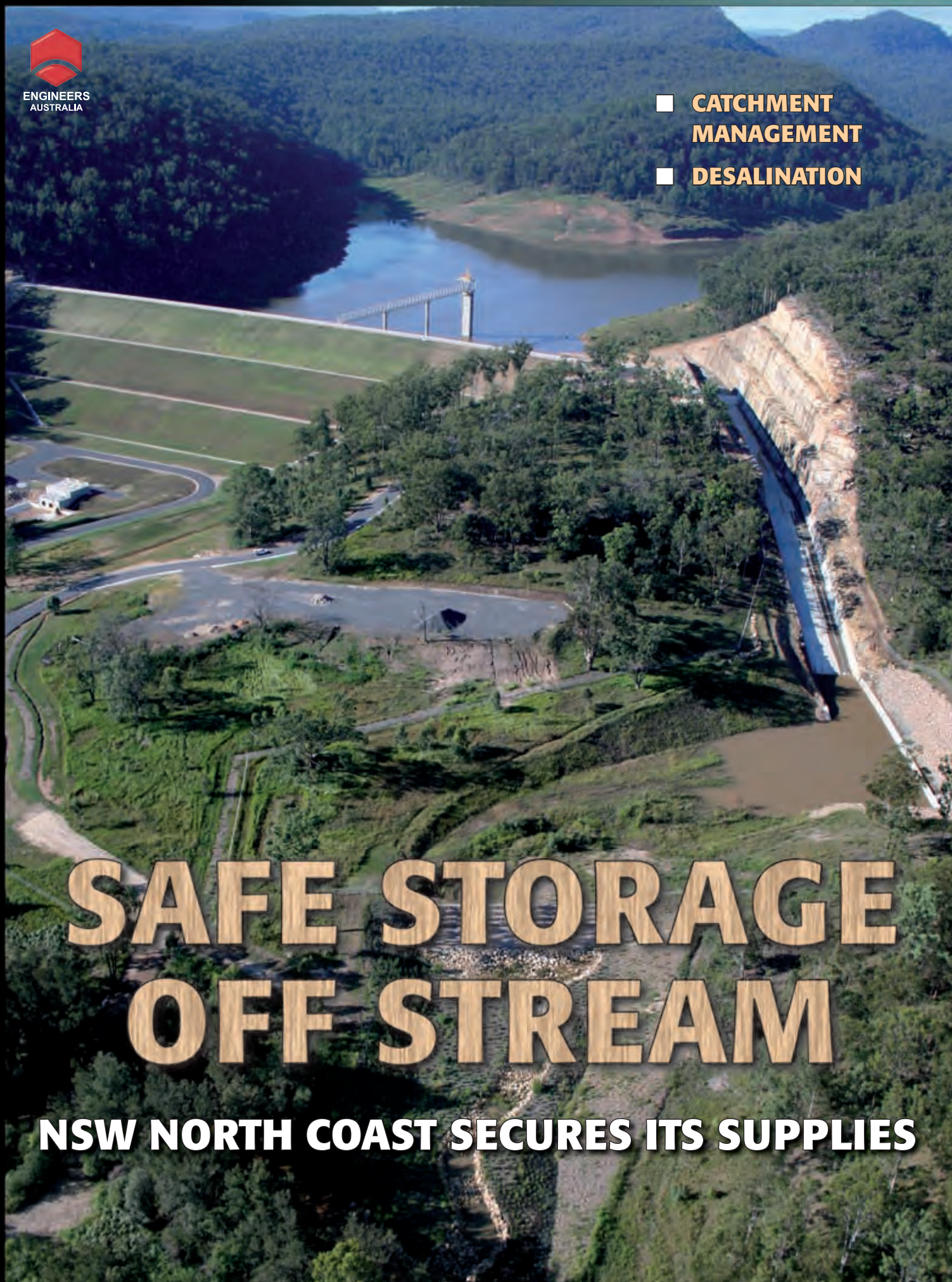
www.waterengineeringaustralia.com.au

WATER ENGINEERING
AUSTRALIA

ENGINEERS
AUSTRALIA



- CATCHMENT MANAGEMENT
- DESALINATION

SAFE STORAGE OFF STREAM

NSW NORTH COAST SECURES ITS SUPPLIES

Volume 3 Number 4, May 2009

$9.40 INCL. GST

This article is largely an edit of material supplied by Leighton Contractors and North Coast Water.

A crowning moment for a regional strategy

Working toward the vision of how to meet the challenges of a growing population and the need to ensure a secure water supply for future generations, Coffs Harbour City Council partnered with North Coast Water (a business unit of the Clarence Valley Council) and the NSW state government to develop a strategy to provide a secure bulk water supply to 2021 and beyond.

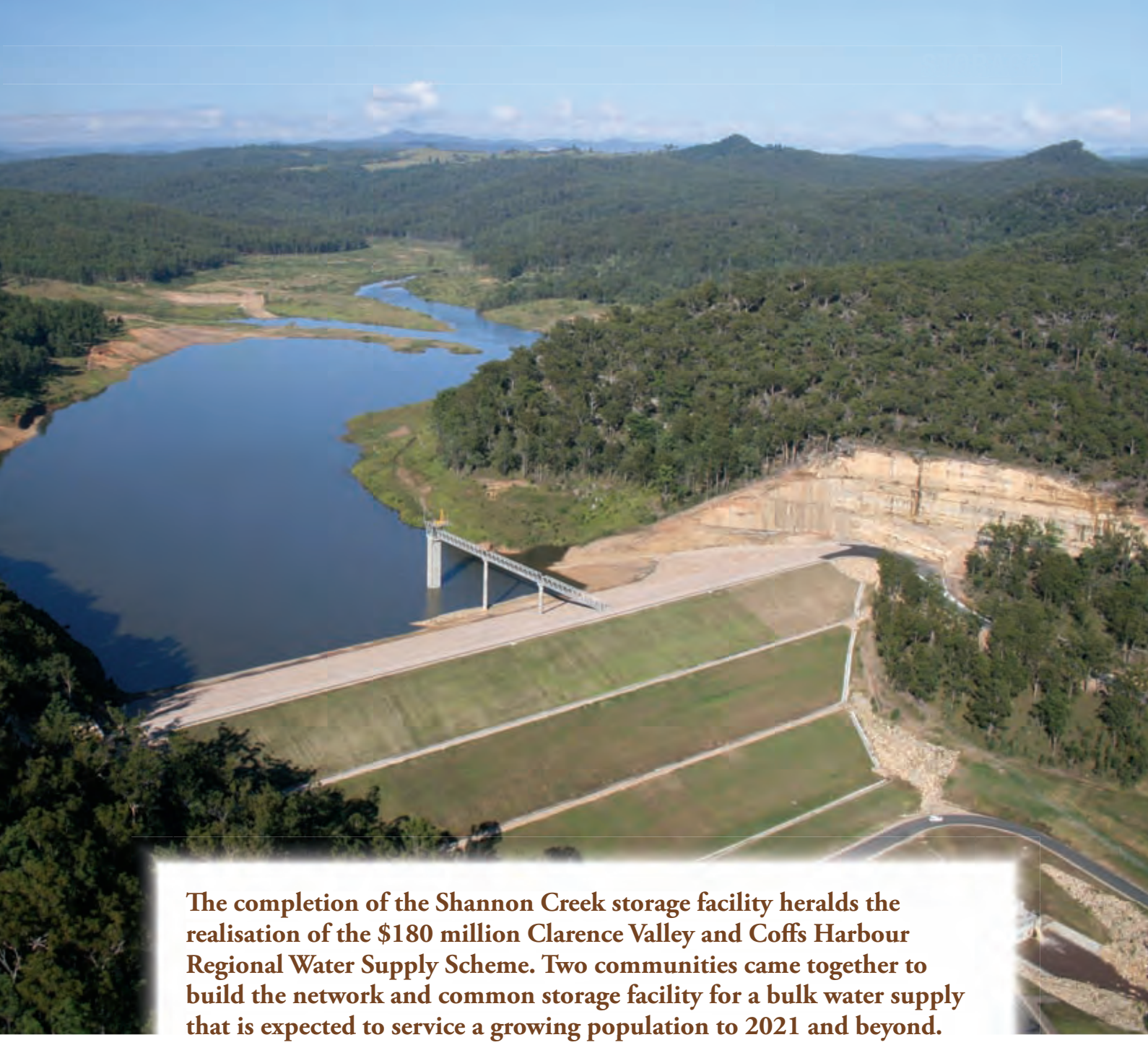
The bulk water supply system currently services over 95,000 people living in the Clarence Valley and Coffs Harbour areas on the NSW north coast. The population of the region served by the water supply is expected to more than double in the next 50 years to approximately 220,000 persons.

"This is a massive project and a good example of two local government areas joining forces to get the best outcome for the region," said councillor Gavin Smithers, deputy chair of Coffs Harbour City Council's city services committee.

Coffs Harbour was previously largely supplied by water pumped from Orara River to its 5600ML storage at Karangi Dam. The Clarence Valley was supplied by water extracted and gravity fed from Nymboida River at Nymboida weir, and had only 100ML of storage located near Grafton. As part of a new regional strategy, North Coast Water has connected these systems to make better use of the more regular flows of the Nymboida and enable one shared storage to be built rather than two separate storages.

The Clarence Valley and Coffs Harbour Regional Water Supply Scheme has involved construction of a storage facility at Shannon Creek, as well as 90km of underground pipeline to serve communities from Iluka in the north to Sawtell in the south.

Under the regional project, when there is ample flow in the Nymboida River during normal to wet periods, water from the weir on the Nymboida River will be gravity fed by pipeline to the Shannon Creek storage where it will be held until it is needed. The scheme has been designed so that no water will be taken from the Orara and Nymboida rivers during periods of low flow. There will be no water extractions from the Nymboida when flow is less than 225ML/d. In these times water will be pumped



The completion of the Shannon Creek storage facility heralds the realisation of the $180 million Clarence Valley and Coffs Harbour Regional Water Supply Scheme. Two communities came together to build the network and common storage facility for a bulk water supply that is expected to service a growing population to 2021 and beyond.

from the Shannon Creek storage facility to both the consumers in the Clarence Valley and to Karangi Dam at Coffs Harbour.

The regional scheme is designed to supply a secure yield of 22,836ML/a, the combined yield of the Orara and Nymboida sources. The yield will be shared between the two communities with 12,020ML/a for Coffs Harbour and 10,816ML/a for the Clarence Valley. The cost sharing for the scheme has been based upon these predicted demand figures.

The Shannon Creek storage facility is the final remaining component and centrepiece of the $180 million Clarence Valley and Coffs Harbour Regional Water Supply Scheme.

The completion of construction of the 30,000ML off-stream water storage and associated infrastructure, valued at $95 million, heralds the realisation of this regional strategy. The storage facility has the capacity to hold three years storage on current demands.

In North Coast Water controlled land of 6100ha between Coffs Harbour and Grafton, an area of 210ha of grazing land and native vegetation was earmarked for the storage facility. Following a competitive tender in early 2006, North Coast Water appointed Leighton Contractors to undertake the construction of the storage facility, working in partnership with the NSW Department of Commerce under a GC21 contract. Funding partners were Clarence Valley Council, Coffs Harbour City Council and the NSW state government.

Due to its remote location, road works were required to provide the only means of construction access to the site. Maunsell AECOM was engaged for the design of the access roads. The upgrade of 8km of an existing access road was required along with the construction of 6km of new road from Coutts Crossing to the site. The construction of the new road was a challenge as it weaved through sensitive bush land and through an escarpment. New pavement was constructed along with two new bridges and transverse drainage structures.

The site is located between two sandstone escarpments that provide habitat to many threatened native flora and fauna. Vegetation clearing works were required within the inundation

storage area to safeguard the future water quality standards of the facility's water. Wherever possible, significant habitat features on the edge of the work site or high water mark were retained and modifications to the road corridor and drainage design were undertaken. Within the inundation area, vegetation within gully reaches inside the inundation zone was retained to improve biodiversity and provide fish habitat for when the storage is full.

Shannon Creek flowed right through the job site and so needed to be diverted prior to excavation and grouting of the dam wall foundation. Though the new storage facility is located on Shannon Creek, it is designed to only store waters from Nymboida River, and any natural flows that fall within the Shannon Creek catchment are to be released in as close to a natural manner as possible downstream. As such, the dam aims to operate as a transparent structure in terms of Shannon Creek environmental flows.

"Throughout the foundation preparation works, Shannon Creek flows were maintained and disturbance to the original creek line was minimised until the creek could be diverted through a newly constructed diversion conduit," Leighton Contractors said.

A 2100mm steel diversion conduit was installed to allow the flow of creek water through the site during construction, and now continues to allow environmental creek flows downstream of the dam during the storage facility's operation.

The 2100mm steel penstock has a 16mm wall thickness and was fabricated in 12m lengths offsite by Pipelining and Coating. In addition, a 750mm NB MSCL conduit for the town water supply and storage filling was also fabricated in 12m lengths by Pipelining and Coating. Both pipes were installed in a concrete-encased trench excavated into rock 3m deep by 5m in width. The length of the Shannon Creek diversion conduit is 330m which allows for the possibility of raising the dam wall if required in the future.

During construction of this conduit the project team faced many challenges, Leighton Contractors explained. The trench had to be excavated, cleaned, and mapped to the NSW Department of Commerce Geologist's instruction. Dewatering was constant in the trench and each field weld was 100% ultrasonically tested and 10% Xray tested by technicians from Pearlstreet ETRS. At completion of the installation of both pipes, the protective coating at the weld joint of each length of pipe was prepared by Caps Beta.

Leighton Contractors said safety was a great challenge in this section of works with the confined space work environment of welding inside the pipes and safe distance requirements needed for Xray testing onsite. To meet one of these safety challenges, Leighton Contractors said, a specially fabricated platform was installed around the 2100mm pipe to enable welders to access the top of the pipe to carry out welding safely.

To connect the storage facility to the Nymboida River weir, a pipeline was required to tap into an existing 750mm DICL water main that had been laid up to the eastern escarpment. Due to environmental and hydraulic design constraints, the NSW Department of Commerce specified that this pipe needed to be taken through the escarpment using directional drilling techniques. The tunnel would then also be used for electrical and communications conduits.

Works progress on the storage facility located within 6100ha of North Coast Water controlled land.

The water pipeline would have a dual purpose of piping water into the dam via gravity from the nearby Nymboida River, and piping water out of the dam under pressure from the pump station into the surrounding North Coast Water network.

Leighton Contractors chose to use 900mm PN16 polyethylene pipe (approximate wall thickness 75mm) sourced from Kingston Bridge Engineering, in lieu of mild steel. The reasons cited for using polyethylene were due to it being more flexible, more resistant to damage, no concerns about corrosion or damage to protective coatings, could weld the pipe in one continuous length before installation, and was suited to the directional drilling process.

The length of drill for the original design was 270m, however Leighton Contractors decided to increase the grade of the original design, thereby lengthening the distance of the drill by 50m.

Leighton Contractors said: "The original design had the pipe exiting the escarpment at a very steep point with overhanging rock. The remaining 50m would have to be trenched into the side of the escarpment and concrete anchors constructed around the pipe to prevent it from sliding. The new alignment meant that we could cut a vertical face into the existing ground and drill and install pipe at a constant grade."

While HDD-Consult was consulted to assist in contract review and set-up, as well as undertaking site inspections and providing advice, the directional drilling and the installation of pipes was subcontracted to UEA, a company that had just recently purchased a D300 x 500 Vermeer drilling machine.

The Vermeer D300 initially drilled pilot bores. Once these had burst through the escarpment a larger drilling head was fixed to the end of the drilling shaft and the holes were reamed slightly larger with each pass. The hole was enlarged to approximately 1050mm. The new alignment resulted in the drilling hole being self cleaning and the use of bentonite clay kept to a minimum. Tailings would be removed from the hole by the water used in the drilling process. Water runoff was stored in a catchment basin constructed adjacent to the drilling site. This water was continually recycled and used in the drilling process.

Once drilling was completed, the shaft of the Vermeer D300 was connected to one end of the polyethylene pipe. The machine then pulled the pipe back through the hole into its final position. One end of the hole was then grouted/concrete encased for a distance of about 40m to stabilise the pipe and prevent any seepage from around the pipe.

Prior to the commencement of embankment construction, the foundations of the dam needed to be grouted. A grout curtain of up to 65m in depth was specified, because at this depth, the grout curtain is able to accommodate a potential raising of the embankment at a future date.

The original design showed a single grout curtain. However, after the foundation was uncovered and there was evidence of valley bulging as well as loose ground condition (mainly a weak mudstone formation in the centre of dam wall location), it was decided that three grout curtains were required along with blanket grouting upstream and downstream of the main grouting curtain. Significant additional drilling and grouting works were therefore required to overcome the foundation conditions uncovered.

Due to these extra requirements and to mitigate some of the

The team of workers and equipment gather together onsite at Shannon Creek for a photo opportunity.

The original design showed a single grout curtain. However, after a weak mudstone formation was uncovered, it was decided that three grout curtains were required along with blanket grouting upstream and downstream of the main grouting curtain.

The intake tower formwork arrives onsite at Shannon Creek.

potential delays to the project, Leighton Contractors opted to self-perform over 85% of the grouting. During peak times, four rigs were operating simultaneously.

"To further mitigate some of the delays, and to perform drilling and grouting works safely, a split shift was worked to allow drilling operations to be undertaken during the day, and grouting operations performed at night, for a period of around six months," Leighton Contractors said.

The grouting works took over 12 months to complete and placed considerable time pressures on other elements of the project.

Leighton Contractors said approximately 80,000 20kg bags of grout were used in approximately 26,000m of drilling in around 810 holes ranging in depth from 5m to 65m at 60° to the horizontal.

"Dewatering was a constant challenge due to working in the valley floor and groundwater seepage," Leighton Contractors said.

The interface between grouting works and embankment construction required close staging and site management to ensure the highest construction standards were maintained while mitigating construction delays resulting from large increases in the grouting scope.

In constructing the clay core earth-fill dam, approximately 1.5 million cubic metres of material was required. The dam wall is approximately 400m long and 45m high with a top width of 6m and a base width of 260m.

The clay core of the dam wall consists of approximately 170,000m^3 of clay sourced from a borrow area within 2km of the dam wall.

"The borrow areas were carefully managed to ensure the highest quality clay was selected and placed within the embankment," Leighton Contractors said.

The outer zones of the embankment provided support to the clay core and consisted of approximately 1,300,000m^3 of granular material sourced from various borrow areas within 3km of the dam wall.

The upstream face of the embankment was protected with a 200mm thick layer of 20mm minus granular material over which a 500mm layer of rip-rap rock was placed.

Leighton Contractors explained: "A key challenge was to locally source hard rock materials of sufficient quality for inclusion within the embankment filter layers and also for use as upstream face protection of the embankment."

A quarry was set up offsite to provide necessary materials for the dam wall and road works. This quarry was responsible for supplying 38,000t rip rap, 52,000t specially graded coarse filter material and 42,000t road base material over the course of the project.

The dam design provided for the use of sand filters to remove water from the embankment. Sand was sourced on site and a dedicated sand washing plant was set up to wash sand to the required standard.

"This washing process presented significant environmental management challenges due to the volume of dirty water produced. This required dedicated sediment basins to be established to collect the wastewater which then required treatment to meet

water quality standards prior to its release to the creek system," Leighton Contractors said.

Embedded in the embankment is an array of instrumentation including piezometers and surface settlement points. Water seepage through the embankment is measured at the seepage weirs adjacent to the valve block.

The spillway was excavated in sandstone, north of the embankment, using drill and blast techniques. The concrete lined section of the spillway was 340m in length and 15m wide at its base. The design concrete thickness of the base and walls was 300mm. Anchor bolts were installed as per a set pattern and depth to bind the concrete lining to the rock.

Instead of using conventional formwork systems for the walls of the spillway, Leighton Contractors offered the NSW Department of Commerce the alternative of using finished shotcrete. This alternative was accepted as there was a significant cost saving. The shotcrete and steel reinforcement for the walls was completed by Rix Shotcrete Solutions.

The concrete mix used was a 32MPa "pool" mix from Cemex. Rix Shotcrete Solutions could apply the finished shotcrete up to 375mm thick. Where the thickness exceeded this a blinding layer of shotcrete was applied first.

"Also, where there was water seepage, a core filter blanket was installed to allow drainage from behind the spillway wall," Leighton Contractors said.

Within the dam inundation zone, an intake tower was constructed, consisting of a concrete base excavated into rock 10m in depth, and a concrete stem and platform 41m in height. A steel gantry frame was placed on top to support a gantry crane and lightning protection.

The purpose of the tower is to allow water to flow into the storage area, as well as to allow water to flow out of the storage area, for potable supply or to enable environmental flow of the creek further downstream.

Water can be taken from different levels of the water storage by the manipulation of large steel baulks that are lowered up and down the tower shafts by the use of an overhead crane. Steel trashracks are also lowered up and down the shafts to prevent large debris from entering the pipes and causing damage or blockages.

Two non-symmetrical shafts reside in the stem of the tower. To construct the stem, two internal steel forms were specially fabricated using designs by Mark Johns of MJ Civil. These were made so that they would collapse inwards by the use of hydraulic arms. This would minimise the amount of time inside the shaft.

The spillway was excavated in sandstone using drill and blast techniques. The concrete lined section of the spillway was 340m in length and 15m wide at its base.

An internal scaffold was erected for access as well as to provide a secondary support in case the hydraulics failed. The height of the steel form was approximately 4.5m. The outside forms were designed and provided by Peri. These were specially made to eliminate the need for through ties. However, after the first pour, two ties were added as some deflection was noticed.

Each pour was approximately 4m in height. A steel reinforcement cage was prefabricated on the ground. Each cage was 4m in height and had to be reinforced and welded. A special lifting platform was fabricated to lift each cage in position. This platform also provided access for the placement of concrete on top of each pour.

"Due to the access problems at height and the complexity of the reinforcement, this was the safest way of installing the reinforcement," Leighton Contractors explained.

As the dam embankment was constructed and raised, bridge piers were also completed. This would then enable erection of the steel access bridge from the tower to the dam wall. The initial design called for more bridge piers and large pre-cast concrete girders, however, Leighton Contractors offered an alternative design which removed the number of bridge piers and made for a lighter bridge structure.

The bridge consists of three spans, each 45m in length and of steel truss/concrete deck construction.

"The bridge spans were fabricated offsite by HF Hand in 15m segments, transported to site, joined together and then lifted into position in one 45m span," Leighton Contractors said.

At the same time the steel gantry frame was erected on the ground (including platforms, lightning protection and cabling) and lifted into position on top of the tower. This minimised the problems of access and working at height.

As stratification of still water bodies can lead to undesirable anaerobic conditions near the dam wall, a destratification line was also run along the bridge, down the tower and into the storage area. The destratification system consists of poly pipe that is suspended in the water with floats and weights. Compressed air is pumped through the pipe and released through small holes beneath the water line to prevent the stratification of the water.

A new 66kV substation, together with the construction of overhead and underground cabling was constructed to provide permanent power to the dam site. The substation was fitted with specialist SCADA and communication systems to the dam site. Powerserve, subcontracted to Leighton Contractors, undertook the construction of the high voltage infrastructure.

A pump station was constructed on site to facilitate the pumping of water from the storage facility back into the North Coast Water supply network via the same pipeline that gravity feeds water into the storage site.

The pump station is a brick-clad steel portal frame building founded on continuous flight auger piles.

The main pump hall houses the three Flowserve Super Titan 500kW pumps in duty/duty/stand-by mode. These are capable of pumping 700L/s.

Adjacent to the pump hall is the electrical control room incorporating the switchboards and electrical control systems.

At the end of the Shannon Creek diversion conduit, a valve house was constructed to house the valves which control the water movements, both into and out of the storage. Various cone valves were installed within the valve block to dissipate the water released downstream as part of the environmental flows. Erhard FDC Valves were installed and are approved for use as both regulating and isolating valves.

Now that all of the construction work is completed, landscaping is being undertaken using native seed stock collected from plants growing within a 20km radius of the site. The use of the local seed stock ensured all landscaping works utilised endemic plants, which are more favourably suited to site conditions, thereby reducing the potential for the introduction of weeds and exotic species. Picnic and BBQ facilities are now incorporated into the site.

The Shannon Creek storage facility is currently 15% full and expected to be full by the end of 2010. It will come online as part of the supply network when the dam capacity reaches 50% and when the water quality is acceptable. ●

Environmental concerns

The construction of a bulk water storage facility affecting 210ha of land does not come without its controversy.

The Environmental Defender's Office, a not-for-profit community legal centre specialising in public interest environmental law, acted on behalf of Friends of Shannon Creek Action Group (FOSCAG) who objected to the construction of the facility because it said construction and operation would "have a significant potential to reduce the longterm regional viability of some listed and nominated threatened species and potentially place these at risk of local extinction".

So too, the Clarence Environment Centre objected to the works citing "environmental horror stories relating to the Shannon Creek dam fiasco". The Clarence Environment Centre kept a vigilant eye over construction proceedings over the past three years and raised a number concerns with the NSW Department of Environment and Climate Change, including concerns for erosion control during rain events; "unacceptable" management and monitoring of threatened species; and concern about the spread of the disease that causes tree die-back *Phytophthora cinnamomi*.

Leighton Contractors said the project was regularly audited by the NSW Department of Environment and Climate Change who were satisfied with the extent of controls and the proactive nature of the environmental management. No stop work notices or prosecutions were issued in the lifetime of the project, Leighton Contractors said.

To work with the community, North Coast Water and Leighton Contractors also put in place various environmental and community initiatives and provided opportunities for the community to visit the site on a regular basis through fortnightly community tours which operated for over a year. In addition, two community open days were held which enabled the community to visit the site and get an understanding and appreciation of the extent of works undertaken. ●

WATER ENGINEERING
AUSTRALIA

ENGINEERS
AUSTRALIA
Water Engineering

Supported by Engineers Australia's National Committee on Water Enginering.

Would you like to subscribe to Water Engineering Australia?

Water Engineering Australia is a new communication service for all engineers involved in the water industry.

It includes a monthly printed news magazine and a number of services accessible on the related website.

To subscribe to Water Engineering Australia fill in the form at www.waterengineeringaustralia.com.au/subscriptions2.aspx, contact Pam Chenery on 02 9438 1533 or email subscriptions@engineersmedia.com.au.