Assets Planning and Delivery Group
Engineering

DESIGN STANDARD DS 72-01

Lime Storage Mixing & Dosing System – Basis of Design

VERSION 1
REVISION 2

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FOREWORD

The intent of Design Standards is to specify requirements that assure effective design and delivery of fit for purpose Water Corporation infrastructure assets for best whole-of-life value with least risk to Corporation service standards and safety. Design standards are also intended to promote uniformity of approach by asset designers, drafters and constructors to the design, construction, commissioning and delivery of water infrastructure and to the compatibility of new infrastructure with existing like infrastructure.

Design Standards draw on the asset design, management and field operational experience gained and documented by the Corporation and by the water industry generally over time. They are intended for application by Corporation staff, designers, constructors and land developers to the planning, design, construction and commissioning of Corporation infrastructure including water services provided by land developers for takeover by the Corporation.

Nothing in this Design Standard diminishes the responsibility of designers and constructors for applying the requirements of the Western Australia's Work Health and Safety (General) Regulations 2022 to the delivery of Corporation assets. Information on these statutory requirements may be viewed at the following web site location:

Overview of Western Australia's Work Health and Safety (General) Regulations 2022 (dmirs.wa.gov.au)

Enquiries relating to the technical content of a Design Standard should be directed to the Senior Principal Engineer, Treatment Section, Engineering. Future Design Standard changes, if any, will be issued to registered Design Standard users as and when published.

Head of Engineering

This document is prepared without the assumption of a duty of care by the Water Corporation. The document is not intended to be nor should it be relied on as a substitute for professional engineering design expertise or any other professional advice.

Users should use and reference the current version of this document.

DISCLAIMER

This Standard is intended solely for application to the acquisition of water infrastructure in Operating Areas in Western Australia where the Water Corporation has been licensed to provide water services subject to the terms and conditions of its Operating License.

This Standard is provided for use only by a suitably qualified professional design engineer who shall apply the skill, knowledge and experience necessary to understand the risks involved and undertake all infrastructure design and installation specification preparation work.

Any interpretation of anything in this Standard that deviates from the requirements specified in the project design drawings and construction specifications shall be resolved by reference to and determination by the design engineer.

The Corporation accepts no liability for any loss or damage that arises from anything in the Standard including loss or damage that may arise due to the errors and omissions of any person.

REVISION STATUS

The revision status of this standard is shown section by section below:

REVISION STATUS						
SECT.	**VER./ REV.**	**DATE**	**PAGES REVISED**	**REVISION DESCRIPTION (Section, Clause, Sub-Clause)**	**RVWD.**	**APRV.**
1	1/0	27/02/12	All	New Version/Revision	ST	NH
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2	1/0	27/02/12	All	New Version/Revision	ST	NH
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DESIGN STANDARD DS 72-01
Lime Storage Mixing and Dosing Systems – Basis of Design

CONTENTS

1 Introduction

1.1 Purpose

The purpose of the document is to explain the reasoning behind the Water Corporation's design and installation requirements for its Lime storage, mixing and dosing facilities and to provide specific information relating to the Corporation's preferences and best practices that have evolved over years of experience. This design standard identifies the key design parameters for Lime facilities and provides some background information on how this basis of design was developed.

1.2 Background Information

Lime is a commonly used water treatment chemical which can be applied to achieve a range of treatment functions. Lime is generally dosed at Water Corporation sites as a means of increasing the pH, alkalinity and calcium content of clear water, as part of the post-treatment stabilisation process, to condition the water to protect downstream pipelines from corrosion. Lime is also be dosed at treatment plants as a method of pH adjustment to achieve optimal coagulation prior to sedimentation or filtration. In addition to this, lime is dosed as part of the lime softening process which is used to reduce the calcium and magnesium content in treated water to meet the hardness aesthetic water quality target from the plant.

Commercial lime is normally supplied in three forms:

- Hydrated Lime, Calcium Hydroxide – $Ca(OH)_2$
- Lime Putty, Calcium/Magnesium Hydroxide and other components - $Ca(OH)_2$, $Mg(OH)_2$, SiO_2, $CaCO_3$, Al_2O_3 and H_2O
- Quicklime, Calcium Oxide – CaO

The Corporation's preferred Lime dosing system consists of hydrated lime storage in silos, milk of lime preparation in mixing tanks, dissolution and saturation in a clarifier to produce lime water, which is then dosed into the recipient water by dosing pumps. Although this is quite a complex system, it is preferred for the following reasons:

- Handling hydrated lime, compared to non-slaked lime products, is considered a low hazard risk
- A properly functioning lime water dosing system does not impart excessive turbidity into the water it is being dosed into. Therefore, post treatment dosing can occur without exceeding ADWG turbidity guideline values in the recipient water.
- Lowest NPV[1]

Lime putty systems have been used by the Corporation in the past, but these systems have been associated with the following operational, maintenance and water quality problems, making this a less attractive option:

- Lime putty dosing introduces impurities such as silica, manganese, magnesium and aluminium to the system.
- The manganese can subsequently oxidize causing fouling of on-line analysers.[2]
- The abrasive action of the silica content in the lime putty causes damage to dosing pumps.
- More expensive NPV[3]

Although quicklime is the cheapest source of lime, the slaking process required to be carried out before dosing is considered very hazardous due to the large amount of heat generated. Also, it is a very labour intensive operation and therefore it has not been used at any Corporation sites.

[1] Refer to Wanneroo GWTP Alkali Dosing PDR for NPV calculation and assumptions.
[2] Refer to pH Correction Review for Wanneroo GWTP for information on manganese fouling.
[3] Refer to Wanneroo GWTP Alkali Dosing PDR for NPV calculation and assumptions.

This basis of design document concentrates solely on the Corporation's preferred Lime dosing system. The standard design P&IDs referenced by this basis of design document are JD71-060-84.1 through to JD71-60-85.2.

1.3 Hydrated Lime Quality

Hydrated lime is commercially available in two grades. The difference between the two grades is the active lime content, the type and amount of other impurities and the bulk densities as shown in Table 1-1 below.

Table 1-1: Industrial Grade and Premium Grade Hydrated Lime Quality

Description	Units	Industrial Lime		Premium Lime	
		Typical	Range	Typical	Range
Available Lime	%	85	81 – 90	92	89 – 95
Silicon Dioxide	%	5.0	4 – 7	0.5	<0.1 – 2
Carbon Dioxide	%	1.0	0.5 – 2	0.8	0.2 – 2
Magnesium Oxide	%	4.0	2 – 5	4.5	1 – 11
Other Impurities	%	5	3 – 7	2.2	1 – 4
Loose Bulk Density	kg/m^3	375	315 – 435	290	230 – 350

Premium lime is thought to offer the following benefits over industrial lime; however, insufficient operating and maintenance information has been collected to confirm this:

- Lower residual production
- Less wear on pumps and other equipment[4]
- Increased lime water concentrations

As there is a significant price difference between Industrial and Premium Lime the decision to use or change to Industrial or Premium lime should be based on the following site-specific factors:

- Sludge handling capacity
- Residual disposal method
- Lime water concentration required to meet pH or alkalinity demands[5]

1.4 Design Philosophy

Lime is a difficult product to handle therefore the overarching emphasis of any lime system design should be to minimise maintenance requirements and whole of life cycle cost.

Two identical and independent milk of lime preparation systems consisting of lime storage, feeding and mixing components shall be provided (Duty & Standby) to ensure a high level of security in the supply of milk of lime to the downstream lime system process units.

Due to the high capital cost and labour effort required to maintain a lime clarifier at peak performance it is recommended that only a single clarifier (no standby) be installed with critical spares held on site. Unless the plant capacity and lime addition needed requires multiple clarifiers to be operated simply to meet limewater demand.

Lime water storage tank is a low maintenance item with no moving parts therefore an adequately sized duty tank (with no standby) is considered acceptable.

[4] Several incidences have been recorded with industrial grade lime of mill balls being recovered from lime mixing tanks.
[5] To date, lime clarification systems operating with premium lime have had better success at achieving higher lime water concentrations. Perth Desalination Plant operating on premium lime can achieve lime water concentrations in the order of 1400 – 1500mg/L.

The lime water dosing system shall consist of duty/standby dosing pumps and spears to cover the full range of plant operation.

1.5 Standards

This design standard refers (directly or indirectly) to the following standards:

Australian Standards:

AS 1170	Structural Design Actions
AS 1345	Identification of the contents of pipes, conduits and ducts
AS 1554	Structural Steel Welding – Welding of Steel Structures
AS 1657	Fixed Platforms, Walkways, Stairways and Ladders – Design, Construction and Installation
AS 1688	Part 2: Mechanical ventilation for acceptable indoor air quality
ANSI Z358.1	American National Standard for Emergency Eyewash & Shower Equipment
AS 3691	Solvent cement and priming (cleaning) fluids for use with ABS pipes and fittings.
AS3780	The storage and handling of corrosive substances
AS3894.1	Site testing of protective coatings – Non-conductive coatings – Continuity testing – High voltage (‘brush’) method.
AS4020	Testing of products for use in contact with drinking water
AS4129	Fittings for polyethylene (PE) pipes for pressure applications
AS4680	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
NOHSC3009	Guidance Note for Placarding Stores for Dangerous Goods and Specified Hazardous Substances

Water Corporation Standards:

DS 20	Electrical Design Process
DS 22	Ancillary Plant & Small Pump Stations – Electrical
DS 24	Electrical Drafting
DS 26	Type Specifications - Electrical
DS 27	Regulating Valve Control
DS 28	Water and Wastewater Treatment Plants - Electrical
DS 30	Mechanical General Design Criteria & Glossary
DS 31-01	Pipework
DS 31-02	Valves & Appurtenances
DS 32	Pump stations
DS 33	Water Treatment Mechanical Design Standards
DS 35	Ancillary Plant Mechanical Design Standards
DS 40	SCADA Standards
DS40-09	Field Instrumentation
DS 62	Site Security Treatments
DS 78	Chemical Dosing
DS 79-02	Emergency Safety Showers and Eyewash Stations Standard

DS 80	WCX CAD Standard
DS 81	Process Engineering
DS 100	Suspended Flooring (Grid Mesh and Chequer Plate)
	Strategic Products Register
S399	Dangerous Goods Signage and Markers standard
S151	Prevention of Falls Standard

1.6 References

This design standard refers (directly or indirectly) to the following documents and publications:

- Wanneroo GWTP Alkali Dosing – Chemical Dosing System Modifications Preliminary Design Report, April 2007
- Perth Seawater Desalination Project, Lime Storage & Mixing Equipment Specification (Doc No P2553SPE169), 22 November 2005
- Perth Seawater Desalination Project, Functional Specification, Lime Storage, Mixing & Dosing System (Doc No P2553SPE170), April 2006
- Water Treatment Plant Design (4th ed), American Water Works Association, McGraw-Hill Inc © 2005
- The GHD Book of Water Treatment © GHD Pty Ltd, December 2005
- Lime Dosing Systems – A Summary of Issues and Suggestions for 'Best Practice'. Lime Users Workshop, May 2004
- Samson Brook Water Supply Scheme – Samson Trunk Main Chemical Dosing Plant Engineering Design Report, May 2002
- pH Correction Review for Wanneroo GWTP, August 2001
- Integrated Design & Operation of Water Treatment Facilities (2nd ed), Susumu Kawamura, John Wiley & Sons Inc, © 2000

1.7 Terminology & Abbreviations

ADWG	–	The National Water Quality Management Strategy, Australian Drinking Water Guidelines
Corporation	–	The Water Corporation
HMI	–	Human Machine Interface
Lime	–	Unless where specified otherwise, for the purposes of this standard, "lime" will refer to Hydrated Lime, $Ca(OH)_2$.
PCS	–	Process Control System

2 Delivery Requirements

2.1 Delivery Sizes

Cockburn Cement is currently contracted to the Corporation to supply hydrated lime. Their industrial lime is available in 20 tonne loads and is produced at their Henderson manufacturing facility, so it is usually available in the metropolitan area within 24 hours of placing an order.

Cockburn Cement's Premium lime is simply industrial grade lime which has been processed further at their Kemerton plant to remove some of the impurities. Therefore, at least 72 hours' notice is required for a delivery in the metropolitan area.

Hydrated lime is delivered in pneumatic tankers. These tankers have their own power supply on board to drive the compressors/blowers for lime transfer, so no additional site power needs to be provided. The lime transfer rate during unloading is approximately 333kg/min; therefore, it typically takes 60 minutes for a 20 tonne delivery.

2.2 Delivery Apron

A hard stand area will need to be provided for the lime tankers to park up on during a delivery. As the tanker will be parked for at least an hour, it is best if this apron is not located on the main plant access road unless the road is wide enough that other vehicles are still able to safely pass.

This apron shall be at least 36m long and 5m wide to allow the tanker to stop and extend stabilizing legs prior to the commencement of unloading. The apron must be incorporated as part of a drive through route, otherwise a turning circle of 30m diameter shall be provided.

Unlike liquid chemical delivery aprons the perimeter of this apron does not need to have a trafficable lip for the capturing of spills, nor does it need to be graded to a sump which can be isolated during a delivery. It will require normal road drainage requirements to direct rainwater to the site stormwater sump or drainage basin.

This apron shall be located on the same side of the building as the storage silo filling points to keep the filling line route as direct as possible. This is discussed in more detail in section 3.3.

2.3 Transfer Point – Fill Nozzle

Each lime storage silo shall have a 100mm stainless steel or aluminium male camlock as its fill nozzle. The camlocks are to be fitted with dust covers to prevent moisture build up in the filling line.

These camlocks shall be located outside the lime building on the wall adjacent to the delivery apron and shall be positioned so that they are pointing directly downwards and should terminate at 1.2m above the apron level.

A safety shower with eye wash unit (complying with DS79-02) is to be provided within 2 and 7 metres of the load-in transfer point, on the same level. Being an external shower, this shall also be fitted with a thermal relief valve.

2.4 Load-In Panel

A load-in panel displaying the following indicators, visual and audible alarms for each storage silo is to be provided:

- Load-in Valve Open Status Indication (ZIH 84101/84201)
- Load-in Valve Closed Status Indication (ZIL 84101/84201)
- Open Load-in Valve Hand Switch (HS 84101C/84201C)
- Close Load-in Valve Hand Switch (HS 84101D/84201D)
- Silo weight indication (WI 84102/84202)
- OK to Fill Silo Light (WAL 84102/84202)

- Silo Full, Stop Load-in Warning Light & Audible Alarm (WAH 84102/84202)
- Silo Overfull, Load-in Stopped Alarm Light (WAHH 84102/84102)
- Silo High Level, Load-in Stopped Alarm Light (LAH 84103/84203)
- Silo High Pressure, Load-in Stopped Alarm Light (PAH 84104/84204)
- Alarm Acknowledge Pushbutton (HS 84117/84217)
- Manual Alarm (light/siren) Test Pushbutton (HS 84118)

All of these visual and audible alarms are to be provided on a weatherproof panel, complete with sunshade, mounted on the lime building near the silo fill points.

The load-in panel shall also have a maximum fill level label mounted on, or adjacent to the panel (if space doesn't permit), so that delivery drivers and operators can check that a silo has sufficient free volume to accept a full delivery of lime prior to the commencement of unloading to reduce the risk of overfilling the silos.

3 Lime Storage

The lime storage system consists of hydrated lime storage silos, load cells, dust filter system, bin activators, valves, pipework and associated instrumentation. Each of these units will be discussed in more detail in the sections following.

3.1 Lime Silos

3.1.1 Silo Number & Sizing

At least two storage silos shall be provided so that each silo can form part of a duty/standby milk of lime preparation system. Each silo should be sized to accept a full delivery of hydrated lime plus some reserve storage. The lime supplier can split the load between two silos, if necessary, but if this results in longer unloading times, it may attract additional charges.

The total storage capacity of the lime silos should be sufficient to hold 7 days' supply of lime at maximum plant flows and dose rates, or 14 days' supply of lime at average plant flows and dose rates, whichever is the greater. Some remote sites may want to allow additional storage space to cater for the longer transport time required and to have less frequent deliveries.

Lime silos shall be designed and constructed to store both industrial and premium grade lime as the quality of the lime required to be used at a site may change in the future.

Each silo shall be cylindrical in shape as these silos are less susceptible to side wall hang-ups, which tend to occur in corners of bins of other shapes[6]. The height of the silo is typically 2.5- 4 x the diameter of the silo[7] and the maximum silo diameter used at Water Corporation sites is approximately 4.1m.

Each silo shall have a conical lower section. The designer shall optimise this cone angle and the other dimensions of the silo to suit the properties of the lime. However, as a guide, the minimum cone angle should be 70º from the horizontal. Silos with cone angles less than 60º can have a tendency for the lime to bridge and bind to the silo wall which causes flowability issues like rat-holing.

3.1.2 Mechanical

The bottom cone of the silo shall mate with the bin activator flange. The seal between these two components shall be airtight to prevent lime powder and dust escaping.

Each lime storage silo shall have a fully sealable, airtight, access manhole on top of the silo for inspection. Each access cover shall be easily lifted by one person and shall be capable of being restrained in the open position.

The top of the silo shall have nozzles for mounting the dust filter system, a vacuum/pressure relief valve, lime feed line, pressure switch and level switch. All connections mounted on the lime silos shall seal airtight to prevent lime powder escaping into the environment.

If flowability and lime hang-up is predicted to be an issue due to a particularly humid environment, or is known to be a problem due to an existing sub-optimal silo design then air injection ports can be installed on the side of the silo to fluidise the lime. These ports are usually located approximately 2m above the bin activator and are plumbed to a dry air source to provide jets of dry air to break up lime clumps and improve flowability.

3.1.3 Structural

Hydrated lime is abrasive, but not corrosive, therefore the lime silos shall be constructed of steel and structurally designed in accordance with AS 1170 and AS 1554. As mentioned previously the silos shall be designed to store both industrial and premium grade lime, in addition to this the structural design shall take into consideration an increase in bulk density up to 680kg/m3 due to compaction that can occur in the lime silo.

[6] Information obtained from Water Treatment Plant Design – Chapter 15.
[7] Information obtained from Water Treatment Plant Design – Chapter 15.

The silo support legs shall be welded (not bolted) to the silo ring beam. Cross bracing of the silo legs is not possible as maintenance access is required to the lime transfer equipment located under the silos. Any bracing of the silo legs shall be achieved using lateral members located sufficiently high as to not impede access under the silos.

Each silo shall have a flashing angle welded around the perimeter. The flashing angle will overlap an angle welded to the roof of the building the silos pass through to provide a weather seal. There shall be no structural connection between these two angles.

Brackets shall be provided on the outer wall of the silos to support the silo filling pipes.

Stairway access to the top of the silos shall be provided. The stairs and platforms shall not be structurally joined to the silos in any way, so that free movement of the silos is possible and the performance of the silo load cells is not affected. The interconnecting access platform between the roofs of the silos shall also be designed such that the performance of the silo load cells is not impeded. This means a sliding connection must be provided. The stairways and platforms shall comply with the requirements of DS 100 and AS 1657.

The top of each silo shall be designed with a slight radial downward slope from the centre to prevent pooling of water and shall be coated with an anti-slip surface finish. A 1.5m high balustrade, with vertical in-fill members at a maximum spacing of 150mm and a handrail located at approximately 1m, shall be provided around the circumference of each silo top for additional fall protection. This is in place of the standard "Monowills" handrail that is typically used around Water Corporation structures. Toe boards or kick-plate will also need to be installed if not incorporated into the silo design.

3.1.4 Instrumentation & Control

Each silo will be fitted with the following instrumentation:

- Load Cells to monitor the silo weight (WIT84102/WIT84202). These units will be discussed further in section 3.2.
- A vibrating fork level switch to activate a high level alarm and trigger closure of the filling valve when the level in the silo is too high (LSH84103/LSH84203).
- Pressure switch to generate an alarm when the pressure in the silo is too high (PSH84104/PSH84204). This switch will also cause the filling valve to close.
- A proximity switch on the access manhole cover (YS84105/84205). This switch shall activate when the access cover is opened. When this switch is activated the silo filling valve will be closed and the bin activators cannot be operated.

As discussed earlier in section 3.1.2, nozzles shall be provided on the top of the silos for the mounting of the level and pressure switches. These are best located away from the main thoroughfare, so as not to cause tripping hazards.

The level, proximity and pressure switches shall be selected from a supplier on the Water Corporation's SCADA Approved Equipment list.

3.1.5 Surface Protection

The lime storage silos shall be coated externally with a suitable corrosion protection coating. An example of a suitable coating system is shown in Table 3-1 below.

The finished external colour shall be white unless specified otherwise by the project contract documents.

The internal surface of the silos does not require a coating, but internal welds shall be ground smooth and the whole internal surface shall have a wire brush finish.

As stated previously, the top of the silos shall be provided with a non-slip surface coating.

Table 3-1: Lime Storage Silo – External Coating System

Coating	Product Description	Dry Film Thickness (Microns)	
		Min	Max
Surface Preparation	Abrasive Blast Class 21/2	-	-
Primer	Inorganic Zinc Silicate	75	90
Second Coat	High Build Epoxy	200	225
Third Coat	Polyurethane Gloss	75	90
Total Dry Film Thickness		350	405

3.2 Load Cell (WE84102/84202)

Each silo shall be mounted on load cells. These load cells shall monitor the weight in each silo. There shall be four load cells per silo (one under each leg), which shall have a combined accuracy of +/-100kg.

Strain gauges inserted in the silo legs have been considered for monitoring the weight in the silos in the past as they were thought to be less affected by wind. However, strain gauges are only suitable for silos holding more than 60T[8]. Most of the silos designed for the Water Corporations facilities are not large enough to successfully use strain gauges.

Local weight indication will be provided on a wall adjacent to each feed system and on the load-in panel. Silo weight indication will also be displayed at the HMI.

3.3 Filling Line

Each lime storage silo shall have its own DN100 filling line. The optimal arrangement for this filling line is best described as a candy cane shape, straight up and over, with a single 180^{o} bend. In many cases, the lime building layout and roof structure prevents such a simplistic arrangement and additional bends and horizontal runs are unavoidable, but they should be limited where possible.

The filling line shall enter the silo through the centre of the roof to maximise silo storage volume and it shall have an A-frame support. The filling line shall also be well supported by brackets on the silos and pipe supports attached to the building. These supports shall be fabricated from steel and coated to the same standard as the silos.

3.4 Load-In Valve (VA84101/84201)

Each filling line shall be equipped with a DN100 automated isolation valve. A gate or straight-through flow way body type diaphragm valve is recommended for this purpose as these valves are suitable for solids handling. These valves are to be supplied with handles or hand wheels for manual override operation, so their location must be easily accessible and at a safe working height. Normally these valves are located within 300mm of the delivery transfer point on the outside of the lime building or within 1000mm if they are located on the inside of the lime building.

A delivery normally takes 45 to 60 minutes to unload after which the driver will close the load-in valve from the load-in panel. The valve shall be programmed to close if it remains open for 90 minutes unless the unloading is still taking place as indicated by a continuing increase in the lime silo weight. This valve shall automatically close when there is a failure (fail-closed). Closing the valve also acts as a safety feature to prevent the dust filter extractor fan on top of the silo from overheating as the fan is programmed to stop 15 minutes after the load-in valve closes.

These valves shall comply with the requirements of DS31-02 (Valves & Appurtenances) and shall be selected from one of the models and suppliers on the Water Corporation's Strategic Products Register.

[8] Strain gauge information received from Transmin Pty Ltd.

3.5 Dust filter & Extraction Fan (FN84106/84206)

Each lime storage silo shall have a dust filter system installed on top of the silo to prevent the escape of lime dust into the environment. Both bag type or cartridge type filters are acceptable provided that the bags or cartridges are sized such that they can be easily carried up to the top of the silos and replaced by maintenance personnel. The dust filter lid (for bag/cartridge replacement) shall have a rubber seal to prevent the escape of lime dust and shall be chained or secured to the filter by some means to prevent it being blown away in high winds. Easy accessibility to open the dust filter lid and replace the filter bags/cartridge shall be provided including proper constructed steps/platform if required.

Each dust filter shall have a dedicated extraction fan which shall maintain a slightly negative pressure within the associated storage silo whilst the silo is being filled. Each dust filter shall have a minimum filtration capacity of $42m^3$/minute to meet the maximum air conveyance rate at the end of the delivery. Each filter shall be capable of capturing 95% (or greater) of the dust particles at a size of 1µm particle diameter. Distributions of the particle size for both Premium and Industrial Quality Lime can be found in Appendix A. The extraction fan shall be side mounted or in such a position that it doesn't need to be removed during bag/cartridge replacement.

Each dust filter shall have a pneumatic reverse pulse cleaning system which shall be operated on a pressure differential and/or timed basis. The extractor fan and its pulse cleaning system shall operate during load-in and for 15 mins after the load-in valve closes. The compressed air supply for the pulse air cleaning system shall be clean and dry and shall meet the minimum pressure requirements as requested by the supplier (400 - 650kPa is typical). Pressure regulating valves shall be included as part of the dust filter supply package should a specific pressure be required for the dust filter cleaning system.

All materials shall be compatible with hydrated lime as appropriate and shall be suitably surface protected for their external application. All components of the filters and extraction fans shall be readily accessible for the replacement bags/cartridges and maintenance of fans and drives. Should the dust filters height or shape mean they cannot be maintained from a standing position, then additional access equipment such as stairs or platforms with handrails shall be permanently erected on top of the silo for this purpose.

3.6 Pressure/Vacuum Relief Device (VA84107/84207)

A pressure and vacuum relief device shall be provided on each silo roof to protect the silo from over pressurising should the dust filter become blocked during load-in and to protect the silo from implosion damage should an excessive vacuum form due to erroneous extraction fan operation or lime discharge.

A pneumatic pressure relief valve installed on the delivery tanker limits the conveying air pressure to 165kPa.

3.7 Bin Activator (BA84108/84208)

Each silo shall have a vibrating bin activator connected to the bottom of the silo cone. A bin activator is a discharge aid to facilitate the free flow of lime from the silo. The attached motors (single or double depending on size and design) vibrate the bin activator cone to help dislodge lime from around the circumference of the cone into the outlet.

The designer shall correctly size and select the bin activator based on the following factors:

- diameter of the silo
- maximum lime discharge rate required
- bulk density of the lime
- flow properties of the lime

The connections at both ends of the bin activator shall seal airtight to prevent lime powder escaping into the work area. All materials shall be compatible with hydrated lime as appropriate. Flexible rubber bands with stainless steel bandit clamps are typically used to provide the sealed connection between the silo cone and the bin activator.

The bin activator shall be programmed to ensure that it only operates for sufficient time to vibrate down enough material to balance the downstream feeding systems. If the bin activator operates for longer than required, this will result in unwanted compaction in the lower cone. The bin activator supplier shall advise the initial bin activator run and off times (for example 3 seconds on and 60 seconds off) and these shall be verified and modified during commissioning as required to ensure adequate flow of hydrated lime.

It is imperative that the bin activator be electrically interlocked so that it cannot be run when the downstream equipment is stopped. Similarly the bin activator shall not be operated when the silo is empty as this can cause excessive deflection in the bottom section and may cause hanger failure and stress fractures. Each vibrating bin activator drive motor shall comply with the Water Corporation's Design Standard DS 26-06. The bin activators shall be monitored for operation status, motor fault and hours run.

3.8 Knife Gate Isolation Valve (VA84109/84209)

The bin activators shall incorporate a manually operated isolation knife-gate valve to provide positive isolation of the silo contents for downstream maintenance, but not to impede the lime flow during regular operation. This valve shall be able to be manually operated by one person under all conditions. Appropriate steps or platform (permanent or portable) shall be provided to allow easy access to the valve.

The knife gate isolation valve shall have an enclosure bonnet and leak-proof stem seal to prevent escape of lime dust to the exterior. The valve shall be fully closed for the first fill of hydrated lime into the silos. The lime shall be allowed to settle and de-aerate for approximately an hour before opening the valve and operating the bin activator. After this waiting period the gate valve shall be moved to the open position.

If necessary, the surfaces shall be thoroughly cleaned with a wire brush to remove all lime and dust and a liberal amount of silastic shall be applied on both sides (top and bottom) to prevent further escape of lime dust. For future operation and closure of the gate valve, for maintenance or otherwise, the silastic will first need to be cut away. Once the maintenance has been completed and the gate valve has been re-opened the silastic sealing procedure will need to be carried out again to ensure a dust tight seal.

4 Lime Feeding & Mixing (Milk of Lime Preparation)

Two identical systems shall be provided for the preparation and dosing of the milk of lime.

Lime water shall be used for mixing and flushing to minimise the potential for calcium carbonate scaling, due to the decreased carbon dioxide content, as recommended in the Suggestions for 'Best Practice' produced from the Lime Users Workshop.

4.1 Rotary Valve (RV84111/RV84211)

Each silo shall be fitted with an electrically-operated rotary valve, mounted beneath the knife-gate isolation valve, to maintain a regular flow of lime to the corresponding loss-in-weight feeder. The rotary valve is operated when the loss-in-weight feeder undergoes a filling operation.

Each valve shall be a fixed speed unit, capable of delivering lime to the loss-in-weight feeder at a rate of 10 x the maximum feed rate (the output) required of the loss-in-weight feeder.

All materials of the rotary valves shall be compatible with hydrated lime as appropriate. The inlet and outlet connections of the rotary valves shall seal airtight to prevent lime powder escaping into the work area. Flexible rubber inlet and outlet socks with stainless steel worm clamps are typically used to provide these sealed connections.

Each rotary valve drive motor shall comply with the Water Corporation's Design Standard DS 26-06. Each rotary valve shall also be monitored for operation status, motor fault and hours run.

4.2 Loss-in-Weight Feeder (FD84112/84212)

A gravimetric loss-in-weight feeder shall be mounted beneath each rotary valve to accurately deliver a required feed rate of lime into the associated lime mixing tanks. The feed rate set point for the loss-in-weight feeder will be determined by the plant PCS based on the lime water production required, which is based on the lime water flow rate to the stabilisation system.

Each loss-in-weight feeder shall include a heater element, transition hopper, hopper agitator, filter sock, variable speed screw feeder, load cells, speed sensor and inlet and outlet flexible sleeves (heated). The hopper agitator and the screw feeder shall be operated by two separate drives as a single drive performing both functions has been found to easily burn out. The inlet and outlet connections of the loss-in-weight feeders shall seal airtight to prevent lime powder escaping into the work area. The side or front of the feeder shall be easily opened to provide clear access to the agitator and screw feeder for operational inspection and maintenance purposes. All materials used shall be compatible with hydrated lime as appropriate. The loss-in-weight feeder selected shall operate in continuous mode rather than in batch mode with an accuracy of 1-2%.

Each loss-in-weight feeder shall be supplied with its own proprietary loss-in-weight control system, incorporating load cells and a speed sensor. The control system shall continuously take loss-in-weight measurements of the lime as it is metered out of the screw feeder and shall use this to calculate the actual discharge rate in kg/hr. This calculated rate is continuously compared to the desired feed rate set point which in turn is calculated based on the lime water dose flow rate, the lime water concentration, the reactive lime in the supplied hydrated lime and the clarifier operating efficiency. The speed of the screw feeder shall then be adjusted via a variable speed drive to correct any deviation from the required feed rate.

When the lime in the loss-in-weight feeder hopper reaches a predetermined low level it is refilled via the rotary valve. During this hopper filling operation the weight measurements are suspended and the screw feeder speed remains constant; hence, the rotary valve needs to be sized appropriately to fill the loss-in-weight feeder quickly.

The loss-in-weight feeder drive motors shall comply with the Water Corporation's Design Standard DS 26-06. Both loss-in-weight feeders shall be monitored for operation status, motor fault and hours run.

4.3 Vortex Mixer (VM84308/84408)

Each mixing system shall have a vortex mixer, or an equivalent device, located underneath the loss-in-weight feeder outlet and shall be used to pre-wet the hydrated lime before it enters the mixing tank. Other devices also used by the Water Corporation in the past to prevent inlet clogging include a "jet wet venturi" and "aqua-shear" mixer.

The objective of the vortex mixer is to keep dust levels down and alleviate any mixing problems before entering the lime mixing tank. A vortex mixer is a fully enclosed conical shaped vessel which bolts to the top of the lime mixing tank. Hydrated lime is fed into a roof mounted central nozzle (typically DN150) and the mixing lime water enters via two tangential feed water inlets (typically DN15) at the top of the chamber. The wetted mixture will exit centrally out of the base of the cone.

Each vortex mixer shall be able to handle the full range of feed rates from the loss-in-weight feeder. Each vortex mixer shall have a rubber sealed inspection door on the top with locking wedges. Each vortex mixer shall be fitted with a float level switch which shall be monitored by the plant PCS. When this switch is activated it indicates a blockage in the vortex mixer.

All materials shall be compatible with hydrated lime, milk of lime, lime water and Rydlyme[9] as appropriate. All connections of the vortex mixers shall seal airtight to prevent lime powder escaping into the work area.

4.4 Lime Mixing Tank (TA84310/84410)

Lime mixing tanks are required to prepare a milk of lime suspension (lime slurry) for dosing into the lime clarifier.

4.4.1 Size & Number

There shall be two vertical cylindrical lime mixing tanks, one for each preparation system. These tanks will be located beneath the lime silos and will be used to prepare the milk of lime solution at concentrations up to 5% w/w.

The capacity of each tank shall be determined by the designer such that the lime mixing system can be operated in a continuous mode with a minimum detention time of 15 minutes[10] at maximum plant production. The working capacity of each tank shall be measured from the top of the tank outlet nozzle to the bottom of the tank overflow.

As the tanks must interface with other structural and building works it is important that the tank designer and fabricator be made aware of any necessary or restricted dimensions, such as maximum/minimum tank height (so as to match the mezzanine floor height) or footing set out.

4.4.2 Mechanical

Each mixing tank shall be fitted with a hydrated lime inlet (from the vortex mixer), mixing water inlet, process outlet (to the milk of lime dosing pumps), scour and overflow connections. Each mixing tank shall have a fixed roof (a flanged and bolted roof is acceptable) suitably designed as a working platform and have a top mounted fully sealable, airtight, access manhole. Manhole covers shall be hinged as they are used frequently and the covers shall be easily lifted by one person and shall be capable of being restrained in the open position. A DN800 side mounted flanged and bolted access cover shall also be provided for easy access into the mixing tank for maintenance.

The top of each tank shall include an offset mixer mount flange. An offset mixer is recommended to reduce wave formation in the tank. The exact location of the mixer flange shall be determined in consultation with the mixer supplier. Internal baffles may be required to provide good mixing, but this will be dependent on tank geometry and mixer selection.

[9] Rydlyme is a biodegradable, non-toxic, non-hazardous, proprietary de-scaling solution used to dissolve lime scale.
[10] If milk of lime solutions are transported before stabilisation is complete, dissolved solids contained in the dilution water will precipitate on piping, valves and pumps as scale. A detention time of 15 minutes in an agitated tank is usually sufficient for maximum development of salt crystals, which tend to grow on themselves. – Information obtained from Water Treatment Plant Design (4th ed) chapter 15.

The top of the tank shall also include nozzles for the mixing water inlet, vortex mixer exit and instrument mountings. All connections mounted on the mixing tanks shall seal airtight to prevent any possible lime powder from escaping into the work area.

The slurry in the tank should be kept at a fairly constant level as high as possible. This will reduce the chance for the lime dust to mix with the mist above the slurry and attach to tank walls and cover.

The mixing tanks shall have a base that slopes in one direction to the drain outlet to assist in the complete emptying and removal of settled solids from the tanks. The tank should be drained directly onto the lime building bund floor from where the tank discharge can be hosed down to the lime building sump. Piping the drain outlet to the sump should be avoided as the settled material tends to clog up the pipe.

The tank outlet to the milk of lime dosing pump shall be located 200mm above the tank base to avoid blockage from the settled solids.

The overflows on the lime mixing tanks shall be plumbed to the lime building sump or shall discharge into a water bath (which can be easily cleaned and refilled) so any lime dust escaping via this route will be contained.

All materials used shall be compatible with hydrated lime, milk of lime, lime water, and Rydlyme as appropriate.

4.4.3 Structural

The lime mixing tanks shall be fabricated from carbon steel plate and be structurally designed in accordance with AS 1170 and AS 1554. The tank support legs shall be welded to the tank body. The support structure of the mixing tanks shall be located on concrete plinths and grouted into position with 30mm nominal grout.

The top of the mixing tanks shall be designed so that pooling of water will be prevented after washing down. Access to the top of the mixing tanks and all of the equipment mounted on the tank shall be provided by means of a stairway and grid-mesh platform (compliant with DS 100) around the tank roof to allow routine operational inspections and maintenance to be carried out.

4.4.4 Instrumentation & Control

Each mix tank shall be fitted with the following instrumentation:

- A vibrating fork high level switch to activate a high level alarm and shutdown the lime preparation system to prevent overflow when the level in the mix tank is too high (LSH84313/84413).
- A vibrating fork low level switch to generate an alarm when level in the tanks is too low (LSL84313/84413). This switch will shut down the lime preparation system to prevent the milk of lime dosing pump from running dry.
- Level transmitter (LIT84312/84412) to provide level indication locally and on the HMI and to generate high and low level alarms which can terminate the lime preparation system and initiate and stop the mixer operation.

Nozzles shall be provided on the top of the mix tanks for the mounting of the high level switch and level transmitter. The low level switch shall be mounted through a nozzle on the side of the tank located just above the tank outlet nozzle.

Ultrasonic level transmitters have generally been used in the Water Corporation's lime mixing tanks due to their relatively low cost and acceptable service. However, ultrasonic devices can be affected by the dusty conditions and therefore proper and correct setup of the level transmitter is required. An alternative is to use a radar level transmitter mounted above a blank flange on top of the tank, which separates the level transmitter from the dusty and corrosive atmosphere in the tank.

The high dust conditions can also affect the performance of the vibrating fork high level switch. To overcome this issue it is recommended that the switch be installed in a flanged DN50 PVC sleeve which extends into the liquid surface to eliminate the majority of the dust and allow only the liquid level to be detected. The bottom of the sleeve shall be cut on an angle to prevent lime solids accumulation and the

top of the sleeve shall have a hole drilled into the sleeve to allow air to escape as the liquid level in the tank rises.

It is recommended that the local tank level indication display be mounted on the lime building wall alongside the local silo weight indication display.

The level switches and transmitters shall be selected from a supplier on the Water Corporation's SCADA Approved Equipment list.

4.4.5 Surface Protection

The lime mixing tanks shall be coated internally and externally. An example of a suitable external coating system with an aesthetic finish is shown in Table 4-1 below.

Table 4-1: Lime Mixing Tank – External Coating System

Coating	Product Description	Dry Film Thickness (Microns)	
		Min	Max
Surface Preparation	Abrasive Blast Class 21/2	-	-
Primer	Inorganic Zinc Silicate	75	90
Second Coat	High Build Epoxy	200	225
Third Coat	Polyurethane Gloss	75	90
Total Dry Film Thickness		350	405

The finished external colour shall be of high reflectivity to minimise heat absorbance and shall be selected to suit the architectural theme of the treatment plant site, and minimise aesthetic impact on existing and future neighbours.

An example of a suitable internal surface coating for abrasion resistance is shown in Table 4-2 below.

Table 4-2: Lime Mixing Tank – Internal Coating System

Coating	Product Description	Dry Film Thickness (Microns)	
		Min	Max
Surface Preparation	Abrasive Blast Class 21/2	-	-
First Coat	Tank Lining Epoxy	200	225
Second Coat	Tank Lining Epoxy	200	225
Total Dry Film Thickness		400	450

Stripe coatings applied by brush to edges, welds and seams etc are recommended. High voltage continuity testing of the internal coating as per AS3894.1 is required. Also, the coating must have approval for use in contact with potable water and comply with AS/NZS 4020.

The finished internal colour shall be white unless specified otherwise by the designer or superintendent's representative.

4.5 Lime Mixing Tank Mixer (MX84311/84411)

Each of the lime mixing tanks shall be fitted with a top entry tank agitator capable of keeping a 2-5% w/w concentration lime slurry in uniform suspension. Each tank mixer shall function at all operational levels in the tank and be designed for continuous service. The mixer shall be capable of re-suspending the milk of lime slurry after a power failure of 6 hours duration.

The mixer selection and design shall comply with the requirements of DS33 section 42. The lime tank mixer drive motors shall comply with the Water Corporation's Design Standard DS 26-06.

The mixer shall be designed to eliminate the possibility of leakage of oil from the gearbox. Where this requirement is not met within the design of the gearbox itself, a suitable drip tray capable of retaining the full volume of gearbox oil plus 10% will be an acceptable alternative.

As discussed in section 4.4.2, it is recommended that the mixer be mounted offset to reduce wave formation. All necessary support steelwork for the mixers shall be provided.

All materials used for the mixer shall be compatible with hydrated lime, milk of lime, lime water, and Rydlyme as appropriate.

The mixers shall be kept running at all times when the tanks have contents. As such, the mixers shall be included on the Water Treatment Plant's list of critical drives and instruments to be backed-up by the generator during a mains power outage. This requirement is important because if the lime is allowed to settle in the mixing tanks it can be extremely difficult to resuspend and may even need to be removed by other methods.

4.6 Lime Water Mixing Valves & Flow Meter

4.6.1 Lime Mixing Tank Dilution Water Valve (VA84305/VAVA84405)

Each lime mixing tank shall have a diaphragm flow control valve to control the lime water inflow and maintain the milk of lime level in the lime mixing tank. These control valves shall be modulated by a level control loop working off the level transmitter for each tank.

This valve shall be selected from a supplier on the Water Corporation's Strategic Products Register and shall be suitable for a lime water application. This generally means that the valve body is has a specialised coating or liner to resist scaling. This valve shall also be supplied with a hand-wheel or similar mechanism for manual override.

It is recommended that the discharge pipework of this valve, which enters the lime mixing tank through the roof, be fitted with a spray nozzle to assist in keeping dust levels down.

4.6.2 Vortex Mixer Lime Water Valve (VA84306/VA84406)

Each lime mixing tank shall have a diaphragm flow control valve to maintain the lime water flow to the vortex mixer (or pre-wetting device) at a constant flow rate. The required flow rate and pressure will be determined by the designer/supplier based on the size of the vortex mixer and the hydrated lime feed rates. These control valves shall be modulated by a flow control loop working off the flow meter installed in each discharge line.

This valve shall be selected from a supplier on the Water Corporation's Strategic Products Register and shall be suitable for a lime water application. This generally means that the valve body has a specialised coating or liner to resist scaling. This valve shall also be supplied with a hand-wheel or similar mechanism for manual override.

4.6.3 Vortex Mixer Lime Water Flow Meter (FE84307/FE8407)

Each lime mixing tank shall have a magnetic flow meter installed in the lime water line feeding the vortex mixer (or pre-wetting device). As discussed in section 4.6.2above, this flow meter is used in the flow control loop to modulate the associated lime water control valve.

These flow meters shall be selected from a supplier on the Water Corporation's SCADA Approved Equipment List, and shall be suitable for measuring lime water.

Even though the pipework arrangement around the vortex mixer and mixing tank can be quite congested it is important that the flow meter be installed as per the manufacturer's recommendation and with at least 10 diameters upstream and 5 diameters downstream of straight uninterrupted pipework.

The local display for these flow meters shall be mounted on the mezzanine level lime building wall adjacent to the load cell indicators and tank level indicators.

4.7 Milk of Lime Dosing Line

Each of the lime preparation systems shall have a lime dosing line which transfers milk of lime from the mixing tanks to the lime water clarifier. These lines shall not be interconnected and the length of these lines shall be kept to an absolute minimum.

To prevent the settling of lime solids and impurities in these lines the velocity of the milk of lime through the lines shall be maintained at a minimum of 2m/s. To prevent the accumulation of solids at elbows wide radius bends should be used where possible and pipes and valves should have a constant diameter throughout.

At many Water Corporation lime dosing sites milk of lime ring mains with manually adjusted back pressure valves have been used to maintain the high milk of lime velocities. However, these back pressure valves have a tendency to wear out so it was recommended at the Lime Users Workshop that these valves be automated, or, taken a step further, the ring main be designed out if not crucial. Hence the development of this new lime design standard which does not include a ring main. It should however be noted that a ring main[11] may still be required for installations where the dosing rates and hence velocities vary widely.

Each dosing line shall incorporate a flow meter and a sample point for the purpose of manually checking the lime concentration feeding the lime clarifier.

Automatic valves and flushing systems shall be provided to enable flushing of either of these lines all the way to the clarifier. Flushing shall occur automatically at the end of a milk of lime dosing period. Manual valves and flushing connections shall also be provided for the manual de-scaling of these lines using Rydlyme, or another de-scaling agent such as hydrochloric or sulphuric acid, during a plant shutdown or maintenance period.

4.8 Milk of Lime Dosing Pump (PU84505/84605/84619)

Each dosing line shall have a milk of lime dosing pump which transfers milk of lime from the mixing tanks to the dose point on the lime clarifier at high speed (greater than 2m/s).

The pump shall be a horizontal, end suction casing pump suitable for pumping a 2–5% w/w lime slurry. Flanged connections shall be provided at both the inlet and discharge ports.

Each pump set shall be constructed from materials identified in Table 4-3 below. All wetted parts shall be High chromium white alloy iron with a minimum chrome content of 27%.

Table 4-3: Milk of Lime Dosing Pump – Material Specification

Item	Component	Material	Standard	Grade
1	Shell	High chromium white alloy iron	*Supplier to nominate* *Minimum chrome content to be 27%*	
2	Suction Liner	High chromium white alloy iron	*Supplier to nominate* *Minimum chrome content to be 27%*	
3	Suction Wear Plate	High chromium white alloy iron	*Supplier to nominate* *Minimum chrome content to be 27%*	
4	Pedestal	Grey Cast Iron	AS1830	T220
5	Shaft	Stainless Steel	ASTM A276	431 or 316
6	Impeller	High chromium white alloy iron	*Supplier to nominate* *Minimum chrome content to be 27%*	
7	Bearing Housing	Grey Cast Iron	AS1830	T220
8	Shaft Sleeve	Carbide Coated Steel	*Supplier to nominate*	

[11] The Perth Desalination Plant Lime Dosing System was designed, constructed and commissioned without milk of lime ring mains in 2006, just high velocity dose lines. No problems attributed to this design change have been experienced to date.

Mechanical seals shall be constructed from the materials identified in Table 4-4 below.

Table 4-4: Milk of Lime Dosing Pump Mechanical Seal – Material Specification

Item	Component	Material	Standard	Grade
1	Casing	Cast Iron (Rubber Lined)	ASTM A240	S32760 S32750
2	Rotating face	Solid silicone carbide	N/A	N/A
3	Stationary face	Solid silicone carbide	N/A	N/A
4	Elastomer	EPDM	AS1646	*Supplier to nominate*
5	Spring	Nickel-chromium-molybdenum alloy	ASTM B574	Hastelloy C-4
6	Metal parts	nickel-chromium-molybdenum alloy	ASTM B574	Hastelloy C-4

These materials represent the minimum basic requirements. Materials of equivalent or superior quality are acceptable.

The pumps shall be installed and aligned in accordance with Water Corporation's Installation – Mechanical Design Standard, DS38-01.

The rotating elements of the pumps shall be balanced in accordance with the balancing requirements of the Water Corporation's General Design Criteria – Mechanical Design Standard, DS30-02.

Baseplates and shafts shall be designed and supplied in accordance with the Baseplates and Shafts section of DS30-02. Shafts shall be sealed using double-acting unbalanced mechanical seals. The shaft shall be solid through the mechanical seal area, but of a design which allows the mechanical seal to be removed from the pump without disassembly of the pump.

Bearings shall be supplied in accordance with the Bearing section of DS30-02.

The electric motor shall comply with the Water Corporation's Design Standard DS 26-06.

These pumps shall be fitted with a variable speed drive which is adjusted by a feedback signal from the flow meter in the milk of lime dosing line to maintain a fixed flow rate to the clarifier. This is so the flow from these pumps (which draws from the mixing tanks) can be set to balance the flow entering the mixing tanks (from the lime mixing pumps).

Manual diaphragm valves throttled back have been used in the past to control the flow from fixed speed pumps, but this was found not to be an ideal situation as lime would build on the partially closed valves and eventually cause a complete blockage. Therefore a VSD is seen as a more appropriate engineering solution as the speed of the pump can be automatically adjusted to accommodate the lime build-up in the dosing line.

Should seal flushing water units be required on the milk of lime pump's mechanical seals then the designers must make provision for the supply of service water at the required flow and pressure and the proper disposal of this water. This normally requires the used flushing water to be plumbed to the building sump. Allowing the flushing water to run along the building floor to the sump is not acceptable as this creates a slip hazard. The seal flushing water shall be interlocked with the operation of the pumps.

Due to numerous problems with the milk of lime dosing pumps in the past, a third identical complete pumpset shall be procured at the same time as the two other pumps as part of the critical spares held on site. It is recommended that the three pumps be rotated regularly to ensure their performance be kept optimal.

4.9 Milk of Lime Dosing Valves and Flow Meter

4.9.1 Milk of Lime Dosing Valve (VA84501/84601)

On the outlet of each mixing tank, on the suction lines to the milk of lime dosing pumps, a full diameter automated straight through diaphragm isolation valve shall be installed. Where possible this valve shall be flanged close to the tank to eliminate dead legs which cannot be flushed.

This valve shall be selected from a supplier on the Water Corporation's Strategic Products Register and shall be suitable for a lime slurry application. This generally means that the valve body is rubber lined or has a specialised coating to resist wear. This valve shall also be supplied with a hand-wheel or similar mechanism for manual override.

4.9.2 Milk of Lime Flushing Valve (VA84502/84602)

An automated diaphragm valve shall be installed to facilitate automatic flushing of the milk of lime dosing line and pump. The pump and dosing line shall be flushed whenever the pump stops whether it be due to a fault, shutdown or operator-initiated changeover.

The flushing water shall be introduced as close as possible to the discharge side of the milk of lime dosing valve VA84501/84601. The proximity of the flushing connection to the dosing valve is required to reduce the length of dead legs which cannot be flushed. As mentioned previously, lime water shall be used for flushing to reduce the amount of scale formed. This valve shall be selected from a supplier on the Water Corporation's Strategic Products Register and shall be suitable for use with lime water.

4.9.3 Milk of Lime Dosing Flow Meter (FE84509/84609)

Each milk of lime dosing line shall have a magnetic flow meter installed on the discharge line of the milk of lime dosing pump. This flow meter is used to monitor the flow of milk of lime transferred to the lime clarifier and this data is used to automatically adjust the speed of the milk of lime dosing pump to maintain a fixed flow rate (even during periods of lime build-up in the dosing line).

These flow meters shall be selected from a supplier on the Water Corporation's SCADA Approved Equipment List, and shall be suitable for measuring the milk of lime slurry which can have solids present and has a tendency to abrade surfaces. These flow meters shall be installed as per the manufacturer's recommendation and with at least 10 diameters upstream and 5 diameters downstream of straight uninterrupted pipework.

4.10 Lime Building Sump Pump (PU84610/84611)

Two waste liquid drainage pumps shall be provided in the lime building sump for the transfer of waste lime liquid (milk of lime, sealing flushing water and general hose down) to the sludge drying beds or waste handling facilities. These pumps shall be sized to dispose of waste liquid at a rate which is faster than the rate of liquid entering the bund sump through normal seal water flushing, or milk of lime tank overflow or dump. These pumps will normally operate in a duty/standby arrangement, however they shall also operate in parallel when a high high level is reached in the sump.

Each pump shall be a submersible sump pump that conforms to the requirements of DS32 and shall be selected from one of the models and suppliers on the Water Corporation's Strategic Products SRegister.

The pumpsets shall comply with SPS 503 - Submersible Sewage Pumps except for the following modifications/exclusions:

- Pumps shall be capable of pumping unscreened lime drainage water.
- Pumps shall provide solids handling of 70 mm minimum.
- Lifting Chains shall be SS316
- Guide bars shall be SS316.
- Quick release docking stool shall be SS316.

- Pumps shall be supplied with 10 m of submersible cable, quick release docking stool and guide rail.

Drives shall comply with the requirements of SPS 503. Instrumentation supplied with the pumps shall be as per SPS 503.

5 Lime Building

5.1 Layout & Design

The lime storage and mixing equipment shall all be housed in a well-ventilated building. A building is preferred over an external facility as any moisture ingress can adversely affect the operation of the silos and feeding equipment. Also by housing the feeding and mixing equipment in a building it limits the effects of any lime leakage to inside the building rather than to adjacent facilities and the environment.

To enable the hydrated lime to gravitate from the silos through the feeding equipment into the mix tanks, without the need for intermediate inclined screw feeders, it is necessary for the process units to be arranged in essentially a vertical orientation with the silos protruding through the roof of the building with the feeding and pre-wetting equipment located directly beneath and then the mixing tanks located on the lowest level. The areas where the silos protrude through the roof shall be sealed in a suitable manner to weatherproof the building. However, this cannot be a structural connection, so the vibration of the bin activators is not transferred to the building and so the performance of the load cells is not affected.

Frequent (at least daily during normal operation) access to the top of the lime mixing tanks and lime feeding equipment is required for inspection and housekeeping purposes. Therefore, a mezzanine level shall be constructed in the lime building to provide clear unobstructed access to these units and the equipment and instruments mounted on them. An internal staircase shall link the lower level to the mezzanine level.

The lower floor of the lime building where the lime tanks are located shall be a concrete bunded area. This bund shall be sized to contain the entire contents of at least one mixing tank, making allowance for the volume occupied by equipment plinths and footings. A drainage sump shall be included in one of the corners of the building and the floor should slope towards this sump. Open channel collection gutters with grating covers leading to the sump should be constructed within the bunds for safer and easier clean up of spills, overflows and scours. It is of paramount importance that the floor be constructed so that the fall to the collection gutters and sump is even and positive, so that no waste spillage is retained on the floor.

This sump shall be suitably sized to allow the installation of two (duty/standby) submersible sump pumps along with level detection equipment. Typically, a sump which is 2.5m long by 0.8m wide and 0.7m deep will be adequate. The sump shall be covered with a galvanised ‘webforge’ mesh grating or an approved equivalent.

The floor of the lime storage building area shall be at road level. The Water Corporation has built lime facilities in the past where the lower level of the lime building is below ground level to reduce the visual impact of the elevated silos. This arrangement has been found to be not ideal as the lower basement level was prone to flooding when the sump pump fails, and natural ventilation could not be maximised.

The building shall be designed so that the mixing tanks and other large items can be removed and replaced through either the roller doors or removable wall sections. Ramps over the drops in floor levels should be included at appropriate locations for easy moving of tanks and equipment in and out of the building. The structural steelwork of the building shall be designed to allow for easy personnel access to all equipment.

The internal layout shall be as uncluttered as possible with all piping to be located either around the periphery of the building, or attached to the ceiling, to give a smooth tidy arrangement which leaves adequate access to all components. The piping shall also be appropriately located to facilitate unobstructed cleaning of the work areas when hosing down.

Internal and external lighting shall be provided, all with easy and safe access for lamp maintenance. These lighting levels and other characteristics shall be designed to the requirements of DS28.

5.2 Materials of Construction

Various materials of construction may be appropriate for the lime storage and mixing building – pre-cast concrete panels, masonry walls or metal clad. Choice of building materials will need to consider the architectural and security requirements that apply to the site.

5.3 Ventilation

Due to the dusty lime environment adequate ventilation in accordance with the Water Corporation's mechanical standards (DS30-02) and complying with AS 1668 shall be provided.

Vermin proof, weather protected wall mounted louvres shall be provided at high and low levels where possible to maximise natural ventilation. However, to combat all of the lime dust mechanical ventilation is also required with exhaust systems located on the mezzanine level where the majority of the dust is released. These extraction fans shall be activated by hand switches located near the personnel access doors.

5.4 Roller Doors

Roller door access will need to be provided at both ground level and mezzanine level for the removal of equipment for maintenance and replacement. These roller doors should be at least 3 m high and 2.5 m wide and large enough for the safe removal of the largest piece of equipment on each level. A single roller door spanning both levels is also acceptable providing the opening mechanism can be stopped at each level.

The operation of these roller doors shall be automatic using a heavy-duty motor and they shall be equipped with a chain override. These roller doors shall be industrial strength with galvanised fixtures and guides and a pad bolt shall be provided on each side of the door internally to receive padlocks.

The mezzanine level roller door opening will need to be fitted with an internal removable safety barrier or sliding gate, to prevent accidental falls when the roller door is open.

5.5 Personnel Doors

Personnel access doors shall be provided at each level. These doors shall be solid core, waterproof, metal-faced security doors. They shall have pull handles and catches for holding in the open position.

5.6 Safety Showers & Hose Reels

Safety showers complete with eye wash facilities shall be provided on both the ground and mezzanine levels.

Hose reels shall also be provided on the ground and mezzanine levels for the hosing down of lime spillage and for general housekeeping duties. The length of hose provided must be sufficient to reach all areas of the building.

The safety shower and hose reel requirements are discussed further in section 11.

5.7 Air Compressor Room and Compressed Air Line Outlets

The compressed air supply system including air receivers, compressors and dryers shall be housed in a separate room away from the lime dust which tends to contaminate and clog the compressed air equipment.

Compressed air outlet points shall be provided for cleaning purposes on both the ground and mezzanine levels of the Lime Building.

6 Lime Water Clarification

6.1 Lime Water Clarifier

The purpose of the lime water clarifier is to dilute and dissolve the lime in the milk of lime suspension to form a solution of calcium hydroxide (lime water), close to saturation, which is free of suspended particles, such that it can be dosed into the treated water to increase alkalinity and pH without adversely affecting the clear water turbidity.

The clarifier shall be a solids contact up-flow design. Milk of lime slurry shall be fed continuously into the feed well of the clarifier, where it is mixed with dilution water and recirculated sludge, which is lifted from near to the bottom of the clarifier by a draft tube with a recirculation impeller. The mixed lime solution shall flow outwards and under the feed well steel curtain and rise through the clarifier tank at a slow rate. Lime water shall collect in the overflow launders at the top of the clarifier and flow by gravity to the lime water storage tank.

At some sites the milk of lime slurry is fed into the dilution water line feeding the clarifier feed well rather than directly into the feed well. This can cause problems as instantaneous precipitation of calcium carbonate can occur, so by the time the diluted milk of lime reaches the feed well the already formed fine calcium carbonate particles will not coagulate. Therefore, dosing into the feed well is typically the preferred arrangement so that the calcium carbonate precipitation occurs in a high solids environment. There are exceptions to this preferred arrangement. If polyelectrolyte (poly) dosing is also required to meet the turbidity targets of the clarifier then the poly should be dosed directly to the feed well and the milk of lime should be injected into the dilution water. This is because the optimum results are achieved when poly is dosed after all other chemicals and after the pin-flocs have formed.

Insoluble lime, carbonate solids and other impurities shall settle as sludge in the lime water clarifier. The rake at the base of the clarifier will keep this sludge mobile and scrape this sludge towards the underflow cone for removal. The level of the sludge in the clarifier is an important parameter to be monitored and controlled. If the sludge level is allowed to build up too high it will affect the turbidity of the lime water produced by not providing sufficient space for stratification and this can cause suspended solids to carry over. Conversely, if the clarifier is operated with a little or no sludge bed then the performance of the clarifier will also be affected as the draft tube will not be able to recycle solids and the filtering benefits of the bed will not be experienced. Therefore, to control the sludge level, the sludge shall be removed periodically and this is discussed further in section 9.

In the event when the operation of the lime clarification system is terminated, the clarifier rake should be kept running to prevent the lime sludge from settling unless there is a problem with the rake itself.

The lime water clarifier designed and supplied shall be a proven design for lime saturation applications. Where possible a process guarantee shall be obtained from the clarifier designer/supplier to ensure the lime water concentration and turbidity targets are met. In order to receive this guarantee pilot trials may need to be conducted using the site's proposed dilution water supply and lime supply.

6.1.1 Number & Sizing

As mentioned previously, where possible a single lime water clarifier shall be provided as it is a costly piece of equipment to duplicate, successfully operate and maintain.

The size of the clarifier shall be based on achieving a lime water concentration 1200mg/L with a maximum clarifier rise rate of 1.75m/h. The lime water turbidity target shall be 30NTU.

The maximum size of the clarifier will also be affected by the construction methodology adopted for the site. Should a bolted and flanged clarifier be required, to reduce the amount of on-site assembly, then the maximum clarifier size is typically 16m in diameter as this is the maximum length which can be transported by road. If the clarifier is to be welded on site, then multiple smaller piecewise portions can be transported. This latter approach means not only does final fabrication have to occur at site, but any surface treatments will also have to be carried out in-situ.

For sites which will only have one clarifier, special consideration shall be given to the critical spares held on site. It is recommended that any critical spares or long lead items be procured at the same time

as the clarifier, or at least during commissioning, and held on site to minimise plant downtime in the event of a breakdown or failure.

6.1.2 Mechanical

The clarifier shall include the following equipment:

- Tankage (TA84720) and free standing tank support structure;
- underflow cone, overflow launders and weir box;
- feed well with feed piping;
- rake mechanism (SS84724) including both rotation and lift systems and electric motors;
- draft tube with recirculation impeller (MX84723) and motor;
- full span bridge and walkway crossover with drive mechanism weather canopy and handrails;
- peripheral walkway with handrails;
- access staircase from ground level to clarifier;

All drive components shall have guards to protect personnel against injury from moving parts. The internal re-circulation impeller shall be mounted in the draft tube.

The clarifier tank shall include the following nozzles:

- Clarifier Outlet;
- Clarifier Overflow;
- Clarifier Underflow;
- Clarifier Drain;
- Level Transmitter Connection;
- Dilution Water Inlet;

A circumferential v-notch launder collection trough is preferred; however, if radial launders are supplied then the walkway shall be modified to facilitate cleaning of this style of launders.

A basket strainer with 10mm diameter opening size shall be provided in the outlet of the overflow box to prevent any foreign matter from entering the lime water storage tank.

The clarifier rake shall be supplied complete with drive shaft, rake arms, underflow cone scraper, planetary gearbox with electric motor and VVVF Drive, and automatic lift/lower mechanism including lift guides/slides.

Food grade type of oils shall be used for all motors and equipment above the clarifier and oil catchment trays shall be provided under all operating assemblies to prevent oil and grease entering the clarifier. The trays shall be drained to a location external to the clarifier.

Fire hydrant type wash down hoses with sufficient hose length, water pressure and volume to reach all areas of the clarifier shall be provided at both ends of the clarifier bridge for the cleaning of the launders. High water pressure and volume are required to efficiently clean the clarifier and this may be provided by a pumped supply source such as the process water lines.

All materials shall be compatible with hydrated lime, milk of lime, lime water, process water, Rydlyme and lime sludge as appropriate. Where applicable the lime water clarifier components shall comply with the requirements of the Water Corporation's General Design Criteria – Mechanical, DS30-02 and Water Treatment Plants - Mechanical, DS33.

6.1.3 Structural

The clarifier tank shall be structurally designed in accordance with AS 1170 and AS 1554. Cross bracing between all tank legs is not possible as maintenance access is required to the clarifier underflow equipment located under the tank. Any bracing of the tank legs shall be achieved using either lateral

members located sufficiently high to not impede access under the tank, or bracing shall be designed to only be required between every second bay, thus leaving sufficient maintenance access.

The elevations of the weir level, overflow, clarifier outlet, and the top of the tank shall be specified by the designers such that the product lime water flows by gravity into the lime water storage tank with no intermediate pumping and so that there is clear access for Operators to be able to stand beneath the clarifier tank in all areas.

The peripheral walkway shall span the complete circumference of the clarifier to facilitate the washing of the circumferential launders. The peripheral walkway shall be constructed of webforge grid mesh with handrails and a 150mm kick-plate on edges to prevent tools falling from heights.

The bridge walkway shall have sealed checker-plate surface with handrails and 150mm kick-plate on the edges and additional 20mm wire galvanised mesh up to the knee rail level on both sides to prevent tools and dirt from entering the clarifier tank. 8mm holes may need to be drilled into the bridge walkway to prevent rainwater pooling in low-lying areas. This is best carried out once the bridge walkway has been erected and the low spots are known. For the same reason of avoiding tools and equipment from falling into the clarifier tank, valves and flow meters should not be installed directly over the clarifier water surface.

All clarifier walkways and handrails shall comply with DS 100 and AS 1657 and include harness anchor attachment points. The peripheral walkway shall have access points to the lime building stairs and the lime tank walkway. If access points to the lime building stairs are not possible then stairway access from ground level to the clarifier shall be provided.

The full span bridge shall include a drive mechanism weather canopy. This canopy shall be large enough to protect the instrument displays and drive cubicles from the elements and provide adequate working space around the drives for maintenance. Generally, these enclosures are approximately 5m long, 2m wide and 2.4m high. It shall be constructed of Colorbond and shall be fully enclosed on one side, have a sloping roof line and the Colorbond cladding up to at least 1.2m on the other side. The roof shall be fitted with lifting lugs for the removal of the canopy. This may be required if the rake drive is ever needed to be removed for maintenance. Therefore it is important to ensure that there are no connections between the canopy and the bridge, such as electrical conduit or cable tray, which prevents its removal.

A davit lifting base shall be provided at an appropriate location on the bridge walkway to allow the use of a davit lifting unit for removal of equipment, etcetera from the clarifier when required.

The clarifier shall be installed on a concrete bunded pad which is graded to a sump. The bund sizing is not intended to hold the full contents of the clarifier, but simply to contain any minor overflows, leakage and spills to facilitate their clean-up. Typically a concrete bund height of 150mm is suitable for this application. As this bund is located outside and is exposed to rain it is important that the floor be evenly graded and constructed to prevent pooling or puddling.

The sump shall be fitted with a sump pump as discussed in section 6.3 and connected to the sludge drying beds or waste treatment facilities for the disposal of the spillage. The sump shall be covered with a FRP grating to protect operators from accidental entry.

6.1.4 Electrical

All drive motors used in the clarifier design shall comply with the Water Corporation's Design Standard DS 26-06. All switchboards and control panels shall comply with DS26-09.

Lighting in accordance with DS28 shall be provided for the clarifier bridge canopy and for the stairway access to the clarifier.

6.1.5 Instrumentation and control

The lime water clarifier shall have the following instrumentation and control:

- VVVF torque monitoring;
- sludge bed level monitoring (LIT84719);
- bed mass monitoring (LIT84718);

- automatic rake lift/lower logic;
- rake direction control;
- conductivity monitoring (AIT84722);
- turbidity monitoring (AIT84721);
- associated alarms and trips.

The clarifier components shall have local starting and stopping equipment, local status indication and alarms and a control system all housed in a control cabinet to be installed on the clarifier operating platform under the canopy. All motor power connections shall be permanently glanded to the control panel.

All instrumentation will feed information back to the plant PCS and include high and low alarms. All motors shall have automatic, manual and off operational modes. Each motor shall be monitored for operation status, motor fault and hours run. The recirculation impeller operating speed shall also be monitored.

Manual stop/start control of the clarifier rake and draft tube recirculation impeller, along with manual adjustment of the rake and impeller speeds, and auto reset pushbuttons shall be provided on the front of the instrument cubicles so the operators can activate these functions without having to call out an electrician to access the inside of the cubicle.

An automatic lifting device with the appropriate logic shall be provided for raising the rake on high torque. Provision shall also be made for manually controlled lifting and lowering of the mechanism in non-high torque conditions. Forward and reverse manual rake direction control shall also be provided.

Instruments provided for bed level, bed mass, turbidity and conductivity monitoring shall be selected from the Water Corporation's SCADA Approved Equipment list. When selecting the individual models it is important to consider how the instrument will be mounted on the clarifier and to design or purchase specific mounting equipment.

Typically, the sludge level monitoring is an ultrasonic device which is mounted from the clarifier bridge. This instrument shall have a local display mounted on the clarifier bridge within the canopy and shall be displayed on the HMI. This instrument shall be used to generate high and low sludge level alarms.

The bed mass instrument is mounted on a nozzle on the underflow cone of the clarifier. So this device can be removed and maintained without having to drain the clarifier, an isolation valve, and flushing and drain valves shall be incorporated into this arrangement as shown on the P&ID JD71-60-84.7. This instrument shall also have a local display mounted on the clarifier as well as being displayed on the HMI. This instrument shall also be used to generate high and low sludge level alarms.

The turbidity and conductivity instruments are used to monitor the quality of the lime water being produced by the clarifier. The turbidity instrument gives an indication of the suspended solids carry over from the clarifier and potential impact on the final water quality despatched from the plant whereas the conductivity instrument provides an indication of the lime water concentration being produced. As such, these instruments would be best located in the overflow weir box to give representative sample. However, the overflow weir box is usually a much too turbulent zone for these instruments to perform effectively, so instead they are usually mounted off a support arm in the main tankage of the clarifier close to the surface and launders.

The accuracy of the turbidity analyser can be affected by surrounding light, so this is normally mounted in a PVC sleeve to block the UV light. Both instruments shall have local displays mounted on the clarifier bridge, as well as displaying the information on the HMI. These instruments shall be used to generate high turbidity alarms and low and high conductivity alarms.

It is important that the bed level, conductivity and turbidity instruments have their trends recorded on the PCS as this information is required to optimise the performance of the clarifier and particularly to determine the best operating sludge level.

6.1.6 Surface protection

The lime water clarifier components shall be internally and externally coated. An example of a suitable external coating system with an aesthetic finish is shown in Table 6-1 below.

Table 6-1: Lime Clarifier – External Coating System

Coating	Product Description	Dry Film Thickness (Microns)	
		Min	Max
Surface Preparation	Abrasive Blast Class 21/2	-	-
Primer	Inorganic Zinc Silicate	75	90
Second Coat	High Build Epoxy	200	225
Third Coat	Polyurethane Gloss	75	90
Total Dry Film Thickness		350	405

The finished external colour shall be white unless specified otherwise by the architect or superintendent's representative.

An example of a suitable internal surface coating for abrasion resistance is shown in Table 6-2 below.

Table 6-2: Lime Clarifier – Internal Coating System

Coating	Product Description	Dry Film Thickness (Microns)	
		Min	Max
Surface Preparation	Abrasive Blast Class 21/2	-	-
First Coat	Tank Lining Epoxy	200	225
Second Coat	Tank Lining Epoxy	200	225
Total Dry Film Thickness		400	450

Stripe coatings applied by brush to edges, welds and seams etc are recommended. High voltage continuity testing of the internal coating as per AS3894.1 is required. Also, the coating must have approval for use in contact with potable water and comply with AS/NZS 4020.

The finished internal colour shall be white. This is for operating purposes so plant personnel can observe and monitor the colour and clarity of the lime water.

The handrails, grating and checker-plate shall be hot dipped galvanised to AS/NZS 4680 with a dry film thickness of between 85 and 100 microns.

6.1.7 Polyelectrolyte Dosing

The performance of a lime clarifier may be improved by the addition of flocculants and coagulants such as Polyelectrolyte and Ferric Chloride. These chemicals assist in the flocculation and settling of suspended colloidal material.

Many of the Corporation's lime clarifiers perform well without the need for polyelectrolyte dosing; however, some required a small addition (0.1-0.3mg/L) of polyelectrolyte to help achieve lime water turbidity targets. The need for polyelectrolyte dosing appears to be influenced by a couple of factors:

- Quality of lime (premium or industrial) – industrial lime has a greater percentage of insolubles, which are thought to provide sites for the calcium carbonate to precipitate on. This is thought to improve settling as larger heavier particles are formed, rather than individual micro-particles.
- Quality of dilution water (raw surface water, filtered ground water or desalinated water) – dilution water with a higher carbon dioxide content will lead to increased precipitation of fine particulate calcium carbonate.

Therefore, unless pilot trials are carried out to prove otherwise, all lime clarifiers shall be designed and supplied with the provision for future polyelectrolyte dosing in case it is found to be necessary. This means polyelectrolyte dosing nozzles and/or spargers for the clarifier and adequate covered space shall be provided for a polyelectrolyte storage and batching plant including a progressive cavity dosing pump.

6.2 Clarifier Dilution Water Supply

As discussed above dilution water is fed to the clarifier to dissolve and dilute the milk of lime slurry to achieve the required concentration and turbidity. The clarifier dilution water supply will vary from site to site.

At surface water sites it is typically process water or service water, which is filtered water or raw water which has not been stabilised or disinfected. At groundwater sites this is typically service water which is taken from the Clearwater tanks. At desalination plants it will generally be permeate, which can have a higher carbon dioxide content than other sources. Sometimes this supply will also be blended with other sources such as recycled heating and ventilation system cooling water.

6.2.1 Dilution Water Pump (PU84901/84902/84903)

As a minimum, duty and standby dilution pumps are required (N+1). Depending on the turndown rate required, generally 3 variable speed centrifugal pumps are used to supply dilution water to the clarifier. Each pump is capable of supplying 50% of the maximum flow and the third pump is provided as a standby.

These pumpsets shall comply with the Water Corporation's Strategic Product Specification (SPS) 501 - End Suction Centrifugal Motor Pumps. These pumps shall be selected from one of the models and suppliers on the Water Corporation's Strategic Products Register. These pumps shall be supplied with all hold down bolts and fixings for support bases, brackets and stools.

The electric motors shall comply with the Water Corporation's Design Standard DS 26-06.

Some sites with sufficient dilution water flow and pressure will not require dilution pumps. Instead, the correct flow of dilution water into the clarifier can be maintained simply by a control valve.

6.2.2 Dilution Water Control Valve (VA84917)

An automatic modulating butterfly valve shall be installed to provide secondary control of the flow of dilution (process) water into the clarifier. The valve is normally fully open, it only exhibits control action when a single dilution (process) water pump is operating at minimum speed and the flow is in excess of that required.

This valve shall be selected from one of the models and suppliers on the Water Corporation's Strategic Products Register.

6.2.3 Dilution Water Flow Meter (FE84703)

A magnetic flow meter shall be installed on the dilution water line feeding the clarifier. This flow meter shall be used to generate high and low alarms, but will have no interlocks or control associated with it.

This flow meter shall be selected from a supplier on the Water Corporation's SCADA Approved Equipment List. This flow meter shall be installed as per the manufacturer's recommendations and with at least 10 diameters upstream and 5 diameters downstream of straight uninterrupted pipework. Typically this flow meter is installed in the vertical section of pipe leading up to the clarifier dilution water inlet nozzle so that it is always full and air entrainment is not an issue. This arrangement generally requires a sunshade to be provided over the magflow.

The display for this flow meter shall be mounted on the clarifier bridge under the canopy along with the other instrument displays. The flow information will also be displayed on the HMI.

6.3 Lime Clarifier Sump Pump (PU84820)

A waste liquid drainage pump shall be provided for the transfer of waste lime liquid (milk of lime, lime water, flushing water and general hose down) to the sludge drying beds or waste handling facilities. This

pump will operate when a high level is reached in the sump as detected by the float switch mounted in the sump.

The pump shall be a submersible sump pump that conforms to the requirements of DS32. It selected from one of the models and suppliers on the Water Corporation's Strategic Products Register.

The pumpset shall comply with SPS 503 - Submersible Sewage Pumps with the exception of the following modifications/exclusions:

- Pump shall be capable of pumping unscreened lime drainage water.
- Pump shall provide solids handling of 70 mm minimum.
- Lifting Chains shall be SS316.
- Guide bars shall be SS316.
- Quick release docking stool shall be SS316.
- Pump shall be supplied with 10 m of submersible cable, quick release docking stool and guide rail.

Drives shall comply with the requirements of SPS 503. Instrumentation supplied with the pumps shall be as per SPS 503.

7 Lime Water Storage

Lime water shall flow from the lime clarifier into a lime water storage tank under gravity. The working capacity of this tank shall be designed such that it is capable of balancing inflows and outflows over the full operational range of the lime water clarifier and lime water dosing systems. As a guide, usually 2 hours storage at maximum lime water demand is required.

The tank shall be fitted with inlet, outlet and bottom scour connections, instrumentation nozzles and a roof mounted gooseneck vent pipe. It shall have both a side-mounted and a roof-mounted DN800 access manhole with flanged and bolted cover. The tank can have a dedicated overflow connection or it may not be required if the tank roof is higher than the clarifier overflow level as any overflow would take place at the clarifier instead. For scouring, the lime water shall drain from the tank to the sludge drying beds or waste treatment facilities for disposal either directly by gravity or via the clarifier sump and pump.

The lime water tank shall be fitted with a roof-mounted ultrasonic level transmitter for level monitoring and control. This is an important instrument as it provides feedback control to a level control loop which determines the flow rate into the clarifier. Pressure transmitters rather than ultrasonic level transmitters are generally adopted for monitoring levels in chemical tanks due to prevailing working at heights occupational safety and health (OSH) requirements from Prevention of Falls standard. However, it has been generally agreed that the lime water storage tank could be treated differently due to unavoidable sediment that forms at the base of the tank which could affect the reading of the pressure transmitter installed at the base of the tank. The tank would have to be cleaned at least annually and this requires proper access to the roof manhole regardless of whatever level measuring transmitter is installed.

When selecting the location of the ultrasonic level transmitter it is important to consider the location of the lime water inlet to ensure splashing from this inlet does not interfere with the performance of the level transmitter. The ultrasonic level transmitter shall also be installed away from the tank wall to avoid interference to its reading.

The lime water tank shall also be fitted with a low-level side-mounted pressure transmitter as a back-up device and to prevent the lime dosing and mixing pumps from running dry. Both of these instruments shall be selected from the Water Corporation's SCADA Approved Equipment List.

Safe access to the top of the tank is required for the maintenance of equipment mounted on the roof and to access the roof manhole. Depending on the layout of the lime facility this can normally be achieved by providing a walkway, stairs and platform with handrails across from the lime clarifier walkway.

The tank roof shall be designed with a slight radial downward slope from the centre to prevent pooling of water and shall be coated with an anti-slip surface finish. If the roof is not designed to take body weight, a working platform shall be constructed on the tank roof for that purpose. For tanks greater than 3m in height, edge protection complying with the requirements of the Prevention of Falls standard is required on the whole circumference of the tank to enable safe inspections and repair work.

The materials of construction used for lime water storage tanks at Water Corporation facilities are wide ranging. Some sites have used fibreglass tanks, others have used metal tanks and one has used a glass lined tank. All of these tanks have provided adequate service to date.

The following factors shall be considered when selecting the most suitable material for the lime storage tank:

- Ability to store lime water with pH of approximately 11;
- UV resistance of material - as tank is located outside normally with no cover;
- Construction timeframe - off site fabrication is usually preferred for tight construction time frames;
- Ability to safely access and enter tank for maintenance and cleaning - cleaning is required on a yearly basis due to build up of lime scale and sludge in the tank;
- Architectural concept for the site; and

- Whole-of-life cost.

8 Lime Water Dosing

8.1 Lime Water Dosing Area

The lime water dosing pumps and lime water mixing pumps shall all be located in a concrete bunded area. The concrete bund shall have a graded floor to a sump to allow any spillage or waste to flow to the sludge drying beds or waste treatment facilities either by gravity or by a dedicated sump pump, or via one of the other lime area sumps, which has a sump pump. If a dedicated sump pump is to be provided, then this sump shall be fitted with a high-level float switch for the automatic operation of the pump.

A sampling point with a gooseneck shall be provided before the lime water dosing pumps. The location of the sampling point is important in providing an accurate sample of the lime water before aeration from the pumps affects the calcium carbonate content of the sample.

If not located inside a building, the lime water dosing area shall be covered by a steel framed rain shelter. Every pump in the area shall have clear access by personnel for removal, maintenance and operation. It is important that the floor be evenly graded and constructed to prevent pooling and puddling especially if the area is not fully enclosed and exposed to rain.

An adequately rated overhead travelling gantry crane (OC85120) shall be provided to enable the safe removal of pumps. A vehicle access area shall be provided adjacent to the slab, so that the pumps can be loaded onto the vehicle to be taken away for servicing or repair.

All motors, electrical equipment and instrumentation shall be mounted above the maximum water line in the bund.

A hose reel shall be provided on this slab for the clean-up of spillage and leaks.

8.2 Lime Water Dosing Pump (PU85111/85112/85113)

As a minimum, there shall be at least two lime water dosing pumps, so there is one redundant pump under all operating flow rates (N+1). Depending on the turndown rate required for lime water dosing, typically 3 variable speed centrifugal pumps are used to dose lime water into the recipient water main. Each pump is capable of supplying 50% of the maximum flow and the third pump is provided as a standby.

These pumpsets shall comply with the requirements of DS32 and the Water Corporation's Strategic Product Specification (SPS) 501 - End Suction Centrifugal Motor Pumps. These pumps shall be selected from one of the models and suppliers on the Water Corporation's Strategic Products Register. These pumps shall be supplied with all hold down bolts and fixings for support bases, brackets and stools.

The electric motors shall comply with the Water Corporation's Design Standard DS 26-06.

Unless specified otherwise these pumpsets shall be supplied with the supplier's standard coating system.

These pumps shall be mounted on a concrete plinth within the lime water dosing bunded area. The baseplates shall be grouted into position once alignment checks and modifications have been carried out. These pumps shall be spaced to provide clear access around each unit so that maintenance of pumps and valves can easily and safely be carried out while adjacent pump units are operating. Particular attention should be paid to the layout of cable trays and conduits around these pumps to ensure these do not obstruct access or create tripping hazards.

Connections shall be provided on either side of these dosing pumps for the introduction and flushing with Rydlyme or another de-scaling solution. An air release valve shall be located on the highest point of the discharge header pipework for the priming of the lime dosing pumps and dosing line during commissioning.

8.3 Lime Water Pumps Common Delivery Valve (VA85121)

An automated isolation butterfly valve shall be installed on the common delivery outlet of the lime water dosing pumps. The valve will close when all the lime water dosing pumps are not operating.

This valve shall be selected from one of the models and suppliers on the Water Corporation's Strategic Products Register. This valve shall also be supplied with a hand-wheel or similar mechanism for manual override.

8.4 Lime Water Dosing Flow Meter (FIT85119)

A magnetic flow meter shall be provided on the common lime water dose line, as shown on P&ID JD71-60-85.1 to monitor the amount of lime water being dosed into the recipient water main. The signal from this flow meter shall generate high and low flow alarms on the HMI. This flow meter also plays an important role in the control of the lime mixing and clarification system as discussed further in section 12 on Process Control.

This flow meter shall be selected from one of the supplier's on the Water Corporation's SCADA Approved Equipment List and shall be installed in accordance with the manufacturer's recommendations and complying with the requirements of DS40-09 – Field Instrumentation.

For this flow meter to measure accurately at least 10 diameters of straight uninterrupted pipework is required upstream of the flow meter and 5 diameters of straight uninterrupted pipework is required downstream.

8.5 Lime Water Dosing Spargers & Valves

There shall be three separate full diameter spargers for the lime water system. The design of each of the spargers shall ensure that thorough mixing of the lime water occurs within the recipient main over all operating flow rates.

The dispersion holes on the sparger shall be suitably sized and spaced to ensure that headloss and lime water mixing efficiency are optimised. The holes on the dosing sparger should face away from the direction of flow (be on the downstream side of the sparger) and the flow direction should be marked on the flange of the sparger. The lime water dosing spargers shall be constructed of 316 stainless steel.

Each dosing sparger assembly on the recipient water main shall incorporate a flanged spigot and sparger socket assembly consisting of a locating spigot, guide bush and bush retainer. The sparger shall be mounted through a gate valve so that the recipient water main can be operated even when the sparger is not in place.

Non-return valves shall be provided on the dosing line near the sparger to ensure the recipient water does not back-feed up the dosing line when the sparger is not in operation. Isolating ball valves shall also be provided to enable the individual spargers to be isolated from the lime water and removed for maintenance whilst the other spear is in operation. As shown on the P&ID JD71-060-085.2, these ball valves also allow the non-return valves, which tend to block with scale, to be removed for maintenance and cleaning without interrupting the entire lime water dosing system. A flushing connection shall also be provided between the non-return valve and the ball valves to allow individual spargers to be de-scaled in situ.

Scaling of lime water dosing lines and spargers is a common problem that the Water Corporation currently faces. When lime or any alkali chemical is dosed into a recipient water with a hardness greater than 30mg/L it is likely that the diffuser orifices will become clogged within several months. Provision for periodic cleaning should therefore be included in the design.

Several projects are currently being carried out at different locations to investigate better alternative arrangements to reduce the scaling problems in the dosing lines and spargers. One such investigation work is the trial of a polyethylene lime water dosing spear at Samson Brook plant. Another research and development project is currently being carried out to investigate the mixing properties of the current sparger designs and to investigate an alternative dosing spear arrangement, which combines the lime water and carbon dioxide dosing spears to reduce scaling. When the results of these investigations are known this section of the lime standard shall be updated as required. In the meantime, for sites which dose both lime water and carbon dioxide solution it is recommended that manual cross connections with necessary valving be provided on the dosing lines to allow the dosing lines to be swapped over from time to time to utilise the acidic nature of the carbon dioxide solution to gently de-scale the lime water dosing line.

Some sites do not utilise spargers and instead the lime water is dosed directly into a turbulent mixing chamber, such as a common filter outlet weir, or gravity fed from a trough above the water surface. This is one way to avoid the scaling issues associated with spargers, but it cannot always be adopted, especially if the pressure in the recipient water main is to be preserved.

8.6 Lime Water Mixing Pump (PU85114/PU85115)

Limewater shall be used for hydrated lime mixing and flushing of the milk preparation system as it is thought that the use of this clarified solution with lower dissolved solids and carbon dioxide content would prevent scale forming in mixing tanks, pipes, pumps and valves.

Duty and standby lime water mixing pumps shall be provided to transfer lime water from the storage tank to the vortex mixers and lime mixing tanks for the preparation of the milk of lime. These pumpsets shall be fixed speed centrifugal units and shall comply with DS32 and the Water Corporation's Strategic Product Specification (SPS) 501 - End Suction Centrifugal Motor Pumps. These pumps shall be selected from one of the models and suppliers on the Water Corporation's Strategic Products Register. These pumps shall be supplied with all hold down bolts and fixings for support bases, brackets and stools.

The electric motors on these pumps shall comply with the Water Corporation's Design Standard DS 26-06. Both pumps shall have pressure sensor type flow switches mounted on their discharge pipework. These switches are used to generate low flow alarms on the HMI to indicate there is a problem with a specific lime mixing pump.

Unless specified otherwise these pumpsets shall be supplied with the supplier's standard coating system.

These pumps shall be mounted on a concrete plinth within the lime water dosing bunded area. The baseplates shall be grouted into position once alignment checks have been carried out. These pumps shall be spaced to provide clear access around each unit so that maintenance of pumps and valves can easily and safely be carried out while adjacent pump units are operating. Particular attention should be paid to the layout of cable trays and conduits around these pumps to ensure these do not obstruct access or create tripping hazards.

Connections shall be provided on either side of these mixing pumps for the introduction and flushing with Rydlyme or other de-scaling solution. An air release valve shall be located on the highest point of the discharge header pipework for the priming of the lime mixing pumps and line during commissioning.

9 Sludge Management

As discussed in section 6.1, insoluble lime and other impurities will settle as sludge in the base of the lime water clarifier. This sludge shall need to be removed periodically. At all Water Corporation Lime sites, the sludge is removed on a timed basis to maintain optimum sludge levels. Reliance on sludge level instruments to automatically de-sludge the clarifier has not been implemented due to the lack of confidence in these instruments and the success achieved with maintaining the sludge level using the simple timer arrangement.

The solids concentration of the sludge withdrawn from the clarifier is typically in the range of 0.5 – 6%, which is still very liquid and not suitable for immediate transport or disposal to landfill. Landfill sites generally require the sludge to be "spadable", approximately 20-25% solids before they are willing to accept it. Transporting sludge at solid concentrations less than this is also not very cost effective as the majority of what is being transported is water. Therefore, a certain level of handling and treatment is required at site to increase the solids content prior to ultimate disposal of the sludge.

- Residual disposal limitations – required solids concentration for ultimate off-site disposal.
- Climatic conditions of the site – rainfall and evaporation rates.
- Availability of land.
- Economics – energy use, operating and maintenance costs.
- Degree of operator involvement and familiarity with particular systems.
- Impact on neighbourhood – creation of noise, attraction of insects.
- Other sludges and residuals produced at the site – there may be the opportunity to combine sludges to improve treatment techniques.

Common processes for sludge handling include sludge drying beds and lagoons, and mechanical methods such as thickening and dewatering. Some of these processes, particularly the ones which have been implemented at the Water Corporation sites, will be discussed further in the following sub-sections.

There shall be at least three DN100 nozzles provided on the lime clarifier underflow cone to enable the sludge to be removed from the clarifier. One nozzle shall be connected to the underflow pumps to transfer lime sludge to the sludge drying beds or next treatment step. This is the normal route for sludge removal. Another nozzle shall be connected to a dumping pipe which allows the contents of the clarifier to discharge under gravity to the clarifier sump and/or the sump pump discharge lines. The third nozzle is used for emergency dumping and as a scour outlet and it simply releases the clarifier contents onto the clarifier pad.

9.1 Clarifier Underflow (Sludge) Discharge Valve (VA84712)

A straight through automated diaphragm valve shall be installed in the clarifier underflow line to bleed sludge from the base of the lime clarifier. As discussed above, this de-sludging operation is carried out on a timed basis with the time intervals configurable on the HMI screen.

This valve shall be selected from a supplier on the Water Corporation's Strategic Products Register and shall be suitable for a lime sludge application, so it shall be able to handle solids. This generally means that the valve body is rubber lined or has a specialised coating to resist wear. This valve shall also be supplied with a hand-wheel or similar mechanism for manual override.

To avoid draining the clarifier this valve shall be specified to fail-closed under all operating scenarios.

9.2 Clarifier Underflow (Sludge) Pump (PU84805/84815)

Duty and standby clarifier underflow pumps shall be provided to transfer sludge from the clarifier to the sludge drying beds or waste treatment facility. Each clarifier underflow pump set shall be of compact, close-coupling design and shall be a self-priming, positive displacement and progressive cavity type. The pump, along with associated drive appurtenances, shall be mounted on a common fabricated carbon

steel base plate. Each pump set shall be supplied as a fully assembled, integrated, tested and certificated unit comprising each of the elements identified below:

- Progressive cavity (helical rotor) pump.
- Dry run protection sensor.
- Mechanical seal.
- Baseplate and coupling guard.
- Driver-to-pump coupling.
- Fixed reduction between motor and pump.
- First fill lubricant(s) (sufficient for 12-months of operation).
- Fixed speed electric drive motor.

The pumps shall be of a proven design for lime applications and shall be suitable for pumping lime sludge with a maximum solids content of 40%w/w.

Each pump set shall be constructed from materials identified in Table 9-1 below.

Table 9-1: Progressive Cavity Pump – Material Specification

Item	Component	Material	Standard	Grade
1	Wetted casing parts	Cast Iron (Rubber Lined)	AS 1830	T220
2	Non-wetted casing parts	Cast Iron	AS 1830	T220
3	Universal joint sleeve	NBR	AS 1646	Perbunan
4	Universal joint protector	Austenitic stainless steel	ASTM A320	316
5	Coupling rod	Stainless Steel	ASTM A276	316
6	Rotor	Stainless Steel	ASTM A276	316
7	Rotor coating	Hard chrome	*Supplier to nominate*	*Supplier to nominate*
8	Stator	Elastomer	Nitrile	
9	Plug-in shaft	Stainless Steel	ASTM A276	316
10	Base plate	Carbon steel	*Supplier to nominate*	*Supplier to nominate*

Mechanical seals shall be constructed from the materials identified in Table 9-2 below.

Table 9-2: Progressive Cavity Pump Mechanical Seal – Material Specification

Item	Component	Material	Standard	Grade
1	Casing	Cast Iron (Rubber Lined)	ASTM A240	S32760 S32750
2	Rotating face	Solid silicone carbide	N/A	N/A
3	Stationary face	Solid silicone carbide	N/A	N/A
4	Elastomer	EPDM	AS 1646	*Supplier to nominate*
5	Spring	Nickel-chromium-molybdenum alloy	ASTM B574	Hastelloy C-4
6	Metal parts	nickel-chromium-molybdenum alloy	ASTM B574	Hastelloy C-4

These materials represent the minimum basic requirements. Materials of equivalent or superior quality are acceptable.

Each pump shall employ a convoluted rotor operating within a similarly convoluted stator. The convolutions shall be configured to form a cavity between the rotor and stator which shall progress from the inlet of the pump through to the discharge port with the operation of the rotor. The fit between the rotor and stator at the point of contact shall compress the stator material sufficiently to form a seal and to prevent leakage from the discharge back to the inlet end of the pumping chamber. The stator shall be moulded with a seal integral to the stator elastomer preventing the metal stator tube and the bonding agent from the elastomer from contacting the pumped liquid.

Flanged connections shall be provided at both the inlet and discharge ports.

The pumps shall be installed and aligned in accordance with Water Corporation's Installation – Mechanical Design Standard, DS38-01.

The rotating elements of the pumps shall be balanced in accordance with the balancing requirements of the Water Corporation's General Design Criteria – Mechanical Design Standard, DS30-02.

Baseplates and shafts shall be designed and supplied in accordance with the Baseplates and Shafts section of DS30-02. Shafts shall be sealed using double-acting unbalanced mechanical seals. The shaft shall be solid through the mechanical seal area, but of a design which allows the mechanical seal and all other wetted tool rotating parts to be removed from the pump without disassembly of the pump or gear motor bearings.

Transmission drives shall be supplied in accordance with the requirements of the Water Corporation's General Design Criteria – Mechanical Design Standard, DS30-02.

Pumps shall be supplied with fixed reduction between the motor and the pump. The reduction ratio shall be that required to operate the pump at its maximum operating speed when the motor is operating at its nominal rated full.

Guards shall be supplied in accordance with the requirements of the Water Corporation's General Design Criteria – Mechanical Design Standard, DS30-02.

The clarifier underflow pump sets shall have a close coupled motor and gearbox, and be suitable for abrasive slurries. Each pump set shall have a non-flushed seal and shall be supplied with a steel mounting foot. The discharge branch of the pump shall be located at the non-drive end of the stator. The maximum pump speed shall be 500 RPM. Both pumps shall provide a solids handling capacity of up to 50 mm diameter.

Electrical drive motors shall be sized in accordance with DS22, Section 3 and shall be supplied in accordance with DS26-06. Pressure switches (PSH84807/84817) shall be installed on the discharge line of each pump to notify the operator of an unacceptable high pressure. A pressure indicator (PIT84809) shall be installed on the common discharge line to give an indication of fouling or blockage.

For pump protection the pump stators shall be fitted with a sensor sleeve and thermistor sensor that is capable of measuring the stator temperature and a corresponding relay. The discharge pipework of the pumps shall also be fitted with a pressure relief valve.

The sludge pumps shall be located at the lime water dosing pump station, providing this pump station is situated sufficiently close to the lime clarifier, so the sludge can gravity feed to the pump suction. The lime water pump station is the preferred location as it is fitted with an overhead gantry crane that can be used for the underflow pumps as well. Unless there is no other better alternative location, installing the pumps on the concrete pad beneath the lime clarifier is undesirable as access to the pumps could be more difficult. Regardless of where the pumps are located, they shall be arranged in such a manner to allow clear, unobstructed access by personnel to each pump and its component parts for removal, maintenance and operation.

9.3 Clarifier Underflow Flow Meter (FE84811)

A magnetic flow meter shall be installed on the common discharge line of the clarifier underflow pumps to measure the flow of sludge or flushing water being transferred to the sludge drying beds or waste treatment facilities. This flow meter shall generate high and low flow alarms.

This flow meter shall be selected from one of the supplier's on the Water Corporation's SCADA Approved Equipment List and shall be suitable for measuring both lime sludge and service water. The flow meter shall be installed in accordance with the manufacturer's recommendations and complying with the requirements of DS40-09 – Field Instrumentation.

For this flow meter to measure accurately at least 10 diameters of straight uninterrupted pipework is required upstream of the flow meter and 5 diameters of straight uninterrupted pipework is required downstream.

9.4 Lime Clarifier Underflow Flushing Valve (VA84706)

An automated flushing isolation valve shall be installed to introduce flushing water immediately downstream of the clarifier sludge discharge valve to enable flushing of the sludge pumps and discharge line all the way to the sludge drying beds or waste treatment facilities. Service water or process water shall be used for this flushing.

This valve shall be selected from one of the models and suppliers on the Water Corporation's Strategic Products Register. Whilst this valve shall only have water through it, it shall need to be able to seal adequately against the lime sludge. This valve shall be fitted with a hand-wheel or similar mechanism for manual override.

9.5 Sludge Drying Beds

The most commonly used sludge management method for Water Corporation sites is sludge drying beds with off-site disposal of the dried sludge to landfill (although opportunities for beneficial reuse should be considered). All Water Corporation Lime dosing sites, except the Perth Desalination Plant, have adopted this sludge management method. In regions where the weather is mild to hot and evaporation exceeds rainfall, this is the simplest and most cost-effective method.

Advantages of sludge drying beds:

- Does not require regular attendance.
- Low operating and maintenance costs.
- Operator familiarity.

Disadvantages of sludge drying beds:

- Large land requirement.
- Performance is sensitive to climatic conditions.
- Possible damage to under-drains during cleaning.

The characteristics of lime sludge vary as a function of magnesium hydroxide content. Lime sludge containing low levels of magnesium hydroxide may be dewatered to 50 to 60% solids using drying beds. Yet these figures will be reduced to 20 to 25% solids if the sludge has higher concentrations of magnesium hydroxide[12] .

The sludge produced from a lime clarifier can often be combined with the backwash stream from a conventional water treatment plant to correct the pH of the backwash stream before thickening. The combined thickened sludge can then be further mechanically treated. However, if the only sludge handling technique for the site is sludge drying beds, then it is recommended that the lime sludge and alum (or ferric) sludge be kept separate as the two types of sludges have different handling characteristics and often have different ultimate disposal routes.

[12] Information from Integrated Design and Operation of Water Treatment Facilities (2nd Ed)

9.5.1 Number and Sizing

A minimum of 6 lime sludge drying beds shall be provided for each site. Each bed shall be capable of holding the amount of sludge produced over a period of 2 to 3 months. The sludge drying beds shall be operated on a rotation basis with manual changeover between beds.

Mass balances and empirical formulas or rules of thumb that exist in textbooks can be used to estimate the amount of sludge that is likely to be produced at a site. Usually the results obtained from these methods vary widely, so often it is more accurate to base predictions on the historical data of sludge volumes produced from similar sized Water Corporation sites. This data is normally easily available as flow meters installed on the clarifier underflow lines monitor these quantities. However, allowances will need to be made for any flushing volumes if these are also recorded by the flow meter totaliser.

The sludge drying beds shall be rectangular with a length/width ration of approximately 4:1. Each bed shall have a total depth of 0.6m (0.3m effective storage depth and 0.3m freeboard). The embankments shall be earthen berms or concrete and designed to withstand liquid for the full depth.

9.5.2 Sludge Inlets and Distribution

There shall be a minimum of four sludge inlet points per bed. These shall be located around the perimeter of the bed. This is to ensure the sludge is spread evenly over the beds as lime sludge tends to build–up near the inlet. These inlets shall be designed to incorporate valving so that the operator can select which inlet to direct the sludge to. They shall also be designed so that they are always clear of the pond contents, even when full and that scouring does not occur during a sludge discharge. This may require the design and construction of a splash box at each inlet to prevent undermining of the sand and gravel layers. The sludge inlet valves shall be readily accessible from outside the bed and protected from vehicular damage.

9.5.3 Underdrain System & Decanter Pits

The beds shall have an underdrain system consisting of slotted pipes in crushed aggregate/gravel filled trenches. 100mm diameter plastic pipe is recommended with pipe spacing at 2 – 6 metres apart. These pipes should be installed with a minimum 1% slope in a 14mm crushed aggregate/gravel layer approximately 400mm deep. This gravel layer shall be overlaid by a geotextile membrane then a uniform medium grained sand filter layer approximately 400mm deep shall be applied. The geotextile membrane is required to prevent the infiltration of sand from clogging the underdrains. Some sites also wrap the underdrain pipes with a geotextile fabric for additional protection.

There are many different views on sand selection and sizing for sludge drying beds. One text book may suggest a typical sand with an effective size of 0.3mm – 0.75mm and a uniformity coefficient not greater than 3.5[13] . However, another text may recommend sand with an effective size of 0.5mm – 2mm[14] . Some trials conducted at Samson Brook WTP found that lime sludge dried better on two types of well graded sand (effective size 0.85-2mm and 6.4-10mm) then it did on “yellow fill” sand (with quite a lot of fine grains). At first there was no discernable difference, but when left to dry for a period of a month the well graded sand produced a drier sludge. The price of “yellow fill” sand is approximately a tenth of the price of graded sand, so at this stage it is undecided if the extra cost can be justified.

Each bed shall have decanter pit to allow surface water to be decanted from the bed to assist the sludge drying process. Typically, these concrete pits are 900mm wide x 900mm long x 500mm deep with removable aluminium stop boards along the side of the lime drying bed and a graded concrete floor to a DN100 outlet which connects to the underdrain system. These pits were introduced in the upgrade of the Samson Brook WTP lime sludge beds and have been found to speed up the drying process by decanting off any rainwater and surface water once the lime solids and insolubles have had sufficient time to settled out of the sludge. These pits also require grating covers and handrails to provide safe access for operation and maintenance.

[13] Information from Water Treatment Plant Design (4th Ed)
[14] Information from Integrated Design and Operation of Water Treatment Facilities (2nd Ed)

9.5.4 Bed Cleaning and Access

Once the lime sludge has dried sufficiently it will need to be removed from the bed and carted off-site so the drying bed can start the sludge drying cycle again. Truck and bob cat access to the sludge drying bed will be required for the removal of dried sludge. Therefore, each bed shall have a 3m wide concrete access ramp with a non-slip surface and 1:10 maximum grade for truck entry and egress. Road access shall be provided around the sludge drying beds and to the drying bed access ramps.

9.6 Mechanical De-watering

In localities where there is negative evaporation, or where sufficient land is not available, or at a premium, then sludge drying beds may not be an option. Instead, mechanical de-watering devices shall be considered, such as:

- Centrifuges;
- Vacuum filters;
- Belt press; and
- Filter press.

The Water Corporation has some experience with the use of centrifuges for the dewatering of combined sludge (ferric and lime sludge). At Perth Seawater Desalination Plant, centrifuges are used in conjunction with a lamella clarifier/thickener "Densadseg"[15] to dewater the combined sludge. Therefore, only centrifuges will be discussed in further detail here.

Centrifuges perform solids separation by applying a centrifugal force to the contents of a spinning bowl. The centrifugal force applied is typically 1,500 times that of gravity[16] . A scroll inside the bowl moves the solids towards discharge from the unit. Various proprietary centrifuge designs are available; they may also be called solid bowl, basket bowl, and scroll discharge or decanter centrifuges. Centrifuges can be either counter current, meaning the solids and liquid discharge from opposite ends, or co-current in which the solids and liquid discharge from the same end.

The main advantages and disadvantages of centrifuges are listed below:

Advantages:

- Much smaller footprint than sludge drying beds.
- Can consistently produce a drier sludge than sludge drying beds.
- Cake produced with relatively high percent solids (33-70% for lime sludge).
- Minimum operator attention compared with other mechanical dewatering techniques.
- Maintenance requirements relatively low compared with other mechanical dewatering techniques.

Disadvantages:

- Power consumption.
- Reliance on mechanical equipment.
- Sludge storage considerations over holiday periods (if site is unattended for a few days).

If centrifuges are to be used for mechanical dewatering, they shall operate continuously rather than in batch mode. As a minimum, duty and standby centrifuge units shall be provided. Centrifuges shall be specified to resist corrosion, abrasion and wear. Stainless steel or ceramic bowl liners shall be considered. Before selecting a centrifuge, the anticipated life of the components, ease of parts replacement and availability of replacement parts shall be carefully considered.

[15] A Densadeg is a proprietary Degremont Thickener/clarifier design
[16] Information obtained from Water Treatment Plant Design (4th ed).

Along with the centrifuges units, the other equipment and ancillaries which may be required to successfully operate a centrifuge de-watering system include:

- Centrate pump station – to return the liquid separated from the solids to head of plant or disposal route.
- Building - to house works.
- Series of screw conveyors – to transfer cake from centrifuge to disposal bins.
- Bins - to collect cake solids for disposal off-site.
- Sludge holding tank – contingency to hold sludge in the event of plant breakdown/repair.

The layout of the centrifuge system shall provide adequate clearance around all units for operations and maintenance personnel. An overhead travelling gantry crane shall be provided for the removal of centrifuge covers and other parts for adjustment and maintenance.

10 Pipework

10.1 Pipe Materials

Acrylonitrile Butadiene Styrene (ABS) and Polyethylene (PE) are the two most common pipework materials used on the Water Corporation's Lime facilities.

ABS is popular because of its good resistance to strong alkalis and better mechanical strength than PVC-U. ABS tends to be used inside the lime building for the milk of lime mixing pipework around the mixing tanks and outside the building for the lime water pump station and dosing lines. The use of ABS should be avoided for systems which have cyclic loading such as multiple pump starts and stops and multiple valve openings and closures.

PE Pipework tends to be used on the dilution water pump station and lines, the milk of lime dosing lines that run to the clarifier and the lime sludge lines. Its flexibility means it can be readily formed into wide radius bends which do not block as easily. If ABS is used for the lime slurry applications then long radius bends shall be specified and installed.

All ABS pipework and fittings used shall comply with the design, manufacturing, testing and inspection requirements as specified in the Water Corporation's Mechanical Pipework Standard, DS31-01 and shall be PN12 minimum.

All PE pipework and fittings used shall be high density PE 100 material and shall be PN12.5 minimum. The PE Pipework and fittings shall comply with the design, manufacturing, testing and inspection requirements as specified in the Water Corporation's Mechanical Pipework standard, DS31-01.

Both ABS and PE shall be de-rated for the effect of fluid temperature in accordance with the manufacturer's recommendation.

The silo filling line is generally carbon steel and coated to the same specification as the lime storage silos. All carbon steel pipework and fittings shall comply with the design, manufacturing, testing and inspection requirements as specified in the Water Corporation's Mechanical Pipework Standard, DS31-01 and shall be Schedule 40 minimum.

10.2 Pipework Jointing

All ABS pipework joints and fittings shall be solvent welded, except the tank to pipework connections and some pipework to equipment connections which shall be flanged.

The solvent welded pipe joints shall be made as per the manufacturer's installation instructions and AS 3691.

Where PVC or metallic valves are installed in ABS lines it is necessary to use flanged or threaded connections (such as adaptor bushes, nipples and sockets). Cementing ABS directly to PVC is not recommended as the solvent cements used on ABS and PVC are different, they are material specific. Liquid thread sealants such as "loctite" or PTFE paste shall not be used on threaded joints as they contain chemicals which may attack the plastic materials. PTFE tape is the recommended thread sealant[17].

PE pipework joints and fittings shall be either electro-fusion or butt welded, except pipework to equipment and tank connections which shall be flanged. These joints shall be carried out as per the manufacturer's installation instructions and in accordance with AS 4129.

Where PVC valves are installed in PE lines this connection can be made using PE flange adaptors. Where butterfly valves are installed in PE lines it may be necessary to include spacer rings to allow the valves to open due to the wall thickness of the PE pipe.

EPDM gaskets, with hot dipped galvanised bolts, nuts and washers are generally suitable for lime application flange jointing.

[17] Information obtained from Installation Section of the Eurapipe – ABS Pressure Pipe Systems Product Specification Manual.

10.3 Pipework Supports

All pipework shall be supported at specific intervals depending on the pipe wall temperature and the pipe diameter. The pipe manufacturer will be able to advise on this spacing and they typically provide published data in their design guides.

All supports shall be constructed of materials compatible with hydrated lime, milk of lime, lime water, process water, Rydlyme and lime sludge as appropriate. Pipe supports such as saddles, pipe clamps, cable tray, brooker rod and unistrut constructed from hot dipped galvanised mild steel, FRP & PE are typically used.

10.4 Pipework Identification & Labelling

Even though ABS pipework is UV resistant, all above ground ABS pipework shall be painted with at least two coats of acrylic water based paint in accordance with the Water Corporation's Standard Colour Coding for Pipework (EG71-1-1) for ease of identification. PE pipework is not required to be painted as it difficult to achieve an aesthetically pleasing finish. PE pipework should instead be labelled to designate the medium flowing through it – refer to DS79-04.

All ABS & PE pipework shall be labelled for ease of identification and to comply with the requirements of AS 1345.

Buried pipework or pipework installed in culverts (not exposed to UV) does not require painting, but will still need to be labelled for identification purposes.

10.5 Pipework Testing

All pressure pipework shall be hydrostatically pressure tested in accordance with AS 4041 before being commissioned. Unless specified otherwise the pipework should be tested to 1.5 x the maximum design pressure. Care must be taken to remove or isolate equipment from the lines which cannot be safely tested to the same pressure as the pipework.

11 Ancillaries

11.1 Safety Showers

At least four safety showers shall be provided for the lime facility. One safety shower/eye wash unit shall be provided at ground level outside the lime building between 2m and 7m horizontal distance from the tanker hose connection point. One safety shower/eye wash unit shall be provided on the ground floor inside the lime building and another unit shall be provided on the mezzanine level. The remaining safety shower shall be provided adjacent to the lime water dosing point into the recipient water.

All safety showers are to comply with the requirements of DS70-4 and AS 4775 and are to be fitted with flow switches to alarm their use. A 1 minute time delay in the control systems prevents these alarms being initiated simply when the showers are being tested (as should occur prior to a delivery).

The external safety showers, adjacent to the load-in apron and the lime water dose point, or any other shower where the supply pipework is run externally is also to be fitted with a thermal relief bleed valve.

For large sites where a dedicated potable water supply is distributed across the site (in addition to a service water supply) than this should be used as the preferred source of water for the safety showers.

For smaller sites or sites where a potable water supply is not available then service water can be used to supply the safety showers. However, the safety shower supply off-take must be located upstream of a reduced pressure zone device (RPZD) and any chemical connections are to be located downstream of the RPZD to protect the safety shower supply from contamination.

11.2 Hose Reels

Retractable wash down hose reels shall be provided and located such that all areas of the load-in and lime facility can be accessed with the hose for cleaning purposes. This typically means that at least nine hose reels are required:

- one outside the lime building on the delivery apron;
- two inside the lime building – one on each level;
- two on the lime clarifier bridge or walkways for cleaning the circumferential of launders (fire hydrant type hose with high water pressure and volume);
- one underneath the clarifier;
- one at the lime dosing pump station;
- one near the lime dosing point; and
- one in the vicinity of the sludge drying beds for truck hose down.

Fire hose reels connected to the fire-fighting water system should not be used for this requirement.

12 Control Philosophy

Compared to other chemical dosing systems, the lime storage, mixing and dosing system has quite a complex control system and is made up of four sub-systems, namely:

- Lime water storage and dosing
- Lime clarification
- Milk of Lime Preparation System 1
- Milk of Lime Preparation System 2

Essentially, the control system starts with the lime water dosing system and cascades back to the hydrated lime addition to the milk of lime preparation systems. To describe it simply:

- Lime water is flow-paced into the recipient water main.
- Dilution water addition to the lime clarifier is flow paced to the lime water flow and level control on the lime water tank is used to trim this dilution (process) water addition.
- Milk of lime flow to the clarifier is maintained at a fixed rate, but the milk of lime concentration varies.
- The milk of lime mixing tank is under level control, with the milk of lime flow out of the tank balanced with the make-up lime water addition to the tank.
- The hydrated lime addition to the mixing tank is under weight control by the loss-in- weight feeder. The rate of lime addition is matched to the lime dosed into the recipient water main.

The overriding objective of the lime control system is to balance the lime water flow rate produced through the milk of lime preparation and clarification process such that it will closely match the lime water flow rate discharged out of the lime water storage tank into the recipient clear water.

The control loops, calculations, interlocks and sequences for this control system are covered in detail in the Lime Storage, Mixing & Dosing System Control Functional Specification (DS 72-02) and is summarised below.

12.1 Lime Water Dosing System

As discussed above, the first system to commence operation is the lime water dosing facility. This operation will automatically be initiated when the recipient water flow exceeds a minimum preset flow for longer than 30 seconds.

The number of lime water dosing pumps to operate and their speed is controlled by a flow control loop paced from the flow meter (FIT 85216) in the recipient pipeline. The set point flow rate is calculated from the recipient water flow rate and operator inputs for the required lime addition and the lime water concentration (both in mg/L).

The operation of the lime water dosing system will then trigger the operation of the lime clarification system, to maintain a preset level in the lime water storage tank, and operation of the duty milk of lime preparation system that will feed milk of lime into the clarification system.

12.2 Lime Clarification System

The lime clarification control loop is used not only to balance the flow out of the lime water tank but also to respond in a stable manner to maintain a constant lime water level in the tank.

The number of dilution water pumps supplying the clarifier and their speed is determined by a control loop which is flow paced from the flow meter (FIT 85119) located in the discharge pipeline from the lime water dosing pumps. This control loop incorporates a PID level control loop refinement that considers the lime water level in the lime water storage tank.

12.3 Milk of Lime Preparation Systems

There are duty and standby lime preparation systems. The duty milk of lime preparation system is automatically initiated when the lime water dosing system is operating. Each milk of lime preparation system incorporates four control loops operating on the mixing tanks.

Firstly, the feed rate of lime into the mixing tank is flow paced from the flow meter (FIT 85119) located on the discharge line from the lime water dosing pumps. The mass of lime injected into the recipient water main (which is lost from the lime system) is calculated from this flow rate based on the operator entered parameters of known lime water concentration (in mg/L) in conjunction with reactive lime content (in %) and the clarifier operating efficiency[18] (in %). This mass is then fed into the mixing tank by the screw feeder controlled by the proprietary loss-in-weight control loop (WKIC 84112/84212).

Another control loop around the mixing tank is the vortex mixer flow control loop. This flow control loop operates to maintain a set flow rate through the vortex mixer (as measured by FIT 84307/84407) by adjusting the position of the flow control valve (VA84306/84406).

The operating level in the milk of lime mixing tank is maintained by a level control loop. This control loop regulates the position of the lime water mixing control valve (VA84305/84405) to maintain a set level in the tank that is monitored by the level transmitter mounted on the tank.

Lastly, the flow rate from the milk of lime preparation system to the lime clarifier is maintained at a constant rate by a flow control loop. This control loop uses a flow meter on the discharge side of the milk of lime pumps (FIT84509/84609) to adjust the speed of the milk of lime pumps (PU84505/84605) to maintain the milk of lime flow set point. Previously ,manually adjusted pumps have been used for this purpose; however, the build-up of lime scale in the milk of lime dosing lines meant the flow rate diminished over time, so frequent operator attention was required to maintain a constant flow rate.

12.4 Other Systems

12.4.1 Lime Underflow Pump Operation

As discussed previously, intermittently the sludge accumulated in the base of the lime clarifier will need to be removed. The operation of lime underflow pumps will automatically occur on a cyclic timed basis whenever the lime clarification process is operating. The operator is also able to manually intervene and initiate pump operation.

After the execution of a underflow pump operation, whether it is in automatic or manual mode, a flushing sequence will be automatically initiated to clear the pump and sludge line of any solids.

12.4.2 Sump Pump Operation

Operation of the lime building and lime clarifier sump pumps is independent of the milk of lime preparation, lime water clarification and dosing systems. Under automatic control the sump pump operation is initiated and terminated by level switches located in the sumps. These pumps can also be operated under manual control, where the operator can initiate and terminate pump operation independently of the level switches.

12.4.3 Silo Filling Operation

The lime silo filling operation is independent of the milk of lime preparation, lime water clarification and dosing systems. This is essentially a manual operation and providing the access hatch on the silo is closed, the extraction fan is available to operate and the level in the lime silo is sufficiently low (so as to accept a full delivery of lime) then the lime silo isolation valve (VA 84101/84201) is permitted to be opened and the filling operation can be carried out.

[18] Clarifier operating efficiency is a factor used in lime calculations to account for the lime "lost" in the clarifier due to the formation of insoluble calcium carbonate, or simply remains undissolved, both of which settles out of the clarifier as sludge. Typically clarifiers operate at around 95% efficiency; however this may be dropped to 80% during commissioning when a sludge bed is being established.

There are interlocks associated with this operation which will automatically close the silo isolation valve and prematurely terminate the filling operation. This includes the registering of a high level, high pressure or high high weight in the lime silo by the control system.

13 Labelling & Safety Signage

The following hazardous chemical signs complying with S399 "Plant Safety Signage and Markers Standard" and its referenced Signage Specifications (available to external designers under the heading "Chemical signage standards" at: Design standards (watercorporation.com.au)) shall be provided for any lime storage, mixing and dosing facility:

- A Hydrated Lime Facility sign (DS WCSS050-1) shall be posted near each entry door to the Lime building. These signs shall be displayed so as to be clearly visible from the normal direction of approach.
- A Hydrated Lime Silo sign (DS WCSS050-2) shall be posted on the silo bin activator(s). These signs shall be displayed at a level so that it is visible from the normal direction of approach.
- A Lime Silo Fill Point sign (DS WCSS050-3) shall be posted on the outside wall of the Lime building above the load-in point(s) related to the appropriate storage silo(s). These signs shall be displayed to be clearly visible from the normal direction of approach.
- A Milk of Lime sign (DS WCSS050-4) shall be posted on the milk of lime mixing tanks. The sign shall be displayed at a level so that it is visible from the normal direction of approach.
- Storage Tank Identification & Volume Labels (DS WCSS404) indicating the silo/tank number and size shall be posted on each milk of lime mixing tank and above each load-in point for the silos. These labels shall be displayed at a level so that it is visible from the normal direct of approach.
- Emergency Shower & Eyewash Signs (DS WCSS306) shall be posted on the wall next to the safety shower unit or attached to the rear of the shower. These signs shall be displayed to be clearly visible from the normal direction of approach.
- Maximum Fill Level Labels (DS WCSS402) shall be posted on the load-in panel. These labels shall be clearly visible to the person conducting the transfer of product into the storage tanks.
- Buried Chemical Line Signs (DS WCSS154) shall be used to identify buried lime water and lime sludge lines. These signs should be positioned at every change of direction or at a maximum of 50m intervals.
- Pipe Identification Markers (DS WCSS452) shall be posted on all pipework to indicate pipe contents and flow direction. These markers should be prominently displayed on the pipework to ensure the observer can clearly read the information.

All signs shall comply with the requirements of AS 1319 and the Western Australian Dangerous Goods Safety Regulations 2007.

Where a sign is fitted onto or near a door, the sign shall be easily visible with the door either open or closed. This may require identical signs to be fitted to both sides of the door.

14 Appendix A: Industrial & Premium Hydrated Lime Product Specifications

Cockburn Industrial Grade Hydrated Lime

Values stated within this specification are based upon monthly mean test results from daily grab samples. Individual results may from time to time lie outside these ranges and such occurrence should not necessarily be regarded as failure of the sampled batch to conform to this general specification.

Table 14-1: Cockburn Industrial Grade Hydrated Lime – Material Specification

Parameter	Method	Units	Typical	Range	AS1672-1997 Limits
Available Lime (as Calcium Hydroxide)	AS4489-1997	%	85.0	81.5-90.0	≥65%
Carbon Dioxide	AS4489-1997	%	0.7	0.3-1.2	≤4%
Fineness Index					
Residue on 600µ sieve	AS4489-1997	%	0.1	Nil-0.1	≤5%
Residue on 300µ sieve	AS4489-1997	%	0.3	Nil-1.0	
Residue on 150µ sieve	AS4489-1997	%	2.5	0.1-5.5	
Residue on 75µ sieve	AS4489-1997	%	6.5	1.9-11.0	
Loose Bulk Density		kg/m3	375	315-435	

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Cockburn Premium Grade Hydrated Lime

Values stated within this specification are based upon monthly mean test results from daily grab samples. Individual results may from time to time lie outside these ranges and such occurrence should not necessarily be regarded as failure of the sampled batch to conform to this general specification.

Table 14-2: Cockburn Premium Grade Hydrated Lime – Material Specification

Parameter	Method	Units	Typical	Range	AS1672-1997 Limits
Available Lime (as Calcium Hydroxide)	AS4489-1997	%	92	89.0-95.0	≥65%
Silicon Dioxide	XRF	%	0.5	<0.1-2.0	
Carbon Dioxide	AS4489-1997	%	0.8	0.2-1.6	≤4%
Fineness Index					
Residue on 600µ sieve	AS4489-1997	%	0.2	Nil-1.0	≤5%
Residue on 300µ sieve	AS4489-1997	%	0.4	Nil-1.5	
Residue on 150µ sieve	AS4489-1997	%	1.0	0.2-2.0	
Residue on 75µ sieve	AS4489-1997	%	1.5	0.5-3.0	
Loose Bulk Density		kg/m^3	290	230-350	

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15 Appendix B: Typical Supplier Listing

Provided for information only is a list of suppliers who have provided equipment for Water Corporation installations in the past:

Table 15-1: Typical Supplier Listing

Equipment	Supplier	Contact Details
Lime Storage & Mixing Equipment - Silos, Bin Activators, Rotary Valves, Dust Filters and Mix Tanks	Transmin	33-35 Denninup Way Malaga WA (08) 9249 6116
	WAM Australia	5 Eastspur Court Kilsyth South VIC (03) 9737 4700
	Lime Systems	133 Kurnall Road Welshpool WA (08) 9259 8400
Dosing Pumps	Malcolm Thompson Pumps	Unit 1, 9-11 Colquhoun Road Perth Airport WA (08) 6462 7755
	Kelair Pumps	Unit 1/14 Crocker Drive Malaga WA (1300 789 466)
Lime Clarifiers	Outotec Pty Ltd	Level 2, 1 Walker Avenue West Perth WA (08) 9211 2200
Lime Water Storage Tanks	GRP Technology Pty Ltd	7 Kalmia Road Bibra Lake WA (08) 9434 1707
	The Newell Group Pty Ltd	191 Adelaide Road Murray Bridge SA (08) 9532 2455
	Permastore Tanks & Silos	PO Box 240 Hornsby NSW (02) 9477 7944
Clarifier Underflow (Sludge) Pumps	Mono Pumps Pty Ltd	497-499 Great Eastern Highway Redcliffe WA (08) 9479 0444
	Blakers Pump Engineers	29 Paramount Drive Wangara WA (08) 9302 1855
	Kelair Pumps	Unit 1/14 Crocker Drive Malaga WA (1300 789 466)
Sump Pumps	Grundfos	1/7 Marchesi Street Kewdale WA (08) 9353 4595
	ITT Water & Wastewater	20 Tarlton Crescent Perth Airport WA (08) 9479 1511

16 Appendix C: Lime Standard Design - Equipment List

The list of equipment for the Lime Storage, Mixing & Dosing System is provided in this appendix (refer to document named DS72-01 Appendix C - Equipment Schedule, Nexus document # 58557062).

END OF DOCUMENT