BUNDAMBA ADVANCED WATER TREATMENT PLANT STAGE 1A & 1B

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ABSTRACT

In 2006, Queensland was in the midst of its worst drought on record. Faced with dwindling water reserves and crippling supply restrictions, the Queensland Government, through the offices of the Coordinator General, turned to Thiess Pty Ltd, one of the state's oldest and most trusted construction companies, and global water engineering giant Black & Veatch to fast track the delivery of a vital infrastructure project.

In a very short and carefully planned 10 months for stage 1A, the Thiess/Black & Veatch Joint Venture (TBJV) designed, procured, constructed, commissioned and operated the 20 MLD stage 1A plant of the Bundamba Advanced Water Treatment Plant (BAWTP). A few months later, TBJV was awarded the stage 1B contract to increase the capacity of the Stage 1A plant by 50% and build an additional plant with 36 MLD capacity. The integration of combined stages 1A and 1B plants increased capacity to 66 MLD. The project has redefined industry benchmarks and has been widely acknowledged as world best practice for a project of this type in terms of quality of build, quality of product and sustainability.

The project was completed with an excellent safety record: zero LTI (no Lost Time Injury).

The environmental management was challenging. However the project has achieved outstanding results of processing purified recycled water (PRW) and discharging waste to EPA guidelines with no harm to people or the environment.

Working in very close proximity to an active community was a challenge. This challenge was overcome with a strong relationship with the community and the project was delivered without complaints.

The successful outcome was due to TBJV's capability through the formation of a hand picked team, experienced with world's best practice in design innovation, leading the delivery of a world class asset in record time. Our team has achieved the project vision, despite the public scrutiny and media publicity, and in the process generated interest from industry leaders worldwide and government ministers from Australia and overseas including Singapore, USA, China and Malaysia.

KEYWORDS

ACAA**,** Western Corridor, recycled water, Bundamba, Alliance, drought, microfiltration, reverse osmosis, advanced oxidation, innovation

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THE PROJECT

Stage 1A and 1B are the first two phases of BAWTP, which is one of three major advanced water treatment plants built as part of the AU$2.4 billion Western Corridor Recycled Water (WCRW) Project, the largest water recycling scheme in the Southern Hemisphere.

The WCRW Project will eventually produce purified recycled water (PRW) from existing wastewater treatment plants in the Brisbane and Ipswich areas, providing a secure alternative water source for local industry as well as supplementing the region's stored surface water supplies and guaranteeing cooling water to power supply for South-East Queensland.

Stage 1A of the BAWTP provided capacity to produce 20 mega-litres of PRW each day. Stage 1B provided a further 36 MLD of PRW and increased the capacity of the Stage 1A plant to 30 MLD. The combined capacity of 66 MLD uses the entire output of the nearby existing Bundamba, Goodna, Wacol and Oxley waste water treatment plants, which previously released waste directly into the Bremer and Brisbane Rivers.

BAWTP Stage 1A and 1B use microfiltration (MF) membranes followed by reverse osmosis (RO) membranes and advanced oxidation, comprising hydrogen peroxide and UV energy to remove contaminants and impurities, resulting in PRW which is of a quality compliant with Australian Drinking Water Guidelines (AWDG).

The PRW is currently being pumped to the nearby Swanbank and Tarong Power Stations to be used as cooling water. Previously, this cooling water (enough to supply the daily needs of almost 500,000 people) would have been drawn from precious water supplies in Wivenhoe Reservoir – adversely affecting the availability of Brisbane's drinking water supply. The Project PRW is of such high quality that it can safely be diverted to water reservoirs, where it would be mixed with catchment run-off and used as drinking water, a first for Australia.

THE CONTRACT

The BAWTP Stage 1A and 1B contracts were delivered through an alliance between the TBJV and the Queensland Government Department of Infrastructure. The TBJV partners were selected based on their capability and commitment to completing the project within a tight schedule. The Alliance leaders defined the scope of work with the following objectives in mind:

- Maximising functionality, water quality, plant performance and delivering the project under budget
- Minimising project schedule while maintaining quality, safety and flexibility to adapt to changes

A Project Alliance Agreement (PAA) was developed, which defined the project requirements, technical specifications, commercial framework and pain/gain share model. An Alliance Leadership & Management Teams (ALT &AMT) were established to oversee the project. The Alliance contracts for stage 1A & 1B were signed respectively on 17 November 2006 and on 1 August 2007.

CONTRACT MANAGEMENT INNOVATION

For a project of this type with a tight time schedule and many uncertainties, an alliance contract provided the following principal advantages:

- The commercial framework provided the necessary comfort for all parties to cooperate and make 'best-for-project' decisions, allowing collaboration between partners. This enabled all parties to work together to develop and agree to a comprehensive contract in a very short time
- The non-adversarial administrative arrangement encouraged cooperation between partners and formed one branding team 'Bundamba Alliance'. Resources and skills were shared among all alliance teams and operated from one office and committed to the set objectives
- The partners agreed that the AMT were to handle all problems directly, within the mandate of the Alliance Management and Leadership Team, to negotiate best outcome
- The Owner was fully involved in all stages of the project and the team leaders were committed and outcome focused to deliver this engineering feat in record time

PROJECT SCOPE

1. **SITE PREPARATION**
   Removal of existing structures and houses from the 5 hectare site and works including mass grading and placement of more than 180,000m^3 of engineered fill for stage 1A and 1B project structures.
2. **RAW WATER PUMP STATION AND STORAGE TANK**
   A new raw water pump station built on the existing Bundamba Waste Water treatment facility off site and connected by 1km of 1000mm diameter pipeline which pumps effluent water to the new 15 mega litre Raw Water Storage Tank at BAWTP 1A.
3. **PRE-TREATMENT LAMELLA CLARIFIERS**
   Is a new chemical coagulation, flocculation and sedimentation facility with capacity to treat up to 100ML/d of wastewater. The pre-treatment process removes phosphates from the water enabling the Reverse Osmosis operation to be optimised.
4. **MF/RO BUILDING**
   One 5000m^2 MF/RO building was built for each stage of 1A and 1B to house the three core treatment processes to remove contaminants and impurities.
   - Microfiltration – this is the first treatment process is microfiltration where water is forced through a fibre membrane with pores 0.014 microns wide, removing particulate matter, protozoa and some viruses, leaving only salts and organic molecules in the filtered water
   - Reverse Osmosis - after microfiltration, the water is passed at high pressure through specialised large 18" diameter membranes to remove salts, viruses, pesticides and organic compounds
   - Advanced Oxidation – this process uses chemicals and ultraviolet light to destroy any remaining organic traces in the water
5. **CHEMICAL AREA**
   Two separate chemical areas were built for stage 1A & 1B. After purification, the water is very soft and has low alkalinity, making it highly corrosive to piping and pumping equipment. In the chemical area, lime and carbon dioxide are added to harden the water and increase alkalinity. Each chemical area also stores 12 other chemicals used throughout the plant.
6. **TREATED WATER STORAGE TANK**
   Once treatment is complete, the purified water is stored in a 20 mega-litre Treated Water Storage Tank. In total, the plant converts more than 82% of the raw water it receives to purified recycled water suitable for augmentation of drinking water supplies.
7. **OVERFLOW ATTENUATION TANK**
   An overflow attenuation tank provides redundancy by collecting spillage from the facility tanks.
8. **TREATED WATER PUMPING STATIONS**
   There are two pump stations where treated water is pumped from the treated Storage Tank directly to Swanbank and Tarong power stations
9. **RESIDUALS AREA**
   Residue from the treatment process is biologically and chemically treated to remove nutrients before being released into the Brisbane River. Sludge treatment is also provided to dewater solids to enhance water recovery on site. The residuals area includes the following structures:

Stage 1A	Stage 1B
▪ Microfiltration and backwash tanks ▪ ROC tanks and lamellas ▪ Solids contact clarifiers and denifitrication tanks	▪ Reverse Osmosis Concentrate (ROC) Tanks and lamellas ▪ ROC biological nitrification process tanks ▪ Gravity sludge thickener ▪ Sludge dewatering plant

PROJECT DEVELOPMENT CHALLENGES

The commencement of construction while the design was still in the early stages led to numerous design challenges. The design was made more complex by the lack of fixed project parameters. These parameters included varying quality of the water intake which depends on the source and the surrounding environment, future water quality requirements and changes in demand for recycled water.

TARGETS AND OUTCOMES

TIME

Of all the challenges faced by the Alliance, time was the most critical. With water supply in the south-east corner were running dry, the project simply had to be delivered safely ahead of schedule (13 mths) The project planning was thorough and despite site access to the area only being granted on 29 October 2006 for 1A and 5 May 2007 for 1B, both plants began producing purified water within 10 months of construction start. First water for stage 1A and 1B were delivered to Swanbank power station on 23 August 2007 and 22 February 2008 respectively. This achievement is 2.5 times faster than the normal construction practices of similar plant in the industry. This success has been recognised worldwide and had set a new benchmark for the best practice in the advanced water treatment industry. Within this period:

- Parameters for water quality were researched and defined
- The plant was designed, fully engineered, materials were procured and resources secured
- The facility was constructed, commissioned, operationally proven and handed over to the operators.

COST

The target cost estimate for Stage 1A and 1B of the BAWTP was $186.6M and $188M respectively. Civil and structural works accounted for 60% of this total, mechanical and electrical works 40%. The project cost control was managed through the JD Edwards system with revenue running up to $56M during project peak months. Through efficient project management and prudent resourcing, stage 1A & 1B projects were completed below the agreed TCE budget.

ALLIANCE CULTURE OUTCOME

Our culture of working collaboratively meant breaking down walls between the different parties in the Joint Venture and the Alliance. We aligned our different organisation cultures, systems and resources in order to execute our set objectives and vision, giving everyone the opportunity to say what was on their mind and offer constructive suggestions. This in turn assisted in the efficiency of the project. Several of our alliance members have worked together on previous projects and this also helped to promote a positive open culture.

COMMUNITY INTERACTION

The location of the BAWTP Stage 1A &1B site boundaries were no more than 50m from residential areas had presented a challenge. Building such a project required diligent care and a strong relationship with the community. From the start, the project leaders engaged in face-to-face consultation with the local community, sponsoring functions and hosting BBQs. Our project team maintained relationships with the community through a website and 24-hour telephone hotline. All concerns were addressed promptly within one day through evening information sessions as required. In addition, TBJV provided a public face to the Alliance for providing contributions to special schools/clubs

CONSTRUCTION SAFETY

A key aim of the Alliance was to maintain the highest possible safety standards on-site to deliver the project with no harm to project personnel. To achieve this, a HSE Activity Schedule was developed and implemented, inclusive of job observations and workplace inspections. This schedule allowed safety initiatives to integrate seamlessly with the project's tight schedule. In addition, the project developed & piloted a Fit For Duty screening program, checking for impairment from alcohol/drugs, fatigue, illness/medical conditions. This improved the team's awareness/harnessed a positive safety culture.

The project team worked over 1,700,000 man-hours and completed the phase 1A and 1B projects with no Lost Time Injuries (zero LTI's). This is a remarkable achievement considering the compressed project schedule, the cramped dimensions of the site and the large, multidisciplinary project workforce. This was a tremendous milestone and raised expectations for personnel health and safety throughout the construction industry.

OPERATIONAL SAFETY

The BAWTP commissioning and operation teams were trained to deal with the identification of hazards and elimination of risks and the application of operational procedures. This ensured no one was at risk during the commissioning or operation of the plant from incoming effluent water or processed rejected waste. To meet these obligations, multiple redundancies were built into the system to ensure there was no possibility of contamination in either the purified recycled water (PRW) or harm to the environment from the waste stream discharge.

QUALITY

The Alliance had to work within two clearly defined quality constraints; the PRW had to meet the specified quality (Compliance with Australian Drinking Water Guidelines), and the facility itself had to be constructed and operated efficiently and represent a lasting investment for the people of Queensland. These two constraints were met through having a high-quality facility that would operate reliably and efficiently for many years.

While the PRW was initially earmarked for industrial use, a very real possibility existed that it may need to be diverted to supplement drinking supplies in the future. For this reason, the Alliance aimed to produce the highest quality PRW. The result is the first water recycling plant in Australia to produce water of a quality suitable to be used for indirect potable reuse (IPR). After drinking the BAWTP PRW at the official opening ceremony on the 2 September 2007, then Qld Premier Beatie quoted:
"Ten months ago this was a paddock. Now we have a high-tech plant producing some of the best-grade recycled water in the world, which easily meets Australian drinking water standards"

ENVIRONMENT

The Alliance was committed to delivering the project with minimal effect to the environment and producing a facility that would operate within the defined environmental guidelines. Making this task more complex was the need for the Alliance to research and define these guidelines themselves, educating local authorities as the plan was developed.

Once guidelines were defined, more than 25 licences and approvals for the plant operation and waste stream discharge were fast-tracked in collaboration with the State Government and local councils. Through effective environmental management and due diligence, stage 1A & 1B were completed without any environmental prosecutions, breaches or harm to anyone. In addition, the completed BAWTP facility delivers two major environmental benefits to the community - it reduces the amount of waste discharged into river systems by 82%; the plant's recovering 15-20 tonnes of solid waste everyday; and it maximises the reliance of power stations on PRW in lieu of potable water supplies.

CLIENT SATISFACTION

The Queensland Government has been highly impressed with the execution of the project and the quality of the completed facility. The project has been delivered ahead of schedule, under budget, to an extremely high quality and without incident or negative publicity from the community or media.

As the first completed component of the WCRW Project, BAWTP Stage 1A has demonstrated the viability of the project and has provided confidence to the community that an alternative solution to the water crisis is at hand. The client has been using the BAWTP as a showcase:
"The Bundamba Alliance's achievements in building the Bundamba Advanced Water Treatment Plant have been brilliant" Ken Smith, Director General, Queensland Government, Department of the Premier and Cabinet.

Following the opening ceremony of stage 1A on 3 September 2007, the current Queensland Premier Ms Anna Bligh quoted in the Queensland Times:
"They met a timetable that some said was impossible. It's a tremendous feat of engineering recognised around the world."

TRAINING & PERSONNEL

From the early stages of project planning, it was obvious to the Alliance that only an extraordinary workforce could deliver the results needed. This commitment was realised in the project's extensive functional and technical skills training program.

Over the duration of stage 1A and 1B more than 120,000 hours (over 7% of total project work hours) were allocated to competency-based training and up-skilling of project employees and subcontractors. Much of this training was provided through a partnership with the local Bremer TAFE that delivered formal and recognised portable qualifications to project personnel, including Certificate III trade qualifications.

Employees were provided with excellent modern facilities on site including a games room, TV's and internet access. Numerous team-building events were also organised for project personnel on and off-site and the project soon gained a reputation in the industry as 'Fundamba', a positive site where hard work was well rewarded.

RECRUITMENT

Securing resources during a significant shortage of skilled labours and operators presented yet another challenge. The project team used two strategies to attract personnel to site:

- They adopted a professional approach to recruitment, highlighting the project's location, work environment, excellent facilities and positive culture
- They offered a comprehensive training program, allowing them to recruit from a wider pool of relatively inexperienced workers who could then be up-skilled to project requirements

These strategies enabled them to attract staff from inter-state and overseas.

INDUSTRIAL RELATIONS

As a high-profile project the BAWTP had the potential to be derailed through industrial action. The project team had a genuine concern for their workforce and were determined to develop a positive workplace with an emphasis on teamwork, problem solving and interactive communication.

A detailed Industrial Relations Plan was developed and the project leaders drew on their extensive relationships with union officials / on-site delegates to work out potential issues before they impacted on the project schedule. The result was excellent outcome with no industrial action taken on-site.

MEDIA AND PUBLIC SCRUTINY

As the flagship component of the state government's water infrastructure program, public and media interest in the BAWTP was high. The project team was keen to ensure that the public and all levels of media were kept abreast of project activities and understood the project's key achievements. The coverage by the media was overwhelmingly enthusiastic due to the stricken drought in SE Queensland adversely impacting on peoples lives. The project was delivered beyond expectations, resulting in positive news to the public about BAWTP achievements along the way.

In addition, the project received extensive media coverage due to its innovative engineering and official visits from local and international industry dignitaries and experts and government ministers from Australia, Singapore, China, Malaysia, USA and many other countries.

INNOVATION

Major items with long lead times were selected and orders were placed as soon as the contract was awarded. Due to lack of parameters and time constraints the major process equipment design had to be back-engineered based on equipment availability from vendors and flexibility to deliver in short timeframes. To expedite the delivery of equipment we accelerated the production by air freighting vendor material to their factories to expedite manufacturing time and embedded our team at the vendor facility to ensure progress. Some major components were air-freighted from overseas in lieu of sea freight to meet schedule.

The design team anticipated and planned for possible expansion and integration of innovative ideas to suit client requirements for each element of the treatment process.

To shorten the lengthy process of preparing deep foundations using piling, the innovative use of shallow mat foundations were supported on replaced engineering fill reduced the project schedule significantly.

As much of the works consisted of large concrete water storage tanks, innovation was required to avoid lengthy multiple-pour sequences. Instead, we utilised two different formwork systems which combined prefabricated reinforced cages built off-site then installed in large mats allowing single in-situ concrete pours to be done for 25m long and 10m high walls. Each of these 250m^2 panel wall used 170m^3 of concrete and took less than 4 days from form to pour and strip. Other precasted concrete segments such as tank roofs were manufactured offsite and erected in place on delivery.

Staggered integration of 29 discrete packages allowed commissioning to progressively integrate each treatment barrier into the process, resulting in the shortest possible commissioning time for the project. To reduce site congestion, we have maximised off-site fabrication. The most remarkable example was the construction of two clarifier tanks, each more than 12m long, 8.3m wide and 6m high, reducing the delivery time of these critical components from 6 months to 10 weeks. The project team had to coordinate a team of 60 team members/escort pilots to overcome rails and power lines during transport of the tanks to site. They were the largest items ever transported by road in Queensland at the time. In similar operations, a total of six elect.switch rooms weighing 80 tonnes were assembled and tested off site before being transported in an escorted convoy and erected on the project site within 3 days.

THE DESIGN & CONSTRUCTION TASK

While the construction of a world-class water treatment plant is a complex task, the time constraints imposed on the BAWTP Stage 1A & 1B magnified the difficulty of the project and created a raft of specific challenges. Navigating a course around these obstacles was possible only through determined cooperation between all project partners.

DESIGN

To meet the BAWTP Stage 1A & 1B delivery dates, procurement and construction began while the design was still in its early stages, leading to numerous design challenges.
Systematic investigations of the proposed water quality specification to provide input to the development of a preferred AWTP design involve:

- Review environmental impact assessment reports and impact of a proposed AWTP
- Review of preliminary concept layouts for the Bundamba AWTP and limitations of the biological processes for nutrient removal
- Assessment of Client's requirements for an AWTP with the capability to cope with anticipated population growth and meeting a regulatory requirement to ensure a significant proportion of the treated effluent can be recycled for industrial purposes
- To develop construction methodologies to fast track project completion within 10 months (this schedule was never achieved before as the normal industry standard takes 16-24 months)

A key objective was to deliver purified recycled water to the Swanbank Power Station on time that meets technically challenging 19 water quality design parameters standards e.g. Ecoli, Colstridium perfringens, F-RNA bacteriophage Somatic Colophage etc…

Other technical challenges of BAWTP Stage 1B activities included:

- Design of BAWTP Stage 1B to treat industrial wastewater of variable quality originating from various wastewater plants (Oxley, Goodna, and Wacol WWTP's) which contain significant levels of nutrients including phosphates, and nitrates, etc
- The development of a unique method for on site construction of the electrical switch-rooms and integration of stage 1B SCADA with built stage 1A SCADA and the integration into the overall communication system other Western Corridor Recycled schemes.

EVOLVING CLIENT REQUIREMENT

Given the limited initial requirements and the fact that this project was the first step in a much wider scheme, it was inevitable that the client requirements of the project would evolve through the construction process. Therefore a design team for each element of the water treatment process was based in Brisbane. The team was structured to deal with process innovation and plant HAZOP supported by designers from other Black & Veatch offices around the world. Other design teams were

focusing on the infrastructure, electrical and mechanical detailing while dealing with construction requirements and changes to fast-track the work execution.

MINIMAL DEFINITION

The design was made more complex due to limited time for identifying and agreeing to defined project parameters. The defined parameters were minimal, limited to a site location and overall footprint, feed and product water quality specifications, minimum process treatment steps and redundancy and safety in design and operation requirements. In terms of the physical works required, this was essentially a blank canvas. To ensure all requirements were met the design team used a combination of treatment technologies that had never before been used on a project of this size.

DESIGN COORDINATION

The compressed timescale of the project prevented TBJV from assembling a dedicated design team in a single location. Instead, Black & Veatch identified resources in their Singapore, Mumbai and United States offices and coordinated them from the Brisbane based project office.

Whilst it was difficult managing resources across different time zones, this approach allowed an experienced design team to be quickly assembled and international expertise in design, problem solving and procurement strategies to be captured. Local designer and engineering expertises were sourced and engaged to fast track and support the construction team on site.

PROCUREMENT OF LONG LEAD TIME ITEMS

Early procurement of components and materials was critical to meeting the tight project schedule. In total, the project team had to secure more than 200 major capital equipment packages and orders, many from overseas and all with long lead times, some quoted with up to 45 weeks delivery.

Items with long lead times had to be ordered and procured from the start of the first week of the project lifecycle, often before relevant components of the design had been finalised. Under special instruction to proceed vendor engineers were engaged to start equipment detailing and collaborated with our designers on a daily basis to track and expedite design. Close relationships forged among the project teams and vendors that allowed a flexible design and reverse engineered these critical components.

Faced with extremely short lead times, vendors were often unable to guarantee delivery within the required timeframe. The project team worked with the vendors, providing engineering assistance and airfreighted vital raw materials to manufacturers' workshops to expedite production. In other instances components were sent overseas to gain production priority.

Importantly, over $45M worth of long-lead-time equipment and materials were purchased or secured place in production queue for the project before the design was finalised.

Furthermore, off-the-shelf components were chosen that reduced the amount of related construction. For example, 18" reverse osmosis membranes were chosen instead of the more-common 8" membranes as they offered a quicker delivery schedule and simpler installation, even though they were a relatively new technology and had never been used before in a project of this scale.

MAXIMISING OFF-SITE FABRICATION

A critical function of the design process was to identify opportunities for prefabricating mechanical and electrical components and pipe spools off-site, allowing on-site construction time to be significantly reduced. By using detailed 3D modelling, the design team was able to identify clashes and construction tolerances in order to eliminate re-work in the field.

The design team identified opportunities for off-site fabrication. The project team had sourced/managed resources as required to help vendors/fabricators meet the timeframes by adopting these strategies:
Sourcing and providing skilled workers to vendors from interstate to enable round-the-clock production

- Quickly securing services through pre-existing relationships in lieu rather of tendering processes
- Pre-booking vendors facilities and fabrication workshops for extended periods
- Using international vendor experts to produce some of their components at local suppliers and fabricators, where possible, to reduce delivery times and enable short-notice design changes
- Mobilising international experts to Brisbane to oversee production at local fabrication shops

The most remarkable offsite fabrication were the two clarifier tanks described under 'Innovation'.

While precasted concrete panels and structural/ mechanical prefabrication reduced the delivery time of these critical components from 6 months to 10 weeks for stage 1A and 1B.

CONSTRUCTION

The complexity of the BAWTP Stage 1A and 1B construction is reflected in the project statistics. In less than 10 months the following was achieved:

Descriptions	Stage 1A	Stage 1B
Project personnel	950	750
Earthworks	103,000m3	85,000m3
Structural concrete works	22,000m3	9,000m3
Reinforcement works	4,200 tonnes	2,200 tonnes
Supply & installation of structural steel & piping	1,000 tonnes	1,000 tonnes
Supply & installation of SS process piping	18 km	15 km
Supply & installation of yard piping	13 km	9 km
Supply & installation of power instruments cables	90 km	90 km

SITE ACCESS

For both logistical and public relations reasons, project personnel, contractors and suppliers needed to access the site without increasing traffic through neighbouring residential areas. The project team gained permission from the Ipswich City Council to open a construction-only road to route traffic directly from the nearby highway. A traffic management plan was optimised and distributed to relevant local councils and the police to minimise traffic congestion. This access operated without incident for the duration of the project for stage 1A and 1B.

LAND ACQUISITION

To meet the project schedule, properties had to be resumed by the Queensland government and houses and land were cleared in the shortest possible time. Through full and open interaction with the local community, the project team gained the cooperation and trust of affected residents and provided physical support while they were vacating their property. As a result, project works were able to start as soon as access to the site was granted.

FOUNDATIONS

To shorten the lengthy process of preparing foundations due to long lead of piling equipment, the construction team worked with the design team and identify time-saving alternatives. A shallow mat foundation alternative was identified. Through Thiess plant fleet, we were able to mobilise earthwork equipment in record time allowed us to expedite the site mass grading. We also negotiated to obtain ex–quarry stock for the 180,000m^3 of base course material used in lieu of deep foundations and piles.

TANK CONSTRUCTION

With much of the major infrastructure and large water storage tanks, the project team realised that time could be saved by avoiding lengthy multiple-pour sequences to construct the 10m high concrete walls. The tank roofs were supported by installing precast panels spaning across the width of the intermediate wall and top finish layer of in-situ concrete. For tank walls we have utilised a self supported formwork with conventional propping system. We have minimised congestion by utilising mechanical telescopic platforms and scissor lifts in lieu of traditional scaffolding and extra workforce for manual handling.

ON SITE PLANT

Wherever possible, the project team used plant to expedite project delivery. Scaffolding was minimised by using cranes and elevated work platforms to assemble components and access work areas. One tower crane and six crawler cranes with capacities ranging from 100 to 150 tonnes were chosen for their reach and capacity, ensuring good coverage of the site with minimal crane relocation. During peak

works, 21 mobile cranes, from 10 to 150 tonnes capacity, were used and more than 60 elevated work platforms were operating on the congested site with area less than 250m by 320m.

MECHANICAL WORKS & COMMISSIONING

The structural, mechanical and piping (SMP) team worked very closely with the design, procurement and civil teams. This identified priority of mechanical and piping design, fabrication priority and access to work phases. The SMP teams were integrated with the early mobilised commissioning team, allowing them to liaise closely with the construction team to allow for the earliest possible delivery of treated water. The tight production schedule on the project meant that parts of the plant were being commissioned while other components were still being constructed, and in some cases designed. Also, the client scheme operator was involved in the project from the design stage to help identify potential problems and to allow for a smooth transition from the operation team when the project was completed.

To facilitate planning, work on the BAWTP the construction activities was split into 29 discrete packages, allowing construction and commissioning of the various project elements to be prioritised. As each treatment barrier was constructed and pre-commissioned water could be introduced for final commissioning. It was then progressively integrated into the treatment process, resulting in the shortest possible commissioning time for the project.

The process performance test of the completed facility was passed successfully on the first attempt, a testament to the outstanding performance of the project team.

SCHEDULE AND PROGRAM

The BAWTP Stage 1A & 1B project schedule was nothing short of remarkable, with design, procurement and construction activities beginning almost simultaneously. This schedule achieved in less than 10 months what would typically take two years.

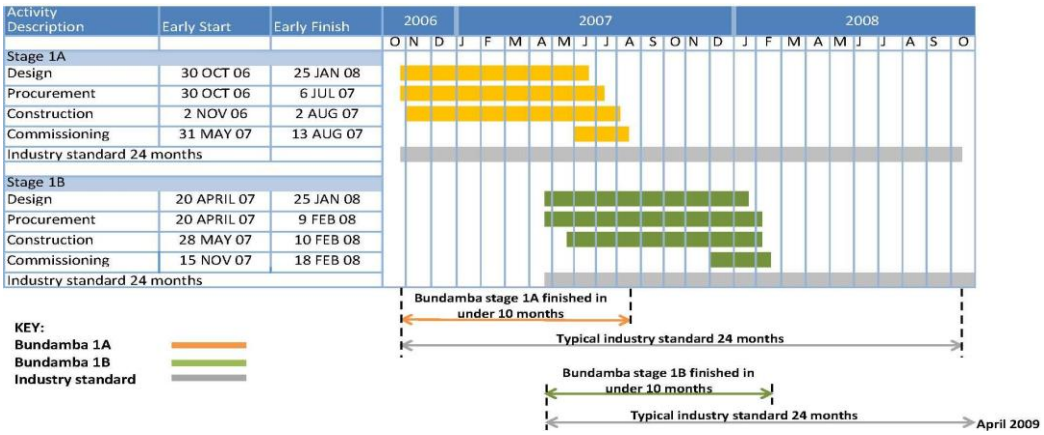

Figure 1: Bundamba Stage 1A & 1B program as compared to industry standard program

To meet this schedule, construction continued around the clock for the duration of the project. This intensity of activity required close monitoring to avoid plant and work area conflicts and maintain the project's strict health and safety requirements.

LEADERSHIP AND MANAGEMENT

Although assembled rapidly and immersed immediately as an ambitious challenging project schedule, the project team drew on its shared skills & experience to steer the project to completion in record time. "*It could not have happened without an outstanding team from around the world, three highly committed Alliance partners of WCRW Pty Ltd, Thiess and Black & Veatch and the collaboration that can and does occur only in successful Project Alliances*." Peter Trueman, ALT Member representing the Coordinator General.

THE PROJECT TEAM

Collectively, the project team shared many attributes which contributed to the success of the project:

- They benefited from the guidance, resources, governance and strategy of the AMT leadership and a strong, decisive and industry-respected Project Director
- They had enormous experience with both the type of project and the type of contract, allowing them to accelerate the design process and quickly identify items that needed early procurement
- They shared a drive to complete the job safely and on time, whatever it took
- They had formed credible relationships with relevant government departments and industry bodies
- They remained open to any innovation that could improve the project
- They shared"no blame" and "best for project" attitude that was quickly adopted by other project members, sub-contractors, suppliers and their collective decisions were made with conviction.

SPECIFIC LEADERSHIP CHALLENGES AND INITIATIVES

The nature of the project created numerous management challenges for the project team, each requiring innovation and experience to keep the project on track. The project team developed strategies to meet the project's tight schedule and lack of clear regulatory framework:

- An Employee Relations Strategy was developed that allowed maximum flexibility to workforce
- Where risks were identified, alternative pathways were actively pursued to prevent project delays. Traditional methods were challenged while innovation and teamwork actively encouraged
- Critical materials/ equipments were procured with a 'hands on' approach, allowing delivery within the project schedule and giving the project focus throughout all stages allowing for rapid resolution

The project team had to manage a relatively large multidiscipline workforce, including direct and indirect trades and skilled personnel, on a small and congested site. The concentration of personnel on the site presented two challenges to the project team:

- They had thorough EPC planning to intensively monitor the project's extensive schedule to ensure that there were no scheduling clashes
- They had to apply high execution standard and upheld the project's immaculate HS&E record

Careful planning and experience were all that could be relied upon. Therefore we had to empower all personnel at all levels to actively participate in the planning and risk workshops. This ensured all the project teams were accountable and aware of their responsibilities.

SUMMARY OF OUTCOMES ACHIEVED

	Expected	**Delivered – redefining what is possible**
Safety 1A	Zero Lost Time Injuries (LTIs) Leaders in visible safety leadership on site	Throughout the 608 days of stage 1A & 1B, we have achieved over 1.7 million MHrs with no LTI
Time 1A	10 month onsite delivery schedule where industry standard is 18-24 months First water achieved 30 August 2007	An intensive 24hr/ 6 days work pattern was adopted and we have completed the project ahead of schedule on 23 August 2007, 9.5 months after first access to site
Time 1B	12 months onsite delivery schedule	The project has produced first water by 22 Feb 2008 about 3 months ahead of contract schedule (13 months)
Cost 1A	The TCE Stage 1A - $186.6 million	The project was completed under the agreed TCE
Cost 1B	The TCE Stage 1B - $188.0 million	The project was completed under the agreed TCE
Quality & Stakeholder Satisfaction	To adhere to the Qld treated water quality specifications	Stages 1A & 1B met all treated water quality standards Widely regarded as world's best practice in the industry
Environment	No harm to the environment Seamless environmental approvals	Effective environmental management training Project delivered with no prosecution, breaches or fines
Sustainability	Delivery of a world class project to operators	Successful transitioning of 1A & 1B to plant operators
Community & Cultural Heritage	Project delivered with consideration for cultural heritage and community	Cultural heritage trainings delivered, active community engagement and stakeholder relations were maintained throughout stage 1A & 1B without any dispute
Training	Provision of functional and technical	Over 83,000 training hours were completed during

	skills training	stage 1A and 47,000 during stage 1B
Industrial Relations	In accordance with federal requirements	No industrial actions were taken on-site
Media	Key achievements were understood by the media	No negative publicity throughout the project delivery of stages 1A & 1B

CONCLUSION

Climate change, manifested in severe drought, coupled with a rapidly expanding population in South East Queensland, have conspired to force the government to take desperate measures to secure drinking water supplies and hence the region's future.

Delivering a world class Advanced Water Treatment Plant in record time and on budget would not have been possible without a dedicated and highly skilled management team, workforce, suppliers and subcontractors and local and State representative's dedications – people with proven track records, who could see the possibilities, and had the experience to rise to the challenge. Testament of the aforementioned statement, the project success was recognised in the industry from several institutions from around the world and won 9 awards, including:

- 2008 Water Project of the Year (Global Water Awards)
- 2008 Global Honour Innovation Award, Design Projects (International Water Association)
- 2008 International Project of the Year (Construction Management Association of America)
- 2008 Environmental Engineering Excellence Award (Australia Engineering Excellence Awards)
- Finalist of the Australian Construction Achievement Award 2009

The Alliance partners are very proud of what has been achieved throughout the project phases of design, procurement, construction, commissioning and operation of the BAWTP Stage 1A & 1B. Through this tremendous contribution from the project team, they have delivered very evidently delivered on their project outlined vision: "*to provide an innovative long term sustainable solution to the South East Queensland water shortage through the safe delivery of a world class recycled water asset in record time*". Certainly the project team have delivered the BAWTP engineering feat vision amazingly in record time and transformed it into reality and established new industry benchmarks..

ACKNOWLEGEMENTS

We acknowledge everyone who contributed to the project success including suppliers & subcontractors worked collectively by providing services that met the project time constraint and mainly the following:

Major Supplier	
Design & Procurement	
Black & Veatch	Design Services
Parsons Brinckerhoff Australia Pty Ltd	Design Services
Koch Australia Pty Ltd	Reverse Osmosis Equipment
Siemens Ltd	MF/UF Equipment
TrojanTrojan Technologies	Advanced Oxidation System
Severn Trent Water Purification Inc	Denitrification Filtration Equipment
Infilco Degremont Incorporated	Solid Contact Clarifiers
Thiess Process & Thiess Queensland	Project management services and procurement
Subcontractors	
SJ Electric (QLD) Pty Ltd	Design, supply, installation, commission of electrical instrumentation
Thiess Kentz	Electrical and Instrumentation Services
Multifix Constructions Pty Ltd	Design, supply, form and place concrete
Gay Constructions Pty Ltd	Supply, fabricate and erect structural steel
D&R Stainless	Stainless steel pipe spooling fabrication