Showcase

Title: Lockyer and Mid Brisbane River Integrated Sensor Network

Sector: Drinking water (catchment):

☒ drinking water sources

☐ drinking water treatment

☐ drinking water distribution

☐ wastewater collection / influent

☐ wastewater treatment

☐ wastewater effluent / receiving water

☐ other

Utility: Queensland (Australia) Bulk Water Supply Authority trading as Seqwater

Date: 2014

Introduction & background information

Seqwater is a Queensland Government statutory authority responsible for ensuring a safe, secure and reliable water supply for almost three million people across South East Queensland and providing essential flood mitigation services. It also provides irrigation services to around 1000 rural customers in five water supply schemes.

The authority is one of Australia's largest water businesses with the most geographically spread and diverse asset base of any capital city water authority in the country. With operations which extend from the New South Wales border, to be the base of the Toowoomba ranges and north to Gympie, Seqwater manages more than $9 billion of water supply assets and the natural catchments of the region's major water supply sources. This includes dams, weirs, conventional water treatment plants and climate resilient sources of water through the Gold Coast Desalination Plant and the Western Corridor Recycled Water Scheme. Twelve of the largest treatment plants are connected by a 600-kilometre pipeline network which allows water to be transported across the region.

Water quality challenges

The Mid Brisbane River is defined as the reach of the Brisbane River downstream of the Lake Wivenhoe Dam wall to the Mt Crosby Weir, which acts as a natural water supply conduit from Wivenhoe Dam to the Mount Crosby Water Treatment Plants. Somerset Dam, feeds water into Wivenhoe Dam, which is the largest drinking water storage in South East Queensland (1100 GL), and the primary drinking water supply for the city of Brisbane. The 65 km section of the Mid Brisbane River has several major tributaries including: Spring Creek, England Creek, Black Snake Creek, Lockyer Creek, Branch Creek, and Cabbage Tree Creek (Lake Manchester). Of particular interest to Seqwater and their Water Treatment Plants is the contribution of several creeks that flow into Lockyer Creek, as well as Blacksnake Creek which feeds directly into the Mid Brisbane River. Lockyer Creek runs West to East through the middle of the Lockyer Valley, with is renowned as "Australia's Salad Bowl", with an estimated 35% of Queensland's vegetable crop coming from the fertile grounds of the Valley, which is under constant high agricultural pressure. The Lockyer creek is managed under an irrigation scheme with a number of aquifer recharge weirs located along its length, culminating at O'Reillys Weir, located almost at the junction with the Mid-Brisbane River. Discharges from the Lockyer can bring very high turbidity and organic loads during large rainfall events or significantly hard and saline waters during lower flow periods. This water is mixed with water released from Wivenhoe Dam and can take anywhere between two weeks to several hours to reach the Mt Crosby Treatment Plant, dependent on release volumes. In addition to Lockyer Creek; Blacksnake Creek, and to a lesser extend a few smaller creeks flowing from the Lockyer Valley also pose significant salinity risks with Blacksnake Creek being intermittently connected to the Mid Brisbane during periods following rainfall. The ability of the Treatment Plants to continue and manage supply through these high salinity or high turbidity events is partially reliant on the early detection of poor water quality issues in the river, and the subsequent increased dilution of poorer quality water with higher quality water released from Wivenhoe Dam or the optimisation of Water Treatment Processes at the plant to handle the changing source water conditions. This project is designed to provide a quasi (near) real time response capability both for routine and environmental event (large rainfall) periods.

Purpose / Need for on-line monitoring

The water quality related issues are centred around two key areas:

a) During routine operations the water quality instrument network functions as an early warning systems for Treatment Plant operators of the two affected WTPs, at Lowood and Mt Crosby, giving the operators information on the raw water quality that will be received at offtake prior to arrival, which can then inform plant treatment capabilities assessments and where required trigger the increased release of water from Wivenhoe Dam to dilute incoming poor water quality issues and increase the treatment capability of the plants to handle the highly variable source water.
b) During flood or event-based operations again the telemetered water quality installations provide critical raw water information to Treatment Plant Operators about what conditions are like upstream of the treatment plant so that they can assess if their Water Treatment Plant can operate an effective multi barrier treatment program with generally: high sediment, high nutrient and high DOC waters. In some cases this information enables operators to process the water for a certain period of time before taking the Treatment Plant offline until raw water quality parameters improve.

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Approach and implementation

The current monitoring program developed in response to shifting water quality challenges in the Mid Brisbane River system arising from south east Queensland moving from a period of extended drought conditions to a series of seasonal floods from 2010 through 2013.

The increase in available water following 2010 rains and subsequent floods resulted in a reconnection of hypersaline groundwater with surface waters in various regions of the Brisbane Valley. This in turn led to saline surface water discharge via Blacksnake Creek to the Mid Brisbane River. Additionally, the extensive rain and subsequent flooding mobilised substantial sediment loads across the Lockyer Creek sub-catchment. These saline and turbid discharges required significant deployment of Seqwater staff to undertake field sampling programs to measure and track water quality throughout the Mid Brisbane River on a sub weekly basis. This intense non-routine in-field sampling tied up resources and put increased pressure on an already time-constrained field team.

Some locations already had fixed automated and telemetered samplers/sensors employed within the Locker and Mid Brisbane catchments, however these systems were not optimised for providing operationally relevant data during these extreme weather events. Further, following the 2013 floods, it also became apparent that these existing stations needed to be elevated and reinforced to ensure their continued operation during extreme weather events.

In order to provide accurate data from numerous points around the Mid Brisbane and key tributaries within relevant timeframes, while at the same time keeping field staff time within safe limits, the Lockyer/Mid Brisbane integrated sensor network system was developed. Six new sensor systems were installed at various points in the Lockyer Creek and Mid Brisbane River catchments . The capability of these new sites include telemetry and, in some locations, automated water quality sample collection and refrigeration (O'Reillys Weir), as well as the capacity for communication and sensor upgrades to meet future water quality monitoring needs.

<u>Systems, methods, and monitoring instruments</u>

The central requirement of Lockyer/Mid Brisbane integrated sensor network is to ensure the collection and effective timely communication of scientifically valid raw water quality information to the treatment plant operations Team at Mt. Crosby.

Water quality parameters (minimum at each site of dissolved oxygen, temperature, pH, conductivity, redox and turbidity) are measured via instrument probe array based on a YSI (Pty Ltd) Sonde Instrument linked to a Campbell (Pty Ltd) data logger. The information that is collected from the water quality instrumentation is polled on three hourly intervals, with information is transmitted through the use of solar and battery powered Next G telecommunication modems and data loggers that store and then transmit data to a central processor for automated compilation and display through internet based graphical user interfaces.

<u>Control Segment</u>

The control segment used consists of a large metal or plastic weatherproof housing, containing several subsections, the first of which is the powerpack. The powerpack supplies power the water quality instrumentation, data logger and communications modules. The powerpack consists of a 12-volt gel cell battery with either an 18 to 24 Ah capacity, connected to a 10 or 20 watt solar panel. The solar panel is mounted on angle brackets at an angle of approximately 28° from horizontal, to ensure maximum solar panel output for the South East Queensland latitudes. The communication and data logger modules are also housed inside the weather proof housing and consist of a Campbell Scientific CR1000 data logger, coupled with a Maxon ModMax Next G modem. The entire control segment is mounted on an elevated platform, such as a pivot pole with is cemented into the ground with a large footing and keeps the control segment several meters above the ground to protect it from flood inundation, keep the sky view clear for maximum solar panel production and to protect the infrastructure from possible vandalism. The data cables for the water quality instrumentation are run through the pivot pole into the ground, where they are intersected by a variable lengths of trenched pipework. The trenched pipework is laid from the control module to the river bank and commonly protrudes out into the flow of the river below the low water mark to expose the end of the water quality instrumentation to flowing water. The pipework is commonly intersected on the crest of the river bank by a metal or cement hatched access pit. This pit enables the straight-line deployment and recovery of the water quality instrumentation into the river through a trenched pipe, which is accessible in anything except flood conditions. The final segment of the installation is water quality instrumentation which consists of an YSI Exo Sonde, which is deployed down the tube to an endcap which has perforations to allow the flow of water through the end of the tube and past the sampling probes. Data is then sent to the data logger on a 10- to 15-minute basis for collation and broadcast to the database when poled.

These water quality sampling stations were installed to handle flood conditions and house the communication modules above considerable flood waters (1 in 1000-year flood heights).

Project Execution and Delivery

The general site installation previously described is a dynamic construct, and is optimised for each site dependent on a range of factors including: Access to site, existing underground installations (power, telecommunications cables), existing site infrastructure (sheds, pipework), river bank stability, bridges, crossings, land ownership, public interactions etc.

Once an individual site has been determined, custom pipework and trenching is generally performed by external contractors, along with the installation of the pivot poles, including cement footings all other install/ optimisation/ performance assessment works performed by Seqwaters Environmental Systems Team.

Costs and maintenance

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The prices quoted below are indicative of an average installation, if the pipework distance is longer or shorter than below (assumed 100 m length), then the trenching, pipework and data cable costs will vary by approximately $2500 per 100 metres greater than an average length of 100 m quoted below, shorter by 40 metres saves $600.

Purchase and Installation

Solar Panels and Batteries B&R Case	$ 1,000
CR1000 Data logger	$ 1,500
Next G Modem	$ 400
Pivot Pole	$ 1,000
Pipework	$ 750
YSI Exo Sonde	$ 15,000
YSI Cable and Connector	$ 2,700
Sonde Pit	$ 300
Incidentals	$ 200

Installation

Trenching:	$ 1000
Footings, Rock, Cement:	$ 350
Install Labour Costs:	$ 3400 (7 x 10-hour days, for PO 3.4 staff)
Vehicle Costs:	$ 400
TOTAL INITIAL COST:	$ 27,000

Maintenance

Calibration Solutions:	$ 75
Monthly Data Charges:	$ 30
Calibration Time:	$ 90
Deployment and Field Time:	$ 200
Vehicle Costs (site only):	$ 30
YEARLY ONGOING:	$ 5,500 (based on 14 trips, 12 routine, 2 site fault-checking)

Qualifications:

Field Deployments are performed by Tertiary Education Scientists with additional technical skills, calibration are performed by Tertiary Educated Scientists (Hourly rate ranging from $35 to $45 per hour).

Data collection and storage

Data from each of the remote telemetered water quality systems is poled using Campbell Scientific's Loggernet Software via the Next G cellular network on a three-hourly basis, with the information transmitted over the cellular network to a 3G modem connected to the telemetry computer. The data is collated by the Campbell Scientific software and converted to a usable format before being stored on a server network in a raw format (with automated backup on parallel server). Data from the primary server is imports into a Wiski Database and is also duplicated on a separate server, for manipulation and web-based display using Campbell Scientific's Real Time Monitoring Control (RTMC) software for web-based display. Surfer is used to generate and present time series contour plots as images for web-based display.

Data validation is currently performed through a visual assessment of the time series data by Seqwater's Environmental System's team, with any erroneous data flagged from further investigation to ensure the issues are resolved and the data is not used for future data analysis.

The data once collated and stored can be access either directly from the database, or through web based visual displays, which is the most commonly accessed data form used by the Treatment Plant Operations Team.

Data handling

The data, on arrival through the Next G communication network is transformed from SDI12 data into usable information by the Campbell Instruments Software Packages prior to export to servers, databases and web based graphical user interfaces. The RTMC software module, is responsible for the actioning of alerts, which can be arranged in a hierarchical response, depending on the desired outcome. If the water quality monitoring system goes offline, Seqwater's Environmental Systems Scientists are alerted so that they can schedule maintenance. In the case of water quality parameters, the type and amount of alert-based notifications depends on the level of parameter exceedance. Alert notifications are communicated via email, which is accessible by the majority of operational and senior management staff at Seqwater that are on the alert network for the individual water quality installation, with the emails being accessed through their data enabled smart phones. Additionally text messages can be programmed directly into the Campbell CR1000 data loggers at the water quality instrumentation site, with a series of pre-determined text messages sent when different pre-defined actions occur.

Data is also fed into a simple predictive model that can be accessed by operators to look at changes in the system with lead indication of the change. This is a simple flow/dilution model that takes the proportional flows in the system, combines them with the on-line water quality to predict key parameter changes.

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Quality Assurance / Quality Control

All remotely deployed instrument probe arrays (in this case YSI Sonde) are on a rotation-based calibration system where a calibrated sonde is redeployed each month, enabling the other sonde to be calibrated and if required have probes replaced if nearing the end of their operational life. All sondes are calibrated using in-house calibration procedures derived from the YSI Sonde operational manuals and optimised for our freshwater sampling conditions.

part from visual inspections of parameters there are currently no QA/QC processes applied directly to the data, mainly due to the very heavy field load of the Environmental Systems Scientists dealing with floods and the subsequent repairs of installations in both 2011 and 2013.

Operational Changes

There are several aspects to this program, all of which have derived quite large operational savings, through a significant reduction in field sampling requirements, particularly for high conductivity period, which might have required a field team and vehicle to spend up the five hours a day, three days a week sampling the river in two-person teams (can be in excess of $1,800 wages and vehicle expenses a week).

In addition to the savings in Catchment Water Quality Team, the Treatment Plant Operators are better informed about the quality of water upstream and are therefore able to make valid and informed operation decisions on Treatment Plant Process Optimisation to handle the variable water quality, especially during period of high sediment or conductivity. The communication of this data and the quazi real time alert system is also a highly effective communication tool for senior operators and upper management in the company to keep abreast of near real time catchment water quality issues.

Successes & Limitations

The benefits of water quality monitoring programs incorporating near real-time data communication are clear. These systems provide the ability to remotely track change of water quality parameters over time, during a range of climatic conditions. In doing this they a more comprehensive picture of what is occurring in the catchments, giving WTP operators a better ability to respond to routine and emergent water quality issues, and put in place effective controls prior to the poor water quality being received at the intake. On-line instruments give much greater temporal understanding and significantly reduce the demand for field sampling and associated resourcing.

The greatest limitation of the current program comes from the lack of resilience in the systems during significant events. Instrumentation sites have been damaged a number of times through large events ranging from loss of power to site to complete destruction of the site. In some respects, this is to be somewhat expected due to the nature of the deployments and can be substantially mitigated through robust and initially expensive infrastructure options, however, such measures are an important consideration for these installations. During significant weather events (which present the most critical data periods), the stations are also most susceptible to dependent services failure (power failure, telecommunication network failure etc).

Users also need to be very familiar with the operating and calibrated ranges for the instruments and the application of their use, including outside these ranges. Most probes that are calibrated for routine conditions do not perform well in event conditions and this needs to be carefully considered when installing and maintaining gear. For example, some key Seqwater sites carry two turbidity sensors, low range and high range to ensure peak events are adequately captured

Project Review

This project has been hampered by two floods in 2011 and 2013 that damaged much of the water quality sampling infrastructure, but also the Next G telecommunications and power networks for several months following the floods. These incidents then placed even greater workload pressure on the Environmental System team to rebuild these stations leading to significant resourcing issues. If more capital was spent developing more robust and resilient installations at the start of this project, significant savings would have been made financially and with respect to resourcing for the long term and is a foremost consideration with new installations.

Additional issues that have been highlighted and are currently being addressed, is the requirement to have heavily flood resistant installations, with standalone power supplied, with dataloggers, modems, batteries and solar panels located on elevated platforms, poles and in sampling sheds above flood waters to ensure data transfer throughout the event, barring instrument damage caused by bank scour and impact with flood debris.