## BARANGAROO RESERVE TECHNICAL PAPER

ENTRY FOR THE 2016 AUSTRALIAN CONSTRUCTION ACHIEVEMENT AWARD

# lendlease



### ABSTRACT

Barangaroo Reserve is Sydney's newest harbour foreshore park – marking the transformation of one of the city's oldest and ugliest industrial sites into a sixhectare headland open space.

The Lendlease team were given an immensely ambitious brief; to design, deconstruct and reconstruct an industrial wasteland to create a new six hectare parkland with over 2km of paths and trails, 1.4km of sandstone foreshore and a 75,000 cubic metre subterranean cultural space.

To do this the team has re-engineered the Sydney Harbour coastline from an industrial container terminal to the naturalistic curves of a wooded, pre-colonial Australian headland as what can essentially be summed up as "construction in reverse".

In this paper, Lendlease demonstrates how new technologies, processes, innovations and a 'think outside the box' culture resulted in extraordinary solutions to seemingly intractable logistical, sustainability and safety issues.

# **KEY WORDS**

Lendlease | Barangaroo Reserve | Sydney | sandstone | sustainability |safety | community engagement | asbestos, landscaping | water re-use system | heritage | parkland | concrete | caisson removal | counterfort wall

### **TYPE OF CONTRACT**

The Barangaroo Reserve project was a traditional Design and Construct contract, awarded by Barangaroo Delivery Authority to Baulderstone (now Lendlease) on 23 May 2012.

## SCOPE OF WORKS

The \$250 million project involved:

- Recreation of a pre-colonial headland including the excavation of a new 100,000 cubic metre cove in Sydney Harbour
- Construction of a 75,000 cubic metre subterranean cultural space (the Cutaway) with over 300 space carpark – one of the largest subterranean spaces in Australia
- A 1.4 kilometre ribbon of sandstone foreshore with material extracted and processed on site
- Re-use of 200,000 cubic metres of fill within the park, in keeping with the project's sustainability commitment

- Six hectares of naturalistic bushland with over 70,000 native species of plants, shrubs and trees
- An underground water re-use system which provides full irrigation of the park
- Preservation of heritage items including the adaptive re-use of a 1900's sewer pumping station
- Integration works to better connect Barangaroo Reserve to surrounding city streets.

Construction of Barangaroo Reserve commenced in May 2012 and was completed on time in August 2015.



### **KEY PROJECT OUTCOMES**



The project achieved over 1.5 million man hours without a single Lost Time Injury (LTI) to the workforce. Given the project's duration of over three years and having up to 300 people on site, the record is quite exceptional in the industry. The Safety in Design and Risk Management processes were a critical part of ensuring hazards and risks were eliminated where reasonably practicable with much of the work not previously undertaken on a typical civil construction project. Construction of the project consisted of undertaking 17 out of the 18 regulated high risk construction activities, the only exception being the use of explosives.

Notably, the placement of sandstone blocks was carried out over 18 months with zero lost time and zero medical treatments outside of minor first aid. This outcome was made possible by the design and development of an industry first block handler attachment for an excavator by the project team. The block handler allowed the project team to lift 5 - 15 tonne blocks and place them next to each other with joint tolerances of 20 millimetres and without any worker interface, ensuring optimal safety and design outcomes.

The Total Recordable Injury Frequency Rate for the Project (TRIFR) was 3.73 which was significantly below the regional business target of <8 and compared favourably to the industry standard.





The project was awarded to Lendlease in May 2012, however due to client constraints, mobilisation to site commenced in August 2012. The contract was varied by the client in early 2014 to include a 35 per cent increase in scope.

Three years later in August 2015, the six hectare park, the Cutaway and carpark, foreshore walkway through Barangaroo Central and surrounding integration works in Millers Point were completed and opened to the public, as planned by the client.

The original contract had a completion date of June 2015 and through the team's ability to design and construct concurrently, a diligent design program and planning controls, the park opened to the public less than 2 months after the original completion date despite the significant increase in scope.

The project team held daily program updates and submitted weekly 6-week look ahead programs to the client as well as the standard monthly update contract programs to remain accountable to the program. The implementation of sophisticated field-based technology also allowed for live daily updates of key elements such as concrete pours, sandstone block placement and civil bulk earth works.



Lendlease carried out a major retender submission prior to award to ensure 'best for project' cost savings for the taxpayers of NSW. Providing taxpayer value was foremost for the project team, with significant savings passed onto the client during the tender stage, achieved through iterations of the design including the revised cultural space and the replacement of the underwater caisson repairs with a more cost-effective solution.

This was an extremely collaborative process and in line with the client's priorities.

This exercise saved the client in the region of \$40 million from the original tender submission through intense value engineering.

The final project value is being agreed presently and as such limited budgetary information is able to be provided from BDA, however the final project value is within the client's project budget.





#### SANDSTONE SPECIFICATION

Although there are a number of historical, harbour-facing seawalls constucted of sandstone around Sydney's harbour that are still in reasonably good shape, there is a lack of in-depth study on the general durability of sandstone (and in particular Hawkesbury Sandstone) in a marine foreshore environment.

A project-specific sandstone block quality specification therefore had to be developed to provide a practical means of assessing the likely long-term durability of the sandstone blocks.

The project team sought input from various specialists, namely John Braybrook of Douglas Partners, Ron Powell of the Department of Public Works, Aurecon and onsite stonemasons to develop a specification with a flow chart process that resulted in a final grading for the individual primary blocks, before final processing (saw-cutting and trimming) by the stonemasons.

The grading classification adopted was a simple, two-code, grading based on final placement: N or S (for North or South zones); and Dry (for land placement above the Highest Astronomical Tide (HAT) level, or Wet (for submerged blocks below Lowest Astronomical Tide (LAT), or Tidal (placed between LAT and HAT).

The assessment of durability, in terms of placement on the foreshore, relied primarily on the assessment of intact rock strength and whether or not an individual block can be improved by trimming and removal of significant defects. To anticipate from the onset the known durability properties of sandstone, a Quality Control process was developed and implemented during the sandstone block extraction operations that aimed to quantitatively and qualitatively assess and screen every batch of blocks extracted and apply a grading in terms of final placement. Simple and practical geotechnical field and laboratory test methods were applied such as Schmitt Hammer testing, supplemented by visual inspection of individual blocks to assess zones of weaknesses and/or defects.

This process helped to ensure that the best quality blocks were selected for placement in the Tidal zone of the foreshore, this being the most aggressive zone. Although some deterioration of the sandstone block foreshore would be expected over the park's design life, this will not be to the extent that the functionality of the foreshore revetment is compromised.

#### **CONCRETE ELEMENTS**

From new concrete works to adaptive re-use of existing submerged concrete caissons adjacent to Sydney Harbour, durability was a key driver to the decisions made for materials selection.

All concrete elements were designed with a 100 year design life to AS5100 Bridge Code, whether they are submerged in saline water from the harbour or are within the building.

In relation to the Cutaway, a combination of concrete mix design, control of cracking through the construction methodology, care during concrete placement, drainage design and waterproofing provides a durable weather sealed structure to meet the criteria for the design life without compromising the function or aesthetics of the structure and with minimal design life maintenance or financial cost.

#### APPLICATION OF DEFECTS MANAGEMENT MODEL

Barangaroo Reserve was the first civil infrastructure project in NSW to implement the newly developed Project Centre Defects Management model. This was significant because the project team was able to log/ capture defects on site, automatically sync back to a cloud server and allow for defects to be assigned to a subcontractor, compared to the traditional approach which involved capturing the defect with a camera, downloading it and maintaining a manual excel spreadsheet. The new approach allowed defects to be easily tracked and with greater accuracy, saving time and streamlining the defects management process.

The sheer quantity of quality documentation developed - over 3,100 Construction Lots and over 2,500 Hold and Witness Points clearly demonstrates the priority placed on delivering a high quality final product.

Our NCR process allowed us to identify deviations from the specification, often for an improved and robust solution and detail early and clearly the change as constructed.

The project had a strong quality assurance system in place which was continuously demonstrated by the various audits conducted on the project. In total, five Quality & Systems Audits were conducted by Lendlease and independent third parties with zero non-conformance reports or corrective actions raised.



The Barangaroo development represents one of the largest and most controversial city developments in recent years and posed unique environmental challenges for the project team.

Recreating the foreshore and undertaking sensitive marine works without adversely impacting the environment was a key priority for the project team. The team successfully delivered on this priority, with zero infringements or fines recorded during the project's three year duration.

The team achieved this success by utilising construction methodology, installing a six metre deep silt curtain around the headland and undertaking continuous water quality monitoring outside of the construction site.

Key successes:

- In relation to water quality, the project team installed a water collection system, which captured construction water and delivered it to a water treatment plant via a series of sumps and a pipe network. Construction water was treated to strict criteria and discharged into the harbour at higher quality compared to the receiving environment, which is above normal construction practice.
- Successful and safe remediation of 99 per cent of excavated material. The process has established new systems and set new industry standards for the management of asbestos in soil.

- The installation of a six-metre deep silt curtain around the Barangaroo headland as part of major marine works. The barrier was demarcated in the water by special markers and provided a marine exclusion zone as well as turbidity control for construction works, including the demolition of existing caissons.
- The replacement of mineral oil with biodegradable hydraulic oil for the operation of the 55T long reach excavator and 125T excavator minimised risk of marine pollution in the event of hose damage.

The project team successfully incorporated several State significant heritage items into the final design including:

- Recreation of the 1836 headland, using original survey maps.
- The discovery, retention and incorporation of the 1820's Munn's Slipway into the new sandstone foreshore of the Headland Park.
- The discovery, salvaging and incorporation of the 1865 Cuthbert sandstone seawall into the landscape entry of the cutaway.
- The preservation, relocation and adaptive reuse of the early 1900's sewage pumping station #14 at the Towns Place entrance to the park.
- The retention and incorporation of the 1903 sandstone seawall along the north western edge of the foreshore.







Sustainability was both a key result area and a pillar for a successful outcome for the Barangaroo Reserve Project.

The Lendlease team was tasked with delivering the highest level of outcomes across a broad range of categories which were based on the 10 guiding principles of sustainability.

- Zero Carbon
- Zero Waste
- Sustainable Transport
- Sustainable Materials
- Local and Sustainable Food
- Sustainable Water
- Land Use and Wildlife
- Culture and Heritage
- Equity and Local Economy
- Health and Happiness

The team adopted an ambitious Sustainability Strategy and Action Plan that challenged their thinking against the principles, from concept through design, procurement, delivery and right through to the completion the project. By setting specific targets and initiatives in line with the ten principles the team was successful in not only delivering on the initial targets but exceeding expectations in many of them. A fact that has been recognised, not only by the client but more broadly by industry. **Culture and Heritage** – The concept for the Reserve was to return the area back to the original form of a cove and headland skirted by a sandstone foreshore as an acknowledgment to the Gadigal people of the Eora Nation, the traditional custodians of the land. The park's namesake, Barangaroo, was a Cameraygal woman who was a key leader in the Aboriginal community.

When the project team considered the design and construction of the headland, foremost in their minds were the coves and bays women such as Barangaroo would have skimmed and navigated to provide food for their families. With the guidance of early navigational maps from the 1800's and period paintings, the team was able to recreate this to great effect and levels of accuracy.

Water - Hidden beneath the park is an integrated water reuse system, which provides for the capture, treatment, storage and reuse of seepage and stormwater for the irrigation of the park. Located underneath the underground carpark are two tanks - an enormous 1,200 cubic metre rainwater tank and 180 cubic metre seepage tank. The water reuse system will meet the irrigation needs of Barangaroo Reserve during and beyond the 100 year design life of the park. Land Use and Wildlife - The park features more than 70,000 plants all native to the Sydney region. Many of the species could not be found in commercial nurseries, so seeds and cuttings were collected from wild sites around Sydney Harbour and the Hawkesbury River. The plants were grown in similar conditions to their final planting location at Mangrove Mountain on the Central Coast. Growth rates have been spectacular, with a failure rate of less than 1 per cent.

Sustainable Materials - Sandstone blocks for the foreshore and park were predominantly sourced from the footprint of the building basement car parks during the construction works. 93% of the blocks were able to be sourced from onsite which meant the majority of the sandstone was excavated and processed adjacent to its final location, minimising transportation impacts and carbon emissions.

#### **Barangaroo** salutes the Sydney sun NEWS, PAGES 8-9

Harbour's latest drawcard ope reviews on a clear day

**Fun and games** 

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#### TROY LENNON HISTORY EDITOR stretch of parkland on Sydney Harbour comes fu circle this weekend. As the

siness as they had done for centuries Although the smallpox epidemic in 1789 had an impact on the numbers they encountered, a painting from 1820 shows colonists alongside Cadigal enjoying the foreshore.

Wharf in 1903, primarily for handlin wool shipments. Old houses, wharve and other structures were demolished and in 1909 Hickson Rd was built to give better access to the docks. During the Depression long lines of wharfies



#### STAKEHOLDER SATISFACTION

Barangaroo Reserve has transformed what was an inaccessible industrial back side of the city into a continuously accessible public domain and western face of Sydney's CBD. The collective effort by Barangaroo Delivery Authority and Lendlease has returned the site to the people of Sydney for the first time in 100 years, creating a lasting legacy for future generations. It is a gift to the people of Sydney.

The park is unlike anything else in Sydney, with never-seen-before views of Sydney Harbour, numerous lookouts, extensive walking and cycling trails, coves and tidal rock pools, and one of the largest subterranean spaces in Australia.

The opening of Barangaroo Reserve also completes an uninterrupted 14-kilometre foreshore walk stretching from Anzac Bridge to Woolloomooloo.

In 2016, Barangaroo Reserve became a focal point for Sydney's Australia Day celebrations with the nation's Aboriginal heritage reflected in both the park and celebrations. For the first time, fireworks exploded over the Western Harbour, bringing huge crowds back to the western side of Sydney Harbour Bridge.

Barangaroo Reserve is already one of the city's premier destinations with Sydneysiders and visitors flocking to the park, on top of significant media coverage and industry accolades such as the 2015 World Architecture News Award and Banksia Award. In January 2016, the New York Times included Barangaroo Reserve in its list of top 52 places to go in 2016.



### **CONSTRUCTION COMPLEXITY**

### **UNIQUE RISKS**

Throughout the project, significant unexpected issues arose, all of which which were successfully resolved within the project's program and budget. Key risks to the program included:

- Major client lead scope and design changes due to the desire to optimise the final design. This process continued up to the final stages of construction. There was in the order of 6 per cent of the value of the project requested as variations within the last few months of the works. This required the team to be focused on delivering the agreed existing scope and also be adaptive to major changes in design and scope. Lendlease accepted every change requested by the Client, as we understood the overall benefit to the completed park and the value to the public experience at opening.
- The EPA mandated revised asbestos acceptance criteria midway through construction. For example, the levels of ACM acceptable in the soil changed from 1 per cent to 0.006 per cent by volume, which had huge potential impacts on time and cost. Lendlease avoided sending all the material to landfill as was first anticipated and worked with the Client, the EPA, independent Hygienists, Unions and the workforce to develop technical solutions and robust work practices to ensure adherence to EPA criteria and reuse of 99 of material on site. This outcome yielded a significant saving to the program and a large cost saving to the State Government.
- Significant archaeological finds were made during the project with Munn's Slipway, Cuthbert's seawall and an existing western edge seawall being retained and the shoreline design amended to suit. All these changes happened long after the design was complete and required intense redesign to successfully merge into the overall project.

### LOGISTICS

### SANDSTONE EXTRACTION, PROCESSING AND PLACEMENT

The construction of the 1.4 kilometre sandstone foreshore alone involved extracting, processing and placing 6,600 sandstone blocks, weighing up to 15 tonnes each and placed as deep as three metres under the harbour.

Adding further complexity to this work was the design requirement for a naturalistic finish, which demanded 60 unique cross sections with a variety of heights. In all, there were 300 different sizes of block to be produced, tracked, stored and placed.

The logistics of harvesting and handling 300 uniquely dimensioned blocks of stone were highly demanding, and more so given a large expanse of land was simply not available on site. Similarly the trimming, handling and placing had to be managed to minimise the losses that are inherent with working with large blocks. Overcoming these complex challenges required the team to think outside the box and combine traditional stonemasonry techniques with modern technology.

- Using Revit, a 3D interactive virtual model of the foreshore was developed which utilised Revit's in-built intelligence to facilitate a sandstone cutting schedule for the blocks and their careful positioning. Each block was uniquely identified and allocated rock quality attributes and then placed using GPS technology, smart-phones and tablets. This process optimised processing and placement from cradle to grave.
- While Sydney Sandstone is a tough, durable building material that has been used in major buildings for over a century, the rock is not simple to extract.



Just like stonemasons of a century ago, the project team spent months studying the existing rock fractures and sandstone's inherent natural properties. Instead of using timber wedges and hammers to remove rock, the project team had the advantage of modern technology and used specially designed cutting blades to remove "birthing stones" – each one eight metres long but coming in four different widths to match the natural splits in the rock.

The combination of traditional stonemasonry techniques and modern technology allowed the project team to make sympathetic cuts to the sandstone, maximise the yield and minimise the wastage of sandstone being removed from the extraction pit.

 The foreshore sandstone blocks were placed with an industry first block handler, specially designed and developed by the project team over 6 months. The block handler had the capability to lift 15 tonne blocks and place them with tolerances of 20mm, eliminating the need for people interaction and cranes and ensuring optimal safety and design outcomes Other complex challenges taken into account included:

- Meeting the design intent of landscape architects PWP and JPW;
- Ensuring an accurate interpretation of the original shoreline;
- Replicating natural jointing in sandstone by ensuring joint tolerances of 20 millimetres;
- Constructability of the sandstone foreshore, ensuring safety in the design and construction stages; and
- Suitability of sandstone in marine environment taking into account tidal patterns

Sandstone placement was achieved with a team of 30 people and divers placing blocks for 18 months critical incident and injury free – a massive achievement.

#### CAISSON REMOVAL AND RE-USE

The demolition of the old caissons, which formed the perimeter of the former container terminal, presented enormous logistical challenges.

To recreate the original 1836 topography, the project team effectively re-cut the headland, by wire-sawing the concrete caissons four metres under the harbour with a specifically designed wire frame with saw and marine divers.

The caissons, weighing up to 380 tonnes each, were then lifted with a 600 tonne shear-leg barge, transported back to land, crushed and recycled within the park. The project team significantly improved the speed and efficiency of the wire cutting process, reducing the cutting time from eight days for the first caisson to 1.5 days for the last caisson.

In what can only be described as a hugely successful logistical exercise, 33 caissons were removed and lifted in the busiest channel of Sydney Harbour with zero disruption to cruise ship timetables and zero environmental incidents, zero LTIs or critical incidents. This had never been done before and is unlikely to be undertaken ever again.

#### **INTERFACES**

The project had to contend with complex internal work interfaces and multiple external boundary interfaces, both having many unique challenges, with the boundary being over 3.5 km, of which 1.4 km was Sydney Harbour shoreline.

At the commencement of the project, the project shared the site with the Overseas Passenger Terminal, located at Central Barangaroo, which meant large passenger ships were docking alongside our works.

This situation required detailed planning and program coordination with multiple stakeholders – cruise operators, the tug boat company and the harbour master, whom we met weekly during our peak marine works. RMS were also closely involved in the general harbour works as they were taking possession of the newly established cove and had input to the design and new alignment of the shoreline throughout the process.

As a result of the strong relationships the project team forged with key stakeholders and undertaking detailed planning and coordination, 1.4 kilometres of reconstructed shoreline was completed with no disruption to harbour traffic and zero complaints from Sydney Ports and RMS.

During the first 18 months of the project, as part of our contract the team provided public access through the middle of our construction site, from one end to the other for a large-scale public foreshore walk. This created logistical and safety challenges with multiple cross over points and public viewing areas needing to be managed and altered to suit the daily changes in work sequencing. Together with the client and subcontractors, the team cooperatively managed the safety of visitors, giving them a unique first hand view of progress at one of Sydney's most high profile projects. Lendlease's contract was varied to include integration works within Millers Point, with the City of Sydney being a financial contributor to the works and the end owner of the asset. This required a distinct design and delivery process to the other works being carried out, with the staging and handing back of areas to the public intersecting with the main construction program and being critical to progressing other areas of work.

BDA, as a roads authority had ownership of Hickson Road, another significant portion of the project's boundary. Again, a different approach to delivery was required as they were new to their role as a roads authority and simultaneously acting as client in another capacity.

The combination of integration works, including Hickson Road presented the project with an ever-changing public and construction interface. Through detailed planning, significant road and access upgrades have been incorporated into the design during the construction stage, which have significantly enhanced the park's connections to Millers Point and the surrounding CBD.

Within the construction site itself, Lendlease had marine, quarrying, large civil earth works, construction of an 18 metre high counterfort wall and construction of a basement carpark, and 6,000m<sup>2</sup> building works all being carried out in a site with a cross section of less than 200 metres from rock face to harbour.

The skill of the team in moving 250,000 cubic metres of dirt to highs of 21 meters above ground level, while quarrying over 12 metres deep, just metres away and placing 6,600 large sandstone blocks under the harbour in such close proximity was second to none.

Doing all this injury free and on-time was a direct result of collaboration within the discipline and intense day-to-day planning.

#### CONSTRAINTS

#### Construction of the cultural space roof

The construction of the Cutaway was impacted by a number of constraints including: confined site footprint for the building, interface with the program for sandstone extraction given the location of the extraction pit and the safety risks of working at heights

To overcome these constraints, the use of pre-cast concrete was maximised, consisting of approximately 400 individual precast elements including Super T's, Headstocks, V Slabs and RTA Planks, which form the entire roof structure and its approaches.

The main roof structure was installed in an exceptionally complex and high-risk operation, utilising a 450T mobile crane working off a suspended slab without backpropping. Two years of planning was required to facilitate the operation including the creation of a 3D model to accurately represent the multiple stages of the installation which was deemed required due to the difficult conditions.

The model exposed all the potential issues ahead of time and the most economic sequence to enable a smooth install when it came to the actual construction stage. The sequence was fully coordinated meaning that the restricted working area would permit the 450T crane, jinkas, sizable precast elements, support cranes & trucks along with personnel functioning on multiple levels all working in harmony in a safe environment.

All the planning and preparation supported the highly prescriptive temporary works restrictions and meant they could then be implemented to enable 50+ tonne precast headstocks and Super T girders to be driven onto the suspended slab alongside the 450T crane, imposing extreme loading on the suspended structure and safely lifted into their final resting place.







#### REDESIGNING THE WATER RE-USE SYSTEM

The original water re-use system included three rainwater collection tanks located adjacent to the harbour's edge. This created major risks of tidal flooding during construction and the requirement for future maintenance at three different locations.

Changing site conditions dictated the sandstone excavation pit needed to go deeper to overcome a shortage of good quality sandstone, which presented an innovative design alternative for the water re-use system.

The revised design amalgamated the tanks into one large 1,200 cubic metre tank constructed beneath the carpark basement (the site of the excavation pit), eliminated safety risks associated with excavating under the water table and provided a single location for future maintenance greatly improving outcomes for long term facilities management of the park.

#### **RELOCATION OF SPS14**

Respecting the site's history and heritage was an ongoing focus for the project team, especially during construction.

The relocation of a 1904 heritage sewer pump station involved extensive planning of methodology and collaboration with structural, temporary works and heritage consultants.

The operation involved:

- Wire saw cut 1 metre below existing surface level to separate pump station from pump well.
- Installation of custom designed temporary steel structure as lifting point
- Dual lift of 110 tonne pump station with 250 tonne and 350 tonne mobile crane completed with no structural damage
- Incorporation of heritage listed item into the park's final design with heritage elements restored.

The pump station relocation was successfully completed critical incident and injury free. Fittingly, it has been re-purposed as a public restroom.

#### SUCCESSFUL COMMUNITY ENGAGEMENT:

Over 130,000 Community notifications Over 230 Site Tours provided to the public and key stakeholders Over 300 Community Consultation & Key Stakeholder Meetings

#### **COMMUNITY ENGAGEMENT**

The complexity of the park's design, its location in a highly sensitive and visible area adjacent to Sydney Harbour and the Sydney CBD and the breadth of stakeholders presented unique community challenges throughout the project's duration.

The project team adopted a proactive, honest and responsive approach to community engagement and developed strong relationships with local residents and businesses located in the immediate vicinity of the project.

This commitment to best practice resulted in no community issue threatening project delivery.

Given the high profile of the Barangaroo precinct, the project team worked closely with the client to provide opportunities for the public to see firsthand the transformation underway.

The project team facilitated a foreshore walk through a live construction site during the first 18 months of construction, which required extensive planning and safety controls for people and plant separation.

A number of Open Days were also carried out, as well as an archaeological dig for Munns Slipway and Cuthbert's sea wall.

Throughout the 3 year construction period, the project team accommodated over 20,000 visitors.



We will permit others to challenge us on our behaviours and encourage us to improve

### LEADERSHIP AND MANAGEMENT OF THE PROJECT

#### **OUR "ONE TEAM" APPROACH**

The Lendlease project team proactively adopted a solutions-driven philosophy throughout the duration of the project to overcome engineering challenges and meet client needs.

From the outset, the project team worked with key partners including the Client, Client's Landscape Architect and lead Design Engineers to form a project charter, which spelt out how the parties intended to work together and what was expected of each of the parties to achieve the unified goal of creating an iconic project for the people of Sydney.

The Charter was signed by the parties including the Client and was displayed in prominent locations on the project to instil a 'one team approach' to delivering the highest quality park achievable. The Charter challenged individual approaches to innovation, safety, and quality and helped the team overcome different project pressures to deliver the best solutions, not just 'business as usual' solutions.

The project had three key areas, Marine, Building and Civil/Landscape, however there was always a focus on coordination. Group meetings were regularly held to share ideas, coordinate works and plan future activities.

The project team's collaborative approach was a key contributor to the success of the project.



#### **DESIGN AND PLANNING**

The complex nature of the project and the multiple activities and interfaces across the site, as identified in various sections of this submission, required very detailed planning and control across the project. Impacts from one area of design or program change affected multiple other areas with critical paths running through various sections of the works and all coming together across the entire site at one point in time right at the end.

A significant complexity was that the entire fabric of the site changed so significantly in material from the existing asphalt, to timber, sandstone, grass, concrete and even harbour and also the elevations changed so dramatically across the site from the existing level site to 12 metre excavations over 6,000m2 and the upper bluff of the park being created 21 meters in the air. This meant that no one area could be finished early, all parts of the jigsaw needed to come together at the end. This required a very detailed design planning process with emphases on staging of the works, constructability and interdependencies of the entire scope. Key design planning and control achievements:

• The use of BIM technology to design and track the progress of the building construction, which was not commonly used on civil projects at the time but is something that will become the norm into the future when the full power of BIM is understood. BIM was also utilised to develop a deep design plan for the temporary works involved in the construction of the precast roof.

The use of BIM to create a 3D model, which accurately represented multiple stages of installation, enabled a safe, smooth and fully coordinated installation of the pre-cast roof in a restricted working area.

BIM provided the project team with early certainty of project design in a visual manner and the ability to track against the program.

As a result of the detailed planning and design of the complex temporary works systems, the project team achieved seamless installation of 5500m2 of roof structure in 15 days, compared to a >5 month programme had the structure been built using traditional methodologies.

• Application of the Revit program to design the foreshore, which enabled the project team to experiment and test the design and installation months before having to carry out the works in the field, thus maximising the efficiencies gained by the modelling and the life size shoreline models constructed on site.



#### **HEALTH AND SAFETY**

The key safety message "Safety Matters" empowered every employee to take ownership of safety performance on their part of the project.

The project team prided itself on a positive safety culture, which was achieved through the development and rollout of a 'Project Culture Program'. This program targeted safety leadership, behaviours, innovation, technology, regular engagement and training.

Senior project leaders regularly participated in various engagement campaigns such as "Safe Start" and "Finish Strong" that focused on critical risks and the Project Director and Construction Manager attended every project induction, providing clarity regarding the leaders' commitment to health and safety. Both the Project Director and Construction Manager regularly reiterated the importance of an outstanding safety record, that befitted the iconic status of the park.

The WHS Committee engaged the workforce on key risk activities such as asbestos and silica management and undertook regular consultation through weekly inspection walks and meetings and provided a platform for committee members to develop into safety leaders.

Regular project health checks, culture refreshers and safety workshops were also undertaken, supplementing the continued focus on the Project Charter, which was developed in collaboration with the client, project staff and construction workers.



#### Key achievements:

- Emergency Response Preparedness (ERP) Training covering:
  - Marine rescue
  - Mobile plant rollover and collision
  - Excavation and trenching collapse
  - Confined space rescue
  - Tower crane rescue
  - Formwork and scaffold rescue
  - Fire response
  - Security threat

ERP training has since been adopted at Lendlease's Barangaroo South, Darling Harbour Live and NorthConnex Projects.

- Asbestos awareness training to all personnel on site in addition to asbestos removal training for selected workers
- Engaged full time Lendlease occupational hygienist to supervise works in addition to hygienist consultants, which other Lendlease projects are now seeking to emulate
- Development of Occupational Hygiene Procedures
- Regular Mates in Construction Program training and awareness provided to site, creating a strong focus on good mental health
- Dust Diseases Board health monitoring provided to approx. 150 workers
- Regular engagement with key stakeholders including Workcover NSW, EPA, Industry Unions, Community, WHS Committee and Client.

#### **INDUSTRIAL RELATIONS**

There were over 300 people working on the project at peak. The project's good working relationship with the unions ensured there was no lost time due to industrial action.

Early and ongoing engagement with unions and workers in relation to contamination on the site, in particular the presence of asbestos contaminated material (ACM), ensured work was conducted safely and in line with best practice.

Asbestos awareness training was a part of the project induction and regular discussions were held with the WHS committee and health and safety representatives of the workforce around the scope of works, the low levels of asbestos found in the pre-works testing and the potential for far greater levels of ACM being found during construction given the history of the site.

During the works and in response to the anticipated asbestos found on site, the project engaged an independent Occupational Health expert, Peggy Trompf, who reviewed the plans and work methods and worked with the team to ensure best practice was being undertaken for the health and wellbeing of the workers and the community.

Peggy has since requested Lendlease compose a joint industry paper on the practical methods and applications followed on the job as she believes them to be industry leading.



#### NEW TECHNOLOGIES AND INNOVATION

Barangaroo Reserve is a story of innovation and industry firsts. In summary;

- An industry first wire saw that cut through 33 caissons and allowed them to be safely and cleanly removed in a sensitive marine environment and reused within the park. This was a world first and effectively eliminated the need for underwater demolition and substantial environmental risks and resulted in significant savings to the client.
- The first time Super-T Girders were used in a pre-cast roof structure. The use of Super-Ts (in the pre-cast roof), normally used for constructing bridges to achieve long spans, removed two rows of columns from the interior of the Cutaway, giving the client maximum flexibility in utilising the space, in addition to significant time and cost savings on the project.
- The introduction of a world-first ground anchor system in the cultural space, which removed millions of dollars of earthworks risk, as dualstage anchors guaranteed bond length prior to backfill
- An industry first sandstone block handler which allowed 15 tonne blocks to be lifted and placed without any worker interface, ensuring optimal design and safety outcomes. Through the block handler and tracking system, productivity doubled from original forecasts of ~12 blocks a day, to a peak installation rate of 115 blocks per day.



- Remediation of asbestos contaminated fill – the project team adopted the most stringent practices in Australia for asbestos management on any site, which were introduced during the delivery phase and in doing so, set new benchmarks for the safe use of soil containing asbestos.
- The first time in over 100 years that such a large volume of site won sandstone has been used on a project in Sydney, in addition to the re-use of 99% of excavated fill.
- The use of BIM to create a 3D model of the Cutaway, which accurately represented multiple stages of installation, enabled a safe, smooth and fully coordinated installation of the pre-cast roof in a restricted working area. BIM was also utilised to develop a deep design plan for the temporary works involved in the construction of the precast roof.
- The application of Revit to facilitate a sandstone cutting schedule for the foreshore blocks and their careful positioning. Without the application of Revit, the sandstone foreshore would have taken ten times longer to build.
- The development of a project specific app which enabled sandstone blocks to be uniquely identified and tracked using GPS technology. This app, combined with the use of Revit optimised sandstone processing and placement from cradle to grave.

#### TRAINING AND DEVELOPMENT

All staff, direct labour force and subcontractors that passed through the Barangaroo Reserve gates were given the opportunity to develop their existing skillset, career and personal growth, departing the project more skilled than when they arrived.

The project culture was built around an emphasis on training and development, specifically in the areas of Environment & Sustainability, Safety, Personal Development, Verification of Competencies, High Risk Work Licences and Administrative Training.

The project team, direct labour force and subcontractors also had access to the Barangaroo Skills Exchange, a learning hub situated on the Barangaroo South construction site. Lendlease successfully secured government funding for this initiative, which allowed Barangaroo Reserve workers to access training for High Risk Work licences, WHS Diploma, First Aid, Computer Classes and Literacy and Numeracy Tests.

During the course of the project, approximately 1,800 individuals undertook training, culminating in over 6,000 training hours.

#### INDIGENOUS PARTNERSHIPS

The project worked closely with the Koori Job Ready Program (KJRP) to ensure that opportunities for employment and training would be made available for 70 Aboriginal people during the life of the project.

The project has successfully engaged:

- 10 direct employment placements for both office and site based activities
- 17 subcontracted employment placements
- Provided an additional 60 employment opportunities to the wider Aboriginal community.

## ACKNOWLEDGEMENTS

Client:	Barangaroo Delivery Authority Client's Project Manager and D&C Contract Superintendent– Advisian
Completion:	2015 - Barangaroo Reserve
Size:	6 hectares - Barangaroo Reserve; 22 hectares - Barangaroo Precinct
Collaborators:	
Principal Contractor:	Lendlease
Lead Design Consultant - Civil, Geotechnical and Structural Design:	Aurecon Australia
Client Landscape Architect:	PWP Landscape Architecture, Berkeley, California
Hydraulic and Fire Design Consultant:	Warren Smith and Partners
Landscape Architect:	Johnson Pilton Walker Architects
Architect:	WMK Architecture
Horticulturalist:	Stuart Pittendrigh, Norcue
Soil Consultant:	Simon Leake, SESL Australia
Sandstone Extraction and Placement Consultant	Troy Stratti
Heritage Consultant	Rintoul Associates
Archaeologists	Austral Archaeology
Marine Design Consultant:	Hyder Consulting
Electrical Design Consultant:	Webb Australia Group
Mechanical Design Engineer:	Waterman AHW
Lift Services Design Engineer:	Norman Disney and Young
BCA Consultant	Philip Chun
Accessibility Consultant	Morris Goding Accessibility Consulting
Occupational Hygiene Consultant	Dr Peggy Trompf, Industrial Health Matters
Environmental Validation and Classification Consultant	JBS&G

Temporary Water Treatment Subcontractor	Synergy Resource Management
Environmental Management Subcontractors	Prensa (Air Monitoring Subcontractor), Pure Contracting and Enviropacific Services (Asbestos Removal Subcontractors)
Cassion Removal and Demolition	A Quick Core Cutting Service (Wire Cutting Subcontractor), Delta (Demolition Subcontractor)
Diving Services Subcontractor	McLennan Diving Service
Landscaping Subcontractor:	Regal Innovations
Trees, Plants and Shrubs Suppliers	Andreasens Green Wholesale Nurseries
Stonemason:	Stone Mason & Artist
Sandstone Processing and Supply	Gosford Quarries and Bundanoon Sandstone International
Paving Subcontractor	Sam the Paving Man
Civil Subcontractor:	Ford Civil Contracting (Integration Works)
Building Structure Subcontractors	BKH Group (Building), Favetti (Brickwork) and Quickway (Counterfort Wall), VSL Australia (Permanent Ground Anchors)
Precast Element Suppliers:	Australian Precast Suppliers (Marine Counterfort Walls), Structural Concrete Industries (Roof Elements and Marine Toe Blocks) and XL Precast (Roof Elements)
Cranage Subcontractor	Gillsepie Cranes and Melrose Cranes & Rigging (Precast Roof Install)
Concrete and Reinforcement Supply	Holcim (Concrete) and ARC (Reinforcement)
Building Fitout Subcontractor:	Gartner Rose
Electrical Services Subcontractor	John Goss Projects (Building and Park) and Subakette (HV Substation)
Building Services Subcontractors	Flamesafe Fire Protection (Fire Services), McPherson Plumbing (Hydraulic Services), ThyssenKrupp Elevator Australia (Lift Services), Triple-M (Mechanical Services)
Temporary Works Designer	Jorn Hanson
Water Reuse System Subcontractor	SAS Water Solutions
Gravity Sewer Diversion Subcontractor	Trazelbat



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