RISERLESS BORE PUMPING SYSTEM - NEW GENERATION OF GROUND WATER BORES

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1.0 INTRODUCTION

1.1 Catalyst for Groundwater Bores Rehabilitation at Riverina Water

Riverina Water County Council (RWCC) began constructing groundwater bores from 1967 to provide an economical and reliable water supply to independent water supply systems and to augment their existing interconnected supply systems. Currently RWCC has 28 bores with diameters ranging from 250mm to 400mm and providing yields 1 l/s to 150 l/s. Ground water sources supply up to 80% of peak summers demand and currently comprises approximately two thirds of RWCC's total township water allocations.

Many of these original bores were constructed with mild steel casings and these began to show significant signs of corrosion typically at welded joints, imperfections along the bore casing (such as welded notches used during transport of bore casing and bore construction processes), and at random locations associated with localised pitting. The general life span of mild steel casings experienced at RWCC ranges from 25-40 years depending situational factors such as:

- Quality of mild steel used
- Evidence of bio-corrosion (ie. from micro-organisms)
- Stray and induced currents (primarily from motor operations)
- Erosion (depending of velocities, cavitations)
- Physical and chemical characteristics of groundwater
- Pump & motor material selections promoting exchange of ions between the anodic and cathodic surfaces

From 1997, RWCC began to visually inspect the structural integrity of its ageing mild steel bores and prioritised their rehabilitation based on importance to water supply systems (ie. reliability, production, water quality).

It was decided to consider rehabilitation of existing bores rather than redrilling new bores to reduce the uncertainty and risk in maintaining water quality and yield. RWCC had already experienced drilling new bores (say) within 5-20 metres of original bores where the resulting water quality was totally different to the original bore water and was untreatable, therefore these new bores had to be abandoned.

Rehabilitation methods adopted by RWCC included relining of mild steel bore casing with stainless steel. However, this was only possible if there was still sufficient structural integrity remaining of the mild steel casing to avoid bore collapse. Use of stainless steel relining also ensured adequate service life and economic return on investment.

Depending on the desired pump flow velocities and diameter of the parent mild steel bore basing, the stainless steel reline was either inserted with periodical swaging to centre the stainless steel liner, or where the maximum internal diameter had to be maintained, the stainless steel liner was continuously swaged along the entire depth of the bore.

2.0 OPPORTUNITIES TO IMPROVE BORE OPERATING SYSTEMS

As part of RWCC's bore rehabilitation programme to reline existing bores with stainless steel liners, other opportunities were considered to improve the overall bore operations, such as:

- Greater flexibility and future proofing of bore operations to suit variability of hydrological conditions as experience during the recent 10-year drought
- Improved and safer maintenance systems for installation and removal of bore pumps & motors
- Increased operational life spans of bore pumping components
- Improved pumping efficiencies, operational costs and better return on investments
- Greater reliability and interchangeability of bore pumps and motors

Based on RWCC's experience, these other considerations are briefly described below.

1.1 Installation of Pump Motor Variable Speed Drives (VSDs)

Installation of VSD controls with suitable bore pump motors assists the following:

- Reduced wear and tear on thrust bearings during starts/stops
- Opportunity to control bore extraction rates to match standing water levels above the pump to ensure sustainable pumping operations. For example, RWCC reduced many of Wagga Wagga's production bore extraction rates from their designed flowrate of 150l/s to 100l/s during the drought by use of VSDs in order to maintain sufficient standing water levels above the pumps.
- Significant energy savings have been achieved in reducing flowrates using VSDs compared to traditionally throttling valves to reduce extraction rates.
- Other advantages include ability to maintain constant flowrates from each bore within in a multiple bore rising main to assist fluoride trim dosing. For example, each bore typically has a different natural fluoride concentration so controlling a bore's output to be constant allows a PLC to be programmed to calculate the required fluoride trim dosing based on which bore(s) is/are in operation.

However, it should be noted that there are some negative issues regarding VSDs that include:

- Greater initial cost but may be justified over a longer payback period
- Higher motor temperatures at lower speeds
- Possible output harmonics and induced power line harmonics depending on the quality of the VSD used and sensitivity of nearby electronic equipment

1.2 Installation of 4-pole Bore Pump Motors

Greater benefit is gained when 4-pole motors are used in conjunction with VSD controllers compared to 2-pole motors. 4-pole motors allow greater flexibility in pumping operations by providing necessary torque at a range of speeds. That is, they can operate across a greater speed range whilst providing the necessary torque to drive the pumps when controlled by a VSD ie. no 'forbidden speed windows'.

With respect to bore operations, 4-pole motors in conjunction with VSDs have been used at RWCC to:

- Maintain constant discharge pressure in the rising mains
- Maintain a constant flowrate against variable system pressures

- Maintain a constant standing water level above the pump when groundwater level drawdown becomes significant

2-pole motors generally run at higher speeds (ie. 2900 rpm) therefore more prone to wear than slower 4-pole motors, however, it should be noted that 2-pole motors are generally cheaper. It should be noted that the selection of either 4-pole or 2-pole motor may be depended on available bore internal diameters after relining and ensuring adequate flow velocities for cooling bore pump motors. That is, a 2-pole motor typically has a smaller diameter than a 4-pole motor but as stated above, operate at higher speeds.

1.3 Use of Stainless Steel Pumps and Motors

To reduce various types of corrosion (ie. electro and chemical) of bore casing, pumps and motor components, it was justified to consider installation of stainless steel pumps and motors. For example, bore depths at Wagga Wagga production bores typically ranged between 70-90 metres depth with relatively high concentration of dissolved gases, mostly carbon dioxide and hydrogen sulphide. These dissolved gases reduce pH of the groundwater and increase the potential of corrosion of susceptible metallic components. For example, a bronze pump and/or impeller often only lasted 12-18 months under these conditions.

Use of stainless steel pumps and motors within a bore relined with a stainless steel liner also reduced potential of galvanic corrosion.

The cost-benefit analysis justified this decision. For example, a recently inspected stainless steel pump and motor installed in a Wagga production bore in 2003 showed no noticeable wear or corrosion, compared to previous installation of a bronze pump impeller where it only lasted 12-18 months at the same location.

1.4 Standardisation of Bore Pumps and Motors

RWCC had a range of different types, makes and models of bore pumps and motors and switchboards. This was often the outcome of making the most economical decision during procurement processes. The trade off of selecting the most economical purchase at each instance often meant that pumps, motors and switchboards could not be interchanged between installations without significant effort and time.

For example, poor quality power supply into a bore site resulted in damaging the main switchboard, VSD and bore motor. As a consequence, only one of the three bores was in operation leaving no backup to supply a major industrial area (as maintenance was being conducted on another bore and could not be reinstated easily ie. 2-3 weeks). RWCC was able to relocate and commission a VSD, bore pump and motor from a bore site in another bore field within Wagga Wagga within 1 ½ days.

It should be noted that when procuring high capacity stainless steel pumps and motors, there are only a few number of suppliers which may help justify standardisation of compatible pumps and motors.

1.5 Installation of Riserless Pump Packer System

A riserless bore pump packer system utilises the bore casing above the pump and motor to be part of the rising column by utilising an inflatable packer around the pump & motor assembly. The inflatable packer provides the seal and also supports of the pump & motor assembly in the bore casing (refer Figure 1). The technology was developed and introduced into Australia by AGE Developments (Perth) during the mid 1990's.

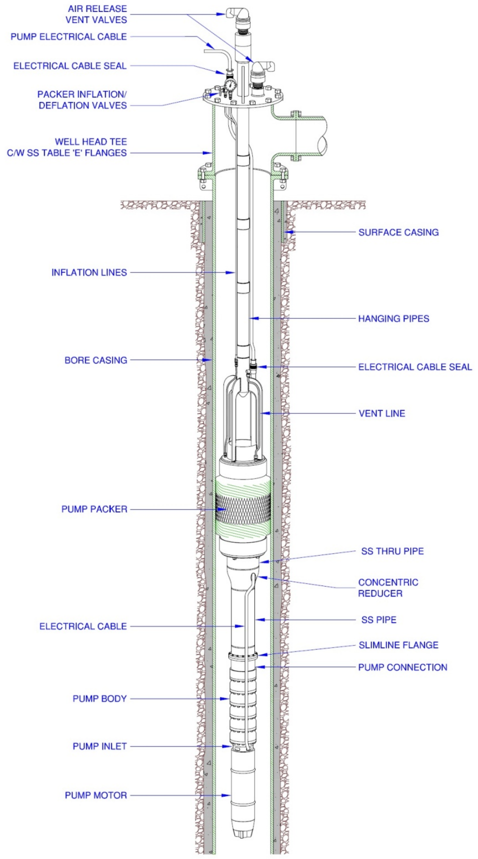
The technology is still considered relatively new in Australia and provides the final piece of the 'jigsaw puzzle' in establishing 'best practice' for groundwater bore installations.

Basically, the riserless pump packer system eliminates the need for a separate riser column and offers a range of economic and safety advantages including:

- Allows greater ease and safer installation and extraction of bore pumps & motors compared to traditional methods associated with separate rising columns.
  - For example, a 90 metre bore installation with a separate rising column comprised of 3m segments (either screwed for flanged) would take 4-5 people 1 complete day of heavy manual handling and significant safety risks in handling rising column lengths. With a riserless system where the pump & motor assembly is hung on a small diameter stainless steel screwed rods, up to 3 persons for 3-4 hours are required to handle the stainless steel hanging rods in a much safer manner.
- Reduces frictional pumping losses and energy costs.
  - Significant energy savings can be achieved compared to the use of a separate rising column simply by reducing the frictional losses.
  - An example of energy savings is illustrated in Figure 2.
- Eliminates need and costs associated with a separate riser column
- May even reduce required bore diameter for new installations
- Pump packer may accommodate pressure transducers to be installed near pump
- Improve water quality management by reducing air contact with bore casing and therefore reducing potential bacterial activity
- Packer is able to secure pump & motor assembly to the bore casing, reducing possible chaffing between pump & motor assembly and the bore casing
- The bore installation maybe fully sealed to prevent flood water ingress and remain in operation even if the site is totally submerged as experienced in March 2012 floods in Wagga Wagga. Note: ensure that the air valve is raise above possible flood levels.

2.6 Typical Installation/Removal of Riserless Pumping System

Illustrated below in Figure 1 is a typical installation of a riserless pump packer system. Note the hanging rods that are supporting the pump & motor from the well head plate and the inflation lines to the pump packer.



<u>Figure 1:</u> ***Illustration of typical Riserless Pump Packer system (source: AGE Developments 2011)***

Removal of the bore pump & motor requires:

- Deflation of the pump packer to drain water above the pump & motor ie. the lifting process does not include lifting a separate rising column that is often still full of water (depending whether the pump has a foot valve installed)
- Unbolting the head plate from the well head tee
- Lifting of screwed segmented hanging rods and disassembling
- Feeding power and inflation lines onto drums to prevent damage to cables
- Ability to lift and raise the pump packer system with pump & motor above the well head tee

Installation is simply the reverse of the removal process removal.

2.7 Power Savings

An example is provided based on RWCC's North Wagga Bore 2 installation to demonstrate significant energy savings. The calculations can easily be used to develop a business case in justifying installation of a riserless pump packer system

AGE Riserless Pump Packer V Traditional Riser Column Head Loss Running Cost Estimator

Bore Name	**North Wagga #2**	
Bore Casing ID	377	mm
Bore Casing Material	Stainless Steel	
Pump Setting Depth	45	m
Pump Outlet Size	200	mm
Flow rate	150	L/sec
Traditional Riser Equivalent Information		
Rising Column ID	200	mm
Rising Column Material	Stainless Steel	
Rising Column Hazen Williams Coefficient	120	
Riserless Pump Packer Hazen Williams Coefficient	94	

Hazen Williams Coefficients	
Fiberglass	150
Steel / Stainless Steel Pipe	120
Concrete / Cast Iron	100
Riserless Pump Average	94

		Riserless Pump Packer	200mm NB Riser Column	
Internal Area	m2	0.111627856	0.031415927	
Flow Velocity	m/sec	1.344	4.775	
Calculated Head Loss	kPa	4	51	
Pump Efficiency	%	70	70	
Pressure Loss Power Consumption	kW	0.781158359	10.89699132	
Peak Power Cost	$/kWH	$0.3131	$0.3131	Synergy R3 Tariffs 2011
Peak Operational Hours	Hours	14	14	
Off-Peak Power Cost	$/kWH	$0.0964	$0.0964	Synergy R3 Tariffs 2011
Off-Peak Operational Hours	Hours	10	10	
Power Cost per Year based on Operational Hours		$1,525	$21,269	
Riserless Pump Packer Estimated Head Loss Savings per Annum		$19,744		

Figure 2: *Example of energy savings for North Wagga Bore 2 at designed bore output of 150l/s (source: AGE Developments 2011)*

3.0 SUMMARY

RWCC has invested significant resources in developing, constructing, operating and maintaining their groundwater facilities. This paper only provides a brief description of factors that should be considered either as part of new groundwater bore installations, or in RWCC's case, part of groundwater bore rehabilitation programmes.

If you would like further information on RWCC's groundwater bore installations, please contact:

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