring Performance

The tests which are to be carried out on the primary sedimentation tank can also be carried out on the trickling filter. The BOD measurement is the most important with a large decrease expected in the BOD of the effluent as compared to the influent.

A simple test, easily performed at the plant, is measuring the pH. This is done with a pH meter and should be checked periodically to make sure the pH is remaining between 6.5 and 8.5 (for most effective operation of trickling filters). Whenever toxic or septic waste is suspected the pH should be taken to see how the trickling filter is handling the situation.

The settleable solids test should be carried out on the humus tank influent and effluent. This gives a clear idea of how well the solids are settling in the tank. The test should be done regularly on both tanks. A suggested monitoring regime is described in Table 4.

Table 4: Suggested Monitoring of STP Humus Tanks

<table>
<thead>
<tr>
<th>Humus Tanks Monitoring Location</th>
<th>Monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>pH</td>
</tr>
<tr>
<td></td>
<td>Settleable Solids</td>
</tr>
<tr>
<td></td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>Effluent</td>
<td>pH</td>
</tr>
<tr>
<td></td>
<td>Settleable Solids</td>
</tr>
<tr>
<td></td>
<td>BOD</td>
</tr>
<tr>
<td></td>
<td>Total Suspended Solids</td>
</tr>
</tbody>
</table>
8.0  Sludge System

Section Outline
8.1  Principles of Anaerobic Digestion
8.2  General Description
8.3  Operating Goals
8.4  Operation
8.5  Maintenance
8.6  Troubleshooting
8.7  Monitoring Performance

8.1  Principles of Anaerobic Digestion

Sludge produced by the primary sedimentation and trickling filter processes is treated in two anaerobic sludge digesters and disposed offsite.

The raw sludge consists mainly of putrescible organic material which cannot be disposed of untreated without creating objectionable odours. The sludge is therefore treated (stabilised) by anaerobic digestion. Commonly, two digesters are operated in series. Most of the treatment occurs in the first (primary) digester, and the secondary digester acts mainly to thicken the treated sludge before drying:

![Anaerobic Digestion Diagram]

Anaerobic digestion is a biological process carried out by bacteria in the absence of free oxygen. Two steps are involved and these are carried out simultaneously by two different groups of bacteria known as the acid formers and the methane formers:

- **Complex Organics** → **Acid Forming Bacteria** → **Organic Acids** → **Methane Forming Bacteria** → **Methane + Carbon Dioxide**

The acid formers use the organic solids for food. In the process they solubilise a percentage of solids and produce so-called volatile fatty acids such as acetic acid. The methane formers use these acids...
as food, converting most of the acids to the gasses, methane and carbon dioxide. Overall, sludge stabilization comprises conversion of putrescible organic solids to methane and 40% carbon dioxide. The sludge residue consists of inorganic solids, non-biodegradable organic solids and bacterial cells. Digestion efficiency is usually judged by the percentage reduction in volatile solids. Common reductions are 50-60%.

The efficiency of the digestion process is affected by the residence time of sludge in the digester, particularly in the primary digester. The time required is governed by the methane formers, which cannot grow as fast as the acid formers. Maximum growth rates are affected by environmental conditions in the digester, particularly pH, temperature and the presence of substances which are toxic or inhibitory to the bacteria. The most common toxins are heavy metals. Oxygen is toxic to the methane formers and their growth is inhibited by high levels of volatile acids.

pH is a particularly important parameter. The methane formers grow best in the pH range 6.6 – 7.6. The acids produced by the acid formers tend to depress the pH but removal of the acids by the methane formers keeps the pH in the right range. If the concentration of volatile acids in the digester increases, perhaps because of the introduction of substances toxic to the methane formers, or because the rate of acid production suddenly increases following an increase in the rate of sludge feed, the pH falls. Both the low pH and the high concentration of volatile acids are unfavourable to the methane formers. The digestion process may then fail completely, with acid sludge, lack of gas production and foul odours. Digesters in this condition are often referred to as “stuck”.

The optimum sludge temperature is 35°C, which is frequently achieved by heating the digester. At lower temperatures bacterial growth rates are slower and longer sludge residence times are necessary. Common residence times used in primary digesters are 15 days at 35°C and 25-30 days at 20°C.

Good mixing of the digester contents is also important. This distributes the feed sludge, maintains uniform conditions throughout the digester and prevents the occurrence of dead volume within the digester. It also minimises the formation of a layer of scum at the surface and a layer of settled solids, particularly grit, on the floor. Without effective mixing these layers can build up and seriously reduce the active volume of the digester. Secondary digesters, which are generally unmixed, stratify into three layers – a lower layer of thick digested sludge, a middle layer of relatively clear supernatant and a surface layer of scum.

8.2 General Description

There are two digesters, each with total volumes of 200m³. Raw sludge is pumped to the digesters by pumps PS1 and PS2 at PST No. 3. Digested sludge is discharged to the disposal channels and supernatant is returned to the plant inlet via a humus sludge pump station.

Digester pipe work is arranged to allow three main modes of operation. In the normal mode the northern digester acts as a primary and the southern digester acts as a secondary. Alternatively, if the residence time in the primary digester is too short, both digesters can be operated in parallel as primaries. In addition, if either digester is out of service for maintenance, the other digester can be operated as a primary alone.

The digesters are provided with a sludge recirculation type of mixing system but are not heated.
They are fitted with conical concrete roofs open at the top. There is no provision for gas collection. The roofs help to reduce scum problems by minimising the surface area exposed to the air and concentrating gas flow at that location. They also minimise blockage problems in gravity transfer pipe work by increasing the rate of change of water level in the digester and thereby increasing velocities in the piping.

Pipe work incorporates blank flanged tees and flanged bends to facilitate clearance of blockages. Non-potable water connections are provided to the discharge side of the four pumps. The digesters are fitted with side-mounted manholes for maintenance access.

Digester pipe work is shown on plant drawings NH85/368 and 369 in Appendix D. Digester process and instrumentation diagrams are shown in Figures C3 and C4 in Appendix C. There are two sets of pipe work which are almost independent of each other. The feed and decanting pipe work shown in Figure C3 and Drawing 368 is the piping system used in normal mode of operation for sludge feed and supernatant return. The sludge circulation and withdrawal piping shown in Figure C4 and Drawing 369 is the system used for mixing of the primary digester and discharge of sludge for disposal offsite.

Refer firstly to Figure C3. In the normal mode of operation raw sludge is fed to the primary digester by pumps PS1 and PS2. At the same time the digested sludge automatically overflows to the secondary digester via the withdrawal piping, overflow bellmouth and sludge transfer pipe. While this is happening, supernatant builds up in the secondary digester. Based on experience, the operator should regularly transfer supernatant from the secondary digester back to the inlet works. The supernatant transfer should be carried out at least every 9-10 days using pumps PS13 and PS14.

Piping is also provided to allow scum from either digester to be discharged to the pump well and then disposed offsite. Emergency overflow piping on both digesters will operate if the withdrawal pipe becomes blocked.

Refer now to Figure C4. Normally only the primary digester will be mixed while the secondary digester acts as a sludge thickener. Sludge pumps PS11 and PS12 mix the primary digester via the main circulation draw off and circulation inlets. A subsidiary draw off pipe is provided for use should the main draw off become blocked. Sludge can be circulated into the sides of the digester, into the hopper at the bottom or onto the scum layer on the top. The secondary digester can also be mixed as desired to mobilise the scum or sludge layers.

Pumps PS11 and PS12 are also used to transfer digested sludge from the secondary digester to the disposal channels via the main subsidiary sludge draw off pipes.

The other two modes of operation referred to above can be traced on the process flow diagrams. The piping also allows other operating techniques to be used. For example, sludge can be transferred between digesters in either direction using the sludge pumps PS11 and PS12, and sludge can be pumped to the discharge channels using PS13 and PS14. These variations are not discussed further in this manual.

8.3 Operating Goals

The basic goal is to treat and dispose of sludge from the treatment plant in an economical and environmentally acceptable manner.

Specifically:

1) Digesters and discharge channels should be non-odorous
2) The quantity of digested sludge should not overload the discharge channels
3) Supernatant and filtrate returned to the treatment plant should not cause operating or effluent quality problems
4) Sludge should be disposed in a manner which does not cause problems with respect to pathogens or nutrients

8.4  Operation

Only the usual mode of operation will be described. The same general principles apply to the alternative modes.

8.4.1 Normal Operation

The keys to successful digestion are adequate detention time, effective mixing of the primary digester, and uniform feeding.

1) On the sludge feed and decanting system (Figure C3) set the valves and pumps as follows:

Raw sludge feed
- Set V10 to direct feed to the northern digester (No.1).

Digested sludge transfer
- Adjust the overflow bellmouth on digester 1 to RL 8.9 (250mm below the digester overflow pipe and 400mm below the top of the overflow box). The bellmouth will have to be lowered a little if it is found in operation that the sludge level rises to the digester overflow when sludge transfer between digesters is occurring.
- Set V23 to direct flow from the overflow box through the sludge transfer pipe.

Supernatant decanting
- Adjust the overflow bellmouth on the secondary digester (No. 2) to RL 8.3 (1000MM below the top of the overflow box). This will provide sufficient head between digesters 1 and 2 for transfer of sludge and will allow the overflow box on digester 1 and most of the transfer pipe to drain between sludge feeding cycles.
- Open V26 so that supernatant is decanted from the middle of the digester between scum and sludge layers and from a location separated as far as practicable from the sludge inlet pipe. Close valves V24, V24A, V25, V27 and V28.
- Open V29.
- Set V30 to direct supernatant from the overflow box to the pump well.
- Set V48 and V38 to direct pump well overflow to the discharge channels.
- Open V56.
- Set PS13 or PS14 to AUTO and the other to MANUAL. The duty pump can be rotated daily or weekly to approximately equalise operating hours.

2) On the sludge circulation and withdrawal system (Figure C4), set the valves and pumps as follows:

Mixing of Primary Digester
- Open valve V35 and close valve V36 to withdraw sludge from the floor.
If running pump PS11 set V37 to direct flow from the digester to the pump. If running PS12, set V37 and V47 to direct flow to that pump.

If running pump PS11 set V39 to direct pumped flow to digester 1. If running PS12 set V49 and V39 to direct pumped flow to digester 1. Close V52.

To provide the most effective mixing, it is suggested that the three side inlets and the top inlet be operated alternately one day at a time. The floor inlet need only be used if it is desired to stir up settled solids. As an example of valve settings, if V31 is being used, open V31 and close V32, V33, V34 and V40.

On the secondary digester, close V41-V46, and V50.

Run PS11 or PS12 24 hours per day.

Transfer of Digested Sludge to Discharge Channels and Disposal Offsite

- Stop recirculation on digester 1.
- Set V37 and V47 to allow PS11 or PS12 to withdraw sludge from digester 2.
- Open V45. Use V46 only if V45 is blocked.
- Set V39 and V49 to direct sludge to the drying beds.
- Open V52.
- Run PS11 or PS12.

3) The operating procedure is as follows:

- Set up PS1 or PS2 to feed raw sludge on time clock control (see Chapter 6).
- Run PS11 or PS12 continuously on recirculation duty on the primary digester. Change the inlet daily as indicated in 2 above.
- Set up PS13 or PS14 to return supernatant on AUTO as indicated in 1 above.
- Stop recirculating sludge and use PS11 or PS12 to transfer a predetermined quantity of digested sludge from digester 2 to the discharge channels, as explained in 2 above. Sludge should be transferred from the secondary digester as required. It is the responsibility of the operator to initiate the discharge of sludge from the secondary digester when the sludge level nears its upper limit. To identify if the sludge level needs discharging, the operator should determine if sludge is present in the supernatant upper layer of the secondary digester by discharging supernatant from the upper withdrawal valve. If sludge is observed in the supernatant, the sludge level is near to its upper limit and the operator should commence the sludge disposal process.

- Sludge should be collected from the discharge channels by a truck equipped with storage and pumping facilities as it is discharged from the secondary digester. The sludge needs to be analysed for chemical components and graded using benchmark criteria (NSW EPA guidelines) so that it can be disposed offsite using acceptable methods.

4) When transferring digested sludge to the discharge channels, the volume pumped should be set by running PS11 or PS12 for a preset time under timer control. The important parameter is the ratio of the volume of digested sludge transferred to the discharge channels to the volume of raw sludge fed to digester 1. Because PS1 and 2 and PS11 and 12 are positive displacement units and are all the same size, the ratio of pumping times can be used instead of volumes.

The principle revolves around the thickening behaviour of the secondary digester:
$Q = \text{raw sludge flow, kL/d}$
$Q_s = \text{supernatant flow, kL/d}$
$Q_d = \text{digested sludge flow, kL/d}$
$C_o = \text{solids concentration in raw sludge}$
$C_1 = \text{solids concentration in digested sludge}$
$C_s = \text{solids concentration in supernatant}$
$C_d = \text{solids concentration in thickened digested sludge.}$

$C_s$ is small compared with $C_d$ and can be ignored for the purpose of control. A mass balance on digester 2 gives:

$$QC_1 = Q_d C_d$$

$$\therefore Q_d = \frac{QC_1}{C_d} \quad (1)$$

Assuming that the raw sludge solids are 70% volatile and that 50% reduction of volatiles occurs in digester 1:

$$C_1 = 0.65C_o$$

$$\therefore Q_d = Q \frac{0.65C_o}{C_d} \quad (2)$$

The mass of solids transferred to the discharge channels is essentially equal to the mass of solids entering digester 2. If the volume transferred ($Q_d$) is reduced, the concentration of thickened solids ($C_d$) must increase. This is achieved by an increase in the depth of the sludge layer in the digester, which produces greater thickening. Thus the volume withdrawn each day sets the concentration in the sludge withdrawn, and this in turn sets the depth of the sludge layer. If insufficient sludge is withdrawn the depth of the sludge layer will increase until sludge appears at the supernatant off take.

The volumes to be withdrawn can be calculated from equation (2). Volume can be converted to time recognising that the feed and withdrawal rates are both the same (10L/s of 864 kL/d rate):

$$t_d = t \frac{0.65C_o}{C_d}$$

where $t_d = \text{pumping time for PS11 or PS12}$
$t = \text{pumping time for PS1 or PS2}$

Initially, assume $C_o = 2\%$ solids, and that the sludge layer will be of satisfactory depth if $C_d = 5\%$.

$$\therefore t_d = 0.26t$$
If $t$ is set at 20 minutes per day, $t_d$ should be set at 5 minutes per day. Initially, try withdrawing digested sludge for 15 minutes every third day. This would represent 9kL of sludge. Adjust the operating time based on the behaviour of the secondary digester.

5. Sludge analyses should be conducted regularly to detect the first sign of process upset. Refer to 8.7 below. Corrective action is similar to process start up (see 8.4.2 below).

The depth of scum and settled solids layers in both digesters can be checked by running sludge from the various withdrawal lines.

6. Naked flames should not be allowed near the open tops of the digesters. Digester gas will be concentrated in these areas and 5-15 % of methane in air forms an explosive mixture. Oxygen levels will also be low within the open digester tops (probably too low to breathe).

### 8.4.2 Digester Start-up

The digestion process must be started up slowly so that the growth of methane formers is not outstripped by acid production. The principle involved is to keep the daily ratio of feed solids to digester solids constant as the digester solids build up. The load can be gradually increased each day until full load is reached. The procedure is as follows:

1) Fill the digesters with water or sewage.
2) Seed the primary digester with as much sludge as possible from an operating digester. If seed sludge is not available the start-up time will be much extended.
3) Operate the mixers in the primary digester continuously.
4) Based on measured or calculated solids concentrations in the primary digester and the raw sludge, feed sufficient raw sludge each day to keep the solid ratio at about 0.10 kg feed solids/kg digester solids per day.
5) The digester solids concentration will now begin to increase. Measure or estimate the solids concentrations daily and increase the load correspondingly. It will take some weeks or even months to achieve full load. The expected daily increase in solids concentration in the digester can be calculated from the following equation (derived from a mass balance around the digester):

\[
\frac{\Delta C_1}{\Delta t} = \frac{1}{\theta} (C_o - \frac{1}{C_1}) - K
\]

Where

- $C_o$ = solids concentration in raw sludge
- $C_1$ = solids concentration in digester
- $\Delta t$ = residence time in digester at prevailing raw sludge feeding rate
- $K$ = solids degradation rate, say 0.04d$^{-1}$

\[
\frac{\Delta C_1}{\Delta t} / C_1
\]

is the daily increase in $C_1$ as a fraction of the current $C_1$ value.

6) The solids accumulation rate will increase if mixing is stopped prior to sludge feeding so that less solids are lost to the secondary digester. If solids loss in the primary digester effluent is negligible:

\[
\frac{\Delta C_1}{\Delta t} / C_1 = \frac{1}{\theta} (C_o - C_1) - K
\]
In this case, if the start-up technique is to maintain a constant solids ratio as in 4 above, the digester solids will grow at a constant percentage per day.

7) Monitor operating conditions in the primary digester daily. Measure volatile acids, alkalinity, pH, and solids concentration. The key indicator of stress is the ratio of volatile acids (VA) to total alkalinity (TA). VA is expressed as mg/L of equivalent acetic acid, TA as mg/L of equivalent calcium carbonate. The VA/TA ratio should not exceed 0.5 and preferably be below 0.3. If it is higher then pH is likely to fall and process failure ensues. In that case, reduce or stop the daily feed to bring the ratio down.

On the other hand, if the VA/TA ratio is much lower than 0.3, the feed rate can be increased to shorten the start-up period.

A simpler alternative to VA measurements is a modification of the TA test:

Total Alkalinity (TA) – determined by titrating down to pH 4.3.
Partial Alkalinity (PA) – titrate down to pH 5.75
Intermediate Alkalinity (IA) – titrate from 5.75 to 4.3.

PA is a measure of bicarbonate alkalinity and IA is a measure of volatile acid concentration. Thus the IA/PA ratio can be used in place of VA/TA. Corresponding ratios are:

<table>
<thead>
<tr>
<th>VT/TA</th>
<th>IA/PA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>0.43</td>
</tr>
<tr>
<td>0.5</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Thus maintain IA/PA below 0.4 – 0.7 during start-up.

8) If complete process failure occurs and pH does not rise with resting, correct the pH by adding an alkali to the digester. Lime, caustic soda or sodium bicarbonate can be used. If lime is used pH cannot be raised much above 6.5 because of precipitation of calcium carbonate (avoid overdosing). Dose gradually and mix the chemical uniformly by operating the mixing system continuously. Begin gradual feeding again and monitor pH. If the process still does not recover because of high acid levels, dilute the digester contents with water or sewage or remove part of the contents and refill with water or sewage.

Recovery from a process upset is similar to start-up. It is evident that start-up and recovery from an upset are lengthy and troublesome operations. It is therefore essential that regular process monitoring be carried out so that the first sign of stress can be detected and corrective action taken.

8.5 Maintenance

The maintenance program for the sludge circulation pumps and controls is shown in Section 16.0 (Table 11 and Table 12). To ensure a good quality biosolid material is produced it is recommended that a full clean (de-sludge) is undertaken to remove all materials from the primary and secondary digesters using an appropriately qualified contractor. A complete de-sludge would provide the following benefits:

1) Remove any remanent contaminants (e.g. heavy metals) from the base of the digesters which may contaminate incoming sludge material
2) Ensure maximum digester volume is available by removing build up of any sand and grit material.

Following the de-sludging process digester start up procedures as outlined in the Operation and Maintenance Manual should be undertaken. It is further recommended that full de-sludging of the digesters is undertaken every 4-5 years.

8.6 Troubleshooting

A range of possible problems which may occur in the digestion process, their causes and potential solutions are shown in Table 5.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Cause</th>
<th>Possible Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatile acids rise, pH falls</td>
<td>Sudden increase in sludge load. Toxic material in sludge. Aeration of digester.</td>
<td>Reduce load then increase gradually. Transfer seed sludge from secondary digester. Add alkali. Dilute digester contents to reduce acid level. Identify toxic material and dilute or remove chemically. Identify source and prevent further discharge. Stop aerating.</td>
</tr>
<tr>
<td>Ejected sludge odorous</td>
<td>Insufficient digestion time caused by excessive feed sludge volume, or scum or grit accumulation.</td>
<td>Reduce raw sludge pumping time. Remove scum or grit.</td>
</tr>
<tr>
<td>Supernatant has too many solids</td>
<td>Sludge layer too high. Scum excessive. Short-circuiting between secondary digester inlet and outlet.</td>
<td>Increase digested sludge pumping time. Use alternative supernatant withdrawal pipe. Mix secondary digester temporarily to reduce scum. Remove scum. Modify pipe work to provide low inlet.</td>
</tr>
<tr>
<td>Drying beds overloaded</td>
<td>Digested sludge too thin. Sludge load too high.</td>
<td>Reduce digested sludge pumping time (and possibly use higher supernatant pipe). Extend drying beds.</td>
</tr>
</tbody>
</table>
8.7 Monitoring Performance

The suggested sampling program required to monitor the condition of the digestion process and the effect of supernatant return on the treatment plant is shown in Table 6. Additional tests will be required during start-up and when abnormal conditions are detected.

Table 6: Suggested Sampling Program for Digesters

<table>
<thead>
<tr>
<th>STP Component</th>
<th>Weekly</th>
<th>Monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Digester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw Sludge</td>
<td>Settleable Solids</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>Mixed Sludge</td>
<td>pH</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td></td>
<td>Temperature</td>
<td>Volatile Solids</td>
</tr>
<tr>
<td></td>
<td>Settleable Solids</td>
<td>Volatile Acids</td>
</tr>
<tr>
<td></td>
<td>Partial Alkalinity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intermediate Alkalinity</td>
<td></td>
</tr>
<tr>
<td>Secondary Digester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supernatant</td>
<td>Settleable Solids</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td></td>
<td>¹</td>
<td>BOD</td>
</tr>
<tr>
<td>Thickened Sludge</td>
<td>-</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volatile Solids</td>
</tr>
</tbody>
</table>

NOTES:

1) See Section 8.4.2 above.

It is recommended that biosolids monitoring include stabilisation grading and contaminant grading. Stabilisation grading enables classification of biosolids for land application, providing increased opportunities to pursue a range of biosolids disposal paths. Biosolids sampling should generally be implemented to satisfy Schedule 2 of the NSW EPA Publication (1997) Use and Disposal of Biosolids. This shall include such things as sampling location, sampling collection and equipment, record keeping and custody tracking, and transportation.
Biosolids sampling frequencies are determined based on flow data and sediment loading. Assuming a flow rate of 20L/s, detailed sampling is required approximately every 580 days (based on 100 kg dry solids/ML¹). Based on the nature of activities upstream of the STP, it is suggested that biosolids monitoring, including both contaminant and stabilisation grading, is undertaken every four months.

Table 7: Suggested Biosolids Monitoring for Secondary Digester

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Cadmium¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Chromium¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Copper¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Lead¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Mercury</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Nickel¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Selenium¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Zinc¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Moisture %</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Nitrite as N³</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Nitrate as N³</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen as N³</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Total Phosphorus as P³</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Reactive Phosphorus as P³</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Oil and Grease (mg/kg)⁴</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Total Petroleum Hydrocarbons (TPH)⁵</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>C₆-C₉</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>C₁₀-C₁₄</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>C₁₅-C₂₈</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>C₂₉-C₃₉</td>
<td>Every Four Months</td>
</tr>
</tbody>
</table>

Notes:
1) Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium and Zinc must be tested as their concentrations directly impact biosolids reuse/disposal opportunities
2) Moisture content is determined to identify actual volumes of dry solids transported from plant
3) Nutrient analysis is important to determine the nutrient cycle and disposal pathways throughout the STP
4) Oil and grease to determine efficiency of upstream physical separators
5) TPH analysis due to previous levels exceeding ANZECC trigger values and to provide an indication of the efficiency of the TWTP

¹ Metcalf & Eddy, 4th Edition, Pg 1456
9.0 Odour Control

Section Outline
9.1 General Description
9.2 Operating Goals
9.3 Operation
9.4 Shutdown Procedure for Chemical Dosing Units
9.5 Troubleshooting

9.1 General Description

Sewage within wastewater reticulation systems over a period of time can become septic or anaerobic. Under anaerobic conditions, thiobacillus bacteria located in the slime layer along the wall of the reticulation pipework reduce sulphates to aqueous hydrogen sulphide. Solubility limitations and turbulence can result in the release of hydrogen sulphide gas which is in turn oxidised by bacteria on surrounding structures to form corrosive sulphurous and sulphuric acids. Thus, where anaerobic conditions occur, there are often associated odour and corrosion problems within a wastewater reticulation system.

9.2 Operating Goals

OCS Australia Pty Ltd provided a magnesium hydroxide dosing system at the RAAF WLM PS 189 which discharges raw wastewater to the RAAF WLM STP. The dosing system is designed to inject magnesium hydroxide liquid (MHL) into the well of PS189 to control septicity (odour and corrosive conditions) in the wastewater reticulation system.

9.3 Operation

The dosing pump is controlled by a Programmable Logic Controller (PLC) which is configured to dose the MHL at rates which are commensurate with the existing flows. This is done on a triurnal basis over a 24 hour period. The dosing function is independent of the operation of the wastewater pump. The dosing system consists of the following components:

1) Storage Tank
2) Concrete slab and bund
3) Steel framed clad enclosure
4) Dosing pump and hosing
5) Control cabinet and switchboard
6) Mixing system
7) Carrier water system

1) Storage Tank
The tank is a “Nylex Rotomould” type which is manufactured from polyethylene and is 1500 litre capacity. It is fitted with a bottom filling connection, a drain connection and an overflow pipe. The tank is free standing inside the bunded area.

2) Concrete Slab
The slab for the 1500 litre unit is 3.0m x 3.0m and has walls made from concrete blocks up to 450mm high. The bund is drained to a sewer through a PVC ball valve contained in a surface box located adjacent to the pathway.

3) Steel Framed Clad Enclosure
The enclosure comprises an engineer-designed RHS frame clad with “Kliplock” sheeting. The enclosure is ventilated through a roof-mounted ventilator. The enclosure is finished in a Colorbond “Wilderness”. Shed frames are secured to the bund wall using Dyna-Bolts.

4) Dosing Pump and Hosing
This unit uses an OCS-4 type pump incorporating a Dema peristaltic pump. It has a nominal rate of 20 litres/hour. The OCS-4 pump is lubricated using non-petroleum silicon grease. The suction hose is ½ helistell hose on a PVC float. The delivery is a direct connection of the peristaltic hose through a 20mm non-return valve into the carrier water hose.

5) Control Cabinet & Switchboard
The control panel houses the Programmable Logic Controller (PLC) and all switching needed to operate the MHL dosing system. The control cabinet is fed from a circuit breaker in the main switch room adjacent to the dosing system. The operation of the dosing pump, mixer system and carrier water solenoid is controlled through the control cabinet. All functions are automated but can be run in manual mode for testing purposes. The solenoid valve and dosing pump operation are directly linked. The heart of the control is a Siemens’ “LOGO” PLS. This is programmed with a number of functions including:

a) Timed operation of the dosing pump – three (3) different dosing rates commensurate with the respective sewer flow rates.

b) Integrated operating of the carrier water solenoid valve

c) Timed operation of the mixer systems

d) PLC parameters can be adjusted on-site

Controls:

- **Local Isolator** – controls power for the dosing controls – “ON” or “OFF”
- **Pump Control** – a “MAN – OFF – AUTO” switch which allows for manual or automatic operation of the dosing pump. Normal operation is in “AUTO” mode; however, for testing purposes the switch can be set to “MAN”. When the switch is then turned to “AUTO” mode, the pump and carrier water will operate for one (1) cycle at the present time then revert to the cyclic operation as set.
- **Mixer Control** – a “MAN – OFF – AUTO” switch which allows for manual or automatic operation of the mixer unit. Normal operation is in “AUTO” mode, however for testing purposes the switch can be set to “MAN”. When the switch is in “MAN” mode, the mixer will operate continuously. When the switch is then turned to “AUTO” mode, the mixer will operate for one (1) cycle at the present time then revert to the cyclic operation as set. Long run times in manual mode should be avoided as it can alter characteristics of the MHL. Inside the cabinet is the main switch, a circuit breaker for the lighting and an ELCB circuit breaker for the 240 volt GPO (which is mounted on the side of the cabinet). The GPO is used during the tank filling operating.

6) Mixing System
An automated mixer is fitted to the top of the tank. The operation of the mixer is controlled by the PLC which operates the mixer for around 1 minute every 8 hours. Mixing is required to maintain a suitable consistency of the MHL.

7) Carrier Water System
The MHL is injected into a carrier water system which dispenses the product more evenly. Control of water usage is achieved with a solenoid valve which regulates the water flow and operates in conjunction with the dosing pump. A 20mm ball valve is fitted in line before the solenoid valve. It has been set at partially open to restrict the volume of the flow. The carrier water hose is 20mm TMP reinforced PVC hose. A backflow prevention device is fitted to the mains water system. A siphon break has been fitted to the carrier water hose after the injection point. This allows the hose to empty after water has shut off and stops the hose from being collapsed.

9.4 Shutdown Procedure for Chemical Dosing Units

There is a labelled isolation switch for the MHL dosing in the pump station electrical switchboard. There is also a local isolator on the front panel of the control cabinet. Switching either switch to the “OFF” position will shut down the dosing unit.

9.5 Troubleshooting

1) One of the drawbacks with MHL is its tendency to clog the pathways during dosing. As a consequence, frequent checking of the lines is important. Blockages can usually be cleared with a blast from a water hose. Individual parts to check are:

- Suction line – Can be removed from the pump by undoing the hose clamps. It should be removed to a drain and flushed with water. Beware of excess product attached to the line – allow it to drain off.
- Peristaltic hose – the suction and delivery fittings need to be removed first. The peristaltic hose can be removed by carefully removing the five (5) screws in the pump faceplate and removing the face plate. The peristaltic hose can then be removed by simply pulling it out carefully. It can be flushed out with water.
- Reflux Valve – This valve, one removed from the hose assembly, should be inspected for signs of debris which may prevent the valve from sealing. The valve should be washed thoroughly in water, ensuring all debris is removed. If necessary, the valve sections can be separated to allow removal and cleaning of the valve poppet and spring.
- Re-assembly is the reverse of the disassembly. Ensure that the suction line is at the left hand side of the pump. The roller cam rotates in a clockwise direction.

2) Operation of the mixer is automatic and should not give any problems.

3) The carrier water flow is controlled by the electric solenoid and the isolating ball valve. The ball valve is used to restrict the volume of the water flow. If there is no water flowing during dosing, check the following:

- Water flow – check water main valve is open etc.
- Solenoid valve – can the valve be heard “clicking” when operated.

For additional information or assistance from OCS staff, refer to the Magnesium Hydroxide Dosing System Operation Manual March 2007.
10.0 Disinfection Facility

Section Outline

10.1 General Description
10.2 Operating Goals
10.3 Operation
10.4 Maintenance
10.5 Troubleshooting
10.6 Monitoring Performance

10.1 General Description

Chlorination is a means of disinfection used to destroy pathogenic (disease-causing) organisms in the effluent. Chlorination is the most commonly used method of disinfection and involves uniform mixing of chlorine with the effluent followed by a contact time to allow destruction of pathogens to occur. The chlorine dose rate allows for a residual free chlorine concentration in the effluent at the end of the contact period.

Disinfection is provided by a sodium hypochlorite dosing facility, and a chlorine contact tank. Effluent from the humus tanks travels to the effluent chamber where it is chlorinated at the inlet to the chlorine contact tank. The chlorination dosing system consists of a circulation pump, a Dulcotest CTE chlorine probe, a BJC pH sensor, a Dulcometer D2C analyser/controller, and a sodium hypochlorite tank (ref. Figure A1). Chlorine concentration levels are measured and controlled using this dosing system. The chlorine contact tank is rectangular and contains 6 baffles which provide an average contact time of approximately 120 minutes. Sodium hypochlorite is dosed at the base of the weir centre at the start of the contact tank, where it is well mixed prior to reaching the sampling point at the end of the first baffle (ref. Figure A2). The distance of the sampling point from the dosing point allows the chlorine to be sufficiently dispersed into the effluent before sampling, however it is close enough to reduce the impact of flow fluctuations within the contact tank.

10.2 Operating Goals

The disinfection system should be operated to reduce faecal coliform readings at the contact tank outlet to less than 200 CFU/100ml. A target total chlorine residual of between 1 and 3 mg/L at the contact tank outlet ensures that adequate disinfection of pathogenic material has been achieved without waste of chlorine, or excessive hazard to the receiving stream.

10.3 Operation

A circulation pump collects effluent from the contact tank and distributes a proportion of it for sampling by the chlorine probe. The chlorine probe measures total chlorine concentration. As the chlorine permeates the probe membrane, it reacts electrochemically with the membrane electrode, producing an electric signal proportional to the chlorine concentration. The probe has a measuring range of 0.01 to 10 mg/L, and a pH range of 6.5 to 9.5. The temperature range for sampling is between 5 and 45°C, and the pressure should not exceed 3 bar.

These measurements could be interfered with by a number of compounds including oxidizing and reducing reagents.

The Dulcometer, which communicates with the chlorine probe, analyses the probe readings and controls the dosing process. The Dulcometer has a number of settings which control the dosing process. These include:
- Set point (optimum chlorine value)
- Maximum pulse rate
- $xp$ value (defines the deviations either side of the set point which activate the maximum pulse rate)
- $Ti$, the time integral (or time step) for which the pulse rate is altered

Importantly, an iterative approach has been used to define these settings. Since the installation of the disinfection facility, samples of effluent at the CCT outlet have been analysed to compare chlorine concentration and the presence of pathogens. The target criterion is 100% removal of pathogenic material. System settings have been approximated using this ‘trial and error’ approach. The operator has determined from experience that total chlorine concentrations at the outlet of the CCT of between 1 and 3 mg/L provide effective disinfection of the treated wastewater.

When a chlorine concentration is returned which is a deviation from the set point, the pulse rate will be adjusted either up or down as necessary. If the concentration at the next time step returns to the set point, the pulse rate at the previous time step will be retained. However, if the reading remains deviated, the pulse rate will increase or decrease until the set point is achieved.

The pulse rate varies according to a linear relationship associated with the $xp$ value and probe range, and the deviation of the probe reading from the set point. The $xp$ value represents a percentage of the probe range. It is used to establish upper and lower bounds either side of the set point with which the maximum pulse rate is activated. If for example the $xp$ is 10%, then when the chlorine reading is 10% of the probe range (for example, 10 ppm) away from the set point (ie 1 ppm away), 100% of the maximum pulse rate will be achieved. If the chlorine reading is 0.5 ppm away from the set point, 50% output is achieved.

The extracted effluent which does not go to sampling is passed into the dosing line. The sodium hypochlorite is pumped into this line, mixing with the effluent prior to entering the contact tank. The dosing line is discharged at the base of the weir centre at the start of the contact tank, where it is well mixed.

Equipment operational manuals suggest that the chlorine analyser should be checked against the reading of a chlorine test kit once a week. In the case of an error, a chlorine calibration should be performed. A ‘slope calibration’ setting can be adjusted to calibrate the chlorine analyser. For more information on dosing settings and maintenance, such as cleaning and calibration procedures, refer to the operating manual provided by Prominent (supplier of the sodium hypochlorite dosing system).

10.4 Maintenance

The float device on the side of the sodium hypochlorite tank should be checked regularly to ensure that sufficient storage is available for effective disinfection. Provisions should be made to restore full supply when the storage level falls below the quarter tank level. If failure or damage to the disinfection facility occurs, advice from Prominent should be sought. An appropriate arrangement for ongoing maintenance should also be made with Prominent.

Refer to the supplier’s operating instructions in Appendix F (section 2, p16) for further details on maintenance requirements.
10.5 Troubleshooting
Refer to the suppliers operating instructions in Appendix F (section 1, p23 and section 2, pp17-19) for further details on possible operational problems and solutions.

10.6 Monitoring Performance
Refer to Section 13.0 for monitoring to be undertaken of flow passing through the chlorine contact tank.
11.0 Effluent Disposal

Section Outline

11.1 General Description
11.2 Operating Goals
11.3 Maintenance
11.4 Troubleshooting

11.1 General Description
The effluent from Williamtown is disposed of outside the plant area in three effluent lagoons. The first two lagoons are fed through pipes from the chlorine contact tank and the third lagoon accepts the overflow from the second lagoon.

11.2 Operating Goals
The purpose of the effluent disposal system is to allow treated effluent to evaporate and infiltrate into the sand beds around Williamtown. It should be operated so that the effluent lagoons are always able to accept the total flow, and do not flood the area.

11.3 Maintenance
The effluent lagoons should be checked regularly (weekly at least) to be sure that effluent disposal is taking place without excessive ponding or flooding. If a point on the outlet box for each lagoon is chosen, then the water depth can be measured from that point and the measurement recorded. The water level will rise in wet weather and fall during dry weather, but should stay within a certain range. If the level ever rises more or faster than would be expected from experience, then there may be a problem with the disposal pathways.

A basic water balance undertaken suggests that a large percentage of the effluent is lost through the underlying sand layers to groundwater. The likely cause of a reduction in effluent release may be high effluent suspended solids, or a gradual build up of solid particles in the sand at the base of the lagoon.

11.4 Troubleshooting
Problem: Effluent discharge from lagoon reduced due to plugging by solids.

Solution:

i. Ensure plant effluent quality is meeting discharge criteria
ii. Confirm build-up along the base of each lagoon in turn by draining and performing a visual assessment before undertaking any remedial action.
iii. Should significant amounts of material be identified on the bed of either lagoon a backhoe (or similar) may be used to scrape 150-200mm of sand off the bottom.
12.0 Instrumentation and Controls

Section Outline
12.1 General Description
12.2 Electrical Controls
12.3 Maintenance

12.1 General Description
Instrumentation at the Williamtown STP is minor. A digital flow meter at the Parshall flume is attached to an instrument in the control building which records the flow on a circular sheet. The flow meter controls the pumps which recirculate effluent to the trickling filters. If the flow passes 8L/s the second pump cuts out and at 16L/s the first pump cuts out.

Control panels are set throughout the plant, and they control the equipment concerned with the section in which they are located. Most of the panels are used to control pumpsets; these are found at PST No.3, the humus tanks, the digesters, and PST No.1 and PST No.2. The grit trap and scum ejector are controlled from the panels under the inlet works. The panel for the humus tanks, as well as controlling the pumpset, controls various other equipment for the tanks.

The control building houses the flow recorder and two large indicator panels. These are attached to various parts of the plant and contain lights which indicate operational faults in the plant equipment.

There are also three alarms outside the building which light up and ring to warn that something is wrong in the plant. One light indicates that the grit trap must be cleaned out, and that it must be shut off immediately before any damage is done. The second alarm sounds if the incoming flow is very heavy and the level of water is rising very high in the inlet works. If it sounds the inlet works must be closely monitored.

The third alarm sounds if the plant fails and it can fail due to many problems. If this alarm sounds, all processes must be shut down and all equipment and each pipeline must be carefully inspected until the problem is found and repaired, at which time the plant can start up again.

12.2 Electrical Controls

12.2.1 Grit Handling System
The electrical starters for the grit handling drives are all located in the critical cubical MCCA. The existing drives have been modified to allow PLC control and also facilitate an emergency stop pushbutton in the field.

12.2.2 Screening Facility
The electrical starters for the screening drives are located in electrical cubical MCC9 which is fed from CB 23 on MCC4. The drive for the screen itself incorporates a variable speed unit. This unit can be configured to vary start-up time, speed, forward and reverse control and shutdown time. All these parameters should be configured at commissioning to optimise the operation. The emergency stop is wired directly into the supply to the variable speed drive to ensure an immediate stop against a controlled stop.
12.2.3 Hydraulic Booster System

The hydraulic booster system has onboard controls and the supply is fed from CB 26 on MCC4.

12.2.4 Controls

The automatic and manual controls for both the screen facility and grit handling equipment are all located in MCC9. The automatic facility is controlled by an Allen-Bradley PLC which sequences all drives as described in Section 4.0.

12.3 Maintenance

Indicating lights, switches, and locks should be inspected regularly to ensure that they are in good order and operate correctly. Connections should also be checked regularly for tightness on current carrying, main earth and secondary earth connections on distribution.

The entry of moisture and dust into electrical equipment can cause malfunction. During maintenance operations, inspections should be carried out for evidence of dampness or condensation in all electrical equipment and if observed, remedial action should be taken (e.g. by improvement of ventilation, the provision of heaters or other suitable means). Ensure that water entry to electrical panels is also prevented.

Where practical, the entry of dust should be prevented. Any dust/foreign matter within electrical panels should be blown out with dry compressed air.

External surfaces should be wiped clean with a slightly damp cloth then buffed dry. Any stubborn stains and marks should be removed with a mild non-abrasive cleaning (non-flammable) agent.

Table 8 shows the recommended maintenance procedures, together with their frequency, for the various plant components. Reference should also be made to the manufacturing/suppliers proprietary information contained in succeeding sections of this manual. For further maintenance details, refer also to the maintenance and lubrication schedules for all the main plant components shown in Table 11 and Table 12 in Section 16.0.

Table 8: Maintenance Program for the Instrumentation and Controls

<table>
<thead>
<tr>
<th>System/Item</th>
<th>Daily</th>
<th>Weekly</th>
<th>Monthly</th>
<th>Yearly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronic Drivers</td>
<td>During operation, check current draw of</td>
<td>No</td>
<td>Ensure motors, particularly the air</td>
<td>Grease bearings as required. Re-align</td>
</tr>
<tr>
<td></td>
<td>the motor. Observe for excessive noise and</td>
<td>Action</td>
<td>inlets, are free of dust and obstructions.</td>
<td>pump and motor after pump overhaul.</td>
</tr>
<tr>
<td></td>
<td>vibration.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instruments and</td>
<td>No Action</td>
<td>No</td>
<td>Check for cleanliness and for damage to</td>
<td>Replace batteries in PLC as required by</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>Action</td>
<td>wiring.</td>
<td>manufacture.</td>
</tr>
<tr>
<td>Electrical</td>
<td>No Action</td>
<td>No</td>
<td>Vacuum inside the panel. Visual inspection</td>
<td>Inspect panel construction/mounting</td>
</tr>
<tr>
<td>Control Cubicles</td>
<td></td>
<td>Action</td>
<td>of wiring and components for discolouring/overheating. Lamp Test.</td>
<td>fasteners for tightness. Inspect equipment mounting for tightness.</td>
</tr>
<tr>
<td>Motor Protection</td>
<td>No Action</td>
<td>No</td>
<td>Using test button check trip</td>
<td>Check trip mechanism and calibration of</td>
</tr>
<tr>
<td>Circuit Breakers</td>
<td>Action of terminals binding during operation, discolouring indicating overheating.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switches</td>
<td>Inspect for: tightness of terminals binding during operation, discolouring indicating overheating.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
13.0 Monitoring STP Performance

Section Outline
13.1 General Description

13.1 General Description

Sampling and laboratory testing of the STP is required to determine the effectiveness of treatment processes. Sampling analysis can provide information on why some parts of the plants are not working properly and how to correct the problem, as well as giving warnings about pollution problems.

Laboratory controls for each part of the system have been explained in the sections concerning that part. Testing on individual units should be done regularly so that any failures will be quickly identified.

A summary of the influent and effluent tests and how often they should be performed is given in Table 9 and Table 10. Experience will tell if some parts of the plant need testing more or less often than given. If it is difficult to interpret the results when unusual conditions occur, expert assistance should be sought.

Table 9: Summary of Influent and Effluent Testing Schedule

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Location</th>
<th>Frequency 1</th>
<th>Target Effluent Concentration Limit 2</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>STP Inlet</td>
<td>Daily</td>
<td>6.5 – 8.5 L/s</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>STP Inlet</td>
<td>Daily</td>
<td>6.5 – 8.5 L/s</td>
<td></td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>30 – 40 mg/L</td>
<td></td>
</tr>
<tr>
<td>Chemical oxygen Demand</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>60 – 80 mg/L</td>
<td></td>
</tr>
<tr>
<td>Biochemical Oxygen Demand</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>20 – 30 mg/L</td>
<td></td>
</tr>
<tr>
<td>Nitrogen (total)</td>
<td>STP Inlet / Outlet</td>
<td>Twice per month</td>
<td>20 – 40 mg/L</td>
<td></td>
</tr>
<tr>
<td>TKN</td>
<td>STP Inlet / Outlet</td>
<td>Twice per month</td>
<td>- mg/L</td>
<td></td>
</tr>
<tr>
<td>Nitrate</td>
<td>STP Inlet / Outlet</td>
<td>Twice per month</td>
<td>- mg/L</td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td>STP Inlet / Outlet</td>
<td>Twice per month</td>
<td>- mg/L</td>
<td></td>
</tr>
<tr>
<td>Phosphorous (total)</td>
<td>STP Inlet / Outlet</td>
<td>Twice per month</td>
<td>10 mg/L</td>
<td></td>
</tr>
<tr>
<td>Phenols</td>
<td>STP Inlet / Outlet</td>
<td>Twice per month</td>
<td>- mg/L</td>
<td></td>
</tr>
<tr>
<td>MBAS</td>
<td>STP Inlet / Outlet</td>
<td>Twice per month</td>
<td>- mg/L</td>
<td></td>
</tr>
<tr>
<td>Faecal Coliforms</td>
<td>STP Inlet / Outlet</td>
<td>Twice per month</td>
<td>200 CFU/100ml</td>
<td></td>
</tr>
<tr>
<td>E. coli</td>
<td>STP Inlet / Outlet</td>
<td>Twice per month</td>
<td>100 CFU/100ml</td>
<td></td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>STP Inlet / Outlet</td>
<td>Twice per month</td>
<td>10 mg/L</td>
<td></td>
</tr>
<tr>
<td>Aluminium</td>
<td>STP Inlet / Outlet</td>
<td>Twice per month</td>
<td>0.1 mg/L</td>
<td></td>
</tr>
<tr>
<td>Total Chlorine</td>
<td>CCT Inlet / Outlet</td>
<td>Daily</td>
<td>1.5 mg/L</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>CCT Inlet / Outlet</td>
<td>Daily</td>
<td>6.5 – 8.5 mg/L</td>
<td>-</td>
</tr>
</tbody>
</table>
Enterococci

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Location</th>
<th>Frequency</th>
<th>Practical Quantitation Limit</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Chlorine</td>
<td>CCT Outlet</td>
<td>Daily</td>
<td>0.2</td>
<td>mg/L</td>
</tr>
</tbody>
</table>

Notes:
1) Samples taken during weekdays only
2) Guidance on discharge criteria obtained from generic emission factors from NSW EPA (1998)
3) Where possible, separate samples should be taken from each catchment contributing to the STP influent (i.e. RAAF WLM’s Military Working Dog Facility, RAAF WLM domestic sewage, RAAF WLM’s TWTP, Williamtown Domestic Airport). Separate sample points would be required to be installed into the STP’s influent pipework.

The Practical Quantitation Limit (PQL) is the lowest level at which a substance can be routinely quantified and reported by a laboratory. In addition to the above monitoring, it is suggested that the PQL for some select heavy metals be adopted as trigger effluent concentration limits to determine their presence in the wastewater and the their fate as they travel through the STP. This type of data is useful as most heavy metals are expected to adhere to the organic fraction of the wastewater and accumulate in the biosolid material. Table 10 shows the suggested monitoring regime for heavy metals in the STP’s influent and effluent.

Table 10: Influent/Effluent Heavy Metals PQL

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Location</th>
<th>Frequency</th>
<th>Practical Quantitation Limit</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium (Al)</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>0.1</td>
<td>mg/L</td>
</tr>
<tr>
<td>Arsenic (As)</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>10</td>
<td>µg/L</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>5</td>
<td>µg/L</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>10</td>
<td>µg/L</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>10</td>
<td>µg/L</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>20</td>
<td>µg/L</td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>0.5</td>
<td>µg/L</td>
</tr>
<tr>
<td>Oil and grease</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>10</td>
<td>mg/L</td>
</tr>
</tbody>
</table>
14.0 Services

Section Outline

14.1 General Description
14.2 Maintenance

14.1 General Description

The services provided at the Williamstown works include electricity, potable water and a bore water supply. The electricity is supplied by the RAAF Base and is used throughout the plant. Also provided from the Base is the potable water supply to be used for drinking and general cleaning use.

The bore water supply is stored in a tank at the plant and is designed to provide a continuous high pressure supply for distribution to several points on the treatment works. The bore water is used in the chlorination system, for general purpose hosing down and washing, lawn watering and sewage pumpsets gland services.

The bore water system is made up of:

- Two centrifugal pumpsets
- A 72.5L capacity pressure tank
- A lockable control cubicle
- Pump suction isolation valves and discharge manifold complete with non-return and isolation valves
- Pressure and no-flow switches for pump control
- Pressure regulating valve
- A filtomat self cleaning filter

The control panel includes:

- Mains isolator, control and pump circuit breakers
- Alternating relay, run and overload indicating lighting
- TOL reset push button
- Pump failure flashing warning light with mute switch

Warning signs are fixed next to every hose cock on the bore water system making it clear the water is not drinkable.

14.2 Maintenance

The bore water distribution system should be completely checked over once a year to make sure all parts are in working order. The pressure gauges on the tanks should be checked daily so that any problems in the system can be found quickly and repaired.
15.0 Safety Precautions and Hygiene

Section Outline

15.1 General Safety Practices
15.2 Chlorine
15.3 Personal Hygiene

15.1 General Safety Practices

Physical injuries and body infections are always a possibility at sewage treatment plants. A number of common hazards are encountered around the plant, the risk from which can be greatly reduced by a careful, common sense approach by the operator. A number of the most common hazards and preventive are outlined below:

1) Exercise caution when walking around or working close to the edge of tanks, walking along elevated platforms and climbing or descending ladders. Lifebuoys are positioned around the site in case of an accidental fall.

2) Take care when working on or close to mechanical equipment, especially mechanical screens, pumps, blowers, motors and other rotating or moving items. Before commencing work on any particular item of machinery, equipment should be isolated on both the main control panel and the local switch. The cabinet should then be locked if possible to prevent accidental starting and a Do-Not-Operate tag fixed at both control positions.

3) Prior to working in collecting pump wells and sludge sumps, close off liquid inflows and apply forced ventilation into the well for at least 60 mins.

Equipment that is required at the work area includes:

- Lifelines and handlines
- First aid kit
- Safety belt (to be worn at all times)
- Lifting harness
- Breathing apparatus

One person (at least) must be above the confined area while work is being carried out. The top person must keep in touch with the person below by calling or signalling to them at frequent intervals. If conditions become dangerous the person below must be removed immediately.

15.2 Chlorine

Sodium hypochlorite is a hazardous chemical which can cause irritation, burns, and eye damage. Skin and eye contact and inhalation of vapours should be avoided. Appropriate protective clothing including gloves, overalls, safety goggles or face shield and respirator should be worn when dealing with sodium hypochlorite. Hands should always be washed before smoking, eating, drinking or using the toilet. Contaminated clothing or other protective equipment should be washed before storing or reusing.

Sodium hypochlorite should be stored and used in well ventilated areas to ensure concentrations are below exposure standards.
15.3 **Personal Hygiene**

Water-borne diseases are numerous and include gastroenteritis, typhoid fever, cholera and hepatitis. It is therefore very important to practise good hygiene.

The following points should be observed:

1) Hands and fingers should be kept away from the nose, mouth, eyes and ears
2) Rubber gloves should be, where practicable, worn when coming into contact with untreated wastewater, sludge, screenings or grit
3) Before eating or smoking and after work, the hands should be washed thoroughly with soap and hot water. A surgical type disinfectant such as Hibiclems should preferably be used. It is advisable to use a barrier cream on your hands before commencing work
4) Fingernails should be kept short and clean
5) Clean work clothes should not be stored with used work clothes
6) All cuts and scratches must be given first aid treatment
Part C - Maintenance Guidelines

16.0 Preventive Maintenance

Section Outline
16.1 General
16.2 Establishment of Programme
16.3 Maintenance Schedule
16.4 Equipment Categories
16.5 Servicing Procedures and Checklists
16.6 Records and Cost Accounting

16.1 General

Preventive maintenance requirements must be determined and incorporated into a preventive maintenance programme, to allow these tasks to be planned and scheduled into the normal flow of work.

Preventive maintenance can be defined as programmed work done to prevent breakdown, reduce wear, improve efficiency, and extend the life of equipment and structures. The greatest reliability and dependability of equipment are experienced only when a well planned and organised preventive maintenance programme is carried out. Another reason for setting up a preventive maintenance programme is that emergency repair costs are generally higher than the routine work required to prevent breakdowns.

16.2 Establishment of Programme

A good preventive maintenance programme consists of three basic parts:

1) A method of periodic inspection, lubrication, adjustment and/or servicing of machinery, equipment and structures
2) A record of repairs, alterations and replacements
3) A method of cost accounting for the different parts of the preventive maintenance programme

All three parts of the preventive maintenance programme should be simple, reliable and accurate. A sound preventive maintenance programme need not be elaborate to effect reductions in down time and expensive and untimely repairs and replacements.

The following items will be necessary in establishing an efficient preventive maintenance programme.

1) A simple and comprehensive preventive maintenance inspection form
2) Inspection of equipment and structures on a regularly scheduled basis
3) Proper servicing of equipment
4) Accurate recordings of work performed
5) Notification of proper supervisor when repairs are beyond preventive maintenance team capability
6) Adequate planning and proper assignment of duties
7) Efficient execution of task
8) A balanced work load  
9) Complete system of cost accounting

In order to establish a preventive maintenance programme, data must be collected on all of the equipment items to be included in the programme. Typically the data collected should contain such information as manufacturer, model, type, size, serial number, location and motor power. Routine servicing procedures and checklists should also be formulated.

16.3 Maintenance Schedule

Scheduling is another important part of any preventive maintenance programme. Establishing an efficient schedule requires knowledge of servicing procedures, and a knowledge of the function each item of equipment plays in the overall plant performance. The following is an outline of the basic steps required to effectively schedule preventive maintenance activities:

Step 1 - List all equipment requiring preventive maintenance. Use manufacturers’ recommendations for this step (Volumes 1-3).

Step 2 - Determine the preventive maintenance requirements and their respective frequencies for each item of equipment, not forgetting repainting of both equipment and structural items for corrosion protection.

Step 3 - Estimate the time and skills required to perform each preventive maintenance task.

Step 4 - List all preventive maintenance tasks in the weekly frequency group. Total the maintenance time requirements and compare this total with the available man hours in the maintenance work week.

Step 5 - Establish a preventive maintenance schedule for a typical work week. This schedule must be adjusted for corrective maintenance requirements, monthly, quarterly, semi-annual and annual preventive maintenance requirements, and any other items that would take maintenance time away from weekly preventive maintenance activities.

Step 6 - On a yearly calendar select tentative dates for performing monthly, quarterly, semi-annual and annual maintenance.

Step 7 - The typical work week schedule now becomes the basic maintenance schedule for planning each week’s maintenance activities.

Step 8 - Each week, the basic schedule is modified as required to handle preventive maintenance tasks other than those in the weekly frequency group. The schedule must also be adjusted for work priority changes due to jobs being carried over from the previous week.

Step 9 - Planning and scheduling preventive maintenance is a continuous function. Planning must take contingencies into account and scheduling must be flexible enough to handle maintenance emergencies.

Step 10 - Using a basic schedule for planning each week’s preventive maintenance activities will help ensure the maintenance effort is properly coordinated and directed. Management must emphasise the need for proper scheduling if maintenance objectives are to be achieved.

Included in Table 11 and Table 12 is the recommended maintenance schedule for the various plant components. Reference should also be made to the manufacturing/suppliers proprietary information contained in succeeding sections of this manual.

<table>
<thead>
<tr>
<th>System/Item</th>
<th>Daily</th>
<th>Weekly</th>
<th>Monthly</th>
<th>Yearly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Works</td>
<td>No Action</td>
<td>No Action</td>
<td>Inspect foundations and concrete slabs for signs of mechanical damages</td>
<td>Same as Monthly</td>
</tr>
<tr>
<td>Asset Type</td>
<td>Action 1</td>
<td>Action 2</td>
<td>Action 3</td>
<td>Action 4</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>Steelwork, Handrails and Pipe Supports</td>
<td>No Action</td>
<td>No Action</td>
<td>Check that all sliding supports appear to be free. Inspect supports and foundations for signs of failure. Repair as necessary</td>
<td>Carry out corrosion repairs</td>
</tr>
<tr>
<td>Pipelines</td>
<td>No Action</td>
<td>No Action</td>
<td>Inspect pipework for leaks and support failure</td>
<td>Random inspection of flanged connections for tightness. Corrosion repairs</td>
</tr>
<tr>
<td>Pumps</td>
<td>During pump operation, observe for excessive noise and vibration indicating internal problems</td>
<td>During pump operation, check discharge pressures. Check glands for leakage, tighten as necessary</td>
<td>Ensure pumps are clean and that there are no leaks from fittings and flanges</td>
<td>Pump overhaul to check condition of impeller/rotor</td>
</tr>
<tr>
<td>Electronic Drivers</td>
<td>During operation, check current draw of the motor. Observe for excessive noise and vibration</td>
<td>No Action</td>
<td>Ensure motors, particularly the air inlets, are free of dust and obstructions</td>
<td>Grease bearings as required. Re-align pump and motor after pump overhaul</td>
</tr>
<tr>
<td>Flexible Couplings</td>
<td>No Action</td>
<td>No Action</td>
<td>No action</td>
<td>Check coupling for sign of fatigue and failure</td>
</tr>
<tr>
<td>Instruments and Control</td>
<td>No Action</td>
<td>No Action</td>
<td>Check for cleanliness and for damage to wiring</td>
<td>Replace batteries in PLC as required by manufacturer</td>
</tr>
<tr>
<td>Motor Protection Circuit Breakers</td>
<td>No Action</td>
<td>No Action</td>
<td>Using test button, check trip mechanism</td>
<td>Check trip mechanism and calibration of units</td>
</tr>
<tr>
<td>Switches</td>
<td>No Action</td>
<td>No Action</td>
<td>No Action</td>
<td>Inspect for tightness of terminals binding during operation, discoloring indicating overheating</td>
</tr>
<tr>
<td>Valves</td>
<td>No Action</td>
<td>No Action</td>
<td>Check ease of valve operation. Inspection for leakage at glands and seals, valve cleanliness, noise and vibration</td>
<td>During valve overhauls, inspect components for wear/damage and replace as necessary</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
<td>-----------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Drum Screen | No Action | 100hrs Operation | Check gearbox oil level 3 Months  
Grease Trunnions | Water blast screen, remove all residue.  
2 years or 10,000hrs  
Replace gearbox oil |
| Grit Pump   | No Action | No Action | Check seal oil condition after first 1000hrs operation. Grease bearing at 1000hr intervals | Check seal oil condition or more frequently if site experience dictates |
| Sludge Recirculation Pumps | No Action | No Action | Check oil level after first 500hrs then every 3000hrs thereafter | Six monthly  
Check all bolts and welds.  
Check gearbox oil level and colour |
| Dewatering Screw Press and Grit Classifier | No Action | Check electrical safety equipment functions correctly | Clean if necessary.  
Check liner for wear.  
Check packaging box for leaks.  
Check spiral for wear and/or damage |

Table 12: Lubrication Schedule

<table>
<thead>
<tr>
<th>Equipment Item</th>
<th>Lubrication Type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drum Screen</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| • Gearmotor    | Mobilgear 630    | 10,000hrs operation or 2years interval  
100 hours operation |
| • Trunnions    |                  |           |
| Screening press|                  |           |
| • Packaging Box| Lithium Based Grease | When Overhauled  
Mobilgear 630 | 10,000 hrs operation  
Or 2 years interval |
| • Gearmotor    |                  |           |
| Grit Classifier|                  |           |
| • Packaging Box| Lithium Based Grease | When Overhauled  
Mobilgear 630 | 10,000 hrs operation  
Or 2 years interval |
| • Gearmotor    |                  |           |
| Grit Pump      | Castrol EPL2 Grease | 1000hrs operation  
Shell Tellus C10 | 1000hrs operation |
| • Bearings     | Shell Omala 320   | 500hrs then |
| • Seal Oil     |                  |           |
| Sludge Recirculation Pumps | Shell Omala 320 | 500hrs then |
### Equipment Categories

The equipment manufacturer’s maintenance manual is generally the best maintenance guide for any particular item of equipment. However, the adequacy of the manufacturer’s information should be verified. Most equipment is mass produced on a competitive basis and the cost of its maintenance should be consistent with its value, life expectancy, and replacement cost. Equipment should be rated as to its critical position in the plant operating system and its maintenance priority. This information will aid management in determining the maintenance expense which will be consistent with an item’s value, life expectancy, and replacement cost. The following is an example of how the equipment may be broken down into categories.

**Category A**

Small dollar value items, such as spark plugs, fluorescent lamps, and other similar items, should be replaced at appropriate intervals of operation unless a breakdown will not interfere with normal plant operation.

**Category B**

Intermediate value equipment justifies preventive maintenance when there is little labour and material cost involved. This includes minor repairs and replacement of part of small motors, lawn mowers and similar items which can be replaced promptly with no major downtime involved.

**Category C**

Equipment such as large pump motors and compressors must have adequately scheduled preventive maintenance. The breakdown of a minor part may cause the failure of a major component of the item of equipment. Major components of equipment are not ordinarily carried in stock, either at the plant or by the manufacturer. For this reason, minor spare parts should be available at the plant for rapid installation. Likewise, proper lubrication and adequate preventive maintenance on this category of equipment must be performed.

### Servicing Procedures and Checklists

The preparation of a preventive maintenance servicing procedure and checklist for each item of equipment can be of significant value to maintenance personnel in efficiently performing maintenance tasks. In preparing such a procedure, only those items applying to the particular item of equipment should be included. Directions appearing on the procedure eliminate the wasted time that results when maintenance personnel try to follow poorly prepared maintenance directions. The servicing procedures normally follow the manufacturer’s recommended preventive maintenance schedule. A checklist virtually rules out the possibility of accidentally overlooking an important preventive maintenance check. The checklist can be modified and added to over the years to make it more complete and functional.
16.6 Records and Cost Accounting

Records of all preventive maintenance inspections and services should be kept for planning of future maintenance and for reference in case of major breakdown. This record should include full details of work carried out, man hours involved, list of spare parts used, cost, date and maintenance personnel involved. Such records should be kept for all equipment under the maintenance programme.

This record system should be supplemented by a cost accounting system which summarises the cost of repairs, replacements and general maintenance performed on each equipment item.
17.0  Repair Maintenance

Section Outline
17.1  General
17.2  Records and Cost Accounting

17.1  General
Planning and scheduling of maintenance work must also make provisions to handle corrective maintenance tasks. Corrective maintenance can be defined as un-programmed work required for repairs and non-routine maintenance functions. The maintenance personnel must always be ready to handle these work tasks as equipment failures occur and emergency conditions arise. A review of equipment will aid in determining what failures may occur. Knowledge of these potential failures will aid in determining spare parts and equipment required to correct these problems, should they arise. In planning for corrective maintenance, provisions should be made with the outside repair service of contractors for assistance should major problems occur.

Procedures for performing corrective maintenance tasks should follow the manufacturers’ recommendations for disassembling and assembling their items of equipment. Manufacturers frequently provide troubleshooting checklists for use with their equipment. These troubleshooting guides should be readily available to persons performing corrective maintenance tasks.

17.2  Records and Cost Accounting
Records for repair maintenance should be kept in conjunction with records for routine maintenance. The record will be similar but will also include details of breakdown cause and details of any outside repair service used. Together, over a number of years, these records build into a maintenance history for each equipment item, identifying inherent defects and common breakdown causes. They also assist in future planning and scheduling of maintenance resources.

Costs for these non-routine repairs should also be recorded in the cost accounting system. The total maintenance cost records can aid in estimating operating expenses and in determining the time at which it is more economical to replace an item of equipment instead of repairing it.
18.0 **Maintenance Management**

**Section Outline**

18.1 **Housekeeping**
18.2 **Tools, Spare Parts and Lubricants**
18.3 **Protective Coatings**

18.1 **Housekeeping**

Housekeeping of buildings and grounds should receive similar attention as maintenance of operating equipment. A clean and tidy plant generally reflects a well operated plant and also aids in promoting public support. Other advantages of good housekeeping include:

1) It is more pleasant to work on the plant
2) It is safer to work on the plant
3) Frequent cleaning and tidying is less onerous than occasional large clean-ups
4) The risk of contracting a disease is reduced
5) It promotes work satisfaction amongst operators and encourages them to keep up a good standard of maintenance

Routine housekeeping should be incorporated into the standard operation work schedule.

Doors, windows, floors and other areas should be kept clean and in good repair for appearance and to minimise odour sources. Outside maintenance work such as mowing, cleaning gutters and drains, and painting of buildings should be scheduled as required.

18.2 **Tools, Spare Parts and Lubricants**

**General**

Good maintenance depends on the availability of proper tools and spare parts to perform the job. An important consideration is to have a regular storage place for these items. Space in the storage building should be allocated specifically for storage of special tools, spare parts and lubricants. Also special equipment should be listed on an inventory and a record of issue and replacement should be kept.

**Tools**

A set of common mechanical tools should be kept on site for general use by the operators. Special tools which have been supplied by the equipment manufacturers should be clearly labelled and kept in the storage building.

**Spare Parts**

A list of spare parts, both those supplied by the equipment manufacturers and others, should be made. These spares should be carefully stored and should be replaced as soon as they have been used.

**Lubricants**

It is important to make a list of common and special lubricants to be kept on site for use on mechanical equipment.
18.3 Protective Coatings

To reduce deterioration of materials, it is essential to reinstate or touch-up paintwork as soon as possible after damage is discovered. When paintwork deteriorates to the stage where regular touching up is no longer satisfactory, the surface should be prepared and repainted in accordance with the original specification or equivalent.

Surfaces below water level should be inspected regularly and repainted if necessary. Tanks must obviously be emptied during this operation.
Appendix A: List of Technical Words

1. **ADWF**: Average Dry Weather Flow.
2. **Aerobic**: A condition in which dissolved oxygen is present.
3. **Aerobic Micro-organisms/Bacteria**: Micro-organisms/Bacteria which live and reproduce only in an environment containing oxygen which is available for their breathing, such as atmospheric oxygen or oxygen dissolved in water. Oxygen combined chemically, such as in water, cannot be used by aerobic micro-organisms.
4. **Aerobic Process**: A waste treatment process conducted under aerobic conditions.
5. **Alkalinity**: Resistance of water to a reduction in its pH. Measured as the mass of strong acid (expressed as equivalent calcium carbonate) required to reduce pH to about 4.3.
6. **Anaerobic**: A condition in which both dissolved oxygen and nitrate are NOT present.
7. **Anaerobic Micro-organism/Bacteria**: Micro-organisms/Bacteria which live and reproduce in an environment containing no “free” oxygen or dissolved oxygen. Anaerobic Micro-organisms obtain their oxygen supply by breaking down chemical compounds which contain oxygen.
8. **Anaerobic Digestion**: Sewage solids and water (about 5% solids, 95% water) are placed in a large tank where bacteria decompose the solids in the absence of dissolved oxygen. At least two general groups of bacteria act in balance.
   - a) Saprophytic bacteria break down complex solids to volatile acids.
   - b) Methane formers break down the acids to methane, carbon dioxide and water.
9. **Anoxic**: In the absence of oxygen (except molecular oxygen).
11. **BOD (Biochemical Oxygen Demand)**: The BOD indicates the rate of oxygen utilized by sewage under controlled conditions of temperature and time.
12. **Bacteria/Micro-organisms**: Living organisms, microscopic in size, which consist of a single cell. Most bacteria use organic matter for their food and produce waste products as the residue of their life process.
13. **Biosolids**: Solid waste (or sludge) suitable for beneficial use which is separated from sewage effluent during treatment.
14. **BOD**: Biochemical Oxygen Demand.
15. **CFU**: Coliform Forming Unit.
16. **Chlorination**: The application of chlorine or chlorine compounds to water or wastewater, usually for disinfection, but frequently to obtain other biological results.
17. **CCT**: Chlorine Contact Tank: A detention tank provided to secure the diffusion of chlorine through the liquid.
18. **Chlorine Demand**: The difference between the amount of chlorine added to the wastewater and the amount of residual chlorine remaining after a given contact time.
19. **Clarifier**: Settling tank, sedimentation tank. A tank in which sewage is held for a period of time, during which the heavier solids settle to the bottom and the lighter material floats to the surface.
20. **Concentration**: (1) The amount of a given substance dissolved or suspended in a unit volume of solution. (2) The process of increasing the solids per unit volume in a liquid.
21. **Digester**: A tank in which sludge is placed to allow sludge digestion to occur.
22. **Disinfection**: The process by which pathogenic (disease) organisms are killed. There are several ways to disinfect, but chlorination is used most often in sewage treatment.
23. **DO**: Dissolved Oxygen: Atmospheric oxygen dissolved in water or sewage.
24. **Distributor**: The rotating mechanism that distributes the sewage evenly over the surface of the trickling filter.
25. **Effluent**: Wastewater or other liquid: raw; partially or completely treated, flowing from a tank, treatment process or treatment plant.
26. EP: Equivalent Person. A unit used in the design of wastewater treatment facilities, principally to indicate the magnitude of the pollutant load.

27. EPA: Environment Protection Authority, NSW (Now part of the Department of Environment and Conservation)

28. ET: Equivalent Tenement. A unit used in the design of wastewater transportation facilities, principally to indicate the magnitude of the wastewater flow.

29. Evapotranspiration: Transfer of water to the atmosphere through a combination of evaporation of free water and transpiration from the leaves of plants.

30. Faecal coliforms: Bacteria found in the gut of warm-blooded animals (used as an indicator of sewage pollution). Escherichia coli is generally the dominant species.

31. Grit: the heavy material present in sewage such as sand, egg-shells, gravel and cinders.

32. HRT: Hydraulic Retention Time.

33. I/I: Inflow and Infiltration. Stormwater and groundwater in wastewater collection systems that has entered through leaks in the system.

34. Imhoff Cone: A clear, cone shaped container, marked with graduations used to measure the volumetric concentration of settleable solids in wastewater.

35. Influent: Wastewater or other liquid: raw or partially treated, flowing into a tank, lagoon, treatment process or treatment plant.

36. Km: Kilometre.

37. Loading: Quantity of material applied to a device at one time.

38. Mg: Milligram.

39. Mol: Millilitre (1/1000th of one litre)

40. ML: Megalitre (1,000,000 litres)


42. NHMRC: National Health and Medical Research Council.

43. Non-potable: Describes water that does not meet the relevant NHMRC guidelines for drinking water quality, but may be safe for other purposes.

44. NPV: Net Present Value.

45. Organic Waste: Waste material which comes from animal or vegetable sources. It generally can be consumed by bacteria. Inorganic wastes are chemical substances of mineral origin and may contain carbon and oxygen whereas organic wastes contain mainly carbon and hydrogen with other elements.

46. P: Phosphorus.

47. Parshall Flume: The flume is an instrument which measures critical depth to determine flow rate.

48. PDWF: Peak Dry Weather Flow

49. Peak Load: The maximum rate of flow to a sewage treatment plant.

50. pH: pH is an expression of the intensity of the alkaline or acidic strength of water or sewage. The pH may range from 0 to 14 where 0 is the most acidic, 14 the most alkaline, and 7 neutral.

51. PLC: Programmable Logic Controller.

52. Ponding: A condition occurring on trickling filters, when the voids become plugged to the extent that water passage through the filter is inadequate. Ponding may be due to excessive slime growths, trash or rock breakdown.

53. Potable: Describes water that meets the relevant NHMRC guidelines for drinking water quality.

54. Prechlorination: Chlorination of the headworks of the plant.

55. PWWF: Peak Wet Weather Flow.

56. Raw sewage: Plant influent or sewage before any treatment.

57. Recycled water: Treated wastewater that can be used for recycling. The level of treatment applied is dependent on the end use of the water.

58. Residual chlorine: The amount of chlorine remaining after a given contact time and under specified conditions.
59. SCADA: Supervisory Control and Data Acquisition System.

60. Septic: A condition produced by the growth of anaerobic organisms. If severe the sewage becomes black, gives off foul odours and creates a heavy oxygen demand.

61. Settleable Solids: The matter in sewage which will not stay in suspension during a pre-selected settling period, either settling to the bottom or floating on top.

62. Sewage: The used water and solids from homes that flow to a treatment plant.

63. Sloughing: Trickling filter slimes that have been washed off the filter rocks. They are quite high in BOD and will degrade effluent quality unless removed.

64. Sludge: The settleable solids separated from liquid during sedimentation.

65. SPS: Sewage Pumping Station.

66. SRT: Sludge Retention Time.

67. STP: Sewage Treatment Plant.

68. Stabilize: To convert to a form that resist change. Organic material is stabilized by bacteria which convert the material to gases and other relatively inert substances. Stabilized organic material will not give off obnoxious odours.

69. Supernatant: Liquid removed from settle sludge Supernatant commonly refers to the liquid between the sludge on the bottom and the scum on the surface of an anaerobic digester.

70. Suspended Solids: Defined by testing methods but roughly defined as all non-dissolved solids that take a certain minimum time to settle in still water.

71. Toxicity: A condition that may exist in waste that will inhibit or destroy the growth or function of any organisms.

72. TN: Total Nitrogen.

73. TP: Total Phosphorus.

74. Treated wastewater: Wastewater that has been passed through a process that removes or inactivates some contaminants from the water. Thus, treated wastewater can be of any quality from septic tank effluent to a water which is of potable standard after passing through advanced treatment processes.

75. TSS: Total Suspended Solids.

76. UPS: Uninterruptible Power Supply.

77. Volatile Solids: Roughly defined as combustible solids.

78. Wastewater: Water that has been contaminated by use.

79. Weir: A vertical obstruction, such as a wall, or a plate, placed in an open channel and calibrated in order that a depth of flow over the weir can easily be converted to a flow rate.
Appendix B: Reference Material

Further information relating to the theory and principles of wastewater treatment and plant operating procedures can be obtained from the reference list below:

1) Manuals of Practice of the Water Pollution Control Federation (WPCF):
   - No I “Safety in Wastewater Works” 1975
   - No II “Operation of Wastewater Treatment Plants” 1976

2) Published Operating Manuals:

3) WPCF Laboratory Manuals:
   - “Simplified Laboratory Procedures for Wastewater Examination” 1986.

4) Text Book:

A number of journals which relate to this field of engineering can also provide relevant information. The following publications are particularly recommended.

1) Journal of the Water Pollution Control Federation.
Appendix C: Drawings
FIGURE C4
SLUDGE CIRCULATION AND WITHDRAWAL PIPING
DIGESTER PROCESS AND INSTRUMENTATION DIAGRAM
WILLIAMSTOWN STP

SLUDGE CIRCULATION AND WITHDRAWAL PIPING

SLUDGE FROM PS13 AND 14

MAIN SLUDGE DIGESTER
SECONDARY DIGESTER

DIAGRAM PIPING

MAIN

DRAINOFF PIPE

SLUDGE DRAWING BEDS

NON-POTABLE WATER

PS11

PS12

TOL1A

TOL1B

V41

V42

V43

V44

V45

V46

V50

V52

V38

V39

V31

V32

V33

V34

V35

V36

INITIALS

DATE: 22.02.08
REV. A

NO. 60025938-C4

CAD ref: K:\60025938_WRAAFSTP\5_CADD\5.3_Working\Autodesk\Fig_for_Report\60025938-C4.dwg Last modified: 21 Feb 08 - 09:57
Appendix D: Manufacturers Manuals from Upgrade Phase 1*

Manufacturers manuals are available in hard copy only. Copies are accessible by contacting RAAF base Williamtown representatives.
Appendix E: Manufacturers Manuals from Upgrade Phase 2*

Manufacturers manuals are available in hard copy only. Copies are accessible by contacting RAAF base Williamtown representatives.
Appendix F: Manufacturers Manuals from Upgrade Phase 3*

Manufacturers manuals are available in hard copy only. Copies are accessible by contacting RAAF base Williamtown representatives.
Appendix G: Recommended Monitoring Program

Note: For geographical details of monitoring locations, refer to Figure C5 in Appendix C.

**Influent and Effluent**

**Table G1: Summary of Influent / Effluent Monitoring Regime**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Location</th>
<th>Frequency 1</th>
<th>Target Effluent Concentration Limit 2</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>STP Inlet</td>
<td>Daily</td>
<td>-</td>
<td>L/s</td>
</tr>
<tr>
<td>pH</td>
<td>STP Inlet</td>
<td>Daily</td>
<td>6.5 – 8.5</td>
<td>L/s</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>30 – 40</td>
<td>mg/L</td>
</tr>
<tr>
<td>Chemical oxygen Demand</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>60 – 80</td>
<td>mg/L</td>
</tr>
<tr>
<td>Biochemical Oxygen Demand</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>20 – 30</td>
<td>mg/L</td>
</tr>
<tr>
<td>Nitrogen (total)</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>20 – 40</td>
<td>mg/L</td>
</tr>
<tr>
<td>TKN</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>-</td>
<td>mg/L</td>
</tr>
<tr>
<td>Nitrate</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>-</td>
<td>mg/L</td>
</tr>
<tr>
<td>Ammonia</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>-</td>
<td>mg/L</td>
</tr>
<tr>
<td>Phosphorous (total)</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>10</td>
<td>mg/L</td>
</tr>
<tr>
<td>Phenols</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>-</td>
<td>mg/L</td>
</tr>
<tr>
<td>MBAS</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>-</td>
<td>mg/L</td>
</tr>
<tr>
<td>Faecal Coliforms</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>200</td>
<td>CFU/100ml</td>
</tr>
<tr>
<td>E. coli</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>100</td>
<td>CFU/100ml</td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>STP Inlet/Outlet</td>
<td>Twice per month</td>
<td>10</td>
<td>mg/L</td>
</tr>
<tr>
<td>Total Chlorine</td>
<td>CCT Inlet/Outlet</td>
<td>Daily</td>
<td>1.5</td>
<td>mg/L</td>
</tr>
<tr>
<td>pH</td>
<td>CCT Inlet/Outlet</td>
<td>Daily</td>
<td>6.5 – 8.5</td>
<td>-</td>
</tr>
<tr>
<td>Enterococci</td>
<td>CCT Outlet</td>
<td>Twice per month</td>
<td>-</td>
<td>CFU/100ml</td>
</tr>
<tr>
<td>Free Chlorine</td>
<td>CCT Outlet</td>
<td>Daily</td>
<td>0.2</td>
<td>mg/L</td>
</tr>
</tbody>
</table>

Notes:

1) Samples taken during weekdays only
2) Guidance on discharge criteria obtained from generic emission factors from NSW EPA (1998)
3) Where possible, separate samples should be taken from each catchment contributing to the STP influent (i.e. RAAF WLM’s Military Working Dog Facility, RAAF WLM domestic sewage, RAAF WLM’s TWTP, Newcastle Airport Limited).
4) Effluent parameters provide information on the efficiency of the plant as well as and potential impacts to the receiving environment. Assessment of potential environmental impacts require all parameters to be investigated.

The Practical Quantitation Limit (PQL) is the lowest level at which a substance can be routinely quantified and reported by a laboratory. In addition to the above monitoring, it is recommended that the PQL for some select heavy metals be adopted as trigger effluent concentration limits to determine their presence in the wastewater and the their fate as they travel through the STP.
Table G2: Recommended Influent / Effluent Heavy Metals PQL

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Location</th>
<th>Frequency</th>
<th>Practical Quantitation Limit</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>0.1</td>
<td>mg/L</td>
</tr>
<tr>
<td>Arsenic (As)</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>10</td>
<td>μg/L</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>5</td>
<td>μg/L</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>10</td>
<td>μg/L</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>10</td>
<td>μg/L</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>20</td>
<td>μg/L</td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>0.5</td>
<td>μg/L</td>
</tr>
<tr>
<td>Oil and grease</td>
<td>STP Inlet/Outlet</td>
<td>Every four months</td>
<td>10</td>
<td>mg/L</td>
</tr>
</tbody>
</table>

Biosolids

Table G3: Summary of Biosolids Monitoring for Secondary Digester

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic ¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Cadmium ¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Chromium ¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Copper ¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Lead ¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Mercury</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Nickel ¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Selenium ¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Zinc ¹</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Moisture % ²</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Nitrite as N ³</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Nitrate as N ³</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen as N ³</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Total Phosphorus as P ³</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Reactive Phosphorus as P ³</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Oil and Grease (mg/kg) ⁴</td>
<td>Every Four Months</td>
</tr>
<tr>
<td>Total Petroleum Hydrocarbons (TPH) ⁵</td>
<td>Every Four Months</td>
</tr>
</tbody>
</table>

Notes:
1) Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium and Zinc must be tested as their concentrations directly impact biosolids reuse/disposal opportunities
2) Moisture content is determined to identify actual volumes of dry solids transported from plant
3) Nutrient analysis is important to determine the nutrient cycle and disposal pathways throughout the STP
4) Oil and grease to determine efficiency of upstream physical separators
5) TPH analysis due to previous levels exceeding ANZECC trigger values and provide an indication of the efficiency of the TWTP
### Treatment Processes

#### Table G4: Summary of Monitoring of STP Components

<table>
<thead>
<tr>
<th>STP Component</th>
<th>Weekly</th>
<th>Monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Sedimentation Tank No. 3</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effluent</td>
<td>-</td>
<td>BOD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Settleable Solids</td>
</tr>
<tr>
<td><strong>Humus Tanks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed</td>
<td>-</td>
<td>pH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Settleable Solids</td>
</tr>
<tr>
<td>Effluent</td>
<td>-</td>
<td>BOD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Settleable Solids</td>
</tr>
<tr>
<td><strong>Primary Digester</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw Sludge</td>
<td>Settleable Solids</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>Mixed Sludge</td>
<td>pH (^1)</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td></td>
<td>Temperature</td>
<td>Volatile Solids</td>
</tr>
<tr>
<td></td>
<td>Settleable Solids</td>
<td>Volatile Acids</td>
</tr>
<tr>
<td></td>
<td>Partial Alkalinity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intermediate Alkalinity</td>
<td></td>
</tr>
<tr>
<td><strong>Secondary Digester</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supernatant</td>
<td>Settleable Solids (^2)</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>Thickened Sludge</td>
<td>-</td>
<td>BOD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volatile Solids</td>
</tr>
</tbody>
</table>

**NOTES:**

1) Maintaining a pH range of between 6.6 and 7.6 is critical to the effective operation of the anaerobic digesters. A more accurate pH assessment process is required, potentially in association with automated pH adjustment upstream of PST No 3. Coupled with daily onsite assessment of the digested sludge’s pH, optimum operational pH levels in the digesters could be obtained.

2) Visual Inspection only. Presence of sludge material in the upper supernatant of the secondary digester suggests offsite sludge transfer is required

#### Surface & Groundwater Monitoring

A monitoring program is currently being undertaken for Williamtown STP to determine the quality of surface and groundwater. Details of this program (at the time this Operation and Maintenance Manual was updated) are available in the document titled CNN 235 Review of Sewage Treatment Works: Review of Monitoring Program (Maunsell, February 2008).