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Environmental Impact Statement – Executive Summary

Warragamba Dam Raising

Reference No. 30012078
Prepared for WaterNSW
10 September 2021

SMEC INTERNAL REF. 30012078

Introduction to the Project

The Hawkesbury-Nepean Valley (the valley) in western Sydney has a long history of flooding. According to the Insurance Council of Australia, the region has the highest flood risk exposure in New South Wales, if not Australia.

In 2012, extensive flooding across south-eastern Australia, including the Hawkesbury-Nepean Valley, saw Warragamba Dam spill for the first time in 14 years. This again raised awareness about the potential impacts of flooding in major urban areas.

The NSW Government undertook, the Hawkesbury-Nepean Valley Flood Management Review (2013 Review) that found that there was a significant existing and growing flood risk in the valley and concluded there was no simple solution or single infrastructure option that could address all the flood risk.

Following the recommendations of the 2013 Review, the NSW Government established the Hawkesbury-Nepean Valley Flood Management Taskforce (the Taskforce) in 2014 to develop a whole-of-government approach to flood risk management and preparedness in the valley.

A key objective of the Taskforce was to identify, develop and assess potential alternatives and options for reducing flood impacts and risks in the valley. This included developing the key elements of the Hawkesbury-Nepean Valley Flood Risk Management Strategy (Flood Strategy) for Government's consideration.

In June 2016 the NSW Government adopted the recommendations of the Taskforce, which included a range of targeted outcomes designed to:

> **'reduce flood risk to life, property and social amenity from regional floods in the Hawkesbury-Nepean Valley now and in the future'**

The Taskforce found that the most effective and efficient infrastructure option to reduce the significant risks to people's lives and property from regional flooding is to raise Warragamba Dam for flood mitigation.

The Flood Strategy, overseen by Infrastructure NSW (INSW) is delivering nine outcomes to maximise the flood risk mitigation benefit:

- Outcome 1: Coordinated flood risk management across the valley now and in the future — including a new Hawkesbury-Nepean Valley Flood Risk Management Directorate to oversee implementation of the Flood Strategy
- **Outcome 2: Reduce flood risk in the valley by raising Warragamba Dam wall — the preferred infrastructure solution**
- Outcome 3: Strategic and integrated land use and road planning — including preparation of a Regional Evacuation Road Master Plan and a Regional Land Use Planning Framework to better manage flood risk in the valley
- Outcome 4: Accessible contemporary flood risk information — improving mapping of flood risk and making this information widely available
- Outcome 5: An aware, prepared and responsive community — including a coordinated focus on raising community understanding of flood risk and flood evacuation routes
- Outcome 6: Improved weather and flood predictions — updating the Bureau of Meteorology's Hawkesbury-Nepean weather prediction and flood forecasting model
- Outcome 7: Best practice emergency response and recovery — providing for periodic reviews and updates of emergency and recovery plans maintained by the NSW State Emergency Service and the NSW Office for Emergency Management
- Outcome 8: Adequate local roads for evacuation — undertaking around 40 high priority local evacuation road upgrades
- Outcome 9: Ongoing monitoring, evaluation, reporting and improvement of the Flood Strategy — establishing a monitoring, evaluation, reporting and improvement framework.

Outcome 2, the proposal to raise Warragamba Dam Raising Project for flood mitigation (the Project), is the focus of this Environmental Impact Statement (EIS). The Project does not change the permanent full water supply level of the dam and is solely to provide flood mitigation for downstream communities through the creation of a dedicated air space.

WaterNSW is a New South Wales state owned corporation and is the owner and operator of Warragamba Dam.

The Hawkesbury-Nepean Valley has the highest single flood risk exposure in NSW, if not Australia.

Raising Warragamba Dam would provide flood mitigation through the temporary storage and controlled release of floodwaters.

Raising Warragamba Dam would reduce risk to life and reduce flood damages downstream by about 75% on average.

The Flood Strategy does not change the location of the existing floodplain development levels.

Since records began in the 1790s, there have been about 130 moderate to major floods in the valley. The largest flood in living memory was in November 1961 (approximately 1 in 40 chance in a year flood), when the water reached around 14.5 metres above normal river height at Windsor.

Use of the Dam for flood mitigation would not change the full supply level or lead to permanent upstream inundation.

The proposed raising of Warragamba Dam is one of nine outcomes under the NSW Government's Hawkesbury-Nepean Valley Flood Risk Management Strategy.

Raising Warragamba Dam would reduce the flood risk but it will not completely eliminate all flooding impacts.

Over 80 dams in Australia have been raised at some point after their original construction.

Why is an EIS required?

WaterNSW was requested by the NSW Government to seek planning approvals for the Project. WaterNSW, as the proponent and a determining authority for the Project within the meaning of Part 5 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act), formed the view that the Project is likely to significantly affect the environment and, therefore, would require the preparation of an EIS.

WaterNSW engaged SMEC Australia Pty Ltd to prepare the EIS on its behalf.

The Project is declared State Significant Infrastructure under section 5.12(2) of the EP&A Act and approval is required for the Project under Part 5, Division 5.2 of the EP&A Act.

This EIS provides a detailed assessment of the Project impacts and the mitigation measures and offset strategies proposed to address the impacts.

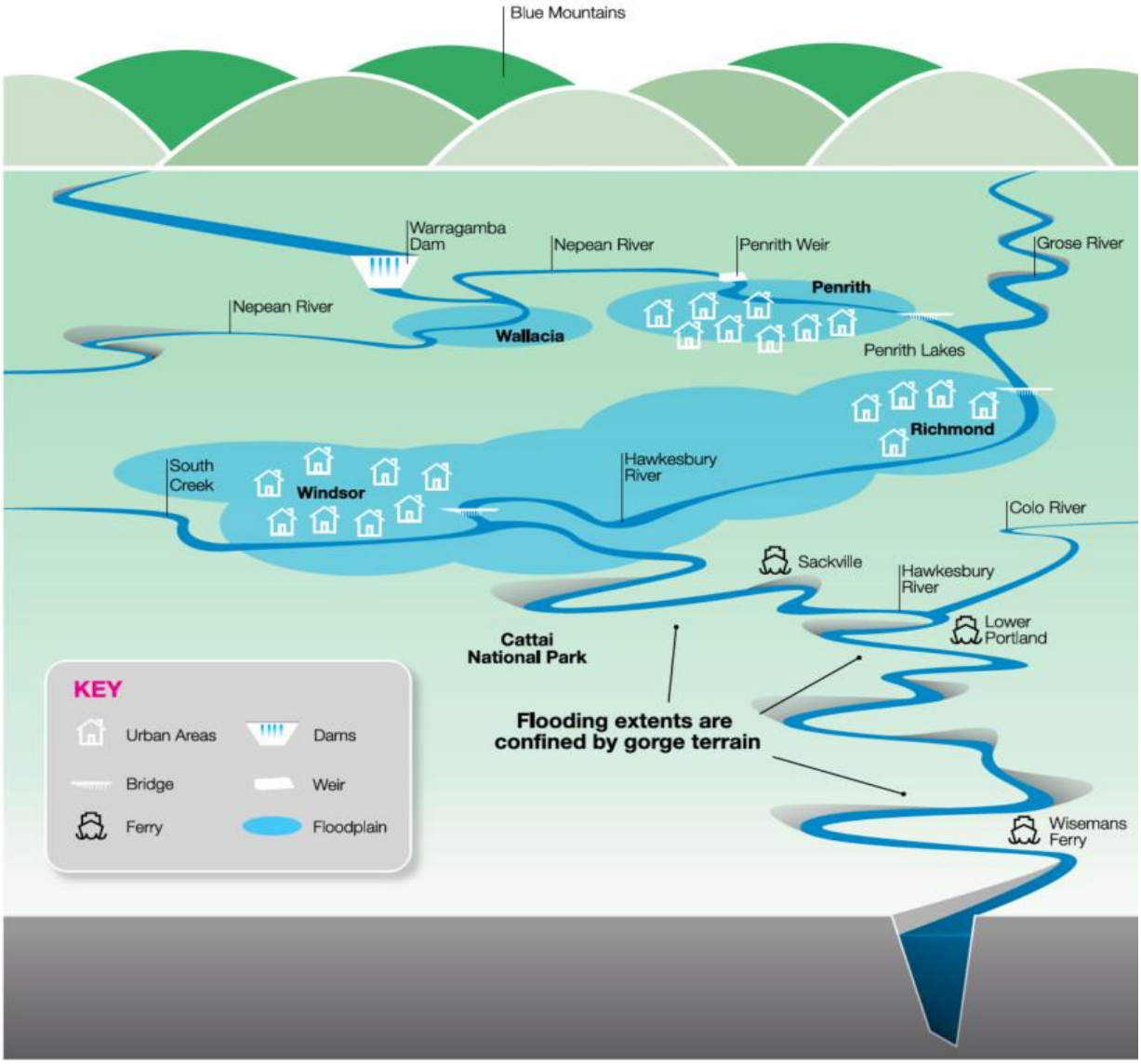
How is flooding influenced in the valley?

Flooding is a naturally occurring hazard. Flood risk is a combination of the likelihood of a flood happening and the consequences of that event when it occurs. Flood risk varies according to the frequency of exposure to flooding, the severity of flooding, and the vulnerability of the community and its supporting infrastructure.

The high flood risk in the valley arises from the contribution from five major tributaries flowing into one river system constrained by narrow downstream gorges. This causes floodwaters to back up across deep and broad floodplains – known as the 'bathtub' effect (see Figure 1).

The floodplain is home to a large existing population potentially impacted during flooding. Around 140,000 people currently live or work in the floodplain. It is this combination of flood likelihood and exposure of a large population that makes the risk so high.

Figure 1. Topography and features of the Hawkesbury-Nepean Valley showing bathtub effect

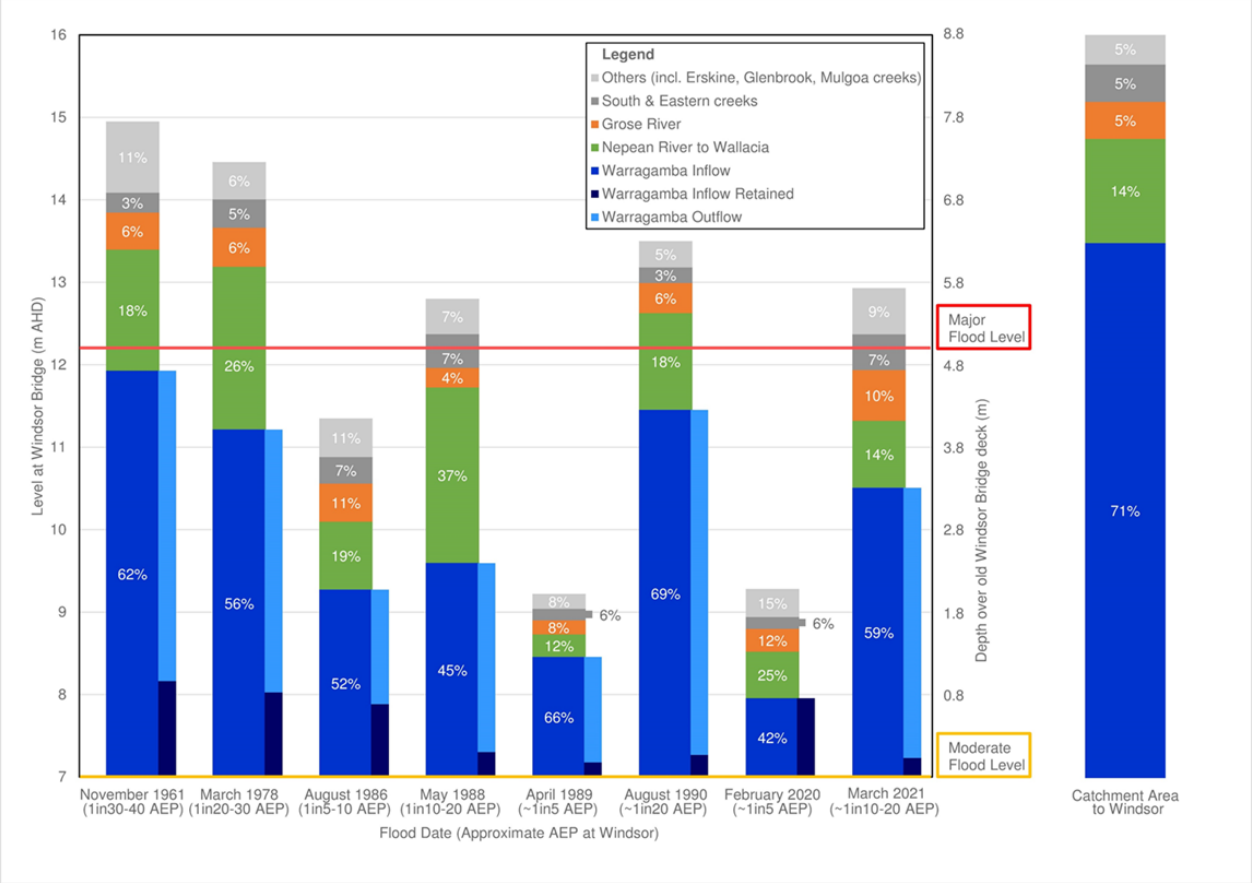


Source: INSW (2017)

Warragamba Dam contribution to downstream flooding

The large Warragamba Dam catchment historically contributes up to 70 percent of flows during flooding in the Hawkesbury-Nepean (see Figure 2). Extensive Monte Carlo modelling of around 20,000 possible floods undertaken for the Taskforce showed this contribution could be as high as 75 percent.

Figure 2. Relative contribution of different river catchments in a range of floods in the Hawkesbury-Nepean Valley



Source: INSW (2021)

Due to flows from the various tributaries and depending on the catchment conditions, floods can occur without contribution from the Warragamba catchment. This is what happened in February 2020 when the Warragamba Dam storage levels were at around 42 percent at the start of the event due to drought, and the dam didn't fill. Without a contribution from the Warragamba catchment, the flood at Windsor was a small 1 in 5 chance in a year event (see Figure 3).

Figure 3. February 2020 flood – view from North Windsor looking north

Source: INSW (2020)
Photo: Adam Hollingworth

Figure 4 shows the March 2021 flood from a similar location at North Windsor as shown above in February 2020. At the start of the 2021 flood, Warragamba Dam was nearly full and as a result, contributed around 60 percent of flows to this larger event.

Figure 4. March 2021 flood – view from North Windsor looking north

Source: INSW (2021)
Image: Top Notch video

Flows from the other catchments combined contribute up to around 40 percent. Figure 5 shows the dam spilling during the March 2021 event contributing around 1,200 billion litres to the downstream flooding over the course of the event.

Most large floods will include a significant contribution from the Warragamba catchment, historically up to 70 percent. Additional contributions of floodwaters can also come from the Nepean River, the Grose River, South Creek and others.

Figure 5. March 2021 Flood, Warragamba Dam spilling

Source: INSW (2021)
Photo: Adam Hollingworth

What is the objective of the Project?

The Project objective is to:

'Reduce risk to life and property damage downstream in the valley by raising Warragamba Dam wall'

Considerations in meeting this objective include:

- reducing peak flood heights and reducing the flood rate of rise (or delaying the flood peak) downstream
- minimising upstream environmental, cultural and social impacts from increased temporary inundation within the catchment of Lake Burragorang
- minimising downstream environmental, social and economic impacts from changes in water releases from the dam
- minimising construction impacts
- maintaining the primary role of Warragamba Dam for water supply
- ensuring the upgrade meets dam safety requirements
- delivering a scheme that has the greatest net benefit for current and future conditions.

Based on the Taskforce Options Assessment Report (INSW 2019), and subsequent investigations, the Project would significantly reduce the risk to life and allow more time for evacuations during critical flood events. By reducing the depth and extent of flooding, it would provide a reduction to property damages to people's homes and communities by on average around 75 percent over the long term.

The major benefits would be experienced in the Wallacia, Penrith/Emu Plains, Richmond/Windsor, and South Creek/ Eastern Creek areas of the floodplain, and to a lesser extent in the Lower Hawkesbury.

Where is the Project located?

The Project site is located about 65 kilometres west of the Sydney Central Business District in the Wollondilly Local Government Area. An aerial view of the Warragamba Dam wall location is shown in Figure 6 below.

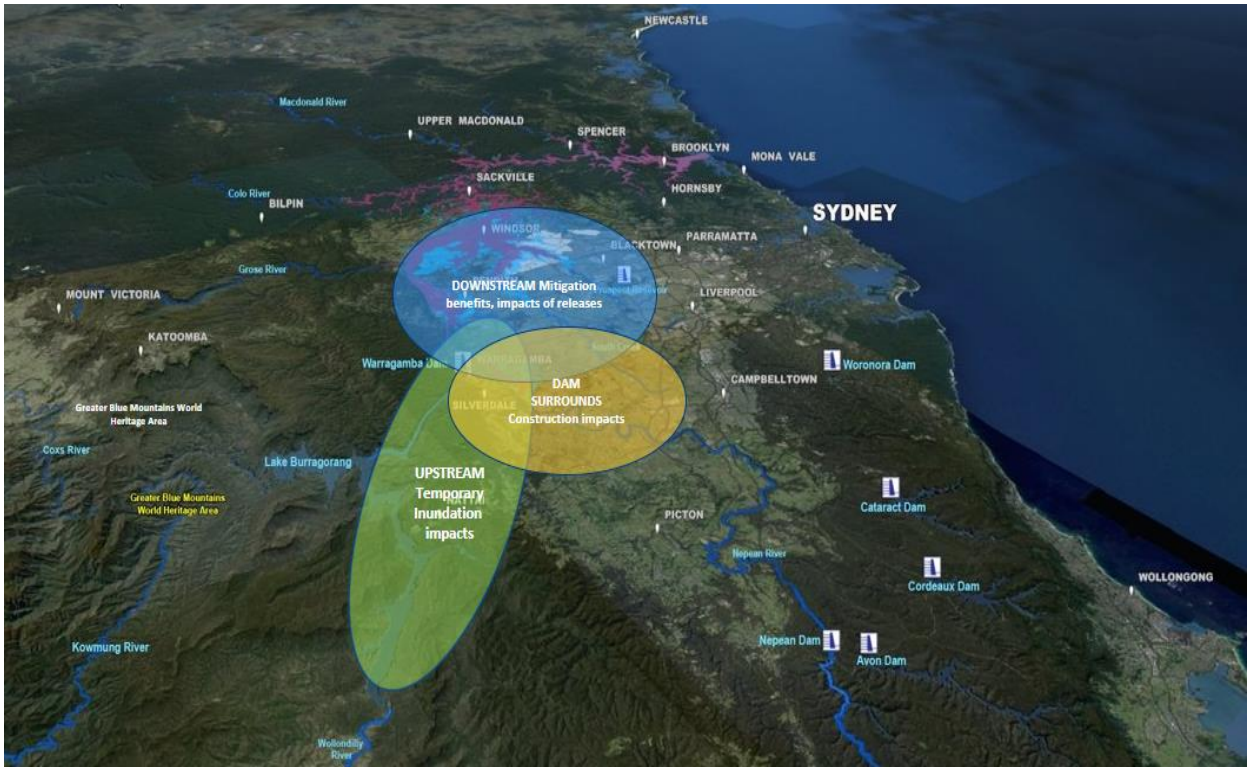
To the west of the Project site are the Blue Mountains, various national parks and state conservation areas, and the Greater Blue Mountains World Heritage Area which make up part of the catchment of Lake Burragorang - the water storage formed by Warragamba Dam.

To the east are the Warragamba and Silverdale townships and surrounding rural residential areas. Warragamba Dam is located in a narrow gorge on the Warragamba River, 3.3 kilometres before it joins the Nepean River. The Nepean River becomes the Hawkesbury River downstream at the junction with the Grose River at Yarramundi. This entire river is referred to as the Hawkesbury-Nepean River.

For the environmental impact assessment, study areas were segregated based on geographical location and potential impact. The study areas are shown in Figure 7, highlighting the upstream, dam surrounds, and downstream areas potentially affected by Project.

Figure 6. Aerial view of the Warragamba Dam wall location

Figure 7. Project study area (indicative only)



Source: INSW (2018)

About Warragamba Dam

Warragamba Dam is a water supply dam and provides around 80 percent of Sydney's water supply. The dam was constructed between 1948 and 1960, and is 142 metres high and 350 metres wide across the river. It is currently not designed or operated for flood mitigation.

Previous works at the dam including raising the dam wall by five metres in the mid-1980s and constructing the auxiliary spillway in early 2000s were to improve the dam's safety. These works did not increase its capacity of storage for water supply or provide any flood mitigation capabilities.

Warragamba Dam has two spillways:

- the central spillway is 90 metres wide with gates
- the auxiliary spillway is 180 metres wide on the right abutment.

Warragamba Dam is a mass gravity concrete dam which means the weight of the wall anchors the dam and allows it to hold back the water in the catchment. Figure 8 shows the existing Warragamba Dam from the downstream side looking east when the dam was spilling in March 2021.

Figure 8. The existing Warragamba Dam during a flood

Source: INSW (2021)
Photo: Adam Hollingworth

Over 80 dams in Australia have been raised at some point after their original construction. There have been higher raisings of concrete mass gravity dams globally, the highest being the Guri Dam in Venezuela which was successfully raised in the 1980s from 106 metres to 162 metres – a raising of 56 metres. In 2015, the San Vincente Dam in California – a similar dam to Warragamba Dam - was raised by 36 metres to 102 metres.

In this context, the proposed Warragamba Dam raising, while a major construction undertaking, is not a pioneering engineering project. The experience and lessons learned from other similar dam raising projects have been utilised for the design and will be leveraged for the construction. This will improve project outcomes in terms of safety and quality assurance.

What is proposed?

The Project would provide flood mitigation through the temporary storage and controlled release of inflows from a flood mitigation zone airspace created by the raised dam. Figure 9 provides an artist's impression of the raised dam from the downstream side.

Figure 9. Artist's impression of the raised dam

Source: WaterNSW (2021)

The flood mitigation zone creates airspace above the full supply level. When the lake level rises in a flood, water is temporarily stored in the zone.

The Project would significantly reduce flood extents and damages in the Hawkesbury-Nepean Valley and reduce risk to life and the scale of evacuations during critical flood events.

Similar dam raising projects have been undertaken successfully in Australia and overseas.

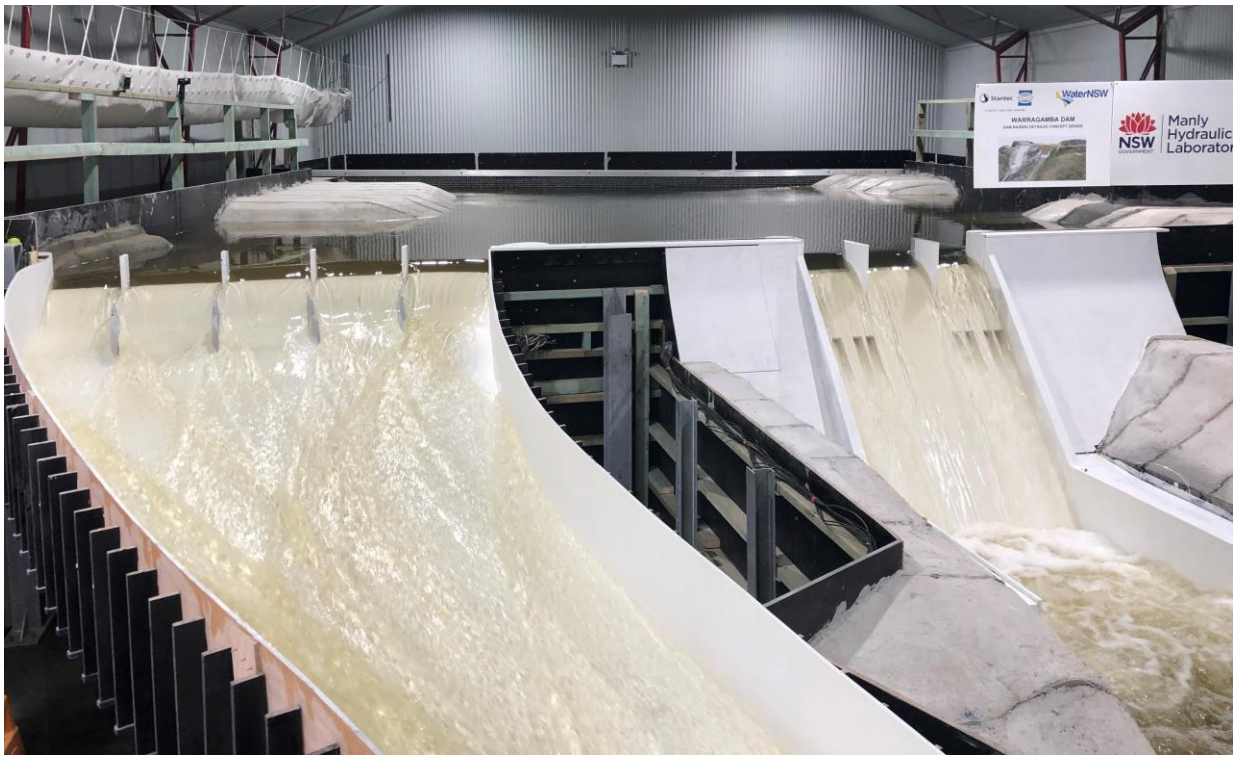
The Project would only influence the level of the lake. The project will not have any effect on the rate of inflows or impacts caused by rainfall, run-off and erosion

The Project would have impacts that cannot be avoided either through design, operation or mitigation measures. Offsets will be required to compensate for unavoidable environmental impacts.

Designing the dam raising

- Strict regulations control construction and modification of dams. Safety and structural soundness are the first priorities.
- The Warragamba Dam raising concept design has been developed by specialist engineers from Australia and overseas.
- The concept design addresses the requirements of Dams Safety NSW which regulates large dams in NSW. These regulations align with national and international guidelines which are being applied to the design.
- An independent technical peer review panel, experienced in the investigation and design of large dams, has provided reviews to ensure the design meets international best practice.
- The Warragamba Dam Raising project team used sophisticated digital design tools to develop a design to safely raise the dam - considering factors such as structural integrity and the way water spilling from the dam will behave.
- To test the concept design, the team built a physical scale model (see Figure 10) of the proposed dam. This scale model was used to run a series of simulated flood events to test the physical results against those forecast from the computer modelling.
- Extensive investigation of the dam foundations, existing concrete and testing of proposed concrete materials has been undertaken.
- Although extreme floods and earthquakes are rare, the dam wall is being designed to remain stable under all conditions

Figure 10. Image of the scale physical hydraulic model



Source: Manly Hydraulics Laboratory (2019)

Project construction

The development includes the following:

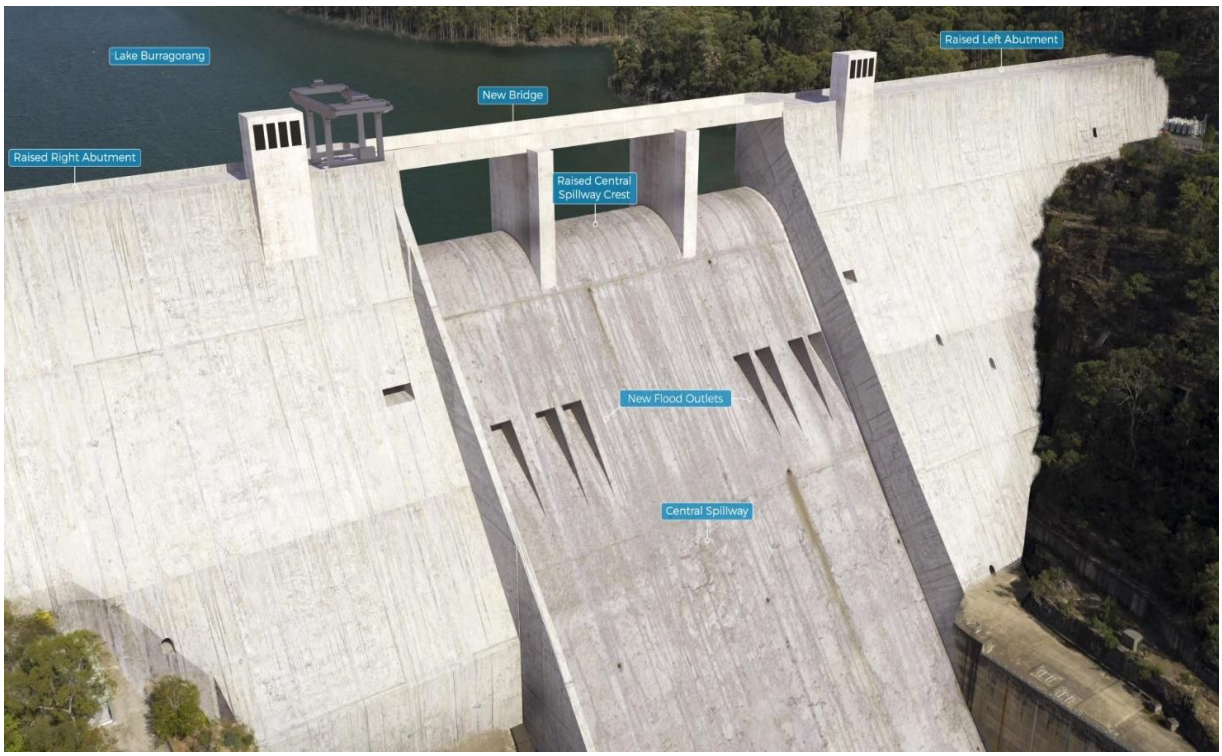
- raising the level of the central spillway crest by around 12 metres and the auxiliary spillway crest by around 14 metres above the existing full supply level for temporary storage of inflows.
- raising the dam side walls (abutments), including dam access road by up to 17 metres providing resilience for future impacts to projected climate change
- a designated area within the existing dam precinct of around 105 hectares for construction and laydown areas
- infrastructure to allow for environmental flows to be released from Warragamba Dam.

The Project would include the following main activities and elements:

- demolition or removal of parts of the existing Warragamba Dam, including the existing drum and radial gates, to allow for the new works
- thickening and raising of the dam abutments
- thickening and raising of the central spillway
- new gates or openings for release of water from the flood mitigation zone
- modifications to the auxiliary spillway
- other infrastructure and elements including new roads, bridges and ancillary facilities
- environmental flows infrastructure.

Project construction is expected to be completed about five years from commencement. Figure 11 and Figure 12 provide artist impressions of the raised dam from different viewpoints.

Figure 11. Artist's impression of the downstream face of the raised dam



Source: WaterNSW (2021)

Figure 12. Artist's impression of the upstream face of the raised dam

Source: WaterNSW (2021)

To enable the Project to be constructed, ancillary facilities such as concrete batch plants, materials storage areas, access roads, coffer dams and other temporary features would need to be provided and operated during the construction period. These would all be located adjacent to Warragamba Dam on land owned by WaterNSW.

Construction hours would be Monday to Friday (7am to 6pm); Saturday (8am to 1pm); and no work on Sundays and public holidays. However, some out of hours works for key activities may be required including:

- operation of chilled water plants for cooling and curing of concrete
- operation of the batching plants for the delivery and pouring of concrete
- preparatory or emergency works for a flood during the construction
- in the case of emergencies, delivery of oversized items or unexpected issues.

During peak construction periods the project would require up to 500 workers and generate daily traffic of about 250 light vehicles and 100 heavy vehicles. Approximate quantities of construction materials include 620,000 cubic metres of concrete, 11,000 tonnes of reinforcing steel, 22,000 square metres of steel and timber formwork and 24,000 cubic metres of fill.

During most of the construction phase, the maximum water level of the dam will need to be maintained at around five metres below full supply level to allow construction activities to operate safely.

Operation of the dam

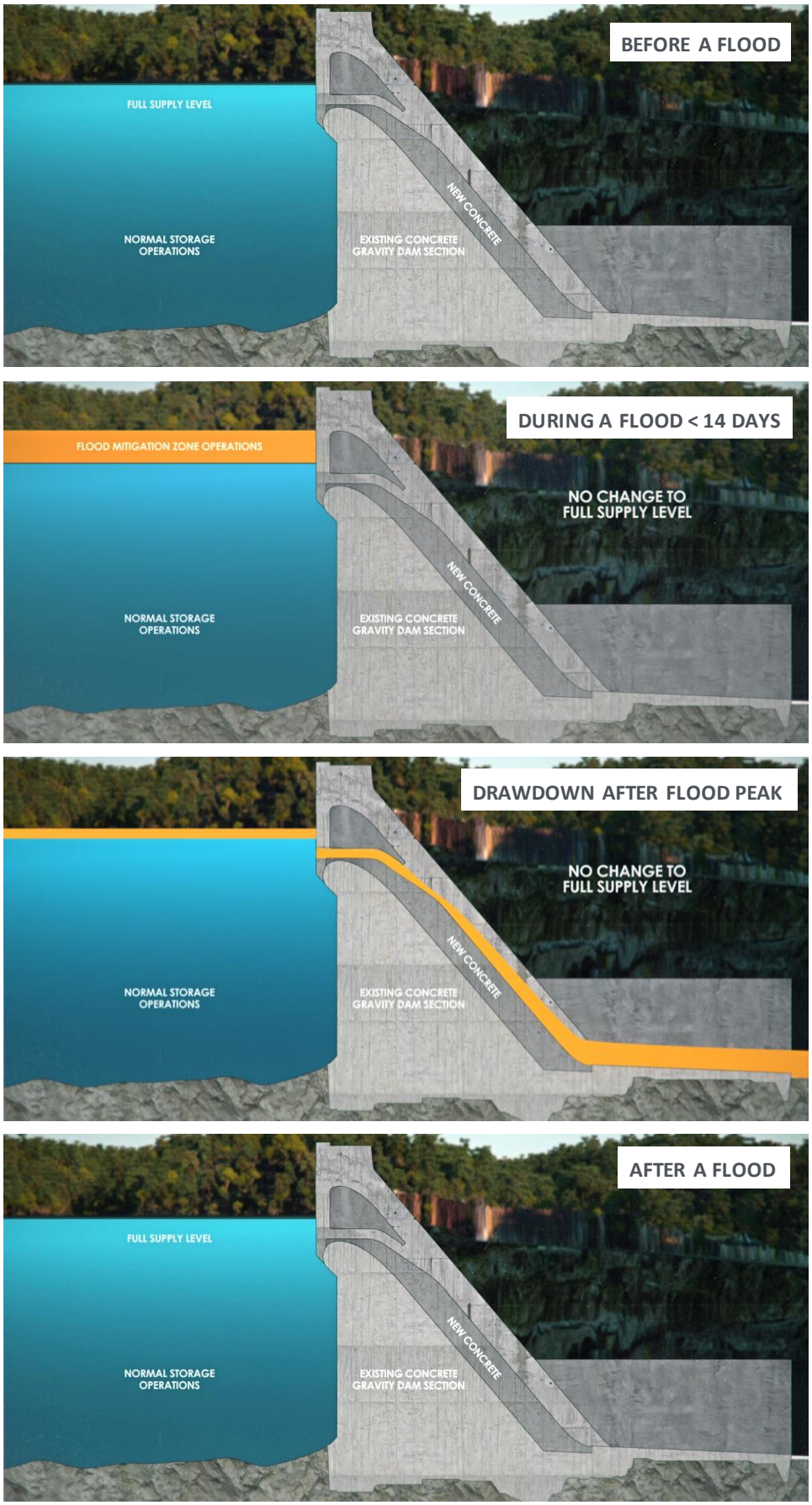
Normal operation would apply when the reservoir level is at or lower than the full supply level, which is when the water level in the dam is at or below Reduced Level (RL) 116.7 metres. The water storage capacity of the dam at full supply level is around 2,000 gigalitres (2,000 billion litres). Environmental flow releases would occur during normal operations.

During large upstream inflow events when the storage level rises above the full supply level, environmental flow releases would cease, and flood operations mode would commence. In this mode, inflows to Lake Burragorang would be captured and temporarily stored in the airspace created above the full supply level.

The raised dam would provide capacity to store around 1,000 gigalitres (1,000 billion litres) of water in its flood mitigation zone. The temporarily stored water would be discharged in a controlled manner until the dam level returns to full supply level.

A schematic depicting operation of the flood mitigation zone is shown on Figure 13.

Figure 13. Operation of the flood mitigation zone

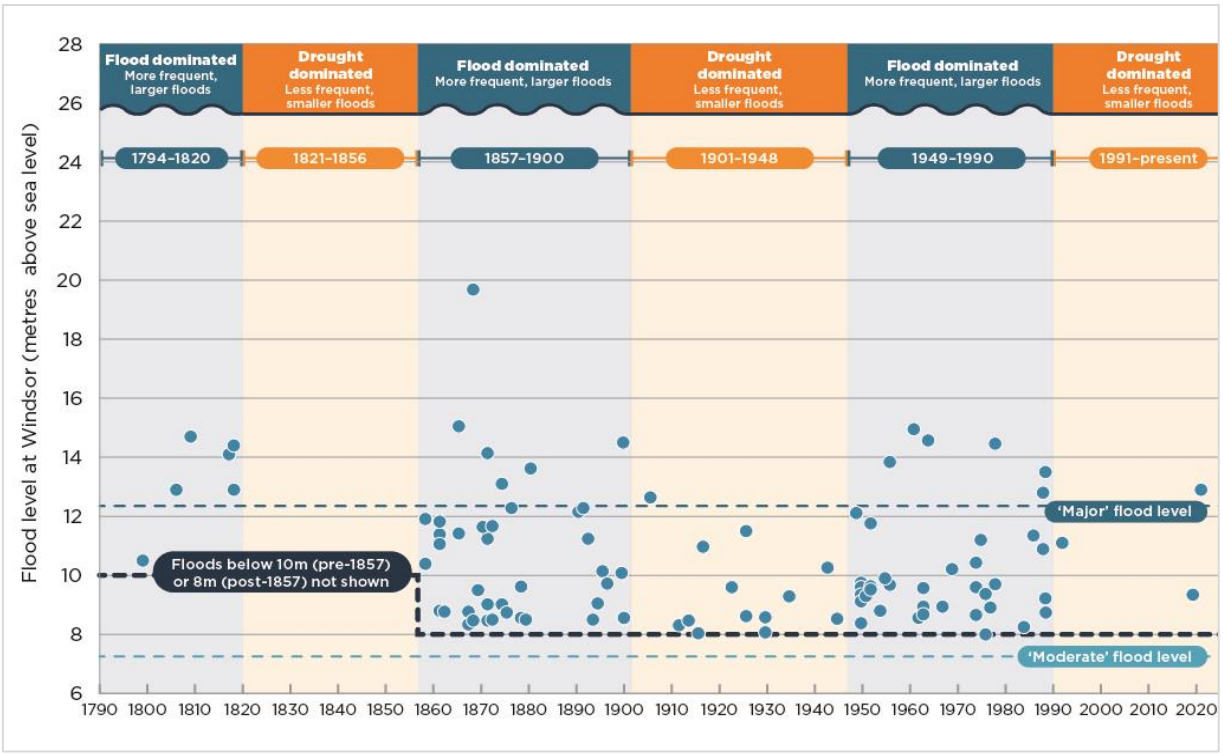


Source: WaterNSW (2021)

History of flooding in the valley

Since records began in the 1790s, there have been about 130 moderate to major floods in the valley. The Hawkesbury-Nepean experiences flood-dominated and drought-dominated cycles – lasting 30 to 50 years. The region has experienced a drought-dominated cycle since the early 1990s (see Figure 13). When the next flood-dominated regime happens, there will be more floods, and there will be bigger floods.

Figure 14. Flood cycles in the Hawkesbury-Nepean Valley (based on Windsor, 1790 to present)



Source: INSW (2021)

The largest flood on record in the valley was in 1867 (close to a 1 in 500 chance in a year event). At Windsor this flood event reached around 19 metres above sea level (see Figure 15). Known as the 'Big Flood', it caused loss of life and catastrophic damage across the floodplain (Hawkesbury-Nepean Valley Regional Flood Study, INSW 2019).

The largest flood in living memory was in 1961 when floodwaters reached 14.5 metres above sea level at Windsor, inundating large parts of the floodplain (see Figure 16).

Figure 17 shows the extent of flooding in 1961 compared to photos of the same location taken with no flood.

Figure 15. Illustration of the 1867 record flood in the valley

Caption: Windsor became a small 'flood island' in the 1867 flood, completely surrounded by floodwaters.

According to newspaper reports from the time, hundreds of local residents sheltered there, many having been rescued by boat from farms across the floodplain. Thirteen people loss their lives in the flood.

Source: Illustrated Australian News, 27 July 1867 p8. State Library of Victoria

Figure 16. 1961 flood inundation at Windsor – looking west to the Blue Mountains

Source: INSW (2017)

Figure 17. George Street, Windsor, and same view during the 1961 flood

Source: INSW (2017)

How would the Project reduce this risk?

Raising Warragamba Dam to provide dedicated flood mitigation capacity for temporarily capturing inflows reduces and delays downstream flooding, with benefits for evacuation. This is because most large floods will include a significant contribution from the Warragamba catchment, historically up to 70 percent of flows. The recent large flood of March 2021 was the first major flood in the valley since 1990.

While the flood caused devastation amongst some communities, particularly in low-lying areas, it was a relatively small event with a likelihood of 1 in 10 to 1 in 20 chance in a year across the floodplain. The large Warragamba Catchment contributed around 60 percent of flows for this event, with the other small catchments contributing around 40 percent combined. The photos in Figure 18 show some of the impacts from the March 2021 event.

Much larger floods are possible and can occur at any time. The Project is needed to reduce the extent of the downstream flooding that is contributed from the large Warragamba Catchment, and reduce the risk to life and extent of flooding damage that would typically occur.

Figure 18. March 2021 Hawkesbury-Nepean flood (around 1 in 10 to 1 in 20 chance in a year event, 3 views shown)

Caption: (top) Floodplain looking east over Windsor; (centre) McGraths Hill streets; (bottom) Lower Hawkesbury damage and debris

Source: INSW (2021)
Images: Top and centre, Top Notch Video; bottom, Adam Hollingworth

March 2021 flood – with a raised Warragamba Dam

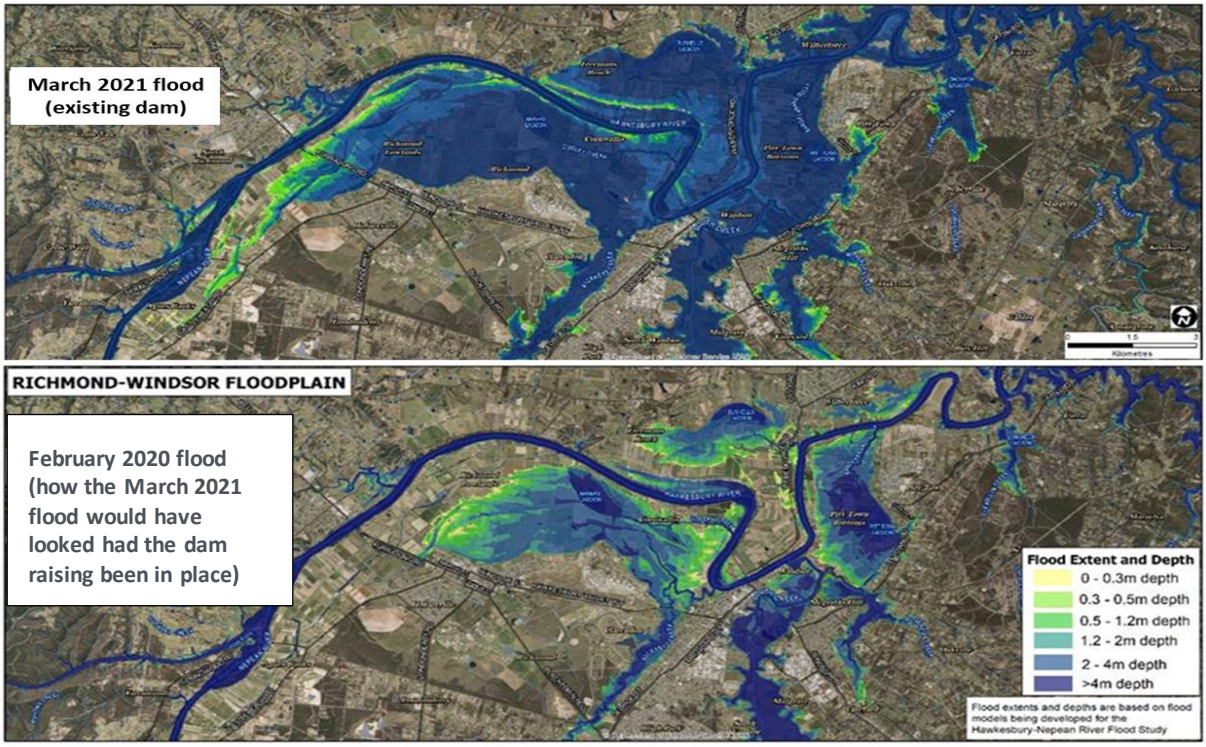
While it is not possible to stop floods in the valley, their impacts could be significantly reduced through mitigation. This flood event has not formed part of the EIS analysis however modelling was able to demonstrate the extent of this flooding if the wall had been raised.

This modelling by NSW Government post flood event has shown that raising Warragamba Dam to create a flood mitigation zone would result in a significant reduction in the number of properties flooded and overall flood damage costs. In addition, the Project would allow more certainty than currently exists for evacuation of downstream communities. The flood mitigation zone behind the dam wall would both delay and reduce the impact of a flood. Some key evacuation roads and bridges would either remain open or remain open for longer.

With Warragamba Dam raised as proposed, the March 2021 flood would have peaked around 3.6 metres lower at Windsor. As a comparison of how the raised dam would have altered the flooding for March 2021 it would have been reduced to those similar to the smaller and less damaging event in February 2020, which had around a 1 in 5 chance in a year of happening. For a comparison of the events, see Figure 3, Figure 19, Figure 20 and Figure 21.

The spill from Warragamba Dam would also have been delayed by around three to four days, significantly increasing the opportunities to evacuate people and their property from low lying areas. The initial closing of the new Windsor Bridge would have been delayed by around half a day, and the length of the bridge closure would have been reduced by several days.

Figure 19. Richmond-Windsor floodplain March 2021 (top) and February 2020 (bottom) floods extent



Note: Maps are based on modelling of March 2021 and February 2020 floods by Rhelm/Catchment Simulation Solutions for INSW; modelling of reduction in March 2021 peak flood level by WMAwater for INSW
Source: INSW (2021)

At Penrith, the dam raising would also have made a significant difference to the flood height in March 2021, reducing the peak by around five metres. This is illustrated in the images below showing flood height at the Victoria Bridge across the Nepean River at the peak of the flood on 21 March 2021 (see Figure 20), compared with a photo showing levels around five metres lower – equivalent to the reduction in flood height achieved with the proposed dam raising (see Figure 21).

Figure 20. The Victoria Bridge at Penrith near the peak of the March 2021 flood

Source: INSW (2021)
Photo: Adam Hollingworth

Figure 21. The Victoria Bridge at Penrith with levels five metres lower than March 2021 flood peak – equivalent to the reduction with the raised dam

Note: Reduction of March 2021 peak flood level based on modelling by WMAwater for INSW.
Source: INSW (2020)
Photo: Adam Hollingworth

Mitigating larger floods

While the dam raising would have significantly reduced the March 2021 flood, it would have greater benefits for the more dangerous and damaging floods – those with between a 1 in 50 and 1 in 1,000 chance in a year of happening.

In a 1 in 100 chance in a year event (Flood Planning Level), the raised dam would delay the peak, keep evacuation routes open, and reduce the flood height by around four metres in the Richmond/Windsor floodplain. This would:

- significantly reduce risk to life
- reduce the number of people to be evacuated by around 40,000
- reduce the homes impacted from around 5,000, and
- decrease flood damages by around $3 billion.

In such a flood, a raised dam would reduce flood depth keeping the main evacuation route, Jim Anderson Bridge, open at Windsor (Figure 22). This would allow thousands of people to make their way out of the floodplain to safety. In a larger 1 in 500 chance in a year flood, similar to the worst on record, around 45,000 people would avoid evacuation, 11,000 fewer homes would be impacted, and flood damages would be reduced from around $8 billion to $2 billion.

Figure 22. The Jim Anderson Bridge at Windsor in a 1 in 100 chance in a year flood – without the raised dam (top) and with the raised dam (below)

Caption: With the raised dam, the main evacuation route at Windsor (Jim Anderson Bridge) would be kept open during a 1 in 100 chance in a year flood.
Note: Modelling of reduction in 1 in 100 chance per year flood level by WMAwater for INSW
Source: INSW (2021) adapted from flood animation videos on NSW State Emergency Service website.

In parts of the floodplain, the impacts in suburbs adjacent to South Creek and Eastern Creek occur when floodwaters from the Hawkesbury River back up into these tributaries and spread over the floodplain.

The difference in flood height in this part of the floodplain is clear when viewed against local landmarks. Figure 23 shows the reduction in flood peak with the proposed dam raising in a 1 in 100 chance in a year event at Riverstone Station. A reduction of around four metres with the raised dam would mean floodwaters would not reach the station and surrounds in a 1 in 100 chance in a year event.

Figure 23. Riverstone Station in a 1 in 100 chance in a year flood – without and with the raised dam

Note: Modelling of reduction in 1 in 100 chance per year flood level by WMAwater for INSW
Source: INSW (2021) adapted from flood animation videos on the NSW State Emergency Service website.

Key benefits of the Project

Vulnerable communities in the valley have an elevated risk and are likely to be disproportionately affected in floods. These communities have a higher flood risk due to:

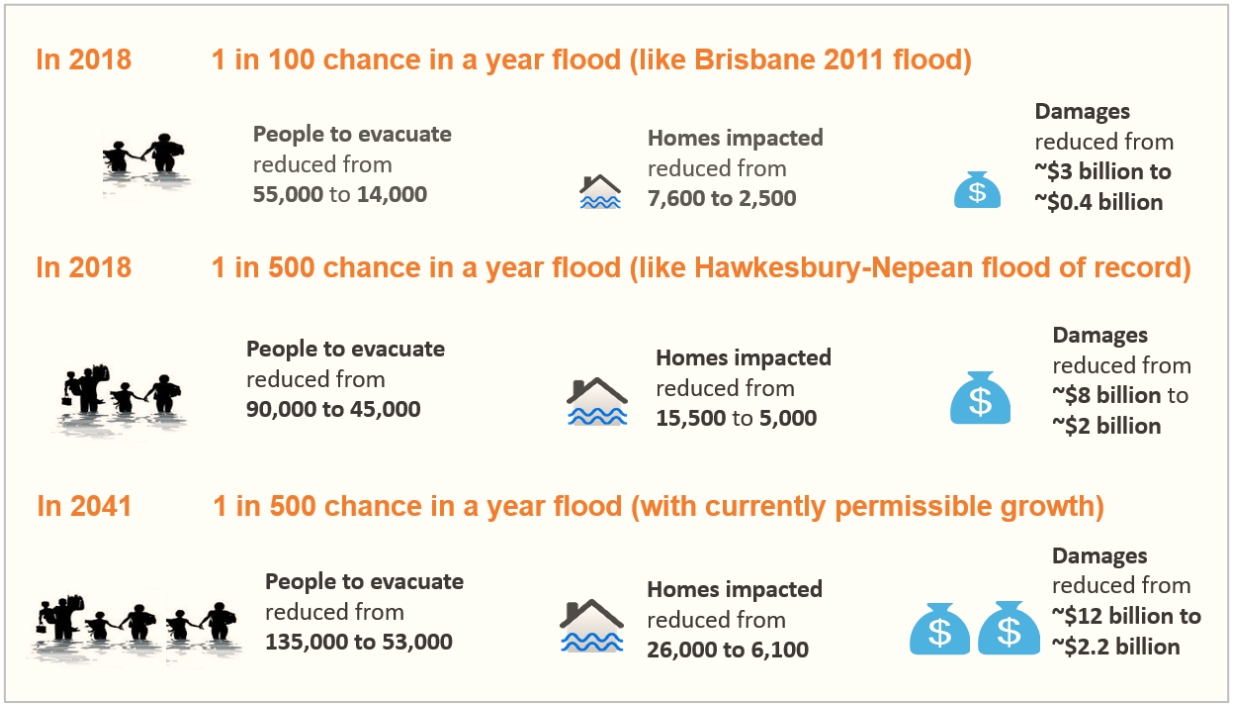
- living in geographic flood hotspot
- having existing disability, social vulnerability and inequality.

These factors frequently overlap to create multiple and complex barriers and disadvantages for vulnerable people and communities in preparing for and responding to flood. As the flood response for the Hawkesbury-Nepean relies on a timely mass evacuation of large numbers of people across a wide geographic area, these factors also create significant challenges for emergency services.

The proposed dam raising would significantly reduce the risk of flood exposure to thousands of vulnerable people and their homes. If evacuation becomes necessary ahead of a major flood, the dam raising would allow more time for emergency services to help prepare and safely evacuate people with additional health, transport and social support needs. Figure 24 below highlights some of the benefits of the dam raising for downstream communities.

Decreasing and delaying the downstream flood peak with the raised dam would also benefit farmers in the floodplain, providing them with more time to safely move farm machinery and livestock away from floodwaters.

Figure 24. Benefits of the Warragamba Dam raising for floods in the critical flood range



Source: INSW (2021)

The above figure does not take account of the life-time costs of the social impacts of flooding on individuals and communities. Research by Deloitte Access Economics has shown that these intangible costs can equal the costs of damage to property and infrastructure.

What alternatives were considered?

As discussed above, in 2014 the NSW Government established a Taskforce to develop a whole-of-government approach to flood risk management and preparedness in the valley. Through 2014-2016, the Taskforce built on the preliminary investigations of the 2013 Review, to develop a strategy under the disaster risk management framework of 'prevent, prepare, respond and recover'.

A key objective of the Taskforce was to identify, develop and assess potential alternatives to a dedicated flood mitigation zone at Warragamba Dam for reducing flood impacts and risks in the valley.

The assessed alternatives and non-infrastructure measures are detailed in the *Taskforce Options Assessment Report*[1] (INSW 2019) and include:

- operational alternatives using the existing Warragamba Dam – these primarily modify how the dam is operated but may require some modification to existing infrastructure; these include:
  - opening Warragamba Dam gates more slowly to temporarily hold back inflows ('surcharge' method)
  - pre-releases from Warragamba Dam water supply to create a temporary flood mitigation zone in advance of a forecast flood
  - lowering Warragamba Dam's water supply storage to create a dedicated flood mitigation zone
  - combined operational alternatives
- new flood mitigation dams – alternatives include new dams built and operated only for flood mitigation:
  - new dams upstream of Warragamba Dam
  - new dam on Nepean River
  - new dams downstream of Warragamba Dam
- infrastructure upgrades to enhance drainage or protect downstream communities, including:
  - construction of diversion channels to improve the drainage of floodwaters
  - dredging of Hawkesbury River to improve drainage of floodwaters
  - levees to provide localised flood protection to flood prone communities
- evacuation road upgrades – involving upgrade packages to improve evacuation road network capacity. Two categories of road upgrades were considered:
  - nine evacuation road upgrade packages for major regional evacuation routes
  - local evacuation road upgrades
- non-infrastructure measures – a wide range of non-infrastructure measures were considered including changes to land use planning controls, improved flood forecasting and response, building community resilience, and better coordination between agencies. Generally, these measures do not result in any reduction in flooding extent or frequency, and so cannot be considered substitutes to flood mitigation infrastructure that would reduce significant existing risk exposure. Nonetheless, these non-infrastructure measures are critical for an integrated and sustainable approach to managing current and future flood risk in the valley.

The assessment concluded that only the options that create flood mitigation zones (of different sizes) act to reduce the extent and depth of downstream flooding. Alternatives such as major new or upgraded regional roads, buy-back of dwellings or disallowing new dwellings do not change flood depths and extents.

The Taskforce concluded that the most effective solution to mitigate flood risk in the Hawkesbury-Nepean Valley is to raise Warragamba Dam to create a 14-metre flood mitigation zone, which is large enough to significantly reduce regional flood levels downstream of the dam.

[1] The *Taskforce Options Assessment Report* is available from the Infrastructure NSW website.

What alternatives and options have been reassessed?

As the assessment of alternatives has followed a progressive shortlisting approach – from the 2013 Review to the Taskforce and the Flood Strategy - only the more feasible alternatives have been subjected to the more intensive methodologies including evacuation modelling to better understand relative risk to life. This approach is consistent with best practice frameworks for disaster risk management.

The further review of the below alternatives and options found that the preferred option remained to be a raising of the dam wall to create a 14-metre flood mitigation zone.

- ***Raise Warragamba Dam spillway levels*** to create a flood mitigation zone of around 980 gigalitres between the existing, unchanged full water supply level and the raised spillways. This would provide air space for the temporary capture of inflows and their controlled release to mitigate downstream flooding. Contrary to a common misconception, this proposal does not increase permanent storage and when implemented would have no impact on Sydney's water security.
- ***Lower Warragamba Dam full supply level by 12 metres.*** This would create a flood mitigation zone of around 795 gigalitres. A lowering of 12 metres would require significant modification to the existing central spillway imposing a higher risk to the existing dam as compared to the dam raising solution. A 12-metre lowering would reduce Warragamba Dam's water storage by around 40 percent, requiring alternative water supply sources to be developed ahead of implementation.
- ***Lower Warragamba Dam full supply level by five metres.*** This would create a flood mitigation zone of around 360 gigalitres for the temporary capture of flood inflows. A five-metre lowering would reduce Warragamba Dam's water storage by 18 percent, requiring alternative water supply sources ahead of implementation.
- ***New or upgraded regional evacuation roads*** incorporating flood resilience in the road design, for improved flood evacuation. Roads are an infrastructure measure to support mass evacuation primarily by private vehicle during flood events as shelter in place is not an option for this valley. Several options were considered including the Castlereagh Connection, and major capacity upgrades to The Northern Road, Londonderry Road, Llandilo Road and Castlereagh Road. While roads are critical for evacuation, they do nothing to mitigate the effect of floods. As a result, roads neither reduce damages nor reduce the risk to life for those people who are exposed to flood risk and cannot or do not evacuate in time.
- ***Buy back all dwellings within the 1 in 100 chance in a year flood extent.*** This reduces flood risk to both life and property by removing dwellings exposed to the most frequent floods and replacing them with a more compatible land use such as recreation. Implementation would have major economic and social impacts on entire communities and would incur considerable costs.
- ***Disallow all new dwellings within the 1 in 500 in a year flood extent.*** This reduces future flood risk but does not reduce the large existing flood risk. Implementation would be costly and difficult, given large areas above the 1 in 100 chance in a year floodplain have been approved and/or zoned for residential development.

What were the outcomes of the reassessment?

- This reassessment of the preferred option and alternatives confirms that, of all the risk-reducing options considered, the proposal to raise Warragamba Dam by 14 metres to create air space for the infrequent, temporary capture of flood inflows offers the most benefit towards meeting the Flood Strategy's risk reduction objectives and KPIs. The reassessment of alternative options is discussed in detail in Chapter 4 of the EIS.
- Both the benefits and costs for the two best performing mitigation alternatives - to raise the dam by 14 metres or lower the full supply level by 12 metres - have increased since 2015. Benefits have increased as a result of more detailed assessments of the impacts on critical infrastructure and using the latest census and planning updated information for properties and assets in the floodplain.
- The major cost of the alternative of lowering the full supply level by 12 metres also includes for water replacement sources of manufactured water, such as desalination plants, to replace water lost from lowering the full supply level. Work underway for long-term water planning for greater Sydney – the Greater Sydney Water Strategy – has informed the revised cost estimates for water supply options.
- While lowering full supply level by 12 metres would provide moderate mitigation of downstream flood peaks, evacuation modelling indicates that by 2041, benefits for reducing risk to life would be about three times less than for the dam raising proposal. The reduction in damages would also be substantially less. The costs to make up for the lost water supply security would be very significant.

What options were considered for a dedicated flood mitigation zone at Warragamba Dam?

The raising of Warragamba Dam as a solution for flood mitigation was further assessed against other options that would achieve a dedicated flood mitigation function at Warragamba Dam without raising the wall.

The other two options of creating a dedicated flood mitigation zone:

- lower Warragamba Dam's permanent full storage level; two options considered – five and 12 metres
- combinations of lowering the permanent full storage level and changed gate operations.

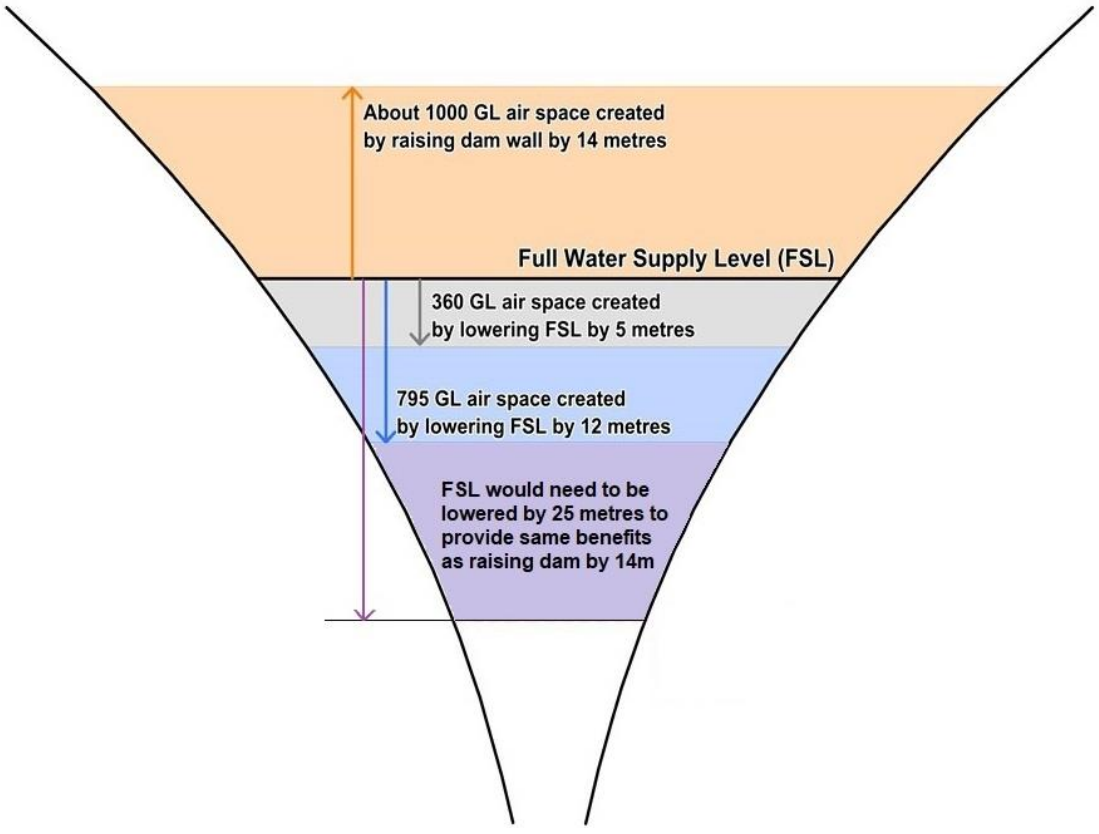
Permanently lowering the full supply level of Warragamba Dam to create a dedicated flood mitigation zone would achieve reductions in flood levels downstream of the dam. However, there are a number of issues relating to lowering the full supply level including:

- downstream benefits limited to smaller flood events
- permanent loss of significant water supply
- potential loss of water quality
- lower cost effectiveness.

The deep V-shaped valley behind Warragamba Dam means that the volume of airspace created by raising the dam by 14 metres is significantly more effective than that created by lowering full supply by five or 12 metres.

The full supply level would need to be lowered by 25 metres to provide the same benefit as raising the dam by 14 metres. Figure 25 shows the comparison of airspace with different options for creating a flood mitigation zone at Warragamba Dam.

Figure 25. Comparison of airspace with different options for creating an FMZ at Warragamba Dam



Source: INSW (2021)

The assessment of the alternatives and options confirmed that, of all the risk-reducing options considered, the proposal to raise Warragamba Dam, to create air space for the temporary capture of flood inflows, offers the most benefit in meeting the Flood Strategy's risk reduction objectives and criteria.

What key changes to the environment would result from the dam raising?

The Project will have impacts to environmental values that are not able to be avoided either through design, operation or mitigation measures. These impacts can be identified across the three study areas as follows:

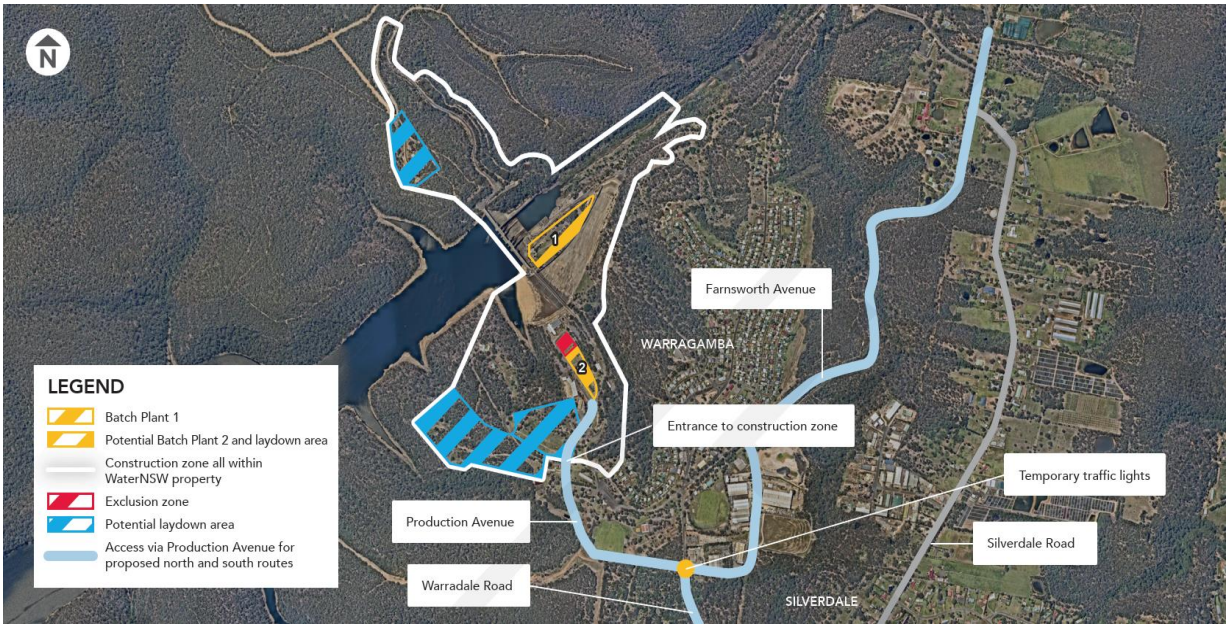
- *Construction area*: there would be temporary amenity impacts from construction of the Project in and around the Warragamba area. There would be limited clearing of vegetation within the construction zone.
- *Upstream*: when the existing dam spills the upstream area is inundated above the full supply level. The Project would increase the temporary inundation in the upstream area. The upstream environmental impact is limited to the net incremental inundation area above what is already inundated with the existing dam.
- *Downstream:* impacts are principally related to a reduction in flood extents and the discharge of flows from the emptying of the flood mitigation zone.

Construction area

The potential key construction impacts include:

- an increase in noise levels for receivers near the construction site during certain construction activities
- congestion within the local road network, while noting that the additional construction traffic is expected to be relatively low, and the local roads and intersections have sufficient capacity
- occasional, temporary and minor dust impacts during construction affecting local amenity
- temporary loss of access to the facilities within Haviland Park and the Warragamba Dam Visitor Centre
- general community disturbance due to traffic and access changes, noise, and visual impacts
- biodiversity affected by the Project construction activities
- impacts to the heritage elements of the State Heritage including Haviland Park
- impacts to heritage items listed on the WaterNSW Heritage and Conservation Register and to local heritage items associated with Warragamba Dam
- minor river water quality impacts from sedimentation and erosion during construction works.
- Figure 26 shows the Project construction area footprint.

Figure 26. Construction area footprint (105 hectares)



Upstream area

The upstream study area comprises the maximum extent of flood prone land estimated from the probable maximum precipitation and resultant inundation. The probabilistic nature of flooding in the upstream study area presents a challenge in identifying appropriate flood events to inform an assessment of potential impacts and noting that for a specific flood event of a particular chance of occurrence, there is already an existing potential impact associated with that flood event. In view of this, it was determined that a suitable approach to assessing potential impacts was required in order to provide relative greater certainty around potential impacts and importantly, to provide a more objective basis for identification and development of mitigation measures. The approach taken has been to identify an 'impact area' that takes account of the variability of flood events and their extent over time.

Operation of the Warragamba Dam will change as a result of the inclusion of a flood mitigation zone with the dam raising Project. The flood mitigation zone creates airspace above the full supply level so that when the lake level rises in a flood, water is temporarily stored within this airspace.

Currently, during large spill events from the Warragamba Dam, modelling shows the likely peak upstream inundation to be 2.8 metres above the full storage level. With the Project, this likely temporary upstream inundation depth would increase to 10.3 metres above full storage level.

The net incremental difference between the likely existing inundation depth and new inundation depth is the upstream impact area. Refer to Figure 27 and Figure 28 for the upstream inundation extents.

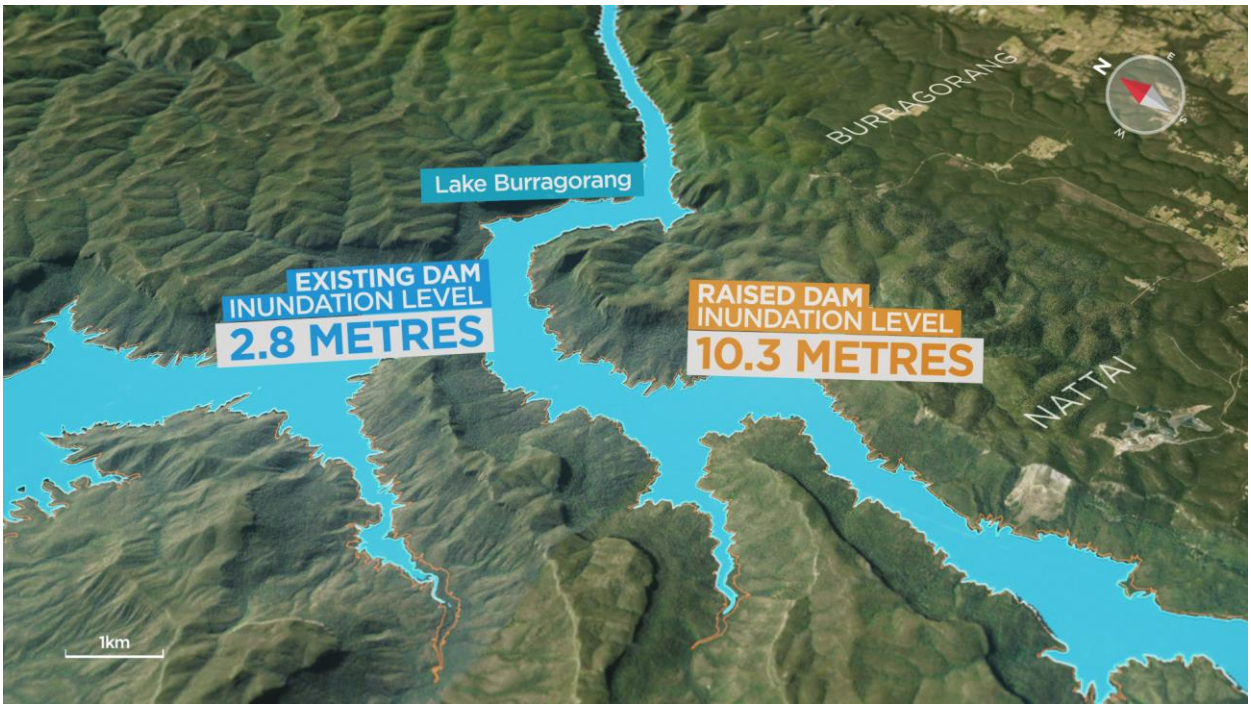
The existing inundation duration above full supply level can be for up to around four days and as a result of the Project for up to around 10 additional days.

Due to the upstream topography, this increased inundation depth and duration reduces moving further upstream in the catchment.

Upstream Impact Area

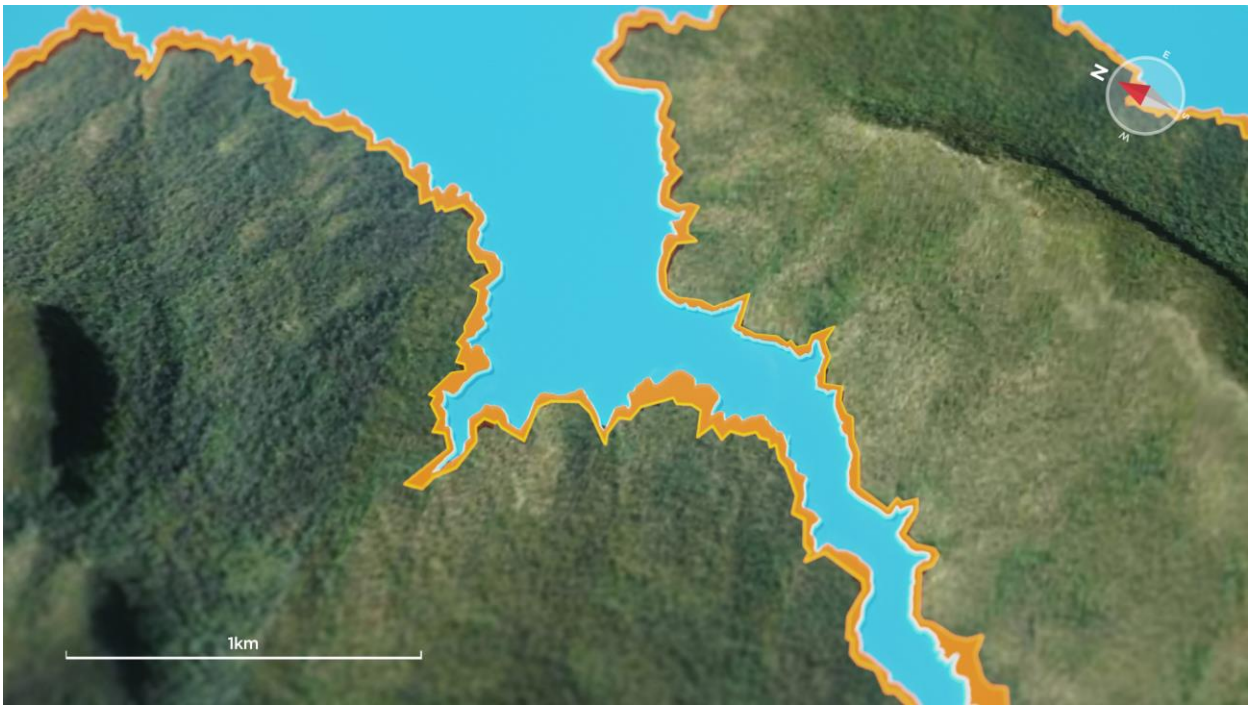
- To assess the potential change in upstream inundation associated with the Project, flood modelling was undertaken. The full range of flood events and lake variables were modelled to determine what the likely inundation level would be.
- A review of the historical records identified at least one large flood above FSL would occur within a 20-year period.
- Building on previous hydrological modelling carried out for the Project, further modelling was undertaken (using Monte Carlo technique) to generate around 20,000 flood events. These events would represent around 200,000 years period of time. This was then analysed by selecting the peak inundation level for each 20-year period to determine the 'average' or likely inundation.
- Using these thousands of modelled flood events, it was determined the likely inundation level with the raised dam is about 10.3 metres above the full supply level. Using the same approach with the existing dam scenario this level was found to be about 2.8 metres above the full supply level.
- These modelling results conservatively reflect the floods recorded since the completion of the dam construction. Over the past 60 years there have been two occasions where inundation exceeded two metres above full supply level; November 1961 flood peaked at 2.8 metres, and June 1964 flood at 2.2 metres above full supply level. This validates the modelling of likely inundation for the existing dam at around 2.8 metres. Further to this, there have been an additional four occasions where the dam lake level exceeded the full supply level by more than 1.5 metres, up to and including March 2021.
- Based on the modelling, and validation by living record, the area between 2.8 metres and 10.3 metres above full supply level has been adopted as the upstream impact area. The size of this area is about 1,400 hectares and a conservative assumption of 100% loss for the impact area has been applied to the assessment approach for all environmental values.
- The upstream impact area has been used as a means to offset the potential impacts of the Project. For the purposes of offsetting the potential impacts of the Project, it has been assumed that there would be a complete loss of values in this area. In reality, this is unlikely as sensitive areas/sites would have differing risks of impact depending on their respective locations in terms of elevation.

Figure 27. Illustration of the upstream impact area



Source: WaterNSW (2021)

Figure 28. Close-up illustration of the upstream impact area



Source: WaterNSW (2021)

Biodiversity

Areas upstream of Warragamba Dam potentially impacted by the operation of the Project comprise largely native bushland that has been designated as a 'Special Area' (see Figure 29 below). This protects and preserves:

- water quality used by over four million residents
- critical water supply infrastructure for Greater Sydney
- natural and cultural heritage.

Surveys and assessments of the flora and fauna in the upstream study area were undertaken to inform this EIS.

Figure 29. Warragamba Dam, Lake Burragorang and the upstream Warragamba Special Area

Source: INSW (2021)
Photo: Adam Hollingworth

The following summarises some of the main impacts on biodiversity associated with the Project based on the flood modelling for the Flood Strategy and the assessments undertaken.

- There would be an increased extent and duration of temporary inundation of native vegetation in the catchment adjacent to Lake Burragorang when the flood mitigation zone is operational. The duration and extent of increased temporary inundation would depend upon the size of the flood event, the lake level at the time and the location of the vegetation in the landscape. Based on the modelling, about a third of the area affected by the Project's temporary inundation has already experienced inundation. Under existing conditions inundation above full supply level can be by up to four days.
- The duration of increased inundation would range from hours up to around 10 days. The increased extent, depth and duration of temporary inundation may result in the loss or damage to vegetation depending on the flood tolerance of species (see Case Study on next page).
- While temporary inundation may impact certain aspects of ecosystem health, the extent to which this may occur is substantially dependent on a large range of independent variables such as topography, frequency, depth and duration of inundation, geographic setting, ecosystem characteristics, land use, germination from flood-borne seeds, edge effects and similar matters.
- There would be an increased extent and duration of temporary inundation of three threatened ecological communities in the catchment when the flood mitigation zone is operational.
- The increased extent and duration of temporary inundation of native vegetation may affect habitat for threatened flora and fauna species. Based on a precautionary approach, assuming species presence even when not identified in surveys, up to 76 threatened flora species and up to 16 threatened fauna species could potentially be impacted.

- Decreased extent of flooding may impact on native vegetation in downstream areas. Some plant community types, individual species and threatened species may require flooding as part of their life cycle or to remain healthy.

Case study: *Eucalyptus benthamii* (Camden White Gums)

Figure 30. Camden White Gum CSIRO Study

On behalf of WaterNSW, CSIRO undertook an inundation experiment with *Eucalyptus benthamii* (Camden White Gum), a species in the Project study area (see Figure 30)

The study used a plantation of mature *Eucalyptus benthamii* planted at Deniliquin in the 1990s as part of the dam raising proposal at that time. The trees were grown from seed sourced from Kedumba in the Warragamba catchment.

The recent study aimed to assess the tolerance of the trees to soil waterlogging of between one and six weeks - noting the temporary upstream inundation with the raised dam would be a maximum of around two weeks. This maximum duration would occur around the edges of the lake, below the lowest known occurrence of the species.

The experiment assessed the survival and health of 80 trees over a 12-month period (later extended to 24 months.) The trial conditions at Deniliquin were regarded as 'tough' due to heavy soils, high temperature and low rainfall.

The CSIRO study concluded that, while the flooding treatments were effective in causing soil conditions long enough to cause root death in susceptible eucalypts:

- the *Eucalyptus benthamii* kept growing through the flood treatments and thereafter
- there was no significant effect associated with the flooding
- there was no difference observed in mortality between the plots inundated and the control sites.

Caption: Camden White Gums temporarily inundated in the CSIRO study at Deniliquin
Source: CSIRO (2019)

Protected lands

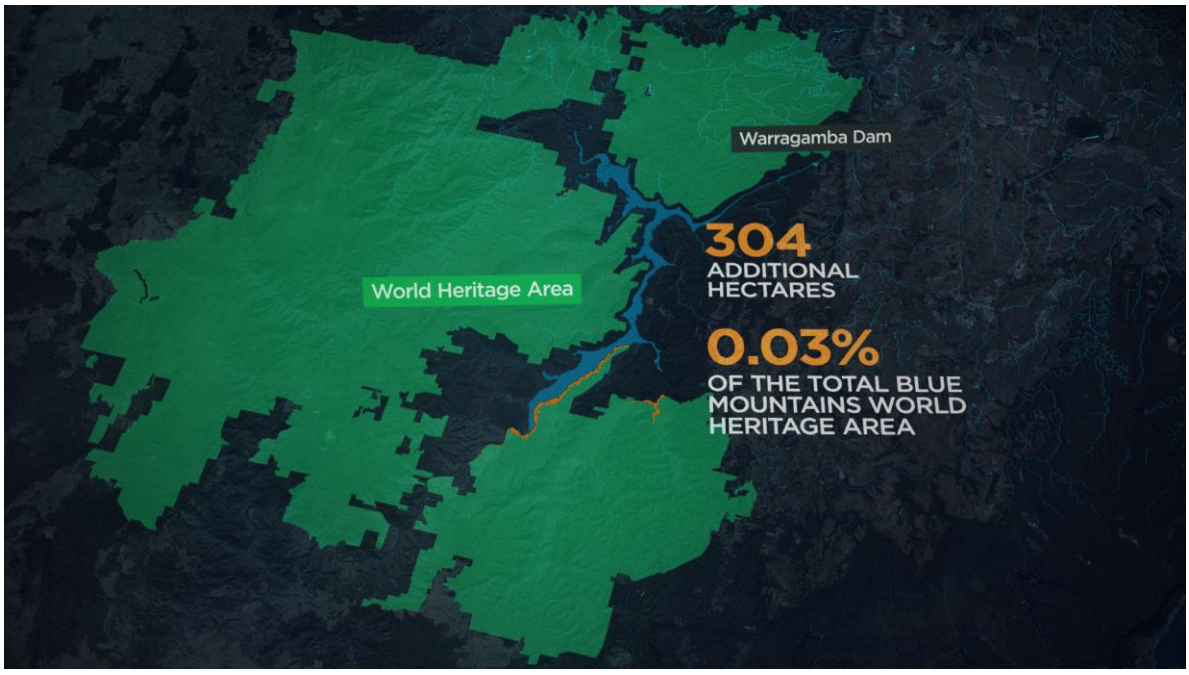
The upstream catchment area contains national parks and state conservation areas, parts of which would experience an increase in the depth, duration and extent of temporary inundation from what already occurs from the existing dam. The increase in depth and duration of inundation would diminish moving away from the dam wall and out of Lake Burragorang and up into the catchment upper reaches.

Part of the Kowmung River has been declared a wild river under the NPW Act. GIS analysis using spatial data sourced from NSW Spatial Services identified a small section of the Kowmung River (about 1,250 metres) within the Project study area but well above the upstream impact. An analysis of depth-duration curves for the closest cross section downstream of the declared wild river catchment (about 250 metres downstream) showed no material difference between the existing situation and with the Project for all flood events up to the 1 in 100 chance in a year event and a very small difference (less than 0.3 metres) up to the 1 in 1,000 chance in a year event. In real world terms, the Project would not impact on the declared wild river section of the Kowmung River.

World Heritage in the Upstream Impact Area

- The Greater Blue Mountains World Heritage Area is one of the largest tracts of protected bushland in Australia. The area covers more than one million hectares and extends for more than 250 kilometres from the edge of the Hunter Valley, to the Southern Highlands near Mittagong.
- There is about 300 hectares of the upstream impact area within the listed Greater Blue Mountains World Heritage Area. This represents about 0.03 percent of the Greater Blue Mountains World Heritage Area (see Figure 31).
- The impacts of temporary inundation would depend on many factors such as:
  - the timing and magnitude of the rainfall events
  - catchment conditions at the time of the rainfall event
  - the existing storage level in Warragamba Dam
  - the duration, depth and extent of inundation for an individual flood event
  - species tolerance to inundation and other available habitat for fauna
  - the type and condition of Aboriginal cultural heritage items and places in the area.
- To compensate for and offset the assessed impact, the Warragamba Offset Strategy focuses on purchasing and managing additional and appropriate land containing the values of the Greater Blue Mountains World Heritage Area to achieve no net loss.

Figure 31. Upstream impact area (shown in orange) relative to the Greater Blue Mountains World Heritage Area



Source: WaterNSW (2021)

Aboriginal cultural heritage assessment

The Aboriginal Cultural Heritage Assessment (ACHA) for the Project has been prepared in line with all relevant guidelines. The purpose of the ACHA is to:

- identify the cultural and archaeological values that may be present within the upstream area
- determine the effect the Project will have on the identified tangible and intangible values
- propose measures to manage and mitigate potential impacts to the Aboriginal cultural heritage values identified.

Aboriginal Cultural Heritage Assessment summary

- **Consultation effort**: Following a publicly advertised call for expressions of interest, 22 organisations and individuals nominated for and met the requirements to be considered Registered Aboriginal Parties (RAPs) for the project. The consultation process with the RAPs subsequently involved ongoing engagement throughout the survey, assessment and development, review and revision of the Aboriginal Cultural Heritage Assessment Report (ACHAR) that commenced in 2017.
- **Methodology:** The RAPs reviewed a draft methodology and provided comments which were incorporated into the methodology used for collecting information on Aboriginal cultural heritage values and assessment of potential impacts to these values from the Project. The agreed methodology was in keeping with state guides and requirements that provide direction on how to appropriately gather a representative sample for a project of this scale.
- **Survey extent**: A total area of 2,655 hectares was surveyed to inform the ACHAR. The surveys included 76 days of field work within a 13-month period. In line with the agreed methodology, the survey coverage achieved is a strong representative sample of the landscape. The survey extent is sufficient representative coverage as compared to the defined upstream impact area of about 1,400 hectares.
- **Archaeological findings:** The survey extent identified 334 archaeological sites in the upstream study area and adjoining land, comprising previously recorded sites and new sites.
- **Sites within the upstream impact area**: Representative survey sampling allowed for the development of a predicative model to estimate the potential of 174 sites (including 43 identified sites) to be within the upstream impact area. The construction works at the dam will not harm any known Aboriginal sites.
- **Archaeological scientific significance:** The archaeological significance of sites identified within the upstream impact area are categorised as low, medium or high scientific significance. However, the sites are all assessed by the RAPs as high from a cultural significance perspective.
- **Cultural values:** An Aboriginal Cultural Values Assessment Report was prepared to assess the potential impacts of the Project on the intangible Aboriginal cultural heritage values within the upstream study area. The cultural values assessment considered 19 dreamtime story sites within the upstream area which were all at least partially impacted by Lake Burragorang.
- **Recommendations of the Aboriginal Cultural Heritage Assessment**: In consultation with the RAPs, 11 recommendations have been made to improve the understanding and the approach to management of Aboriginal cultural heritage values in the catchment for the purpose on intergenerational equity.

The Aboriginal Cultural Heritage Assessment is an extensive body of work detailed in Chapter 18 of the EIS and included in Appendix K. The assessment includes the following elements however some culturally sensitive information has not been made publicly available at the request of RAPs but is included for regulators to enable an informed decision.

- Appendix 1: Archaeological Report
- Appendix 2: Cultural Values Assessment
- Appendix 3: Aboriginal Community Consultation Log
- Appendix 4: Warragamba Dam Wall Raising: Assessment Methodology
- Appendix 5: Information Session Attendance Records
- Appendix 6: Supporting Figures
- Appendix 7: Written comments by RAPS in regard to the ACHA
- Appendix 8: Responses to the Methodology
- Appendix 9: Representative photos of Aboriginal cultural heritage sites
- Appendix 10: Full list of contributors to cultural heritage surveys
- Appendix 11: Consultation Records

Niche Environment and Heritage on behalf of SMEC Australia Pty Ltd has undertaken consultation with the RAPs in accordance with the *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (DECCW 2010a).

It is important to note that from this consultation and assessment effort, the majority of the RAPs consider the proposal to raise the dam for flood mitigation as a further accumulation of impacts to Aboriginal cultural heritage that has previously been affected by the original construction of Warragamba Dam and associated permanent upstream inundation from water storage.

Visual amenity

The impacts to visual amenity by the Project can be summarised as follows:

- *Upstream:* There would be negligible visual impacts for the upstream area. Any changes due to flooding would occur rarely along the Wollondilly River arm on the eastern shoreline of Lake Burragorang. This area is visible from Burragorang Lookout with the nearest part being about five kilometres from the lookout. Most of the areas subject to temporary inundation are where public access is not permitted.
- *Dam site*: There would be some impacts on non-Aboriginal heritage due to the visual prominence of the raised dam wall.

The main changes to visual amenity would occur during construction and would affect:

- Viewing Platform and Warragamba Visitors Centre
- Valve House Road, Warragamba Dam
- 18th Street Lookout, Warragamba
- Haviland Park, Warragamba Dam.

The 2019-2020 bushfires in the catchment

New South Wales experienced severe bushfires starting in June 2019 and continuing through to early 2020. The bushfires have been described as unprecedented in their extent and intensity affecting about 5.4 million hectares (seven percent of NSW) with more than 2.7 million hectares of national park estate affected (about 37 percent of the NSW park system).

The fires affecting the Project study area began in late October 2019 in remote bushland near Lake Burragorang, near Yerranderie, as well as within the Kanangra-Boyd National Park. The fires eventually merged in late November 2019 to become the Green Wattle Creek fire which burnt for about nine weeks. Figure 32 shows the Project location in relation to the broader bushfire impacted area. More than 81 percent of the World Heritage listed Greater Blue Mountains Area was affected.

Bushfire mapping prepared by the Department of Planning, Industry and Environment was used to assess the severity and extent of the bushfire event in the Project upstream study area. About 10 percent of the upstream study area is classed as 'High' or 'Extreme' in terms of burn severity, about 28 percent as 'Moderate', and the remainder as 'Unburnt' or 'Low'. The bushfire event had a limited effect on the downstream study area.

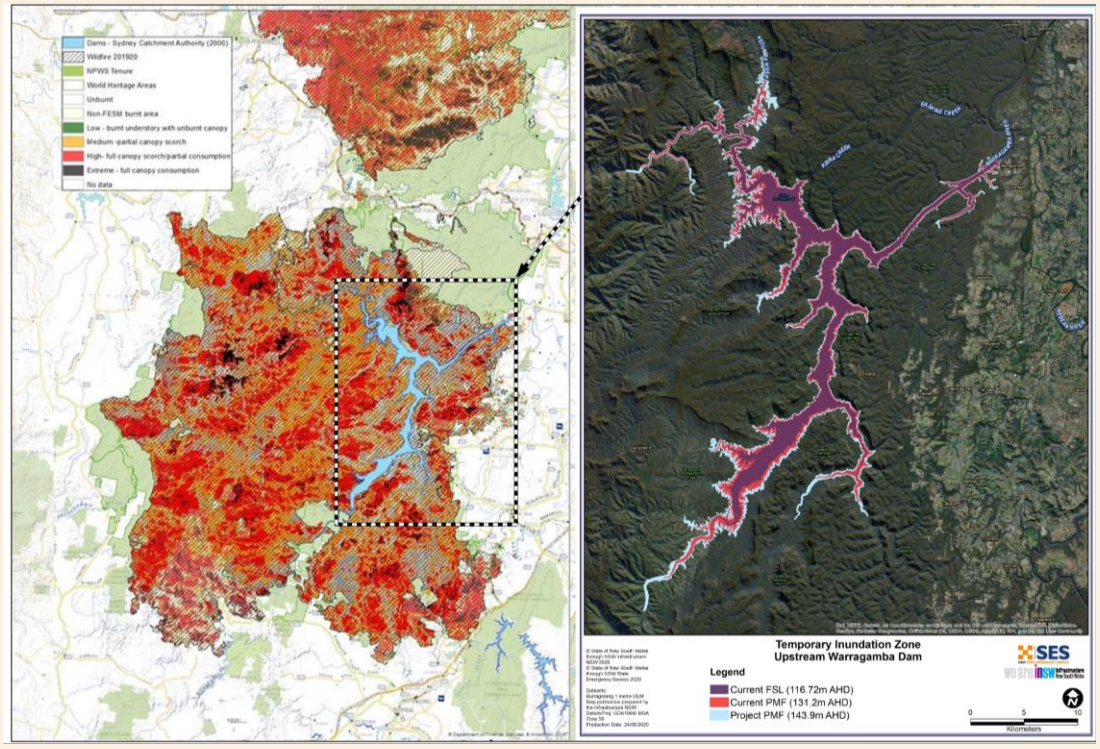
The biodiversity assessment for the upstream study area was carried out in accordance with the NSW Government's Framework for Biodiversity Assessment. In early 2020, the Department of Planning, Industry and Environment released the *Guideline for applying the Biodiversity* Assessment Method at severely burnt sites.

The guideline outlines the approach to identifying the biodiversity values that existed on the land prior to severe bushfire for the purpose of preparing or finalising a Biodiversity Development Assessment Report or a Biodiversity Certification Assessment Report.

The fieldwork to inform the biodiversity assessment for the Project was completed prior to the bushfires, therefore as per Section 4.1.1 of the guideline, the information generated from the assessment has been used to inform preparation of the Biodiversity Development Assessment Report for the upstream Project area.

As per Section 4.1.1 of the guideline, WaterNSW consulted with the Department of Planning, Industry and Environment regarding any additional considerations that may be required because of the severe bushfire. As a result, the assessment includes consideration of the unburnt area as refuge for species displaced.

Figure 32. Project location in relation to the 2019-20 bushfires in the Warragamba catchment



Source: INSW (bushfire map from Department of Planning, Industry and Environment)

Downstream area

The extent of the downstream assessment was defined by the influence of the Project on the environment. The downstream limit of the Project in terms of its influence on the environment, including biodiversity values, occurs around Wisemans Ferry.

The river downstream of the dam has been significantly modified since European settlement. A large urban area is centered around Penrith/Emu Plains, with numerous smaller urban areas along the length of the Hawkesbury-Nepean, including Richmond, Windsor and Pitt Town. Between these centres are agricultural areas, which occur on both sides of the of the river and in the sub-catchments of South Creek and Cattai Creek. Deep gorge country extends from Sackville to the river mouth – comprising natural bushland, with villages, farms, caravan and recreational parks.

The downstream study area for the ecological assessment was defined by the land within the existing probable maximum flood. However, within this study area on-ground biodiversity surveys were undertaken in the area which is defined by the land contained within the existing 1 in 10 chance in a year flood event. The 1 in 10 chance per year flood event is used as it would reduce the extent and duration of flooding downstream have the greatest difference in inundation extent between the existing and project flood scenarios for existing wetlands that rely on smaller flood inundations.

Some plant communities that occur close to the extent of small flood events may experience less flooding. While these plant communities would still experience some flooding, the frequency at which this vegetation is flooded would decrease. It should be noted that most of these areas until March 2021, had not been inundated for around 30 years - suggesting they are reliant on local catchment flooding from other tributaries or groundwater.

Downstream biodiversity

The NSW biodiversity offsets policy for major projects commenced on 1 October 2014 and applies to State Significant Infrastructure, such as this Project, under the EP&A Act. The policy applies to most impacts on biodiversity likely to be caused by major projects, however, there are some impacts that are not addressed. The policy does not provide guidance around certain impacts on biodiversity that are not associated with clearing of vegetation, such as downstream impacts on hydrology or the effects of environmental flows on surface vegetation and groundwater dependent ecosystems. Separate assessment of these and other impacts may be required. Any additional biodiversity assessment requirements are incorporated into the Secretary's Environmental Assessment Requirements (SEAR's.) In accordance with the SEARs for the Project, the downstream impact assessment on threatened biodiversity, native vegetation and habitats followed the *Guidelines for Threatened Species Assessment* (July 2005).

Where an offset package is proposed for any downstream impacts to biodiversity the SEARs require that it meets the *Principles for the use of biodiversity offsets in NSW*. Operation of the flood mitigation zone will result in changes to downstream hydrology and environmental flows, however potential impacts and offset benefits are not quantifiable due to the vast size of the Hawkesbury-Nepean Valley and many other tributaries such as the Nepean and Grose Rivers as well as localised run-off and development. Therefore, offsets are not proposed as there are no quantifiable significant impacts downstream that can be attributed as a result of the project and meet an offset principle that the gain in biodiversity from the offset is quantifiable.

Operation of the dam with flood mitigation zone

After the peak of a flood has passed the temporarily stored water in the flood mitigation zone would be released in a controlled way in coordination with the NSW State Emergency Service. The assessment considered the downstream area that would be affected by inundation during emptying of the flood mitigation zone as this area would experience a longer duration of low-level river flows as flood waters recede compared with how the existing dam operates. For example, this change in operation would result in potential limited access for road users from the extended closure of low-lying bridges during releases from the flood mitigation zone (see Figure 33).

Figure 33. The low-lying Yarramundi Bridge could remain closed for hours and up to around 10 days longer with controlled releases from the dam

Caption: Yarramundi Bridge during the February 2020 flood
Source: INSW (2020)
Photo: Adam Hollingworth

Warragamba Offset Strategy

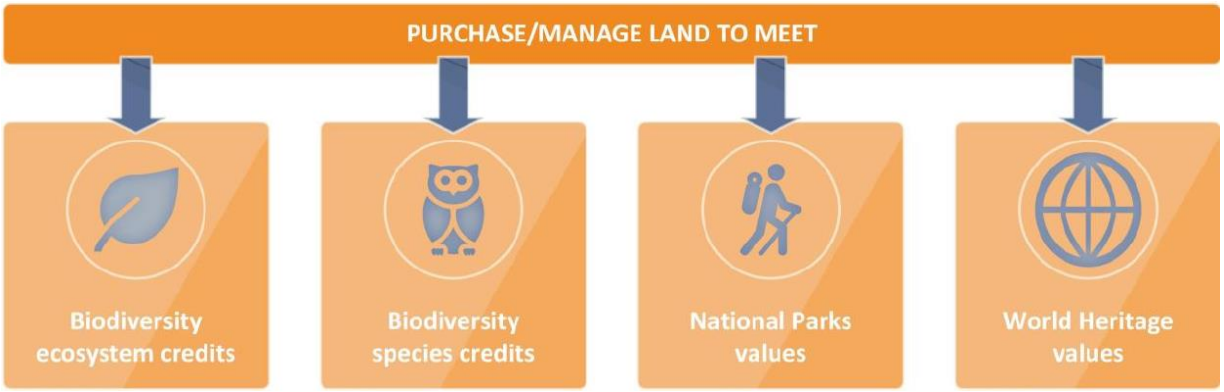
The objective of the Strategy is to provide a framework for the delivery of offsets for the potential impacts of the Warragamba Dam Raising Project (the Project) and to achieve a long-term conservation gain for the threatened species, populations and communities, and biodiversity-related national parks and World Heritage values impacted by the Project. It includes the biodiversity offsets required under the Framework for Biodiversity Assessment (FBA) and set out in the SEARs, and offsets addressing potential loss of biodiversity-related World Heritage and national park values.

The Warragamba Offset Strategy incorporates all offset requirements for unavoidable upstream, downstream and construction area impacts. The Strategy will meet the biodiversity offset requirements of NSW and Commonwealth Offset Policies and would source appropriate compensation for impacts to protected lands through:

- the purchase of suitable land and retirement of biodiversity credits
- other supplementary measures (e.g. actions within specific threatened species recovery plans targeted at potentially impacted species).

It should be noted that while the Warragamba Offset Program will prioritise land suitable for inclusion in the National Park estate additional offsets may be needed through purchase and retirement of biodiversity credits in order to meet the credit requirements for the project. Any land containing suitable offsets must also be appropriate for the National Park estate and supported by NPWS for this purpose. It is intended that as a minimum the quantum of land required to compensate for impact on National Parks (including the affected part of the GBMWHA) will be equivalent to or greater than the area impacted (1,400 hectares) and that this would incorporate a minimum area of 304 hectares containing OUV values to offset potential impacts to the GBMWHA. Figure 34 illustrates the goal of the Warragamba Offset Program to target offset sites that meet both biodiversity and protected lands goals.

Figure 34. Targeting of offsets



Offsetting options

Offset strategies can include both on-site and off-site or local area schemes that contribute to the long-term conservation of threatened species and communities. Offsets are required to compensate for the residual impacts associated with the Warragamba Dam Raising Project.

The *NSW Biodiversity Offsets Policy for Major Projects* (NSW Government 2014) prescribes four types of strategies that can be used to fulfil the offset requirements:

- offsetting through a site secured stewardship (formerly known as biobanking) agreement
- purchasing credits
- supplementary measures following the rules prescribed in Appendix B the policy
- monetary contribution into the Biodiversity Conservation Fund.

Principles of biodiversity offsets for major projects?

The *NSW Biodiversity Offsets Policy for Major Projects* provides a standard method for assessing impacts of major projects on biodiversity and determining offsetting requirements (NSW Government 2014). The policy is underpinned by six principles:

- Principle 1: Before offsets are considered, impacts must first be avoided, and unavoidable impacts minimised through mitigation measures. Only then should offsets be considered for the remaining impacts.
- Principle 2: Offset requirements should be based on a reliable and transparent assessment of losses and gains.
- Principle 3: Offsets must be targeted to the biodiversity values being lost or to higher conservation priorities.
- Principle 4: Offsets must be additional to other legal requirements.
- Principle 5: Offsets must be enduring, enforceable and auditable.
- Principle 6: Supplementary measures can be used in lieu of offsets.

Mitigation and management measures considered

Key environmental planning and management mitigations outlined in this EIS include:

- a construction traffic management plan to manage construction traffic
- a construction noise and vibration management plan, including for out-of-hours work procedures
- a construction air quality management plan to manage dust and other air quality risks
- a construction soil and water management plan to manage risks to water quality upstream and downstream of the dam
- a construction flora and fauna management plan to minimise impacts on flora and fauna during construction
- a National Parks environmental management plan to account for impacts of temporary inundation on National Parks assets and values.
- a detailed operational protocol for the operation of the flood mitigation zone that would include minimising environmental impacts as one of its objectives
- an Aboriginal cultural heritage management plan to address intergenerational equity including recording of Aboriginal cultural heritage
- various non-Aboriginal heritage plans and strategies to minimise impacts during construction, and to restore heritage values after construction has been completed. This would include preparation of a landscape scheme for the restoration of Haviland Park and preparation of a Heritage Interpretation Strategy
- the Warragamba Offset Strategy to address impacts of the Project on biodiversity, national parks and the Greater Blue Mountains World Heritage Area
- ongoing consultation with affected community and stakeholders.

The design, construction and operation of the Project would be carried out in accordance with the management measures identified in this EIS, as well as any additional measures identified in the Project's conditions of approval.

Stakeholder consultation for the Project

Consultation on the Project began with the release of the Flood Strategy and identification of the Project as the preferred infrastructure alternative in 2016.

Upon being tasked to prepare the environmental assessment of the proposal to raise Warragamba Dam, a community and stakeholder engagement and consultation program was developed to ensure community and stakeholder insights would inform the Environmental Impact Statement undertaken.

The overarching objective of the program is to support the following five phases of project delivery:

- Phase 1 – Program preparation and scoping stakeholder interests
- Phase 2 – Public awareness and consultation on studies for the EIS
- Phase 3 – Finalisation of feedback on draft studies for EIS
- Phase 4 – EIS Public Exhibition
- Phase 5 – EIS submissions taking, analysis and reporting.

To date, in addition to engaging with local stakeholders, Registered Aboriginal Parties and government agencies, the program has involved community engagement activities such as community information sessions, distribution of newsletters, interviews, surveys and workshops

The pre-EIS phases were intended to *inform* the community and stakeholders of the key features, benefits and impacts of the proposal, to *consult* and to *involve* respondents by inviting feedback that informs the Project, enabling preparation of a Consultation Issues Report and the drafting of the EIS Consultation Chapter. The fourth phase is ongoing while the EIS is placed on public exhibition for the agreed duration. The fifth phase is for the coordination of, and response to, submissions received for the EIS.

Consultation undertaken for the EIS involved informing, educating, and capturing feedback from community and stakeholders. Key objectives were to:

- build on the consultation program activities undertaken for the Flood Strategy
- build awareness and improve the broader community's understanding of the Project and its primary purpose of reducing flood risk and impact to downstream communities
- identify key community members/groups of stakeholders and build long-term relationships for ongoing communication
- provide accessible and targeted opportunities for the community and stakeholders to provide feedback on the Project
- ensure community and stakeholder issues were identified and considered during preparation of the socioeconomic impact assessment (SEIA) and technical impact assessments
- capture community and stakeholder feedback to identify potential mitigation measures for environmental and social impacts
- provide accessible plain English communication materials to increase the knowledge and understanding of need, impacts and benefits of the Project upstream, downstream, and adjacent to Warragamba Dam
- raise awareness of the planning approval process for the Project and how the community and stakeholders could provide input
- inform and refine ongoing engagement and consultation
- provide timely responses to questions about the Project from the community and other stakeholders.

Should the Project proceed, these phases will be followed by detailed community and stakeholder engagement plans for both the construction and operation phases.

Key issues and interests identified by these early activities and in subsequent engagement activities and feedback channels have been mapped by LGA within the study areas. The summary below illustrates the range and diversity of issues and interests, including:

- ecological impacts on upstream areas from temporary inundation, including on specific threatened species
- impact on Aboriginal cultural heritage upstream of the dam from temporary inundation
- protecting the values and listing of the Greater Blue Mountains World Heritage Area
- concern about potential economic effects associated with construction and lack of access to the dam
- potential impact on downstream businesses including fishing, boating, recreational and tourism
- concerns that the Project is not proceeding quickly enough, or may not proceed at all
- concerns about flood insurance – many houses in vulnerable areas are not adequately covered
- concerns about levels of development in the floodplain
- interest in better understanding the options considered and alternatives to proposal.

What is the approval process for the Project?

The Project is State Significant Infrastructure and requires assessment and approval under Part 5, Division 5.2 of the EP&A Act.

The Project is also a controlled action and requires assessment under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as it has the potential to impact on matters of national environmental significance. Figure 35 identifies the six major steps in the assessment process for State Significant Infrastructure and highlights where WaterNSW is at in this process.

The EIS has been prepared in accordance with the provisions of the EP&A Act, EPBC Regulations and the NSW Department of Planning, Industry and Environment Secretary's Environmental Assessment Requirements (a full checklist of the Secretary's Requirements is provided in Appendix A (Statutory requirements).

In accordance with the bilateral agreement reached between the NSW and Australian Governments, an EIS under the EP&A Act for State Significant Infrastructure can also be used for an assessment under the EPBC Act for a controlled action, where directed by the Commonwealth Minister for the Environment.

The direction was given for the Project to be assessed under the bilateral agreement on 17 July 2017. The Project will first be assessed by relevant NSW government departments, followed by consideration by the Commonwealth Minister for the Environment.

The EIS is being publicly exhibited to provide the community, agencies and stakeholders with an understanding of what is proposed and an opportunity to make comment.

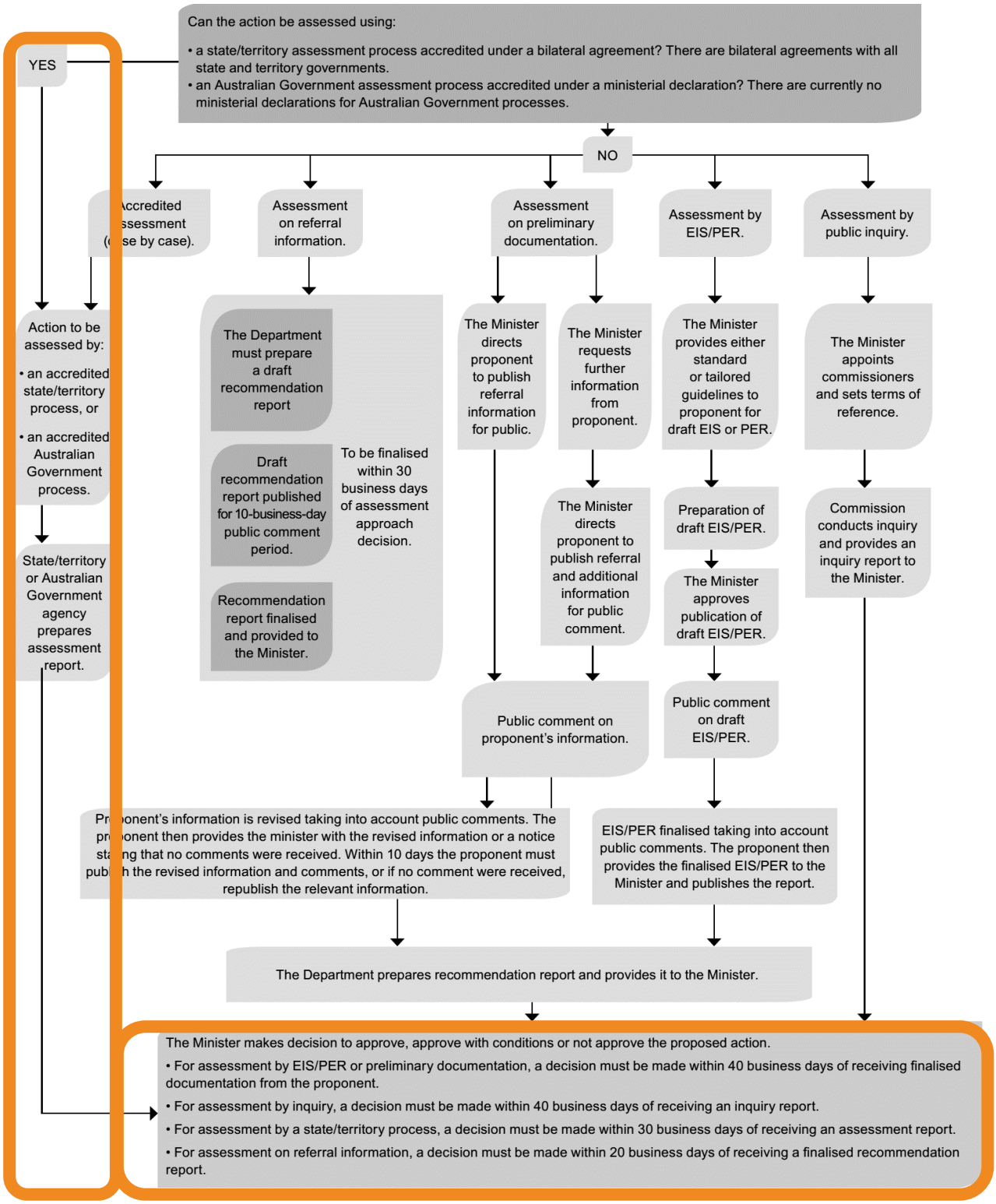
WaterNSW will respond to the feedback and prepare a report that documents the submissions and responds to issues. This will be submitted to the NSW Department of Planning, Industry and Environment. The Department will prepare an assessment report for the Minister for Planning and Public Spaces who will then determine whether to grant approval and what conditions may be attached to the approval.

All environmental impact assessment documentation including the NSW project approval conditions would then be considered by the Commonwealth Minister for the Environment who would then determine whether to grant approval under the EPBC Act and whether to apply any additional conditions (see Figure 36).

The final decision on the proposal to raise Warragamba Dam for flood mitigation will not be made by the NSW Government until all the environmental, cultural, financial and planning assessments are complete.

Figure 35. EIS assessment process for State Significant Infrastructure under NSW legislation

Figure 36. EPBC Act environment assessment process—assessment/decision whether to approve



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